Demographic Research Monographs

Heiner Maier
Jutta Gampe
Bernard Jeune
Jean-Marie Robine
James W. Vaupel
Editors

Supercentenarians

Springer

Demographic Research Monographs

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Editor-in-chief

James W. Vaupel
Max Planck Institute for Demographic Research,
Rostock, Germany

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Foreword

This volume on supercentenarians, people 110 years old and older, is the seventh book of a series of Demographic Research Monographs published by Springer Verlag. It is the result of almost a decade of effort by a brigade of dedicated researchers who have discussed their work at seven research workshops, spaced at roughly annual intervals and held in Germany, Denmark, the United States, France, Japan, Italy and Canada, and who will soon meet again - in Spain.

The volume begins with a chapter on age validation and ends with two chapters that emphasize this endeavor; the three chapters include short accounts of specific supercentenarians that add life to the demographic research. Because most reports of reputed supercentenarians are erroneous, age validation is essential to compilation of accurate data. The accounts of specific supercentenarians reveal that there is apparently no secret of longevity: supercentenarians appear to be almost as diverse as individuals at younger ages, albeit almost all are women, most enjoyed comparatively good health until advanced old age and none were heavy cigarette smokers. The number who did not marry or who had fewer children than average appears high compared with marriage and childbearing patterns for people who died younger.

Evolutionary theory predicts that there should be a trade-off between survival and reproduction, so this finding-which needs to be carefully scrutinized and verified-may be a result of genes that reduce mortality at the expense of fertility (Baudisch, 2008; Doblhammer, 2003). That genes may be important is also suggested by the fact that longevity appears to run in families, but there could be non-genetic factors that run in families that account for this finding. Studies of twins suggest that about 25% of the variation in adult lifespans can be attributed to genetic variation among people and that this percentage may increase somewhat for elderly people (Herskind et al., 1996; Hjelmborg et al., 2006). No longevity genes, however, have been found-in replicated studies-to slow the process of ageing and only one gene, ApoE, is reliably known to have polymorphisms that somewhat raise or lower the chance of death at older ages (Christensen, Johnson, and Vaupel, 2006). All functioning genes either contribute to survival or fertility, so genetic variation at each of hundreds of loci may slightly affect the chance of surviving to 110.

The second chapter in this volume provides an overview of the International Database on Longevity (IDL) that is the repository for data on supercentenarians. The chapter emphasizes the importance of age validation and also the importance of obtaining data on all supercentenarians in some population that is defined by strict rules. This is important because some kinds of identification procedures may pick up people who are, say, 115, with greater probability than people who are merely 110. Such an age-bias in the inclusion of supercentenarians in a database can result in serious misestimates of mortality patterns.

Subsequent chapters examine data on supercentenarians in a series of countries. These chapters explain the unique features of data sources in different countries and how supercentenarians can be identified and validated. The chapters were completed at various times, some, including the chapter on the United States, a few years ago and the one on Spain just a few weeks ago: Spain joined the supercentenarian consortium only about a year ago. In all the main countries in the project, however, data collection continues and various improvements in methods are regularly introduced. It was difficult to say that now is the time to publish what we have up until now, but this volume is published and further work will have to be reported in subsequent articles and perhaps a follow-up book.

The analytical fruit of the demanding, time-consuming research on supercentenarians is presented in the chapter by Jutta Gampe. The main finding is remarkable: human mortality levels off at a probability of death of 50% per year, at least from ages 110 through 114 and apparently afterwards (although the data are too sparse to make a firm judgment). When the supercentenarian project was started, it was not known whether death rates continued to rise at advanced ages, leveled off, or started to decline. This uncertainty was highlighted in an article in Science in 1998 and was the main motivation for launching the supercentenarian endeavor (Vaupel et al., 1998). The chapter following Gampe's chapter, on the life expectancy of French supercentenarians, presents results that are generally consistent with Gampe's, especially considering the small sample size of the French supercentenarian population compared with the entire IDL compilation. The French chapter demonstrates how much can be learned from a small number of supercentenarians, but the larger IDL database permits deeper, more confident analysis.

The leveling off of death rates is probably due to a balance between two tendencies: (1) individuals tend to become more decrepit with advancing age and (2) the frailest individuals at any age tend to die first, leaving a more robust population of survivors. Achieving and maintaining such a balance is difficult and probably impossible if individuals differ from each other in their rate of deterioration. Surprising as it may seem, however, such a balance at advanced ages is plausible if individuals differ in their level of deterioration, such that, for instance, some individuals reach a level of senescence at age 70 and a greater level of senescence at age 80, whereas other individuals reach these two milestones when they are 10 years older (Vaupel, 2010). Ongoing research at the Max Planck Institute for Demographic Research, building on a pathbreaking article by Roger Thatcher (Thatcher, 1999) (the author of the chapter on England and Wales in this volume) suggests that the death rates may increase at the same pace for nearly all older humans today-and also in the past. Exceptionally long-lived people appear to reach advanced ages not because they senesce more gradually than others but because they reach old age in a better state of health. This hypothesis is consistent with the finding that the process of senescence is being delayed over time rather than being decelerated. Genetic defects have been found that speed the process of ageing in unfortunate people who suffer progeria, but as noted above no mutation has been discovered that decelerates the process-and it may be that no such mutation is prevalent in human populations.

In any case, the hypothesis that individuals who survive to advanced old age do so because they reach older ages in better health and not because they age more slowly is worth careful further study and, working with the members of the supercentenarian consortium and others, I intend to make this a research priority. It would be useful to have more data and we plan to keep adding supercentenarians to the IDL database. We also have started to extend the database to younger ages-109, 108, and when feasible 105, and plan to intensify these efforts. The Kannisto-Thatcher Database (available at `www.demogr.mpg.de`) provides serviceable death rates up to 105, but death rates for semisupercentenarians between 105 and 110 are almost as murky as supercentenarian mortality was before publication of this volume. The annual probability of death may be close to 50% at ages below 110: this demands investigation.

The series of Demographic Research Monographs is under the editorial supervision of the Max Planck Institute for Demographic Research. I am Editor-in-Chief. I am advised by an Editorial Board that currently consists of Prof. Elisabetta Barbi (Messina University, Italy), Prof. Gabriele Doblhammer (Rostock University, Germany), Dr. Jutta Gampe (Max Planck Institute), Prof. Joshua Goldstein (Max Planck Institute), and Prof. Bernard Jeune (University of Southern Denmark). Additional members are temporarily appointed to the Editorial Board as needed to review manuscripts submitted for possible publication. The current manuscript was reviewed and accepted by Gampe, Jeune and myself, based on advice from a group of referees that also included Elisabetta Barbi, Heiner Maier, Trifon Missov, Tenko Raykov, Jean-Marie Robine and Axel Skytthe. The Editors thank Frank Haake and Miriam Hills for helping prepare the manuscript for publication.

The Demographic Research Monographs series can be considered the successor to the series called Odense Monographs on Population Aging, edited by Jeune and me. The volumes in this now-terminated series were first published as hardcover books by an academic publisher, Odense University Press, and subsequently made available online at `www.demogr.mpg.de/books/odense`. The nine Odense Monographs on Population Aging include two collections of research articles that focus on specific subjects on the frontier of demographic research, three volumes by senior researchers that present path-breaking findings, a review of research on a topic of emerging interest, a presentation of a new method for analysis of demographic data, an outstanding doctoral dissertation, and a unique collection of important demographic data on non-human species.

The series of Demographic Research Monographs continues this mix, with books that are often under 200 pages in length but can, like the current volume, be much longer, that have a clear focus, and that significantly advance demographic knowledge. Research related to population aging continues to be a focus on the series, but it is not the only one. We hope that eventually the series will embrace all of demography, broadly defined. As indicated by the first volume in the series, an important subject is historical demography. We will also publish research on fertility and family dynamics, as in the case of the previous volume by Dr. Nadja Milewski. Mathematical demography is the core of the population sciences and we will strive to foster monographs, such as the one on How Long Do We Live?, that use mathematics and statistics to further develop the theories and methods of demography. Biodemography is a small but rapidly growing and particularly innovative branch of demography: we will seize opportunities to publish monographs, such as the one by Dr. Annette Baudisch, at the intersection of biology and demography; such monographs can pertain both to humans and other species, and can include demographic research with ties to such fields as epidemiology, genetics, evolutionary biology, life-history biology, experimental demography, and paleodemography.

Each volume in the Demographic Research Monograph series will have a substantial link to the Max Planck Institute for Demographic Research. As well as being published as hardcover books by Springer-Verlag, the volumes of the Max Planck series of Demographic Research Monographs will subsequently be available at `www.demogr.mpg.de/books/drm`. The online version may include color graphs, supplemental analyses, databases and other ancillary or enhanced material. Parallel publication online and in print is a significant innovation that will make the monograph series particularly useful to scholars and students around the world.

James W. Vaupel
Editor-in-Chief

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Part I

General

On the age validation of supercentenarians

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Abstract. As age inaccuracy was often observed in past populations, and is still commonly observed today in populations without efficient civil registration, age validation is essential to all scientific research on longevity in demography, genetics, epidemiology, and medicine. Thoms, in 1873, was probably the first scientist who pointed out that the ages of most centenarians were effectively exaggerated. To address this problem, Thoms introduced strict rules for researchers to follow when validating ages. Even today, these strict rules are still not being systematically applied, although some authors have recently proposed precise classifications for the level of age validation. In this chapter, we will look at some of the ways age validation is currently being conducted in different settings, and we will then present details on the age validation of some recent supercentenarians, including several exemplary cases of invalidation.

1 Introduction

The validation of the ages of alleged centenarians is essential for scientific research in demography, genetics, epidemiology, and medicine. Age inaccuracy was often observed in past populations, and is still commonly observed today in populations without efficient civil registration. Studies show that inaccurate reporting of age may be significant, tends to increase with age, is more often observed in illiterate populations, and is more common among males than among females (Bennett and Garson, 1986; Bowerman, 1939; Condran, Himes, and Preston, 1991; Jeune and Vaupel, 1995, 1999; Mazess and Forman, 1979; Myers, 1978; Palmore, 1984; Rosenwaike, 1979; Rosenwaike and Stone, 2003).

There are three different attitudes prevalent among researchers facing the age validation problem:

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- A tendency to be too optimistic, and to not consider age validation to be necessary, or to even skip the problem;
- A tendency to be too pessimistic and very sceptical, and, therefore, to disregard the concerned populations for the purposes of research without thorough investigation of the situation; and
- A determination to be positively critical, and to develop adequate age validation exercises before launching larger research projects in order to identify populations with exceptional longevity.

We have chosen to adopt the third attitude, as it is the only acceptable approach from a scientific point of view.

The age validation of centenarians is essential in all longevity studies. However, it comes second after the identification of the potential centenarians. This identification can be done in two different ways: either on a random basis, without ensuring the exhaustive collection of data; or on a systematic basis, while trying to ensure the completeness of the data and the identification of all centenarians in a given population. As we will see later, the way in which centenarians are identified may have some impact on age validation.

Legally speaking, the basic identification criteria are those that can be found on the birth record: full name (family name and all given names), sex, and date and place of birth. Consequently, the validation of the age of a person, centenarian or not, consists of checking if a given birth record is accurately attributed to a specific person, so that his or her age may be calculated without doubt. That is ensured by a perfect administrative and civil registration system, but, in the case of centenarians, that means that this system would have had to have been working perfectly for at least 100 years. In many countries, there are some doubts as to whether the birth registration system was working correctly in the 19th century, resulting in the low quality of the identification of persons[1].

Therefore, a detailed system of age validation is often needed. To perform this exercise, we face two different situations depending upon whether the person is still alive, or if he or she is already dead. If the person is alive, any appropriate administrative sources, such as a

[1] This full registration of persons was first achieved in Sweden in 1749; in Belgium, in 1779; in the UK, in 1837; in 1866 in Italy; in 1872 in Japan; in the U.S., in 1933. Because it takes more than 100 years for the persons born (or claiming to be born) to be counted for the validation of a longevity area, we may consider that the Swedish records achieved accuracy around 1860, at the end of the 19th century in Belgium and mid-20th century in the UK, and more recently, in Italy and Japan; while accuracy has yet to be achieved in the U.S.

population register, a family book, an identification card, or a passport are sufficient to start the age validation process. In no case can a self-declared age be used as a form of proof for the purposes of age validation. If, on the other hand, the person is dead, the death record should provide all the information needed to make a clear identification of the person, and can serve as a starting point in the age validation process.

After a short review of the history of age validation for centenarians, we will detail the validation procedure step by step. We will, therefore, consider different types of basic documents, and discuss the differences between original documents and copies. Whether some contextual factors influence the age validation process, and how best to conclude the validation exercise, are two important questions we intend to address before moving on to present some examples of validation or invalidation of the ages of supercentenarians.

2 Some features of the history of age validation for centenarians

Quételet (1846) was certainly among the first statisticians who used a validation process, having relied upon validation in checking the exact ages of all centenarians identified in the 1846 Belgian census[2]. A quarter of century later, Thoms (1873) was probably the first scientist who pointed out that the ages of most centenarians were effectively exaggerated. As mentioned by Jeune and Vaupel (1995), these are the steps that Thoms proposed for investigating every case of exceptional longevity:

1. Search in register for birth record.
2. Check all births under the same name in the same register.
3. Have the certificate corroborated by other forms of evidence.
4. Lead the conversation with the centenarian so as to learn facts which can be verified through other sources, and which corroborate the birth certificate. The latter assumes that the verification of age is carried out while the person is still alive, and while communication is possible.

In his second book, Thoms (1879) explained why additional corroborative pieces of evidence are essential. These include basic information on parents, brothers and sisters, date and place of marriage, and dates

[2] See the result of this investigation in Poulain, Chambre, and Foulon (1999)

of birth of all children; but also all additional information, like entry into the army, admission to school or acceptance for public employment.

Later, Young (1899, 1905), Bowermann (1939), and Vischer (1945) also pointed out the problem of age exaggeration, and the need for appropriate age validation. However, in a large number of subsequent studies, the age was still based on self-declaration, and no reference was made to the use of the birth records or any administrative registers for the purposes of validating age. In studies of populations in the Caucasus, a region considered as experiencing exceptional longevity, the focus of most of the authors when validating age was on the appearances of elderly people, their physical and labor activities, lifestyles, diet, social environments, etc. (Medvedev 1974). Further studies carried out in the same region attempted to verify the ages of the oldest old by looking at all the main stages of their life histories through the investigation of biographical records of family members, such as an identification of the ages of children and grandchildren, and detailed information about the person's family life, starting with the first marriage, first birth, etc. In a second step, researchers tried to connect the information collected with events of national and local importance that had known dates, like wars and earthquakes, and by reconstructing in a person's memory the relationship between these events and life events. The conclusion reached by Palmore (1984) was that only one-third of all interviewed nonagenarians in this study were effectively aged 90 years and more, while none was found to be a supercentenarian, aged 110 years or more.

Thatcher (1992) mentioned that, during the early years of the 20th century, and, indeed, well before, there were considerable doubts about the accuracy of some of the high ages recorded in both the censuses and the death registrations. This was because of the well-known tendency among old people to overstate their ages and also partly because most of these persons were born before the registration system was established in a given country.

Skytthe and Jeune (1995) introduce four different levels of certainty of age, ranging from the lowest level, D, to the highest level, A:

- Level D : Date and age at death without verification
- Level C : Birth registration
- Level B : Life story
- Level A : Family reconstructed

Accordingly, level D is simply a reported age of 100 years or more and a date of death without any other verification. This is, of course, insufficient. As a minimum, the birth or baptism must be documented by a record in a parish register or in a civil register (level C). Both authors recognized that it was necessary to have more information in order to verify the age with certainty. The reconstruction of at least part of the life history of the person using data from other sources, such as appearance in the census lists, confirmation, military service, etc., is needed to ensure verification at level B. In addition, it is necessary to find all brothers and sisters because of the fairly common practice of naming a newborn baby after a predeceased brother or sister. Therefore, the full family reconstruction is essential, and achieving that reconstruction will lead to possible validation at level A.

During an IPSEN workshop held in Paris in 1996, Jeune and Vaupel proposed a larger number of levels of credibility for the age validation by splitting the A level into three sub-categories: A++, A+, and A. In addition, Jeune and Vaupel added E and F levels to describe the lower levels of credibility, which may apply in countries where official documents are sparse. Here are the proposed levels of credibility:

- A++ is the highest level of credibility. A case earning this level must be supported by "compelling evidence," and be based on a well-documented life history, including documents proving birth and death, or, if the person is alive, age confirmation through interview. Some plausible documentation of the individual's existence and residence over the life course with no gap exceeding 10 years is also requested. In addition, there should be a well-documented, plausible vital statistics history of the immediate family. This history should give no specific grounds for suspicion, effectively removing any possibility that one individual may have been confused with another individual of same name, or a very similar name.
- A+ is applied to cases for which there is "strong evidence," while A is used when there is "plausible evidence." In these two levels of credibility, some information may be missing or incomplete in the life history or the family reconstitution, gaps between events may be longer than is ideal, and some forms of evidence are plausible, but not as strong as those presented in the A++ level.
- B means that there is "good" evidence of age validation, and, as proposed by Skytthe et al. (1995), no family history is required. At this level of credibility, there can be one or more suspicious indications that cannot be countered by plausible evidence. Taken into account is the statistical evidence that the individual's alleged lifespan is plausible according the level of mortality in the whole population.
- C indicates that "little" evidence is available, and the validation is only based on birth and death information. One or more suspicious

indicators may be accepted, as long as none of these makes it appear likely that the individual's age has been misreported.

- D means "weak" evidence is present, and is based on either birth documentation and assertion of age, or death documentation; in both cases, with at least a 10% chance that the age could be correct.
- E is applied when only "flimsy" evidence offered, such as when no official documentation is available on birth and death, but an assertion of age is made by the individual while alive, or by a knowledgeable relative or official. At this low level of credibility, the statistical evidence should be at least 1% that the age is correct.
- F indicates there is "negative" evidence for age validation, as in cases where the statistical evidence is such that there appears to be less than a 1% chance that the age could be correct.

Following the intentions of the authors, the highest level of validation would be required for the age validation of exceptional cases, and probably for all supercentenarians, while levels B or C may be satisfactory when trying to estimate the level of longevity of a given population by enumerating the number of centenarians in different birth cohorts.

More recently, the International Database on Longevity (IDL), a joint research project of the Institut national de la santé et de la recherche médicale (INSERM, University of Montpellier), the Institut national d'études démographiques (INED, Paris) and the Max Planck Institute, Rostock, initially used a "star" system to rank the accuracy of the age validation for all supercentenarians included. In this system, stars are granted according to the documents available to validate each case:

- "One star" indicates that there are two different documents in existence on the same person with no ambiguity: one testifying to the date of death (a death record), and another testifying to the date of birth, or dating a point in time close to the reported date of birth (for example, a census sheet indicating that the person was 19 years old on a certain date)
- "Two stars" mean that age, date of birth, and date of death are officially communicated by the national authorities in charge of vital statistics of the population, but without any particular verification effort having been made for the supercentenarians.
- "Three stars" indicate that the birth record and the death record (or photocopies) have been brought together and hand-checked, side by side, to verify the exceptional reported age.
- Meanwhile, "four stars" might be used for thoroughly validated cases that include events from the life history.

- Finally, “five stars” are to be awarded only when a full family reconstruction has been obtained and deemed satisfactory.

However, due to difficulties encountered when building the IDL’s present structure and content (as presented in Cournil et al., this volume), the project now follows a more pragmatic set of rules, and the supercentenarians are classified in three categories according their validation status:

- “0” means that the case is not validated, as the reported age has not been sufficiently verified;
- “1” corresponds to an in-between situation whereby the case is considered to be validated, but no personal document on the individual is available in the database;
- “2” indicates that the case is considered validated, and the main types of documents which were used to perform the validation are recorded in the database (for this status, the IDL relies on a reference person who is considered to be responsible for the validation in a given country).

3 The age validation procedure

If the person is dead, the age validation should prove that there is a perfect and unambiguous link between the death and the birth records attributed to this person.

If the person is alive, the age validation should consist of attributing a given birth record to a living person based on all elements of identification, which should be without ambiguity.

The ideal validation procedure will consist of the following steps:

1. Identification of an alleged centenarian is based on the declaration of age, on a newspaper article, on a special investigation carried out place by place, or on an available official list of inhabitants or centenarians.
2. If the alleged centenarian is alive, collect all basic information through identity cards, passports, family or household books, or any other pieces of identification that may be available. If the alleged centenarian is dead, locate the death record.
3. In both cases, regardless of whether the alleged centenarian is alive or not, locate the birth record.
4. Collect all documented life events related to the centenarian, including information on marriage(s), characteristics of the spouse, and births of all children.

5. Finally, collect all data on births, marriages, and deaths among the centenarian's parents and brothers and sisters, and identify among the newborns of the period following the birth of centenarian any other newborns with similar names and surnames.

4 Three types of basic documents for validation

1. Some documents, such as birth and death records, are legal documents, and have legal force to prove the existence of a given person. The basic elements for identification are included in these documents: date and place of birth, date and place of death, name and surname, and a notation of marital status in the death record. Issuing of birth or death records is done upon declaration in the presence of witnesses, or is, more recently, based on hospital, maternity, or physician declarations. Marriage and divorce records are documents that prove the civil status of person within the society; these documents, and the rules associated with these type of documents, may, therefore, vary according the basic rules of the respective society (for example, divorce may not be allowed, while polygamy may have an official civil status in a given country). In most countries, before civil registration was organized, church records performed the role of legal records. This situation was still valid in Sweden until 1991[3].
2. Some documents are administrative, such as lists of inhabitants or extracts from the population registration system, family books, passports, identity cards, electoral registers, tax registers, military registers, etc. First, it is essential to understand in detail the purposes of the documents, as well as how they are prepared and updated. The way in which identification elements are introduced is a key question. In any case, because these are secondary sources, the corresponding information may have been transcribed or self-declared, and may not have been systematically checked against the primary source of information.
3. Finally, some documents are statistical documents, like census or specific statistical forms, which are completed when certain events occur (e.g., birth, marriage, divorce, migration, or death). The way in which all the information is introduced in these documents must be very carefully checked: self-declaration by the concerned person, declaration by a close family member or a person of reference for

[3] Please note that church records are not necessarily exhaustive where being member of a church is not compulsory.

the household, transcription from an administrative or legal source, etc.

For all these types of documents, it is essential to investigate the relationship between them. How are marriage, divorce, and death records completed, and what kind of checks are made against the original birth record? How are population registers, passports, identity cards, and census forms completed or issued when it is not possible to verify identification through a direct check of the birth record? To ensure full age validation, only verified documents should be used. Therefore, it is necessary to conduct a preliminary investigation of the rules related to the creation of these documents and their reliability.

5 Original document versus copies

It is important to identify the original document, and make a distinction between copies and certificates issued at a later date. The original document may be unique, or there may be a duplicate made simultaneously that is stored in another safe location. There are basic methods used in history to verify the original character of a document, including type of paper, ink, type of writing, possible overwriting, language used, stamps, method of dating, etc. All this must be taken into consideration and applied in order to identify the original document. Moreover, it is essential to know how and where these original documents are stored: a register in which all records are bonded by the date of occurrence, or are, as is sometimes the case, numbered and indexed, will be favorable for the purposes of age validation; while a separate document is definitively more difficult to validate, and will be less helpful for the age validation.

A clear distinction should be made between the original document, and a certificate copy or extract supplied upon request at a later date, even if the certificate is a photocopy of the original one. Certificates include information probably verified as similar to the information found on the original documents, but some reading or transcription errors may occur. Moreover, there is often no way to check whether all the information has been precisely extracted from the correct original, and that it has not been taken from a similar one with the same name and other common characteristics; this is the most common error found in age validation.

In all cases, the roles of all the actors involved (e.g., concerned person, reporter, recipient of declaration, or a person collecting information from original records) have to be assessed. All possible errors should be considered, including random misreporting of age or voluntary age exaggeration, and all personal advantages that might accrue to the actors for untrue declaration or transcription should be identified. More precisely, when dealing with age validation, the possible role of some age thresholds should be checked, as some privileges may be granted only to people who have reached some specified age, and, therefore, some concrete incentives may exist for exaggerating age in order to meet the conditions. Besides these voluntary untrue declarations or transcriptions, age may also be overestimated on the declaration simply because of the attraction of rounded ages, or just because older ages and extreme longevity are considered desirable within a family or within the local community.

We must be prepared to imagine what may have occurred at the time when the document in question, whether an original or a copy, was written; and we should try to establish whether somebody might have an interest in falsifying any declaration or writing. Within the same context, we should identify all consistency checks that are foreseen by administrative rules to verify the validation of information.

As a consequence, a personal and critical examination of all documents is definitively needed. Based on our experience, the level of reliability is different according to the type of document. The reliability of original civil records is very high, while it is only high for the birth and death certificates. Other administrative sources, like population registers, passports, identity cards, election registers, and military files have a medium degree of reliability. Finally, census nominative lists are less reliable, and press articles or published lists of centenarians offer a very low level of reliability for the purposes of age validation.

6 How to conclude a validation process?

According to Thoms (1873), when the age of a centenarian is being validated, the proof should be clear, distinct, and beyond dispute. When discussing the probability of finding centenarians before 1800 and supercentenarians before 1950, Hynes (1995) pointed out that the validation process may face a range of difficulties which might be impossible to overcome. As an example, the failure to locate a relevant record should not, in her view, necessarily disqualify the candidate from the list of potentially verifiable centenarians. Hynes argued that, for centenarians of the past, Thoms' criteria are too strict, and suggested that more flexibility is needed. This is also the reason why Skytthe and Jeune (1995) proposed four levels of evidence. However, Jeune and Vaupel (1995) concluded that it would be more fruitful to discuss the conditions of falsification than to corroborate what may be a false tenet. Like Vincent (1951), they do not believe "jusqu'à preuve du contraire" and therefore support the strong rules proposed by Thoms (1879). If birth and death certificates exist and are consistent, but only a few pieces of evidence of the history and family reconstruction are collected, it cannot be concluded with "no doubt at all" that the same name in the birth and death records in fact refers to the same person, especially when information is lacking from a large part of the life of the alleged centenarian. The richness of information on family reconstruction will often vary depending upon the number of brothers and sisters, marital status, and the number of children. Nevertheless, our opinion is that all necessary investigations have to be consistent in order to prove validity of age. If one important piece of information is missing, we will be unable to proceed to validation with "no doubt at all;" but if one element is wrong, the entire validation process will result negatively. It is definitively easier to prove that this person is not a centenarian than the opposite. In fact, the validation will never be final, while the invalidation is generally final when only one clear ground for invalidation is found.

All information collected through interviews with an alleged centenarian or close family members is influenced by subjective memory and the specific context of interview. The validation of a centenarian cannot be confirmed only on the basis of such interviews. We consider the use of this additional source mainly in order to obtain complementary information about some documents, like photos or letters, but also in order to identify the need for further investigations within administrative data sources, or to help explain any particular situation that appears in administrative data and is not easy to understand without knowing some contextual elements.

The validation process will, in practice, consist of bringing together, piece by piece, information that will improve the probability of the alleged age. When an alleged centenarian is identified, let's consider before starting the validation process that the validation probability is about one chance out of two. But, in fact, all contextual elements relating to the population and the area where the centenarian is living will bring this initial level of validation probability higher or lower. As an example, for an alleged centenarian living in a country with a normal prevalence of centenarians, with normal numbers of people who have reached extreme age at death, and where most other centenarians have been previously validated, the probability that the age will be validated can be as high as 90%, even before starting any investigations in order to find supporting documents. At the opposite end of the spectrum, the validation probability of an alleged centenarian in a remote area with a deficient registration system, a large prevalence of centenarians, large numbers of people who have reached extreme ages at death, and no other centenarians already validated, will be only 10% when starting the procedure.

Thereafter, any piece of information that fits with previous ones and confirms age validation will increase the probability of age validation, while any information that does not support validation will decrease more or less strongly this probability of validation. By considering documents one by one, we will progressively increase the probability of validation, but a unique negative proof may bring this probability close to zero. However, at the end of the validation procedure, we will never reach a situation were the age of a centenarian will be fully validated with 100% probability, nor can the alleged age be assigned a 0% probability.

As far as life events and the information on parents and siblings are concerned, all corresponding ages will be considered and compared with the normal demographic life pattern for this population, and this specific period of time. Doing so can help us calculate a plausibility index that will tell us how plausible the centenarian's demographic history is. A very plausible demographic history will be an argument in favor of age validation when added to all other positive pieces of information, while a relatively implausible demographic history will argue in favor of invalidation.

In conclusion, a well established argument will be sufficient in order to invalidate with high probability the age of an alleged centenarian, while a large set of fully consistent documents are needed in order to conclude with high probability that an age has been validated.

7 Some examples of validation or invalidation of the age of supercentenarians

7.1 Age validation in Sardinia

For the purposes of validating a centenarian in Sardinia, the following official and administrative registers and documents are available:

1. Civil status registers with birth, marriage, and death records; those registers have been maintained in Sardinia since 1866, and include the following information:

- Birth: These records include the name and surname of the newborn; identification of the parents[4], including, in most cases, the names or surnames of some of the grandparents; and the age of father, if he declared the birth. Marginal notes made on each birth record are very useful, as they provide some information on the marriage (date and place of marriage, and name of the spouse), and on the death (date and place). In the different cases we have studied, the proportion of birth records with marginal information was very high (more than 90%), and this information was found to be reliable and very useful[5].
- Marriage: These records include the names, surnames, and ages of spouses; and names and surnames of both parents, with indication of survival and place of residence. In the records of a few marriages, we found the complete list of children born before the civil marriage, as was the case for Antonio Todde (see below).
- Death: These records include the name and surname of the deceased, age at death, date and place of birth, the names and surnames of the parents of the deceased, and, if the person was married, the name and survival status of the spouse.

2. Parish registers that include baptism, marriage, and death records

These registers are useful if a confirmation of the civil registration is needed, and in tracking information for events that occurred before 1866. It may also be necessary to refer to parish registers in cases in which a civil marriage was celebrated long after the religious marriage. However, age-related information included in parish registers is often less complete and less reliable than that of civil status registers.

3. Population registers: Anagrafe

The Anagrafe is a continuous register that provides permanent information about the composition of the population living in a commune. This register, which was initiated after the 1930 census, is now computerized in all communes we have visited, allowing the local administrations to identify all persons living in their territory by sex, age, and address, including the household composition. Using this system, all

[4] In a few cases, the father is not identified, and this is usual for an illegitimate child. On the other hand, we see a few cases where the mother is not known due to the fact that the father and the mother are not married on a civil basis at the municipality, but are only married on a religious basis at the parish.

[5] On a more general level, marginal information on death may be found for one newborn out of three at the end of the last century. Most of the newborns without marginal information on death are not alive, but died during the first part of this century when no systematic transfer of information was organized between the commune of death and the commune of birth.

communes are able to compile a list of all nonagenarians and centenarians alive, with exact dates of birth and places of residence. Before the Anagrafe was computerized, the register included a sheet with information on each individual living in the commune. Two copies of those individual sheets are still available, with the first copies being classified by name and sex, and the second by household and address. When a person died or emigrated, the corresponding individual sheet was withdrawn from the active Anagrafe and kept separately in a folder called eliminati. These individual sheets have proven very useful, mainly for checking the ages at death of the parents of all validated centenarians. However, access to these eliminati may vary from one commune to another. In the most successful case, we were able to find information on a centenarian's parents, who were born before 1866 and died after 1930. In the same source of information, we were also able to find the dates and places of emigration for persons who left the commune after 1930, and that information was useful in tracing the brothers and sisters of the centenarian. The individual Anagrafe sheet gives the following information: name and surname; date and place of birth; names and surnames of parents, date and place of marriage and widowhood; date, place, and cause of death; date and place of emigration; and return immigration to the commune. Although these forms of information are not primary, but secondary, we have not found any mistake or falsification in the data collected from the Anagrafe.

The complete validation of the age of the five alleged Sardinian supercentenarians has been carried out within the AKEA research project[6]. We will focus specifically on the Antonio Todde and Damiana Sette cases.

7.1.1 The validation of the age of Antonio Todde

Antonio Todde[7] was declared the oldest documented man on earth in July 2001. Antonio was born in Tiana (Nuoro province, Sardinia) on January 22, 1889, and his birth record stated that he was the son of Francesco Maria Todde and "della sua unione con donna non maritata," without giving the name of his mother. The missing name for the mother was a negative element for the validation of the exceptional age of Antonio. Fortunately, the baptism record in the parish register

[6] For a description of the AKEA project see Deiana et al. (1999) and for a more complete description of the age validation of the Sardinian centenarians see Poulain et al. (2006).

[7] All documents used for this age validation are available in the annex to this chapter in the internet version of this book.

provides the missing information, confirming that Antonio was born on January 22, 1889, and was the son of Francesco and Francesca Angela Deiana. At the time of his birth, his parents were married according to the church, but not yet according to the civil registration. Their civil marriage was not celebrated until December 30, 1908, when Antonio was age 18; in the civil marriage record, all brothers and sisters are correctly listed with their ages. Antonio died in Tiana on January 3, 2002, a few days short of his 113th birthday. His death record has been correctly linked with his birth record, to which a marginal note had been added. In July 2001, he was proclaimed to be the oldest men alive on earth. More information about Antonio Todde has been published by Deiana et al. (2002), while the whole genealogical tree has been recently presented by Caselli et al. (2006).

7.1.2 The invalidation of the age of Damiana Sette

The invalidation of the age of Damiana Sette—who was, up until now, considered to be a supercentenarian—is, in our view, a very instructive one. We will present here the documents supporting this invalidation. The death certificate of Maria Angelica Damiana Sette shows that she died in Villagrande at the age of 110 on February 25, 1985. According this document, she was born in Villagrande on August 8, 1874, and was the daughter of Pietro Sette and Monserrata Pirroni. A child named Maria Angelica Damiana Sette was effectively recorded in the birth register as having been born in Villagrande on August 8, 1874, as the daughter of Pietro Sette and Monserrata Pirroni. The death record is wholly compatible with this birth record. We observe in the birth record the marginal note of the death dated February 25, 1985, and, therefore, a unique link has been established by the civil registration officer between both events and records. Consequently, the degree of certainty of the age validation of Damiana Sette was assigned the level C[8]. Moreover, while Damiana Sette never married and appeared only a few times in the Anagrafe starting from 1930, all collected information was consistent in supporting the claim that she was, effectively, a supercentenarian.

At this stage of the validation process, everything would seem to confirm the contention that Damiana Sette really did die at the venerable age of 110, and this information was even transcribed onto her gravestone in the cemetery of Villagrande. However, the meticulous

[8] The level C of validation is reached when birth and death records have been found and are consistent (Skytte and Jeune, 1995).

Table 1. Family reconstruction for Antonio Todde (1889-2002)

Parents
TODDE Francesco Maria (1.1.1857 - 6.12.1945)
DEIANA Francesca Angela (3.2.1863 - 17.11.1961)
Married in Tiana on 30 December 1908.

Brothers and sisters
TODDE Antonio Domenico (30.9.1883 - 3.8.1887)
TODDE Angela Rosa (30.1.1886 - 19.8.1984)
TODDE Antonio (22.1.1889 - 3.1.2002)
TODDE Giuseppe (4.8.1891 - 17.8.1921)
TODDE Maria Agostina (7.12.1893 - 7.12.1893)
TODDE Giovanni (4.3.1895 - 8.1.1966)
TODDE Salvatore (31.1.1898 - 24.2.1944)
TODDE Agostino (26.5.1901 - 13.8.1973)
TODDE Maria Agostina (6.2.1904 - Alive)
TODDE Francesco Angelo (11.11.1906 - 22.3.1967)
TODDE Antioco (11.11.1906 - 20.8.1979)

Spouse
Married on 15 September 1920 to MADDEDDU Maria Antonia (6.12.1899 - 29.5.1987)

Children
TODDE Laura (23.7.1921 - 30.4.2004)
TODDE Angela (13.2.1924 - Alive)
TODDE Giuseppe (27.3.1926 - Alive)
TODDE Isabella (18.11.1928 - 9.9.1930)
TODDE Antonino (5.4.1933 - Alive)

reconstruction of the family composition of Damiana Sette, based on the civil registers and the Anagrafe (Table 2) led us to the discovery that the person who died in 1985 was not Maria Angelica Damiana Sette, born August 8, 1874; but her younger sister, Maria Monserrata Damiana Sette, who was born on May 5, 1877. In a document labelled "Angelica," we found the exact death record of Maria Angelica Damiana Sette, who died on June 10, 1876, at the age of 22 months. This type of error occurs frequently in historical demography when producing family reconstructions, and in the linkage of different data related to births and deaths. This is due to the fact that, when a child dies at a young age, it is customary to believe that a child of the same sex who is born immediately after this death will, in some way, replace the deceased. Therefore, the next child is given the same forename, or, at the very least, certain identical forenames. This was the case for Maria Angelica Damiana Sette, who died at the young age of 22 months and was replaced by her younger sister, who was called Maria Monserrata Damiana Sette. Damiana Sette was never married, and it was only after consulting the Anagrafe—in particular, the individual sheets that were established after the 1930 census—that we were able find documentary evidence that the birth date of her older sister, who died at a young age, was erroneously attributed to her. This administrative error remained unchanged until her death in 1985, and, consequently, the marginal annotation relating her death appeared on the birth certificate of her older sister. All given names are those of her older sister, although she was usually called Damiana. Accordingly, Damiana Sette was 'only' 107 when she died in 1985.

Table 2. Family composition of Damiana SETTE

Parents
SETTE Pietro (1835 - 2.10.1905)
PIRRONI Monserrata (1844 - 21.11.1913)
Married in Villagrande on 29 November 1866

Brothers and sisters
SETTE, Maria Barbara Lucia (7.5.1867 - 14.8.1945)
SETTE, Maria Agostina (4.2.1870 - 5.4.1898)
SETTE, Maria Luigia Vittoria (7.4.1872 - 16.7.1922)
SETTE, Maria Angelica Damiana (8.8.1874 - 10.6.1876)
SETTE, Maria Monserrata Damiana (5.5.1877 - 25.2.1985)
SETTE, Domenico Antonio Daniele (2.5.1880 - 8.12.1968)
SETTE, Serafino Giovanni Francesco (18.2.1883 - 19.8.1946)
SETTE, Tomaso Salvatore Angelo (12.3.1886 - 17.8.1981)

7.2 The invalidation of the age of Marta Ninashvili's age in Georgia

According to her passport, Marta Ninashvili is supposed to have been born in Kakabeti in 1891. The same information was used in the death record to conclude that she died on August 15, 2002, at age 111. She was the daughter of Aleksei Ninashvili and X. Babale, but no birth record has been found in church books conserved in the Georgian State Archives. She married Dmitri Bazerashvili, but no marriage record has been found, either. However, through interviews, Marta was said to have been married very young, at age 16. Marta had five children. Nino, who is supposed to be the oldest, was said to have been born in 1915. However, a baptism record found in church books in the Sagaredjo Regional Archive shows that he was effectively born on February 2, 1919. The first daughter, Tamara, is supposed to have been born in 1920 and died in 1999. Mariam, the second daughter, was probably born in 1923 and was still alive when Valerian, the second son, was born on July 18, 1925. Valerian was living with his family in Sagaredjo when we met him. Finally, Georgi, the third son, was born in Manavi on November 10, 1929, and lived with his mother Marta in Tbilisi, where we visited him in July 2002.

No birth record was found for Marta in the central state archive or local archive. On the basis of all the household books kept from 1937 until 1963, and the information given by the family, it was concluded that there is a high probability that her age was only 101 years when she died. In fact, information collected in household books shows a progressive increase in her age as the year of birth switches from 1901 to 1900, then to 1895, and later to 1891. The overwriting of 1891 onto 1895 is clearly visible in the 1945 household book. Table 3 give a summary of all the information collected in household books for Marta's family. We see here that, not only was Marta's year of birth revised from year to year, but her husband's year of birth was revised as well. Further investigation would be needed to establish the reasons for this progressive age exaggeration. A desire to avoid army service during World War II may have contributed to age exaggeration, but this applies to males only.

These investigations confirm that Marta was most probably born in 1901, even if no birth record has been found to prove this up to now. This version of events sounds more plausible when the following life histories are compared:

Marta was born in 1891, when her mother was aged 13 (Babale was born in 1878, according to household books). She married at an unknown date, although it is said that she married very young (at age 16, according to her family). Then she had her children between the ages of 28 and 39, but she and her family did not have an explanation for why she had no children up to age 28. She died at age 111 in August 2002.

Marta was born in 1901, when her mother was aged 23 (Babale was born in 1878, according to household books) She married very young, probably in 1917 or 1918 (when she would have been around 16), but

Table 3. Summary of all information on age and year of birth collected in household books for Marta's family between 1937 and 1963 (Sagaredjo Municipality)

Name of family members	Year of household book										
	1937	1938, 1939	1940, 1941, 1942	1943, 1944	1945, 1946, 1947	1948, 1949, 1950	1951, 1952, 1953	1954, 1955, 1956	1957	1958, 1959, 1960	1961, 1962, 1963
Marta	36 (1901)	1901	1900	1895	1891	1891	1891	1891	1891	1891	1891
Dimitri	45 (1892)	1886	1886	1883	1883	1883	1883	1883	1883	1883	1883 (died in 1960)
Babale	-	-	1878	1878	1878	-	-	-	-	-	-
Tamara	17 (1920)	1921	1920	1920	1920	1920	1920	1920	-	-	-
Mariam	14 (1923)	1924	1923	1923	-	-	-	-	-	-	-
Valerian	12 (1925)	1926	1925	1925	1925	1925	1925	1925	1925	-	-
Georgi	8 (1929)	1930	1930	1930	1930	1930	1930	1930	1930	1930	1930

no marriage record was found. Then she had her children between the ages of 18 and 29. She died at age 101 in August 2002.

As a consequence of this reconstruction, there is a high probability that the official age of Marta is invalidated. In the same study (Biridivashili, Herm, and Poulain, 2003), none of the alleged supercentenarians from the Tbilissi area has been found. We proved that there are centenarians living in Georgia, but finding centenarians in Georgia was not a surprise, as ages above 100 are compatible with the estimated life expectancy[9].

7.3 Joan Riudavets was, with high probability, the oldest validated man alive on earth in 2003

The age of Joan Riudavets, the oldest man on earth after the death of Yukichi Chuganji on September 28, 2003, was among the easiest cases to validate, as all administrative pieces fit perfectly with the reported age. All information obtained through a direct interview of Joan and his younger daughter, Francesca, as well as from additional documentation showing Joan as head of local youth in 1912, when he was 23, are complementary forms of evidence that tend to support the accuracy of the birth record. As we observe quite often, claims by Joan's family about his exceptional longevity increase the probability of the accuracy of his age. Joan Riudavets died on March 5, 2004, some months after he celebrated his 114th birthday.

7.4 Kamato Hongo has probably never been the oldest person on earth

The case of Kamato Hongo[10] is also a very instructive one as far as age validation is concerned. First, it should be noted that the Japanese civil registration is different from the European civil registration system, and an in-depth investigation into how this system works was an essential prerequisite to any attempt of validation. The entire Japanese civil registration system is based on the Koseki, in which all official data related to a given family are transcribed, including births, deaths, marriages, and divorces. The Koseki is an official family register that provides details of all familial and legal relationships between family members.

[9] According to revised figures calculated by Yeganyan et al. (2001), life expectancy was 68.6 for men and 75.6 for women in 1999 for Georgia.

[10] I am very grateful to my colleague Kusuto Naito for helping me when trying to validate the age of Kamato HONGO.

The register lists each individual's date and place of birth, rank in the family (whether, for example, a member is the first or second son, or the third daughter), as well as all information on parents, brothers and sisters, grandparents, and spouse(s). The first Koseki, named Jinshin Koseki (壬申戸籍), was adopted as the standard identity register to be used across Japan on April 4, 1871. However, due to sensitivity problems related to caste membership, Jinshin Koseki was phased out, and a new type of register, Genko Koseki (現行戸籍), was introduced with the enactment of a law known as Koseki ho on December 22, 1947. The most important difference between the Jinshin Koseki and the Genko Koseki is that, under the new system, all members are grouped by immediate family (i.e., only parents and children) while under the old system, the registration was done by family lineages, called Iè[11]. All Koseki were renewed in accordance with the new system. Meanwhile, old registers were to be destroyed, and are no longer available for validation purposes. Duplicates of all Genko Koseki are, however, stored in regional or provincial offices of the Ministry of Justice, called Homukyoku. The Genko Koseki presents a kind of lineage tree of all family members related by blood or marital alliance. After leaving the parental home, an adult child branches out from the parental Koseki, and establishes his or her own Koseki. This is, in part, because it would be difficult to report to a parent's Koseki if the son or daughter were living in a distant location when a birth or death occurred within the adult child's own newly established family. Whereas the older Jinshin Koseki encompassed a larger family with three generations, the new Genko Koseki are limited to two generations. Parallels exist between these two types of registers and the two types of certificates or copies issued from Koseki. The first type, the Koseki tohon (戸籍謄本), provides an exact and complete copy of the Koseki, including information for all family members. The second type of certificate, the Koseki shohon (戸籍抄本), provides the same information, but only for a given person requesting the document. In fact, the Koseki shohon serves as an official birth certificate, as no birth registers or death registers exist in Japan. The place where a person is registered in the Koseki, and the place where he or she may request these certificates or copies, is the

[11] The translation and meaning of "Ié" is not clear and still a subject of discussion in Japan between lawyers, sociologists and historians. The most commonly adopted definition states that "Ié" is a large group of persons linked by family lineages with blood link but also by adoption. Each "Ié" has also an economic signification, and the continuity in time of those groups is essential.

Table 4. Family composition of Joan Riudavets (1889-2004)

Parents
RIUDAVETS MOLL[12] Pedro (1860 - 27.5.1927)

MOLL MERCADAL Catalina (1864 - 31.12.1889), she died as a consequence of childbearing her second child.

RIUDAVETS MOLL Pedro remarried on 20 February 1892 with Catalina
MERCADAL MASCARO.

Brothers and sisters
RIUDAVETS MOLL Lorenzo (26.10.1888 - 30.06.1967)
RIUDAVETS MOLL Joan Jose (15.12.1889 - 5.3.2004)

RIUDAVETS MERCADAL Juana (15.8.1893 - 27.9.1976)
RIUDAVETS MERCADAL Jaime (19.4.1895 - 18.7.1915)
RIUDAVETS MERCADAL Catalina (25.2.1897 - 12.2.1898)
RIUDAVETS MERCADAL Catalina (10.11.1898 - 5.9.1994)
RIUDAVETS MERCADAL Pedro (24.10.1900 - Alive in 2004)
RIUDAVETS MERCADAL Francisca (26.9.1902 - 17.7.1904)
RIUDAVETS MERCADAL Jose (11.1.1907 - Alive in 2004)

Spouse
JORDI SALES Juana (4.1.1889 - 4.12.1975)
Married on 17.11.1917

Children
RIUDAVETS JORDI Catalina (6.9.1918 - 30.5.1969)
RIUDAVETS JORDI Juana (26.9.1920 - Alive in 2004)
RIUDAVETS JORDI Francesca (11.10.1924 - Alive living with her father until he died).

Honseki (本籍), or legal domicile, which is not necessarily the usual place of residence.

In addition to the Koseki, population registers called Kiyori seido (literally, "residence system") were created in 1914. The system was revised by a law which went into effect on July 25, 1967, and is known as Jyumin Kihon Daïcho (住民基本台帳法) (literally, "resident popu-

[12] The mother of Joan's father and the father of his mother were both "Moll," which indicate a possible family link between his parents. A similar homonymy is found between Joan's maternal grandmother and his father's second wife ("Mercadal").

lation registers"). This population register is similar to the Anagrafe in Italy and the population registers in Belgium and Nordic European countries. The register shows all household members presently living together in the same household, with information about their dates and places of birth, sex, marital status, relationships to the head of household, and the precise address of the place of usual residence. The Jyumin Kihon Daïcho therefore serves as the continuous registration of the usual place of residence. This document is held at the individual level, and is grouped by household, and not by family. These documents are used for electoral and other administrative purposes, and are stored by the administration of the place of usual residence. The Jyuminhyo is the certificate serving as official proof of the usual place of residence.

In the case of Kamato Hongo, we were, with the agreement of the family, able to obtain four different documents: her Jyuminhyo; her Koseki shohon; the Koseki tohon of her parents, including all family members with brothers and sisters; and the Koseki tohon of her own family. All information collected in these official documents has been used to reconstruct the whole family, as presented in Table 5.

A careful analysis of these documents related to Kamato Hongo immediately reveals an important error: Kamato is said to be the second daughter and the fifth child in the family, and is listed in the fifth position on the Koseki Shohon; meanwhile, according her official date of birth, she should be in fourth position, with her older sister having been born only seven months before her. At that stage of the validation process, strong arguments can be made in favor of invalidation. The case may still, however, have been validated if, for example, Kamato was shown to have been an adopted child who arrived in the family in fifth position when she was already more than three years old. But the Koseki does not mention this hypothetical adoption, and, moreover, when comparing the two following life histories of Kamato Hongo, it would appear more probable that she was the last child born around 1893, as the average interval between successive births is about three years, and could be even more, assuming that this is the last child.

The Kamato Hongo life history appears as follows according all available documents:

Kamato was born in 1887, when her mother was supposedly aged 43. She had two children before marriage, when she was 22 and 25. She married in 1914, when she was supposedly 27 years old; although she claims she was younger when she married. Then she had five other children between the ages of 29 and 45. She died at age 116 in October 2003.

Table 5. Family composition of Kamato HONGO (1887 ? - 2003)

Parents
KIMURA Yoshimi (or Yoshihiro or Yoshikan) (10.8.1845 - ... 1903)
NAGAHARUSAIMOTO Utokane (or Utokako or Utokama) (16.2.1844 - 25.5.1918)
Married before 1872

Brothers and sisters
KIMURA Mitsunori (First son) (15.7.1877)
KIMURA Katayuki (Mangyo) (Second son) (15.8.1880)
KIMURA Meto (First daughter) (9.2.1887)
KIMURA Fukuyama (Fukusen) (Third son) (26.6.1890 - 14.6.1930)
KIMURA Kamato (Second daughter) (16.9.1887? - 31.10.2003)

Spouse
HONGO Hukuyu (or Fuhusuke) (19.10.1893 - 3.6.1964)
Married on 4.8.1914 in Shimajiri-mura, Inutabu

Children
HONGO Yoshi (First daughter) (15.7.1909, recognized)
HONGO Takeyoshi (First son) (15.2.1912, recognized)
HONGO Oto (Second daughter) (15.10.1916)
HONGO Genryou (Second son) (15.3.1918)
HONGO Shizue (Third daughter) (15.2.1924, was living with mother Kamato until she died)
HONGO Taketada (Third son) (15.1.1929)
HONGO Takejiro (Fourth son) (10.1.1933)

The following life history sounds more probable; however, especially if we consider that, during her interview, she and her daughter confirmed that Kamato did not marry as late as 27:

Kamato was born in 1893, when her mother was supposedly aged 49. She had two children before marriage when she was 16 and 19. She married in 1914, when she was 21, and the two first children were recognized at that time. Then she had her other children up to the age of 39. She died at age 110 in October 2003.

In the second life history, the fact that her mother was 49 when she was born may easily be considered the result of age misreporting, as her father was two years younger, and Koseki were not in use before 1871. We have also to consider the fact that Kamato Hongo was born in the same place as Isumi, the famous Japanese supercentenarian who supposedly died at 120 years of age, but whose exceptional age has never been validated. Moreover, as mentioned by Saito in the chapter of this book dealing with supercentenarians in Japan, in which he quoted Matsuzaki (1988), there was a custom in Kagoshima prefecture of using the registration of a deceased child for its younger siblings, so that this person registered as an elder sibling may have easily been listed as five or 10 years older than his or her actual age.

Accordingly,

- Considering the fact that Kamato is said to be the second daughter;
- Considering the fact that her older sister, the first daughter, was born on February 9, 1887, and that she would have been born only seven months before Kamato;
- Considering the fact that Kamato is presented in the fifth position, and not in the fourth position, on the Koseki tohon;
- Considering that having two illegitimate children before marriage at ages 16 and 19 is more probable than having them at ages 22 and 25;
- Considering that having her last child at age 39 is more probable than having her last child at age 45;
- Considering that dying at age 110 is about 64 times more probable that dying at age 116 (based on an average annual mortality rate of 0.5);
- Considering that another brother or sister of Kamato was very likely born between 1880 and 1887, and probably died very young, and that Kamato may have been registered as this potential elder sister; and, finally,
- Considering that an error of transcription may have occurred when the Koseki was renewed following the enactment of the 1947 law, which introduced the Genko Koseki;

we may conclude with a very high probability that Kamato Hongo's date of birth, and, consequently, her age, are invalidated. Accordingly, she should never been considered to have been the oldest validated person living on earth, even if she was given that label by the Guiness Book of Records. There is a large probability that Kamato was born around 1893, and, considering that her date of death was October 31, 2003, we may suppose that the chances that she was a supercentenarian to be about one out of two.

8 Conclusion

All the preceding examples of the validation or invalidation of the ages of alleged supercentenarians clearly demonstrate that the validation of an extremely old person is not an easy task, even if a complete set of official documents is available. Based on our experience, any validation process that includes a large number of alleged centenarians, and does not identify some clearly invalidated cases, may not be definitively considered to have been an in-depth validation exercise. Therefore, we encourage all researchers to be very attentive to all potential pieces of information that will lead to a possible invalidation. Living 110 years and more is so improbable that all forms of evidence supporting such claims should be absolutely solid. Even then, an age validation is never definitive, and may always be reconsidered if a new piece of information that seems incompatible with the previous conclusion is discovered. If an age validation is only highly probable, an age invalidation may be definitively established, as we were able to do in the case of Marta Ninashvili (discovery of a false overwriting in the household book), or in the case of Damiana Sette (discovery of the existence of an older sister who died at 22 months before Damiana was born). However, age invalidation may also be highly probable, but not definitive, as was the case for Kamato Hongo. In such cases, additional pieces of information may be needed before age invalidation can be considered definitive.

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The International Database on Longevity: Structure and contents

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Abstract. The International Database on Longevity contains exhaustive information on validated cases of supercentenarians that allows unbiased estimates of mortality after age 110. This chapter describes the structure and contents of the database, including the different categories of age-validation procedures.

1 Introduction

Individuals who attain ages of 110 years or more are special. They are still rare, but the growth in the number of these so-called 'supercentenarians' in recent decades has permitted research. The emergence and proliferation of these truly oldest-old is of great interest to aging research, as their stories shed light on the prospects for human longevity.

Investigating extremes also helps to validate theories. While there is now undisputed evidence that the exponential increase in human death rates decelerates after about age 80, the ultimate trajectory of human mortality at highest ages has yet to be established. Different patterns have been suggested, but data at the highest ages have been too scarce to permit reliable assessments. Extreme ages are, by definition, rare, but sufficiently large samples are nonetheless needed to allow for accurate estimates. Furthermore, reports of extreme ages must always be

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considered with caution. Age exaggeration is common, and only meticulously validated information should be trusted.

This context has inspired an international collaborative effort to gather demographic data for the highest ages in the form of the "International Database on Longevity" (IDL). The aim of this database is to compile exhaustive information on validated supercentenarians (110 years and over) as reliable data that can be used to estimate mortality trajectories. These data are provided by different countries involved in the IDL project as contributors.

Two aspects are crucially important, and must be stressed. First, the data collection should be such that the resulting samples allow unbiased estimates of death rates at the highest ages. Although a complete list of all supercentenarians would be ideal, for scientific purposes it is sufficient but mandatory that the collected cases are free of age ascertainment bias. This condition has implications for the data collection process. For example, media coverage is more common for the oldest cases, while individuals who died at younger ages (i.e., shortly after their 110th birthdays) will be underrepresented in the press. Thus, screening press reports generally does not constitute an appropriate means of data collection for mortality trajectory estimation.

If the probability of identifying cases is to be age-independent, then we need to have access to what we could call a complete list of supercentenarians. As we will never be able to determine whether a list is truly complete—i.e., that it does not miss a single case— we prefer the concept of an 'exhaustive' list. Such exhaustive lists will comprise all supercentenarians who have been reported and identified in a given region or country, and for a given time period, by national or regional authorities. A failure to include the age of every single supercentenarian should not prevent researchers from producing an estimate of death rates that is free of age bias.

The second crucially important aspect is age validation (see also the chapter by Poulain in this volume). The IDL aims to provide information only on supercentenarians whose ages have been validated. Two levels of scrutiny are used in the classification of the validation procedure, and we will describe the differences between the levels of validation in more detail in Section 2.2.

The IDL was originally designed for the collection of data on supercentenarians, and currently contains information only about individuals who have reached an age of at least 110. However, an expansion of the IDL to younger ages is already being prepared. For several countries, information on so-called 'semi-supercentenarians' (aged 105+) is available, and will be included in the IDL in the future. Naturally, the number of semi-supercentenarians is much higher, which has implications for the feasible validation procedure.

How the supercentenarians were identified, and how their ages were validated in the individual countries that contribute to the IDL, is described in the chapters that make up Part II of this volume. In this chapter, we will outline the structure of the IDL, provide a summary of the different levels of age validation, and give a brief overview of the information contained in the IDL as of October 31, 2008.

While some of the information about the individuals in the IDL, particularly the details necessary for age validation, contains personal and, hence, confidential information, the ultimate aim of the IDL is to make reliable demographic data on the oldest-old humans accessible to the research community. Therefore, a version of the database is made public on the Internet, and can be accessed at `http://www.supercentenarians.org`.

2 Database structure

The International Database on Longevity (IDL) collects information on supercentenarians as well as on the validation process of the cases. A list of variables is given in Table 1. A few additional entries are available on each individual. This information is strictly confidential as it permits identification of the person. However, such information is mandatory in the validation process. Hence these variables, given in Table 2, are accessible only to researchers directly involved in the validation process.

A subset of variables of the IDL, marked by an asterisk in Table 1, is publicly accessible via the Internet. Further details on the public version of the IDL will be given in section 2.3.

2.1 Variables on the individuals

The first group of variables in the IDL contains information on the individual cases. For each person, a unique and permanent—but anonymous—identifier (IDNUMBER) is created. The gender of the person is given in the variable SEX. The variable BDATE lists the date of birth of the individual.

For deceased individuals, the entry AGEY gives the age at death in completed years, and the entry AGED shows the number of days lived past the last birthday. The variable AGEINDAYS reports the age in days and the variable DDATE gives the date of death.

If an individual was still alive when the information was recorded, then AGEY, AGED and AGEINDAYS give the age information corresponding to the date when the individual was last known to be still alive. The corresponding date of last known survival is given by the variable ALIVEDATE. The indicator variable ALIVE records whether the information for a person in the IDL refers to a dead case, or a case that was still alive when the information was registered.

Information on the country of birth (BCOUNTRY), the country of death (DCOUNTRY), or, in the case of persons still alive, country of residence (ACOUNTRY), is also registered.

The remaining variables in Table 1 concern the process of age validation, which is discussed in the following section.

2.2 Age validation

As explained in the introduction, the database aims to compile validated cases for which the recorded age has been ascertained. The methods used for verifying ages differ among countries. Despite these differences, the IDL provides information about how meticulously each case has been validated, what documents were provided to the IDL in the course of the validation process, and the name of the researcher responsible for the validation.

The variable VALIDATION assigns the validation level of a case to one of two categories. VALIDATION=A requires that an early life document, preferably a birth record or baptism record, or an early census record, was available and checked. The respective document type is recorded in the BSOURCE variable. In the same way, the date of death of a fully validated case has to be backed up by a document, such as a death certificate or an entry in a death index. The kind of document used for verification of date of death is recorded in the variable DSOURCE. The reference person, also called informant, who is responsible for the verification, is denoted in the CONTACT field the database (see Table 5 in the Appendix).

If several types of documents can be found to substantiate either the date of birth or the date of death, only one of the available documents is mentioned. In such a case, the most reliable document is given. We are aware that the availability of several documents adds to the quality of the validation. But, for the sake of simplicity, this information is made available in the paper file that holds the various documents pertaining to the case, but not in the database.

Table 1. Variables recorded in the IDL database. Entries marked with an asterisk are contained in the online version (`www.supercentenarians.org`).

Description of the variable	Database field	Coding
Identification number	IDNUMBER*	unique numeric identifier
Age in completed years	AGEY*	Numeric data
Days since last birthday	AGED*	Numeric data
Age in days	AGEINDAYS*	Numeric data
Sex	SEX*	F: female M: male
Country of birth	BCOUNTRY*	ISO 3166 code
Country of death	DCOUNTRY*	ISO 3166 code
Country of residence	ACOUNTRY*	ISO 3166 code
Date of birth	BDATE*	dd/mm/yyyy
Date of death	DDATE*	dd/mm/yyyy
Alive or dead status	ALIVE	1: still alive 0: dead
Date when confirmed alive	ALIVEDATE*	dd/mm/yyyy
Reference person for validation information	CONTACT	3-letter code (see Table 5)
Official source (Statistics Institute)	SOURCE	Initials (see Table 4)
Validation status	VALIDATION*	A: see section 2.2 B: see section 2.2
Any particular observation concerning the validation	OBS	Text
Source of date of birth	BSOURCE	2-letter code (see Table 4)
Original document for birth date validation (photocopy, photo, scan)	BSOURCEORIG	1: yes 0: no 0: no
Source of date of death	DSOURCE	2-letter code (see Table 4)
Location of a paper file for validation documents	PAPERFILE	3-letter code (see Table 4)

Table 2. Variables (containing confidential information) recorded in the restricted part of the IDL database

Description of the variable	Database field	Coding
Last name	LNAME	Full-text
Maiden name	MNAME	Full-text
First name	FNAME	Full-text
Birth place	BPLACE	Full-text
Region of birth	BPROVINCE	Code
State (US)		
Province (CAN)		
Region (FRA)		
Country (England & Wales)		
Place of Death	DPLACE	Full-text
Region of death	DPROVINCE	Code
State (US)		
Province (CAN)		
Region (FRA)		
Country (England & Wales)		

The entry BSOURCEORIG indicates whether information on date of birth is attested by a photocopy, photo, or scan of an original document. This information is only available for birth because it is a much more remote event compared to death, and must therefore be checked more carefully.

If a paper file containing the documents pertaining to a given case is available (with restricted access, because of the confidential information included) the location of these documents is indicated in the PAPERFILE field (see Table 4 in the Appendix).

For several countries, the validation procedure is not documented as thoroughly as category A requires, but individual cases have been thoroughly checked. Such cases are tagged as VALIDATION=B.

They can arise, for example, when a local residence register officially confirms a date of death, but without issuing any personal document on the individual. Or there may be cases in which the sequence of entries in national censuses was carefully checked by the respective national statistical office over the course of the individual's life.

The ways in which such VALIDATION=B cases arise differs between countries, and the actual validation steps are described in the country reports in Part II of this volume. The variable SOURCE in the IDL references the authority responsible for the validation (usually national statistical offices or administrative bodies). In this case, the CONTACT field also gives the corresponding informant for the case.

Seven additional variables are available in the restricted part of the database. These are all data that identify the person, and are only accessible by researchers immediately involved in the case validation.

The last name or family name (LNAME), name at birth or maiden name for women (MNAME), and first name or given name (FNAME) are recorded in full text. For women, both marital name and maiden name are important in identifying the person at different stages of her life.

Detailed information about the place of birth and the place of death can also be found in the restricted area of the database. Although they do not directly serve as personal identifiers, this information, in combination with the date of birth, can easily be used to identify a person. Access to these variables is therefore restricted. The exact place of birth and death is recorded in BPLACE and DPLACE, respectively. Additionally, for some countries there is regional information in the BPROVINCE (and DPROVINCE) entry. These fields give the state for the United States, the province for Canada, the region for France, and the county for England and Wales.

2.3 Publicly accessible information

In keeping with the overall aim of the IDL—namely, to provide reliable demographic information on the oldest-old humans—, the information presented on the IDL website, `www.supercentenarians.org`, is intended to allow researchers to conveniently and appropriately use the IDL for their analyses. The variables included in the public version of the IDL have been discussed in Section 2.1. Besides the information on sex, ages, and dates, researchers will need additional information on data collection.

In particular, it is important to know the sampling frame of the data sets, as this allows researchers to take censoring and truncation into account in the analysis. As these sampling frames differ between countries (as do the validation procedures), the public version of the IDL is structured by country of death (or the country of residence for persons still alive). Information on the observation scheme is added in the so-called 'meta-data'. These indicate either the time period or the birth cohorts covered. The data also specify whether only deaths were sampled, or whether individuals alive were included as well. A brief summary on the validation process is also provided.

3 IDL overview

The IDL is an ongoing project with continuous updates of the information represented in the database. The following summary describes the contents of the publicly available information as of December 31st, 2008. Besides the total number of cases the number of females (f) and males (m), the age range of the individuals and the range of their birth years is given.

Table 3. Summary of the contents of the IDL as of December 31, 2008.

Country	Cases	females, males	Age range	Birth years
Belgium	5	5f	110–112	1882–1890
Denmark	2	2f	111	1884–1889
England & Wales	66	64f, 2m	110–115	1856–1895
Finland	6	5f, 1m	110–112	1878–1897
France	49	46f, 3m	110–122	1875–1893
Germany	17	14f, 3m	110–112	1883–1894
Italy	37	31f, 6m	110–113	1863–1893
Japan	78	66f, 12m	110–114	1884–1893
Quebec	10	8f, 2m	110–112	1852–1892
Norway	8	7f, 1m	110–112	1876–1893
Spain	28	20f, 8m	110–114	1878–1895
Sweden	12	11f, 1m	110–112	1874–1898
Switzerland	4	4f	110	1883–1890
USA	341	309f, 32m	110–119	1867–1889

Acknowledgements

The authors wish to thank all contributors to the IDL. Without their efforts and commitment, this ambitious project would not have been possible. Aurore Clavel and Sophie Le Roy entered the incoming data into the database. They also designed the first version of the IDL web pages. We also acknowledge the assistance of the IT staff of the MPIDR, especially Peter Wilhelm, who implemented the current website of the IDL.

Appendix

Coding of variable (see Table 1)

Table 4. Coding of entries in the IDL (see Table 1)

Birth source (BSOURCE)	
BA	Birth act
BC	Birth certificate
CS	Census list

Death source (DSOURCE)	
DA	Death act
DC	Death certificate
DI	National Death Index
TR	Transcription

Source (SOURCE)	
INE	National Statistics Institute of Spain
INSEE	Institut National de la Statistique et des Études Économiques (France)
ISQ	Institut de Statistique du Québec
ISTAT	Italian Bureau of Statistics
MHW	Ministry of Health and Welfare (Japan)
OGP	Office of the German President
ONS	Office for National Statistics (England & Wales)
SSA	Social Security Administration (USA)

Paper file (PAPERFILE)	
MPL	Université de Montpellier
DUK	Duke University

Table 5. Contact Code (CONTACT)

BDJ	Bertrand Desjardins
BEJ	Bernard Jeune
BEK	Bert Kestenbaum
DCH	Dany Chambre
FOT	Foti Tillo
GJK	Gert Jan Kuiper
HBL	Hélène Blanché
HCM	Heiner Maier
JMC	John McCormack
JMR	Jean-Marie Robine
MLP	Michel Poulain
RGG	Rosa Gómez-Redondo
ROY	Robert Young
RTH	Roger Thatcher
SAI	Yasuhiko Saito
SCO	Stéphane Cotter

Part II

Country reports

Supercentenarians in the United States

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Abstract. We have identified 325 persons who lived in the United States during the prior two decades beyond their 110th birthday, and were deceased as of June 2003. In this chapter we discuss how these supercentenarians were identified, and tabulate their characteristics and mortality.

The United States has contributed to the International Database on Longevity (IDL) 325 persons who lived in the United States during the prior two decades beyond their 110th birthday, and who were deceased as of June 2003. The records used to authenticate their ages at death will be included in the IDL document file to the extent possible. In 2003 the United States' contribution was thus larger than the total contributions of all other IDL countries.

We would guess that the actual number of persons who lived in the United States during the prior two decades beyond their 110th birthday is more than 400, because there are two groups of these people who are not included in the 325. The larger group consists of persons known to us with a recorded age of 110 or more, but whose age has not been verified. Some of them will be added to the IDL as we continue in our verification efforts. Those in the smaller group are supercentenarians of whom we are unaware. These two groups are within our scope; by contrast, persons reaching 110 in the current decade, or who died before 1980, are outside of our scope.

In this chapter we discuss at length how U.S. supercentenarians were identified. We also tabulate their characteristics, and briefly describe two analytic studies involving U.S. supercentenarians. Then, using extinct-cohort methodology, we calculate the mortality schedule implied by the distribution of their ages at death. The chapter ends with our plans for the future.

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At the outset, we wish to communicate the collaborative nature of the project, and acknowledge the major roles played by the Program on Population, Policy, and Aging at Duke University (and Cindy Owens, in particular), under the leadership of Dr. James Vaupel; and by the Population Studies Center at the University of Pennsylvania (and Leslie Stone, in particular), under the leadership of Dr. Samuel Preston. We would also like to acknowledge the assistance of Mr. Robert Young.

1 Casting the net and passing muster

Except for countries with very accurate population registers, a systematic search for supercentenarians proceeds through two stages. First a net is cast to "capture" possible supercentenarians. Then the candidates' credentials are critically examined, and only those passing inspection receive the stamp of authentication. The net should be wide and the examination rigorous.

In countries without population registers, the net is typically cast over decedents with recorded ages of 110 or more on the death certificate, and personal information (name and parents' names, date and place of birth) needed for the next step is collected from the certificate. This net is very wide when death registration is virtually complete, as is the case in the United States, and only the few supercentenarians whose age at death is incorrectly recorded as less than 110 are missed. (The net could be made wider still by including decedents with recorded ages close to 110.) At the present time, however, this approach is not feasible in the United States.

In the United States, the registration of vital events is generally performed by state governments: there are registrars in each of the 50 states, and in Washington, DC, and New York City, as well. Each year, the registration jurisdictions send copies of their files to the National Center for Health Statistics (NCHS) (a federal agency which is part of the Centers for Disease Control and Prevention of the Department for Health and Human Services). The NCHS merges the state files, removes personal identifiers, such as names, and makes a public-use file available to researchers. This file is not useful for our purposes because of the lack of personal identifiers needed to proceed to the validation stage of supercentenarian identification. The National Center does maintain a publicly-available data system from which the personal identifiers have not been removed, called the National Death Index (NDI), but this is a system designed to determine persons' vital status, rather than to produce a list of decedents according to some criteria.

Only recently did we become aware that the NCHS does possess the capability of selecting death registration records with personal identifiers in which the recorded age is 110 or more, back to about 1960. However, this capability can only be exercised with the permission of states officials, who must be convinced of the merits of the endeavor. Despite the likelihood that the need to obtain many permissions means a protracted process, we sent a letter to NCHS in May 2003 informing the agency of our interest in pursuing this avenue.

Given this current status of death certificate files, we chose a different net, one designed to capture persons enrolled in Part B of the Medicare program beyond their 110th birthday. The Medicare program is a two-part federal health benefits program for persons who are ages 65 and over or disabled. Part A, which provides hospitalization benefits, generally does not require premium payments from enrollees; while Part B, which provides benefits for medical services, is partially funded by premiums paid by all program participants. According to estimates from the U.S. Bureau of the Census, more than 96% of the population ages 70 and over participate in the Medicare program.

The federal agency that administers the Medicare program is the Centers for Medicare and Medicaid Services (CMS) in the Department of Health and Human Services. However, the enrollment of most Medicare participants is performed by a different federal agency, the Social Security Administration (SSA), which explains why Medicare enrollment information is present on the SSA master file–the Master Beneficiary Record. The similar CMS master file, the Enrollment Data Base, receives enrollment information from the Master Beneficiary Record, and also receives enrollment records from the Railroad Retirement Board (yet another federal agency) for persons whose entitlement to Medicare derives from careers in the railroad industry.

The Social Security Administration's Office of the Chief Actuary recently completed a study of mortality in the United States during the prior two decades at ages 85 and over (Kestenbaum and Ferguson, 2002). The study tabulated the experiences of persons enrolled in Medicare Part B, as reflected in SSA's Master Beneficiary Record. It had previously been established (Kestenbaum, 1992) that (a) records of current enrollment in only Part A (for which premiums are generally not charged), and not in Part B (which requires the participant to be up-to-date on his premium payments), are suspect, and that (b) the SSA master file is more accurate than the similar CMS master file. In particular, the recent study found that single-age probabilities of death increase fairly steadily with age, reaching a value slightly greater than one-half at age 109.

The identification of potential supercentenarians was a postscript to this mortality study. We have, therefore, chosen to limit the scope of this study to persons reaching age 110 no later than the year 1999, and dying no earlier than the year 1980. We have also chosen to omit three small in-scope groups of supercentenarians: those not enrolled in Medicare, those enrolled in Part A only, and those whose eligibility for Medicare derives from their career employment in jobs covered by the Railroad Retirement system, and who, therefore, will have a record in the CMS master file, but not in the SSA master file. Of course, supercentenarians whose age is less than 110 according to the date of birth recorded on the Medicare enrollment record will also be missed.

Given that the corroboration of date of birth generally requires that we share information with our partners outside the Social Security Administration, the privacy statutes and regulations which protect the confidentiality of the Social Security records of living persons make it impossible to substantiate the dates of birth of candidates not known to be deceased. At the present time, there are nine such candidates born in the U.S. (substantiation for the foreign-born is, in any case, very difficult), although we suspect that all but one of them are, in fact, deceased, and that their records, which show current Medicare B enrollment, are in error. The year of birth for the one person known to be alive has, in fact, been substantiated independently of our study; as of July 2003, she was alive at age 115.

Although the Medicare enrollment record lacks information on parents' names and place of birth, unlike the public-use death certificate record it does contain a Social Security number. With the Social Security number in hand, we can obtain the needed information from another Social Security Administration file, namely, the file of applications to obtain a Social Security number. Although, in fact, many of the old completed applications were not available electronically, we obtained microfilm copies from the agency's storage facility in Pennsylvania.

It is important to mention that we eliminated any candidates who were less than age 110 at death according to the date of birth on the application form. Likewise, we eliminated any candidates who were less than age 110 at death according to their Medicare enrollment record in the CMS master file, or according to their record—if any—in the Supplemental Security Income (welfare) enrollment file maintained by the Social Security Administration. In effect, the net was narrowed to include only those who were at least age 110 according to all their master records at the Social Security Administration and its sister agency.

Since Medicare records, unlike death certificate records, occasionally have incorrect dates of death (e.g., the recorded date may be the date of recordation, rather than the date of occurrence), the date of death required corroboration, as well as the date of birth. Accordingly, we worked together with the Program on Population, Policy, and Aging at Duke University to submit our list of candidates to the aforementioned National Death Index maintained by the National Center for Health Statistics. The NDI consists of a catalog of all registered deaths in the United States since 1979, and a procedure for searching in that catalog–using either the Social Security number or a set of personal identifiers–and reporting the results of the search, including the extent of agreement between the submitted record and the matching records, as well as providing the death certificate numbers of the matching records. We submitted records to the NDI in 2002, when the NDI covered deaths through the year 2000, and again in 2003, after 2001 deaths had been added. For the few deaths occurring in our study population after 2001, according to the Medicare record, we found confirmation for the date of death, sometimes in a death certificate obtained from a state registrar, but more often in an obituary notice published in a newspaper when we were alerted to it (by Mr. Robert Young, for example, who is familiar with the circumstances of several supercentenarians).

Although the NDI system is satisfactory for date of death corroboration, we proceeded to take advantage of the NDI feature that provides death certificate numbers, and requested copies of death certificates from all registration jurisdictions. There are three reasons for taking this step. Probably the most important is that the death certificate might contain personal information which is missing or incomplete on the application for a Social Security number, and which could lead to the authentication of some supercentenarian candidacies that otherwise would not have been authenticated.

Second, we plan to present the death records for any jurisdiction that gives its permission to the IDL for inclusion in the IDL collection of documents. Third, the death certificates provide information on decedent characteristics, such as occupation and educational attainment, as well as other information.

The tasks of establishing contact, completing applications, controlling receipts, and entering data were shared by our Office of the Chief Actuary in the Social Security Administration and the Program at Duke University, and the latter paid for the certificates. The initiative was quite successful in obtaining the cooperation of the many jurisdictions: only three jurisdictions felt the need to either deny us the certificates (Illinois), or to provide a subset of the information on the certificate, rather than the certificate itself (New Hampshire, New York City).

With respect to corroboration of the date of birth, a certificate of birth is, clearly, the ideal evidentiary record. From the entry on the application for a Social Security number (or on the death certificate), we knew the place of birth. Guided by a reference list of the availability of birth certificates from the various state and local registration jurisdictions, and, again, jointly with the Program at Duke University, we requested a birth certificate from the jurisdiction in which a candidate was born if the registration system in that jurisdiction was in operation at the time of the candidate's birth. Unfortunately, given the belated development of U.S. birth registration, much more often than not the system was, in fact, not in place. We were successful in obtaining 52 U.S. birth certificates. We should clarify that we only accepted birth certificates that were recorded in a timely manner, i.e., soon after birth, and not certificates that were recorded years later.

Although for most supercentenarian candidates the folder containing paper documents relevant to an individual's initial and continuing eligibility for Social Security benefits and/or participation in Medicare no longer exists, for a few we were successful in retrieving folders from the various holding areas across the country. In these we found four baptism or family Bible records—including one for a person born in Africa—for persons for whom no birth certificate was found.

A satisfactory alternative to the birth certificate for establishing date of birth is a record from a census about a century ago, when our supercentenarians were very young. In the United States, censuses are conducted decennially, in years ending in zero, and are confidential for 72 years, after which they are released to the public. Considering that our scope is limited to persons born before 1890, the 1890 census would be best; however, the 1890 census records were destroyed by fire. Instead we used the 1900 census, and, additionally, for persons born before June 1880, the 1880 census. These census records are available on microfilm in the National Archives at several locations, including Philadelphia, Pennsylvania.

Additionally, the Church of Jesus Christ of Latter-Day Saints has embarked on an ambitious and arduous venture to computerize and index the census records, and to develop software for searching the files. We were able to benefit from the new technology for the 1880 census records, but the computerization and indexing for the 1900 census were not completed until most of our microfilm searching was done, and the software for searching the files is not yet fully developed. While some of the work with the census records was done in our office, the majority was done in the Population Studies Center at the University of Pennsylvania. A detailed description of the protocol for matching, including the treatment of partial matches, is given in Rosenwaike and Stone (2003); we merely note here that the match rule was fairly sophisticated, incorporating commonness of name into the decision.

Another 256 persons were found in these early census records. This number includes 29 cases where the match was successful only because personal information was obtained from the death certificate when it was missing or incomplete on the Social Security number application. Work with the census records continues, and we anticipate that several more candidacies will be validated.

The policy of the IDL is to classify supercentenarians by their country of last residence, and not by their country of birth. With the assistance of Social Security Administration contact persons in several countries, and of members of the IDL team, we secured birth certificates from abroad for four supercentenarians born in Italy, three born in England, two born in Germany, two born in Greece, one born in Denmark, and one born in Canada. With these 13, the number of foreign-born supercentenarians reaches 14, while the total reaches 325.

The counts of supercentenarians according to the document used to establish their date of birth are gathered together in Table 1. Figure 1 shows the distribution of supercentenarians by the year of attainment of age 110, and Table 2 by the year of death. Deaths in 2003 are for part of the year only.

Table 1. Evidence for date of birth

Evidence Birth certificate (timely)	Number
U.S. born	52
Foreign born	13
Baptism or Bible record	4
1880 or 1900 census	256
Total	325

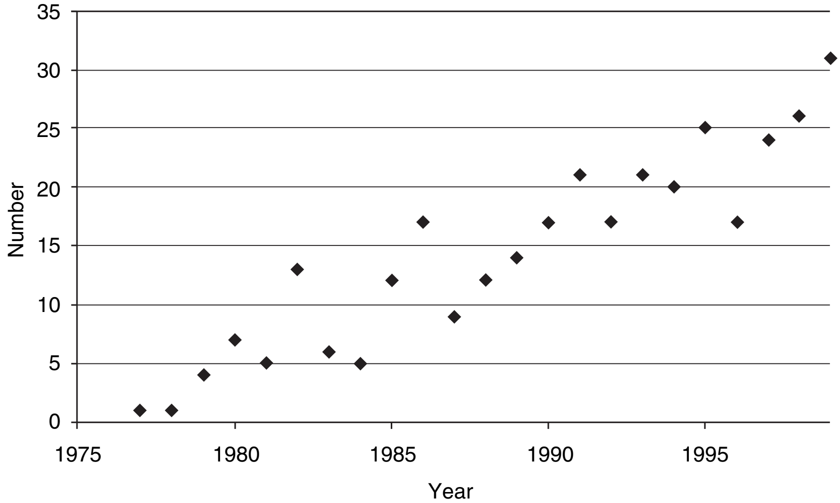

Fig. 1. Year of attainment of age 110

Table 2. Year of death

Year	Number
1980 - 1984	33
1985 - 1989	58
1990 - 1994	88
1995 - 1999	101
2000	18
2001	17
2002	7
2003	3
Total	325

2 Characteristics

The oldest supercentenarian in our contribution to the IDL database is Sarah Knauss, age 119 at death, about whom quite a lot is known (Robine and Vaupel, 2002). The next oldest is Lucy Terrell Hannah, age 117 at death. The oldest male is the Danish-born Christian Mortensen, age 115 at death. Three other supercentenarians survived to age 115. The numbers of deaths at each single year of age beginning with 110 and ending with 114 are: 166, 81, 37, 23, 12. Age at death is the difference in completed years between the date of death on the death certificate and the preferred date of birth. A timely certificate of birth clearly has the highest preference. For most supercentenarians, for whom of course there is no timely birth certificate, we preferred the latest of the dates of birth on the early census records and the set of SSA (and CMS) records–unless there was compelling evidence on the census schedule to discredit the date recorded on SSA records.

Nine out of 10 supercentenarians are females–more precisely, 294 of the 325. Blacks are more numerous than would be expected based on their share of the elderly population: in fact, 15% of native-born supercentenarians are black. Table 3 contains these results, as well as information on place of birth. Sex, race, and place of birth distributions are shown in Table 3, not only for the 325 confirmed supercentenarians, but for the unconfirmed candidates, as well, and the comparison from Table 3 helped us reach our conclusion that most of the unconfirmed cases are not valid. For example, it is not plausible that a large fraction of supercentenarians were born in the set of the four Southern states of Alabama, Georgia, Mississippi, and Texas; rather, the logical explanation is that, in this area of the country, extreme-age misreporting is more acute.

The state in which the largest number of confirmed supercentenarians were born is New York, with 23, followed by Texas (20), Pennsylvania and Illinois (19), and Ohio (16). The states in which the largest number of confirmed supercentenarians resided at the time of their deaths are California (32), Texas (20), Illinois (19), New York (18), and Massachusetts (17).

The earliest achievement of supercentenarianship among the group of 325 was in 1977. Of course, there may be persons in the United States who reached this milestone earlier, but are outside our scope–that is, if they died before 1980.

The initiative to purchase death certificates from registrars, described earlier, produced certificates for all but 11 of the 325 supercentenarians. Data collected on the death certificate provides information on the socioeconomic characteristics of supercentenarians and their marital status. Also present on the death certificate are the cause of death and the relationship of the informant to the decedent. These various data are summarized in Tables 4 and 5, and discussed briefly in the next paragraphs.

The distribution of occupations reflects the preponderance of females among the supercentenarian population, and an era before women entered the labor force in significant numbers. Based on tabula-

Table 3. Sex, race, place of birth

Item	Confirmed supercentenarians	Unconfirmed candidates
Total	325	351
Sex:		
Female	294	279
Male	31	72
Race:		
White	274	168
Black	49	133
Other	0	35
Unknown	2	15
Place of birth:		
United States:	(305)	(242)
Alabama, Georgia, Mississippi, Texas	48	82
Other	257	160
Foreign country	14	91
Unknown	6	18

tions from the 1940 decennial census for females then ages 35 to 54, the educational attainment of supercentenarians was, overall, higher than that of their peers, assuming the informants for the death registration are not knowingly or unknowingly overstating such attainment. The proportion of supercentenarians ever married is about the same as for females ages 45 to 54 in the 1940 census, so there is no evidence of association between ever-married status and the achievement of this milestone age.

The non-specific entry of "old age" is the third most frequent entry for cause of death among supercentenarians. If a relative of the decedent is the informant, that relative is most likely to be the decedent's child.

Leslie Stone of the University of Pennsylvania's Population Studies Center has done two analytic studies using the census records of U.S. supercentenarians.

In the first study (Stone, 2002), the objective was to determine whether early-life conditions are associated with the achievement of supercentenarianship. Information was extracted from 1880 or 1900

Table 4. Occupation, educational attainment, marital status

Item	Number	Percent	
Occupation:			
Homemaker	181	57.6	
Farmer	20	6.4	
Teacher	30	9.6	
Laborer	2	0.6	
Nurse	4	1.3	
All others	63	20.1	
Blank or unknown	14	4.5	
Total	314	100.0	
Years of schooling: (Numbers in parentheses are comparable percentages for females ages 35 to 54 in the 1940 census)			
1-4	11	5.7	(13)
5-8	72	37.5	(47)
9-11	16	8.3	(16)
12	49	25.5	(15)
13-15	23	12.0	(6)
16+	21	10.9	(4)
Total	192	100.0	
Marital status:			
Never married	36	11.5	
Married	1	0.3	
Divorced	4	1.3	
Widowed	264	84.1	
Blank or unknown	9	2.9	
Total	314	100.0	

Source: Death certificates with usable data

Table 5. Cause of death and relationship of informant to decedent

Item	Number	Percent
Cause of Death:		
Arteriosclerosis	71	22.6
Pneumonia	40	12.7
Extreme age	29	9.2
Congestive heart failure	15	4.8
Atherosclerosis	18	5.7
Coronary artery disease	15	4.8
All others	105	33.4
Blank or unknown	21	6.7
Total	314	100.0
Informant:		
Wife or husband	0	0.0
Sister or brother	0	0.0
Cousin	3	1.7
Daughter or son	63	34.8
Niece or nephew	19	10.5
Granddaughter or grandson	20	11.0
Great-granddaughter or great grandson	2	1.1
Other relatives, in-law's	4	2.2
Relative, but relationship not known	49	27.1
Nursing home administrator	4	2.2
Doctor	5	2.8
Friend	3	1.7
Other	9	5.0
Total	181	100.0

Source: Death certificates with usable data

census records of both the eventual supercentenarians, and a random sample of persons in the same birth cohorts. In the comparison of the two groups, many bivariate relationships were statistically significant, but in a multivariate framework, the variable "resides on farm" stood out as significantly (p-value < 0.10) positively associated with such achievement. This finding suggests that an early-life rural environment enhances survivorship a century later!

In the second study (Stone, 2003), the research question was: Considering that siblings of eventual supercentenarians have a genetic make-up similar to them, and generally were raised in the same environment, do they also enjoy a survival advantage relative to their peers? While this question was recently dealt with by Perls, Wilmoth, and their co-investigators in the New England Centenarian Study (2002), using information obtained from next of kin, the Stone study is not geographically limited and is based on recorded information. The siblings are the ones listed on the census schedules together with the eventual supercentenarians. SSA records were searched to determine the dates of death of these siblings, or, failing that, at least the dates of initial application for a Social Security number. Social Security numbers were first issued in November 1936. The study revealed a sustained mortality advantage for brothers of supercentenarians.

3 Mortality

Using edited data on enrollment in Medicare Part B for the decade of the 1990s, Kestenbaum and Ferguson (2002) have shown that, in the United States, single-age mortality probabilities continue to increase past age 100 to reach a value of about 0.5 at age 109. The question remains, however, whether mortality probabilities follow the same pattern at the very oldest ages, level off, or perhaps even decline. If we assume that the age-at-death distribution for deceased U.S. supercentenarians not included in the IDL—either because their ages are not validated or because they were not captured in the SSA Medicare B net—is the same as the distribution for those included, we can proceed with the extinct-cohort method to calculate the extreme-age mortality. We recognize that this assumption is questionable because for supercentenarians who are missed because their age at death was understated in SSA records, the understatement is more likely to be small than to be large. So that we may treat the cohort as extinct, we need to guess the age at death of the 115-year-old still alive–say, 116. We also offer the caveat that (although the U.S. contribution to the IDL is relatively large), because the number of observations is small, particularly after age 111, the results must be characterized as suggestive, rather than definitive.

Given a closed group and its distribution by age at death, the mortality schedule for the group can be determined in a straightforward manner for cohorts which are extinct. Table 6 presents the distribution of deaths for cohorts reaching age 110 no earlier than 1980 (when observation begins). The numbers alive at the beginning of each age interval are obtained in a straightforward fashion, and then the age-specific probabilities of death.

Table 6. Mortality of supercentenarians born 1870 - 1889

Exact age, X	Deaths between X and X+1	Survivors to X	Probability of death
110	165	320	0.516
111	79	155	0.510
112	36	76	0.474
113	21	40	0.525
114	12	19	0.632
115	4	7	0.571
116	1	3	0.333
117	1	2	0.500
118	0	1	0
119	1	1	1.000
120	0	0	

Note: One person still alive, now age 115, is assumed to die at age 116.

The methodology produces a probability of death at both age 110 and age 111 of slightly above one-half, about the same as the probability for females at age 109 during the decade of the 1990s presented in Kestenbaum and Ferguson (2002). The probability of death at the next age is lower, and the probability at age 113 is only slightly higher than at age 110, suggesting that the overall mortality of supercentenarians is not greater than mortality at age 109. Of course, the following caveat is in order: a decrease in mortality at these very extreme ages may not represent a natural phenomenon, but a contrived one, if extraordinary measures were taken to preserve the lives of these amazingly long-lived persons. The values at ages above 113 are based on very few observations.

4 Plans for the future

The scope of the U.S. contribution to the IDL is limited to persons achieving age 110 before 2000 (and not deceased before 1980). Persons achieving age 110 after 1999 are out of scope, but it is possible that they will be included at some future time. On the other hand, we have made a commitment to add any in-scope person if and when the person's date of birth is corroborated by a birth registration or early census record.

If the initiative to obtain death certificates with personal identifiers from the National Center for Health Statistics with the approval of the states goes forward, it will provide for a net for supercentenarians that goes back to about 1960, which is easy to construct and that few will elude. In contrast, (a) the Medicare Part B enrollment data in the Master Beneficiary Record is difficult to work with, and (b) supercentenarians not enrolled in Medicare B through the Social Security Administration are missed. Presumably, our role at the Social Security Administration would be to inspect the list of candidates and delete from the list those whose age at death on the certificate of 110 or more is contradicted by information in our records.

An opportunity presented itself to examine the performance of this new approach in our investigation of California deaths. The public-use files of California death records for the years 1989 through 1999, which we have a copy of, contain Social Security numbers, and can, therefore, be easily linked to Medicare records. Among 82 Californians deceased at recorded ages of 110 and above during this 11-year period, our net missed just one male, in this case because his Medicare eligibility derived from career employment in railroad work. Among the other 81, the Medicare record agreed with the alleged achievement of supercentenarianship about one-half of the time, and disagreed about one-half of the time. This result cannot be generalized, however, because the extent of age misreporting on the death certificate is greater for some geographical areas, and some races, than for others.

We look forward to increasing the United States contribution to the International Database on Longevity.

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The emergence of supercentenarians in Canada

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Abstract. As has happened in other developed countries with low mortality, Canada has seen a dramatic increase in the numbers of very old persons in its population, with a multiplication in the number of centenarians, and the concomitant emergence of supercentenarians. The extent of the phenomenon is, however, difficult to assess. On the one hand, because of a warped view of the protection of privacy, age data from Canadian censuses are available only in rounded figures, which renders them useless when reaching the small numbers associated with supercentenarianism. On the other hand, death statistics in general, and those from people born outside the country in particular, are suspect at the extreme ages, and the information necessary to validate the information is not accessible most of the time; with the Province of Quebec, representing some 23.5% of the Canadian population, being the only exception. Of the 25 reported deaths at an age of 110 or over in Quebec, careful validation has identified 10 true supercentenarians. Eight of them are women, but the earliest one, born in 1852, was a male. The oldest died in 2001 at the age of 112 years and four months, but this record will be soon shattered as a 115-year-old woman is currently living in Montreal. Eleven cases are known for the rest of Canada, but they necessarily represent a fraction of the total number of people who reached the 110-year milestone.

A member of the G8 (a forum which brings together the world's "major industrial democracies"), blessed with a high standard of living, and ranking with the best in life expectancy, Canada stands out as one of the most advanced countries in the world. Its population facts and vital events are registered in the structured manner characteristic of a sound public administration, with reputable statistical offices producing in due time the tabulations that allow analysts to monitor levels and changes in the basic behaviors of society.

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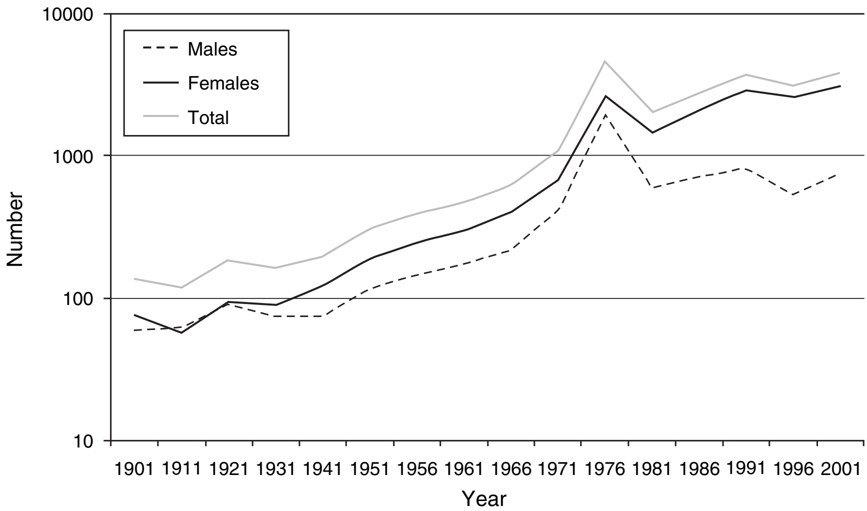
One would thus expect Canada to be in a position to provide complete and reliable data on one of the most fascinating developments of the modern era: the dramatic increase in the numbers of very old persons in populations, illustrated by the proliferation of centenarians and the concomitant emergence of supercentenarians. An overview of the Canadian picture, as it can be defined from the official statistics of the land, will demonstrate that this assumption needs, at the very least, to be qualified. We will then review the Canadian situation in terms of data collection and age validation to arrive at the current state of knowledge on the emergence of supercentenarians in Canada.

1 The tale of the official statistics: Data on population

Complete censuses started in 1851-1852 in Canada, 15 years before the country was organized as a Confederation of Provinces, its current political structure. The censuses were carried out every 10 years up to 1951, and every five years since. Because of the constraints of strict privacy laws, the census forms were kept out of the public domain for 90 years; and the current chief statistician, bent on making censuses from 1911 permanently inaccessible at the individual level, did not ease up on his obsessions until threats to take him to court were made. The price paid for this concession was, however, the introduction of a "consent clause" in the current censuses, which will inevitably lead to only part of the originals being made available to our descendants. Thus, beyond 1911, the only information available up to 1971 is based on tabulated data, in which the oldest were all classified as aged 95+, except for the 1911 to 1931 censuses, in which the grouping was temporarily set at 100+. With the introduction of computerization with the 1971 census, single years of age data became available to age 121 (see Annex). But, at the same time, privacy considerations imposed the rounding of figures to the nearest five, making them worthless for the precise observation of extreme ages. Furthermore, quality control problems were clearly present up to the 1990s, and, even today, extreme age declarations are not verified.

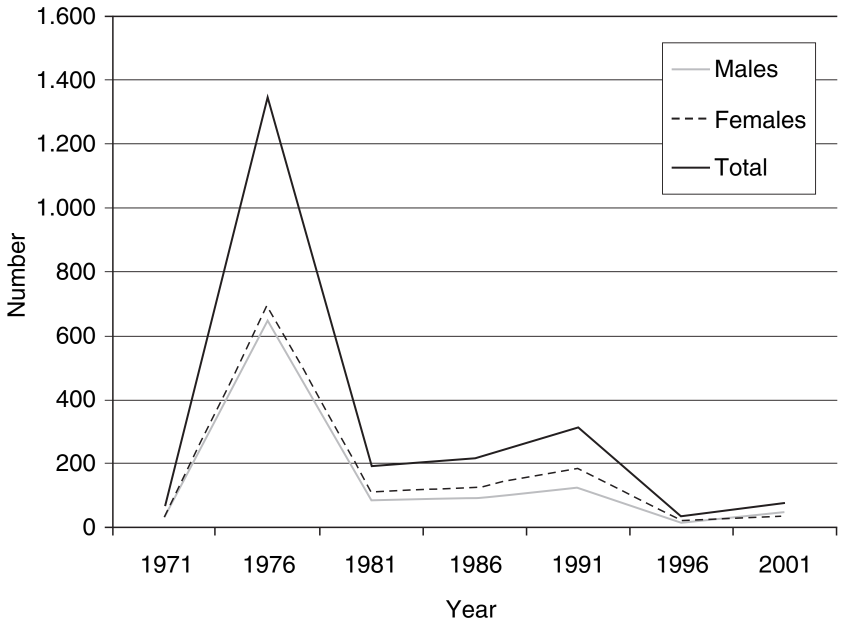
Despite these obstacles, we have plotted the progression in the numbers of centenarians by sex during the 20th century in Canada, as provided by the censuses. Numbers for 1901, and for 1941 to 1966, were derived from the number of persons age 95 and over (Figure 1). Numbering fewer than 100 for each sex for the early decades, the number of centenarians rises steadily from 1931 for females, and from 1941 for males. By 1971, their number reached more than 1,000. Disregarding the data for 1976, which is clearly problematic (Reported numbers are 4,475 centenarians and 1,340 supercentenarians!), the censuses indicate an exponential increase at the annual rate of 6.1% in the number of centenarians for the following 20 years, from 1,075 in 1971, to 3,640 in 1991. The census of 1996 then shows a decrease to 3,120, probably due to the introduction of new data quality controls, and the last census counts 3,795 centenarians, a proportion of 120 per million.



Source: Statistics Canada, Canadian Censuses from 1901 to 2001.

Fig. 1. Population of age 100+, by sex, Canada, Census data from 1901 to 2001

Figures for supercentenarians start in 1971, and, as mentioned earlier, they are rounded for privacy purposes (Figure 2). Even without taking into account the ridiculous numbers of 1976, figures are quite high up to 1991, which shows an improbable number of 310. Numbers that appear to be more realistic are given for 1996, when only 35 persons were listed as having reached the age of 110; and for 2001, when 80 Canadian supercentenarians were counted. But we will later demonstrate that these figures still overstate the real number of supercentenarians, and that only very few people, if any, should have been reported as such starting in the seventies. It is, therefore, important to understand that census data cannot be counted on to monitor with any precision the rise of the extreme old in Canada.



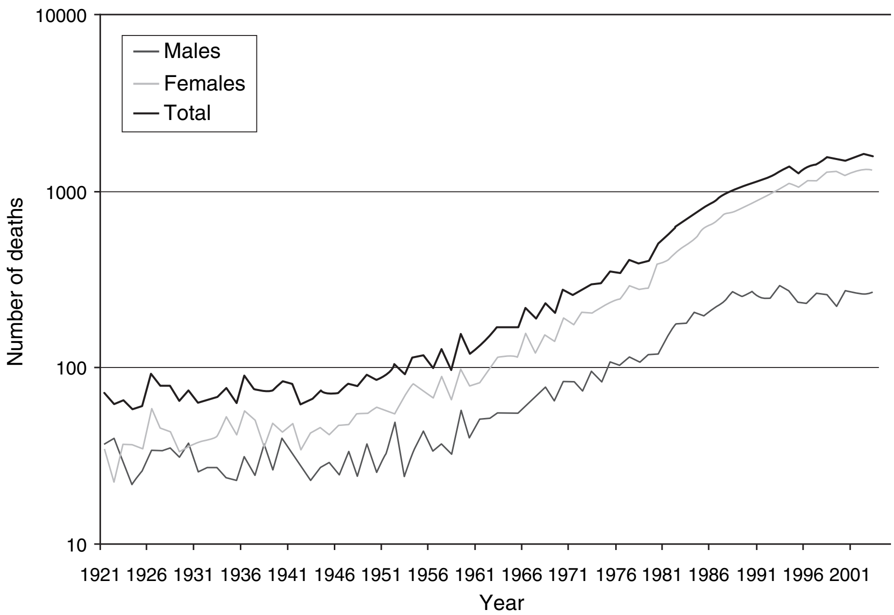
Source: Statistics Canada, Canadian Censuses from 1971 to 2001.

Fig. 2. Population of age 110+, by sex, Canada, Census data from 1971 to 2001

2 The tale of the official statistics: Data on deaths

The Canadian federation was created in 1867 by an initial group of four provinces, to which six others have since been added; the last one in 1949. Under the constitution, all aspects of civil registration fall to the individual provinces, which handle the initial collecting and processing of the data. Since 1921, the central government has produced tabulations from data sent in by the provinces. Data on deaths is thus available in single years of age up to age 100 from 1921 to 1949, and up to age 121 since. However, for reasons those familiar with public administrations will understand, supercentenarians simply disappeared from the data from 1963 to 1973, with all deaths reported at age 110 and over being coded as being age 109! This distortion of the data notwithstanding, we will explore the question of what this death information, such as it is, tells us about the rise of the very old in Canada.

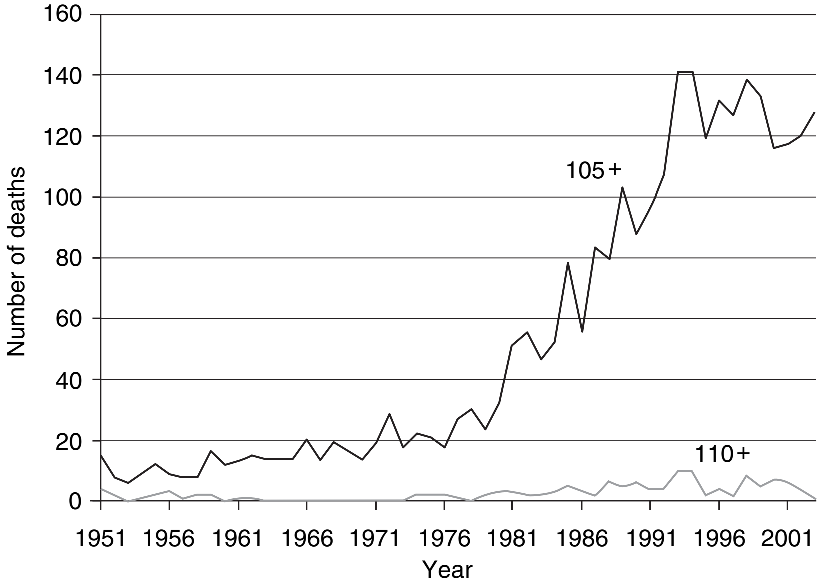
The reported number of deaths of centenarians did not increase significantly from 1921 to the end of the 1940s for either sex, which contradicts the picture given by the census data (Figure 3). It thus seems that the real emergence of centenarians began in the middle of the century, with the number of deaths reaching 151 in 1959, or two times the 1921 count; the next doubling is achieved by 1973, with 301 deaths. But most of the increase took place from 1973 to 2003, when the yearly count reached 1,597 deaths among centenarians, or more than five times the 1973 count. The number of female deaths rose steadily over the period, but the number of deaths of male centenarians leveled off in the 1990s.



Source: Statistics Canada, Vital statistics 1921 to 2003.

Fig. 3. Deaths of centenarians, by sex, Canada, 1921-2003

Focusing on the deaths at ages 105 and over, a sudden surge in the number of reported deaths can be seen starting in the second half of the 1970s (Figure 4). The rise stalls in the 1990s, however, which again points to problems in the older data, with better controls being introduced around 1990 in several provinces. The number of deaths among supercentenarians is very small of course; a better picture is obtained from the detail given in Table 1.



Source: Statistics Canada, Health Statistics Division, unpublished.

Fig. 4. Number of deaths from age 105 and 110, both sexes, Canada, 1951-2003

For the whole period (1951-2003), there are 135 reported deaths among persons aged 110 and over in Canadian vital statistics. For obvious reasons, most of the cases date from after the mid-1970s. There are no cases reported between 1963 and 1973, due to the age limit imposed by the administration, and it is quite reasonable to expect cases occurring before 1963 to be the result of coding mistakes, or of exagger-

Table 1. Reported deaths of supercentenarians, by age and time period, Canada, 1951-2003

Age	Period				
	1951-1962	1963-1973	1974-1989	1990-2003	1951-2003
110	14	0	21	32	67
111	0	0	12	21	33
112	3	0	2	10	15
113	1	0	3	7	11
114	0	0	3	0	3
115	0	0	0	1	1
116	0	0	1	1	2
117	0	0	0	1	1
118	0	0	1	0	1
119	1	0	0	0	1
Total	19	0	43	73	135
Maximum age at death	119	109	118	117	119

Source: Statistics Canada, Health Statistics Division, unpublished data.

ation of age at death. Maximum ages at death point in that direction; it should be noted, however, that a death at 117 did occur in 1998; it is the case of Marie-Louise Chass-Meilleur, who became the world's oldest known individual upon the death of Jeanne Calment, the miraculous French long-liver who died at age 122. Mrs. Chass-Meilleur's age at death was proven correct following a thorough investigation (Desjardins, 1999).

It is impossible to know exactly at the level of each province if and when some kind of validation was performed for these extreme cases. Numbers are obviously too high, especially when one compares them with the numbers for England and Wales: with a population roughly 60% that of England and Wales, Canadian statistics recorded 85 deaths at age 110 or over, compared with 41 for England and Wales for the period 1968 to 1997.

To summarize, four periods can be identified concerning the quality of Canadian data on reported deaths of supercentenarians:

1951-1962: The quality of the data is most suspect, and it is reasonable to think that very few real supercentenarian deaths occurred in Canada.

1963-1973: No deaths were reported over age 109, by administrative decision.

1974-1985: Quality is still to be evaluated outside Quebec.
1986-2003: The quality of the data seems better, but some exaggeration is certainly still present.

Clearly, vital registration data alone cannot used to establish with a sufficient degree of precision the level of extreme survival in Canada. Age validation must be performed to separate the good from the bad in Canadian statistics.

3 About data collection and age validation in Canada

In the absence of a population register, it is impossible to monitor the number of supercentenarians alive at a given moment in the country. Administrative files should contain the information, but the updating of these files is often unreliable in practice; and, in any case, access to detailed versions of these files is unimaginable in the present context of paranoia regarding individual privacy in Canada. Although one might have thought that the mere feat of achieving such longevity would make a person so notorious that cases could be found in their great majority through diverse means–such as through systematic tracking of newspapers and other media–it is evident from our experience that some cases go unnoticed for a variety of reasons (e.g., personal desire for anonymity, discretion of relatives, state of mind or health of the person, etc.). And clearly, as can be seen from the tale of the official statistics, Canadian censuses cannot be used to establish the number of supercentenarians living in Canada: given its current population of 31.5 million inhabitants, only a handful of supercentenarians can be expected to be alive; thus random rounding of the number of cases at each age makes any tabulation at ages 110 and over worthless.

The only possibility of obtaining systematic data on supercentenarians in Canada therefore lies with death registration. Provincial statistical offices do not object to publishing yearly exact numbers of deaths by year of age and sex, but our review of the information currently available has demonstrated they cannot be used as they are. Past data suffers from the fact that they originate from 10 different administrations, each with their own history and traditions, and with 10 different sets of rules and methods varying over time. Given that many cases were suspect, and investigating them would have required going back to the people who had made the initial declaration, collection agencies were slow to adopt controls at the time of data entry because of the costs involved.

Current data collection appears to be better standardized, both in terms of content and quality control. However, structural problems remain due to the characteristics of the country itself. One is that Canada has always been, and still remains, a country of immigration: 28% of the people aged 75 and over in 2001 were born outside the country, and 43% of reported deaths of centenarians during the 1990-1997 period were of foreign-born people. The majority of immigrants up until the 1960s came from European countries, but, as one would expect, many migrated from troubled areas or during difficult times of war or revolution. For example, in an obituary of a reported supercentenarian published in a Montreal newspaper, it was noted that the deceased "never had a birth certificate because he was Jewish, and Jews were not considered important enough to benefit from the care of the Administration." In recent decades, immigration to Canada has become much more diversified, with significant numbers arriving from Asia, Africa, South America, and the West Indies, where the risk of age inexactitude or exaggeration could be greater. Again, a newspaper obituary, that of a prominent member of the Chinese community with many descendants, illustrates the point : the deceased, according to the obituary, "passed peacefully away at the *approximate age* of one hundred and five years." Finally, one can imagine a variety of reasons or circumstances linked to immigration in which age would be unknown, incorrect, or even willfully misstated. For these reasons, there seems to be a strong case not to retain ages at death of the foreign-born which, by definition, can rarely be fully validated, to establish the emergence of supercentenarians in Canada.

But problems are present even if one relies strictly on death registration of the people born in Canada. Civil registration only began late in the 19th century, or even in the 20th century, for all provinces except Quebec (Table 2), and even there, not all events were reported and recorded, as many people and local institutions were suspicious of the government and refused to comply. Church records existed for the preceding periods, but they have no systematic character and are often of poor quality in terms of identifying the persons involved. These possible discrepancies, which may have been exacerbated by the pioneer character of many areas of the country at the turn of the 20th century, mean that a significant number of people born in Canada and dying at very high ages today could be without documentary evidence of their date of birth. Adding the ever present reality that extreme age declarations tend to include errors in any context for various reasons, and the fact that a few inexact ages are sufficient to interfere with the correct observation of extreme age at death given the small number of cases, it is evident that specific age validation is a prerequisite for the observation of supercentenarians in Canada.

Table 2. Year systematic civil recording of births and deaths began in each of the ten Canadian provinces

Province	Year
Alberta	1898
British Columbia	1872
Manitoba	1882
New Brunswick	1888
Newfoundland	1892
Nova Scotia	1908
Ontario	1869
Prince Edward Island	1906
Quebec	1679
Saskatchewan	1895

Although far from perfect, Canadian birth registration of 110 years ago nonetheless allows age validation. Also, the nominative rolls of the censuses, available up to 1911, represent a good secondary source of information in the absence of birth registration; presently, the 1881, 1901, and 1911 censuses are completely indexed and available online. But no age validation can be envisioned without first knowing the names of the persons whose ages are to be verified. And therein lies the overwhelming problem in Canada: contemporary nominative information in any official document is outside of the public domain, and requires specific permission from privacy protection agencies to be disclosed. For death registration, which is a provincial jurisdiction, 10 different organisms are thus involved. There is no guarantee a request for research purposes will be granted, especially since age validation pretty much requires not only the name of the deceased, but also the names of the parents or spouse, and the place of birth. The largest province in Canada, Ontario, for example, has refused a request for the names and other information on people reported to having died at age 110 or over, seeing no reason to supply such "sensitive" information for the purposes of establishing the exact ages of the persons. Luckily, Quebec's *Commission d'accès à l'information* has granted standing permission to access the information under its jurisdiction; as for the rest of Canada, persistent efforts have to this day not yielded any results. The information on the emergence of supercentenarians in Canada is thus restricted at this time to the province of Quebec, which, with a population of 7.5 million, represents 23.7% of the Canadian population.

4 The supercentenarians of Quebec

Although civil registration dates back to the 17th century in Quebec, compilation of the information started in 1926, which means that age at death is only available from that date onwards. A list of all declared deaths of supercentenarians from 1926 up to 2004 was obtained, giving for each case, when available, the name of the deceased, the names of his or her parents and spouse, dates of birth and death, and place of birth. The list numbers 25 cases (Table 3). Eight are immigrants (the country of birth was not given in one case); they originated from the USSR, Poland, Romania, Turkey, China and Belgium. These immigrants are excluded outright from any validation effort, leaving 17 names of possible supercentenarians, 13 of whom were born in Quebec. Age at death is obtained from the difference between the date of death

Table 3. Number of reported deaths of supercentenarians in Quebec, 1926-2004, according to sex and to place of birth

	Born in Canada		Born	Place of	
	In Quebec	Outside Quebec	outside Canada	Birth unknown	Total
Males	4	1	2	0	7
Females	9	3	5	1	18
Total	13	4	7	1	25

and the date of birth, as they appear on the death certificate of the person. Logically, the ideal way to validate the age is by finding the actual birth registration of the person and comparing it to the date on the death certificate. This means forging a link between two documents recorded a century apart, essentially on the basis of the name of the person; this would have been a simple thing to do if births of the 19th century had been indexed across Canada, but several provinces, notably Quebec, have no indexes of births for that period. It is, therefore, often necessary to have more information on the person in order to search for his or her birth registration. Church parish registers were the official registration in Quebec up until recently; they are readily available on microfilm well into the 20th century. But, because death certificates do not record the exact place of birth of the deceased–only the country or province of birth are required–finding a specific baptism would be impossible if the names of the parents and of the spouse are not available to help pinpoint where in Quebec the person might have been born; since all Quebec marriages up to the 1930s are indexed, it is possible to identify among the hundreds of Quebec parishes the one where the baptism of a child might be found on the basis of the place of marriage of the parents. The possibility of finding births elsewhere in Canada is dependent on many different situations, but Ontario, by far the most important province, is, fortunately, one which has an index.

The result of the examination of the 17 reported deaths of supercentenarians in Quebec is given in Table 4. Seven were proven incorrect; the most recent false case is from 1995, one is from 1991, but all the others are more than 20 years old, which probably reflects that minimum controls were introduced by the registration offices. Ten cases were ultimately recognized as valid deaths of supercentenarians. Because that province had no civil registration at the time of his birth, the validation of a case of a male supercentenarian born in Nova Scotia is based on the 1901 census, which confirms his date of birth to the day. Although eight out the 10 are women, the earliest case is that of a male, who died in 1962. The first confirmed death of a female supercentenarian occurred in 1983, and over eight years elapsed before the next one. Since 1991, they have occurred regularly, probably establishing a pattern that is here to stay. The highest age attained is 112 years, four months, and six days; but a person living in Montreal when these lines were written has just celebrated her 115th birthday and will thus augment this maximum by a significant degree. The 10 died on average at age 110 years and 11 months.

Of course, the emergence of supercentenarians means a growing number of people are reaching ages 105 to 109. A good picture of things to come can thus be obtained from deaths at these ages, limited here for the reasons explained above, to French-Canadians born and deceased in Quebec (Table 5). Although some cases with age mistakes could be included, the overall picture is clear: supercentenarians will appear in greater numbers in the death records of the years to come, as the numbers of people reaching the preceding age group slowly but surely rises. Based on validated deaths, the proportion of deaths at ages 105 and over among all deaths of centenarians is estimated at 7.3%, a propor-

Table 4. List of the reported deaths of supercentenarian deaths in Quebec with date and place of birth, date and age at death and validity status, 1926-2004

Sex	Date of birth	Place of birth	Date of death	Age at death	Valid?
F	1866-07-05	Quebec	1979-06-12	112y,11m	No
F	1867-02-28	Quebec	1980-12-22	113y, 9m	No
F	1867-09-23	Quebec	1978-03-03	110y, 5m	No
F	1883-11-15	Nova Scotia	1995-04-06	111y, 4m	No
M	1862-07-07	Quebec	1974-11-29	112y, 4m	No
M	1881-09-10	Quebec	1991-12-11	110y, 3m	No
M	1859-09-02	Quebec	1978-09-02	118y, 9m	No[3]
F	1879-07-15	USSR	1990-02-11	110y, 7m	xxx
F	1880-04-06	Poland	1993-09-21	113y, 5m	xxx
F	1881-07-05	China	1993-04-14	111y, 9m	xxx
F	1883-09-27	Unknown	1994-07-23	110y, 9m	xxx
F	1885-02-07	Belgium	1995-08-10	110y, 6m	xxx
F	1890-00-00	Romania	2001-10-23	111y, 0m	xxx
M	1875-03-10	USSR	1988-11-03	113y, 7m	xxx
M	1875-05-01	Turkey	1985-12-01	110y, 7m	xxx
F	1872-09-06	Quebec	1983-02-18	110y, 5m	Yes
F	1880-06-08	Ontario	1991-12-09	111y, 6m	Yes
F	1882-01-31	Quebec	1993-07-29	111y, 5m	Yes
F	1885-11-10	Quebec	1996-01-28	110y, 2m	Yes
F	1887-03-15	Quebec	1998-10-24	111y, 7m	Yes
F	1889-04-12	Quebec	2001-08-18	112y, 4m	Yes
F	1889-09-08	New Brunswick	2000-02-29	110y, 5m	Yes
F	1892-03-20	Quebec	2002-09-30	110y, 6m	Yes
M	1852-02-26	Quebec	1962-03-16	110y, 0m	Yes
M	1884-06-24	Nova Scotia	1994-07-22	110y, 1m	Yes

tion that exceeds the expected value of about 5% in countries with very good data.

As explained earlier, the 25 cases from Quebec, of which 17 could be examined, represent the only systematic observation of supercentenarian deaths available at this time for Canada. However, several other cases were brought to our attention through media coverage, of which about a dozen appeared quite credible. The list is given in Table 6. It includes the case of Marie-Louise Chassé-Meilleur, a Quebec-born woman

[3] Actually, no record whatsoever could be found that matched the information on the death certificate; given the very high improbability of a male reaching age 118 in 1978, it was considered to be non-valid outright.

Table 5. Deaths at age 105 to 109 by year of age, by sex and year, Quebec, 1985-2004

	Female						Male					
Year	Age					Total	Age					Total
	105	106	107	108	109		105	106	107	108	109	
1985	4		2			6			1			1
1986		1				1		1				1
1987	3	2	1			6	1					1
1988	3	1				4						0
1989	4	1				5	2		1			3
1990	2	2	1			5						0
1991	3		2	1	2	8	1					1
1992	3					3	1	1				2
1993	3		1	2	1	7	1	1		1		3
1994	7	5	1			13	2		1			3
1995	5	3	1	1		10		1				1
1996	3	3	2	1		9				1		1
1997	8	2	2		1	13			2			2
1998	7	2	2	1		12		1	1			2
1999	7	6	2	1		16	2	3				5
2000	6	4	4	1		15	1					1
2001	5	4	3	1		13	1	1			1	3
2002	9	3	1			13		1				1
2003	6	8	1	3	1	19	1	1	1			3
2004	7	7	4	1	2	21	2					2
Total	95	54	30	13	7	199	15	11	7	2	1	36

who died in Ontario at the age of 117, making her at the time of her death the oldest known living person in the world; she holds today the fourth-place ranking among the perfectly validated cases of extreme longevity. Eleven confirmed Canadian deaths of supercentenarians are added; they were validated using birth indexes or census returns of 1901. Being known through media coverage, they are most probably biased towards higher ages. Even if we set aside the exceptional case of Marie-Louise Chassé-Meilleur, they indeed died on average a good four months older than the Quebec cases.

Table 6. List of some validated supercentenarian deaths outside Quebec

Sex	Date of birth	Place of birth	Date of death	Place at death	Age at death
F	1890-09-11	New Brunswick	2002-03-19	New Brunswick	111y, 6m
F	1888-03-28	Ontario	2001-08-06	Ontario	113y, 4m
F	1890-09-05	Nova Scotia	2000-09-16	Nova Scotia	110y, 0m
F	1880-08-29	Quebec	1998-04-16	Ontario	117y, 7m
M	1881-11-17	England	1993-04-12	British Columbia	111y, 4m
F	1879-08-24	Ontario	1993-03-20	Ontario	113y, 7m
F	1878-10-21	Ontario	1989-11-27	Ontario	111y, 1m
F	1878-11-10	Nova Scotia	1989-04-20	Nova Scotia	110y, 5m
F	1878-11-16	Nova Scotia	1988-12-29	Nova Scotia	110y, 1m
F	1877-01-17	Ontario	1988-12-17	Alberta	111y,11m
F	1891-02-27	New Brunswick	2002-03-19	New Brunswick	113y, 9m

5 Conclusion

The observation of supercentenarians in Canada is to be divided into two worlds. In Quebec, observation is systematic from death registration starting in 1926 up to 2004, and new cases will continue to be reported and validated. Each case is known by sex, name, and place of birth, although names cannot be published for privacy reasons, with the exception of cases of exceptional notoriety, which are in the public domain anyway. For the rest of Canada, only numbers of uncertain quality are systematically available. There exists a very partial list of names of which a proportion have been validated; the list carries an ascertainment bias.

Of the 25 reported cases from Quebec, 10 are known to be true supercentenarians. Another 11 cases are known from the rest of Canada, a number which must be augmented to reflect the true Canadian reality. Concerted efforts will be made to obtain a comprehensive list from the province of Ontario to that effect. As things stand today, 1962 has to be considered as the year of the first occurrence of a supercentenarian death in Canada. This date might be pushed back if systematic data from other provinces becomes available.

Acknowledgements

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Supercentenarians in Japan

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Abstract. This chapter provides an overview of two registration systems, the Family Register "Koseki" and the Registry Registration System, which are the basis of age validation in Japan. Data sources for centenarians and supercentenarians are described and the reliability of the information on birth and death is discussed. The chapter explains how we validated the ages of the persons studied and presents trends in the highest ages and the number of supercentenarians in Japan.

1 Introduction

The number of centenarians in Japan reported by the Ministry of Health, Labor and Welfare in 2003 was 20,561. The number had increased more than 130-fold since 1963, when the then Ministry of Health and Welfare started reporting the number of centenarians. At that time, there were only 153 persons aged 100 and over. The source of these figures and the only publicly available data source for living persons aged 100 and over by single years of age in Japan is the government-produced list of centenarians ("Zenkoku Koureisha Meibo"). This list was used to identify the supercentenarians, defined here as those aged 110 and over, to contribute to the International Database on Longevity (IDL). Japan is one of the very few countries having a sizable number of centenarians and supercentenarians in which we could examine the trends over a long period of time. In this report, we first introduce two registration systems which are the bases of age validation in Japan. We then discuss the data available for centenarians, because these data indicate the quality of data sources for supercentenarians. This discussion is followed by an explanation of how we validated the ages of the persons studied, and how we obtained data

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not available on the list of centenarians published by the Ministry of Health, Labor and Welfare. Finally, trends in both surviving and deceased supercentenarians in Japan, followed by concluding remarks, are presented.

2 Basis of age validation

In Japan, the civil registration system is based on the Family Register ("KOSEKI") where all official data related to a given family are recorded, including births and deaths. We have to rely on this registration system in order to validate the age of a person. However, access to the family register has been highly restricted since 1976. Fortunately, there is another registration system, the Resident Registry System, through which it has been, until recently, easier to obtain records for persons of interest for academic research purposes. We discuss each registration system in detail in this section.

2.1 Family Register "KOSEKI"

Family Register "KOSEKI" is a family register containing records of all members of a family, and generally includes sex, dates and places of birth, dates of entry to (marriage, adoption, etc.) and removal from (divorce etc.) a family register, names of parents, and relationship to the head of a family. When a member of a family is dead or removed from a given family register by divorce or adoption, the date of events is recorded in the family register, and the record for the member is simply crossed out by lines. As can be seen in the example in Figure 1, the father of the head of the family died in 1910, and his column was crossed out. But the record remained in the family register until a new family register was created by the changes in the Family Registration Law. When new family registers were created by transcribing records from old family registers, those family members who were dead or removed from the old registers were not transcribed to new family registers. Old registers should have been kept for a minimum of 50 years or 80 years, depending on the registration laws. The registers are kept in the municipality office, which has control over the address for a given family register. Japanese citizens are free to choose any registered address that exists in Japan when a head of a given family files for registration. Therefore, there are people using the address of the Imperial Palace or the Diet building as their registered address for their family register in the recent KOSEKI. The same address for the register can be shared by any number of Japanese citizens. For example, the domicile of the author's family register was shared by his father and brother.

The family registration system, which covers the whole population of Japan, was established by the family registration law ("KOSEKI HO"). This law was enacted on April 4, 1871, went into effect on February 1, 1872, and has been revised many times (see Table 1, which lists only significant revisions). The first registration was called "Jinshin-KOSEKI," with the name coming from the animal year for 1872. A family register for a given family was a piece of paper that was bound together with others to make a book. There was no standardized form for the entire country, but the information to be recorded was specified in the law. In Jinshin-KOSEKI, the date of birth was not recorded, but the age at the registration, including number of months, was recorded. Although Jinshin-KOSEKI was the family register, a family register was based on the domicile of a given family, and the unit of registration was the household, which included unrelated individuals living in the same household. Two copies of a family register were prepared. One copy was kept in a local authority, and the other was sent to the central administrative office. Jinshin-KOSEKI was open to the public until 1968, provided the person who requested a copy of a family register, or asked to see a family register, had reasonable grounds. However, because of a record related to a caste-like system, Jinshin-KOSEKI has been sealed in regional branches of the Ministry of Justice since that time.

In 1886, the Family Registration Law was revised and a standardized form of family register was specified. In this revision, a date of birth for all members of a family was required to be in the records, and a penalty was introduced for those who failed to report births, deaths, etc., within a given period of time after the events occurred. A system of removing family registers ("JOSEKI") was also established in this revision, and a family register which is removed from the binding of family registers was called "JOSEKIHYO". If all members of a family were moved to another location or deceased, a family register for the family was removed from the binding of family registers at the origin. However, the removed family registers should be kept for 80 years by law. After 80 years, each municipality is free to discard or keep the registers.

The Family Registration Law was revised again in 1898. With this revision, the Japanese Family System was established, and each family became a unit of registration. A new column was added in the family register for a head of a family (see Figure 1). Usually the role was

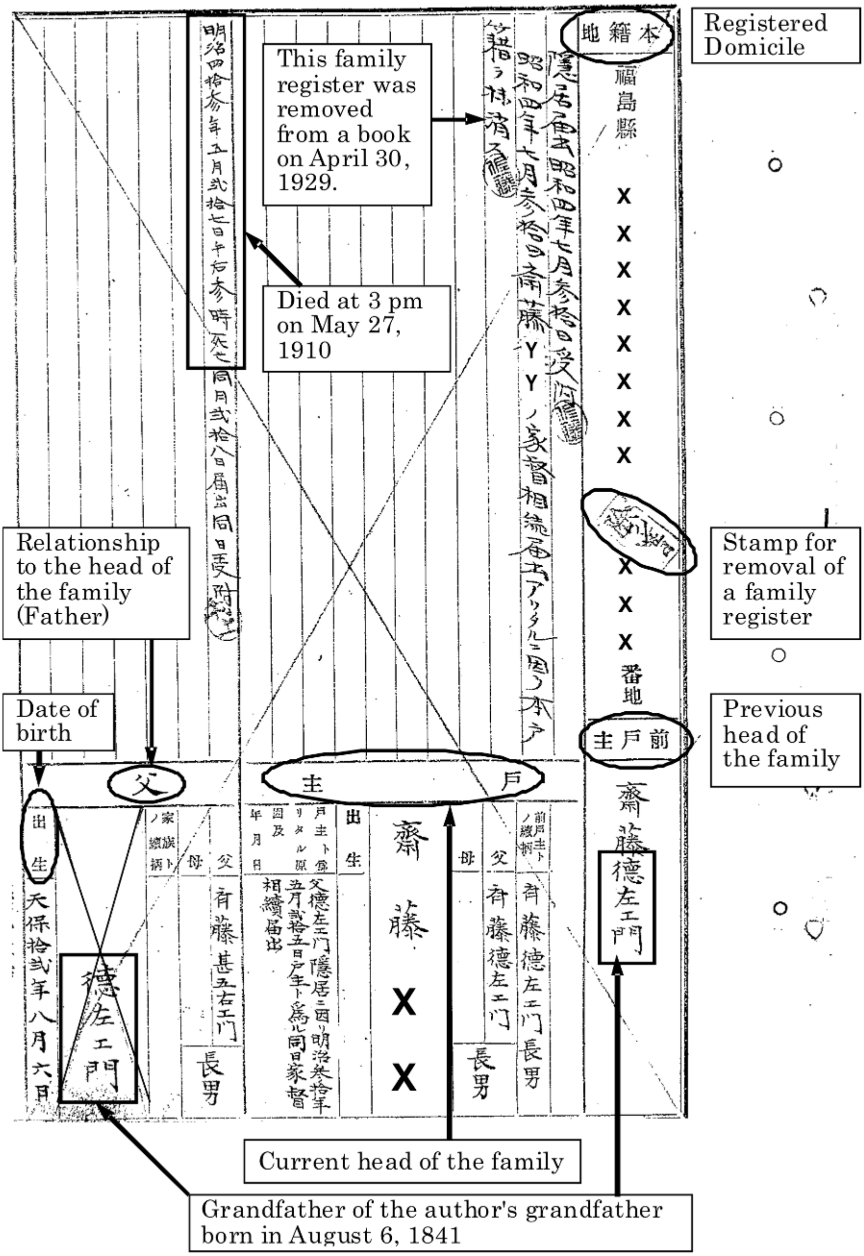

Fig. 1. Example of a family register: 1898 form

passed on to the first son of a family. A head of a family had authority over all family members, but was also responsible for supporting the family. In this revision, family registers, including old family registers, became open to the public, at least in principle.

The law was also revised in 1914 and in 1947, after World War II. In the 1947 revision of the Family Registration Law, the Japanese Family System was abolished some 50 years after it was established, and the unit of registration became a conjugal union. Information on only two generations at the most was recorded in a given family resister, i.e., parents and their children. Although there is no column for a head of a family in the new form of family register (see Figure 2, for example), the order of family members to be listed was specified. The first member of a family to be listed is either the husband and wife, depending upon what name the family carries. A married couple is allowed to decide which family name is to be carried when they register, but they are not allowed to register under different family names for the husband and the wife. Those family members listed in a family register are not necessarily living in the same household.

Using Figure 3, we would like to illustrate changes in a family register, removal of a family member, and removal of a family register. Let's assume that all family members in Figure 3 were listed in a family register in Jinshin-KOSEKI. Then, if the sister (16) of the head of the family got married, and the younger brother (15) died, their column was crossed out in the family register. With the revision of the law in 1886, the new family register was made without transcribing the information of the sister and the younger brother. The old family register was supposed to be kept for 80 years at the municipality office, which has authority over the registered address. If all the family members were deceased or removed from the family register before 1886, then the family register for this family would be removed from a binding of family registers for an area, and would be kept as JOSEKIHYO for 80 years. The information of those who were registered in Jinshin-KOSEKI, or of those who were born before the 1886 revision, may have been transcribed four times by the time 1947 revision of the law went into effect. If all the family members illustrated in Figure 2 were alive before the 1947 revision of the law, four family registers could have been created from the old family register: one for the father of the head of a family (3), the mother of the head (4), the brother of the head (15), and the sister of the head (16); one for the head of a family (1), the spouse of the head (2), and the first daughter of the head (9); one for the first son of the head (5), the spouse of the first

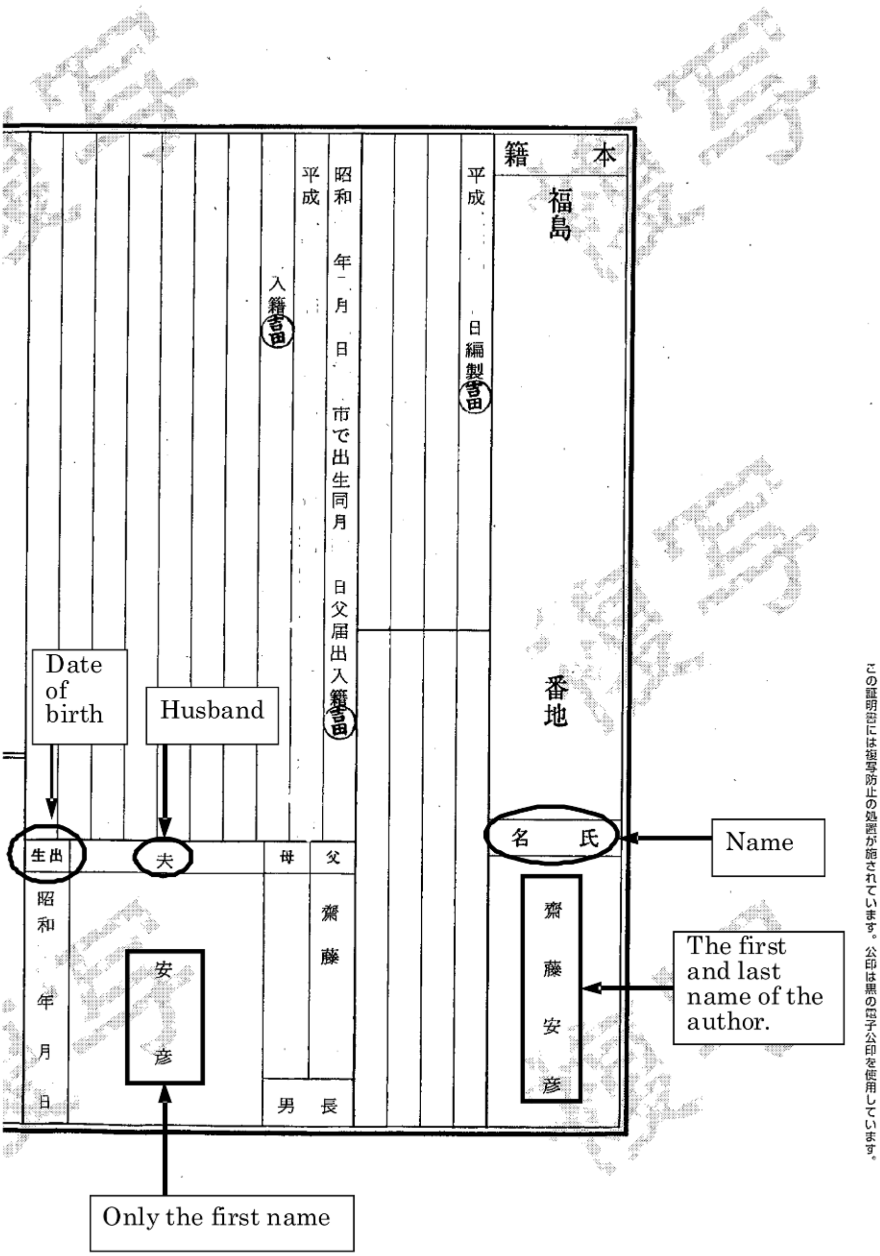

Fig. 2. Example of a Family Register: 1947 Form

son (6), and the grandchildren of the head, (10), (11), and (12); and, finally, one for the second son of the head (7), the spouse of the second son (8), and the grandchildren of the head, (13) and (14).

Often a family register using the form defined by the 1947 revision of the Family Registration Law is called the current family register ("Genko KOSEKI") because the form has been used since then.

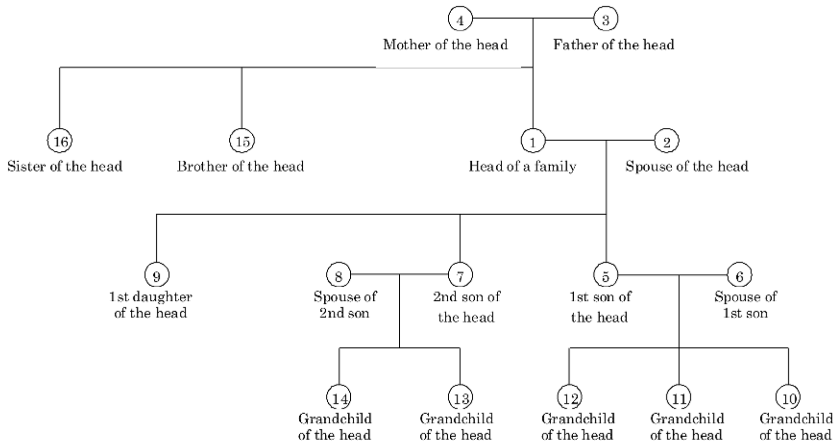

Fig. 3. Illustration of a family tree recorded in KOSEKI before 1947

However, the revision of the Family Registration Law in 1994 allowed municipalities to computerize a family register. Therefore, in those municipalities that had already computerized their family registers, the computerized family register is the current family register, and the previously used family registers are called "Kaisei Gen KOSEKI".

Although Jinshin-KOSEKI was sealed in 1968, as mentioned above, more recent forms of family registers were still available to the public until 1976. With the revision in 1976, access to family registers was restricted.

It is probably worth mentioning what happened to family registers in Okinawa after World War II. Basically, family registers were lost during the war. According to the Okinawa Branch of the Ministry of Justice, the Ryukyu (the name of the kingdom that existed in Okinawa before the Japanese invasion) Government under the U.S. occupation enacted "Koseki Seibi Ho" (law for reconstruction of KOSEKI) on March 1, 1954, and started reconstruction of the family registers based on self-reports by heads of household. The reconstruction of KOSEKI

Table 1. History of the family registration law and resident registry law

	Name of Law	Date of Enactment	Date of Enforcement	Law Number	Remarks
FR*	Koseki Ho	Apr. 4, 1871	Feb. 1, 1872	170	Jinshin KOSEKI, date of birth was not recorded but current age including number of months was recorded instead, recording date of birth started in 1881
FR	Meiji 19 nen-shiki KOSEKI	Oct. 16, 1886	Oct. 16, 1886	22	introduction of Josekihyo, penalty was introduced for those who fail to report births, deaths, etc. within a given period of time after events occurred
FR	Meiji 31 nen-shiki KOSEKI	Jun. 15, 1898	Jul. 16, 1898	12	Japanese family system was established and unit for a family register became family not household, head of a family is recognized
FR	Taisho 4 nen-shiki KOSEKI	Mar. 31, 1914	Jan. 1, 1915	26	
RR	*Kiryu Ho*	*Mar. 31, 1914*	*Jan. 1, 1915*	*27*	*first Resident Registry Law*
FR	Showa 23 nen-shiki KOSEKI	Dec. 22, 1947	Jan. 1, 1948	224	so called Genko KOSEKI, Japanese family system was abolished and information on only two generations can be appeared in a given family register
RR	*Jumin Toroku Ho*	*Jun. 8, 1951*	*Apr. 28, 1952*	*218*	*resident registry is utilized first*
RR	*Jumin Kihon Daicho Ho*	*Jul. 25, 1967*	*Nov. 10, 1967*	*81*	*information on resident registry is linked with information on family registration*
FR	Showa 51 nen revision of KOSEKI Ho	Jun. 15, 1976	Jun. 15, 1976	66	access to the family register was restricted
FR	Heisei 6 nen revision of KOSEKI Ho	Jun. 29, 1994	Dec. 1, 1994	67	computerization of KOSEKI started

Note: FR indicates Law related to Family Registration Law and RR (rows in italics) for Resident Registry Law in Okinawa was completed within a few years. Okinawa was returned to Japan in 1972, and reconstructed KOSEKI by the Ryukyu Government were treated as if they were KOSEKI created by the Family Registration Law revised in 1947.

2.2 Resident Registry

The Resident Registry System is another civil registration system in Japan, and is based on current residence. Limited demographic information for entire members of a given household was recorded in a resident's card ("Jumin-hyo"), including the address registered in a family register, date of birth, date of death, relationship to the household head, and the previous address of the members immediately before moving into their current residence.

The first Resident Registry Law ("Kiryu Ho"), which was enacted in 1914 and went into effect in 1915, was intended to help maintain a registration system. When the Family Registration Law was enacted, the household was the basic unit for the registration. However, the unit for the registration had changed to the family by the 1989 revision. As the volume of migration increased within Japan, the Family Registration System was inadequate for tracking migrants. The Resident Registry Law was amended as "Jumin Toroku Ho" in 1951, and as "Jumin Kihon Daicho Ho" in 1967. The Resident Registry Law was enacted for purposes of taxation, suffrage, health insurance, pension, and schooling of children. The system carries information on the address of the original registration, and the date of birth from the Family Registration System. The Resident Registry System is based on place of residence, and carries records of persons living in the same household. When events such as births, deaths, marriages, and divorces occur, residents are mandated to report such events at the municipality of their current residence. These changes are reflected in the records of the Family Registration System. Once a person dies or changes residence, their records are generally discarded after five years. This is the duration stipulated by law for which records must be kept. Therefore, generally speaking, it is possible to obtain information on the dates of birth of survivors, and the dates of birth and death of deceased persons for the last five years. The difference between a family register and a resident registry is that information included in a resident registry is current only, and cannot be used to trace family lineage.

3 Data sources for centenarians and supercentenarians in Japan

In Japan, there are currently three data sources for the number of centenarians, and only two data sources for supercentenarians. Both data sources for verifying the ages of supercentenarians are based on the registration system outlined above.

1. Census: The census started in Japan in 1920, and has been conducted on October 1 every five years since then, with the exception of 1945, when it was carried out in 1947 instead. In the census, population numbers are reported by sex and age, which is generally expressed as a single year. However, the highest single year of age reported in the census is 99, while higher ages are grouped as age 100 and above. Therefore, we can only observe the trends in the numbers of people aged 100 and above, as shown in Figure 4. The number of centenarians between 1920 and 1965 changed only slightly, increasing or decreasing within the range of 50 to 250. From 1970 onward, the number increased tremendously, almost doubling every five years (Robine and Saito, 2003). The census data are compared later with another data source for centenarians to examine the quality of data for supercentenarians.

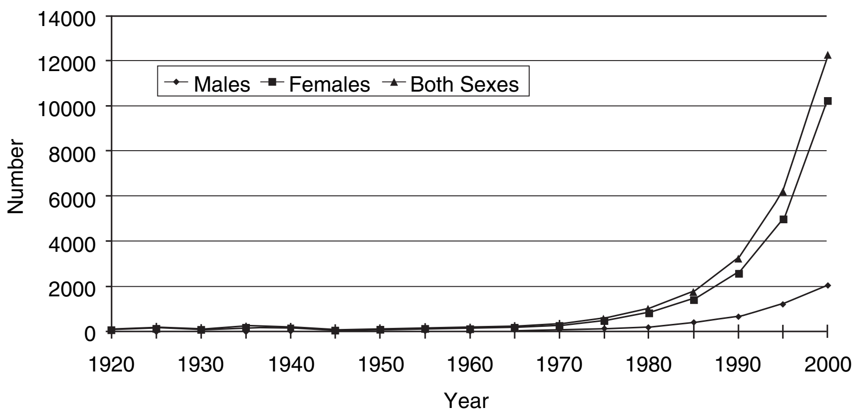

Fig. 4. Number of centenarians: 1920-2000

2. Vital Statistics: Since 1899, the number of deaths by single years of age and sex has been reported annually by the Ministry of Health, Labor and Welfare. Although we are not able to observe living centenarians or supercentenarians, at least we know how many of them died every year. We can also observe the highest age at death reported each year. By examining the trend in the highest age at death, we could have an indication of trends in the highest age reached by Japanese.

3. List of Centenarians ("Zenkoku Koureisha Meibo"): The then Ministry of Health and Welfare started publishing in 1963 the number of people who would reach, as of September 30 of each year, age 100 and above. The list was complied to celebrate the centenarians on "Elderly Day," which later became a national holiday called "Respect for the Aged Day." Because the number of centenarians started increasing substantially around 1965, the timing of the move to compile a list of centenarians has been particularly useful in helping us to observe changes in the number of centenarians.

Figure 5 shows the numbers of centenarians since 1965 from censuses and the list of centenarians, and the differences between these two sources by percentage of the number of centenarians from the census. The differences in the number of centenarians between the two sources range from 7.7% in 1980 to -6.4% in 2000. The differences in the numbers before 1985 are almost all positive, indicating that the number of centenarians from censuses exceeded those from the list of centenarians. However, since 1990, the numbers from the list have exceeded census figures. The excess number of centenarians included in the list is more plausible because the list is compiled in early September, although it indicates the number of centenarians as of September 30. Censuses are conducted on October 1, and some people on the list may have died before the census date. It may be hard to prove which source is more accurate. It is worth noting that censuses are self-reported, while the list of centenarians is compiled by municipalities based on official records—although official records may not be perfect, as we shall discuss later.

4 Validation of date of birth and death

We have used the list of centenarians to obtain information on supercentenarians since 1963. However, the list provides information only on surviving centenarians, and does not contain information on dates of death for deceased supercentenarians. What we are able to observe from a series of lists of centenarians is that some of the supercentenar-

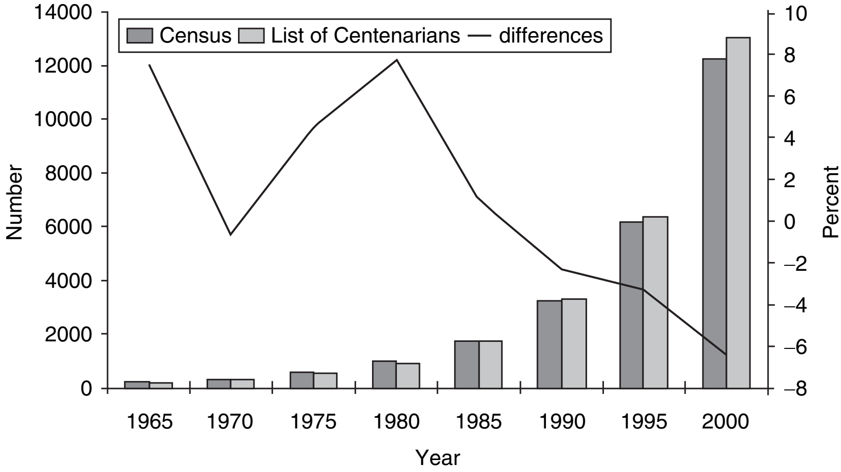

Fig. 5. Number of centenarians in census and the list of centenarians, and difference in percent: 1965-2000

ians' names which had been listed previously disappear from the list over the years. This is an indication that they may have died during a year prior to publication of the list of centenarians for a given year. We also do not know the survival status of those who are on the latest list of centenarians.

When accessing individual records of the Family Registration System and the Resident Registry System in order to obtain information on date of death, two different rules apply. Access to the family registrations is restricted to the members of a given family or lineal descendants of the family. Only they can file requests with municipalities to see and duplicate the records of family members under the Family Registration System. Therefore, we have to ask surviving supercentenarians or family members of deceased supercentenarians to file a request with the municipality for a copy of a family register for a given supercentenarian, and to provide us with the copy. There are two types of certificates that may be requested from a given family register: one shows information on the entire family ("KOSEKI TOHON"), and the other is an abstract of the family register ("KOSEKI SHOHON"). If necessary, a copy of a family register created before 1947 can be requested. The example shown in Figure 1 is the first page of a family register, which is a form specified in the 1898 revision of the Family Registration Law. This is probably the most certain way to validate ages of supercentenarians using records from the Family Registration System. This is partly because we are able to observe ages of siblings and other members of the family as well. However, there is no guarantee that supercentenarians or the families of supercentenarians will agree to provide us with such personal information for academic studies.

In contrast, under the Resident Registry System anyone could request duplicates of a particular person's record, "Jumin-hyo" (a certificate of residence) or "Joseki-hyo" (a certificate of deletion), without the consent of that person. Provided the researcher making the request has information on the name, sex, date of birth, and full address of the particular person of interest; as well as the relevant forms and materials, payment for fees, and a plausible reason for wanting access to the certificate, it is possible to obtain personal information. Academic research can be regarded as one such plausible reason for wanting access to the certificates, although the decision on whether to allow access is made by the head of each municipality. If the person still resides at the address specified by the petitioner, a duplicate of a certificate of residence will be sent. If the person moved from the address, a duplicate of a certificate of residence with a new address will be sent. Otherwise, a certificate of deletion with the date of death will be sent.

This is how we obtained information on the dates of death and validated the dates of birth for the supercentenarians listed between 1995 and 2000. The necessary information for requesting duplicates was taken from the list of centenarians. In early 2001, we had requested information on the survival status of those aged 109 and above who were on the list published in September 2000, as well as of those aged 109 and above who were on the list of centenarians in a given year who had disappeared from the following year's list between 1995 and 2000. According to the Resident Registry Law, information on deceased people is supposed to be kept for five years. This is why we requested a copy of a certificate of residence for five years prior to 2001. We included those aged 109 and above because we had to check whether they died after reaching age 110. There are also two types of certificates of residence that can be requested: one is for the entire household, and the other is for a particular member of a given household. The copy we requested was only for a particular member (supercentenarian) of a given household.

Until recently, it was not too difficult to obtain a copy of a certificate of residence for a member of a given household or an entire household. However, access to the resident registry has been restricted by the enactment of the Privacy Protection Law, which went into effect on April 1, 2005.

5 Results of the validation

As shown in Table 2, which was based on the list of centenarians published between 1963 and 2000, we identified 121 centenarians aged 109 and above. Among those 121 centenarians, 27 centenarians were from the list published in 2000, 42 centenarians were from the lists published between 1995 and 1999, and 52 centenarians were from the lists published between 1963 and 1994. In 69 of these cases (from lists between 1995 and 2000), we requested duplicates of the records from municipalities; in six of these cases, our requests were declined. However, for four out of these six cases, information on the dates of death were obtained from news reports. Information on dates of death reported by newspapers is considered to be accurate. We also requested information on the dates of death for two supercentenarians who were not identified by the municipalities. It is possible that the supercentenarians who were not identified may have moved from the address we specified in the request forms. If the information we provided for the supercentenarians did not match exactly the information on file with the municipalities, our requests may have been denied.

Based on copies of the certificates of residence, we found that, for those from the list published in 2000, seven out of 16 persons aged 109 were alive at that age, four were alive at 110, and another four centenarians were deceased at age 109. For one of the persons aged 109, we could not obtain the information. However, this centenarian died at age 109, according to a news report. Among 11 centenarians aged 110 and above, two were alive at the age listed, four were still alive a year later, another four supercentenarians died at the age reported in the list, and one supercentenarian reached another birthday before dying.

From the lists of centenarians published between 1995 and 1999, 23 persons who had reached the age of 109 were identified. Of these, 12 centenarians died at age 109, and seven centenarians died at age 110. Two of our requests were declined, and another two cases were not identified by municipalities. A total of 19 supercentenarians were on the lists between 1995 and 1999. Eight of them died at the age as listed, and another eight supercentenarians reached one more birthday before they died. Requests for information on three supercentenarians were declined by municipalities, but their deaths were all reported in

Table 2. Summary of supercentenarians in the lists of centenarians and results of age validation

	As of September 1, 2000			As of March 31, 2001					
Year of publication	Age	Sex		Alive at age		Deceased at age		Request declined	Unknown
		M	F	same	+1	same	+1		
2000	113		1		1				
	112		1	1					
	111	1	3		3	1			
	110		5	1		3	1		
	109	4	12	7	4	4		1*	
	subtotal	5	22	9	8	8	1	1	
1995-1999	114		1			1			
	113		3			1	1	1*	
	112		4			2	2		
	111	2	3			2	2	1*	
	110	1	5			2	3	1*	
	109	4	19			12	7	2	2
	subtotal	7	35			20	15	5	2
1963-1994	120	1							
	117		1						
	116	1	1						
	115		1						
	114		1						
	113		3						
	112		1						
	111		4						
	110	1	12						
	109		25						
	subtotal	3	49						
Total		15	106						

Source: "Zenkoku Koureisha Meibo" (List of Centenarians), various years, Ministry of Health, Labor and Welfare
Note: An asterisk ("*") indicates that date of death was reported in the newspaper.

newspapers. According to the reports, each of these three celebrated one more birthday before they died.

Although we did not request copies of certificates of residence for centenarians aged 109 and over listed between 1963 and 1994, we have summarized the numbers by age and sex at the bottom of Table 2. Only three male supercentenarians were identified, compared with 24 female supercentenarians. In addition, 25 female centenarians were listed as age 109 over the same period.

Table 3. Comparison of number of deaths based on the study and Vital Statistics

		Female		Male	
Year	Age	Vital Stat	This Study	Vital Stat	This Study
1996	110	1	1		
1997	110	1	0	1	1
	111	1	1		
	112	1	1	1	1
	113	1	1		
1998	110	3	3		
	111	1	1		
	112	2	2		
	113	1	1		
	114	3	3		
1999	110	1	0		
	111	2	2		
	112			1	1
	113	1	1		
2000	110	4	4	1	1
	111	1	1	1	1

Sources: 1. “Zenkoku Koureisha Meibo” (List of Centenarians), various years, Ministry of Health, Labor and Welfare; 2. Vital Statistics, various years, Ministry of Health, Labor and Welfare

In Table 3, we compared the number of deaths based on this study’s findings, and the number of deaths that appear in the Vital Statistics. We were able to find matches in the Vital Statistics for all deaths among supercentenarians identified by this study between 1996 and 2000. Only two out of 27 deaths reported in the Vital Statistics were missing from our study. If we assume the number of deaths reported in the Vital Statistics is correct, our result indicates underreporting of supercentenarian deaths.

6 Trends in the supercentenarians

6.1 Trends in the supercentenarians in Japan from Vital Statistics

6.1.1 Trends in the number of deceased supercentenarians

As shown in Figure 6, the trends in the number of deceased supercentenarians can be examined by using data from the Vital Statistics since 1899. What is surprising about the data shown in Figure 6 is the very large number of supercentenarian deaths in the early half of the 20th century, compared to the number in the latter half of the 20th century, when living conditions were much better and medical technologies were much more advanced. The number of supercentenarian deaths was 28 in 1916, and this is the highest to date. There were periods of no reported supercentenarian deaths in the 1950s to 1970s. In the 1990s, we can observe an upward trend in the number of deaths of supercentenarians.

6.1.2 Trends in the highest age at death

Jeanne Calment of France lived 122 years and 164 days. So far, she is the longest-lived person in the world whose age has been validated (Allard, Lèbre, and Robine, 1998). The highest age at death for Japan is shown in Figure 7. In Japanese Vital Statistics, we find 13 persons whose reported age at death exceeds 122 years old between 1930 and 1950. The highest age at death recorded in the Vital Statistics in Japan is 125, and was reported in 1943. As Figure 7 illustrates, the highest age at death showed an upward trend from 1899 to 1930, and plateaued at around 120 in the 1930s and 1940s. After the 1950s, the highest age at death ranges between 100 and 115, with very few exceptions. One exception is the case of Shigechiyo Izumi, in 1986. The highest ages at death by sex fluctuate widely, but, without outliers, there seems to be increasing trend in the highest age at death for both sexes. A study of the highest and tenth-highest ages at death also suggests an upward trend in the highest ages at death (Robine and Saito, 2003).

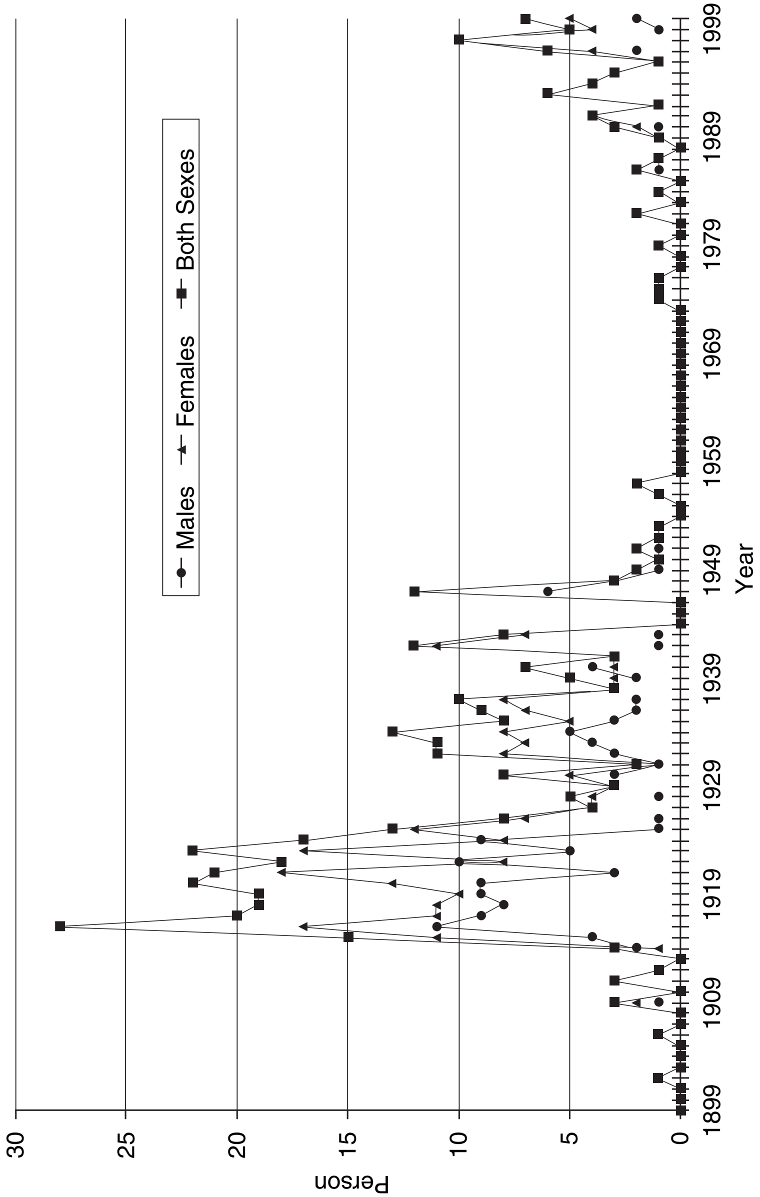

Fig. 6. Number of deceased supercentenarians: 1899-2000

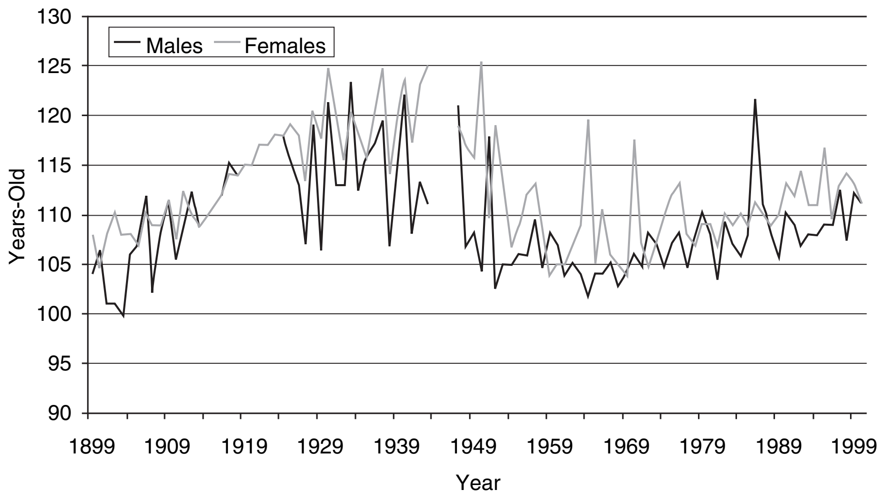

Fig. 7. Highest reported age at death by sex: 1899-2000

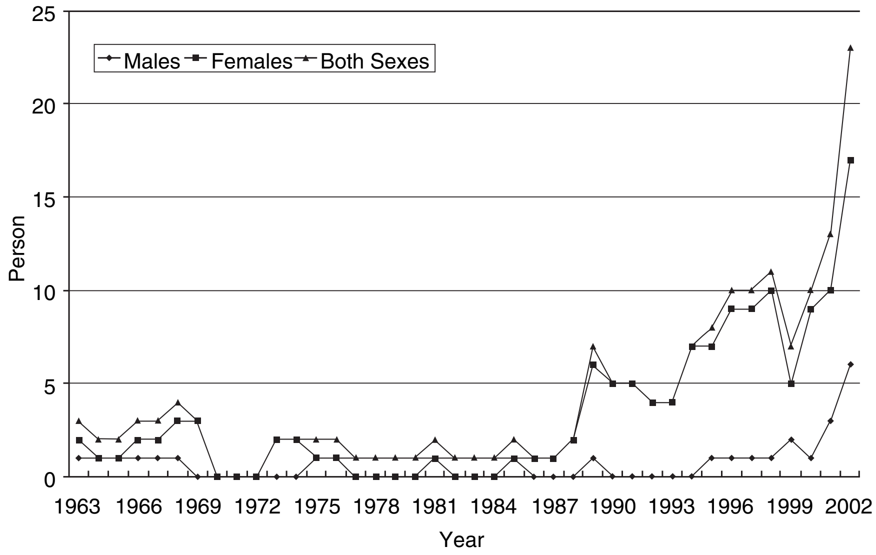

Fig. 8. Number of supercentenarians in Japan for both sexes and by sex: 1963-2003

6.1.3 Trends in the age of the oldest living person

The age of the oldest person alive as of September 30 each year can be also followed since 1963 using the list of centenarians, as shown in Figure 9. Although the increase in the age of the oldest person is small as a trend, there seems to be a slight but steady upward trend in the age since 1970, excepting the case of Izumi.

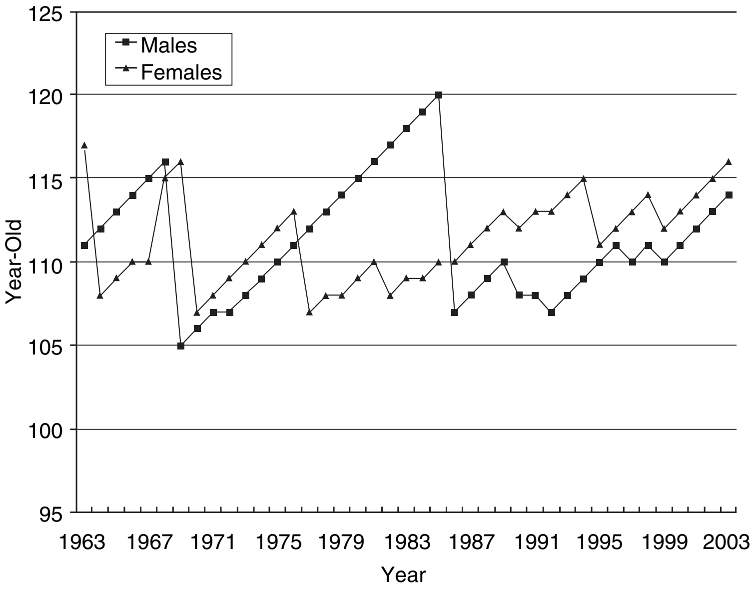

Fig. 9. Reported age of the oldest person alive by sex: 1963-2003

7 Reliability of information on age and date of birth

In order to validate ages for supercentenarians in 1963, for example, when the list of centenarians was first published, we have to be certain that records in the system for 1853, at the latest, are accurate. Unfortunately, this was almost 20 years before the first national registration was compiled.

We have to be aware of two things when we use the records from the Family Registration System to validate ages of supercentenarians. One is how the system operated in its early years. As Kitou (1997) points out, it took some time for the system to become complete and accurate.

The enactment in 1886 of a penalty for failing to report events such as births and deaths within a certain designated time period suggests ubiquitous misreporting of such events before 1886. This, of course, does not mean that all records in the system are incorrect before 1886. We should, however, use the records registered in the early years of the system with caution.

The second issue is how a person's age was reported for those who had already been born in 1872. In Jinshin-Koseki, only self-reported ages were registered. Therefore, there was a possibility of incorrect ages being unwittingly reported at the time of the first national registration. This could be one of the reasons why in Japan there are many supercentenarians who died in the 1930s and 1940s. We must also be aware that those aged 110 and above before 1982 had already been born at the time of the first national registration. We will discuss further possible causes of age misreporting in this section.

7.1 Possible causes of age misreporting in the Family Registration System

Self-reported ages at the first national registration might have been incorrect in some cases, as we mentioned earlier. Although this may not affect our contribution to IDL, this may help understand why there were such a large number of deceased supercentenarians in the 1930s and 1940s, as shown in Figure 6. Of course, we don't know whether those reported ages at death were incorrect. But if it does turn out that these reported ages at death were indeed incorrect, the age misreporting may have happened partly because animal years had been used to count people's ages in Japan at the time of the first national registration. The Western calendar system did not exist in Japan before 1872. The animal year system has a 12-year cycle, and if anyone counts one cycle off of the actual animal year of birth, the person could be 12 years younger or older. We only consider this possibility here for those who may have reported an age that was older than the actual age.

Let's assume that the oldest age that could have been achieved by both sexes in the early half of 20th century is 105 years old. Then consider cohorts of person aged 105 in 1930 and 1950. As shown in Figure 10, they were 27 years old and 47 years old in 1872. At a time when life expectancy was less than 40 years, a person who was 30 years old might not differ much from a person aged 40 or 50. If some members of cohorts born between 1825 and 1845 who survived to age 105 made mistakes in reporting their ages by one or two cycles of animal years, then they may have appeared to have achieved ages of between 117 and 129 sometime between 1930 and 1950. This is just a conjecture, but could explain the upward trends in the highest age at death between 1900 and 1930, and the very high ages at death between 1930 and 1950.

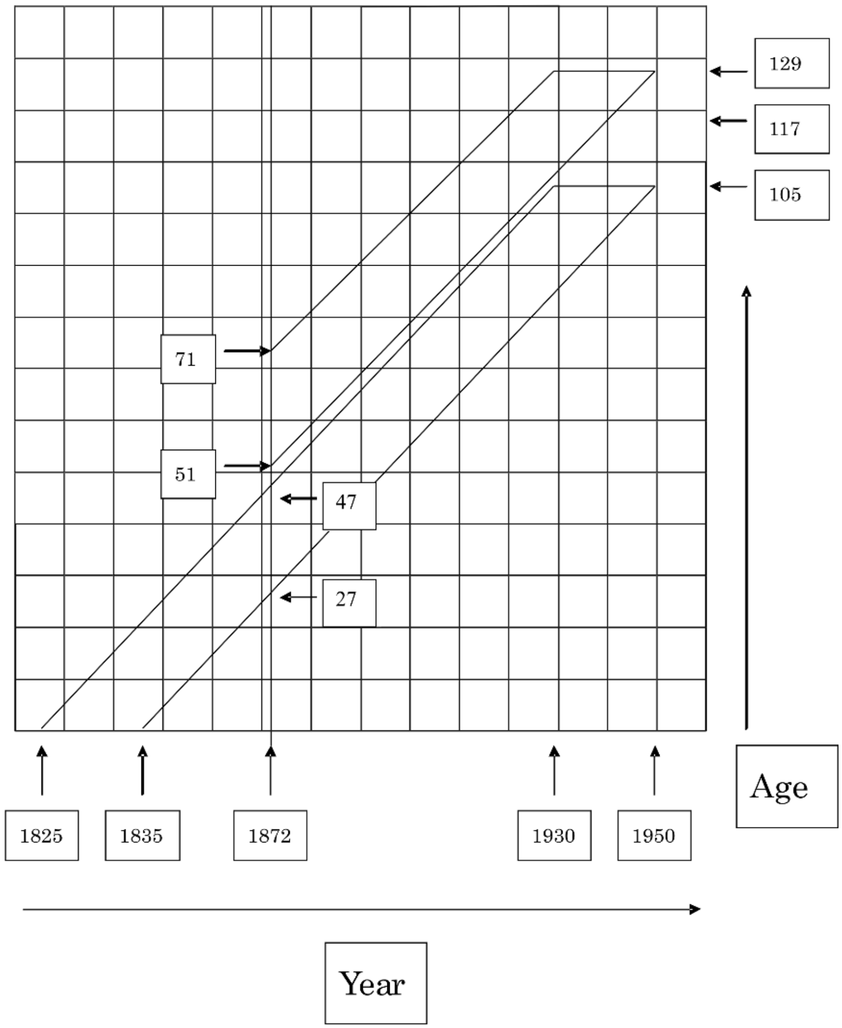

Fig. 10. Depiction of age misreporting

Age might have not been important for a lay person then. There was no age-based system at the time, and the school system did not start until 1872. Moreover, during the early years of the school system, enrollment rates were very low. For example, the enrollment rate in 1872 was 40% for boys and just 15% for girls. Only after a law regulating the elementary school system was enacted in 1886 did enrollment rates start to increase, reaching 92% in 1902 (Umihara, 1979).

7.2 Reliability of information on dates of birth

In order to check the reliability of dates of birth reported in the Family Registration System, it is worth examining possible causes of age misreporting. There are a couple of possible causes of the misreporting of dates of birth in the Family Registration System. Most of them seemed to happen unwittingly, as mentioned by Matsuzaki (1988).

First, there were cases of dates of birth being recorded in the Family Registration System that were simply incorrect due to errors in the transcription of records from an old register to a new register, or between the registers of two different families. The former tended to happen during the update of the registration, and the latter often happened in the cases of those who married and transferred to a spouse's family register. Since there was no computer to keep all the records, each record of family registers had to be transcribed by hand when there were changes in the records. Matsuzaki (1988) reported an error resulting from transcription for a particular supercentenarian in which the age of the person's elder sister was transcribed by mistake when the person married and moved her records from her family's register to her husband's family register. These types of errors can be found by examining older family registers or family registers that were removed (JOSEKIHYO). Matsuzaki conducted a survey on centenarians in early 1970s (1988). The survey revealed that 5% of 117 centenarians studied were not centenarians. He also studied seven centenarians aged 109 and above in the mid-1980s. He found that only two out of seven were, in fact, the age that had been reported.

Second, there was a custom in Kagoshima prefecture of Kyusyu of using the registration of a deceased first child for its younger siblings, as reported by Matsuzaki (1988). This is a very serious problem for age validation. We do not have any way to disprove age in such cases. The age given for a person registered as an elder sibling could be easily five to ten years older than his or her actual age. As Matsuzaki (1988) mentioned, such a custom lasted until the mid-Meiji era (around 1890).

Therefore, we need to pay attention to the dates of birth for those who were born in Kagoshima before 1890.

8 Concluding remarks

Just how reliable is information on dates of birth? That is the question we must try to answer. We discussed possible causes of unreliable reports on dates of birth. Judging from these studies, information on dates of birth seems reliable after around 1885. Those who were born in 1885 can be 110 after 1995. It is from this year onwards that we are requesting information on dates of death.

Over the last few years, it has become very difficult to study supercentenarians and obtain their information. The list of centenarians was the basis for all information we obtained. However, the list was not published by the Ministry of Health, Labor and Welfare as a volume anymore. Both in 2004 and 2005, names of only one hundred oldest Japanese were reported by the Ministry on their home page. Information on those who want to be anonymous was listed on the home page without their names. In 2006, among those aged 109 and above, only those who agreed to be on the list were reported on the home page. These changes can be at least partly attributed to the Privacy Protection Law, which went into effect on April 1, 2005.

Acknowledgement

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Being very old in a young country: Centenarians and supercentenarians in Australia

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Abstract. This chapter will briefly review the history of identification, recording, and documentation of centenarians and supercentenarians in Australia[1]. The paper explains the sources and validation methods used, as well as identifying problems and barriers to validation. The paper then critically comments on the completeness of reported supercentenarian numbers in Australia, using overseas estimates as a benchmark. This will include an evaluation of the accuracy of census and other historical data sources used to validate centenarians and supercentenarians in Australia. The paper concludes with comments on the possible future number of people age 100 years or more, and how Australia might institutionalize their identification and recording.

1 Introduction

While the indigenous population has inhabited Australia for more than 40,000 years, white settlement has existed for only just over two hundred years. Thus, in comparison to say, European states, the Australian settlement could easily be considered relatively "young." Similarly, Australia just recently celebrated its centenary of Federation, with the identity of the nation as a united socio-political state dating from just 1901. Indeed, Australia's national anthem, "Advance Australia Fair," reinforces this perception of "youthfulness" as well. The song begins with the phrase: "Australians all let us rejoice, For we are young and free". This reference to being young and free reflects our independence as a country, but it is also a nod to our British origins, with England often being referred to colloquially as the "Mother Country," as

[1] All information and names either publicly available or provided with informed consent.

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though Australia were the young child. Even today, our centenarians still receive a congratulatory letter from the Queen. (The number of centenarian congratulatory telegrams from the Queen to Australians increased from 595 in 1997 to 854 in 2002, although it appears that only about one-third of those eligible receive them.) Thus, there are many contextual references still current in Australia that support the notion that we are a "young" country.

This image of a young country is, however, somewhat at odds with our changing demographic profile: the median age of the population has increased from 31.6 years in 1988 to 34.6 in just ten years, and the median age of Australians is projected to reach 46 years by 2051 (ABS 2001). In this context, Australia is much more a "middle-aging" than a "young" country. At the same time, however, it is also an "old-aging" country: the proportion of the population age 85 years or more has increased by almost three-quarters over the last decade, and is projected to quadruple over the next fifty years, which indicates a greater structural and numerical aging of both the total and the aged population. The increase in centenarians from 50 in 1901 to about 2,500 in 2001 (ABS 2001) is another example of growth in the very old population.

Formal recognition of very old aging in Australia is, however, fairly minimal, and this is exemplified by the lack of specific and validated publicly available data on people age 100 years or more. Very old people in Australia tend to be either invisible (statistically and even physically), or identified tokenistically by the media as some quaint relic of a bygone era. It is only in recent times through publicity on people like Jack Lockett—who was fully oriented and articulate until his death in 2002 at age 111 years, and who actually carried the Olympic torch 50 meters for the Sydney Olympics in 2000—that there has been some recognition that not all very old people are frail and decrepit. Within this context of limited information on very old people in Australia, this chapter will broadly investigate validation of centenarians in Australia at both the individual and population levels. First, the paper will look at individual centenarian identification and recording, with an emphasis on the validation of supercentenarians, and then move on to try and reconcile the actual population size of the very old in Australia through a range of alternative data sources.

2 Recording Australian centenarians

It needs to be stated at the outset that there are no exact or validated figures on the number of centenarians in Australia. Nor are there any figures on the number of people aged exactly 100 years, 101 years, and so on; as the recent Australian censuses (collected and) provided only a single aggregated number for “aged 100 years or more.” Use of the word “centenarians” here thus usually refers to the sum of those aged 100 years or more. The Australian census for 2001 is the most recent count of centenarians, recording a census count of 2,503 centenarians (784 males and 1,719 [68.7%] females). However, from the early 1900s, the Australian census has consistently reported people living to very old ages, and with slightly more detail and comment than is currently available. For example, the census records show that there were 64 living centenarians recorded at the 1911 census, and that 27 centenarians had died in that year. Information on their deaths was provided in the 1911 Commonwealth Year Book. However, the Statistical Registrar-General commented in relation to “abnormally high ages” that “... no absolute reliance can be placed on the accuracy of the ages shewn, owing to the well-known tendency of very old people to overstate their ages”. The registrar was not only making reference to the important issues of age validation and age misreporting, but also to the poor recordkeeping on registration of births in other countries of origin.

For example, only two of the 14 centenarians who died in 1911 were born in Australia. The majority were born in England, and two were born in China. Ten of the 14 were more than 100 years of age, the oldest being 108 years old. Only three received the public old age pension, while the rest were listed as having an occupation. Similarly, of the 13 female centenarians who had died in 1911, seven were aged more than 100 years, with the oldest being 105 years old. The most frequent cause of death was listed as “senility,” although “rodent ulcers,” “gangrene,” “diarrhoea,” “heart disease,” and “influenza” were also cited. Unfortunately, this level of single year age detail and comment disappeared in more recent censuses, in which very old Australians have been grouped either as part of the “aged 85 years or more” group, or as “aged 99 years or more” at the 1996 census, or as “aged 100 years or more” at the 2001 census. This lack of age detail currently reduces our ability to gain a better understanding of changes in life expectancy at very old ages in Australia, although due to lobbying by demographers, the next census (2006) should collect at least the single year of age for all people in the census.

3 Validating individual supercentenarians in Australia

According to the supercentenarian list compiled in 2003 (Epstein 2003), Australia had 11 validated supercentenarian (SC) cases, going back to 1971. Five of these cases were validated over the previous two years by the author, who joined this research program in 2001. Since 2003, four more cases have been identified and validated by the author, resulting in a total of fifteen validated cases in Australia up to 2006 (see Table 1). Six cases had already been validated by a range of other participants in the research program. Guinness World Records was the main source of validation, having validated and listed four people in their published book of records in the 1970s and 1980s: Carol Mockridge, Jane Piercy, Ada Sharp and Ada Cleggett (Epstein also contributed in the last case mentioned here via a family genealogist's records). Two other supercentenarians, Jack Lockett and Jessie Hurley, were identified and validated by the New England Centenarian Study (and this author added Hurley's death certificate). The author has since validated five other cases with the required birth, death, and marriage certificates: Alice Lindsay, Stella Correll, Molly Yeomans, Christina Cock, and Beatrice Mears. In addition, the author has validated the age of one other deceased supercentenarian, Mary Hurley, using the death certificate, death certificates of both parents, plus family tree information; as well as the ages of the two currently living supercentenarians, Myra Nicholson and Emily Riley, using their birth and marriage certificates. Birth certificates of siblings or children which list the centenarian's name and age were also available for some of the people studied. The fifteenth case is a woman born in Italy who had then moved to France and later migrated to Australia, Marie Piacentino. Her validation records, including birth certificate and death notification, were provided by the French embassy in Australia. For the majority of cases, the official certificates supplied were provided by the family or were found in official registers prior to 2005, when searching such registers was free. Researchers are now required to pay a fee before they can begin their search, and they must also pay additional fees for certificates, if located. This makes the validation process more difficult.

The author has also followed up quite a few other cases found in the newspapers, such as the "gent from Molong" (referred to in Guinness) and an indigenous person referred to as "Old Davey," both of whom were said to have reached 109 years of age in the 1960s, but for whom no records other than single newspaper citations could be found. As stated, the primary validation method used by this author was to search electronically the major newspaper cuttings database in

Australia, available from 1956. Using this database, the author was able to identify media references to most supercentenarians on the list, even before they reached the age of 110 years. No other references to any person aged 110 years or more has emerged. However, this does not mean there are or were no other people who have reached age 110 years or more. For example, the supercentenarians Beatrice Mears and the recently found Emily Riley were media-shy; there was no previous publicity on these women, yet both had solid official proof of age.

Thus, ascertainment bias due to the method of finding cases through media presentation is more than likely present. However, despite these problems, the other cases found do show the value of the media in identifying cases. This sort of approach is needed because, unlike in other countries, our primary data source, the quinquennial Australian census, which has been in operation since the early musters in the 1800s, has never kept records, and continues this practice today, so that no data matching is possible. At the last census in 2001, however, all Australian residents were asked if they wanted their census records kept in the national archives and made available in 99 years' time. This will be the first ever census records kept, but it will not available for a long time yet. Thus, to date, we have the supercentenarian records listed in Table 1.

Table 1. Australian supercentenarians (2006)

Name	Date of Birth	Date of Death	Age	Sex
1. Christina Cock	25 Dec 1887	22 May 2002	114	F
2. Beatrice Mears	4 Mar 1888	3 Dec 2001	113	F
3. Molly Yeomans	1 Jul 1888	30 May 2001	112	F
4. Carol Mockridge	11 Dec 1874	6 Nov 1987	112	F
5. Jessie Hurley	15 Jun 1890	6 Aug 2002	112	F
6. Stella Correll	23 Dec 1888	7 Sep 2000	111	F
7. Jane Piercy	2 Sep 1869	3 May 1981	111	F
8. Jack Lockett	22 Jan 1891	25 May 2002	111	M
9. Alice Lindsay	31 Mar 1893	1 Jul 2004	111	F
10. Ada Cleggett	27 Jan 1885	8 Dec 1995	110	F
11. Mary Hurley	4 May 1880	16 Nov 1990	110	F
12. Ada Sharp	6 Apr 1861	15 May 1971	110	F
13. Marie Piacentino	25 Nov 1888	21 Jun 1999	110	F
14. Myra Nicholson	14 Dec 1894		111	F
15. Emily B Riley	13 Oct 1896		110	F

Generally, the primary approach with individual validation in Australia is similar to that outlined by Jeune & Vaupel (1999), whereby primary "official" certificates, such as birth, death, and marriage certificates for the centenarian are sought and, sometimes, procured; and all corresponding dates, including marriage dates and ages of the centenarian, as well as those of parents and siblings, are checked for correspondence. In a case like that of Christina Cock, born in 1887 in a very old Australian town where recordkeeping was well established, all required primary birth data and certificates were available. The town also had an established newspaper in this period, and corresponding entries were available from that gazette relating to her birth, birthdays, and marriage. In other cases, families may already have elaborately constructed family histories with copies of training or school certificates, and newspaper cuttings of, for example, the presentation of prizes or trips taken. Passports and ship records are often also frequently available, and serve as a reflection of the high migration rates of this country.

Other families however, such as Mary Hurley's, have no official records other than a death certificate, and the process then becomes a genealogical one of working with the many family history groups throughout Australia. Investing the time and money necessary to work with these groups can pay off because their members often have a high level of expertise, particularly in issues pertaining to changed spelling of names and isolated farm areas. Mary's mother, for example, was variously known as Honor, Hanorah, Norah, Nora, and so on; but the expert family history group can reconcile these issues quickly. Mary had died in a nursing home, but no records were available because the compulsory seven-year storage law under the statute of limitations had expired, and all nursing home records had been deleted. A search for her local doctor also did not turn up any information, as he had also died. This sort of detective work can be difficult and frustrating. Eventually, however, solving the puzzle using cross-referenced unique historical data can just as rewarding in terms of validation with documentation. The current development of a National Mortality database by the federal government should be a good future source for tracking centenarians and supercentenarians. The limited data available now indicates that more supercentenarians have died since 1990 than this author can account for through identified cases. Due to privacy legislation, it is not possible to find the names of all those deceased. It appears, however, that there may have been four supercentenarians alive since 1990 in addition to those who are recorded in Table 1. This reinforces the idea that ascertainment bias is present in the Australian collection to date.

4 How many Australian centenarians?

As stated above, there are no exact or validated figures on the number of centenarians in Australia. Nor are there any figures on the number aged exactly 100 years, as the recent Australian censuses (collected and) provided only a single aggregated number for "aged 100 years or more". The Australian census for 2001 is the most recent count of centenarians, and the Australian Bureau of Statistics (ABS) used those census figures (drawn from a box that could be ticked to indicate "aged 100 years or more"), along with birth, death, and migration data, to develop the estimated resident population (ERP) of Australia. According to ABS, the census tends to under-enumerate (ABS 2002), although it is not clear how much this impacts on centenarians. However, the 2001 census count of 2,503 centenarians (784 males and 1,719 [68.7%] females) is considerably different from the ABS ERP for centenarians at June 2001, which was 3,978. The 2001 census count gives a centenarian prevalence rate of 133 per million population, compared to a prevalence rate of 205 per million from the 2001 ERP.

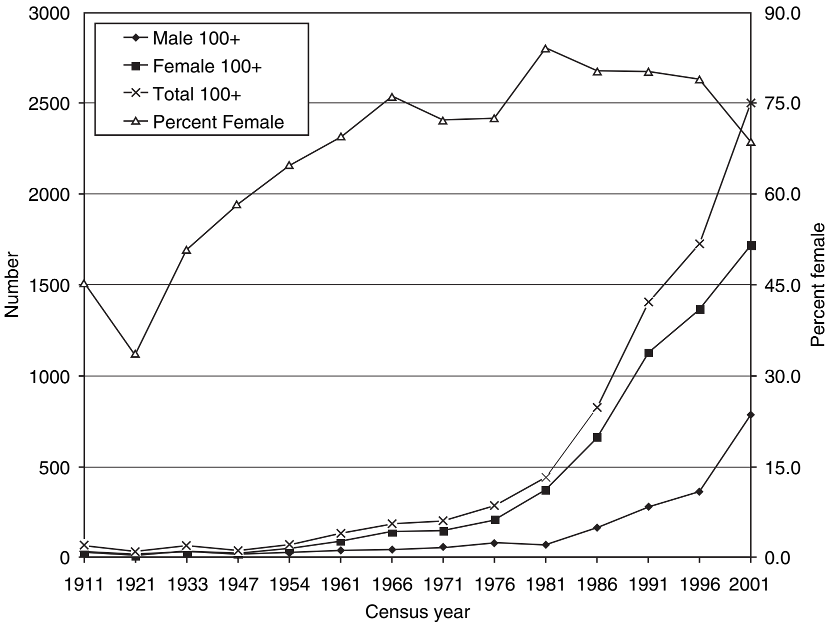
From the author's (2000) calculations of the 1996 and previous census counts of centenarians (in the 1996 census the box was for people aged 99 years or more), the number of Australian centenarians in 2001, based on 7% per annum growth rate, would be around 2,420, which is closer to the census figure than the 2001 ERP figure. The ABS recently released their 2002 ERP figures, which for centenarians were enumerated down considerably. ABS now estimates 2,297 centenarians (1,682 or 73% female) at census date 2001, which equates to a prevalence rate of 118 per million. This rate and the number of centenarians would, using Ruisdael's survey data (2003), mean Australia is in the top ten countries for the centenarians per million index figure, and in the top ten developed countries for number of centenarians. Ruisdael's data show that France, USA, UK, Japan, Italy, Spain, Canada and Sweden would rate above Australia on the index.

In an attempt to cross-validate the Australian centenarian figures, the author, inter alia, calculated Whipple's Index for the oldest-old (Yi and Vaupel, 2003) on the revised 2001 and 1996 ERPs. This resulted in index figures of 102.52 and 102.58 respectively, both of which diverge less than 5% from the recommended standard for identifying age-heaping distortion in the reported ages.

Similarly, the author calculated the Coale & Kisker ratios of very old to old populations, first for those aged 95 years as a proportion of the population aged 70 years and above, then for those aged 100 years or more as a proportion of the population aged 75 years or more in 2001. The proportions of the first group (95:70+) were 1.86 per thousand for males, and 4.51 per thousand for females, both figures being less than the six per thousand noted for countries with "good data" (Yi and Vaupel, 2003). The second ratio (100+:75+) resulted in male proportions of 2.04 per thousand, and for females of 3.07 per thousand, both of which again are under the recommended six per thousand. The male-female ratio found in Australia, especially for the 100+ to 75+ age groups, is considerably higher than that reported by Yi and Vaupel (2003). This seems to be mainly due to the higher male centenarian rate, and may be indicative of some age exaggeration among Australian males.

The author also applied an extinct cohort/survivor approach to the 2001 census figures using death data from the Australian National Mortality Database. Assuming that, of the 2,503 centenarians identified in the census in 2001, about half (see below) would be aged 100 years exactly (1,251), aggregating death data for those aged 90 years in 1991, for those aged 91 in 1992, and so on, up to deaths for 100-year-olds in 2001, resulted in an estimate of 1,304 people still alive at 2001. This corresponds approximately to the author's estimated census figure for those aged exactly 100 years, and provides extra support for the overall estimated number of centenarians in Australia. More work is being done on this approach over a longer period, and for both males and females, by Dr. Len Smith, who maintains the Demographic Databank at the Australian National University. Thus, assuming the census data provide a reasonable estimate of the number of centenarians, as outlined above, Figure 1 illustrates that data over time.

There were low numbers of centenarians until the 1970s, after which the number of centenarians and their growth rate increased substantially. There was then almost a doubling or greater every ten years for people in this age group during the years 1971 to 2001. The increase in females is greater than the increase for males, with females representing 79% of persons aged 99 years or more at the 1996 census, but this dropped to 69% at the 2001 census. Similarly, the gender ratio for this group at that 1996 census was 27 males per 100 females, but this increased to 45 males per hundred females for 2001. As above, and as can be seen from the chart, the reported increase in male centenarians over the last five-year period may be somewhat exaggerated. Overall



Source: ABS
Note: 1996 for 100+ is author estimate.

Fig. 1. Centenarians in Australia (Persons Aged 100+ by Census: Australia 1911-2001)

however, despite these data difficulties, it is clear that there is a marked increase in numbers of people aged 100 years or more in Australia.

In trying to understand what is behind this apparent increase in Australian centenarians, the author applied Thatcher's (1999) methodology to current and historical ABS data and Life Tables to identify relevant individual factors (Table 2).

Table 2. Decomposing Australian centenarian increase

Cause	Male	Female
Increase in births 1860 to 1899	2.14	2.14
Improved survival from birth to age 80 years	3.96	3.92
Improved survival from age 80 to 100 years	7.14	13.1
Changes above age 100 (Ratio 100+:100, 1985-1995)	0.2	0.1
Reduced probability of death at age 100: 1953 to 1995	1.8	1.6
Product of above factors	21.8	17.6

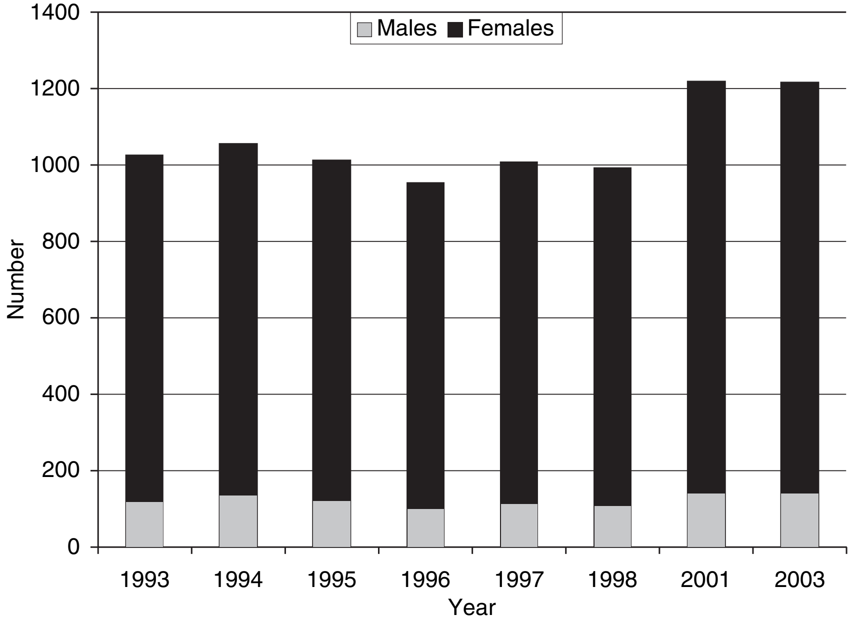
The product of the factors shown accounts for the approximately forty-fold increase in Australian centenarians, from 64 in 1911 to around 2,500 in 2001. Among the individual factors, improved survival from ages 80 to 100 years accounts for about half of the total increase, and females play a larger role in this. However, in the overall product of factors, males account for a higher proportion of the overall increase than do females. Changes above age 100 years so far account for only a small component of the overall increase in centenarians. However, not a lot is known about these age groups, as detailed below. Before moving on to look at these other groups, some brief comments will be made on other centenarian data.

5 Other sources of centenarian data in Australia

Despite the ABS being the official statistical agency for the country, there are many other public and private agencies that identify or hold data on very old people. Canvassing these many other sources is necessary when attempting to consolidate and cross-validate centenarian population figures for Australia. The (print) media is the most frequent place where individual centenarians are publicly identified. Although some people are critical of the media for sensationalizing very old people, by the same token the media can be a useful means of hearing about new centenarians; or, if one has a working relationship with the media, it can be a means of letting the public know to whom they can report new cases.

The author currently maintains an informal list of the oldest people in Australia, and the media find it useful to be able to ring up and ask how some new person they have just heard of compares with others on the list. "Who is the oldest?" is, without a doubt, the most common question. Currently on the list are two 109-year-old women who are ranked as the "oldest," followed by two 108-year-old women and one 108-year-old male, followed by greater numbers of 107-year-olds, and so on, down to 103-year-olds. There are currently five veterans of World War I on the list who turned 103 in 2003. However, according to unpublished government residential care data (see below), there appear to be three people alive claiming to be 110 years old or more. Due to privacy legislation however, these people cannot be identified. The author is currently attempting to secure exemption from the legislation, but this is unlikely to happen.

In an attempt to reconcile the estimated number of centenarians with those recorded as either in care or in the community, the following nursing home and hostel data were obtained from the Department of Health and Aged Care on actual persons aged 100 years or more.



Source: Dept of Health and Aged Care: Unpublished
Note: Data refer to combined nursing homes and hostels for Australia, Dept of Health and Aged Care: Unpublished

Fig. 2. Centenarians in residential care: Australia June 1993-2003

This 2003 centenarian residential data count of 1,206 shown here represents only about half of the estimated 2,500 centenarians for 2001. From other census data the author has purchased from ABS, this centenarian residential care rate is less than the 61% of centenarians reported in "non-private dwellings;" however, there are a range of other eldercare facilities, such as retirement villages, which could see this as a definitional difference in numbers. Elsewhere, the author has pursued government-funded pensioner and veteran data, electoral roll numbers, health system counts in hospitals, and so on. There always seem, however, to be some data discrepancies that represent either definitional complexities or some basic questioning of the correct age reporting through the census. It is probably only through repeated data reconciliation attempts that these differences will be explained and overcome.

6 Semi-supercentenarians and supercentenarians in Australia

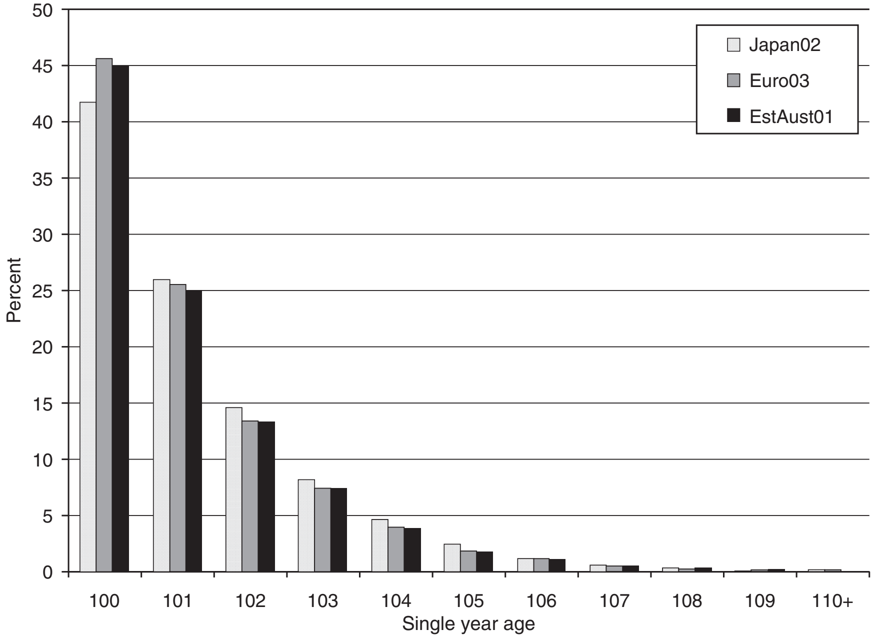
As stated above, there are major difficulties disaggregating centenarians (Cs, and in this section referring to ages 100-104 years) into single year age. Similarly, for other five-year age groupings such as the semi-supercentenarians (SSCs) aged 105-109 years, or the supercentenarians (SCs) aged 110 years or more, difficulties in determining precise ages persist because the officially collected ABS data does not ask centenarians their actual age at their last birthday (nor does it require a birth date). So again, estimates need to be made and other data are used for this, as shown in Table 3. The Japanese data is from the Ministry of Health (2003), while the European data "Euro 9" is from Ruisdael (2003), and is aggregated data for nine European countries with aggregated n = 6109. The "Aus ACAS" data is Australian health data from Aged Care Assessment Services in the state of Victoria for 2002, and the number of centenarians is 218. The "Aus Res Care" data is from the rolls of the Australian government's Residential Care register of centenarians (n = 1216), in what used to be known as nursing homes and lower-level hostels, for the year 2001. None of the people in the Australian data have had their ages validated, as the service they received is based on health need rather than age.

Table 3. Decomposing Australian centenarian increase

Age Group	Japan	Euro9	Aus ACAS	Aus Res Care
100-104	95	95.9	95.9	93
105-109	4.6	3.6	3.6	6.3
110+	0.4	0.5	0.5	0.3

The table shows that the overall the distributions for Cs, SSCs, and SCs are not that different for Australia than they are for other countries. The "Aus Res Care" data is weighted more to the older groups, and this may be because the population here is more unwell or unable to care for themselves, which may be a function of age. Similar health populations for Japan and Europe would be needed to present a better comparison.

This comparison is taken further in Figure 3 at page 113, where the same Japanese and European data is compared to an estimated distribution of the Australian 2001 census figure of 2,503 centenarians distributed across the single year ages, based on an average distribution derived from data from 13 countries presented in Ruisdael's survey (2003). This latter estimate for Australia should be more comparable to Japan and Europe, as it includes the total centenarian population rather than a specialized health component sample.

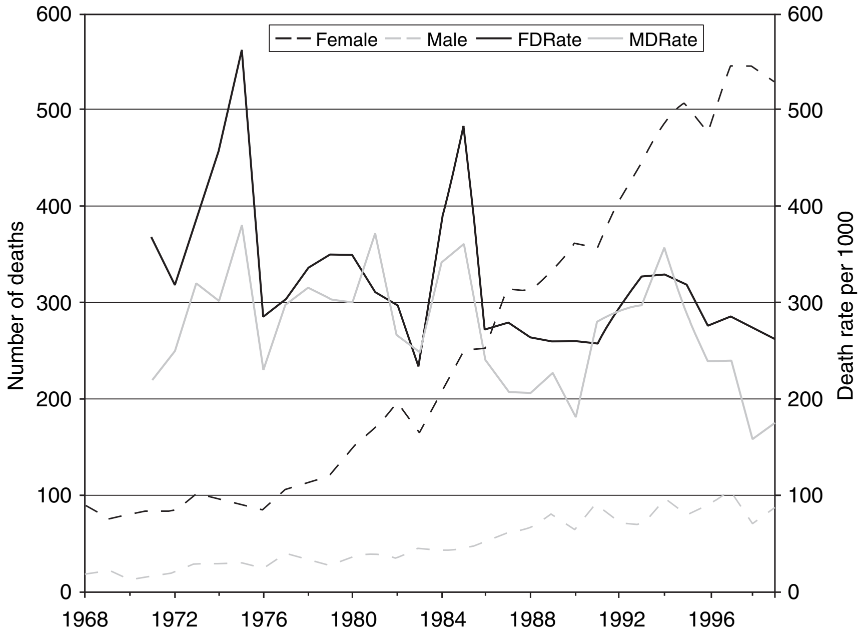


Source: Derived from Ministry of Health Japan 2002; Ruisdael 2003

Fig. 3. Age above 100 years (Age Distributions at 100+ years)

As can be seen from the chart, the general estimate ("EstAus01") is similar to the European distribution, whereas the Japanese distribution has an older profile with fewer 100-year-olds and more people aged 101 and above. Another feature of this age distribution (not shown here) is the gender difference. Analysis by gender shows that, like Kannisto (1994), female centenarians in Australia include, compared with males, a lower proportion of 100-year-olds (average of 44% females and 47% males), and greater proportions of 102-year-olds or older. While there are more female centenarians living longer, this older age profile of female centenarians may have an impact on the higher female death rates shown below. There is a need for more gender analysis of this older female age profile and its impact on the Australian data. One other source of age-specific death data for Australia is the Australian

National Mortality Database, which was only recently developed, and this does have death information by gender.

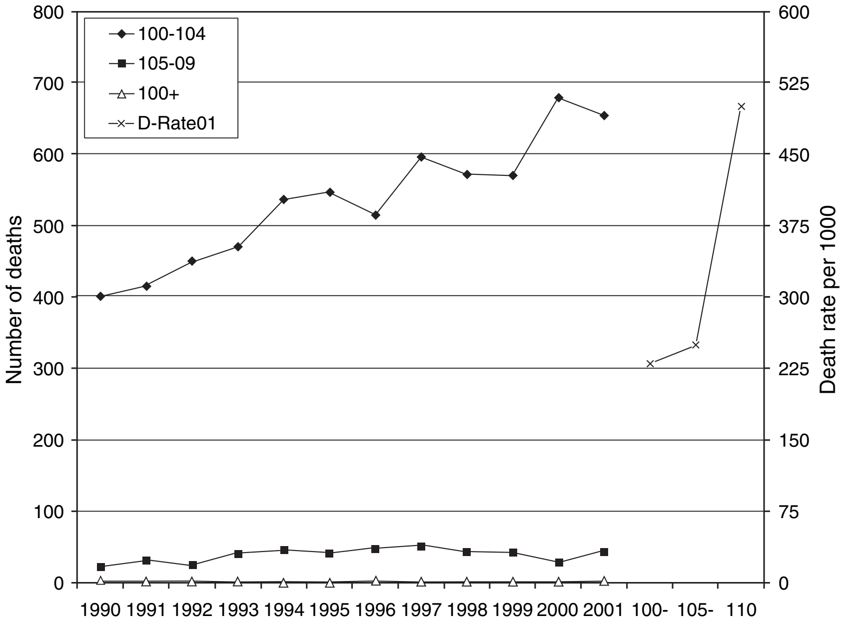


Source: Derived from ABS Cat No 3302.0

Fig. 4. Centenarian death rates (centenarian deaths / death rates by gender, Australia 1968-1999)

Fortunately this data is available with age at death recorded, but age-specific death rates cannot be directly calculated because we do not know the population of each single year age group. However, using the Australian distribution from Figure 2 as the survivors, and adding the deaths to this number, crude centenarian age-specific death rates for the three groups can be estimated. Female deaths show a marked increase since the mid-1970s, while the male centenarian deaths increase has been less marked. This is further illustrated by the greater decline in estimated death rates for male centenarians. As stated above, there is some concern as to whether the increasing proportion of male centenarians is real or a result of misreporting. The apparent greater decline in male centenarian death rates shown here adds further weight to the possibility that, in Australia, male centenarians are slowly narrowing the gender gap in the centenarian population.

Grouping those deaths by the three sub-groups of centenarians reveals the following trends shown in Figure 5.



Source: Derived from ABS Cat No 3302.0

Fig. 5. Centenarian deaths above age 100 years (annual deaths: centenarians, semi-supercentenarians and supercentenarians, & death rate 2001 by age group. Australia 1990-2001)

As can be seen from the figure, the number of deaths for the Cs is increasing considerably over time, while the number of deaths for the SSCs and the SCs is flat. The estimated death rates for the three groups (calculated just for 2001) results in a death rate of approximately 230 per thousand for the age group 100-104 years, 250 per thousand for the age group 105-109 years, and 500 per thousand for the age group 110+ years. These rates may be a little on the low side, especially for the SCs, but this is hard to tell with such limited data. The Cs compared to the SSCs and SCs seem quite different, with substantial change occurring over time. Meanwhile, the SSCs and SCs show little change, and this may due to the small numbers to date.

7 Conclusion

This brief introduction to very old age in Australia has highlighted the deficiencies in our data validation resources for very old age, but has, at the same time, tried to show that there are in fact many bits and pieces of data which can be put together to build up a reasonable montage of very old age in Australia. In contradiction to our national anthem, Australia is no longer a "young" country, and our published demographic data needs to be more specific in relation to very old age, rather than just lumping all those people above the age of 65 in together and calling this group "the aged". The initial disaggregation of those over 100 years of age in this paper, despite the small numbers and somewhat imperceptible differences, is an interesting approach to be developed further. Similarly, increased gender analysis might provide a more definitive picture or description of what is happening to the gender longevity gap at very old age. From the above, male centenarians, despite their lower numbers, seem to be making greater longevity improvement.

In conclusion, one might say that, in Australia, we have a preliminary picture of centenarians. The centenarian information presented above provides a preliminary picture of people in this extreme age group in Australia. Better data are needed however, and this would be assisted by the recording of centenarian's ages in single years, which occurred in former censuses. A register of centenarians—for example, a register maintained by the Centre for Population Research at the Australian National University, and as part of its Demographic Database, in conjunction with the National Mortality Database at the Australian Institute of Health and Welfare—would be valuable aids to centenarian research. A small team to develop "The Australian Centenarian Study" is also needed. This would enable us to investigate the entire population of centenarians and determine with greater clarity how and why they are increasing.

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Supercentenarians in France

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Abstract. Three data sources can be used to enumerate French supercentenarians: a list of names compiled from personal archives, death records from vital statistics, and transcripts of individual records from the RNIPP (Répertoire national d'identification des personnes physiques, or National Identification Register of Private Individuals). None of these three sources is exhaustive. A comparison with the English list of supercentenarians shows that the list of names is quite incomplete. Vital statistics contain a lot of erroneous cases due to inaccuracy in the registration of age at death. Furthermore, until 1987, the French National Institute for Statistics and Economic Studies (Institut National de la Statistique et des Études Économiques, or INSEE) deemed all ages at death exceeding 109 to be unacceptable, and did not record any death beyond that age. The RNIPP is the most reliable source. Among the 83 cases of persons who died at age 109+, the age at death was found to be correct for 67 and false for four, while 12 cases have still not been completely investigated. The age at death was verified by checking dates at both the birthplace and the place of death. By comparing cases from the RNIPP to cases from the list of names, the deaths of 46 supercentenarians were confirmed from 1987 to 2000.

In recent decades, the number of centenarians has increased considerably in industrialized countries. In France, the number of centenari-

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ans rose from about 200 in 1954, to more than 1,000 in 1970; by 1990, the number had reached 3,500 (Labat and Dekneudt, 1989), and, by 2000, it had exceeded 8,000. According to INSEE's latest estimates, on the first of January of the year 2008, there were more than 20,000 centenarians. According to the central scenario of the most recent INSEE projections they would be more than 30,000 in 2030 and more than 60,000 in 2050 (Robert-Bobée, 2006). Depending on constant or low mortality scenarios, the number of centenarians expected by 2050 varies from 32,000 to 330,000.

Mortality being high at very advanced ages, most centenarians do not survive very long. However, the more centenarians increase in number, the more likely it is that some will reach 110 or even more, leading to the emergence and gradual expansion of a new age group: the supercentenarians. The study of this phenomenon is important for two main reasons: not only because of the emergence of a new age group in itself, but because the growing number of its members should make it possible to measure mortality well after the age of 100, and hence, answer the controversial question of how the mortality curve develops at very advanced ages.

Up until the creation of the International Database on Longevity (IDL), to which France is a contributor[6], supercentenarians had not been well identified in France, either by amateur research or in official statistics. True, the wide-ranging IPSEN survey on centenarians was conducted in the early 1990s (Allard, 1991; Allard et al, 1996), but the follow-up on the cohorts included in this sample provided no more than a partial view of the issue. This article is based on three different sources, each looking at a different angle of reality with varying degrees of accuracy and coverage: a partial list of supercentenarians identified by name, either through the IPSEN survey or through the press; a listing of deaths taken from death statistics; and a transcript from the *Répertoire national d'identification des personnes physiques* (RNIPP). We will discuss the validity of these three sources and how we can make the most of their respective strengths for the purposes of this computation with the help of a validation procedure.

[6] The French participation in the IDL is financed by INSERM (ACT Longevité) and by INED (Mortality, Health, Epidemiology Research Unit)

1 Presentation of the data

1.1 An incomplete list of names

It was possible to compile an initial list of supercentenarians thanks to the personal archives of Dany Chambre, a Belgian doctor who for many years has been collecting documents and articles in the press on cases of exceptional longevity in different countries of Europe; and also owing to the systematic detection of centenarians launched in the early 1990s by the IPSEN Foundation (Allard et al., 1996). On July 1, 2005, this list included 37 persons: 33 women and four men whose birth dates had been verified as being correct. Of these persons, three were alive at that date, while the others had died between 1977 and 2005 (see Table 1). During the 1990s, the French media's attention was drawn to centenarians by several events: the survey launched in 1989 by the IPSEN Foundation, *"A la recherche du secret des centenaires"* ("In search of the secret of centenarians"), which drew the attention of the media and of the medical profession; the *"Chronos"* operation of the Jean Dausset Foundation and the Center for the Study of Human Polymorphism (*Centre d'etude du polymorphisme humaine*, or CEPH), which conducted its first study in the early 1990s; the operation *"Les vénérables"* of the IPSEN Foundation, which in the mid-1990s sought to identify, with the help of the press, the oldest persons living in each region of France; the exceptional case of Jeanne Calment, who broke all records for many years before dying at the age of 122 in 1997—a death that was followed by a search for the next oldest person in France. For these various reasons, French supercentenarians are well-known in the media. But, since the end of the 1990s, few new cases have been mentioned in the press. Beyond the search for new record-breaking ages, which have been difficult to find since Jeanne Calment, the French media has shown little interest in supercentenarians; it is also true that, after the excessive media coverage of Jeanne Calment's case, some families prefer to keep secret and protect their elderly members.

As can be easily seen by comparing the results of Table 1 to similar statistics obtained in England and Wales on the basis of a list of names of supercentenarians from the General Register Office (see Thatcher, 2001 and the chapter on England and Wales), the French table is incomplete. Even if France and England and Wales are not strictly comparable, their populations are about the same, and the health situation in both countries has been very similar for over a century. However, 41 supercentenarians were identified in England and Wales before 2000, and only 27 in France for the same period. Figure 1 also shows that the

Table 1. Distribution per sex, year-of-birth group and year-of-death group of the 37 supercentenarians identified in the list of names

Year of birth	Year of death 1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	Alive on 01.07.2005	Total
				Males				
1865-1869	1							1
1870-1874								
1875-1879				1				1
1880-1884					1			1
1885-1889					1			1
1890-1894								
1895								
Total	1			1	2			4
				Females				
1865-1869	5	1						6
1870-1874		2	1					3
1875-1879			2	2	1			5
1880-1884				4	1			5
1885-1889					4	2		6
1890-1894						5	2	7
1895							1	1
Total	5	3	3	6	6	7	3	33
				Total				
1865-1869	6	1						7
1870-1874		2	1					3
1875-1879			2	3	1			6
1880-1884				4	2			6
1885-1889					5	2		7
1890-1894						5	2	7
1895							1	1
Total	6	3	3	7	8	7	3	37

observed cases are not distributed over time in the same way. Whereas in France, no deaths of supercentenarians were detected before 1977, the English list begins in 1968. In addition, although the number of supercentenarians was about the same in France and in England in 1980, since that date there have been fewer in France than in England. It would seem that the French list of names of supercentenarians established in 2005 does not include the earliest cases, which must have appeared in the 1960s, and underestimates more recent deaths of supercentenarians.

Similarly, the distribution of deaths of persons aged over 110, depending on the year of birth of the deceased, shows that the French list begins only with the 1866 cohort (England goes back to 1856), and underestimates the more recent cohorts (see Figure 2).

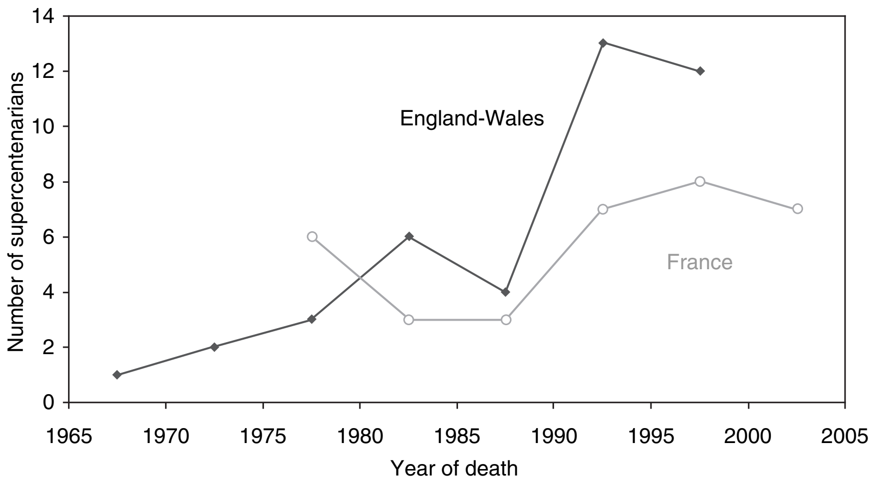

Fig. 1. Trends in the number of deaths at ages over 110 since 1965 in England-Wales and in France

In fact, looking at Figure 3 (restricted to deaths before 2000), it seems that the gaps in the French list concern mainly the deaths of 'younger' supercentenarians. Indeed, the number of persons who died at age 110, and, especially, at age 111, is much smaller in France than in England. This may be simply due to the collection method, which is based mainly on the notoriety of these cases—the more advanced the age, the more the curiosity of the public will be aroused and the more likely it is that the case will be mentioned in the press. In addition, we observe a crucial deficit at the age of 111, since the round number of 110 attracts more attention.

For these reasons, before attempting to estimate mortality at those ages, we found it necessary to complete this initial database through other sources of information.

1.2 Individual death records from vital statistics

Since the 1960s, each statistical record transmitted to INSEE at the time of death has been individually entered in a computer database.

Fig. 2. Distribution of deaths at ages over 110 according to the group of birthdates in England-Wales and in France

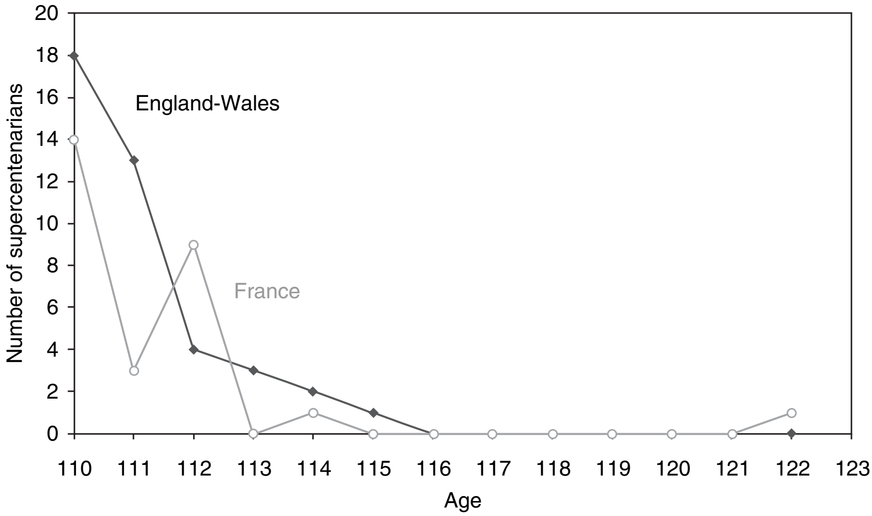

Fig. 3. Distribution of deaths at ages over 110 depending on age at death in England-Wales and in France (excluding recent years after 2000)

In 1999, we obtained a listing of these computer records, which comprised all the deaths of persons aged over 90 between 1968 and 1997[7] (Meslé et al., 2000). Among them, we found 53 supercentenarians (40 women and 13 men). This database was then completed for the years 1998 to 2003, during which 34 female supercentenarians and 10 male supercentenarians died. Thus, for the entire 1968-2003 period, we counted 97 deaths of supercentenarians recorded by vital statistics (74 women and 23 men). However impressive this figure may be, compared to the 37 deaths drawn from the previous list of names, and to the 41 deaths observed in England and Wales over a longer period (1950-1999), it is nonetheless far from accurate for obvious reasons, among which is the fact that we do not find any record of a death at age 122-this means that Jeanne Calment, who died at 122 on August 4, 1997, is not included in the list. But a greater cause for concern, statistically speaking, is the fact that no death over age 110 appears in the statistics prior to 1988. The reason for this also provides the explanation for Jeanne Calment's absence from the records. Indeed, until 1987, INSEE considered all ages at death exceeding 109 to be unacceptable, and did not record any death beyond that age; however, INSEE does not specify in what way the deaths reported at ages 110 and over had been statistically processed. This rule was somewhat modified in 1988, but only by pushing the limit to 119. Thus, an unknown number of deaths of supercentenarians have remained unrecorded by vital statistics.

If, despite these problems, 97 supercentenarians were identified by vital statistics over a period of 15 years (1988-2003), we may suppose that in some cases the ages were exaggerated. Indeed, the age, or rather the date of birth indicated on the statistical death record, is a simple declaration, and its authenticity is not verified. It is a known fact that the age of very old persons is often exaggerated, even in countries where vital statistics have existed for several centuries and where birthdays are traditionally celebrated every year. It is perfectly possible that some of the persons who supposedly died at ages older than 110 were not that old in reality. This suspicion is all the more justified since French statistics pertaining to deaths at ages over 110 seem to show a strong bias in favor of the male sex: 23 out of 97, or almost one-quarter, of the cases were men. In England and Wales, among the 41 cases recorded over the 1950-1999 period, only two were males (less than 5%). Meanwhile, in the French list of names mentioned above, there

[7] We are especially grateful to Laurent Toulemon, who was then head of the division of surveys and demographic studies, and who enabled us to obtain these documents.

were only four males, for a total of 37 (10%). The overestimation of ages in vital statistics remains an important problem. In particular, we may suspect that the deaths observed at ages 124 and 120 in 1998 and in 1999, respectively, are due to this type of error.

In order to use this source of information, the exactitude of the date of birth declared at the town hall of the birthplace must first be checked for each supercentenarian death, a process requiring access to individual records by name, something which is not directly possible with vital statistics. On the other hand, we obtained in 2004 permission from the *Commission Nationale de l'Informatique et des Libertées* (CNIL) to access transcripts of individual records of the RNIPP.

1.3 Transcripts of individual records from the RNIPP

The RNIPP was created along with INSEE in 1945, on the basis of individual files drawn up during World War II by the *Service national de la statistique* (see Appendix).

The RNIPP covers all persons born in France, as well as persons born abroad and living in France, and who have requested a social security number. Since the RNIPP was first and foremost designed for administrative purposes and for the certification of the civil status of individuals, persons born outside of France are registered only if their status warrants it. This database first existed in paper form and was kept in the regional offices of INSEE; in the early 1970s it was computerized and centralized, but it was limited to persons born after 1890[8] (or 1900 for the overseas departments). For persons belonging to older cohorts, the paper listings were preserved in microfiches; they are no longer systematically updated.

The list of persons born in France before 1945 was drawn up by copying birth registers. For later generations, the RNIPP is updated through statistical birth records. Persons born abroad or in overseas territories are included in this listing only when they request a social security number. Deaths are taken into account owing to the death notification form *"7 bis"* for persons deceased in France. Deaths occurring abroad are accounted for only when they are declared at the French consulate.

This register does not measure mortality with perfect accuracy. In particular, for generations born before 1946, many deaths prior to 1945

[8] In fact, persons born before 1945 and who died before computerization were not kept in the computer files. Nonetheless, these files do include persons born before 1891 if they are listed in voting registration files or were listed there in the early 1990s.

were ignored (wartime deaths, departures abroad) and, as a result, some persons are wrongly listed in the RNIPP as being alive. Among the cohorts which are now over 90, the number of persons who were supposedly still alive on January 1, 2005 is quite overestimated. On the other hand, the quality of the information concerning the date of birth is higher than that found in the death records of vital statistics, since this date is already specified in the RNIPP regardless of the report made at the time of death.

In early 2001, INSEE gave us a list of names of 83 persons who died between 1987 and 2000,[9] and for whom, according to the RNIPP, there was a difference of at least 110 years between their date of birth and date of death. Among the 83 persons, there were 75 women and eight men[10]. Of course, some had not yet celebrated their 110th birthday and were thus 'only' 109 years old at the time of their death. For each of these cases, the information provided by INSEE concerned data that was more than 100 years old[11]: name, first name, date, and place of birth. Despite the fact that the information concerning the date of birth given in the RNIPP is probably correct, all the deaths of persons aged 109 and over were systematically checked.

2 Validation of the RNIPP data

In order to determine the validity of the information provided by the RNIPP concerning the deaths of supercentenarians, we must first assess whether the information (in this case, the age) is correct; i.e., we must assess the *specificity* of the observation. Second, we must determine whether the collection system is exhaustive; i.e., we must assess its *sensitivity*.

We first evaluated the specificity of the RNIPP by checking the information concerning the person's birth at the town hall of his or her birthplace, and by taking note of his or her date and place of death

[9] It seems that deaths of persons aged over 110 were not registered in the RNIPP before 1987.

[10] Recently, INSEE gave us a second list of names of 3,272 persons born in 1883 and thereafter, and who supposedly died after their 104th birthday, beginning in 1988. This second list brings in a few new cases of supercentenarians who died after 2000, but the results shown here only pertain to the first list, for which all necessary verifications were made. The new list contains the dates and places of death as we get official permission from the CNIL.

[11] Civil status information more than 100 years old is accessible without confidentiality limitations. However, a request of permission to gather this information has been submitted to the "Informatique et Libert" Committee.

indicated on the birth record. We then turned to the town hall of the commune where the person had died in order to obtain the exact time of death, which, for confidentiality reasons, INSEE had been unable to provide with the 2001 list. These two pieces of information, date of birth and date of death, enabled us to determine whether the age at death of the given person had been correctly recorded.

Second, to evaluate the sensitivity of the RNIPP, we compared all the deceased persons of the RNIPP, who were identified as real supercentenarians, to the supercentenarians included in the list of names (Section 1.1) who had died during the same period. Clearly, this list of names does not represent a "gold standard" since it cannot be used to measure precisely the sensitivity of the list provided by INSEE. In particular, we are aware that this initial list of names is incomplete. In any case, the proportion of cases mentioned in the media and also known to INSEE provides an idea of the sensitivity of the INSEE list.

2.1 Reliability of the RNIPP data

We were able to verify the ages of 71 individuals out of a total of 83 by checking dates at both the birthplace and the place of death (86% of cases). For the other 12 cases (14%), the verification process at the local town halls remains unfinished (see Table 2).

There is a larger proportion of men (three men to nine women, or 25%) among the 12 cases for which we were unable to check the age, than among those for whom the age was verified (five men to 66 women, or 7%); this leads us to believe that for many unverified cases, the age was exaggerated at the time of the notification of death, since we know that this type of bias usually tends to affect men. In addition, there is a high proportion among the unverified cases of persons born outside of metropolitan France (nine out of 12), and, in particular, a high proportion of persons born in Algeria. Indeed, verifications are particularly difficult to carry out for persons born abroad for several reasons: first, because the information pertaining to the place of birth in the RNIPP is less precise when the event took place outside of metropolitan France; and, second, because in some countries the vital statistics system is not as old and reliable as it is in France. This high proportion of foreign births may partly explain the high proportion of men, since these generations of immigrants in France were mostly male, but it also calls into question the ages registered for the 12 unsubstantiated cases. Nonetheless, only four of these files cannot be verified at all, while the others are still being researched.

Table 2. Distribution of the 83 persons who supposedly died at 109 and over between 1987 and 2000, according to the Répertoire national d'identification des personnes physiques (RNIPP) of the INSEE, after validation

		Males	Females	Both sexes	in %	
Age checked						
	Age validated					
	109	2	24	26		
	110+	2	39	41		
	Sub total	4	63	67	94.4	
	Age invalidated					
	89	1		1		
	95		1	1		
	103		1	1		
	104		1	1		
	Sub total	1	3	4	5.6	
Sub total		5	66	71	100	**85.5**
Age unchecked						
Sub total		3	9	12	100	**14.5**
Total		8	75	83		**100**

Out of the 71 cases for which we checked the ages, 67 individuals (94% of the verified cases) had actually reached age 109 or above, and 41 were age 110 or above at the time of death. Only four cases were errors (6%), with real ages under 109 (respectively, 89 instead of 113, 95 instead of 113, 103 instead of 113, and 104 instead of 114) (see Table 2). None of these errors applied to the year of birth. In the four cases, the date of death was incorrect and the error was made during entry: in two cases, 1992 was entered instead of 1982; in one case, 1992 was entered instead of 1974; and in one case, 1990 was entered instead of 1966. These errors artificially lengthened these persons' life spans (twice by 10 years, once by 18 years, and once by 24 years), creating fake supercentenarians and reducing the specificity of the RNIPP data. The opposite error, one that would reduce the life span, cannot be observed here; this error would lead to the exclusion of real supercentenarians. This problem concerns the evaluation of the sensitivity of RNIPP data, and will be discussed in the following section.

Table 3 provides results in terms of specificity. If, for all the deaths at ages 109 and over, the specificity of the RNIPP is 94%, it is only 91% for all deaths at ages 110 and over because all the errors concern supercentenarians. In addition, it varies according to sex. At ages 110 and over, 93% of the observations are correct for women, compared with only 67% for men. It is true that, due to the small sample size, the estimation of specificity is not very precise for men.

Table 3. Specificity of the INSEE list of persons who supposedly died at 109 or over between 1987 and 2000, according to the Répertoire national d'identification des personnes physiques (RNIPP) and on the basis of 71 validated cases

Validation	109 years and over			110 years and over		
	Females	Males	Both sexes	Females	Males	Both sexes
TRUE	63	4	67	39	2	41
FALSE	3	1	4	3	1	4
Total	66	5	71	42	3	45
Specificity	0.95	0.8	0.94	0.93	0.67	0.91

2.2 Sensitivity of the RNIPP data

Each of the 41 cases of death at ages 110 or over listed in the RNIPP was compared and checked against the 21 deaths which occurred between 1987 and 2000 among the supercentenarian deaths of the initial list of names. This comparison made it possible to evaluate the RNIPP's capacity to detect supercentenarians, i.e., its sensitivity (see Table 4). Overall, 46 cases of deaths of supercentenarians were identified either through the RNIPP or through the initial list of names. Sixteen supercentenarians were found in both sources, another 25 were identified though the RNIPP only, and five were in the initial list of names only. On this partial basis, the sensitivity of the RNIPP was established at 89%.

Once again, we observe a considerable difference between the sexes (91% for females and 67% for males), but the male estimate is not very accurate given the very small number of cases.

As may be observed, the five cases unknown to INSEE belong to the first part of the period under consideration (1987, 1989, 1990, 1991, and 1992). For these older cases, this lack of sensitivity is most likely due to

Table 4. Sensitivity of the RNIPP regarding deaths of persons aged 110 or more between 1987 and 2000

Both sexes			
RNIPP	*Name list*		
	Yes	No	Total
Yes	16	25	41
No	5	-	5
Total	21	25	46
Sensitivity			0.89
Males			
RNIPP	*Name list*		
	Yes	No	Total
Yes	2	0	2
No	1	-	1
Total	3	0	3
Sensitivity			0.67
Females			
RNIPP	*Name list*		
	Yes	No	Total
Yes	14	25	39
No	4	-	4
Total	18	25	43
Sensitivity			0.91

errors made in the RNIPP entries concerning the year of birth or year of death. Indeed, as we have seen above, this type of error can lead to the exclusion of real supercentenarians. The ideal solution would now be to research the birth and death dates entered for these individuals in order to find out where the error lies. The differences between periods suggest that the sensitivity of the list has probably improved over time, and that, currently, it may be higher than shown in Table 4. But the opposite may also be true, since sensitivity is estimated here on the basis of an initial list of names which in no way represents a perfect 'gold standard'.

This evaluation of the quality of INSEE data pertaining to very advanced ages reflects the general quality of this data. The list of supercentenarians deceased between 1987 and 2000 provided by INSEE through the RNIPP has a specificity of 94% and a sensitivity of 89%, which is, globally, quite satisfactory. From another point of view, these scores mean that 6% of the deaths that occurred at ages 109 and over according to INSEE in fact occurred earlier, and that 11% of deaths of supercentenarians are not recorded by INSEE. These figures may seem considerable to anyone studying mortality trajectories between 110 and 120 years and wishing to establish the correct numerators and denominators in order to calculate precise mortality rates. Furthermore, this data suggests that the sensitivity of INSEE data is clearly improving. There is also the question of the 'immortals,' i.e., persons who are never crossed off the lists. There could be among them real supercentenarians whose deaths were never registered by the RNIPP.

Even if we cannot generalize the results of this validation procedure to lists from other countries where specificity and sensibility may be different, this first study provides us with an idea of the quality of the data at very advanced ages in a country which has had a vital statistics system for a very long time. In any case, even in a country with a vital statistics system of supposedly good quality, simple death statistics are not sufficient to estimate mortality rates at very advanced ages (Meslé et al, 2000). For anyone wishing to work with data which are as reliable and complete as possible, it seems impossible to do without national population registers, such as the RNIPP, which link together birth and death data on an individual basis. However, we recommend that after the validation procedure, the data found in such registers be checked at the places of birth and death in order to determine their specificity. We also recommend, with a view to evaluating the sensitivity of the data, the comparison of validated cases with cases known through the media.

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Appendix

The RNIPP, a precious source of information for longitudinal mortality analyses

The National Identification Register of Private Individuals (Rèpertoire national d'identification des personnes physiques, or RNIPP) was created at the same time as the National Institute for Statistics and Economic Studies (Institut National de la Statistique et des Ètudes Èconomiques, or INSEE). The RNIPP is based on the files established during World War II by the Service national de la statistique (SNS, which replaced the Statistique gènèrale de la France, or SGF, during the war) under the directorship of R. Camille. The decree n47-834 of 13 May, 1947 (article 6) entrusted INSEE with the task of "drawing up and updating the inventories of the statistical and demographic units, and constituting registers of identification." By giving each individual a number which theoretically never changes, this system makes it possible to identify persons without error, a useful tool for social and fiscal administrative purposes.

The RNIPP includes all persons born in France, as well as persons born abroad but living in France and who have requested a social security number[12]. Since the RNIPP is first and foremost an administrative instrument designed for the certification of the civil status of individuals, persons born outside of France are listed only when necessary. The RNIPP was first constituted as a set of paper files kept in the INSEE's regional offices, but in the early 1970s it was computerized and centralized, and limited to persons born after 1890[13] or 1900 for the overseas departments (DOM). For persons belonging to older generations, the paper files were kept in the form of microfiches, but they are no longer systematically updated.

[12] In 1988, INSEE transferred the section of the RNIPP devoted to persons born in overseas territories (TOM) or abroad to the national pension fund (CNAV) and retained the persons born in metropolitan France or in the overseas departments (DOM).

[13] In fact, persons born before 1945 and deceased before computerization were not kept in the computer files. However, the files do contain persons born before 1891 if they are on voter registration lists or were on these lists in the beginning of the 1990s.

Following the 1978 law "Informatique et Libertès," the decree n82-103 of January 22, 1982 specifies the contents of the RNIPP (see textbox).

The RNIPP includes only the following items pertaining to the civil status of each listed person:
1. Name and given names
2. Sex
3. Date and place of birth
4. Date and place of death
5. If possible, the numbers of the birth and death certificates
6. If necessary to identify a person, in particular in the case of homonyms, the names of the parents and the married name.

The RNIPP also includes:
- A registration number described in article 4
- Indications necessary for the application of article 9
- Any modifications made in the civil status of the registered persons

For persons born in France before 1945, the RNIPP was established by copying the data kept in birth registers. For later cohorts, the data is provided by the birth records that the IGREC (Instruction Gènèrale Relative l'Ètat Civil, or General Instruction Concerning Civil Status, issued by the Ministry of Justice) requests that the municipalities of cities of birth complete at the same time as the birth certificate[14]. Persons born abroad or in the overseas territories are included in the list only when they request a social security number. Deaths are accounted for thanks to the "death notification form 7 bis", for deaths occurring in France. Those occurring abroad and reported at the French consulate are also entered in the RNIPP.

The information pertaining to an individual recorded in the RNIPP may also be changed due to other events: recognition of an illegitimate child or a subsequent marriage legitimizing a birth can lead to a name change, full adoptions also require some modifications in order to prevent access to information which must be kept secret.

As it stands, the RNIPP is not frequently used in demographic research. If it were complete and if the information were perfectly accurate, it could be an excellent tool for measuring the mortality of persons born in France. However, this is not the case. In particular, as regards

[14] Today, most municipalities that have maternity wards are computerized, and the information concerning a birth and entered in the statistical records is often directly transmitted through the computer system.

the cohorts born before 1946, many deaths which occurred prior to 1945 are not indicated (deaths during wartime, departures abroad); as a result these persons are registered as being alive. Among the cohorts older than 90, the number of persons supposedly alive as of January 1st, 2000 is overestimated and the mortality level is thus underestimated. The RNIPP could be used for cohorts born after 1945, but there is little point in using it since mortality can be measured with traditional methods; that is, by comparing the number of deaths given by vital statistics with the total population figure known through censuses or intercensal estimates.

On the other hand, the RNIPP can be effectively used with Vincent's extinct generations method. Indeed, the information concerning the date of birth is of higher quality than that found in death statistics. If we take into account the fact that very old persons who were born in France rarely travel abroad, the RNIPP allows, or rather will allow, a near perfect reconstruction for the cohorts born after 1890, since these generations are not yet extinct.

The RNIPP is a more useful tool for demographic studies when it is combined with other sources. It is often used for longitudinal mortality studies, and also to ensure the good quality of the permanent demographic sample (EDP)[15]. The way the RNIPP has been used in French longitudinal studies is rather interesting: a sample of persons is selected through a census, their complete identities are established by checking with vital statistics, with the agreement of the CNIL (Commission Nationale de l'Informatique et des Libertès, or National Commission for Data protection and the Liberties); these identities and birth dates are then once again verified in the RNIPP. Once the sample has been defined, the deaths occurring among this group are periodically recorded; this makes it possible to measure mortality in the context of the information collected during the census. These studies thus benefit from the advantages of both sources. The RNIPP is incomplete as concerns the record of events, but the dates of birth and death are accurate. On the contrary, the census contains errors in dates (reporting errors, omissions, errors when entering the information on the computer), but its coverage is excellent.

[15] For all the persons born on one of four days of the year (about 1%), the EDP collates all the information collected during censuses (beginning with the 1968 census) and from vital statistics records. Professional or geographical mobility studies can thus be conducted by comparing individual situations at different dates; methodological studies can be conducted for example through comparison of information stemming from various sources or collected at different times, which in theory should be identical.

Using this method, a study of mortality at very advanced ages is now under way: the civil status of all women aged over 97 and males aged over 93, and of a sample of slightly younger men and women, was collected in the 1999 census, and identified in the RNIPP. Very soon, we will be able to measure the mortality since 1999 of the persons who were identified in the RNIPP.

Italian supercentenarians: Age validation of deaths from 1969 to 2000

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Abstract. This report describes the first stage of the age validation process of Italian supercentenarians. The process is still in progress and to date has only concerned supercentenarians deceased in the period 1969-2000. Of 35 potential supercentenarians included in the Italian National Institute of Statistics (Istituto nazionale di statistica, or Istat) database, 21 cases (three males and 18 females) are fully validated, seven cases refer to false supercentenarians—the error often being a misreported date of birth—and seven cases still remain unverified. The maximum age reached by the validated supercentenarians is 111, and the first case is recorded in 1973. In Italy supercentenarians have become a significant phenomenon only in the last few years.

1 Introduction

The decline in mortality at advanced ages plays a major role in determining future numbers of the elderly, and especially of the very old population. James Vaupel (1997) has noted that the remaining life expectancy of 80-year-old women in England and Wales is about 50% higher today than in 1950. This trend is also to be observed in Italy where, since the 1970s, life expectancy for those in their eighties (especially men) has increased much more quickly than for other ages (see Figure 1).

The growing number of 80-year-olds in the population, along with their increased life expectancy, has generated a progressively larger number of centenarians. In Italy, as in many other developed countries,

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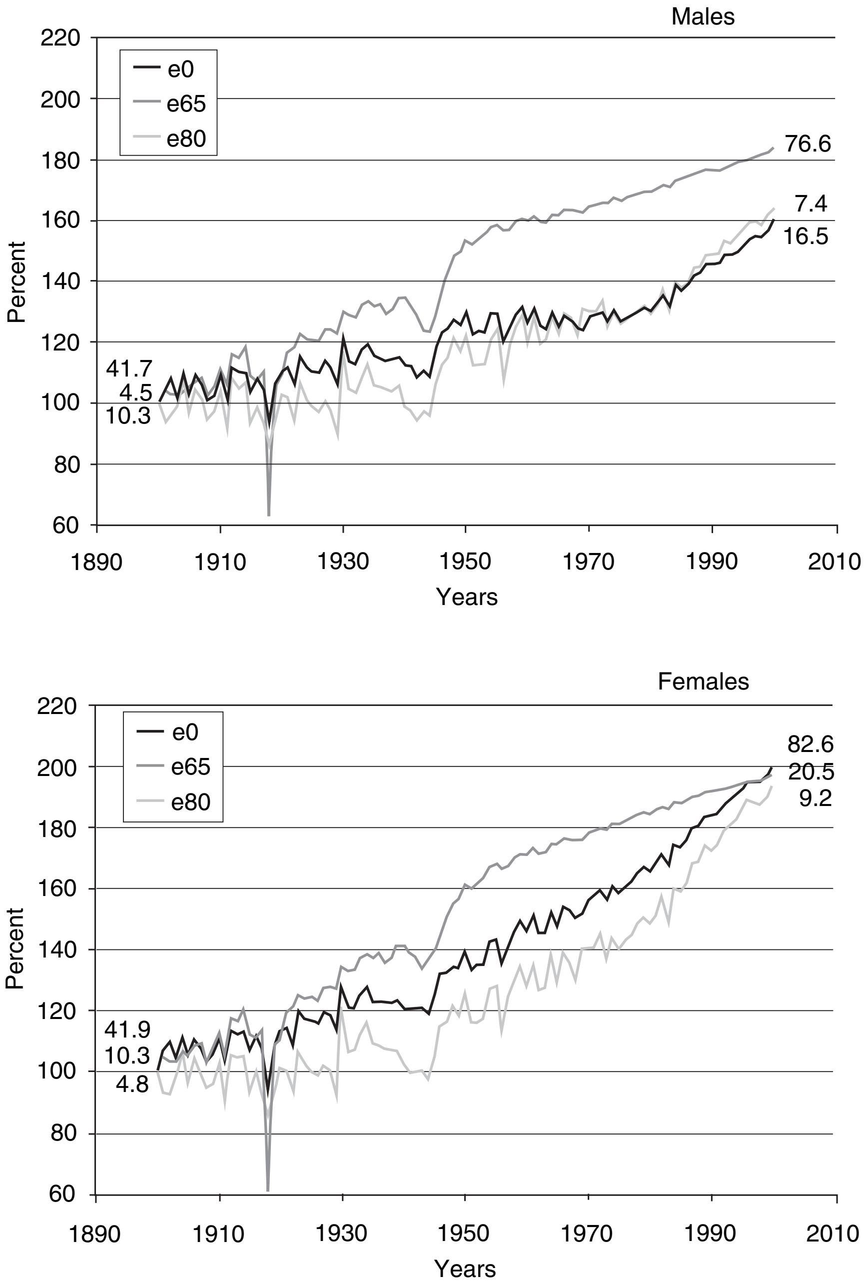


Fig. 1. Relative increases in life expectancy at birth, at age 65 and age 80, from 1900 to 2000, Italy

since the 1970s the number of centenarians, particularly women, has doubled every six to 10 years (Robine and Caselli, 2005). On January 1, 2005, 9,091 centenarians were recorded, compared with 6,300 in the 2001 census (October 21). Moreover, among this population group, the number of people reaching age 105 has also grown, as has the number of people topping 110 years—i.e., the supercentenarians.

Since 2002, statistics regarding centenarians from the Anagrafe (population register of the municipalities) have been modified in keeping with data from the 2001 census. Their total was reduced by 30%, compared with figures dating to January 1 of the same year. This adjustment does not, however, exclude other possible errors that crop up fairly frequently in surveys of the population over the age of 90. Hence, when considering extreme ages, it would be advisable to validate all those who claim these ages. Naturally, no cross-checking is possible if certain generalities are not known. Close cooperation is called for between civil status and population registry offices (Anagrafe), though privacy laws must be fully respected.

Identifying and validating deceased centenarians is a simpler procedure, as each death certificate contains information regarding the deceased's birth (date and place of birth) and death. In 2001, various countries, Italy included, established the International Database on Longevity (IDL), which gathers complete lists of validated supercentenarians (i.e., persons aged 110 and above). For each supercentenarian, the database will include information on sex, nationality, date of birth, and, eventually, date of death; as well as on the methods used to validate the person's age.

This report describes the first stage of the age validation process of Italian supercentenarians. The process is still in progress, and, to date, has only concerned supercentenarians deceased in the period 1969-2000, for which an electronic database is available. The number of living supercentenarians has been recorded in the national 2001 census (Istat). Table 1 shows figures for all those aged 100 and over. Although Istat used a special procedure for centenarians, the number of supercentenarians cannot be considered fully validated, as these cases were not processed according to the IDL protocol.

2 Data sources

The data sources used to build and to update the Italian Database on Supercentenarians are the Civil Status Office and the Istat Causes of Death Register.

Table 1. Living centenarians and supercentenarians, Italy, 2001 Census

	Age													
	100	101	102	103	104	105	106	107	108	109	110	111	112	100+
Male	519	306	111	55	37	21	9	10	2	4	2	1	3	1080
Female	2401	1405	658	381	172	105	48	30	12	10	5	3	3	5233
Total	2920	1711	769	436	209	126	57	40	14	14	7	4	6	6313

Source: Istat - 14th national population census (21/10/2001)

The Civil Status Office of each municipality collects birth, marriage, and death records of the present population in the municipality. It is different from the Anagrafe, the population registry office that maintains records on the resident population in each municipality. When an event does not occur in the place of residence, the Civil Status Office sends the information about the event to the Anagrafe of the municipality of residence. In Italy, there are no central offices at the regional or provincial levels that keep these records.

The Istat Causes of Death Register is an important instrument for the evaluation of the health status of the population, for the assessment of health programs and resource allocation, and for collecting information about individual demographic and social characteristics. It is a sort of 'death census' based on administrative data routinely collected by the Civil Status Office of the municipality on death, and on the diagnosis of causes of death provided by a physician (hospital, family, or post mortem physician). Moreover, it includes other social and economic information about the deceased, such as educational level, professional status, and occupational sector. Data on mortality by cause are annually collected, processed, and published by Istat.

The collection of data included in the Causes of Death Register is done by means of the death certificate (Istat forms D.4 for males and D.5 for females over one year old, and D.4 bis and D.5 bis for infant deaths; see Appendix). This document is the only acceptable official form in Italy, and is to be completed by a physician after the death, and by a Civil Status Officer. Under Italian law, each death must be reported within 24 hours to the local registrar of the municipality of death.

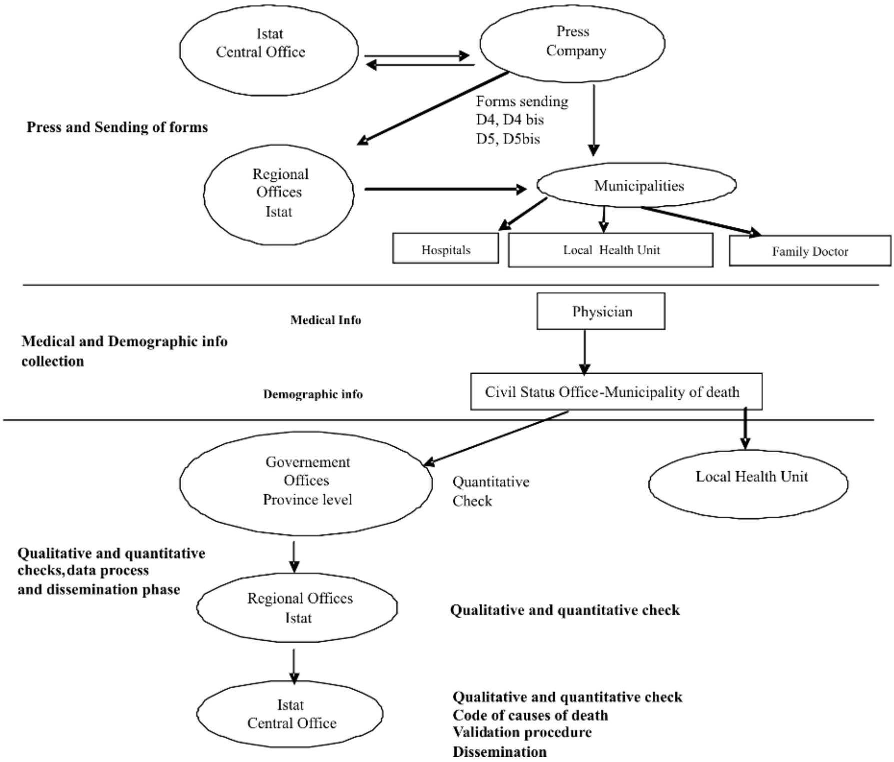
The death certificate is composed of two parts: Part A, to be completed by the physician; and Part B, to be filled out by the Civil Status Officer. Part A contains medical details and the name and age of the deceased. The medical section of the death certificate encompasses all the different pathologies (whether fatal or non-fatal), and, in case of violent death, the traumatic circumstances that occurred before death. Nevertheless, the data published refer to the underlying cause of death, i.e., the one that has mainly contributed to death. Part B contains information on the places and dates of birth and residence, marital status, education, profession, economic activity, citizenship, and an individual code of the deceased. Since 1997, Part B contains the deceased's tax identification number (codice fiscale) as well. This number consists of a code of 16 letters that comprises letters from the person's name, and place and date of birth. The tax identification number was very useful in checking the accuracy of the details recorded in Part B of the death form. Recently, Istat has implemented a new procedure for checking the correctness of the age reported on the death form by comparing the age declared by physicians in Part A to the dates of birth and death, and the tax identification number, reported by the Civil Status Officer in Part B.

Every year, Istat sends the new forms (D4, D5, D4 bis, D5 bis) of the death certificate to its regional offices and to all Italian municipalities, which, in turn, send the forms to the local health units, hospitals and family doctors (Istat 2004). The Civil Status Office of each Italian municipality of death, after receiving the forms completed in Part A by the physicians, must complete the demographic part of the death certificate (Part B). Subsequently, the form follows two different paths. One copy is sent to the local health unit of the place where the event occurred. Meanwhile, a second copy is first sent to the provincial government offices; then to the regional offices of Istat, where a preliminary quantitative check of forms is done; and, finally, to the central office of Istat (Figure 2).

3 The validation procedure and its results

For all deceased supercentenarians found in the Istat Causes of Death Registrar, Istat first contacted the Civil Status Office of the municipality where the death occurred, explaining the IDL project and stressing its importance. The offices were asked to check the data regarding the dates and places of birth and death of the deceased supercentenarian and, as a proof of validation in accordance with the IDL protocol, to provide a copy of the death certificate. In addition, when the places of birth and death coincided, a copy of the certificate of birth was also requested.

Demographic data were available for each deceased supercentenarian, thus facilitating the work of the Civil Status Officers. At times, the



Source: La Nuova Indagine sulle Cause di Morte. La codifica automatica, il bridge coding e altri elementi innovativi - Istat - Metodi e Norme - n.8 -2001

Fig. 2. The Causes of Death Registrar: the data flow

number of the birth registration act transcript over the death certificate was also available, thus facilitating the search for the birth certificate. For deaths recorded in 1969-1997, the names of the supercentenarians were not available, thus it was not always possible to validate the dates and place of birth and death.

Subsequently, for the deceased supercentenarians with different places of birth and death, Istat contacted the Civil Status Offices of the municipality of birth, asking for a copy of the birth certificate.

Results from the validation procedure are shown in Table 2. The Istat Causes of Death Registrar includes 35 possible supercentenarians deceased during the period 1969-2000, with the first case recorded in 1973.

For 27 out of 35 cases, Istat received a copy of the death certificate from the municipalities where the deaths occurred. Of these, 22 were confirmed, whereas for the remaining five cases, the validation revealed false supercentenarians. One municipality replied only by phone, revealing a further case of a false supercentenarian. For four out of 35 cases, the Civil Status Office replied that it was not able to proceed due to lack of information. Three municipalities failed to reply despite several solicitations.

For 21 of the 22 cases verified by the municipalities of death, a copy of the birth certificate was obtained from the municipalities of birth. In the remaining case, confirmed by the municipality of birth and death, which coincided, the whole historical archive had been destroyed during the war. In addition to these 22 records, another case was recorded as a false supercentenarian where a birth certificate was available, but the Civil Status Office of the death municipality did not answer our request.

To summarize, of 35 potential supercentenarians included in the Istat database for the period 1969-2000, 21 cases (three males and 18 females) are fully validated; seven cases refer to false supercentenarians, with the error often being a misreported date of birth; and seven cases still remain unchecked.

The maximum age reached by the validated supercentenarians during the time period studied was 111, and was recorded for men in Calabria and Veneto, and for women in Liguria. This extreme age has already been surpassed in Sardinia by Antonio Todde, who died at age 112 on January 3, 2002, and thus was not included in this study. Table 3 and Figure 3 depict the distribution by sex and region of the validated supercentenarians. Table 4 shows that the number of the oldest old has increased rapidly over the study period. In particular, supercentenarians in Italy have become a significant phenomenon only in the last few years.

4 Some conclusions

This analysis only concerned deceased supercentenarians, but some of these cases have now been entered in the International Database on Longevity as a result of this study. As we pointed out, a stringent procedure is followed prior to entering a name the database. The results obtained here corroborate this approach: of the 35 possible supercentenarians included in the Istat database for the period 1969-2000, only 21 (three men and 18 women) are fully validated. This alone entailed more than 18 months of work. It follows naturally that a greater effort is called for on the part of Italy regarding the "Supercentenarians" international research project, not only to validate the deceased aged 110 and above, but also to validate supercentenarians still living.

It is vital to persuade Istat of the importance of this study so that, as is the case elsewhere, supercentenarians could be identified when they are still living, and not on the basis of their death certificates. In Italy, the ages of individuals can be validated using civil status registries, birth and marriage certificates, as well as population data registries (Anagrafe) containing information on current place of residence. Reference to these sources, together the active collaboration of the civil status authorities, would make possible the validation of Italian supercentenarians.

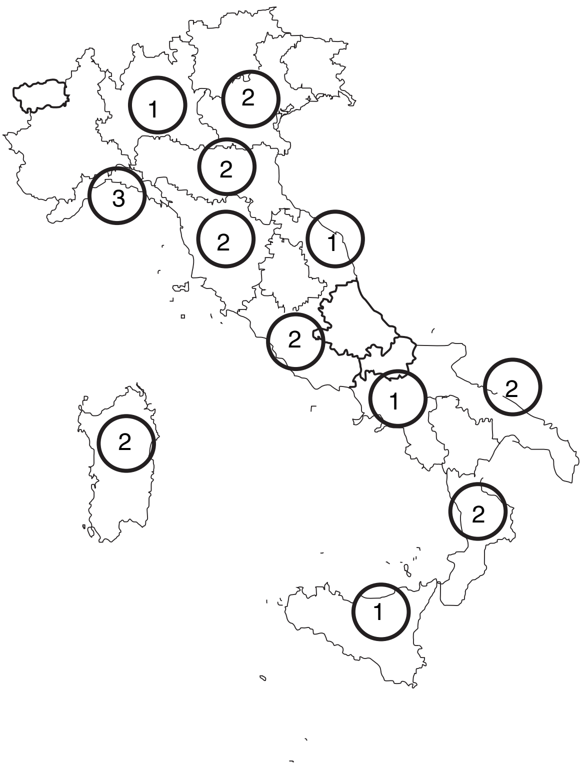


Fig. 3. Distribution of supercentenarians by region of death. Period 1968-2000

Table 2. Italian deaths at age 110 and over. 1969-2000

ID	Result of the validation procedure	Birth year	Death year	Age	Sex	Birth region	Death region	Birth certificate availability	Death certificate availability
1	**checked info**	1863	1973	110	Female	Lazio	Lazio	**Yes**	**Yes**
2	**deceased info not found**	1867	1978	110	Female	Sardegna	Toscana	*No*[1]	*No*[1]
3	**checked info**	1874	1985	110	Female	Sardegna	Sardegna	**Yes**	**Yes**
4	**checked info**	1875	1986	110	Female	Abruzzo	Abruzzo	*No*[2]	**Yes**
5	**no answer from municipality**	1879	1989	110	Female	Sicilia	Sicilia	*No*[3]	*No*[4]
6	**no answer from municipality**	1879	1990	111	Female	Campania	Campania	*No*[3]	*No*[4]
7	**deceased info not found**	1880	1991	111	Male	Emilia Romagna	Puglia	*No*[1]	*No*[1]
8	**checked info**	1880	1991	111	Male	Calabria	Calabria	**Yes**	**Yes**
9	**checked info**	1880	1991	110	Female	Toscana	Toscana	**Yes**	**Yes**
10	**checked info**	1880	1991	110	Female	Campania	Campania	**Yes**	**Yes**
11	**checked info**	1881	1991	110	Female	Marche	Marche	**Yes**	**Yes**
12	**deceased info not found**	1879	1991	111	Female	Sicilia	Sicilia	*No*[1]	*No*[1]
13	**checked info**	1881	1992	111	Female	Liguria	Liguria	**Yes**	**Yes**
14	**checked info**	1882	1993	110	Female	Calabria	Calabria	**Yes**	**Yes**
15	**FALSE supercentenarian -the deceased was 100 years old and not 110 years old**	1893	1993	100	Female	Basilicata	Basilicata	*Yes*[1]	*No*[4]
16	**checked info**	1883	1993	110	Female	Sardegna	Sardegna	**Yes**	**Yes**
17	**FALSE supercentenarian -the deceased was 101 years old and not 111 years old**	1892	1993	101	Female	Lombardia	Lombardia	*Yes*[1]	**Yes**
18	**deceased info not found**	1883	1994	110	Female	Sardegna	Sardegna	*No*[1]	*No*[1]
19	**FALSE supercentenarian -the deceased was 13 years old and not 113 years old**	1991	1995	13	Male	Lombardia	Lombardia	*No*[6]	*No*[5]
20	**FALSE supercentenarian -the deceased was 100 years old and not 110 years old**	1895	1995	100	Female	Piemonte	Emilia-Romagna	*No*[6]	**Yes**

Table 2. (continued)

ID	Result of the validation procedure	Birth year	Death year	Age	Sex	Birth region	Death region	Birth certificate availability	Death certificate availability
21	**checked info**	1885	1995	110	Female	Campania	Liguria	**Yes**	**Yes**
22	**checked info**	1886	1997	111	Male	Veneto	Veneto	**Yes**	**Yes**
23	**checked info**	1886	1997	110	Female	Liguria	Liguria	**Yes**	**Yes**
24	**checked info**	1887	1997	110	Female	Liguria	Emilia-Romagna	**Yes**	**Yes**
25	**FALSE supercentenarian -the deceased was 102 years old and not 112 years old**	1894	1997	102	Female	Emilia Romagna	Emilia Romagna	No^6	**Yes**
26	**FALSE supercentenarian -the deceased was 103 years old and not 113 years old**	1893	1997	103	Female	Toscana	Toscana	No^6	**Yes**
27	**checked info**	1887	1998	111	Male	Veneto	Veneto	**Yes**	**Yes**
28	**checked info**	1887	1998	110	Female	Lazio	Lazio	**Yes**	**Yes**
29	**checked info**	1887	1998	110	Female	Puglia	Puglia	**Yes**	**Yes**
30	**checked info**	1888	1998	110	Female	Emilia Romagna	Emilia Romagna	**Yes**	**Yes**
31	**checked info**	1888	1999	110	Female	Sicilia	Sicilia	**Yes**	**Yes**
32	**checked info**	1889	1999	110	Female	Lombardia	Lombardia	**Yes**	**Yes**
33	**FALSE supercentenarian -the deceased was 109 years old and not 110 years old**	1889	1999	109	Female	Emilia Romagna	Emilia Romagna	No^6	**Yes**
34	**checked info**	1889	2000	110	Female	Toscana	Toscana	**Yes**	**Yes**
35	**checked info**	1889	2000	110	Female	Puglia	Puglia	**Yes**	**Yes**

No^1 = Document not available
No^2 = Document destroyed during war
No^3 = Document requested (2nd time)
No^4 = No answer from death municipality
No^5 = confirmed by phone
No^6 = False Supercentenarian
Yes^1 = False Supercentenarian

Table 3. Distribution of semi-supercentenarians and supercentenarians by sex, age group, and region of death. Period 1969-2000

Regions of death	*Number of deaths*						
	Over 105			Over 108		Over 110	
	Males	Females	F/M	Males	Females	Males	Females
Piedmont	20	86	4.30	0	6	0	0
Valle D'Aosta	0	3	..	0	1	0	0
Lombardy	26	137	5.27	2	9	0	1
Trentino A.A.	1	12	12.00	1	1	0	0
Veneto	19	95	5.00	2	8	2	0
Friuli	4	46	11.50	0	4	0	0
Liguria	16	68	4.25	1	16	0	3
Emilia	14	109	7.79	2	11	0	2
Toscana	18	114	6.33	1	9	0	2
Umbria	10	21	2.10	1	2	0	0
Marche	6	43	7.17	0	4	0	1
Lazio	29	132	4.55	4	9	0	2
Abruzzo	10	34	3.40	0	2	0	0
Molise	4	10	2.50	1	1	0	0
Campania	27	79	2.93	3	6	0	1
Puglia	14	75	5.36	0	14	0	2
Basilicata	8	9	1.13	1	1	0	0
Calabria	14	42	3.00	2	5	1	1
Sicilia	16	89	5.56	1	9	0	1
Sardegna	28	46	1.64	3	10	0	2
Italy	284	1250	4.40	25	128	3	18

Table 4. Semi-supercentenarian and Supercentenarian rates (per 1,000,000) in four periods

Age at death	1969-71	1979-81	1989-91	1998-00
105 and over	0.22	0.32	0.95	2.49
110 and over	0	0	0.02	0.05

Note: The supercentenarians rate is calculated by means of the ratio between the deaths over 105 or 110 years, and the mean population of the periods 1969-1971, 1979-1981, 1989-1991, 1998-2000.

Acknowledgements

The authors thank the following municipalities for their cooperation:

Municipality	**Province**
Alseno	Piacenza
Asiago	Vicenza
Bari	Bari
Berchidda	Sassari
Casaleone	Verona
Catania	Catania
Cesenatico	Forl-Cesena
Collegno	Torino
Fiorenzuola d'Arda	Piacenza
Firenze	Firenze
Forl	Forl-Cesena
Galatone	Lecce
Genova	Genova
Imola	Bologna
Legnano	Milano
Lizzanello	Lecce
Milano	Milano
Monteriggioni	Siena
Nogara	Verona
Palombara Sabina	Roma
Petilia Policastro	Crotone
Piobbico	Pesaro e Urbino
Porretta Terme	Bologna
Rapone	Potenza
Rimini	Rimini
Roccastrada	Grosseto
San Sosti	Cosenza
Sant'Olcese	Genova
Siena	Siena
Taranta Peligna	Chieti
Torre del Greco	Napoli
Truccazzano	Milano
Varese Ligure	La Spezia
Ventimiglia	Imperia
Villafranca di Verona	Verona
Villagrande Strisaili	Nuoro
Zone	Brescia

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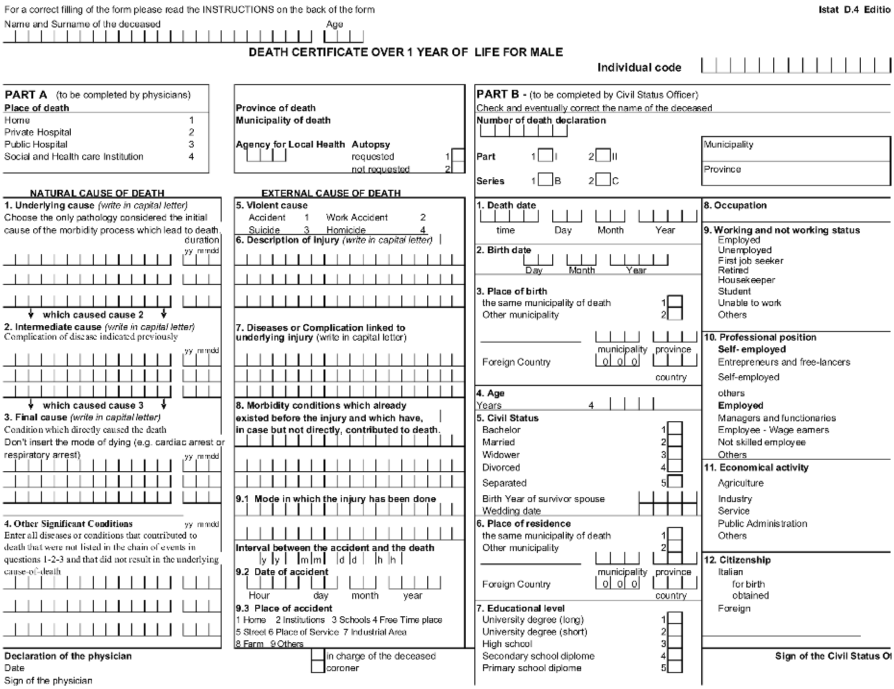
Appendix

Italian Death Certificate (Istat form)



For a correct filling of the form please read the INSTRUCTIONS on the back of the form

Istat D.4 Editio

Name and Surname of the deceased

Age

DEATH CERTIFICATE OVER 1 YEAR OF LIFE FOR MALE

Individual code

PART A (to be completed by physicians)

Place of death

Home 1
Private Hospital 2
Public Hospital 3
Social and Health care Institution 4

Province of death
Municipality of death

Agency for Local Health **Autopsy**
requested 1
not requested 2

NATURAL CAUSE OF DEATH

1. Underlying cause *(write in capital letter)*
Choose the only pathology considered the initial cause of the morbidity process which lead to death.
duration
yy mmdd

↓ **which caused cause 2** ↓

2. Intermediate cause *(write in capital letter)*
Complication of disease indicated previously
yy mmdd

↓ **which caused cause 3** ↓

3. Final cause *(write in capital letter)*
Condition which directly caused the death
Don't insert the mode of dying (e.g. cardiac arrest or respiratory arrest)
yy mmdd

4. Other Significant Conditions yy mmdd
Enter all diseases or conditions that contributed to death that were not listed in the chain of events in questions 1-2-3 and that did not result in the underlying cause-of-death

Declaration of the physician
Date
Sign of the physician

EXTERNAL CAUSE OF DEATH

5. Violent cause
Accident 1 Work Accident 2
Suicide 3 Homicide 4

6. Description of injury *(write in capital letter)*

7. Diseases or Complication linked to underlying injury (write in capital letter)

8. Morbidity conditions which already existed before the injury and which have, in case but not directly, contributed to death.

9.1 Mode in which the injury has been done

Interval between the accident and the death
y y m m d d h h

9.2 Date of accident
Hour day month year

9.3 Place of accident
1 Home 2 Institutions 3 Schools 4 Free Time place
5 Street 6 Place of Service 7 Industrial Area
8 Farm 9 Others

in charge of the deceased
coroner

PART B - (to be completed by Civil Status Officer)
Check and eventually correct the name of the deceased

Number of death declaration

Municipality
Province

Part 1 I 2 II
Series 1 B 2 C

1. Death date
time Day Month Year

2. Birth date
Day Month Year

3. Place of birth
the same municipality of death 1
Other municipality 2
municipality province
Foreign Country 0 0 0
country

4. Age
Years 4

5. Civil Status
Bachelor 1
Married 2
Widower 3
Divorced 4
Separated 5
Birth Year of survivor spouse
Wedding date

6. Place of residence
the same municipality of death 1
Other municipality 2
municipality province
Foreign Country 0 0 0
country

7. Educational level
University degree (long) 1
University degree (short) 2
High school 3
Secondary school diplome 4
Primary school diplome 5

8. Occupation

9. Working and not working status
Employed
Unemployed
First job seeker
Retired
Housekeeper
Student
Unable to work
Others

10. Professional position
Self- employed
Entrepreneurs and free-lancers
Self-employed
others
Employed
Managers and functionaries
Employee - Wage earners
Not skilled employee
Others

11. Economical activity
Agriculture
Industry
Service
Public Administration
Others

12. Citizenship
Italian
for birth
obtained
Foreign

Sign of the Civil Status Of

Emergence and verification of supercentenarians in Spain

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Abstract. During the final decades of the 20th century, there was a small group of people in Spain who reached very advanced ages. This was a phenomenon with no historical precedent in Spain. Despite their importance, the supercentenarians' mortality has not been well defined. To help fill this gap, our work examines the insufficiency of, and errors in, the data used to validate the alleged ages at death of this extremely old Southern European population. We have studied the ages of people who are said to have lived beyond their 110th birthdays, and who died between January 1987 and April 2007. We started with a list of 191 potential supercentenarians. But, after a meticulous process of verification of their ages, we finally validated 28 genuine supercentenarians. In three of these validated cases, the ages of the people studied exceeded 114 years, which is the maximum lifespan so far recorded in Spain. We have contributed the results of our research to the International Database of Longevity (IDL).

1 Introduction

Currently, there appears to be a broad consensus among population researchers that there is no empirical evidence to support the assertion that we have reached the highest limits of human life (Wilmoth, 1997; Jeune and Vaupel, 1995; Vaupel et al., 1998; Wilmoth and Robine, 2001). On the other hand, researchers largely agree that few mortality models fit better than Gompertz's law (Thatcher, Kannisto, and Vaupel, 1998). These two main subjects are key issues, and are the main focus of our future research. Within this framework, we can sub-

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mit preliminary results of our research regarding the following specific objective.

The characteristics of centenarians, semisupercentenarians, and supercentenarians—including their mortality evolution, their appearance, and their chronology and intensity according to ages—have yet to be well established. There is a certain mythology around living to the age of 100 or beyond. This mentality, combined with the late establishment of civil registers in several countries, led to a lack of data for the late 19th and 20th centuries, both for living and dead people at extreme ages. To gain a better understanding of the mortality characteristics of the oldest-old, it is therefore imperative to screen the existing data, especially for the most recent cases. We start by filtering out cases in which the alleged age at death is clearly exaggerated or wrong. Our main goal is to validate the Spanish data.

We must take into account that this detailed and meticulous verification task forms the basis for later methodological advances. This is because, in each and every development or readjustment of a demographic model, we must use filtered and observed data as our starting point. First, we provide a general overview of death and mortality at extreme ages in Spain, which allows us to place the mortality of centenarians and semisupercentenarians in the global context of rising longevity.

As death rates fall and people live longer, the frequency distribution of ages at death has moved to the right. This distribution has become more compressed around a displacing mode (Kannisto, 2000; 2001); furthermore, it seems that the whole mortality distribution is shifting to the right (Bongaarts and Feneey, 2002). Therefore, the exchange between compression and shifting mortality forms the background for the emergence of centenarians.

2 Data and sources

Our main sources, and the most vital ones for the purposes of age verification, are the municipal Civil Registers. The Official Deaths Register was used as an intermediate source that enabled us to compile a list of potential supercentenarians. The Official Deaths Register is maintained by both the Spanish Statistics Institute (INE) and the Ministry of Justice, and is stored as the National Death Index at the Ministry of Health. We will describe this register in detail later. We have also used two additional databases that help us place Spanish mortality in a general context.

The original source of death data is, for the whole period, the National Statistics Institute of Spain (INE), either via the Human Mortality Database (HMD, `www.mortality.org`) (Glei et al., 2006) for the periods of 1908-1946/5 and for 1999 onwards; or via Väinö Kannisto's estimates for the 1947-1998 period. The Kannisto-Thatcher Database on Longevity (KTDB) provides estimates for each simple age, and for each chronological year. In calculating these estimates, the KTDB relies on two main methods: until 2004, the extinct/almost extinct cohort method is used for every age, while from 2005 onwards, the survival ratio method is used for ages over 90 (Thatcher, Kannisto, and Andreev, 2001).

The KTDB computes the number of deaths at age x by summing up the death counts included in the Lexis triangles corresponding to each cohort. Deaths at ages (x1, x2) for a year y for an aggregated population are calculated by:

$$D_{X_1,X_2}(y) = \sum_{X-X_1}^{X_2} (D(x,y,y-x) + D(x,y,y-x-1))$$

The whole methodology can be found online at the Max Planck Institute for Demographic Research website (`http://www.demogr.mpg.de`).

The KTDB was used for the first step in the analysis of the emergence of Spanish centenarians. Managed and maintained by the Max Planck Institute for Demographic Research, this database is an essential tool for any demographic research on longevity, and is especially useful for comparative analysis. The KTDB offers temporary yearly series of deaths and populations from 1908 to 2004, the last year available prior to publication of this book. We can, therefore, draw a picture of Spanish longevity throughout the 20th century based on these databases.

3 Emergence of the deaths of centenarians and supercentenarians

3.1 Deaths of oldest-old people

Before discussing in detail the results of our verification efforts, we wish to provide a general overview of our principal subject. We will focus on the process of the emergence of centenarians, semisupercentenarians, and supercentenarians by studying the deaths of those who have reached the ages of 100, 105, and 110 or more.

We use data drawn from the KTDB because this database offers a wider short-term outlook than the figures provided by the INE. The analysis of the period 1965-2004 shows that the number of deaths among centenarians grew continuously. This tendency occurred parallel to an increase in age of death at advanced ages. The new century arrived with a second surge in centenarians' deaths (see Figures 1 and 2). The change in the figures is dramatic: in 1973, there were 318 deaths, of whom 45 were men and 273 were women; while in 2004, there were 2,323 deaths among centenarians, of whom 500 were men and 1,823 were women. Figure 3 illustrates this trend, showing that, while the number of deaths among people over 100 years old rose throughout the 20th century, this increase did not become exponential until the 1970s.

A very similar trend can be seen in the deaths of semisupercentenarians. We observe the same tendencies throughout the period studied, though obviously with much more modest figures. The smaller number of supercentenarian deaths allows us to verify each one of the cases, a task we address later.

The emergence of centenarians and semisupercentenarians shows a similar profile in different European countries, though Spain experienced a clear delay in the emergence of centenarians when compared to countries like France, where it occurred in the 1960s or even earlier (Robine and Caselli, 2005). In fact, when we use the same source, the KTDB, to compare trends in different countries, we can see that the emergence of centenarians in Spain, which took place during the early 1970s, is very close to the trends found in Germany and Italy[3].

The investigation of deaths at extreme ages may, therefore, also enable us to better understand a remarkable historic phenomenon: the emergence of a new group of people, which is growing both in size, and in terms of the highest age reached. There is an increase in rates of survival, with more and more people celebrating 100th and 105th birthdays every year.

3.2 Mortality among centenarians, a declining issue

Parallel to the emergence of oldest-old people, there has been a drop in the adult mortality rate, especially among the more aged groups. Longevity among the Spanish population has reached a high level in comparison to other countries. In Figures 3 and 4, we can see changes in

[3] In those years when we observe the emergence of Spanish centenarians, there is no noticeable change in the registration system that might account for the observed trend.

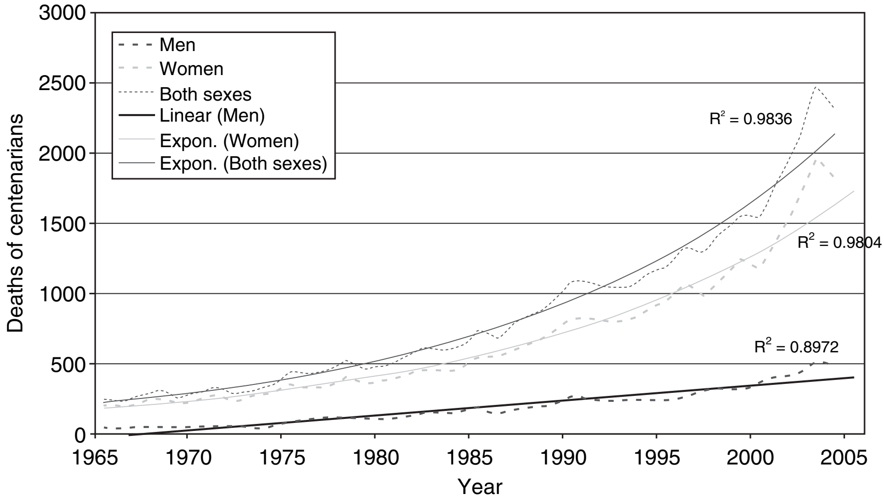

Fig. 1. Deaths of centenarians, by sex. Spain, 1965-2004

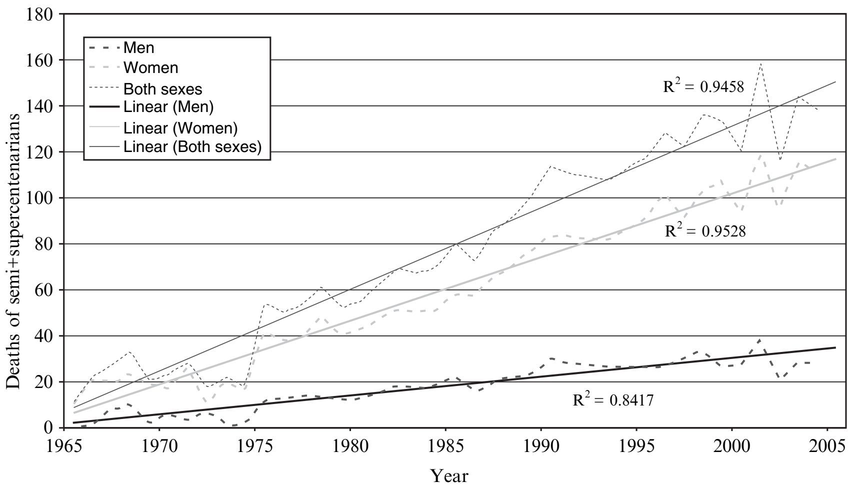

Fig. 2. Deaths of semisupercentenarians (ages 105+), by sex. Spain, 1965-2004

the probability of death among centenarians and semisupercentenarians for each year during the 1908-2006 period. In centenarians, the decrease in the probability of dying is obvious.

Mortality among people who have reached the age of 100 shows big yearly fluctuations. Furthermore, we can distinguish two different periods. During the first period, from 1908 to 1968-1973, mortality clearly increases. We can see the effects of the Civil War (1936-1939) and the immediate postwar period (1940-1942). A partial explanation for the increase seen in the first half of the 20th century may lie in the constant improvement in data quality, although it is difficult to state with total certainty that this is the case[4]. There was an improvement in the census over this period, as increasing attention was paid to the quality of data for very advanced ages, and the data was offered at a higher desegregation level. After 1968-1973, the probability of death leveled off, and even decreased slightly, presenting less fluctuation. This new trend correlates with the fact that, since then, the census and the registers have been extremely reliable.

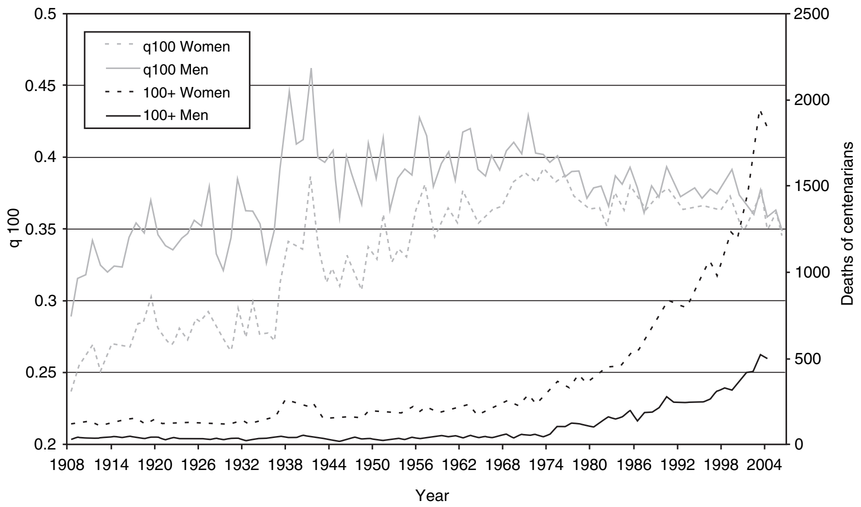

Fig. 3. Deaths of centenarians and q_{100}, by sex. Spain, 1908-2004

[4] Most likely, there was a problem of overestimation in both the centenarian population and in centenarian deaths that was progressively adjusted throughout the period under study. Nevertheless, there is need to study why the statistical artifacts of Vital Registers regarding deaths were improved later than the Census.

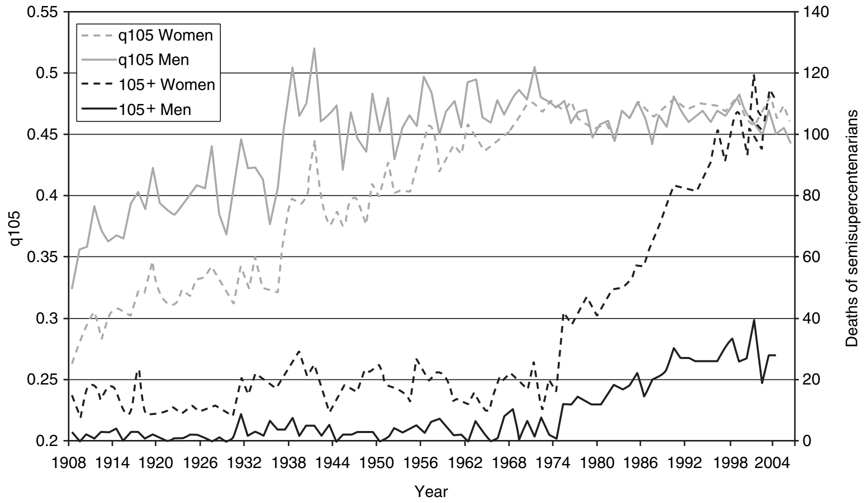

Fig. 4. Deaths of semisupercentenarians and q_{105}, by sex. Spain, 1908-2004

Among people who have reached the age of 105, fluctuations and irregularities are even greater. The trend in the probability of death at age 105 is irregular in both sexes, but has been declining in recent years. Among men aged 105, the intensity of mortality has decreased gradually. Nevertheless, the gender gap in the probability of death has been smoothed out, and the clear differences seen throughout the lifespans of men and women seem to diminish. Due to the limited number of cases, the irregularities observed among semisupercentenarians are even greater among supercentenarians. Until a more complete database for extreme longevity cases, and, specifically for supercentenarians, is compiled, we may want to wait before describing any differential trend by sex at ages 105 and above.

4 Verification of Spanish supercentenarians

As part of this study, we have carried out age validation for Spanish people who had reached the age of 110 or above at the time of their death, each of which occurred between January 1987 and April 2007. We have only included people who were born and died on Spanish territory, due to the difficulties involved in verifying the life trajectories of those born abroad.

4.1 Methodology and process of validation

We begin this part of the chapter with a discussion of the Spanish sources for verifying ages and their characteristics. We then go on to describe the structure of the Civil Register, our methodology, and, finally, the different stages of the process used to verify Spanish supercentenarians.

In Spain, compiling a list of living persons who are 110 years old or older is not a simple matter. There is no register, center, or institute that provides a list of names of possible supercentenarians that would allow us to locate them and investigate their lives, as well as, ultimately, their deaths. Due to the characteristics of the Spanish register and census systems, and to the privacy provisions of the Data Protection Law, it is not easy to establish the existence of people with very high ages until after they died.

The degree of access to individualized mortality data is very different in each country. Some countries allow complete public access to the data, but other countries, like Spain, place restrictions on access to some data, thus hampering research. With some restrictions, we can, however, obtain data on deaths from the state.

All the deaths that are registered in Spain are gathered in an information system called the National Death Index (IND). The IND is regulated by two laws: Order of 25 February 2000 (Boletín Oficial del Estado (BOE), 54, 3 March 2000) and the 2005 modification (Order PRE/2131/2005, 29 June, BOE n. 159, 5 July 2005). This database was launched in 2000, but includes data from 1987 to date. (The IND is compiled as follows: the data from the civil registers (Ministry of Justice) are collected by the National Statistics Institute (INE) (Ministry of Economy). INE provides these data to the Institute of Sanitary Information of the Quality Agency of the National Health System (Ministry of Health). This latter institute compiles and maintains the IND.) This is a restricted data system, and is open only to state institutions, such as research centers and health agencies. The data cannot be accessed by private institutions. Public institutions can obtain both aggregated and individualized data. To gain access to both types of data, the applicant must have the support of an eligible institution. In our case, we obtained permission to access the data from the state administration in March 2007. This was part of a collaboration agreement between the Ministry of Justice and the National University of Distance Education within the scope of our research project. Without this agreement, our research would have been impossible.

Each individual file in the register includes the following information: names and surnames of the deceased; place of birth; last residence; place of death (codified); year, month, and day of both birth and death; volume, book and page where the death is registered; identity card number[5]; sex; civil status; and nationality. The IND has several limitations, including a lack of information about the cause of death. This information can, however, be obtained within the official agreement mentioned above. Because, as previously mentioned, information is only available since 1987, we were only able to verify the ages of supercentenarians who died between January 1987 and April 2007, the last date available when we started this research.

From these data, we developed different stages. The first stage was to refine the data. In Spain, about 400,000 deaths occur each year and, evidently, only very few of them are entered in our list of possible supercentenarians. First, we calculated the difference in years between the date of death and the date of birth to get a list of people who could have reached an age of at least 110. We thus obtained a list of possible supercentenarians. Our first list consisted of 191 potential supercentenarians who had died in the period from January 1987 to April 2007. Using this list, we could start the process of validating the ages of each person who may have lived beyond his or her 110th birthday.

In Spain, the registration of vital events is the responsibility of state governments. Each town has its own municipal Civil Register, where people must register births, marriages, and deaths. There is also a central Civil Register, which is responsible for coordinating the municipal registers. Otherwise, Civil Registers function independently. It is important to point out that Spain has 8,108 towns, and that each municipality has its own Civil Register, regardless of the population size. These registers began operating in 1870. As we have potential supercentenarians since 1987, the temporal difference between the establishment of the Civil Registers and our first data is 117 years, enough time to guarantee that every possible supercentenarian was registered at birth after 1870. Every birth and every death is registered in the municipal Civil Register of the town where the person was born or died. We had to search both birth and death certificates for each potential person who had exceeded the 110-year mark.

We used the following procedures for validating the ages of these people. Although the starting data offer us some guarantees due to their relevance and official nature, it is essential to check each and every

[5] This variable is only available from 1996.

variable. As mentioned previously, the variables that must be checked in the course of the verification process are the following: date and place of birth, date and place of death, and, of course, the name of each potential supercentenarian. This means that two sets of information are required, and that there are two stages in the validation of each case. In the first phase, a communication process is established with the appropriate Civil Registers, including the town of birth and the town of death, so that an official request for the vital records of both of birth and death can be made for each potential supercentenarian. This is a difficult process that includes sending a letter or making a phone call to the officials responsible for the Civil Registers, usually judges, justices of the peace, or town clerks. There are usually no problems with death certificates, but there are a lot difficulties with birth certificates, as we will see later. Civil Registers are obliged to provide certified copies of the certificates free of charge (Law 25/1986, 24 December, BOE, n. 313, 31 December 1986). It is important to get a legal signature of each certificate. We thus guarantee that the documents are official, and that an exhaustive and reliable verification of age has taken place.

Once the documents have been obtained, we enter the second phase, which consists of a comparison of the certified forms received. These documents provide administrative proof of the start and the end of the person's life. In this way, we can define the real age of the people on the list, eliminating false cases of supercentenarians. In carrying out the verification, we have used the technique of matching vital records linked to each of the deaths. The first step is to check the age of the deceased. To do this, we have to certify the exact dates of birth and death of each potential supercentenarian, and then calculate the age. As for the names and surnames, it is important to note that Spanish people have two surnames: the first surname is usually the father's, and the second is the mother's. We can thus check the identity of the deceased against both names. If we want to be even more accurate, we can compare the grandparents' surnames, which are included in the birth certificate along with the parents' names. Finally, both the birth and the death certificate contain the names of the parents. It is then possible to compare them both, lending yet another degree of exhaustiveness to the validation. Therefore, we validate both the age and the identity of the person, first through the dates of birth and death, and second thanks to the peculiar feature of the structure of Spanish surnames. This is meticulous but necessary work, since the quality of the verification depends on how it is carried out. Especially in cases where the line between being or not being a supercentenarian is very thin, the procedures followed in the verification process must be thorough.

This detailed task of filtering does not always eliminate all the errors and inconsistencies in the list of dead people provided by the INE. Such errors are basically caused by the cumulative bias that occurs when family members or other acquaintances fill out forms, as well as in the transfer of data to the INE's computer systems. The main problem, as we have just stated, is the sum total of the cumulative bias that this database presents. Once we have the records, other kinds of bias appear: inconsistencies in dates of birth or death between the INE's data and the actual dates (e.g., a transposition of figures for the years, or registered dates of birth that are later than those included in the death records), different places of birth or death, or incorrect names or surnames (e.g., transposition of letters, and, less frequently, a mix-up in the order of the two family names). Various means of correcting these errors are available, but there is one problem that is practically impossible to solve: missing entries in the Civil Register. A similar problem stems from the burning and destruction of registers during the Civil War. When these types of problems appear, we are usually dealing with lost cases.

4.2 Structure of the validated supercentenarians and their geographic distribution in Spain

Twenty-eight Spanish supercentenarians have been entered into the International Database on Longevity (IDL). These people had reached the age of at least 110 during the period 1987-2007, and they were deceased as of April 2007. We have included the records that certify the dates of birth and death of the supercentenarians, which serve to verify that they lived to the age of 110 and beyond.

As mentioned previously, we started with a list of 191 potential supercentenarians who may have reached age 110 between January 1987 and April 2007. As a result of this verification process, which is ongoing, the number of people whose ages have been verified is 104, but the number of real supercentenarians has been reduced to 28 (see Figure 5). Only one person out of every seven of the potential supercentenarians has been verified as such. The remaining 76 people whose ages were verified were not found to be supercentenarians: four were semisupercentenarians, 24 were between 100 and 104 years old, and 48 were less than 100 years old. The ages of the other 87 potential supercentenarians could not be validated, as 61 could not be found in the Civil Registers, and there were no responses for the other 26 people. But, as the verification is still in progress, new cases of supercentenarians could be announced in the near future.

In Figure 6, we can see that there are huge differences between our verification data, the estimations of the KTDB, and the counts of the INE. The number of potential supercentenarians counted by the INE differs greatly from both the KTDB's estimates and the number validated by this research team. The INE offers constant numeric exaggerations, while the KTDB has the same bias, though it is less noticeable. From 1987 until 2006, the INE counted 191 potential supercentenarians among the deceased, while the KTDB arrived at a figure of 70 until 2004. In any case, the differences between the estimations of the KTDB and our own data will probably be smaller when our validation data process is completed[6].

So far, however, we have verified that there were 28 supercentenarians living in Spain between January 1987 and April 2007. Table 1 shows the distribution of supercentenarians by year of death and sex. There are three females for every male. We can see a distribution by age at death and sex in Table 2.

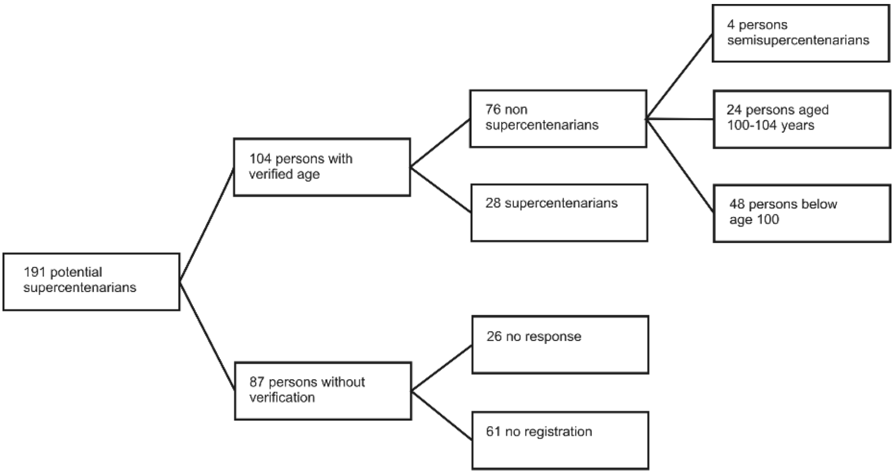

Fig. 5. Process of validation of supercentenarians. 1987-April 2007

Of the cases we investigated, we found 14 people (10 women and four men) who had reached age 110, eight who lived to age 111 (seven women

[6] Nevertheless, the differences by sex between KTDB estimations and our own verified data could represent an overestimation in that database of male deaths, rather than an adjustment for female deaths.

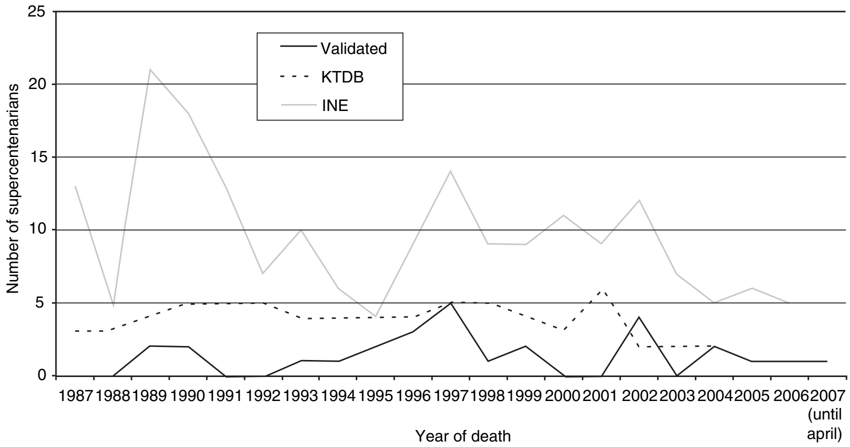

Fig. 6. Comparison of the number of supercentenarians according to different sources. National Death Index (INE), KTDB, and validated. 1987-April 2007

and one man), two who were 112 years old (one woman and one man), one woman of 113, and three people who had celebrated their 114th birthdays (two women and one man). As in other countries, younger ages make up the majority of the cases (Meslé, Vallin, and Robine, 2000). The feminization of the supercentenarian population is clear, as three out of four of these oldest-old people are women (see Table 2 and Figure 7). We should, however, point out that the number of Spanish supercentenarians does not appear to be increasing significantly over time.

Table 1. Distribution of supercentenarians by year of death and sex

Year	Both sexes	Male	Female
1987-1990	4	3	1
1991-1994	2	1	1
1995-1998	11	1	10
1999-2002	6	1	5
2003-April 2007	5	1	4
Total	28	7	21

Table 2. Distribution of supercentenarians by age at death and sex

Age at death	Supercentenarians			% by sex and age regarding total of SC			% by sex and age regarding total of age		
	Total	*Men*	*Women*	*Total*	*Men*	*Women*	*Total*	*Men*	*Women*
114	3	1	2	10.7	3.6	7.1	100.0	33.3	66.7
113	1	0	1	3.6	0.0	3.6	100.0	0.0	100.0
112	2	1	1	7.1	3.6	3.6	100.0	50.0	50.0
111	8	1	7	28.6	3.6	25.0	100.0	12.5	87.5
110	14	4	10	50.0	14.3	35.7	100.0	28.6	71.4
Total	28	7	21	100.0	25.0	75.0	100.0	25.0	75.0

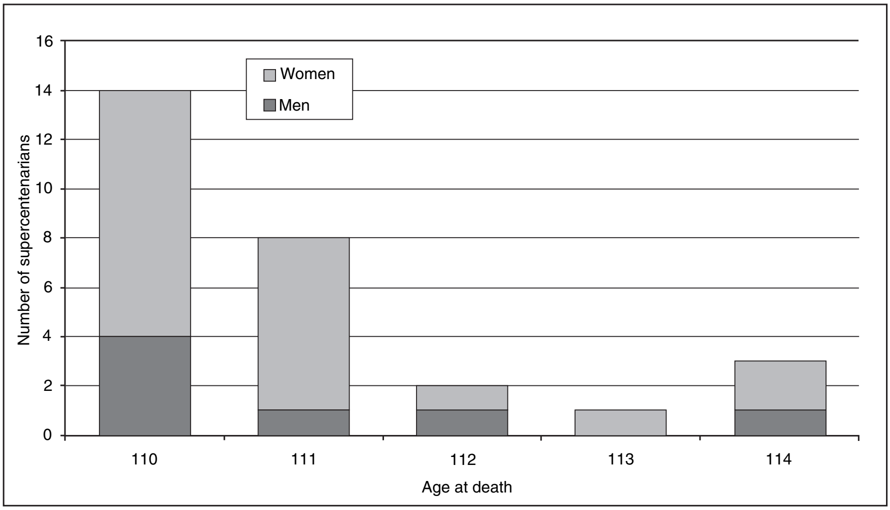

Fig. 7. Feminization of the supercentenarians: number by age and sex

The geographical distribution is shown in Table 3. Although it is still too early to establish an accurate geography of the oldest-old in Spain, we can already distinguish two zones: the North (Castile and León, Galicia, Navarre and Catalonia) and the South (Andalusia and Murcia). Furthermore, there are two regions that must be clearly differentiated from the others: Andalusia and Castile and León, which account for more than half of the supercentenarians verified, both at birth and death.

There is no relationship between the population size of the regions or provinces, and the number of supercentenarians. For example, Palencia is a small province of Castile and León with fewer than 180,000 inhabitants, but four verified supercentenarians were born there. While several supercentenarians died in Spain's most important and populous cities, Madrid and Barcelona, none were born there. This can be attributed to the internal migration from rural to urban zones that occurred during the 20th century.

Table 3. Geographical distribution of the supercentenarians

Place of birth	Number
North	18
South	10
Andalucía & Castilla+León	16
Other regions	12
Place of death	
North	18
South	10
Andalucía & Castilla+León	15
Other regions	13
Total	28

In Table 4, we can see the tabulation of all the supercentenarians who have been verified in Spain. They are arranged by age in years and in days, and each supercentenarian is also identified by sex, region of death, and region of birth. The certified documents include the names of the municipalities of birth and death for each individual case, but their publication is forbidden by law.

As we are continuing the process of verification, we may discover that the number of supercentenarians for the period studied exceeds 28. It is also quite probable that there are other supercentenarians outside of the scope of our research, but it is impossible to know at this point whether this is the case. Conducting this research project has been a long and arduous process, requiring us to employ exacting methods to achieve the highest degree of accuracy in the validation of the ages. As these efforts continue, we may be able to add some new cases to the IDL.

5 The emergence of oldest-old people

In just 31 years, the number of people aged 100 and older multiplied by six. Despite the fluctuations that took place in some of those years, the general trend represents an unprecedented increase. An additional

Table 4. Spanish supercentenarians. 1987-April 2007

Supercentenarian initials	Sex	Region of birth	Date of death	Region of death	Date of birth	Age (in years)	Age (in days)
M.A.C.C.	W	Andalucía	16.01.1996	Andalucía	10.06.1881	114	41857
M.C.L.L.	W	Murcia	03.07.1997	Murcia	03.04.1883	114	41729
J.R.M.	M	Islas Baleares	05.03.2004	Islas Baleares	15.12.1889	114	41718
M.C.F.F.	W	Galicia	25.05.1997	Galicia	28.10.1883	113	41482
J.A.J.	M	Cataluña	20.01.1994	Cataluña	23.02.1881	112	41238
M.E.O.S.	W	Andalucía	15.02.2002	Andalucía	01.09.1889	112	41074
E.M.M.	W	Andalucía	21.06.1997	Andalucía	20.07.1885	111	40878
A.U.H.	M	Murcia	15.11.1999	Cataluña	18.02.1888	111	40812
C.R.R.	W	Andalucía	08.04.2007	Andalucía	27.08.1895	111	40766
E.E.A.	W	Castilla+León	25.03.2002	Castilla+León	18.08.1890	111	40761
E.H.R.	W	Andalucía	16.11.2002	Madrid	28.07.1891	111	40653
F.A.F.	W	Cataluña	09.08.1999	Cataluña	04.05.1888	111	40638
L.M.V.	W	Castilla+León	02.02.2006	Andalucía	13.12.1894	111	40593
A.P.L.	W	Castilla+León	12.04.1995	Castilla+León	26.03.1884	111	40558
U.H.R.	W	Castilla+León	21.04.2002	Castilla+León	19.06.1891	110	40483
G.L.O.	M	Aragón	23.01.1990	Madrid	22.04.1879	110	40453
A.R.S.	W	Andalucía	24.11.1995	Andalucía	01.03.1885	110	40444
A.L.M.	M	País Vasco	01.01.1990	País Vasco	11.04.1879	110	40442
M.C.M.G.	W	Andalucía	06.11.1996	Andalucía	15.02.1886	110	40441
G.M.C.	M	Castilla+León	09.09.1997	Andalucía	24.12.1886	110	40436
A.D.C.	M	Asturias	13.06.1989	Asturias	16.10.1878	110	40417
G.I.B.	W	Castilla+León	27.10.1997	Castilla+León	18.03.1887	110	40400
M.J.R.M.	W	Galicia	01.12.1996	Galicia	08.08.1886	110	40292
R.P.M.	W	Navarra	08.09.1989	Navarra	24.05.1879	110	40284
F.M.M.	W	Navarra	19.01.1998	Navarra	06.11.1887	110	40251
I.D.M.	W	Castilla+León	02.06.2005	Castilla+León	21.04.1895	110	40219
A.A.M.	W	Andalucía	25.11.1993	Andalucía	21.11.1883	110	40181
J.H.C.	W	Castilla+León	26.04.2004	Castilla+León	22.04.1894	110	40181

qualitative and quantitative jump occurred with the arrival of the new millennium, thus increasing the likelihood that even more people will reach age 100 or higher in the coming years.

5.1 A new maximum for the Spanish lifespan: The present

The main objective of the analysis of supercentenarians is to improve our knowledge about human longevity. That is why studies of this type are mainly based on the deaths of people who have reached extreme ages. There is another reason for this methodology, at least in the Spanish case. Due to the characteristics of the Spanish register and census systems, and to the constraints placed on researchers by the Data Protection Law, it is not easy to identify the individuals who are alive at a very old age. It is easier to validate the data and documents after death, but some important limitations remain due to privacy protection laws.

In the course of the verification process, we have identified the person who represents the maximum for the Spanish lifespan: a 114-year-old Andalusian woman called M.A.C.C. We have verified that this woman was born in Andalusia in 1881, and died in the same place more than 114 years later; or, more precisely, after 41,857 days of life. We hope that this new discovery contributes to the discussion of whether there are limits to the human lifespan. As can be seen in Table 4, M.A.C.C. died at a slightly higher age than M.C.L.L., a woman who died in 1997, and J.R.M., a man who died in 2004.

5.2 The potential maximum Spanish lifespan: Who are the future record holders?

If we consider the changes that took place among the Spanish population in the 20th century, it is possible to add another nuance to the emergence of the living centenarians. The changes in the numbers of people aged 100 and older per million inhabitants are remarkable. Whereas in 1950, there were 20.85 100-year-olds for every million inhabitants (5.62 men and 35.08 women), in 2004, after a growth in population of more than 15 million, this same figure reached 160.01 centenarians per million inhabitants (67.61 men and 249.77 women). Since then, the number has increased by an additional 140 people for every one million inhabitants; that is, the number has multiplied by eight. If we take into account gender, the number of male centenarians has multiplied by 12, and the number of female 100-year-olds by 7.1. Although the number of centenarians per million is much higher among women, the increase among men is greater.

Throughout the 1955-2003 period, there were almost 362 women for every 100 men who reached age 100, a ratio of almost four females to one male. There was also an increase in the number of people aged 105 and older. The proportion of semisupercentenarians compared to the whole of the population is more modest than the proportion of centenarians, although not less representative. In 1950, the number of people aged 105 or older was 1.46 for every one million inhabitants (0.37 men and 2.49 women), while in 2006, it had increased to 7.50 per million (3.15 men and 11.73 women). Over the course of these 56 years, the number has multiplied by more than five (8.5 for men, 4.7 for women). Differentials by sex have become a key issue for centenarian and semisupercentenarian research.

If we compare data from different European countries drawn from the same source, the KTDB, we find that the ratio of women in the centenarian and semisupercentenarian populations in Spain is unusually low. While the ratio of women among Spanish centenarians is 3.62 females for one male, the corresponding ratios are 4.12 in Italy and 6.46 in France. A similar trend can be seen among semisupercentenarians. Thus, the increase in the number of male centenarians in Spain is, in fact, much higher than in neighboring countries. One possible explanation for this trend might be related to a differential adjustment by sex in the KTDB's estimations. On the other hand, we should also consider the possibility that the average time lapse between birth and registration was different depending on the sex of the newborn[7]. Within the social context of small villages in the countryside of Southern Europe, and taking into account the well established differences in the value placed on girls and boys among these generations, we might expect to see a higher rate of error in the registration of female births. These considerations could also partly explain why Southern Europe has always had a higher ratio of men to women than Northern and Central European countries.

This increase in the number of centenarians, semisupercentenarians, and supercentenarians suggests the possibility that, among the supercentenarians today, there might be cases that exceed the known maximum lifespan, or that more people are at least getting closer to exceeding it. Among the individuals who have the potential to reach a new maximum lifespan in the future, M.F.F., who resides in the North of Spain, is a good example. Currently 113 years old, M.F.F. has lived

[7] There are cases in small villages in which two newborns (brothers or sisters) were registered at the time of the second birth, thus creating a registration error in the birth date of the first child.

in two different countries, and her life spans three centuries. She is, at the time of writing, the known seventh-oldest validated living person in the world.

6 Discussion

The chronology of the appearance of centenarians and semisupercentenarians in Spain is in line with the more relevant period of the process of exchange between compression and the shifting of mortality at advanced ages. However, it is early to suppose that the evolution of the mortality of supercentenarians will follow the same pattern as that of the younger age groups in the near future. Given the irregularity observed in supercentenarian trends during the last decades, due in large part to the small number of cases studied, it seems imperative to continue this analysis, taking into account later periods.

What is the maximum lifespan human beings will reach? Which is the most accurate mathematical model for mortality at advanced ages? These are some questions that we posed in the introduction to this paper as relevant subjects for contemporary research. In order to answer these questions, and to develop models that allow us to do so, it is imperative to verify both old and current data of supercentenarians. This is an indispensable condition for the estimation of their mortality and the improvement of population projections that involve advanced ages. We have overcome the limited volume of Spanish verified data for the period studied in this chapter, and intend to research other periods. With more recent generations included, we will be able to verify the deceleration of increasing age-related deaths at very advanced ages (Horiuchi and Wilmoth, 1998; Vaupel et al., 1998). The other essential means of deepening our understanding of the process is through contributing to the IDL, both in terms of verified cases and in the methodology used in validation. Through the IDL, we will able to identify aggregates of verified data from different countries and generations that allow new research possibilities for the scientific community (Robine and Vaupel, 2002). Up until the present, our main contribution to the IDL has consisted of carrying out the verification of the corresponding oldest-old population in Spain.

It is only by joint, international efforts that we will be able to determine whether the appearance of supercentenarians is, in fact, the tip of the iceberg of a new trend that is clearly noticeable among centenarians. For the moment, however, our main focus is on checking the quality of our data, so that we can help to shed light on the displacement of Kannisto's invisible wall.

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Age validation of persons aged 105 and above in Germany

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Abstract. As part of the International Database on Longevity (IDL), this study aimed to gather a list of age-validated persons aged 105+ in Germany, as complete as possible. We proceeded in three steps. In a first step, we asked the Office of the President of the Federal Republic of Germany (*Bundespräsidialamt*, or OGP) for a list of all persons aged 105 and older who received a congratulatory letter on the occasion of their birthday from the Federal President in the period from 1989 to 2002 (N=1,487). Second, the local Residence Registry Office (*Meldebehörde*, or RRO) was asked for the vital status of the person and the person's place of birth. Third, the Office of Vital Records (*Standesamt*, or OVR) at the person's place of birth was asked to confirm the date and place of birth. An individual was considered age-validated if (1) a late-life document was available from the RRO showing that the person had reached age 105 and (2) an early-life document was available from the OVR confirming the person's place and date of birth. 970 cases fulfilled both criteria. We monitored the vital status of this group until the end of the year 2004. Demographic data of these persons were then submitted to the IDL.

1 Introduction

This study aimed to gather an unbiased list of age-validated persons aged 105+ in Germany, as complete as possible, to be submitted to the International Database on Longevity (IDL; Cournil et al., this volume). The objective of the IDL is to gather lists of validated supercentenarians (persons aged 110 and above) and semi-supercentenarians (persons aged 105 to 109) in as many countries as possible. For the sake of simplicity, the term "semi-supercentenarians" is used in this chapter to refer to persons aged 105 to 109 as well as persons aged 110 and above.

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With a population of 82 million, Germany is a big country and it is important that information on German semi-supercentenarians is included in the IDL. Germany maintains a high standard in the documentation of civil events (birth, marriage, divorce and death). Mandatory registration of civil events was introduced in 1875. Consequently we can expect to find birth records for persons who reached age 105 in the year 1980 and later.

The German registry system is divided into two components, the registration of residence and the registration of civil events. The registration of residence is organized by Residence Registry Offices *(Meldebehörden*, or RROs), the registration of civil events by Offices of Vital Records (*Standesämter*, or OVRs). RROs and OVRs are independent administrative units in the municipality of a community. Their geographical area of responsibility may or may not overlap. All citizens are obliged to register with the RRO at their place of residence. Similarly, the registration of civil events with the OVR is mandatory for all citizens.

Data from the Human Mortality Database (HMD)[3] allow us a first glimpse at the number of very old persons in Germany. Figure 1 presents trends in the number of centenarians and semi-supercentenarians in Germany from 1956 to 2006, separately for women and men. Absolute numbers as well as numbers per million population are shown. There was an enormous increase in centenarians and semi-supercentenarians in Germany in the last decades, similar to other European countries (e.g., see Figures 1 and 2 in Skytthe et al., this volume). The upward trend in absolute and relative numbers continues unabated until the end of the data series in 2006. The increase is much more pronounced in women than men. Among semi-supercentenarians

[3] The HMD contains detailed raw data on death and population counts by age, year of birth, and calendar year for 33 countries including Germany. Derived variables such as death rates and life table parameters are also included in this database. A complete description of the methodology of the HMD is available in the methods protocol (`www.mortality.org/Public/Docs/MethodsProtocol.pdf`) for the HMD. The approach of the HMD is guided by the conventional knowledge that age reporting in death registration is typically more reliable than in official population estimates. For this reason, official population estimates at older ages are replaced by estimates calculated from death counts, employing extinct cohort methods. Such methods eliminate some of the biases in old-age population and mortality estimates. For Germany, the HMD currently includes data for all years from 1956 through 2006. For German data in the HMD, all official population estimates for age 90 and above were replaced by estimates obtained by applying the extinct cohort method (Vincent, 1951) and the survivor ratio method (Thatcher, Kannisto, & Andreev, 2002).

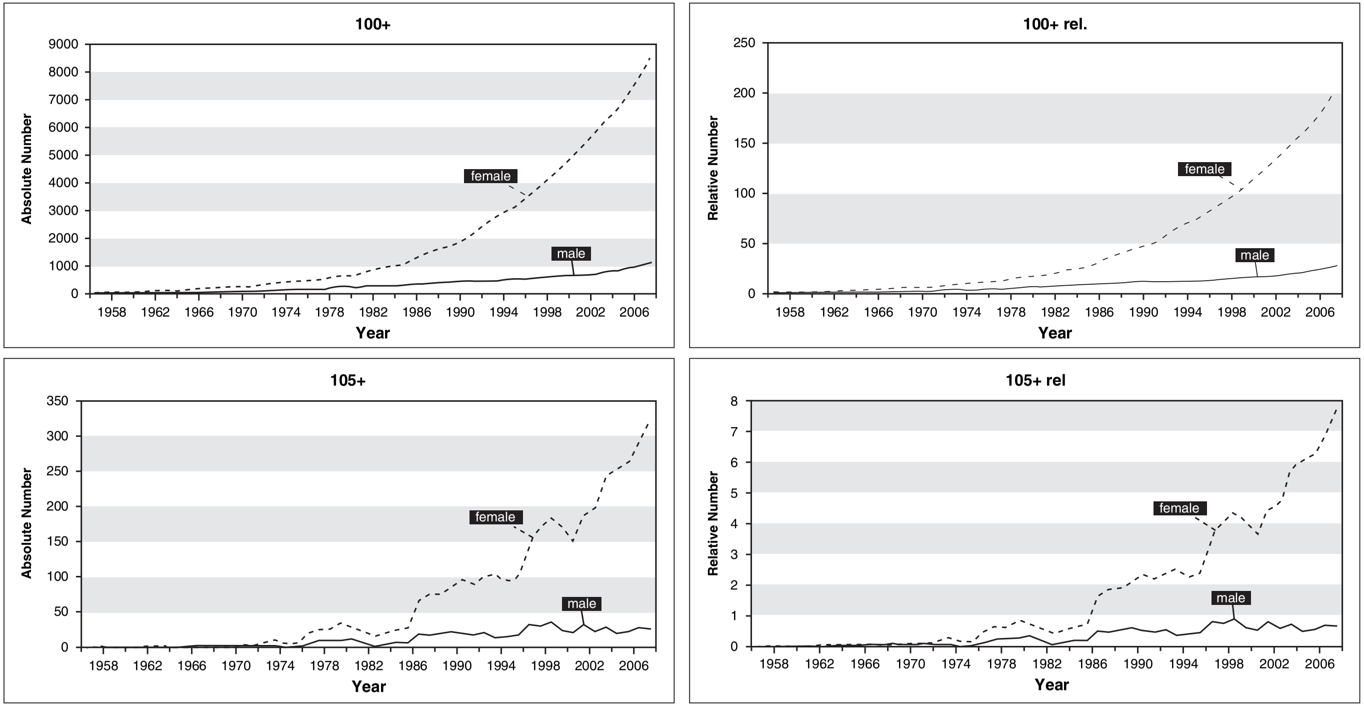
in Germany, women outnumber men by a factor of 8 to10 in recent years.

2 Age validation procedure

The HMD methods eliminate some of the biases in old-age population and mortality estimates. But still, the HMD data are estimates. In contrast, the IDL protocol requires that cases are validated at the level of the individual. When it comes to research on extreme longevity, age validation is very important because many reported instances of exceptional age are incorrect (Jeune and Vaupel, 1999; Poulain, this volume). Age validation at the individual level is challenging in Germany because the country maintains strict data protection laws and has a decentralized registration system. Data on every citizen are stored in the community where he or she lives. It is therefore not possible to extract all individuals with a specific age at a given point in time, e.g., semi-supercentenarians, from one central source. By the end of 1999 there were 8,513 RROs in West Germany including Berlin as one city, and 5,341 in East Germany (Statistisches Bundesamt, 2001). To obtain a first, exhaustive list of alleged semi-supercentenarians, one could ask all RROs for such persons in their community. However, in Germany there were probably only about 350 semi-supercentenarians alive in 2006 (cf. Figure 1), suggesting that more than 97% of the RROs have no such person residing in their local community. Communication with more than 13,000 RROs would have been very expensive, time-consuming, and wasteful.

2.1 First step: Addresses from the Office of the German President

We employed an alternative research plan that is more efficient. An overview of the plan is shown in Table 1. As a starting point, our age validation study utilized a database maintained at the Office of the President of the Federal Republic of Germany (*Bundespräsidialamt*, or OGP). Since 1965 until today the Federal President sends a congratulatory letter to citizens celebrating their 100th or a higher birthday (Franke, 1995). The OGP identifies the centenarians with the help of the RROs. Specifically, the OGP has issued an administrative order (last version July 5, 1995) via the *Staatskanzleien der Bundesländer* requesting that every RRO nominates centenarians in its local community. It is important to note that an RRO cannot freely choose whether to nominate centenarians - it is mandatory for the RRO to nominate.



Source: Human Mortality Database, `http://www.mortality.org`.

Fig. 1. Number of centenarians and semi-supercentenarians in Germany in the period from 1956 to 2006: Absolute number and number per one million inhabitants

Table 1. Research plan of the German age validation study: Sequence of correspondence with three types of offices

Step	Office(s)	Registry system	Information requested	Type of validation document
1	Office of the German President (OGP, *Bundespräsidialamt*)	Database on nominees for congratulatory letters (based on registry of residence)	(1) Name, (2) address, (3) date of birth	List of alleged semi-supercentenarians
2	Residence registry offices (RROs, *Meldebehörden*)	Registry of residence (*Melderegister*)	(1) Confirmation of name, address, sex, and date of birth, (2) birth name, (3) place of birth, (4) vital status	Late-life document
3	Offices of vital records (OVRs, *Standesämter*)	Registry of births, deaths, and marriages (*Personenstandsregister*)	(1) Confirmation of birth name, sex, date of birth, and place of birth	Early-life document

When a centenarian's birthday is near, the local RRO reports this individual to the OGP about one month or so in advance, using a one-page form. The nomination is usually based on a recent update of the local register of residence (*Melderegister*). Based on the nominations from the RROs, the OGP sends the congratulatory letters and retains information about the recipients in a database, including their name, age, and address. Most letters are accompanied by a monetary payment. In the year 2002 the payment amounted to 150 Euro. It was given if the monthly income of the recipient's household did not exceed an upper limit. About 90 percent of all congratulations include the payment. In most instances the OGP sends letter and payment not to the centenarian but to the nominating RRO. The RRO contacts the centenarian prior to his or her birthday and arranges for a visit of the mayor or some other local representative. The local representative visits the centenarian on the day of his or her birthday, congratulates, presents the letter from the president, and gives out the monetary payment. This procedure ensures that the centenarian is alive and can be found. If a centenarian has died before his or her birthday or cannot be found, the RRO is required to notify the OGP and return the payment.

In West Germany this procedure is in place since 1965. After German unification in 1990 it was also installed in East Germany. Congratulatory letters to East German centenarians were sent starting in 1991. In October 1995 there was a change in the procedure. Because the OGP could no longer manage the ever increasing number of nominations, it stopped sending letters to persons celebrating their 101st to 104th birthday. Thus, from 1995 onwards, letters were sent only to persons who celebrated their 100th birthday and to semi-supercentenarians. The database was computerized in 1999.

In a first step of our validation study, we asked the OGP for a list of all semi-supercentenarians who received a congratulatory letter in the period from 1989 to 2002, with the goal to validate their age. Specifically, we asked for the person's name, address, date of birth, and the calendar year of the congratulatory letter (see Table 1). The OGP approved our request and provided us with a list of 1,487 cases.

2.2 Second step: Late life information from the Residence Registry Offices

In a second step we aimed to obtain late life documents for our 1,487 cases, attesting that a person indeed reached age 105. For this we approached the RROs at the persons' place of residence. Each RRO registers citizens living in its local community with the goal to establish and document their identity and verify their residence. The obligation for all citizens to register with the RRO (*Meldepflicht*) began in the 1800s. A standardization process took place in the 1930s. Today every RRO maintains a local registry of residence (*Melderegister*) with data on citizens living in the community. The registry of residence includes information about a citizen's name, address, place and date of birth, as well as place and date of death (if deceased). If a person dies, the RRO is notified usually within four weeks after the death of the person.

Using the 1,487 addresses supplied by the OGP, in a second step of our age validation study we approached all RROs with a semi-supercentenarian residing in their community. We asked the RRO for the person's birth name and place of birth. We also asked if the person was alive or deceased and requested the date of death for deceased persons (see Table 1). We framed our inquiry as an application for a so-called "extended registry information" (*erweiterte Meldeauskunft*) on the semi-supercentenarian. An "extended registry information" is an official document issued by the RRO including information on the person's name and place of birth as well as place and date of death (if deceased). An "extended registry information" is granted if an applicant demonstrates a justified interest. Scientific research constitutes a justified interest. Consequently, all RROs co-operated with our study and provided the requested information—if it was available.

2.3 Third step: Early life information from the Offices of Vital Records

In Germany, civil events in a person's life (birth, marriage, divorce, death) are registered with the OVR in the community where the event takes place. For example, all births in a local area are recorded with the OVR at that area. These records of births are part of the register system called register of births, deaths, and marriages (*Personenstandsregister*). Each local OVR maintains such a local register of civil events. The OVR is also in charge of providing official documents (e.g., birth certificates) certifying these events.

The RROs had supplied us with information on the semi-supercentenarians' place of birth. This information enabled us to identify and contact the OVR at the person's place of birth, where birth records are kept. Utilizing the information about the person's birth name and place of birth, we asked the appropriate OVR whether a birth record existed in its register certifying place and date of birth. Specifically, we asked the OVR to confirm the validity of the information received from the RRO concerning the person's birth name, sex, place of birth and date of birth (see Table 1). We did not ask the OVR to issue an official document such as a birth certificate or a so-called *Geburtsschein*. An OVR is authorized to provide these documents (birth certificate or *Geburtsschein*) only when requested by the person him- or herself, by relatives, or by other applicants with a justified legal interest (§61 *Personenstandsgesetz*). Scientific research per se does not constitute a justified legal interest. However, we asked the OVRs to rely on the local register of births, deaths, and marriages in their response to our request. Thus, the legal status of our inquiry was such that we were not legally entitled to receive the information. The OVRs were not obliged to comply with our request. The decision whether to supply the information was entirely at the discretion of the respective public official at the local OVR. At the outset of the age validation study it was uncertain if public officials would co-operate. In practice it turned out that less than two percent of the OVRs refused to co-operate, while more than 98 percent helped us with information.

Our alleged semi-supercentenarian cases included 409 individuals (about 28 percent of all cases) who were born outside the borders of today's Germany. Their birth records, if preserved, are kept at *Standesamt 1 in Berlin* (OVR 1 Berlin), a special office that archives records on persons born in the former German empire and in foreign countries. Due to war and post-war confusion, we expected that records kept at OVR 1 Berlin would be fragmentary and far less complete than those kept at ordinary OVRs.

2.4 Validation criteria

Prior to the data collection we adopted the following set of criteria for age validation of German semi-supercentenarians. Persons who had died were considered age-validated if

(a) information is available from the OGP stating that the person received a congratulatory letter when s/he was 105 years or older, and
(b) late life information (*erweiterte Meldeauskunft*) is available from the RRO certifying the death of the person at an age above 105 years, and
(c) early life information is available from the OVR corroborating the person's place and date of birth.

Semi-supercentenarians who were alive were considered age-validated if

(a) information is available from the OGP stating that the person received a congratulatory letter when s/he was 105 years or older, and
(b) late life information (*erweiterte Meldeauskunft*) is available from the RRO certifying that the person was registered as alive in his or her local community at an age of at least 105 years, and
(c) early life information is available from the OVR corroborating the information about the person's place and date of birth.

2.5 Mortality follow-up

We monitored the vital status of the surviving semi-supercentenarians in yearly intervals up to 1 January 2005. Vital status information was obtained from the RROs.

3 Results

Table 2 summarizes the results of the German age validation study. Applying the criteria listed in section 2.4 above, we succeeded in validating the age of 970 semi-supercentenarians. Age validation was not successful for 517 cases. Uncorroborated cases can be categorized into five broad and mutually exclusive groups.

Table 2. Result of the German age validation study

Status after age validation procedure	Unconfirmed cases	Total
Age-validated semi-supercentenarians		970
RRO unable to confirm		11
"Test case"	2	
Unknown address	5	
Moved to foreign country	2	
Person could not be identified	2	
Place of birth could not be identified	6	6
OVR unable to confirm		85
OVR refused to cooperate	21	
No entry in register of births, deaths and marriages	62	
Last name did not match	2	
OVR 1 Berlin unable to confirm		359
No entry in register of births, deaths and marriages - born in former German empire	252	
No entry in register of births, deaths and marriages - born in foreign country	107	
Died before age 105		56
Died at age 104	50	
Died before age 104	6	
Total	517	1,487

The first group comprises eleven cases that were not validated by the RROs. Two of them were "test" cases, supplied by the OGP, which did not correspond to real persons. There were also five cases that had moved without leaving an address. Another two persons had moved to a foreign country. Finally, there were two cases that could not be identified because they were not listed in the RRO's registry of residence (*Melderegister*).

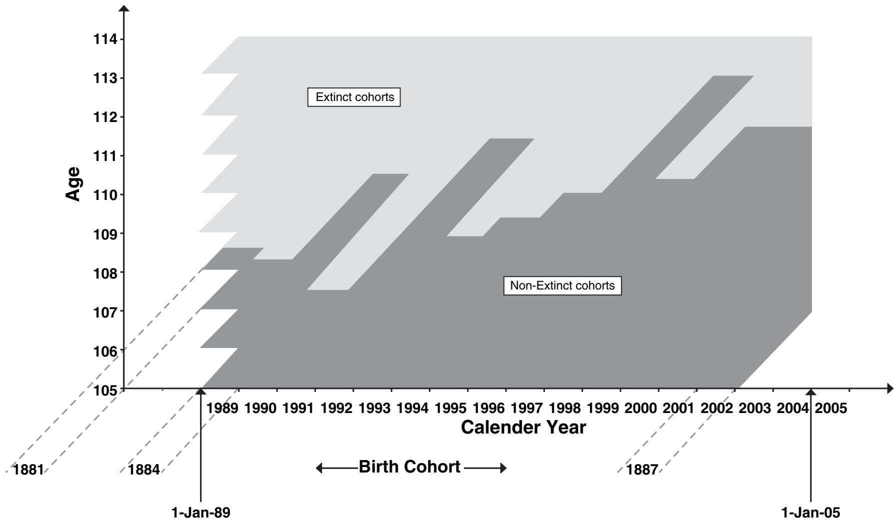
The second group of uncorroborated cases consists of persons with unknown place of birth. The RROs supplied information on place of birth for 1,476 cases. We found the place for 1,470 cases. However, we did not succeed in locating the place of birth for six cases, neither in today's Germany nor in other parts of the former German empire.

The third group includes a total of 85 cases that were not validated by the OVRs. Although co-operation of the OVRs was much better than we had anticipated, there were still five OVRs that refused to comply with our request and denied us the information (21 cases). Validation of another 62 cases was not successful because the OVR did not find an entry for them in the registry of births, deaths, and marriages (*Personenstandsregister*). In some instances, this was due to the fact that documents (*Personenstandsbücher*) from the year of birth were lost. Finally, two cases were validated by both the RRO and the OVR, but their last name did not match.

The fourth and largest group of uncorroborated cases consists of individuals which could not be validated by OVR 1 Berlin, the special Office of Vital Registration that archives records of persons born outside of today's Germany. Of the 409 cases we submitted to OVR 1 Berlin, only 50 were validated while 359 were not. Validation failed for 252 cases born in other parts of the former German empire and for 107 cases born in a foreign country. The low validation rate at OVR 1 Berlin suggests that only a small fraction of the registers of births, deaths, and marriages were transferred from former German territories to the OVR 1 Berlin.

The fifth group of unsupported cases comprises 56 individuals which died before their 105th birthday. These 56 cases were validated by the RRO and the OVR, but they did not reach age 105. Among them were 50 persons who died at age 104, suggesting that they passed away after nomination by the RRO and while the OGP was already preparing a congratulatory letter for them. The remaining six cases were registered as deceased at an age below 104.

Demographic information on 970 age-validated semi-supercentenarians is presented in Figures 2, 3 and 4. Figure 2 represents the observation period of our study as a Lexis diagram. We monitored semi-supercentenarians in Germany from 1 January 1989 to 31 December 2004. In 1989, the first calendar year of our study, we covered only semi-supercentenarians surviving to their birthday in that same year, due to our reliance on the congratulatory letters sent by the Federal President. In the time period from 1990 to 2002 we surveyed all semi-supercentenarians in Germany[4]. The vital status of surviving semi-supercentenarians was monitored until the end of the year 2004. Individuals reaching age 105 in 2003 and 2004 were not included in the study[5].



Note: The gray area designates the observation period. Extinct cohorts are shown in light gray and non-extinct cohorts in dark gray (N = 970 age-validated semi-supercentenarians).

Fig. 2. Age validation study in Germany: observation period by age, calendar year, and birth cohort

[4] This is true with the exception of East German semi-supercentenarians in 1990. The procedure of sending congratulatory letters was installed in East Germany only after German unification in 1990. Congratulatory letters to East German centenarians were sent starting in 1991.

[5] There was one exception to this rule. A woman born in 1898 celebrated her 105th birthday on 3 January 2003, three days after the arbitrary deadline imposed by this study. Her age was validated according to our criteria and we retained her as a valid case in the German list.

We monitored birth cohorts 1881-1883 from the day of their birthday in 1989. We surveyed birth cohorts 1884-1897 starting on the day they reached age 105. Based on 970 age-validated cases, Figure 2 represents extinct cohorts in light gray color and non-extinct cohorts in dark gray. Birth cohorts 1881-1892 were extinct at the end of our study in 2005. None of the age-validated German semi-supercentenarians reached age 113 (Figure 2). The maximum age was observed in 2002, when a woman born in 1889 died at an age of 112 years and 362 days.

Figure 3 presents the number of age-validated semi-supercentenarians in Germany from 1989 to 2002, separately for women and men. In the ten-year period from 31 December 1992 to 31 December 2002, the number of female semi-supercentenarians increased by a factor of 2.9, from 55 to 160 cases. The number of male semi-supercentenarians in that same period increased by a factor of 3.2, from 6 cases in 1992 to 19 cases in 2002. By the end of 2002, women outnumbered men by a factor of 8.4.

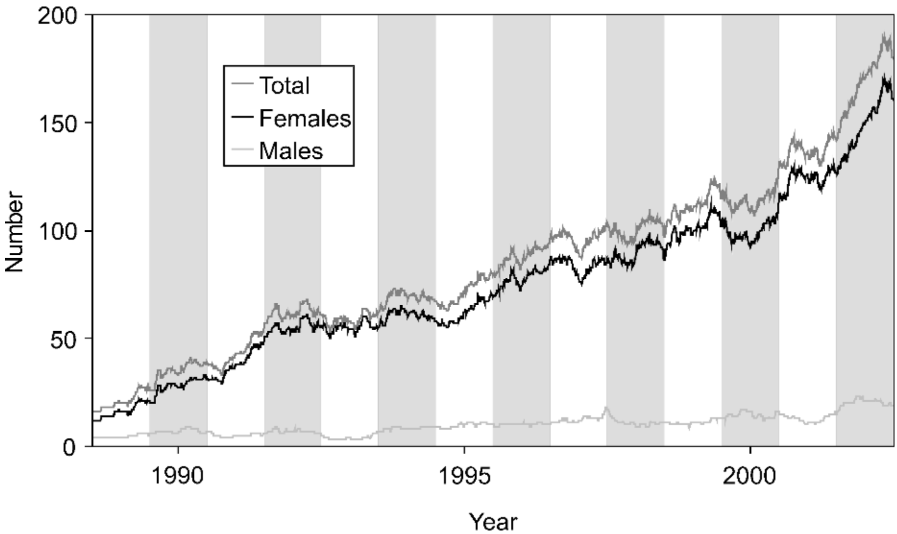


Fig. 3. Number of age-validated semi-supercentenarians alive in Germany, 1989-2002

Figure 4 shows the number of age-validated supercentenarians (aged 110 and above) in Germany from 1989 to 2004. Fourteen women and three men reached age 110. Supercentenarians were rare in the 1990s. Only two individuals surpassed age 110 in the period 1989-1998. Persons aged 110 and above became more prevalent in the period 1999-

2004. In 2003 and 2004, up to five supercentenarians were registered as alive at the same time.

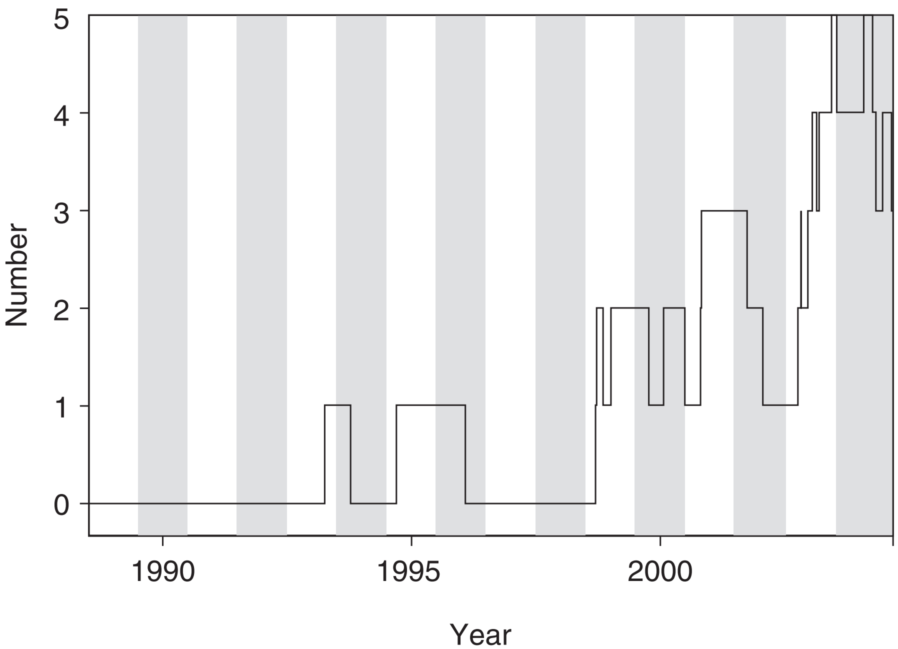


Fig. 4. Number of age-validated supercentenarians (aged 110 and above) alive in Germany, 1989-2004

Demographic data on 970 age-validated semi-supercentenarians were submitted to the IDL. The German list includes 859 women and 111 men. By the end of 2004, 26 semi-supercentenarians were registered as alive and 944 had died. For each person, the German list includes an anonymous case number; sex, country and date of birth, as well as country and date of death (if known). For 26 cases alive by the end of 2004, the German list includes the last known date when they were registered as alive.

4 Discussion

To summarize, the German age validation study followed a distinct procedure (Table 1). In the first step, the office of the German president was asked for a list of all semi-supercentenarians which received a congratulatory letter from the German President between 1989 and

2002. In the second step, the local RRO at the place of residence was asked for information about the vital status of the person and for the person's place of birth. In the third step, the local OVR at the place of birth was asked to corroborate the date and place of birth. 970 semi-supercentenarians were considered age-validated because the RRO confirmed that the person reached age 105 and the OVR verified date and place of birth.

It is essential that lists of semi-supercentenarians submitted to the IDL are free of age ascertainment bias. The IDL aims for an unbiased description of the mortality trajectory at the oldest ages. This description will only be valid if the age of the semi-supercentenarians in a population does not affect their chances of being included in the database. Our research strategy started with all semi-supercentenarians that received a congratulatory letter from the German President on the occasion of their birthday. This strategy minimized age ascertainment bias because the local registries are required by administrative order to report every person reaching the age of 105 in their municipality. However, we cannot completely rule out that the German list is affected by age ascertainment bias. Older semi-supercentenarians (e.g., aged 112) had more opportunities of being included in our list than younger ones, simply because they celebrated more birthdays after age 105. There is the possibility that in some instances the RRO failed to report a semi-supercentenarian to the OGP. If this person died before his or her next birthday, the case would not have come to our attention. On the other hand, if the person survived to the next birthday, it is likely that s/he was then included in the congratulatory procedure and thereby also in our age validation study. But such omissions by the RROs were probably rare. We presume that age ascertainment bias is negligible in the German list.

It is desirable but not essential that lists of semi-supercentenarians submitted to the IDL are complete. The Office of the German President is the only institution in Germany that holds centrally a nearly complete list of all semi-supercentenarians. We compared the OGP's list with population estimates from the Human Mortality Database and found satisfactory agreement (Scholz and Maier, 2005). Nevertheless, the German list of age validated cases is incomplete in several respects. East German semi-supercentenarians are probably underrepresented up to the mid-1990s (Drefahl, 2005; Scholz and Maier, 2005) because the procedure of sending congratulatory letters was installed in East Germany only after German unification in 1990. Foreign-born semi-supercentenarians are probably underrepresented because their birth records are kept at OVR 1 Berlin where documentation is fragmentary. Some German-born semi-supercentenarians could not be age-validated because the appropriate OVRs refused to co-operate. Other German-born semi-supercentenarians could not be validated because documents (*Personenstandsbücher*) from the year of birth are lost. Depending on the particular research question at hand, some of these biases may have serious implications. However, the fact that the German list is incomplete does not necessarily jeopardize the validity of studies examining the mortality trajectory of German semi-supercentenarians.

A very important and unique feature of the IDL is its focus on persons whose age has been thoroughly validated. For age validation in Germany it was necessary to work with personalized information. For example, the name of the person was needed to retrieve and match documentation on the person's birth and death. The data protection procedures and rules adopted in our study are governed by the general principle that identification of individual persons should not be possible from the information that will eventually be included in the IDL. Among these rules is the regulation that only specially trained validation personnel had access to personalized information. Personalized information is not available for researchers and other persons external to the validation process. Personalized information is not submitted to the IDL.

The German study achieved age validation for 970 cases despite the country's strict data protection laws. Correspondence with the OVRs was the most challenging aspect because birth information from the German register of births, deaths, and marriages (*Personenstandsregister*) is not readily available for scientific research. Birth validation depended on the goodwill of the public official at the OVR. We were gratified to note that almost all public officials chose to co-operate. In our request to the OVRs we emphasized that the German President supported our study. This may have helped to win public officials' participation.

The maximum age observed among age-validated German semi-supercentenarians was 112 years and 362 days. This is surprisingly low, given that numerous supercentenarians with higher ages were found in other countries (e.g., Kestenbaum and Ferguson, Desjardins and Bourbeau, Mesle et al., all in this volume). The total number of supercentenarians in Germany (17; 14 women and 3 men) is also very low. It could be that conditions in Germany, especially the hardships associated with two world wars, are not conducive for survival to extreme ages.

Our results show that age-validation is feasible in Germany, a country that has strict data protection laws and maintains a high standard in the documentation of vital events. We were able to validate the age of 65 percent of alleged semi-supercentenarians. We achieved validation for 85 percent of cases born within the borders of today's Germany. Extending the German study into more recent years could be promising because the number of semi-supercentenarians is rising (Figure 3) and the emergence of supercentenarians is a very recent phenomenon (Figure 4).

List of Abbreviations

HMD - Human Mortality Database, `www.mortality.org`
IDL - International Database on Longevity, `www.supercentenarians.org`
OGP - Office of the President of the Federal Republic of Germany (*Bundespräsidialamt*)
OVR - Office of Vital Records (*Standesamt*)
RRO - Residence Registry Office (*Meldebehörde*)

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The growth of high ages in England and Wales, 1635-2106

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Abstract. In England and Wales there were many historical claims of extreme longevity—ranging up to 152 years, said to have been reached in 1635—but it is impossible to verify any of them. A modern approach suggests that it is unlikely that genuine centenarians reached the age of 100 before about 1700. Later, the number of centenarians recorded in censuses was found to be greatly exaggerated. Much more reliable estimates of numbers of centenarians can be derived from the data on registered deaths, which provide a continuous series from 1911 to the present. Details are given of a very well-documented supercentenarian who reached the age of 110 in 1930, and also of the verified supercentenarian deaths since 1968. From 1911 until the 1940s, there were only one or two hundred centenarians, but from the 1950s, the numbers started to increase rapidly. The identified reasons for this are summarized. The numbers have already reached an estimated 8,500. According to the official projections, if trends continue the number of centenarians may reach 486,000 in 2076, and perhaps double that number by 2106; provided, presumably, that there will be enough carers to look after so many. The highest age is expected to rise.

1 The first centenarian

As a prologue, we shall begin by mentioning what is known about the date of the first centenarian in England and Wales, a kind of milestone which was passed before the days of modern statistics.

There has always been intense public interest in reported cases of extreme longevity. Countries and areas and experts vied with each other to find older and older cases, but the idea that extreme ages needed to be verified with extreme rigor was not recognized. A celebrated example was Thomas Parr, who died in 1635 at the reported age of 152. A post-mortem examination was made by William Harvey, who was famous for

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discovering the circulation of the blood. The case naturally attracted considerable publicity. Harvey described in detail the state of Parr's body, but did not make any attempt to check his age. Peter Laslett, the founder of the Cambridge Group for the history of population and social structures, was very critical of this claim, and, indeed, all the other reported very high ages in England and Wales. Laslett and his assistant, Julia Hynes, set out to verify, by the most rigorous methods, as many cases of high ages as they could, but they found that this was not an easy task.

Thatcher (1999a) compared some of the verified ages with the highest ages one might have expected to find in theory, in historical cohorts of sizes which were known at least roughly, and with probabilities of dying which could also be estimated by using a model. The details are in the paper. The method predicted that the longest-living members of cohorts born in the medieval period were likely to have died in their nineties. There were certainly medieval people who were believed by their contemporaries to be over 90 years old, but it is difficult to validate individual cases by modern methods.

However, by the time we reach the cohort born in 1600, the cohorts were larger and the death rates were lower. The theory then suggested that the highest attained age would probably be above 100 years, though whether this could be identified and verified was another matter. This age would not, of course, be reached until 100 years later. Julia Hynes found the case of Sir John Holland (1603-1701), who certainly reached age 97, and whose documentation is described as indisputable. There were also several possible centenarians who died between 1700 and 1800. The presumption is that, in England and Wales at least, one genuine centenarian will have reached the age of 100 in this period.

2 Registration of births and deaths

Soon after the Church of England was established, its clergymen were instructed (in 1538) to keep registers of all the baptisms, weddings, and burials which they had conducted in their parishes. After the Reformation, the registers were confined to members of the Church of England, and did not include Roman Catholics, Nonconformists, Jews, or Quakers. Only the Church of England registers were recognized in law in cases of dispute about inheritance. They remain to this day a source of invaluable information about family history. However, there is no guarantee that all the high ages recorded at death are always accurate.

The compulsory civil registration of all births, marriages, and deaths was introduced in 1837. Moreover, the 1841 census of population was deliberately designed so that the age groups, areas, and occupations of those living could be matched up with the information recorded in the registers of deaths. Thus, the census would provide the numbers at risk to go with the deaths, so that death rates could be calculated by age, area, and occupation. This brilliant idea produced wonderful results, with immediate applications to health policy.

However, for the much more limited purpose of research on longevity, as described in this article, there proved to be a problem. Not all the very high ages recorded in the census were accurate, so the numbers at risk could not be trusted. Methods of great ingenuity were used to overcome this difficulty, as will be described.

3 The census problem

Thatcher (1981) assembled all the statistical data on centenarians which were available at that time—more than had ever been available before—and immediately encountered the census problem in an acute form. The 1971 census had shown 2,320 centenarians, compared with only 479 in 1961. However, the 2,320 who were centenarians in 1971 must have been the survivors of those who were recorded as aged 90 and over in 1961, and it had been expected that there would be only 1,145 such survivors. Thus, there appeared to be twice as many centenarians in 1971 as would be expected.

A major investigation followed. The number described as centenarians in the census was found to be double the number of centenarians who were claiming state pensions. It was seriously unlikely that a genuine centenarian would not be drawing a pension. Also, the centenarians in the census were found to include people who had given very different dates of birth for themselves on official records on previous occasions. Many of the differences were round numbers, like ten years. It only needed such errors by a small proportion of old people to produce the faulty figure for centenarians in the census.

4 The method of extinct cohorts

It had already been recognized by Vincent (1951) that estimates of numbers at risk could be made, at least retrospectively, entirely from data on deaths, without having to use dubious census data. This could be done by classifying deaths according to the year of birth, and then following through the members of a given birth cohort, year by year, at least from some high age onwards, until they had all died. Working backwards, one could then determine how many were alive at each previous date. In its original form, though, the method could only be applied retrospectively, once the cohort had become "extinct," with all its members dead. However, various improvements were added, first by Depoid, and then by Kannisto and Thatcher, in constructing their database on old age mortality, so that provisional estimates of numbers at risk could be made at an earlier stage.

In the rest of this note, the estimates of numbers and death rates high ages are made by using these modifications of the method of extinct cohorts, and do not depend on census data. Although it cannot be claimed that all the ages recorded at death are completely accurate, they are certainly much more accurate than the very high ages which appear in censuses.

5 The "explosion" of centenarians

From 1911 until the 1940s, there were only one or two hundred centenarians in England and Wales, and these were more objects of curiosity than anything else. Then, from the 1950s, the numbers started to grow, roughly doubling every ten years. This produced what was described as an "explosion," with the number reaching 4,062 in 1991, and an estimated 8,513 as of January 1, 2006. The increase from 1911 onwards is shown for selected years in Table 1, and illustrated in Figure 1.

It has been possible to identify the demographic reasons for this increase in considerable detail (Thatcher, 1999b, 2001). The rise in centenarian numbers was, in part, due to an increase in births between 1850 and 1895; in part, to the improvement in survival between birth and age 80; in very large part, to the improvement in survival between age 80 and age 100; and, in small part, to longer survival above age 100. Against these increases, there were reductions in the numbers reaching 100 due to war deaths and net migration.

6 Supercentenarians

Those who reach the age of 110 are known as supercentenarians. Only a few deaths were recorded at ages 110 and over before the year 1969, and there were some doubts about their accuracy. However, from 1969

Table 1. Numbers of centenarians in England and Wales

Year	1911	1921	1931	1941	1951	1961
Males	26	35	25	33	48	85
Females	76	103	145	141	247	472
Total	102	138	170	174	295	557

Year	1971	1981	1991	2001	2005	2006
Males	164	281	455	649	916	1024
Females	1,022	1957	3607	5742	7157	7489
Total	1,186	2238	4062	6391	8073	8513

Note: 1. Estimated numbers aged 100 and over at 1st January in selected years.
2. Numbers from 1991 onwards are not yet final.

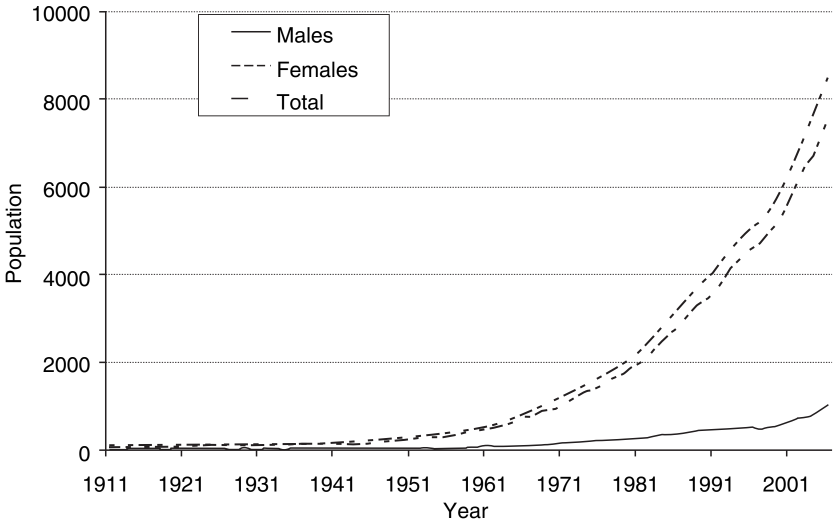

Fig. 1. Numbers of centenarians in England & Wales. (Population aged 100 years and over on 1st January, England & Wales, 1911 to 2006)

onwards all the entries in the registers showing deaths at ages 110 and over were checked systematically, to see whether it was possible to trace a corresponding entry in the birth register 110 years before. If such an entry was found, giving the correct name, date of birth, and place of birth, then the case was described as "verified." It must be remembered, though, that if a supercentenarian death was not verified by this procedure, this did not mean that it was necessarily incorrect. For example, immigrants from other countries would not have had their births recorded in the registers of births in England and Wales, and so could not be verified, even if they had genuinely reached 110 years.

The first list of names of verified supercentenarians in England and Wales showed two males and 19 females, who died between 1968 and 1990. The two males, whose names keep recurring, were John Moseley Turner (1856-1968) and John Evans (1877-1990). The names of all the 21 supercentenarians were published in the paper by Thatcher (1992), which appeared in the research journal *Population Studies*. There was a reason for this. The Office of Population Censuses and Surveys (OPCS), which, in principle, might have published the names itself in one of its official publications, was a statistical organization. It took pride in producing statistics in ways which preserved confidentiality and revealed no information about individuals. On the other hand, the information in the registers of births, marriages, and deaths was not confidential. In fact, under English law, since 1836 any member of the public has been able to obtain a copy of any entry in the registers on payment of a fee. A compromise was easily reached. OPCS did not object to the names being published in a research journal, provided they did not appear in one of its official statistical publications. For the same reason, the second list of names was published in the research journal *Population* (Thatcher, 2001).

By the time of the second list, there were still the same two verified male supercentenarians, but the number of females had grown to 44. The latest list (with deaths up to 2006) still shows the same two males, but now with 64 females. It is possible that the probability that a person who reaches age 100 will die before reaching age 110 may be slightly higher for males than for females, but the numbers are still small, and war deaths in 1914-18 may be relevant. Be that as it may, the cumulative total number of supercentenarians in England and Wales continues to grow. This can be seen from Table 2.

A recent development is that the Office for National Statistics (ONS), which incorporates the former OPCS, now produces frequency

Table 2. Verified cases of supercentenarians

Period	Number of verified cases	Highest verified age
1968-1972	2	111
1973-1977	2	112
1978-1982	7	112
1983-1987	3	114
1988-1992	7	113
1993-1997	17	115
1998-2002	15	115
2003-2006	13	112

Note: Verified cases of deaths at ages 110 and over, England and Wales

distributions for the causes of death of supercentenarians, though not linked to names.

7 A very early supercentenarian

We have described the publication of the names of validated cases of supercentenarians who died in England and Wales from 1969 onwards. There was, however, a much earlier supercentenarian who has been most carefully validated. Her name was Katherine Plunket. She was born on November 20, 1820, and died on October 14, 1932, at the age of 111. She therefore became a supercentenarian in 1930.

She was born and died in Ireland, where she owned a house, but she also owned a house in London. She therefore had at least a partial connection with England and Wales.

Katherine Plunket was a member of the Anglo-Irish aristrocracy. Her grandfather was a Lord Chancellor of Ireland. Her father became a Bishop and inherited the title of Baron Plunket. Her cousins included three titled members of the aristocracy. She was the eldest of six children, but she never married and all her sisters predeceased her. In her later years, she lived alone with her servants, but she traveled extensively and was very well known. At the age of 109, she received congratulations from King George V. She had obituary notices in both the Irish and London newspapers.

There is no shortage of documentation about the entire life of Katherine Plunket. However, perhaps her most important demographic entries appear right at the beginning. She was baptized on December

13, 1820, and was then recorded with her family in the Census of Ireland in 1821.

The year 1930 is very early for the appearance of a genuine supercentenarian in any country. However, Katherine Plunket had near-contemporaries in England and Wales who reached ages 107, 108 and 109, and she lived only two years longer than this. The example of Mme Calment has shown how contemporaries can be outlived.

The documents on Katherine Plunket were traced and assembled by Julia Hynes. For full details, see Thatcher (1999c).

8 Probabilities of dying and the limit to life

We are interested not only in the numbers of people who reach ages 100 and 110, but also in how long they survive. We use the standard terminology. If a number of people reach the exact age x, then the proportion of them who die before reaching age $x + 1$ is denoted by $q(x)$, and this is often described as the probability of dying (within 12 months).

It is not so long ago since it was widely believed that there is a fixed biological limit to the lifespan of the human species, which cannot be exceeded. If this were so, the probability of dying $q(x)$ would start to rise towards 100% as the limit of life is approached. It used to be very difficult to measure these probabilities, but, with the recent explosion in numbers at very high ages, combined with the use of the method of extinct cohorts, it is now much easier.

To cut a long story short, $q(x)$ so far shows no sign of reaching anywhere near 100%. There has been theoretical work on the "trajectory" of mortality, which expresses the force of mortality as a function of age. This work has been based on data for many countries and current theories suggest that $q(x)$ will not exceed a ceiling (asymptote) of about 0.6. There is no firm evidence that this value has been reached in any country (Kannisto, contribution to the discussion on Thatcher, 1999a).

Table 3 shows the official estimates of $q(x)$ for centenarians in England and Wales in 1985-1995, and in 1995-2005. The table does not extend above age 104 for males, and 106 for females, because at ages higher than these there were fewer than 100 deaths in either decade, so that any estimates based directly on the data for deaths will have high standard errors. However, it is notable that the estimates given in Table 3 show no fall in $q(x)$ between the two decades.

The observed values of $q(x)$, at least in England and Wales in 1985-1995, were still less than 0.48, at least up to age 106 for females, and

Table 3. Probability of dying within 12 months $q(x)$

	Males		Females	
Age	1985-1995	1995-2005	1985-1995	1995-2005
100	0.38	0.38	0.35	0.35
101	0.40	0.41	0.37	0.37
102	0.41	0.43	0.38	0.39
103	0.42	0.41	0.39	0.42
104	0.43	0.44	0.43	0.44
105			0.45	0.45
106			0.44	0.48
107				
108				

104 for males. Even at these very high ages, a person chosen at random will still have a better-than-equal chance of living for at least one more year.

9 Prospects for the future

We have described how the number of centenarians in England and Wales, once fewer than 300 until the 1950s, then started to "explode," and reached about 8,513 on January 1, 2006. Projections for the future are published by the Office for National Statistics. Table 4 gives the latest official (2006-based) projection which reaches 486,000 in 2076. Figure 2 illustrates this, and also shows an unpublished continuation (assuming no changes in trends) which reaches about a million centenarians in 2106. Although views on future trends may change, any revisions seem unlikely to change the prospect that a huge further increase in the number of centenarians is to be expected; provided, presumably, that there will be enough carers to look after so many.

Table 4. Projected numbers of centenarians

Year	2008	2026	2046	2066	2076
Official principal projection	10,000	32,000	167,000	403,000	486,000

Note: Projected number of centenarians in England & Wales in selected years (1 Jan).
Source: Data derived from 2006-based principal population projections for England and Wales

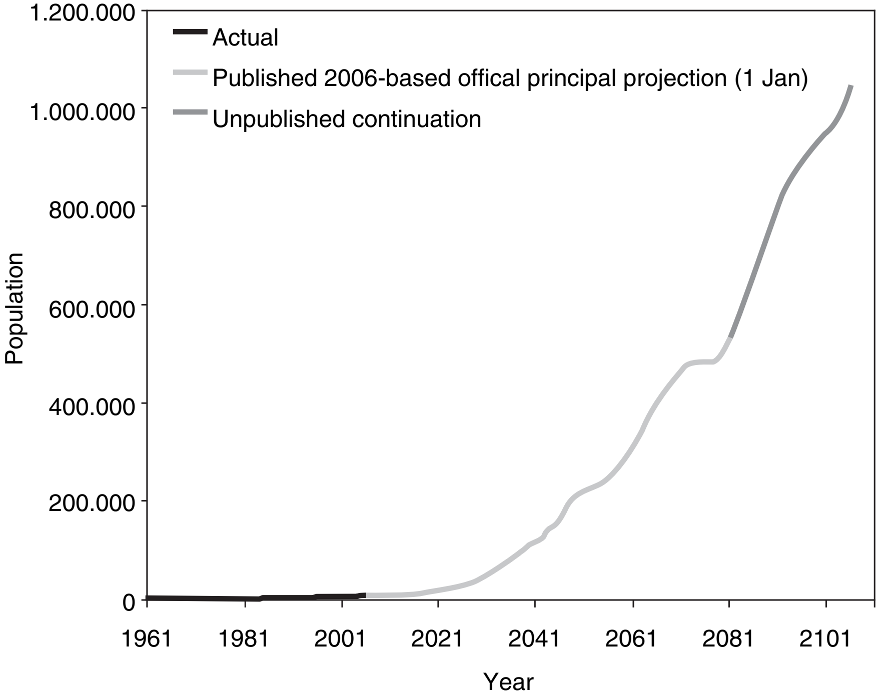

Fig. 2. Actual and projected number of centenarians in England & Wales

Note: Population aged 100 years and over on 1st January, England and Wales, 1961 to 2106

This large impending increase in the number of centenarians means that the record for the highest age can be expected to rise. According to the theory of the highest attained age (see Thatcher, 1999a), the highest age depends not only on the death rates, but also on the numbers. A record age is more likely to happen in a large population than in a small one. Put another way, if only one person reaches (say) 115, then nobody may reach 116. On the other hand, if numbers grow so that several reach 115, we shall not be so surprised if one of them reaches 116. This is how the record age can increase.

The highest age at death in a calendar year varies from year to year, within a range of about six years of age. The highest age recorded so far in England and Wales is 115 years. As the century advances, and if the number of centenarians increases as projected, this highest age can be expected to rise to at least 119 years, and may possibly even exceed the age of 122 years that has already been reached by Mme Calment in France.

Some fairly high ages are to be expected when the large cohort born in 1966 reaches the relevant age range, around the year 2080. This may sound like a long way ahead, but the people born in 1966 are already aged 42.

Acknowledgement

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Supercentenarians in the Nordic Countries

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Abstract. The Nordic countries have a well-developed system of population registration that goes back several hundred years, making it possible to verify individuals with extreme ages. In this chapter, we briefly describe the history of population registration and procedures for registration of births and deaths in Denmark, Finland, Norway, and Sweden. Historically, the church has played a central part in the registration of births and deaths in all countries, and national population registers have emerged in all countries in the second half of the 20th century. Based on statistical reports from the national statistical offices, the movement in the numbers of extremely long-lived individuals, like centenarians and supercentenarians (aged 110 years and above) can be followed. However, in order to accurately describe this development, we must first verify the ages of extremely long-lived individuals. It is, therefore, imperative that we are able to identify the persons in question. For research purposes, identification of these very long-lived persons is possible from the population registers. We report basic data on the supercentenarians identified in the four Nordic countries since 1980, together with verification status. In addition, we provide an example that illustrates the importance of being able to identify the individuals.

1 Introduction

Humans reaching extreme old age have fascinated society for the last couple of centuries, and a number of men who lived several hundred years ago became famous for allegedly attaining very high ages. One

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example is the sailor Christian Drakenberg, who is said to have reached the age of 144/146 before dying in 1787. His life was so exceptional that a contemporary writer wrote a biography of him. Nobody at that time questioned his age, or that of other legendary figures with very long lives, but, about a century later, Thoms proposed that a number of criteria should be fulfilled before someone could claim to have attained an exceptionally high age (Thoms 1873). The legend of Drakenberg has not survived the rigorous examination of his life; information provided in his biography allowed claims about his age to be tested, and it was subsequently shown that several events of his life had been falsified (Ørberg 1972).

In order to study extreme old age, it is of vital importance that the ages of the persons studied are trustworthy. This means that tools and ways of validation must be available to the researcher. It is a question of collecting information needed to verify not only the age, but also the identity, of the person, and a key source for this information is the population registration and the registration of demographic events. Drakenberg is an example of a person whose alleged age could be checked through historical documents and registration of demographic events. The Nordic countries offer excellent options for checking and validating the extreme age of a person. In this chapter, we describe these options in Denmark, Finland, Norway, and Sweden; all countries where at least one person has reached the age of 110. No person from Iceland has yet reached the age of 110, and therefore we do not include Iceland in this chapter. In addition, we provide an overview of the increase in the number of centenarians and supercentenarians in these countries. Finally, basic information on the Nordic supercentenarians of the 20th century is presented.

2 Population registration

The population registration procedures in the Nordic countries share several features, as the development of the registration systems in each of these countries has more or less followed the same track. There are historical reasons for the parallel development in Sweden and Finland, since Finland was part of the Swedish kingdom until 1809, when Finland came under Russian control. However the central administration and administrative procedures from the time of Swedish sovereignty were maintained, even after 1917, when Finland proclaimed its independence.

Similarly, since the 15th century, the Danish king was also the king of Norway. This had a significant impact on Norwegian legislation, and Danish civil servants dominated the administration, both centrally and locally, in the following centuries. In 1814, Denmark was forced to relinquish its sovereignty over Norway, with Norway becoming a part of the Swedish-Norwegian Union. As was the case in Finland, the civil administration remained nearly unchanged from the Danish period. Norway gained independence in 1905.

There are two main traditions for civil administration, and, thereby, registration of the population and changes in the population (i.e, demographic events) in the Nordic area: The Swedish and the Danish. But there are also similarities: both traditions are centered around the church due to the importance of the church in even the most remote parts of the Nordic region at the time of the introduction of population registration.

Population registration in Denmark can be dated back to the 16th century, when the first regular recordings of births, marriages, and deaths took place in some areas (Johansen 2002). Regular parish registers became the norm across Denmark as a result of a missive in 1645 from the Danish king to the Bishop of Zealand. Later, in 1683, the Danish Law of King Christian V included paragraphs of significance for population registration. The law stated that the duties of the vicar in a parish included keeping a book with the names of those who had been born, had died, or were married, along with the dates of these events. The duties were given a more explicit formulation in 1685 in an ecclesiastical law for Denmark and Norway. However, the guidelines for the exact content were rather vague, which resulted in a heterogeneous structure of the registers. From 1812, new and clearer instructions on the content of the parish registers resulted in a much more strict layout, with the introduction of separate sections for births, confirmations of baptism, marriages, and deaths. This basic structure of the parish registers has, with minor modifications, remained unchanged until today. One exception is that, until the end of the 19th century, the parish registers also included lists of migrations, although only a part of the population had to report their migration.

By 1924, a new municipal population registration system was established parallel to the parish registers. The purpose of the municipal population register was to register relevant demographic information, including the address of each inhabitant in the municipality and any changes in the population (births, deaths, migration, etc.), thereby keeping an updated list of all inhabitants in the municipality. The manually kept population registers in the municipalities were replaced in 1968 by the National Civil Registration System (CRS), a computerized central population register comprising all persons who were alive as of April 2, 1968, or who were born after that date, and who had residence in Denmark. At the same time, the 10-digit personal identification number (PIN) was introduced, and the PIN is used in all public administration on the individual level. Despite the introduction of this system, the key institution for registration of demographic events in Denmark remains the vicar in the local parish. Every birth and death is to be reported to the local vicar, who then informs the CRS.

As a supplement to information collected by these constantly updated parish registers, national censuses have been used to enumerate the total population every five or 10 years since 1840, with a few earlier censuses having been conducted at irregular intervals since the first one was taken in 1769. The information collected in these early censuses was centered on households, and included data on address, name, age/date of birth, sex, marital status, occupation, relation within a household, and, since 1845, place of birth. Since 1971, the traditional paper-based census has been replaced by yearly computer-generated censuses based on the information available in the CRS.

In Norway, the earliest parish registers date from around 1640. The structure of the parish registers and the instructions on how to maintain them were mainly the same as in Denmark until the middle of the 19th century. Only minor changes were introduced subsequently; e.g., lists of vaccinations were added in 1820, and special lists for people who did not belong to the Norwegian Church were introduced in 1858. As in Denmark, it was the responsibility of the vicar to register all births and deaths in the parish, irrespective of the religious beliefs of the residents. There was also a requirement that migrations be registered, but not all residents followed the rules, so the lists are not complete. Until the beginning of the 20th century, the parish registers served as a kind of population register, but with a low degree of accuracy with respect to migration.

Although civil birth registration was introduced in 1916, it was still in the hands of the vicars of the parishes to keep and maintain the birth registers, and they had to report the data relating to births to the Norwegian Statistical Bureau. The Bureau received reports regularly from the vicars of the Norwegian State Church, but reports were often lacking from the heads of local religious communities that dissented from the State Church, especially as these were often located in very remote areas of Norway. The accuracy and reliability of the population statistics must, therefore, be viewed cautiously until after the Second World War (Soltvedt, 2004).

Population registers were established locally on a voluntary basis in 1905 with the introduction of the Kristiania (now Oslo) population register, followed by the Bergen population register in 1911. Population registers were established in the most densely populated areas. However, only half of the population were registered in local population registers around 1940. From 1946, it became compulsory for each municipality to establish a population register. In 1964, the state took over the responsibility for population registration with the establishment of the national population register (DSP) under Statistics Norway. In 1991, DSP was transferred to the taxation department (Soltvedt, 2004).

In Sweden (and Finland), the introduction of population registration took place at almost the same time as in Denmark and Norway, and followed more or less the same track, with one important addition. From 1686, it was compulsory for each parish to keep registers on births, deaths, migrations, marriages, and divorces. In addition to these traditional registers, a special register was introduced to keep track of literacy, understanding of the Bible, and other matters of interest to the clergy. This special register, the "Husförhörslängden," became a population register that contained information on all persons living in the parish, including names and dates of birth. It was centered on the households, and all demographic events related to members of a household were registered. Thus, the Husförhörslängden could be used to ascertain the actual population of a parish at any given time, provided the vicars were making the required updates (Lundström 1995). The parish registers formed the bases for the compilation of population statistics when the Swedish statistical office was established in 1749. As the interest in population matters increased during the 18th and 19th centuries, the quality of the registers gradually improved; and, from 1860, strict quality controls were carried out by Statistics Sweden, the agency that compiled the population statistics based on copies of all parish registers. The church remained responsible for the basic collection of demographic data until 1991, when the local tax offices took over the task. A computerized central population register was introduced in 1967 based on the 10-digit personal identification number, which had been in use since 1947 in Sweden.

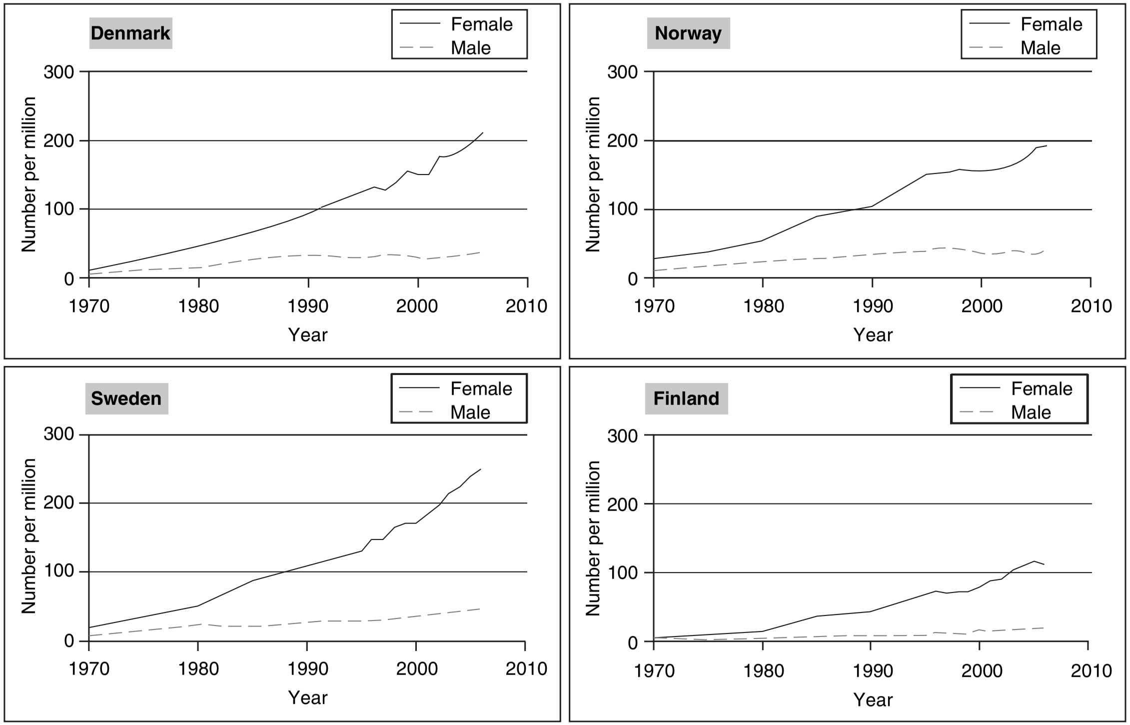
The existence of the central population registers in the Nordic countries makes it possible to follow individuals from day to day, and, with the additional data that is often stored in the registers about relatives and historical data, the validation of extreme ages is possible. Difficulties may arise, however, from different laws in the Nordic countries regarding the protection of privacy. The national statistical offices may publish tables of the age structure of the population, but the validation of the highest ages depends on the ability to identify the person in question. Identification is possible in Denmark, Finland, and Sweden, but not in Norway, where researchers must rely on newspaper notices that name the person.

3 Emergence of supercentenarians in the Nordic countries

Although several claims for reaching the age of 110 or more in the 18th and 19th centuries have been published, we will restrict this discussion to the 20th century, since the earlier claims cannot be verified using the criteria commonly accepted among researchers.

Through the second half of the 20th century, the number of centenarians increased tremendously in all industrialized countries. The centenarian age group is the fastest growing segment of the population (Kannisto 1997). In Figure 1, the number of centenarians per million inhabitants in the four Nordic countries is shown for the last 30 years. An almost exponential increase is observed for women in most countries: the figure reported in 2000 of about 150 centenarian women per million women is five to ten times that of 1970. For men, however, the increase has been slower than for women. The sex ratio among centenarians has actually increased during the 30-year period, from about three women to each man in 1970, to about five women for each man in 2000.

The increasing number of centenarians also improves the chances of reaching remarkably high ages, such as 105 and 110 years. This is illustrated by Figure 2, which shows the number of people reaching the age of 105 in the Nordic countries since 1940. But the actual number of people reaching age 105 is rather low compared to the number of centenarians; in the period shown, fewer than 75 individuals reached age 105 in any year in the four Nordic countries taken together. Kannisto (1997) has calculated the chances of surviving from age 100 to age 110 in different periods for male and female centenarians, respectively; based on data from the most recent period (1980-1990), it has been estimated that fewer than one out of 1,000 male centenarians will reach age 110, while about 2.1 out of 1,000 female centenarians will celebrate their 110th birthdays.



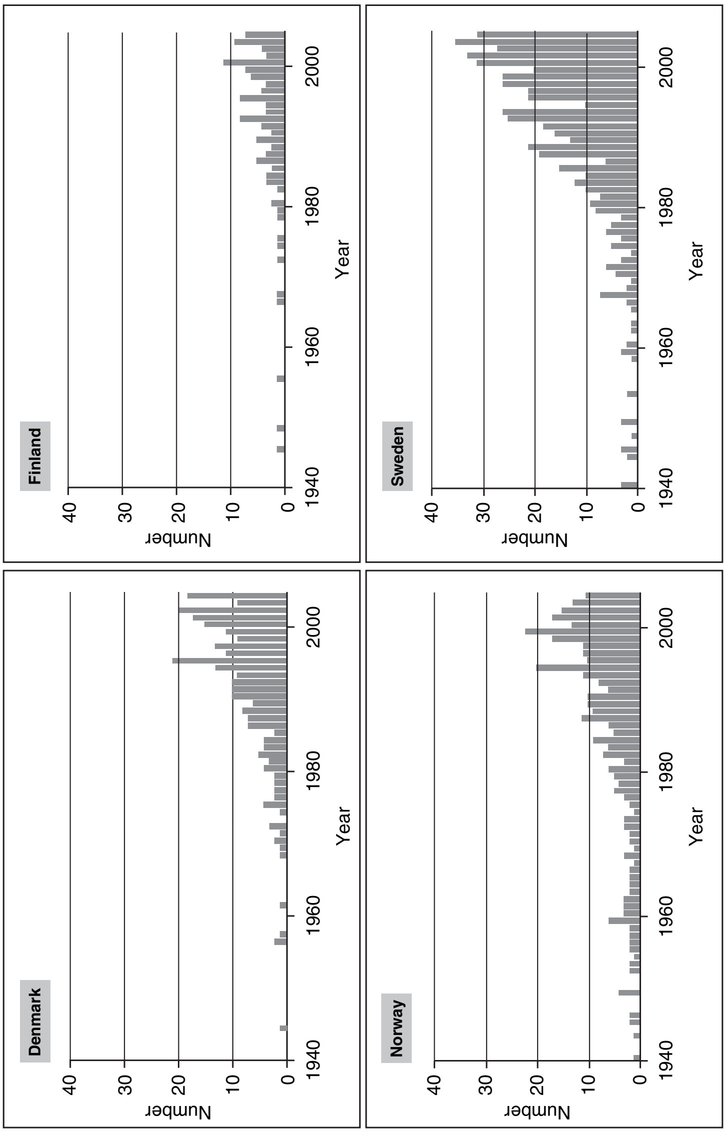
Source: National statistical offices

Fig. 1. Number of centenarians per million inhabitants in each of the four Nordic countries

Every year, the national statistical offices in Scandinavia publish the number of people alive as of January 1 for each single age. These tables can be found online (for links, see the end of the chapter). From these statistics, it is possible to calculate the population dynamics based on the extinct cohort method (Vincent 1951). One assumption for using the method is that there is no migration for the cohorts under study, and this is normally the case in studies of centenarian populations. However, the increasing migration, especially of people from countries with fragmentary or no population registration systems, poses new problems when using the yearly published data from the statistical offices in the study of supercentenarian, and centenarian, demography. For example, two female immigrants from countries with less rigorous systems of population registration were registered as supercentenarians in the Swedish data, one in 1998, and the other in 2001. Another immigrant case from Finland is Andrei Kuznetsov ("Father Akaki"), who was born in Poland and died at the age of 110 years and 106 days in 1984. Such cases will be extremely hard to validate, and, until proven, they will not appear on the list of supercentenarians.

In rare cases, irregularities can be resolved, as an example drawn from official data released by Statistics Norway demonstrates. According to the data for January 1, 1987, a 111-year old-man had turned up out of nowhere. Normally, such a person would have appeared in the data from the year before, but as one year younger. In this case, however, there was no mention of a man in the previous year who was one or two years younger. The data point for this 111-year-old man would have been treated as an error in the statistics, had it not been possible to check this special case. The man in question turned out to be a Norwegian-born emigrant, Herman Smith-Johannsen, who had lived in Canada for many years. For some reason, he traveled to Norway to visit relatives at the end of 1986, and the Norwegian civil authorities registered his visit. Since he was in the country on January 1, 1987, he ended up in the population statistics as the oldest man ever in Norway! Apparently, supercentenarians travel just like other people! Smith-Johannsen died shortly after January 1, 1987, at the age of 111.

Supercentenarians did not emerge in the Nordic countries until the 1980s, based on verified cases (see discussion that follows). Table 1 lists the numbers of supercentenarians in the Nordic countries as of January 1 of each year since 1984. A more accurate picture can be obtained by taking into account the actual dates of birth and death of individual supercentenarians. This is done in Figure 3, which shows in detail the numbers of supercentenarians in Denmark, Finland, Norway,



Source: Kannisto Thatcher Database

Fig. 2. Number of persons reaching age 105 years each year since 1940 in the Nordic countries

and Sweden since 1984. The first supercentenarian to be registered, in October 1984, was a Norwegian-born woman living in Sweden (see Table 2). During most of the 1980s, one (and for short periods, two) supercentenarian was alive, but from 1990 to 1992 no supercentenarian was living in the Nordic countries. With the exception of two periods of a couple of weeks' duration, at least one person aged 110 has been living in one of the Nordic countries since January 1997.

Table 1. Number of living supercentenarians in the Nordic countries as of January 1 of each year since 1984. Each letter represents one supercentenarian. D = Denmark, F = Finland, N = Norway, S = Sweden

January 1, Year	Number	January 1, Year	Number
1984		1997	NN
1985	S	1998	FNN
1986	S	1999	FNSS
1987	NN	2000	DFNS
1988	N	2001	NS
1989	FNN	2002	S
1990		2003	NSS
1991		2004	N
1992		2005	F
1993	S	2006	S
1994	S	2007	F
1995	D	2008	S
1996	DN		

Note: An additional two Norwegian, three Swedish and one Finnish supercentenarians died within the same year they turned 110 years.

A list of all known supercentenarians who were born, lived, and died in the Nordic countries since 1950 is given in Table 2. Age verification has been performed on three different levels, which are defined as follows. Level A corresponds to the highest level, which requires full official documentation of birth registration (transcription of birth registration), death registration (either death certificate or other official death registration), knowledge of family members (siblings, parents), and at least one registration at a time other than birth and death. Level B corresponds to the medium level, which requires documentation of birth registration (transcription of birth registration) and death registration (either death certificate or other official death registration). Finally, level C corresponds to the lowest level, which is used when

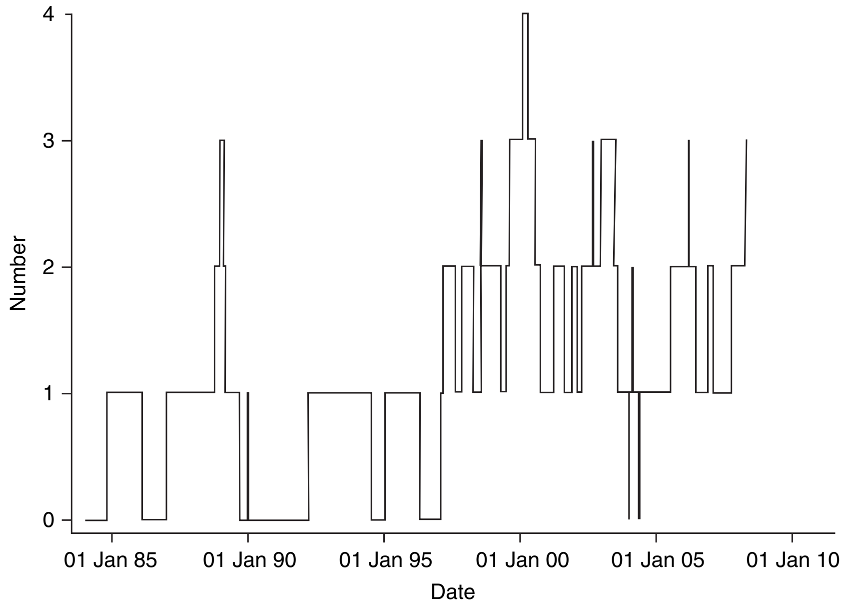


Fig. 3. Emergence of Nordic supercentenarians based on dates. Only supercentenarians with known dates of birth and death are included

the date of birth and date of death are known from the media but are not documented, and the existence of a person with the given age is consistent with data from the national statistical offices.

In addition to the supercentenarians mentioned in Table 2, a Norwegian man aged 111 years appeared on the official list from Statistics Norway on January 1, 1999, but not on the list for the following year, indicating his death in 1999. Similarly, a woman aged 110 years was on the list on January 1, 2001. However, both these cases appear to be false. A possible explanation is a failure to report migration to the population register, and a subsequent lack of follow-up from the population register. The woman mentioned above was born on November 2, 1890, in Denmark, and lived for a time in Oslo. She was registered as having immigrated to Norway from Denmark on July 1, 1974. According to the last entry in the population register, she moved to an unknown location on October 17, 2001. Since she came from Denmark in 1974, it was possible to find her entry in the Danish population register in 1974, when she moved to Oslo. Additional entries were also found: she was married to a Danish man in 1967, and had an address in Denmark from August 1973, but there was no mention of her departure for Norway in

Table 2. Supercentenarians in the Nordic countries as of February 18, 2008. When the country of birth differs from the country of death, the same person may be listed in both countries. Males are indicated by an asterisk. Level corresponds to the verification level (see text)

Name	Date of birth	Date of death	Age (days)	Level
Denmark				
Anne Cathrine Matthiesen	November 26, 1884	March 19, 1996	111 (114)	A
Karen Marie Jespersen	May 5, 1889	August 4, 2000	111 (91)	A
Johanne Svensson	January 24, 1892	May 29, 2003 (S)	111 (125)	B
Finland				
Fanny Matilda Nyström	September 30, 1878	August 31, 1989	110 (335)	B
Lempi Maria Rothovius	October 2, 1887	June 17, 2000	112 (259)	B
Hilda Häkkinen	March 18, 1894	December 31, 2005	111 (288)	C
Anna Hagman	December 27, 1895	April 18, 2006	110 (112)	C
Elsa Tilkanen	September 26, 1896	December 5, 2006	110 (70)	C
Aarne Armas Arvonen*	August 4, 1897			C
Norway				
Wilhelmine Sande	October 24, 1874	January 21, 1986 (S)	111 (89)	C
Maren Bolette Torp	December 21, 1876	February 20, 1989	112 (61)	C
Kristianna Ullaland	December 2, 1878	January 26, 1989	110 (55)	C
Åsne Hustveit	December 2, 1879	December 7, 1989	110 (5)	C
Laura Hansine Svehaug	December 19, 1886	March 6, 1998	111 (107)	C
Karen Svisdal	December 16, 1889	February 23, 2000	110 (59)	C
Olav Hovatn*	October 23, 1892	April 26, 2003	110 (185)	B
Harriet Holm	November 13, 1893	December 22, 2003	110 (39)	C
Borghild Marie Nilsen	December 2, 1893	March 3, 2004	110 (92)	C
Sweden				
Wilhelmine Sande	October 24, 1874 (N)	January 21, 1986	111 (89)	C
Hulda Beata Johansson	February 24, 1882	June 9, 1994	112 (105)	C
Ellen Johansson	January 23, 1887	July 6, 1997	110 (164)	C
Hilda Grahn	June 10, 1888	June 24, 1998	110 (14)	C
Teresia Lindahl	June 10, 1888	March 2, 1999	110 (265)	C
Elsa Moberg	June 30, 1889	November 27, 2001	112 (143)	C
Hanna Erikson	February 26, 1891	June 26, 2001	110 (120)	C
Jenny Karlsson	October 17, 1891	July 13, 2002	110 (269)	C
Johanne Svensson	January 24, 1892 (DK)	May 29, 2003	111 (125)	B
Anders Engberg*	July 1, 1892	November 6, 2003	111 (128)	C
Astrid Elin Zachrison	May 15, 1895			C
Hulda Carlsson	February 2, 1898			C

July 1974. However, she was registered as dead in Copenhagen on May 8, 1975, and her death was verified by an entry in the death register in the church book with data consistent with those from Norway. Similar problems have been found among a small, but significant, number of cases of supposed centenarians from Norway.

Another very special case that we have chosen not to include in the list due to incomplete verification is a woman from Finland, Maria Andersson, who died in 1946 at the age of 117 years. According to available information, she was born on December 24, 1828, in the town of Viipuri, Finland, and died on August 24, 1946. She was known and celebrated as the oldest inhabitant of Helsinki in the years 1930-1946. Her exceptionally high age also demands an exceptionally high level of verification in order to be accepted, requiring birth and death registration and very good information about her family. Unfortunately, the archives that included birth registrations in Viipuri were lost during World War II, so no formal verification of her birth is possible. The evidence for her having been born in 1828 is a note in the family Bible that her mother kept. Currently, we are searching for additional data to support or reject her as the oldest person from the Nordic countries.

Since 1984, 28 Nordic supercentenarians have emerged. The women dominate the list, with only three men appearing alongside 25 women. A further four known supercentenarians are of Nordic origin. Two Norwegian-born women reached 110 years of age in the United States in 2003 and 2004; the two remaining supercentenarians are males, and one has been mentioned above. The other man is the Danish-born Chris Mortensen, who also appears to be the oldest man ever in the world (Wilmoth et al., 1996). Although he emigrated to the U.S. in the beginning of the 20th century and lived there until his death in 1998, his age is extremely well-documented. This was partly due to the existing parish records in Denmark, which documented his birth and his family relationships, but the ability to conduct personal interviews with Mortensen gave an unusual and important opportunity to obtain evidence for Mortensen's age and identity. During these interviews, Mortensen talked about his family and incidents from his childhood and youth, which could subsequently be verified in Denmark (Skytthe et al., 1999).

The oldest Nordic woman is the Swedish supercentenarian Astrid Zachrison, who is still alive as of February 18, 2008, at the age of 112 years and 279 days. The oldest persons from Finland and Norway are Lempi Maria Rothovius, who reached the age of 112 years and 259 days, and Maren Bolette Torp, who died at the age of 112 years and 61 days. Only three men have reached 110 years of age, and Anders Engberg from Sweden is the oldest man, having died at the age of 111 years and 128 days. Only three supercentenarians are alive as of February 18, 2008, two in Sweden and one in Finland.

Although the population registration systems are well established and can be regarded as highly reliable in the Nordic countries, verification at the highest level has not yet been attained for all supercentenarians. However, all the supercentenarians listed in Table 2 are credible to the extent that they correspond to the numbers given by official statistics, and they have been submitted to the IDL database. Work is in progress verifying all persons to at least level B, but this is a time-consuming process, and not all information may be available publicly.

Links to the national statistical offices

Denmark:	www.dst.dk
	www.statistikbanken.dk
Finland:	www.stat.fi
Norway:	www.ssb.no
Sweden:	www.scb.se

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Part III

Research on supercentenarians

Human mortality beyond age 110

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Abstract. The International Database of Longevity (IDL) offers detailed information on thoroughly validated cases of supercentenarians. These data are used to estimate human mortality after age 110. The procedure properly accounts for the country-specific sampling frames in the IDL. The analysis confirms that human mortality after age 110 is flat at a level corresponding to an annual probability of death of 50%. No sex-specific differences in mortality could be found, and no time trend in supercentenarian mortality between earlier and later cohorts could be detected.

1 Introduction

The principal motivation for undertaking the effort of collecting data on supercentenarians in the International Database of Longevity (IDL; see Chapter 2 in this volume) is to estimate human mortality at the most advanced ages, based on information that is age-ascertainment bias-free and thoroughly validated. The shape of the hazard trajectory at the most advanced ages is interesting in itself, but it also has important implications for interpreting the general principles that rule human mortality.

While the exponential increase in the force of mortality, as described by the Gompertz distribution, is accepted for mid-adult and early old ages, there is general agreement that mortality increase slows down after about age 80 to 85, a phenomenon most likely to be explained by earlier selection of the frailer individuals in heterogeneous cohorts. Investigating how this slowing down continues into the highest ages has, however, so far been limited by the availability of sufficient high-quality data. The data provided by the contributors to the IDL now offer the opportunity to make our knowledge more complete.

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Identifying (and subsequently validating) potential supercentenarians is a complex task that differs from country to country due to the different data sources available. The reports in Part II of this volume give a detailed account of the difficulties that needed to be resolved in each country. The sources available for identifying individuals in the relevant age-group has implications for the sampling frame, that is, for how individuals were selected for inclusion in the database. These sampling frames have to be taken into account in the estimating procedure to render valid inference. In particular, the way in which the individuals were identified implies certain truncation and censoring patterns.

The general patterns and the implications for the estimating procedure will be discussed in Section 2, followed by a description of the specific statistical model used. As censoring and truncation are particular forms of incomplete data, the expectation-maximization (EM) algorithm (Dempster et al., 1977) is a natural candidate for obtaining the actual maximum likelihood estimates. Section 3 explains the general principle, while the technical details are provided in the appendix at the end of the chapter. The results for supercentenarian mortality are reported in Section 4, and a summary of the findings concludes the chapter.

2 Sampling frames and likelihood

As the IDL involves individual data with ages given up to the day, we can model on a continuous age-scale. This is conceptually easier and allows for a leaner notation. We will therefore outline the general steps of the analysis in continuous time before moving on to a more specific model in the next section.

We are interested in the random variable X describing the distribution of human life spans after age 110. Its distribution can uniquely and equivalently be characterized by its density $f(x)$, its survival function $S(x) = P(X > x)$, or, most prominently in mortality analysis, its hazard $\mu(x) = f(x)/S(x)$. Once an appropriate distributional family is selected, indexed by an unknown parameter(vector) θ, this parameter will have to be estimated. Maximizing the likelihood function will be the method of choice, due to its good statistical properties overall.

Assuming independent individuals, the likelihood function $L(\theta)$ is the product of the individual contributions $L_i, i = 1, \ldots, n$, for the n individuals in the sample,

$$L(\theta) = \prod_{i=1}^{n} L_i \quad \text{or on log-scale} \quad \ln L(\theta) = \sum_{=1}^{n} \ln L_i. \qquad (1)$$

The individual terms have to reflect exactly the information an individual observation contributes. This includes whether we have exact information on the age at death x_i, or whether the information is censored because we only know that the individual has survived a certain age (right-censoring), or has died between two ages (interval-censoring). The latter typically results if living supercentenarians are listed annually.

Truncated information has to be incorporated in the same way. An observation is truncated if the individual was selected into the sample only because he or she met a certain condition *related to the random variable investigated*. In our case, this means that an individual is included in the sample only because he or she survived a certain age (left-truncation), or because he or she died before reaching a particular age (right-truncation).

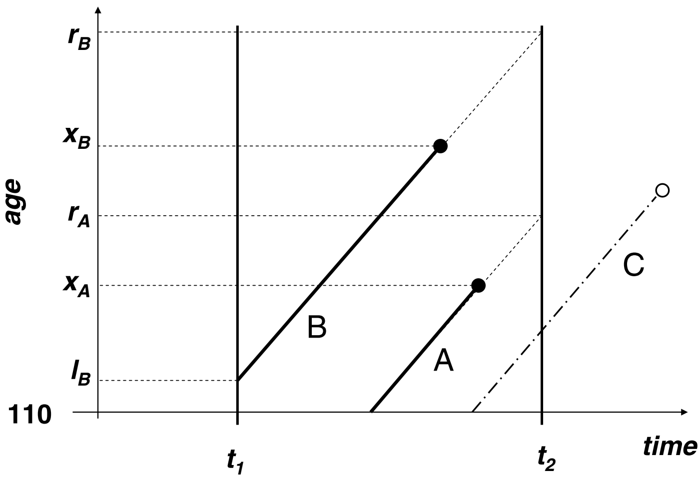


Fig. 1. Sampling frames: Right- and left-truncated observations.

There are several different sampling frames represented in the IDL data, but one of the most common is the identification of supercentenarians based on lists of deaths after age 110 that occurred between two calendar times t_1 and t_2. Figure 1 shows individuals in such a sampling frame in a Lexis diagram.

Individual A, who turned 110 during the observation interval $[t_1, t_2]$, is observed only because he or she did not survive the age r_A that he or she would have reached at time t_2. This individual is right-truncated at age r_A. Assuming we have an exact age at death x_A of individual A, his or her likelihood contribution would have to be

$$L_A = P(X = x_A \mid X \le r_A) = \frac{f(x_A)}{1 - S(r_A)}\,. \tag{2}$$

In the same way, individual B is right-truncated at age r_B. However, additionally, B is in the sample only because he or she survived his or her entry age l_B. If this individual had died before we would not have seen it in the sample. Thus, individual B is left-truncated at age l_B:

$$L_B = P(X = x_B \mid X > l_B, X \le r_B) = \frac{f(x_B)}{S(l_B) - S(r_B)}\,. \tag{3}$$

In contrast, individual C, who crosses the observation interval but does not die in the interval $[t_1, t_2]$, is not seen in the sample.[1]

If we have age-at-death information only in an age interval, or survival information only, the respective numerators in (2) and (3) would have to be replaced accordingly. In general, truncation is concerned with the selective exposure pattern in the sample, while censoring deals with imprecise information on the event time. To practically estimate the parameters of interest, the model distribution, i.e., the specific form of $f(x)$, $S(x)$, and thereby $\mu(x)$, remains to be specified.

3 Statistical model and the EM-algorithm

The ultimate goal is to flexibly estimate mortality after age 110, without imposing a particular shape on the tail behavior of the distribution. As parametric continuous distributions determine the trajectory of the hazard in the limit, we have chosen a quasi-continuous approach (Pagano et al., 1994; Tu et al., 1993). The continuous distribution of X is approximated by a discrete distribution by clipping the age axis after

[1] For sampling frames that follow individuals from when they reach age 110 up until this so-defined cohort dies out, equation (3) still remains valid. $S(l)$ can be replaced by 1 (as in equation (2)), and the right-truncation condition can be pushed to infinity, i.e. $S(r = \infty) = 0$. The denominator in (3) then simply reduces to 1.

age $x_0 = 110$ into small intervals of length δ. The discrete probabilities p_j then correspond to

$$p_j = P(x_0 + (j-1)\,\delta < X \leq x_0 + j\,\delta), \qquad j = 1, \ldots, J.$$

The number of intervals J results from the requirement that the last interval covers the highest age at death. The discrete survival function correspondingly is denoted by $S_j = \sum_{k \geq j} p_k$, which leads to the discrete hazard $\mu_j = p_j / S_j$. If δ is chosen to be one year, then the μ_j directly give age-specific annual probabilities of death. Given that we have age-at-death information up to the day, we can choose δ much smaller than one year and thereby obtain a quasi-continuous estimate of $\mu(x)$ and $S(x)$. The unknown parameters θ in this model are the $J-1$ probabilities p_j (the last, p_J, automatically results from $\sum_j p_j = 1$).

If all individuals were fully observed, i.e., no censoring or truncation were present, then the log-likelihood (1) simply would be of multinomial form

$$\ln L(\theta) = \sum_{i=1}^{n} \sum_{j=1}^{J} I_{ij} \ln p_j \,, \tag{4}$$

where $I_{ij} = 1$, if individual i dies in interval j, and zero otherwise. The maximum-likelihood estimates are $\hat{p}_j = \sum_i I_{ij} / n$.

The simplicity of the complete-data likelihood (4) makes an EM-algorithm an appealing solution. Starting from a current estimate $\hat{\theta}^{(m)}$, the I_{ij} are replaced by the expected numbers $E_{ij}^{(m)}$ that are to be seen, but that cannot be observed due to the truncation or censoring present, as in the case of individual C in Figure 1.[2] This is the E-step.

The M-step maximizes this pseudo-complete data likelihood to obtain the next estimate $\hat{\theta}^{(m+1)}$. The procedure is continued until convergence. The main step in the EM-algorithm is the calculation of the expected values $E_{ij}^{(m)}$. Details are given in the appendix.

4 Results for supercentenarian mortality

The strategy laid out in the previous section was applied to the data in the IDL as of October 31, 2008. Only the most reliable data in the IDL were included, i.e., data from countries with information that was assessed to be of validation level A (see Chapter 2). The cases included come from the countries listed in Table 1.

[2] Turnbull (1976) pictorially called these ‘ghosts’.

Table 1. Number of supercentenarian cases included in the analysis.

Country	Cases	Country	Cases
Belgium	5	Nordic Countries	26
England & Wales	66	Quebec	10
France	49	Spain	28
Germany	17	Switzerland	4
Italy	37	USA	341
Japan	54		

The truncation and censoring patterns result from the sampling procedures in each country. Details on how individual cases were identified can be found in the country reports in Part II of this volume.

The total number of cases included was 637, of which 573 are females and 64 are males. Table 2 gives the ages at death in completed years. The birth cohorts of the individuals are listed in Table 3.

Table 2. Ages at death or at right-censoring of supercentenarians included in the analysis.

	110	111	112	113	114	115	117	119	122
Female	295	150	66	33	20	6	1	1	1
Male	29	17	10	4	3	1			

Table 3. Year of birth of supercentenarians included in the analysis.

1852–64	1865–69	1870–74	1875–79	1880–84	1885–89	1890–94	1895–99
6	10	47	85	152	248	80	9

As can be seen, about half (50.9%) of all individuals die within one year after becoming a supercentenarian, and about three-quarters (77.1%) die within two years after their 110$^{\text{th}}$ birthday.

Figure 2, top panel, shows the estimated hazard for an interval-length $\delta = 0.25$, i.e., a quarter of a year. The results are given on the hazard scale, that is, the discrete probabilities p_j were transformed assuming a piece-wise constant hazard. The dashed line represents a hazard level of $-\ln 0.5 \approx 0.7$, which was obtained by Robine et al. (2005) based on a much smaller set of supercentenarians. This hazard level corresponds to an annual probability of death of 0.5. As can be seen, the estimated hazard varies around this level, with stark fluctuations occurring after age 114 due to the small number of observations at these truly advanced ages. For the three most extreme observations, this model necessarily only gives three isolated spikes in the hazard. The corresponding log-survivorship curve is given in Figure 2, bottom. It clearly demonstrates the constant hazard up to about age 114 by its strikingly linear decline.

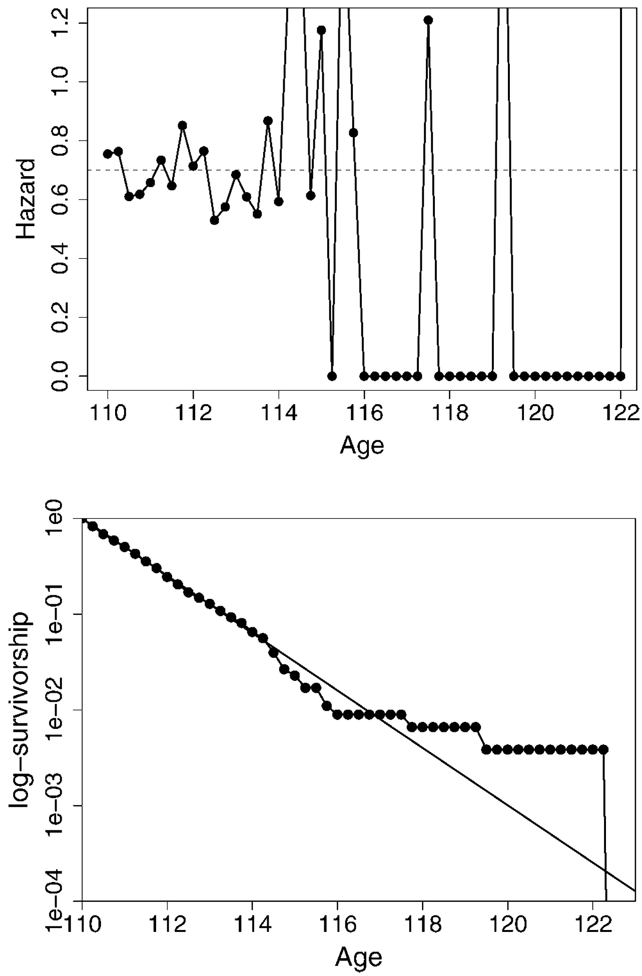


Fig. 2. Hazard (top) and log-survivorship (bottom) estimated for $n = 637$ supercentenarians.

Death rates at older ages have been declining in recent decades, and mortality improvement has been shifting into higher and higher ages. It is therefore natural to wonder whether a time trend in mortality can be observed in death rates after age 110.

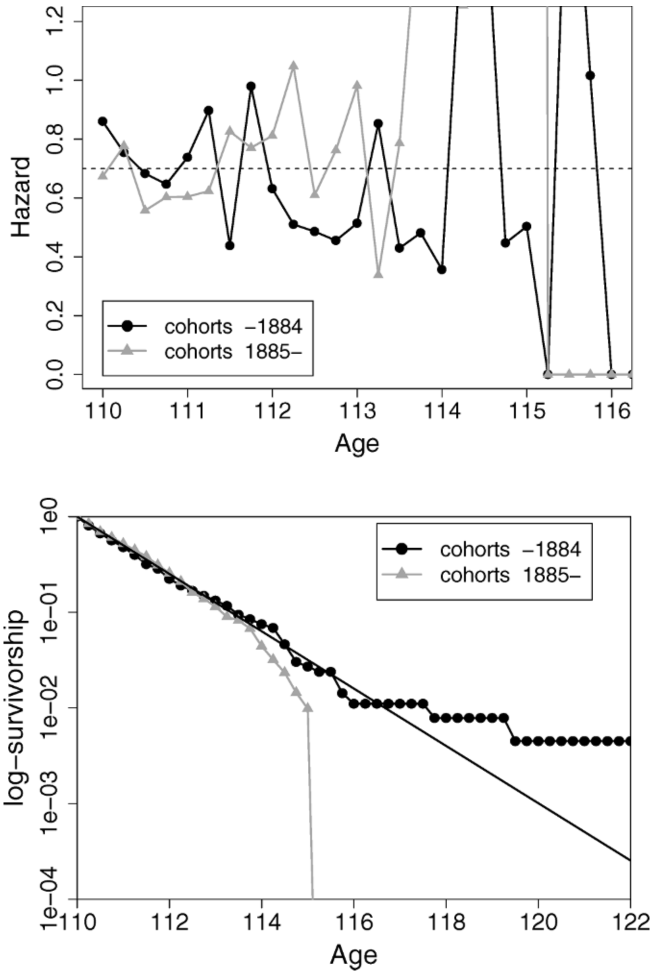


Fig. 3. Hazard (top) and log-survivorship (bottom) estimated separately for the earlier and the later cohorts in the dataset.

To check for such a time trend, we split the dataset into earlier and later cohorts. As we can see from Table 3, the number of observations rises sharply in the decade 1880-1890. To obtain a fairly balanced split, the sample was divided into two groups: earlier cohorts, defined as birth cohorts up to 1884 (300 cases); and all individuals born 1885 or later (337 cases).

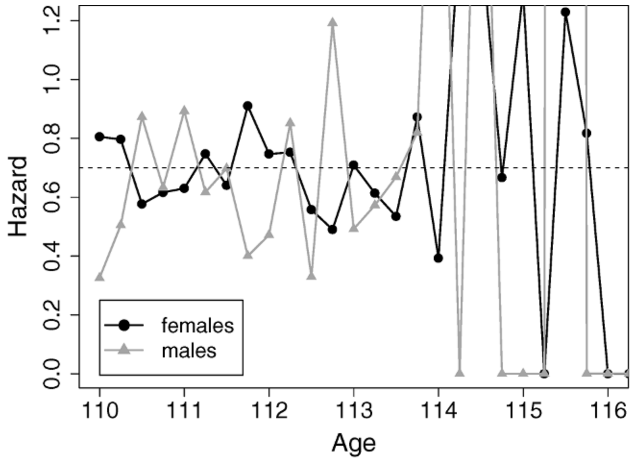
Figure 3 shows the hazard and the log-survivorship curves for early and late cohorts. No time trend in mortality of supercentenarians is supported by the result.

The large majority (almost 90%) of supercentenarians are women. While females enjoy lower mortality than males more or less at all ages, supercentenarians certainly are a highly selected group of individuals. Despite the comparatively small number of male cases, we estimated the hazard for male and female supercentenarians separately. The results are given in Figure 4, and show no significant sex-specific differences.

5 Conclusions

In summary, based on our analysis of 637 supecentenarian cases that were obtained in an age-ascertainment bias-free way, and that were thoroughly validated, we can state the following results.

- Human mortality after age 110 is flat at a constant level of $\lambda \approx 0.7$. This implies an annual probability of death of $q_x = 0.5$. This result confirms the previous analysis by Robine et al. (2005). Correspondingly, life expectancy after age 110 is about 1.4 years. Beyond the age of 114, data become too sparse to allow us to make reliable statements.
- No sex-specific differences can be detected. However, we have to be aware that only a small portion, about 10%, of supercentenarians are males, making the sample size for comparisons highly unbalanced.
- No differences in levels of mortality could be found between earlier and later cohorts.



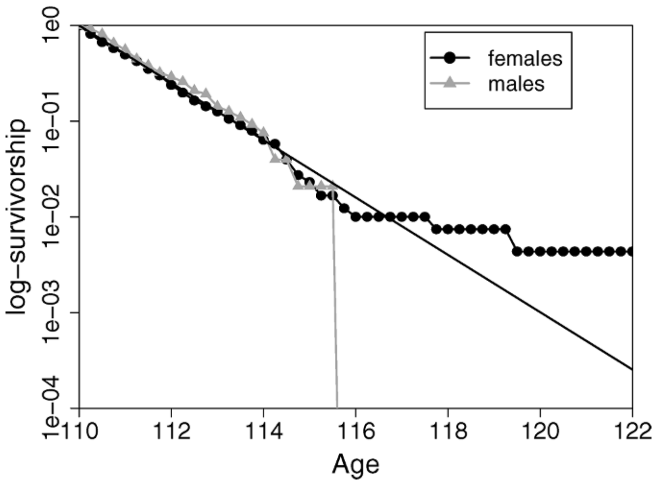


Fig. 4. Hazard (top) and log-survivorship (bottom) separately for male and female supercentenarians.

Appendix

For each individual i we define the censoring set $A_i \subset \{1, \ldots, J\}$ and a truncation set $B_i \subset \{1, \ldots, J\}$. If an exact age at death is observed, then A_i is a single number. If, for example, an individual is only known to have died between ages corresponding to the intervals j_1 to j_2, then $A_i = \{j_1, \ldots, j_2\}$. The same procedure is followed for the truncation sets B_i.

Similar to the I_{ij} in equation (4), we define $\xi_{ij} = 1$, if interval $j \in A_i$ and zero otherwise. And $\eta_{ij} = 1$ if $j \in B_i$ and zero otherwise. The expected values $E_{ij}^{(m)}$ that replace the I_{ij} in the likelihood (4) are the sum of two terms, which we denote by $c_{ij}^{(m)}$ and $d_{ij}^{(m)}$. The $c_{ij}^{(m)}$ are

$$c_{ij}^{(m)} = \xi_{ij} \frac{p_j^{(m)}}{\sum_{k=1}^{J} \xi_{ij} p_k^{(m)}}.$$

For exactly observed age l the $c_{il}^{(m)} = 1$ and $c_{ij}^{(m)} = 0$ for $j \neq l$. If the individual is censored the $c_{ij}^{(m)}$ give the expected value for interval j. Similarly, the d_{ij} give the expected number of individuals to be seen at j if not filtered by truncation:

$$d_{ij}^{(m)} = \frac{(1 - \eta_{ij})\, p_j^{(m)}}{\sum_{k=1}^{J} \eta_{ik}\, p_k^{(m)}}.$$

The $E_{ij}^{(m)}$ to be inserted into (4) are

$$E_{ij}^{(m)} = c_{ij}^{(m)} + d_{ij}^{(m)}.$$

Detailed derivations can be found in McLachlan and Krishnan (1997) or Pagano et al. (1994).

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Is it possible to measure life expectancy at 110 in France?

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Abstract. The observed curve of life expectancy by age seems to be coherent at the oldest ages until about age 107, when the extinct generation method is used. Beyond that age, however, improbably large fluctuations call into question any results directly derived from vital statistics, which appear to suggest that life expectancy at 110 is higher than life expectancy at 107 (2.29 years versus 1.73). A careful study of validation of age at death of all French supposed supercentenarians, undertaken in the framework of the International Database on Longevity (IDL), has established a life expectancy at 110 of 1.76 years, which is a much more realistic figure, if still slightly overestimated. The authors also show that it is possible to improve estimates directly derived from vital statistics by simple intuitive correction of some obvious defects. While such an approach still results in an obvious overestimation of life expectancy at 110 (2.0 years), estimation becomes more accurate each time new cohorts enter the field of computation.

The central question concerning mortality at very advanced ages is the following: Does mortality increase with age in an exponential manner until the complete disappearance of a given cohort; or does it slow down, halt, or even start to decline? Biostatisticians have shown

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that, for some species, in particular flies, mortality ceases to rise beyond a certain age, and then it begins to decrease. One must be careful, of course, when transferring this phenomenon to humans, but some authors have raised the issue (Vaupel et al., 1998).

To answer this central question, we must first have the necessary tools that will allow us to develop an accurate measurement of survival at very advanced ages. For example, is it possible today to estimate life expectancy at 110? Difficult practical questions must be resolved before we can answer this question. First, it is well known that, at very advanced ages, exact age is often misreported for different reasons, including overestimation of age. Furthermore, since very old individuals are very rare, the numbers of deaths are very small, and random mistakes made at the stage of coding can have a crucial impact. It is particularly important to make sure that ages at death have been rigorously checked. This problem has been discussed in the chapter devoted to French supercentenarians.

A second problem arises when we want to compute mortality rates. The problem of age accuracy is even greater for population data than for death registration. First, ages of individuals recorded by censuses are usually much less accurate than ages at death registered by the civil registration system. In particular, overestimation of age is very frequent among very old people. Furthermore, censuses are usually separated by long periods of time, and, due to the uncertainty of ages given by censuses, the age-specific annual population estimates, which could serve as a denominator for calculating mortality rates, are very unreliable. It would be quite unrealistic to compute mortality rates in that classical way. Fortunately, very old ages are also ages at which migration is rare; it is then quite possible to calculate mortality rates using the extinct cohorts method (Vincent, 1951), as its basic assumption seems perfectly acceptable (Meslé and Vallin, 2002).

In the first section of this chapter, we will try to arrive at an estimate of life expectancy at the age of 110 by using only the deaths for which exact age has been carefully substantiated, as reported in the chapter on French supercentenarians. However, in a second section we shall investigate to what extent it would be possible to approach the same results by using the death counts directly derived from the civil registration system using simple intuitive corrections.

1 An estimation of life expectancy at 110?

Let us try to compute life expectancy at 110 on the basis of deaths for which the age of the deceased has been precisely validated, as reported in the chapter on French supercentenarians.

We will thus take into account the 49 verified deaths confirmed by the RNIPP (Répertoire national d'identification des personnes physiques, or National Identification Register of Private Individuals)[6], plus the 20 verified deaths of people on the list of names not found in the RNIPP. Figure 1 represents these 69 deaths on a Lexis diagram, by year of birth and calendar year.

1.1 Fifty deaths which can be used for calculations

We will, however, have to limit our analysis to a reduced fraction of this set. Since, as we have already mentioned, reliable population estimates at advanced ages as of January 1st of each year are not available, the only way to calculate the probability of dying is by applying the extinct generations method (Vincent,1951; Meslé and Vallin, 2002). Using this method obviously means working with generations that are presumably extinct, or, in other words, that have no survivors. If we were to assume that the death of Jeanne Calment marks, for the time being, the extreme limit of life; and if we were to select only cohorts that are absolutely extinct, this would mean limiting our study to cohorts born from 1866 to 1881, since our database ends in 2004. In that case, our database would include only 19 deaths, a figure that is too small to be reasonably used for calculations. However, other than the case of Jeanne Calment, no deaths beyond the exact age of 116 have ever been recorded. In 2004, the most recent cohort to have reached the age of 116 was born in 1888[7]. If we consider it quite unlikely that any deaths might still occur among these cohorts, we may extend our field of analysis to the 50 deaths observed among the cohorts born between 1866 and 1888.

[6] Since the chapter on French supercentenarians was written, an additional eight ages at death were verified, and we can take into account here 49 deaths provided by the RNIPP, instead of 41.

[7] More precisely, only those who were born very early in 1888 could approach age 116 in 2004. The more recent cohort which has completely reached age 116 in 2004, is the 1887 cohort. However, Jeanne Brémond, who died at age 115, is also a unique case, and it is very unlikely that a similar case could occur in the 1888 cohort in the year 2004. On the other hand, it is very useful for the purposes of computation to include the cohort 1888, which produced nine verified supercentenarians.

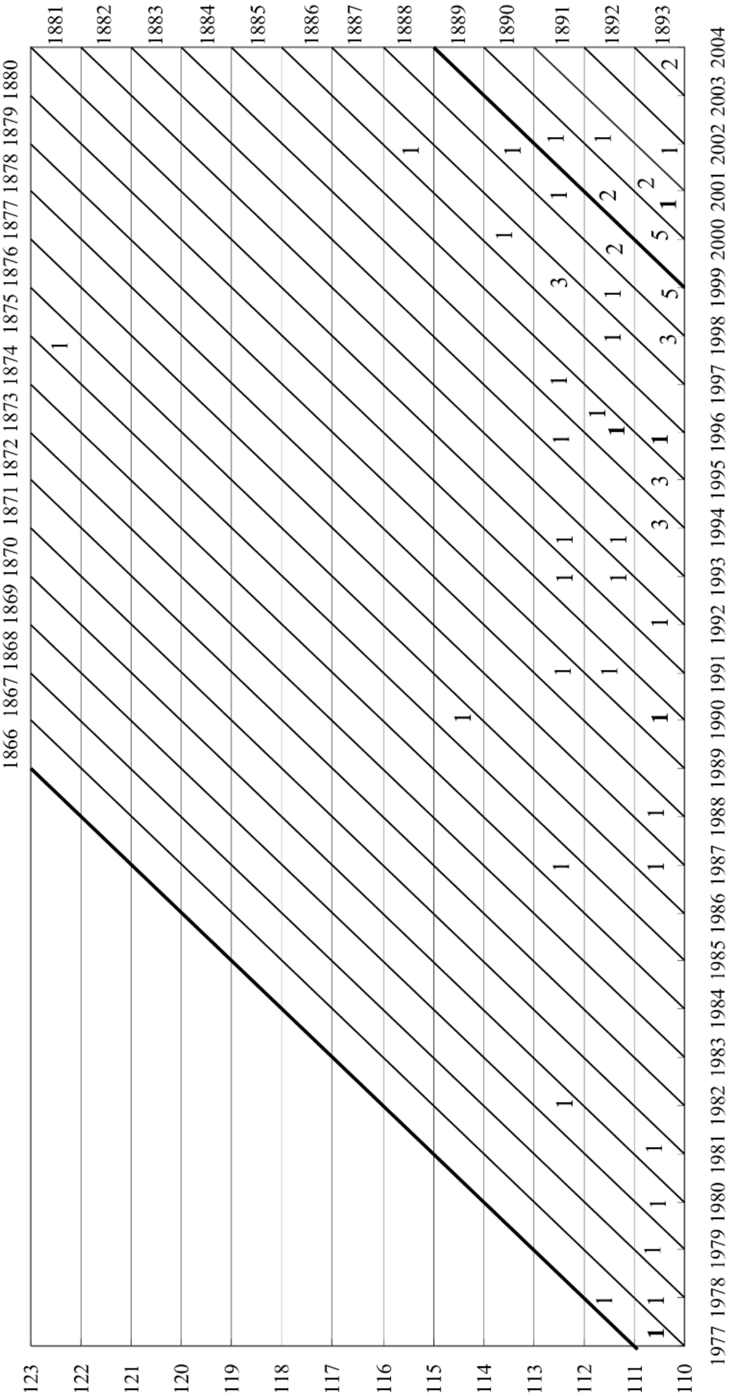

Fig. 1. Representation on a Lexis diagram of deaths at age 110 and over observed in cohorts born from 1866 to 1893

Given the Jeanne Calment precedent, it could be that some individuals born before 1888 may still be alive; nonetheless, the probability of finding such persons is so low that it may be disregarded. This means taking the limited risk of underestimating the life expectancy of these cohorts, but the fact that we still have another 50 deaths to work with reduces the distortions tied to small numbers. On the other hand, we cannot extend the sample any further, and we cannot, unfortunately, take into account the 15 deaths recorded in the later cohorts (beginning in 1889).

An underlying assumption of the extinct generations method is that there are no international migrations at such advanced ages. As demonstrated elsewhere (Meslé and Vallin, 2002), this assumption is perfectly realistic on the scale of a country such as France, since practically the only reason to migrate at that age would be a move to a specialized institution, and it is most improbable that a person who is still in France at the age of 110 would be transferred to an institution abroad, and vice versa.

1.2 Nearly 1.5 years of life expectancy at 110?

According to this extinct generation method, it is possible to determine for each cohort the number of survivors at each birthday by cumulating the number of deaths at each age, starting from the oldest age at death. This was done in Table 1 for the 1866-1888 cohorts.

The cumulated deaths figure directly yields the number of survivors on each birthday. If we establish a ratio between the deaths at each age to the number of survivors on the previous birthday, we obtain the probability of dying (between two birthdays) and we can calculate life expectancy in the same way as with a traditional life table.

Thus, we obtain for all the cohorts born between 1866 and 1888 a life expectancy at 110 of 1.68 years. Of course, the case of Jeanne Calment weighs a great deal in this small database. Given that it is very unlikely that there will be another similar case in the near future, life expectancy estimates at 110 may be expected to decline over time. If we do not include the death of Jeanne Calment at age 122, life expectancy at 110 for the same group of cohorts drops to 1.46 years. Jeanne Calment's case thus raises this life expectancy by 0.2 years. This can clearly be seen in Table 1: at 116, life expectancy suddenly increases to 6.5 years, which corresponds to the number of years of life left to the sole survivor of this group of cohorts, Jeanne Calment. This fact shows the limits of this type of probabilistic calculation, since, when only one survivor remains, life expectancy is no longer an 'expectancy' but the actual number of years subsequently lived by the survivor in question; when this duration is quite long, as in Jeanne Calment's case, it weighs heavily on previous calculations, since they concern very small numbers. In no way does this situation call into question the credibility of Jeanne Calment's dates of birth and death, but the exceptionality of Jeanne Calment's case makes rather obvious that the very small universe of French supercentenarians is much too small to be the true statistical universe of Jeanne Calment, which should include all the supercentenarians of the world, since she is the most extreme case in the world. Consequently, it makes sense to compute French life expectancy at 110 without including Jeanne Calment. In the absence of any other bias, the result underestimates the truth much less than including Jeanne Calment overestimates it.

The sample we have examined includes only four males, which means that we cannot offer separate results for men. We can, however, calculate that the life expectancy of females is 1.76 years for the 1866-1888 cohorts, but 1.52 if we exclude Jeanne Calment.

Of course, these estimates are quite relative, first because they are based on a small number of cases, but also because it is most probable that, despite our efforts, the set of supercentenarian deaths used here does not exactly correspond to reality. In particular, none of our information for the years prior to 1987 (1977-1986) comes from the RNIPP; our only source for that period is the initial list of supercentenarians, and we know that it is incomplete. It is quite likely that the list covers mainly the more exceptional cases, and that persons who died right after their 110th birthday are given less importance in the list than persons who died at an older age.

If this were the case, the mean age at death of the real group of supercentenarians would be slightly younger than the one observed. This is a second reason to think that our result without Jeanne Calment is much closer to the reality than the one with Jeanne Calment. It could even be an overestimation. Let us conclude that French female life expectancy at 110 might be very close to 1.5 years.

2 Return to vital statistics

This result may be compared with vital statistics estimates, even if they are biased; indeed, it is important to situate the estimate of life expectancy at 110 in the context of age-specific life expectancy trends after 100. In order to do this, one must first concretely determine the impact of these biases, up to what age these data can be used, and which kind of adjustment hypotheses would be needed.

Table 1. Cumulative number of deaths in the extinct generations and calculation of probabilities of dying and life expectancies

Age	1866-1888				1866-1888 without Jeanne Calment			
	Deaths	Cumulated deaths	Probabilities	Life expectancy	Deaths	Cumulated deaths	Probabilities	Life expectancy
110	24	50	0.48	1.68	24	49	0.49	1.46
111	10	26	0.38	1.77	10	25	0.4	1.38
112	11	16	0.69	1.56	11	15	0.73	0.97
113	2	5	0.4	2.9	2	4	0.5	1.25
114	1	3	0.33	3.5	1	2	0.5	1
115	1	2	0.5	4	1	1	1	0.5
116	0	1	0	6.5	0	0		
117	0	1	0	5.5	0	0		
118	0	1	0	4.5	0	0		
119	0	1	0	3.5	0	0		
120	0	1	0	2.5	0	0		
121	0	1	0	1.5	0	0		
122	1	1	1	0.5	0	0		
123		0				0		

2.1 Life expectancy after 100, according to vital statistics

We applied the extinct generations method to recalculate life expectancy at 100 on the basis of the entire set of deaths recorded by vital statistics for the 1868-1888 cohorts[8]. This set of cohorts is slightly smaller than those referred to in the chapter devoted to French supercentenarians since, in this database, the first cohort to have reached the age of 100 was born in 1868, and not in 1866.

Since there are only very few men among those reaching the age of 110, it seemed preferable to limit our study to the female sex. The curve titled "crude vital statistics" in Figure 2 shows the trend of female life expectancy after 100, resulting from the application of the extinct generations method to crude death data obtained from vital statistics.

The life expectancy estimates based on this data are clearly quite satisfactory until the age of 108. From 2.0 years at the age of 100, it gradually declines to 1.7 years at 108. Of course, the fact that the decline is gradual does not necessarily exclude the possibility that the life expectancy of centenarians may be overestimated, but it does lend some credibility to vital statistics data until that age. On the other hand, it is clear that the life expectancy trends beyond 108 are not acceptable. Such an increase, from 1.7 years at 108 to 3.8 years at 117, cannot be seriously considered realistic. This improbable increase is the obvious result of the overestimation of very advanced ages at death. We have already mentioned (in the chapter devoted to French supercentenarians) that this database includes the recent death of a woman aged 120, and of another at 124; these women were not known personalities like Jeanne Calment and do not belong to the group of French supercentenarians whose age at death has been duly checked. We therefore assumed that, in these cases, the reported ages at death were incorrect, and withdrew these two deaths from the database and made new calculations. The result is the curve at the bottom of Figure 2 (indicated as "vital stats corr1"). The impact of this simple adjustment was considerable, leading to a reversal of the life expectancy trend after the age of 111, and to a life expectancy of 0.5 years at 117.

However, as may be expected, such a simple adjustment does not really solve the problem, because the life expectancy curve still shows an improbable upswing between 108 and 110. In addition, although the withdrawal of the two deaths at 120 and 124 was correct, one error nonetheless remains due to the fact that vital statistics do not include

[8] Since available vital statistics concern deaths observed between 1968 and 2003 (see chapter on French supercentenarians), the first cohort covered was born in 1868, and the last one, covered until age 115, was born in 1888.

Jeanne Calment's death; if we add the latter to vital statistics data, we get the two curves drawn in fine print in Figure 2, which are no more acceptable than those resulting from crude data. The first (crude vital statistics + Jeanne Calment) is the most unrealistic of all. The second (vital stats corr1 + Jeanne Calment) provides a relatively stable life expectancy between 110 and 117, but there remains the sudden and improbable increase between 108 and 110.

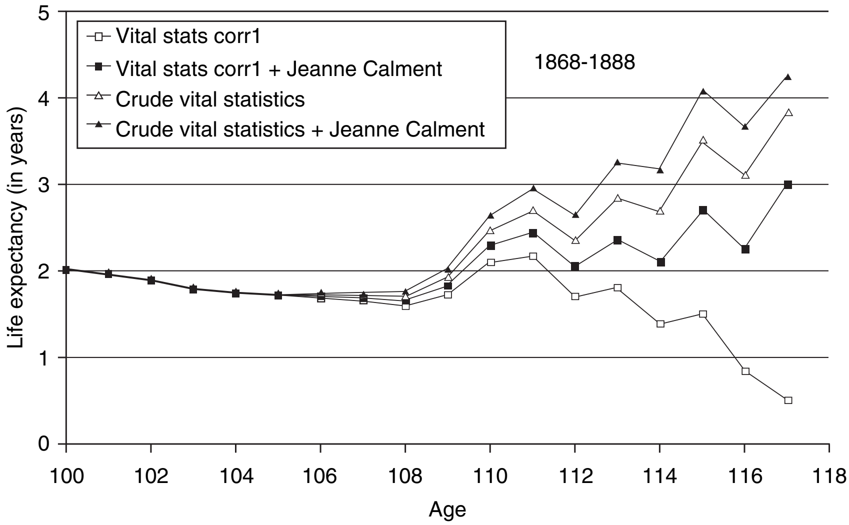

Fig. 2. Life expectancy by age, after 100, according to vital statistics

2.2 Can the artefact produced by INSEE rule on reported age be eliminated?

This sudden upswing is linked to another source of errors which has undermined the reliability of vital statistics: the problem that, prior to 1988, INSEE (Institut National de la Statistique et des Études Économiques, or National Institute for Statistics and Economic Studies) did not accept any ages at death above 109 (see the chapter on French supercentenarians). At first, we assumed that INSEE randomly distributed those deaths over other ages at death. However, if we take a closer look at the probabilities of dying per year of age beyond 100, we observe an unexpected rise at 108 and 109, followed by wide random fluctuations at more advanced ages due to the increasing smallness of the concerned population (Figure 3).

In fact, what happened was that INSEE's exclusion rule did not apply to ages, but to cohorts. In a given year of observation a, all deaths reported as pertaining to a cohort preceding a - 110 were considered unbelievable. The abnormally high level of the death probabilities at 108 and 109 leads us to think that these deaths were attributed to the a - 109 cohort, without changing the day and month of birth. Depending on whether the death occurred before or after the birthday, the result was an excess of deaths at either 108 or 109.

On the basis of this assumption, we tried to estimate the excess number of deaths classified at those two ages, and distribute them over older ages. In order to determine the excess number of deaths classified under ages 108-109, we examined the figures by age, and according to their position before or after birthdays, for the 1968-1987 period. Our observations indicate that, in 25 cases, the deaths occurred the year of the person's 108th birthday, after the birthday had been celebrated. However, the figure rises to 32 cases for those who celebrated their 108th birthday the previous year, when we would instead have expected the figure to drop drastically, since at those ages mortality is very high. At age 109, by contrast, the figure of 14 deaths of persons who had celebrated their 109th birthday the same year is probably too high, although we cannot compare it to the number of persons who celebrated their 109th birthday the previous year, since these were rejected by INSEE as being impossible. We examined the pace of decline in the number of deaths observed by age and cohort at immediately preceding ages, and concluded that nine excess deaths had been classified among the 32 deaths at 108, while only three excess deaths had been included among the 14 that occurred at age 109. The 12 deaths which had been wrongly included among deaths at ages 108-109 were then distributed among older ages[9], in proportion to the deaths observed after 1987 among the 1868-1888 cohorts.

In terms of probability of dying (see Figure 3), this adjustment obviously does not solve all problems, but it does reinsert the probability of dying at 108 and 109 in the continuity of the mortality increase with age before age 108, even if the probabilities of dying after 109 still fluctuate in a very unlikely manner. Such fluctuations make impossible any conclusion on the slope of the mortality curve after age 111, but our correction suggests a plateau from ages 108 to 111 that is not refuted by the general trends shown for successive years.

[9] In fact, at ages 110 and 111 only to avoid reinforcing the already existing bias of aging the oldest old.

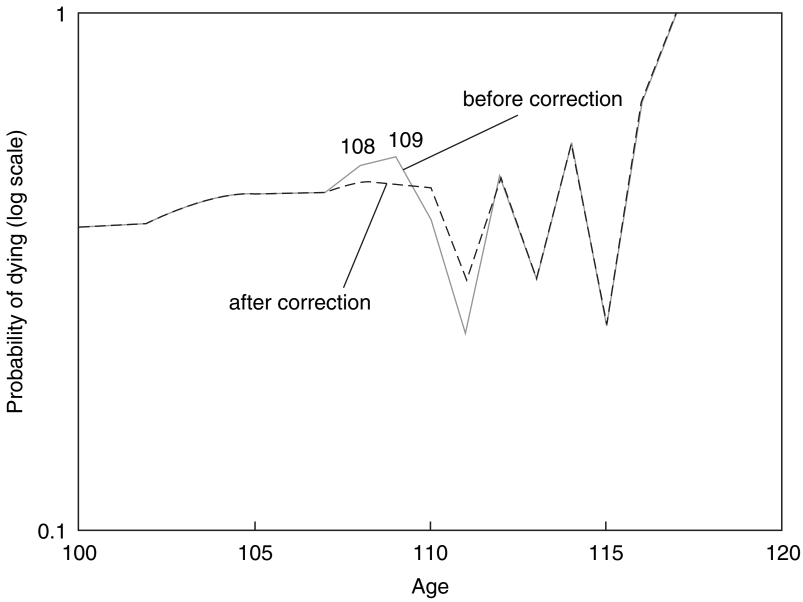

Fig. 3. Female age-specific probability of dying after 100, according to vital statistics, for the cohorts born from 1868 to 1888. Solid line: crude data + Jeanne Calment. Dotted line: after distribution of excess deaths at 108-109

In terms of life expectancy, the adjustment slightly improves results after age 108. The improvement can be seen in Figure 4 if we compare either the two curves including Jeanne Calment, or the two curves in which Jeanne Calment is not added to vital statistics figures. In both cases, life expectancy levels from ages 109 to 111 are considerably reduced and seem much more realistic. Thus, after the double adjustment of vital statistics data (withdrawal of two deaths at 120 and 124, and redistribution of the excess deaths at 108 and 109 to higher ages), life expectancy at 110 is 2.01 years if we add Jeanne Calment to vital statistics data, and 1.86 years without her. These values are closer to those determined on the sole basis of validated deaths (1.76 with Jeanne Calment and 1.52 without) than those given by crude vital statistics (2.29 and 2.10). However, these values still clearly overestimate life expectancy at 110 and beyond. The two simple intuitive corrections made improve the curve of life expectancy by age after 100, but not enough to erase completely the abnormal increase between ages 108 and 111.

This means that a more general overestimation of oldest ages is at work than the two most obvious ones that we eliminated.

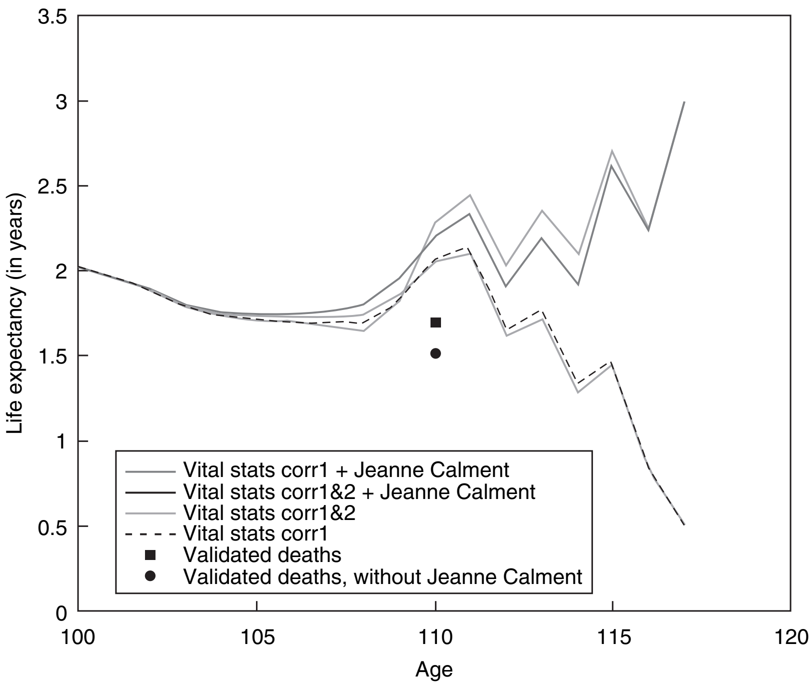

Fig. 4. Age-specific life expectancy after 100 according to vital statistics, depending on various adjustments (1868-1888 cohorts) and life expectancy at 110 according to validated data (1866-1888 cohorts). Females

It is interesting to note that, after age 112, the result obtained from the adjusted vital statistics data is lower than that obtained from the validated deaths with Jeanne Calment included, while it is higher when she is not included. The reason is that Jeanne Calment's relative weight is higher in the smaller group of 16 validated female deaths from the 1866-1888 cohorts than in the group of 26[10] from vital statistics of cohorts born in 1868-1888 (see Figure 5). However, the fact that vital statistics provide a larger number of cases holds another advantage, namely, that of reducing the fluctuations of life expectancy after 110.

[10] The 27 recorded deaths, minus the two eliminated deaths at 120 and 124, plus Jeanne Calment.

This phenomenon is particularly visible here, when Jeanne Calment is not included in the calculation.

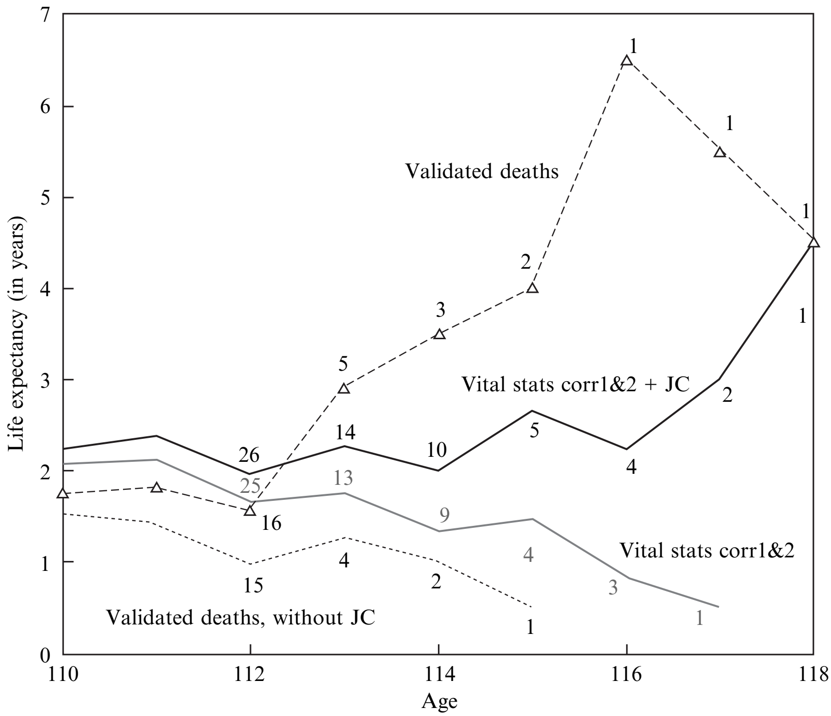

Fig. 5. Life expectancy by age over 110, according to vital statistics (1868-1888 cohorts) and according to validated data (1866-1888 cohorts). Females. (Numbers stand for population on which the computation relies)

2.3 Hope for future improvement of estimation based on vital statistics

Thus, with some caution and several adjustments, it is possible today to obtain an approximate measure of French life expectancy at rather advanced ages on the basis of vital statistics. This measure will probably be improved during the upcoming decades since we can expect a massive increase in the number of observations. As it is, each time the number of generations available to apply the extinct generation method increases, the estimation of life expectancy at 110 gets closer to the results derived from validated cases, even when the correction at ages 108-109 is not made. At the same time, the curve of life expectancy by ages over 100 become less and less abnormal (Figure 6). When our first attempt was published (Meslé et al, 2000), vital statistics gave a life expectancy at 110 of 2.82 years for 1868-1882 cohorts. Four years later, it was 2.36 for 1868-1886 cohorts. It is now 2.10[11] for 1868-1888 cohorts. In short, each time we added two new cohorts, estimation is three months shorter.

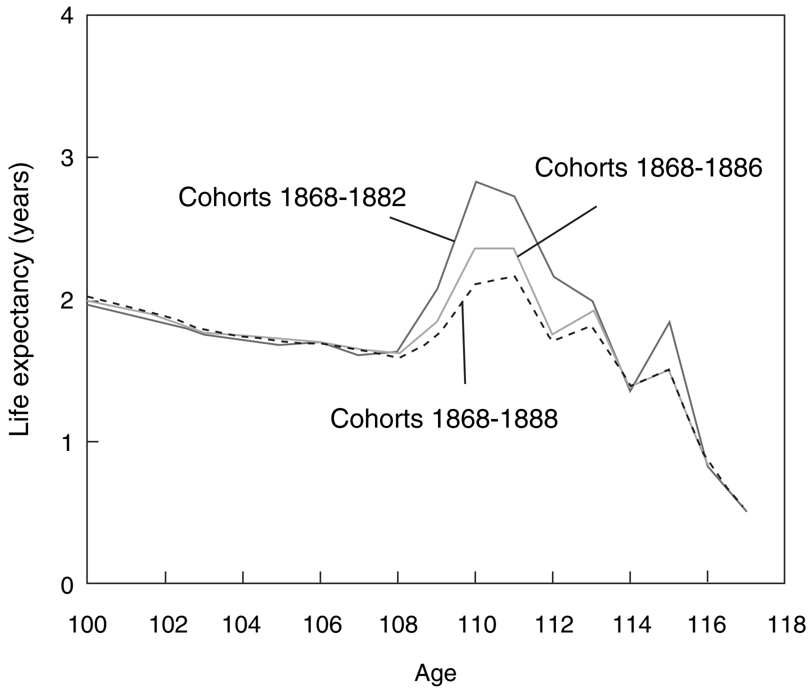

Fig. 6. Life expectancy by age over 100, according to vital statistics for three groups of cohorts. Females. (Not taking in account the two deaths at spurious ages 120 and 124)

[11] In 2000, we hadn't made the second adjustment of the vital statistics data, which consisted of the redistribution of excess deaths at 108-109 years. For this reason, we can only compare life expectancies calculated before this redistribution (2.82 in 2000, 2.36 in 2004, and 2.10 today), but the difference between results is necessarily homothetic.

This does not mean that it is unnecessary to build a complete and validated database—quite the contrary. Experiments based on vital statistics have shown that no procedure produces a life expectancy at 110 in perfect harmony with trends observed at younger ages. With or without Jeanne Calment, life expectancy at 110 is always found to be higher than life expectancy at 107. Of course, we may optimistically assume that beyond a certain age (and why not 107?), mortality ceases to increase with age and instead begins to decline, but for the time being, neither our calculations based on vital statistics, nor those based on verified deaths, can serve as evidence of such a phenomenon. On the contrary, the computation of validated data clearly calls this finding into question, since life expectancy is only very slightly higher at age 110 than at age 107 when Jeanne Calment is included (1.76 against 1.73), and significantly lower when she is not (1.52 versus 1.68). Furthermore, when Jeanne Calment is excluded, validated data show a downward trend after age 110 until the last age for which computation is possible (115). Only a complete and verified database covering a large sample of deaths could possibly confirm or disprove the finding that, at some very old age, life expectancy really ceases to decline. At this stage, we can only insist once again on the importance, in the context of the constitution of the International Database on Longevity (IDL), of updating the French database on deaths of supercentenarians whose ages at death have been duly verified.

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Age 115 or more in the United States: Fact or fiction?

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Abstract. The United States contributed the largest number of cases to the International Database on Longevity and probably has the largest supercentenarian population in the world. This chapter provides a detailed description of the methods used to validate eight supercentenarians in the United States who attained an age of 115 years or older. The chapter also describes five claims to age 115 and beyond that were eventually shown to be false, again emphasizing age validation and the various different problems commonly encountered by researchers.

1 Foreword

It is a rare instance indeed when a revolutionary work not only results in a paradigm shift of scientific opinion, but so thoroughly ingratiates a topic that, some 130 years later, it remains an unassailable tower. Such was the groundbreaking work of William J. Thoms, whose "Human Longevity: Its Facts and Fictions," published in 1873, remains a supreme foundation on which future generations of extreme longevity researchers can build. Thoms' calling to task the shameful instances of otherwise great minds falling for the fallacies of a few countryside storytellers, his examination of fictive claims of a past age of great longevity, and his debunking of the idea that longevity is greater among the poor, resonate well with today's situations. Thoms sets up the principle that the burden of proof is upon the claimant, not the other way around. Page after page, we find Thoms calling out issues involving testimonial fallacy, name-saking (e.g., naming a younger brother after an older brother, or a son after a father), mis-identification, familial context, numbers of descendants, and earliest recollections. Indeed, Thoms did such a thorough job that it must be left to us to explain why a further book is needed.

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If anything has changed at all in the field of age verification research since Thoms's time, it is that people today really are living longer than people in the 1870s. In Thoms's time, the oldest verifiable centenarian that he could find was a mere 103 years old. This is simply not the case today, with some tens of thousands of persons currently living who are aged 103 and older, and a new class of supercentenarians (persons aged 110 and over) emerging; the proven record in 2008 is the 122 years and 164 days, attained in the case of Jeanne Calment; and the oldest living person currently is believed to be 114-year-old Edna Parker (born April 20, 1893) who as of this writing (February 26, 2008) does not yet qualify for this chapter. This apparent increase in the human life span may not actually contradict those who see the human life span as 'fixed;' some may argue that the increases in life span in the past two hundred years are due to the cumulative benefits of increased sanitation, health care, treatment, diet, etc., coupled with a huge increase in sample size and recordkeeping. Indeed, even today in small nations such as Norway, the oldest person is normally only 107-110 years old, whereas in the United States, which has the world's largest centenarian population (estimated at about 80,000 currently)[1] has seen the oldest living American record consistently stay above age 113 (since 1986). Most remarkably, nearly half of the world's verified instances of a supercentenarian aged 115 and older have come from the United States. That alone is reason enough to take a closer look at maximum longevity in the United States.

However, there is a second major reason, as well. In the United States, demographic transition and industrialization over the past two centuries have also been accompanied by parallel shifts in recordkeeping. Such improvements would seem to lend a degree of credibility to American cases. However, these shifts have occurred far more recently than in Western European nations (for example, birth registration in the UK was compulsory by 1837, but was not required in the United States until 1933). Recent research (Jeune and Vaupel, 1995, 1999) has indicated that a period of 100 years or more of compulsory and complete birth registration is needed to finally defeat the myth of aging in that nation. The United Kingdom, once well-known for claims such as that of Thomas Parr, said to have lived to age 152, has seen no verified supercentenarian exceed the age of 115 before the 1990s. The United States, in contrast, remains in transition from a semi-literate to a fully literate society. Even in 2006, age claims in the United States

[1] http://www.census.gov/Press-Release/www/releases/archives/facts_for_features_special_editions\backslash009715.html (accessed Feb 13 2008).

included Alberta Davis of Georgia, 125[2]; Oberia Coffin of Texas, 122; and Lajean Smith of Arkansas, 117. In all these instances, the case is an African-American from the U.S. South. Where birth registrations are absent, age inflation goes unchecked. Yet we would be remiss if we simply presumed that every age claim in the U.S. to age 115 or older was false, or that every false claimant was from the South or African-American. Indeed, some were from the North, and false claims came in every ethnic group.

Below, I provide the cases of verified supercentenarians in the United States who attained the age of 115 years or greater, along with a few of the many cases which turned out to be false. For the sake of space, I have compiled an unabridged list of validated cases[3] followed by a few examples of false cases. This should not be taken to mean that most claims were true; in fact, the vast majority of U.S. claims to age 115 or older have been shown to be either false or unverifiable (see chapter by Kestenbaum and Ferguson in this volume for more details). A complete listing would prove difficult as the claims number in the thousands (again, the words of Thoms from 1873: "Every day and week sends forth a new [case]."). Thus we are reminded why the burden of proof must be on the claimant to establish with certainty the age of the person claimed. In my opinion, that task has been accomplished in the first set of cases. While presenting the details, I expect that future readers will choose their own level of skepticism regarding the veracity of each case. As Thoms noted, the greatest error, that of assuming to be true what has not been shown to be true, was related to appeals to authority and a tendency to believe 'experts.' Thus, readers need not take my word for it, but the evidence itself should suffice to prove beyond a reasonable doubt whether the below cases are true or false. In a few cases, such as those of Maggie Barnes, Elizabeth Bolden, or Susie Gibson, there remains some degree of doubt about exact ages,

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[2] `http://www.wrdw.com/home/headlines/5010191.html` (accessed Feb 26 2008).

[3] With the exception of one case, Lucy Hannah. Lucy Hannah: Aged 117 or 118? (July 16, 1875-March 21 1993) The Lucy Hannah case is different than most in that her claim to age 118 did not gather much attention (if any) while she was living. The first mention of this case in a national listing was in the 1999 SSDI listings. The claim to age 118 would have made Lucy the world's oldest person, if validated. But for reasons unknown, this case never made it into the news.. However, in September 2003, the SSA study reportedly validated the age of Lucy Hannah to be one year younger than claimed, or 117. This would make her the third-oldest validated person after Calment and Knauss but never the world's oldest person, as Calment was a few months older at the time. Due to a lack of detailed information, this case will not be examined closely in this chapter.

but the question is whether these women were 115 or 116; in all cases, they were found to be at least 115 years old, so they are included here.

2 Validated cases

2.1 Sarah Knauss: Oldest validated american ever at age 119 (September 24, 1880 - December 30, 1999)

Sarah Knauss, at 119 years and 97 days, is the oldest American whose age has been validated. She was named the "world's oldest person" by Guinness World Records upon the death of Marie-Louise Meilleur of Canada on April 16, 1998. More importantly, she is listed as the oldest verified supercentenarian in the Social Security Administration's Kestenbaum study of U.S. supercentenarians who reached the age of 110 or greater between January 1, 1980, and December 31, 1999 (see chapter by Kestenbaum and Ferguson in this volume for study details).

The Sarah Knauss case first garnered international media attention in August 1997, following the death of Jeanne Calment at 122, who had held the Guinness record for "world's oldest person" for several years[4]. In an attempt to gain Guinness recognition following the August 4, 1997, death of France's Jeanne Calment, the Sarah Knauss case was researched in 1997 by genealogist Edith Rogers Moyer for Phoebe Ministries. Prior to that time, the Sarah Knauss case had already attracted the attention of both the American media and the scientific community, but documents had not yet been located. Her 117th birthday in September 1997 drew major attention, as did her ascent to the title of "world's oldest person" in April 1998. Her family was featured in Life magazine in February 1999, complete with a photo of six living generations.

Meanwhile, international researchers Tom Perls, Jean-Marie Robine, Bernard Jeune, and John Wilmoth visited Sarah Knauss in 1998. Some may have arrived skeptical, but all left convinced she was really the age claimed. Documents that were located and reported by the genealogist Moyer in 1997 (a partial list of these results has been published) (Robine and Vaupel, 2002), included a 1900 census match, an 1880 census record for the family, a 1901 marriage license, and an August 29,

[4] Guinness World Records gave Calment the title in 1988, aged 113. In 1989, they took it back and gave it to Carrie White (1874?-1991) (see discussion about Carrie White later in this chapter). In 1991 Calment regained the Guinness title and held it for six years, uncontested.

1901, newspaper article. Indeed, checking back through the local Allentown newspaper archives (`http://pqasb.pqarchiver.com/mcall/`) one finds scores of news articles, including coverage of her 106th, 107th, 108th, 111th, 113th, 114th, 115th, 116th, 117th, 118th, and 119th birthdays. Sarah Knauss was featured in a national news article as far back as age 115. There can be no doubt that Sarah was well-known in her hometown as a centenarian a decade before the international media coverage began. In the case of Sarah Knauss, the Social Security records accord with the birth date of September 24, 1880. Indeed, she was featured in a news article as "Three Generations on Social Security." When she was 115, her daughter was 92, and her grandson was 70.

In re-investigating this case, I decided to pretend, for the sake of methodology, that this case had not already been verified. As mentioned before, the first step in such a validation is to establish background details of the person's life. From numerous news articles, I was able to gather that Sarah Knauss was born on September 24, 1880, to Walter and Amelia Clark, in the tiny hamlet of Hollywood, Pennsylvania. She moved as a child to South Bethlehem. On August 28, 1901, she married Abraham Lincoln Knauss, and gave birth to her first and only child, Kathryn 'Kitty' (Knauss) Sullivan, on November 17, 1903. Her husband died in 1965, aged 86. Sarah Knauss died on December 30, 1999, in Allentown, Pennsylvania, alleged to be 119 years old.

Searching the April 1930 census, I found Sarah listed in the state of Pennsylvania, Lehigh County, town of Allentown, as age 49.[5] Included in the listing were Knauss, Abraham L., head, 52, age at first marriage, 23; and Knauss, Sarah C., wife, 49, age at first marriage, 21. Given that someone born in September 1880 would be 49 years old in April 1930, the age accorded with what was expected. The names of the county, town, husband, and middle initials all matched. Even the age at first marriage was roughly correct (off by no more than one year). However, only one relation, the husband, was listed.

Going further back, I ran a search in the 1910 census for an "Abraham Knauss" (families are indexed by "head of household"), and located the Knauss family. The April 1910 census[6] was a perfect match for several reasons. First, the location (Allentown, Lehigh County, Pennsylvania) was correct. The husband, Abraham L. Knauss, is the same as in the 1930 census, but this time "Sarah" is listed as "Sadie." This shows

[5] Roll T626_2604, enumeration district 38, image 0304, page 21 B.

[6] Pennsylvania, Lehigh County, roll 1363, book 2, page 108a lists Knauss, Abraham L., head, 32, married 8 years Knauss, Sadie C., wife, 29, married 8 years Knauss, Kathryn C., daughter, 6 years old Clark, Foster L., brother-in-law, 20 years old.

that “Sarah” and “Sadie” is almost certainly the same person. The middle initial is the same, and someone who was married eight years previously and was 29 years old at the time of the census would have been married at 21. Also of note, we see the daughter, Kathryn, listed as age six in April 1910. This accords with a birth date of November 1903, and the woman listed in the 1999 obituaries as Sarah’s 96-year-old daughter (Kitty Sullivan died in 2005, aged 101). If this were not enough, the brother-in-law, Foster Clark, shows that Sadie Knauss’s maiden name was “Clark.” The age of 29 years old in April 1910 accords with a birth date of September 1880. However, this is still outside the “20-year window” of “validation by proxy,” a generally accepted limit within which a delayed proof of birth may be considered reliable (and the cutoff used by the SSA study). Thus, some earlier form of evidence was needed.

I then ran a search in the June 1900 census, and found the necessary record.[7] We see that Sadie Clark was listed as 19 years old, and as having been born in September 1880. The record is within the 20-year window. Curiously, there is no “Foster L. Clark” listed, but the age of 20 years given in April 1910 suggests he could be listed as “Earl Clark,” born May 1889. One small issue is that there is a nine-year gap between Sarah Knauss and her next-oldest sibling. Were there other children not listed here who either died before June 1900, or were living elsewhere at the time? A skeptic might say that Sarah Knauss could have been born as late as 1888. In that case, she would be a mere 111 years old. However, such a supposition is highly unlikely.

Revisiting the Edith Roger Moyer report, the marriage license states that Sarah De Reemer Clark and Abraham Lincoln Knauss were married by Rev. Dr. Gilbert Henry Sterling on August 28, 1901 (housed at the Cathedral Church of the Nativity in Bethlehem, Pennsylvania). The document states that Sarah Clark was 21 at the time (actually, she was 27 days shy of her 21st birthday). Also of note, the Globe newspaper of South Bethlehem, Pennsylvania, printed on August 29, 1901, a wedding notice that included the words: “of the contracting couple, Abraham Lincoln Knauss and Miss Sadie De Remer Clark.”

This issue might have been further resolved by the 1890 census. Unfortunately, most of the 1890 census (about 97%) was destroyed by

[7] Listed in Pennsylvania, Northampton County, South Bethlehem borough, roll 1447, book 1, page 93 is: Clark, Walter , head, born Apr 1849, age 51, married 25 years Clark, Amelia, wife, born June 1857, age 42, married 25 years Clark, Charles, son, born July 1878, age 21 Clark, Sadie, daughter, born Sept 1880, age 19 Clark, Earl, son, born May 1889, age 11 Clark, Emily, daughter, born May 1893, age 7.

fire in 1921. Pennsylvania was not on the list of states with surviving fragments. Going back 10 years, we find in the June 1880 census, in the village of Hollywood, Pennsylvania, the family of Walter Clark, 31; wife Emelia, 23; son Albert L., four; and son Charles H., two. The ages of Walter, Amelia, and Charles match what is expected from the 1900 census records. The presence of an older brother, age four, shows that Amelia gave birth as early as 1876, when she was 19 years old. The subsequent fate of Albert is uncertain at this time. Sarah Clark, as expected, was not listed. This proves that, in June 1880, she had not been born yet, and thus could be no older than 119 years old.

Taking a close look at the documents, we find that Sarah did indeed have siblings born between 1880 and 1889: Walter Clark, Jr., born on July 19, 1884, and baptized on September 7, 1884, apparently died as an infant; the 1884 baptismal record noted he was deceased. Also of note was the brother, Edward Clark, born November 8, 1885, and baptized July 23, 1886; again, he was deceased by the time of his baptism. This helps to fill in the gap. We can conclude that, if her younger siblings were born in 1884 and 1885, she must have been born no later than September 1883, and even this would be an implausible nine months' separation between births. Thus, we can further state that she was almost certainly born in September 1882 or earlier, and hence aged no less than 117 years old. There is, however, ample evidence supporting the 1880 date, and not one document suggesting any other year of birth. This case is much cleaner than many other cases.

Given all the information available, we can conclude that Sarah Knauss really was 119 years old. The family maintained meticulous records; they never left or migrated outside a small area of the state of Pennsylvania; and the age of Sarah matched the 1880 birth claim in every record checked. We have proof of marriage and name change. While it is possible to further scour the records for more missing details (i.e., to answer the question of what happened to her older brother) and to carry out a further family reconstitution, the false cases mentioned later in this chapter would already have been exposed with such a level of scrutiny.

2.2 Elizabeth Bolden: Was the world's oldest person at age 116 (August 15, 1890 - December 11, 2006)

The African-American Elizabeth Bolden's story surfaced in 2003, when an article ran in the Memphis, Tennessee newspaper about "Lizzie" Bolden's "112th" birthday and was picked up by national newswires. As usual, the first step in investigating an extreme claim is to collect details of the story and try to create an outline. In this case, early factors pointed to Elizabeth being quite old, including reports of children said to be in their eighties, and of great-great-great-grandchildren. When it came to actual documents, however, the story pleaded, as is typical in such cases, that the family did not have them, and that any documents that once existed were destroyed. Since a fire had destroyed the Fayette County, Tennessee, records in 1925, the family had guessed that Elizabeth was born in 1891. Though the newspaper reporter had given up on trying to verify the age before she started, I wanted to make my own attempt. The SSA study also suggested to me that Elizabeth Bolden was listed as still living in their database, but they were not permitted to release the information for confidentiality reasons (the records become public after death in the U.S.).

What did the census records say? First, I found the 1930 census, which listed "Lizzie Bolden," 37, wife of "Louis" Bolden. While Lewis was misspelled, it was the correct location (Memphis, Tennessee) and the children included Queen and Mamie L., matching the names of the children in the newspaper. This first find established that Elizabeth "Lizzie" Bolden was probably at least 110 years old, but listed her as a year younger than expected. However, from hundreds of prior searches, I knew that the ages given for women, especially married women over the age of 30, tend to be understated, and especially if they were older than their husband. Also piquing my interest was the discovery that Lizzie's oldest child, Ezell, was listed as being 21 years old! If she was, in fact, 37 years old, she would have given birth at just 16 years of age (possible, but not likely). Even with this age undercount, in 2003 Elizabeth would have to have been at least 111 years old.

Jeff Knight, Tennessee police investigator and amateur investigator of supercentenarian claims, agreed to assist in my effort to find Lizzie in earlier census records. He located her in the 1920 census.[8] The bad news was that it listed her as 26 years old, in January 1920, suggesting that Lizzie was born in 1893. The good news was that the census listed one of the missing children, John Bolden. In any case, I had found Elizabeth Bolden in the 1910 census as well.[9] As far back as April 1910, Lizzie's age was recorded as 19 years old, and she had a seven-month old son. "Lizzie" Bolden was already married and had a child in 1910! This record suggested that Lizzie was older than the ages recorded not

[8] 1920 United States Federal Census > Tennessee > Fayette > Civil District 8 > District 12.

[9] Tennessee, Fayette county, roll 1498, book 2, page 165. Listed were Lewis Bolden, 19, black, head Lizzie, wife, black, 19 Ezell, son, 7/12 year (7 months old).

only in the 1930 census (born in 1892) and in the 1920 census (born in 1893), but was also older the family thought (born in 1891). Still, I couldn't be certain that Lizzie was really born in 1890. The 1910 census was only one record, and the other census matches did not confirm the birth year as 1890. Moreover, the 1910 census only gives the age, not the month or year of birth. Thus, we needed the 1900 census. But that would be difficult, because I didn't know the names of her parents at the time. A little more background information was needed.

The 2003 article had listed Elizabeth Bolden as the grandmother-in-law of the Memphis police director (James Bolden)[10]. Phone calls to Memphis provided early-life family history—names of Lizzie's parents and siblings. Finally, Jeff Knight located the 1900 census match. To quote Mr. Knight below:

I found what I believe to be her census match. She is listed in the home of Annie Jones with siblings Monroe, Mary, Josie and John. Annie is listed at the head of the household and apparently a single parent at this point. They are living in Fayette County and this clearly lists Lizzie as born August 1890 and age 9. This was taken from the 1900 Census for Tennessee, Fayette County, First District, Supervisors District 10, Enumeration District 2, Sheet 13. This census was taken June 23, 1900.[11]

The 1900 census seemed to confirm the 1910 census. Not only was Lizzie found to be nine years old in June 1900, the 1900 census (unlike the 1910 census) listed the actual year and month of birth (making it a better census for research purposes). And that year and month of birth was listed as "Aug 1890," which would make Lizzie Bolden older than the woman then believed to be the oldest living American, Bettie Wilson (see Bettie Wilson section, below).

But one final question remained: Can we be sure that the Lizzie Jones in the 1900 census is the Lizzie Bolden living today in Memphis, Tennessee? To help me solve that problem, I asked the grandson if he could guess one or more names of Lizzie's siblings. When he said, "Monroe," I was convinced this was the correct match. I was careful not to let the left hand know what the right hand was doing. Mr. Knight did not have the grandson's phone number, and the grandson did not have the 1900 census. Hence, I was convinced that the person listed in the 1900 census as born August 1890 was the same person who was alive when I made the phone call to the family.

[10] Elizabeth also had two grandsons named James.

[11] See `http://health.groups.yahoo.com/group/Worlds_Oldest_People/messages` for details.

At the time of her age validation in April 2005, Elizabeth “Lizzie” Bolden was 114, but, by August 2005, she had celebrated her 115th birthday. Of her seven children, two were still living in late 2006: Queen, age 89; and Mamie, age 86. The birthdates cited for Lizzie’s children matched well with the records: Ezell, the first son, was born September 21, 1909—note that being seven months old in April 1910 would place his birth date in September 1909. Both Queen’s and Mamie’s ages were correct in the 1930 census (April 1930-March 1917 would make Queen thirteen, and April 1930-August 1920 would make Mamie nine). The grandson also said that Lizzie’s second child was John Bolden, confirmed from the 1920 census listing. Finally, the grandson, James Bolden, sent me a copy of a family biography of Elizabeth Jones Bolden from August 1983. The documents confirm the identity of Elizabeth, her parents, and her seven children, long before anyone thought she might become the world’s oldest person.

Elizabeth “Lizzie” Bolden was recognized by Guinness World Records as the “oldest living American” from June 23, 2005. She was briefly recognized as the world’s oldest person for 101 days in late 2005 after the death of Hendrikje van Andel-Schipper of the Netherlands on August 30, 2005 (see chapter by Jeune et al. in this volume) and before Maria Capovilla was awarded the title on December 9, 2005 . After the death of Maria Capovilla on August 27, 2006, Elizabeth Bolden was considered to be the “world’s oldest person.”[12] Her living children were 89 and 86 years old; her oldest son would have been 97 if still living (but he died in 1987, aged 78) and she was said to have great-great-great-great-grandchildren, though the claim to seven generations has not been verified.

2.3 Maggie Barnes: Aged 115 or 116? (March 6, 1881 or 1882? - January 19, 1998)

I first became aware of the claim that Maggie Barnes had reached age 117 in 1998, after her death made the newspapers. The reports said she was born on March 6, 1880, and died on January 19, 1998, which would have made her 117 years and 319 days old—older by five months than Canada’s Marie-Louise Meilleur, who, at that time, was still alive at 117. At first, I was skeptical, as many exaggerated claims had been made by African-Americans in the past. However, upon reading the

[12] Guinness officially bestowed the title on her on September 17, 2006. Bolden is just the second person, after Jeanne Calment, to re-gain the title after losing it to someone thought to be older.

obituary from the local newspaper (Raleigh, North Carolina's News and Observer, January 22, 1998), I noticed several characteristics of this story that stood out from the others I've seen. For one, the surviving children were aged 92, 90, 75, and 71; which compared well with the ages of Marie-Louise Meilleur's surviving children, aged 89 to 71. Another factor was that the family had made a concerted effort to document her age, applying to Guinness for the "world's oldest person" title. Interestingly, the article stated that the family Bible said she was born in 1882, while the 1900 census "put her birth date in 1881," and the marriage license said 1880. It appeared that, although she might not have been the 117 years claimed, a case could be made that she was at least 115 years old.

Searching for Maggie's children, I discovered that three of the four children listed in the article had died, but the youngest, Mildred, was still living. A search of the Social Security Death Index (SSDI) turned up the dates of birth and death for the three children mentioned in the article who had died since: Gladys Roberson (November 7, 1907 - September 7, 1998), at age 90; Clara Barnes (August 30, 1905 - September 8, 1998), at age 93; and Ruth Revell (December 4, 1922 -January 12, 2002), at age 79. This information confirmed the ages of the children given in the story.

The daughter, Mildred, was able to provide information pertinent to her mother's case. Her father was William O. Barnes; there were 15 children, but seven died as infants or in childbirth. The first child born was Lillian, while Gladys also went by the name "Beatrice." The SSDI listed Gladys B. Roberson, so the middle initial matched as well. Maggie Barnes had lived her entire life in Wilson and Johnson counties, North Carolina. Mildred also confirmed that "Hinnant" was her mother's maiden name, not a middle name. The children, as she remembered them, were Lillian, Clara, Mary, Nellie, William, Ruth, Mildred, Marian, Malichai, and Gladys Beatrice. The husband's name was William Orangie Barnes. The family had been sharecroppers.

Searching the 1930 census, I discovered Maggie Barnes, 48, in Beulah, Johnston County, North Carolina. Maggie was listed with husband William O. Barnes, 52, and children Willie, 16(?); Mary, 14; Ruth, eight; and Mildred, four. Since the 1930 census was taken in April, this suggests that March 1882 was the correct birth date. I also noted that the two younger children were definite matches, although the ages given, eight and four, appeared to be rounded up. The names Willie and Mary also match the list of children mentioned by Mildred.

Going further back, the 1920 census for Beulah, Johnston County, North Carolina, listed W.O. Barnes, 48, and his wife, Maggie, 40; as well as children Clara, 15; Beatrice, 12; Nettie, nine; Willie, seven; and Mary, four(?). The names of every child roughly corresponded with what would be expected: Clara, born August 1905, should have been 14; Beatrice, born in November 1907, is correctly listed as 12 years old in January 1920; "Nettie" is likely "Nellie;" while the names Willie and Mary appear again. Ruth and Mildred were not born yet, and thus are not listed. The age of 40 years old in January 1920 suggests a birth date in March 1879, which, if correct, would have made Maggie Barnes 118 years old.

Turning the clock back another ten years, I was able to locate Maggie Barnes again in the 1910 census,[13] which listed husband William Barnes, 32; wife Maggie, 30; daughter Lillian, 10; daughter Clara, 5; daughter Beatrice, 3; and an indecipherable name. The names of the three oldest children all matched what would be expected. Once again, the age of Clara appeared to be rounded up; if born in August 1905 she would have been four years old in April 1910. The age for Beatrice appeared to be rounded up as well: three, instead of two. The age of the husband, William, corresponded with the 1930 listing of 52 years old 20 years later, suggesting the 1920 census record was less reliable in this instance. The age of Maggie, 30 years old in April 1930, suggests a birth date in March 1880.

Mildred Barnes also sent me a copy of the marriage certificate. It stated that William Barnes, 22, married Maggie Hinnant, 19, on October 22, 1899. However, this was a delayed certificate only issued in 1954. From this document, we can say that Maggie Hinnant and Maggie Barnes were one and the same person, but a document written in 1954 (not a 1954 copy of an 1899 original) does not prove that Maggie Barnes was really 19 years old, or that she actually married in 1899. The family Bible, apparently, could not be located. Thus, the last document that remained to be checked was the 1900 census. The 1998 newspaper article stated that Maggie Barnes was listed as born in 1881 in the 1900 census. The 1900 census match was found by the SSA/Kestenbaum study.[14] The 1900 census listed this couple as married less than one year. However, given that the census was taken in

[13] The rolls for North Carolina, Johnston county, town of Kenly, East Beulah township, roll 1118, book 2, page 157.

[14] In September 2003, the Kestenbaum study located in the 1900 census for North Carolina, Wilson County, roll 1224 book 2 page 1 a the following match:
Orangine W. Barnes, head, 21
Maggie Barnes, wife, 19 (born Mar 1881).

June, a marriage date of October 1899 is plausible. Moreover, if born March 1881, Maggie Barnes would have been 116 years and 319 days old at her passing. However, the SSA study decided to "err on the side of caution." Because the family Bible said "1882," the SSA went with age 115.

The issue, then, with this case is not whether Maggie Barnes was older than 115, but how much older. When I asked Mildred how old her mother "really" was, she replied, "116." The evidence almost certainly suggests that the Maggie Barnes who died in 1998 was at least 115 years, 10 months old; and possibly 116 years, 10 months old. However, it may be that the SSA study's conservatism was on the mark: in 2008, I located the North Carolina Death record for Maggie Barnes, which listed her date of birth as March 6, 1882. While this would make her younger than Marie-Louise Meilleur, and even deny her the "oldest living American" title (Sarah Knauss, born September 24, 1880, eclipsed her), all the evidence agrees that Maggie Barnes was one of the first verified persons to reach age 115,[15] and was, at the very least, the world's third-oldest person at the time of her passing.

2.4 Margaret Skeete: Oldest living american at age 115 (October 27, 1878 - May 7, 1994)

Margaret Skeete, said to be born October 27, 1878, in Rockport, Texas, first garnered national media attention in 1993, when she was included in the Guinness Book of Records as the "oldest living American" at age 114. She was again listed in the 1994 edition at age 115. The family actually applied to the Guinness Book and was accepted in 1992, when Margaret Skeete was age 113, according to the local Roanoke Times newspaper (July 11, 1992). Other local press mentions were found for April 1, 1992 (application for Guinness recognition); October 29, 1992 (114th birthday); March 5, 1993 (inclusion in 1993 Guinness edition); October 28, 1993 (115th birthday); and December 8, 1993 (parade marshal). Thus, we have a case where the person was not suddenly declared to be age 115 upon death; instead, the record shows that Margaret Skeete had been verified as 113 years old while still alive, and then went on to live two more years.

The second step in the age investigative process involved combing the news articles for pertinent background details. Of particular note

[15] Including Lucy Hannah but discounting questionable cases, Maggie Barnes would have been the eighth person to reach 115, in March 1997. The ninth person, Christian Mortensen, turned 115 in August 1997 (see chapter by Jeune et al. in this volume).

were the claims that Margaret Skeete was born in Rockport, Texas; that she was recorded in the 1880 census; that she lived in Texas until 1953, when her husband, Renn Skeete died, then moved to Virginia; and that her oldest daughter was Verne Taylor. Also noted in Guinness was her maiden name, Seward. The articles also stated that she had three children.

Searching the 1920 census, I located a listing for Martha M. Skeete, age 41, wife of Renn Skeete, who had three children: Verne, daughter; Seward, son; Charles, son. The record was for Brazoria County, Texas. Since the 1920 census was taken in January, someone born in October 1878 should have been 41 years old at the time, exactly the age given for "Martha" Skeete. The unusual name of the husband matches, as does the name of the oldest daughter, Verne. The older son's name, Seward, suggests he was named after Margaret Skeete's maiden name. The location, Texas, also matches. We can thus conclude that this is the same woman who died in 1994 at the age of 115.

However, 41 years is still too far removed from the birth event to provide certainty. It could be that her age was still off by a few years. If the 1880 listing could be found, however, it would put this issue to rest. Because Rockport, Texas, is in Aransas County, and the county had a population in 1880 of only about 150 people, a simple search of the county should turn up the match—and it did. Located was an R.H. Seward, 39, with wife Margaret, 39, and children Mary, 14; William, 11; Isaac, nine; L.E., seven; Frank, four; and Mattie, two. This was obviously the same match found and sent to Guinness by the family. Of course, knowing the names of the family in advance would have helped, but both the maiden name, Seward, and the name of the mother, Margaret, match. In addition, in such a small population, there was only one Seward family listed. Thus, this appears to be the same person. A minor issue is that if this were the same person, taken literally, she would have been 116 years old, not 115. However, it is likely that the age of the child was rounded up to two, the census having been conducted in June 1880. In any case, finding evidence suggesting Margaret may have been older certainly does not contradict the claim to being "115+," but strengthens it.

Searching again, the 1910 census turned up a match. Once again, we find husband Renn Skeete, 27. Daughter Verne is the only child listed at 1, but the others wouldn't have been born yet. The county, Brazoria, matches the 1920 listing. Interestingly, the wife's name is given as "Mattie Skeete." This proves that the Margaret Skeete who died in 1994 went by "Mattie" at an earlier period, and thus provides more evidence to support the assumption that the Mattie Seward in the 1880 census listing is the Mattie Skeete in the 1910 census, the Martha Skeete in the 1920 census, and the Margaret Skeete who died in 1994 at age 115. Further, the age given, 31 (in April 1910), is consistent with what is expected for someone born in October 1878. Although this case could be studied further, all the evidence combines in a way that strongly supports the contention that Margaret Skeete really was 115 years and 192 days old when she died on May 7, 1994. Mrs. Skeete's cause of death was given as a result of a fall three weeks earlier, breaking a hip.

2.5 Emiliano Mercado Del Toro: Second man to reach 115 (August 21, 1891 - January 24, 2007)

In 2002, it was reported from Puerto Rico that the oldest military veteran in the world was living there at age 111.[16] In early 2003, a family member contacted me to report that Emiliano Mercado Del Toro was "dying" of gangrene in his foot. However, he recovered, and by December 2003, was featured prominently in a New York Times article.[17] It was not until November 2004, following the passing of Fred Hale, 113, that I began receiving documents on this case. At this point, Emiliano was the leading candidate for the Guinness "world's oldest man" title. At the time, I was a correspondent with Guinness, and they sent me the documents for the case to help validate it. While the details of the documents remain confidential, what was impressive in my view was the number of early documents. The family had sent a certified copy of an original 1891 birth certificate written in September 1891, an 1892 baptismal entry stating that the birth had taken place in 1891, and identification cards verifying both his status as a veteran and as a resident of Puerto Rico. Using the personal family details, including parental information, I, with the help of Mr. Jeff Knight once again, was able to come up with some census matches.[18]

The 1910 census in particular was compelling, as it listed Emilio Mercado y Toro as age 19, along with his father (age 45), mother (age 50), sister (age 13), and niece (also 13). Not only was this the correct

[16] `http://www.puertorico-herald.org/issues/2002/vol6n46/Media2-en.shtml` (accessed Oct. 16, 2006).

[17] `http://topics.nytimes.com/top/reference/timestopics/subjects/w/world_war_i_/index.html?query=MERCADO\%20DEL\%20TORO,\%20EMILIANO&field=per&match=exact` (accessed Oct. 16, 2006).

[18] Source Citation: Year: 1910; Census Place: Pedernales, Cabo Rojo, Puerto Rico; Roll: T624_1761; Page: 16A; Enumeration District: 491; Image: 658.

town (Cabo Rojo, Puerto Rico), but the names of both parents matched the birth certificate (Delfin Mercado and Gumercinda Del Toro). Hence, we have a positive identification and an age that points to a birth date in 1890 (since the census was taken in May, the family may have simply rounded up Emiliano's age, as he would have been three months shy of 19, if born in August 1891).

The 1920 census[19] also lists what appear to be Emiliano, his mother, and some siblings, again in the same town, Cabo Rojo. However, the age given this time is 27, or one year younger than expected (and, given that the 1920 census was taken in January, this census record correlates to a birth date in August 1892).

The 1930 census, in contrast, is a clear age underreport. Here we see Emiliano again with his mother, Gumercinda, in Cabo Rojo, Puerto Rico. However, the age given, 32, correlates to a birth date of 1897. Also of note, Gumercinda's age was listed as 59 in 1920, as 50 in 1910, but as 60 (instead of 70) in 1930. This points to the issue of age underreporting. While age overreporting is common for persons over 80, many middle-aged women tend to underreport their ages. Emilio's age underreports in 1920 and 1930 would partly be a reflection of his mother wanting to appear younger, but perhaps also reflected a slight embarrassment with having a 38-year-old, single bachelor still living with his mother. Documents must be viewed in the context in which they were written.

For this case I also received assistance from Lt. Col. Bob Johnson of the Veterans Administration (VA), who had been searching for remaining World War I veterans, especially in obtaining the WWI papers and the VA records. In Emiliano's case, his WWI papers listed his age erroneously (as age 25 in late 1918), which suggested a birth date in 1893. However, given that the two documents were written in 1891 and 1892, we must conclude that these were in error, and that 1891 was the correct date. It should be noted that WWI records often were erroneous, as ages given were adjusted to make a candidate more likely to be drafted (i.e., 17-year-olds became 18, while 27-year-olds became 25). The main importance of these documents is to establish identity. Emiliano never married and never had children, so to conclude that the man living today is the one in the original birth and baptismal records, military records confirming his identity are absolutely necessary. In January 2005, Guinness World Records officially recognized Emiliano as the world's oldest man and oldest veteran.

[19] Source Citation: Year: 1920; Census Place: Pedernales, Cabo Rojo, Puerto Rico; Roll: T625_2049; Page: 12B; Enumeration District: 491; Image: 366.

In short, we have many documents to support this case. In contrast to some cases, the oldest documents (1891 birth certificate, 1892 baptismal record, 1910 census) support the oldest birth date, whereas the later records (1918 WWI papers, 1920 census, 1930 census) suggest birth dates of 1892-1897. The principle of stratigraphy again holds that the older documents, laid down first, are more reliable. Moreover, given that the 1891 and 1892 records were written in 1891 and 1892, Emiliano must have been born in August 1891, assuming the records refer to him. In regards to sibling-switching, in 1910 we see Emiliano listed along with a 13-year-old sister and a 13-year-old niece. According to the 1910 listing, Emiliano's parents had been married for 21 years.[20] This makes it likely that Emilio/Emiliano was the firstborn son.[21] Given that, as of 1910, the mother was listed as 50 years old (and had stopped having children 13 years ago), Emiliano was alive and listed, and the only other sibling listed is a 13-year-old daughter, we can find no room for an alternate explanation. If a younger Emilio had been born, the older one would have died and the younger one would have been listed. That is not the case here. Instead, the Emiliano listed is older, and there is no younger male sibling. Emiliano's age only begins to be less than expected when he is an adult, and when society's assumptions of marriage and independent living, combined with a middle-aged woman's tendency to understate her age, may have led his mother to underreport his age in 1920 (by one year) and in 1930 (by six years). Notably, the mother underreported her age by one year in 1920 and, 10 years in 1930, suggesting that the mother's age was an overriding factor in Emilano's age underreport.

In regards to the Emiliano/Emilio name issue, I found that the original birth and baptismal certificate used "Emiliano," but that many documents, including the census matches and identity cards, used "Emilio." However, first it should be noted that these two names are seen as interchangeable, much like Tom/Thomas or Dave/David in English. Second, rather than one name being used earlier and another later, I instead found that the two names were used interchangeably at

[20] If Emiliano's age were false, it would be more likely that his parents would have been married for a time too short for him to be 19 in 1910. Clearly, this case passes that test, as 21 is greater than 19.

[21] We can also note that Emiliano's father would have been 26 years old and his mother 31 years old at the time of his birth. Given that many false cases forget to change the age of their parents (i.e., the parents gave 'birth' at age 10 or 15), this case passes yet another test. I know of one case, William Coates, where the 22-year age exaggeration claimed placed his birthdate in 1889, while his mother was born in 1890!

various points in time, and with cross-identifying information. Third, the names of the parents and town location, and the double last name, help to confirm that there was only one Emiliano/Emilio Mercado Del Toro who was born in Cabo Rojo, Puerto Rico, on August 21, 1891, to Delfino Mercado and Gumercinda Del Toro.

Given Emiliano's frail health, many did not expect him to survive to his 115th birthday, but Emiliano was not one to give up easily. In August 2006, he reached the age of 115, becoming just the second verified male to reach that age. On December 11, 2006, following the passing of Elizabeth Bolden, Emiliano was named world's oldest person by Guinness World Records, the first time in twenty years a male had held the title. It was not to be long, however: on January 24, 2007, Emiliano passed away "like an angel" according to a family member, at age 115 years 156 days.

2.6 Bettie Wilson: Aged 115 (September 13, 1890 - February 13, 2006)

The Bettie Wilson case first came to my attention in September 2003. Shortly after Bettie's 113th birthday in New Albany, Mississippi, the local newspaper reporter sent me an email informing me that, not only was a local resident turning 113, but that the family had documents as well, including records from the 1900 census. Further, the newspaper story claimed that Bettie was a great-great-great-great-grandmother, and that her son was 94 years old. Not only was Bettie said to be 113, but photos of her also showed her to be in great shape.

The family already had documentation, including a 1900 census match listing Bettie Rutherford as nine years old, born September 1890; a 1919[22] marriage certificate; a 1922 marriage certificate; and a 1959 census copy of the 1900 census match, showing that, in 1959, the family used the 1900 census match, perhaps to identify Bettie Wilson to obtain retirement benefits (she would have been 69 years old in 1959). Moreover, the 1959 document established that Bettie Wilson was then a resident of New Albany, Mississippi. However, the son was said to have been born on October 27, 1909 (which would have made

[22] Marriage certificates in Mississippi did not begin until 1912. Thus, for a marriage license to be issued to an African-American couple some 9-10 years after the birth of their child is not surprising, given the context of time and place. Given the ages of Bettie's son in the 1930 and 1920 census, it seems most likely that Willie Rogers was born in October 1910, although the family claims he was born in October 1909. Bettie's son was thus 95 or 96 years old at the time of his mother's passing.

him 93, not 94, in September 2003). Also, apparently the claim that she was a four-time great-grandmother was an error: Bettie was simply a great-great-great-grandmother, I was told. Nonetheless, my interest was piqued.

Thus, in September 2004, I attended Bettie Wilson's 114th birthday party. There, I talked to her in person, as well as to her family. The family tree book, apparently written in the 1970s, listed Bettie Antry (Rutherford) Wilson as born on September 13, 1890, and her son Willie Rogers, as born on October 27, 1909. It was the only record I saw listing their birth dates. However, each new piece of evidence seemed to help: the 1900 census listed Bettie A. Rutherford, with her middle name now starting with an "A." In November 2004, I returned to Mississippi to interview Bettie Wilson for an oral history project (for Georgia State University in conjunction with the University of Mississippi). In talking to Bettie, I learned that her mother came from South Carolina, and that her father was Solomon Rutherford.

With the best census record, that of 1900, already located, I continued on to the April 1910 census, which included a record of Bettie Rutherford, age 20, a single woman and maid. The age given suggests that her birth date was in September 1889, but she may have been 19 years old. The 1900 census is earlier and seems more accurate (listing her as born in September 1890 and as age nine)—once again, the closer to the birth date, the better.

However, in the 1930 census her age was recorded as 35, and her second husband, Dewey Wilson, was said to be only 32. As the head of household normally gave the information, could it be that Dewey didn't want it to be known that Bettie was much older than he was? Indeed, in the census, Bettie's age at first marriage is given as 27, and Dewey's as 24. But if Bettie was 35 in 1930, the year when she was 27 would have been 1922, the year of her second marriage certificate. For some reason, Mr. Wilson mis-reported Bettie's age at her first marriage as her age at her second marriage, although Bettie's children from the first marriage were listed: "Duke" and Theresia Rodgers, aged 19 and 16. The family explained that Willie's nickname was "Duke," and given that he was listed as the stepson, not son, of Dewey Wilson, this cements the claim that Bettie Wilson was formerly Bettie Rodgers (the marriage records spell the name as "Rogers"). One last note about the census matches: if Willie "Duke" Rodgers was 19 years old in 1930, he would have been born in 1910, not 1909. Also, the April 1910 census lists Bettie Wilson with no children, which also suggests that Willie was not born in October 1909.

Hence, after investigating, I found that Bettie Wilson's age was correct, but that Willie's age may have been off by a year. Still, Mrs. Bettie Wilson had celebrated her 115th birthday and her son, Willie, was still living at age 95 (not 96 or 97). "Miss Bettie," as she was affectionately called, could still read and write at age 114 and still sang gospel hymns at 115. Sadly, Bettie Wilson passed away February 13, 2006, at the home of her great-granddaughter. At the time, Bettie was recognized as the world's third-oldest person.

2.7 Susie Gibson: Aged 115 or 116? (October 31, 1889 or 1890? - February 16, 2006)

When she died in February 2006, Susie Gibson was believed by family and local Alabama residents to be age 116, born on October 31, 1889. Susie herself has said, "I'm the world's oldest person;" and, "I was born in 1889." The Susie Gibson case was mentioned in the press in late 2001, when a story from a local Alabama newspaper ran about a woman celebrating her 112th birthday (this was found by Louis Epstein; he informed me of this case in March 2002), and I located the original story in a newspaper search index. While relatively late for a first mention of a centenarian story, the claim was still made well before anyone alleged an age of 115 or greater.

Later, in November 2002, the claim was made that Susie Gibson had turned 113 years old, and was one of the oldest living Americans. Whereas previous requests for more information made by Mr. Epstein and me were ignored for months when Susie was 112, now that she was in the running for the "oldest living American" title, we were finally getting some responses. Indeed, several people emailed us to inform that "Suzie" Gibson was celebrating her "113th" birthday. Most importantly, the news writer sent me the phone number for the nursing home, which then asked the family if they would allow me to contact them. When they said "yes," the case began to move forward.

This case began with a dispute over whether Susie Gibson was the "second-oldest" American, or not. The local Times-Daily newspaper had touted her as such, albeit without verification. As it turned out, the family of Susie was able to give pertinent details of her life history. Susie was born in Corinth, Mississippi. Her father was Joe Potts, her husband was James W. Gibson, and her only son was James W. Gibson, Jr. To dispel any doubts about the name change, the family sent me a copy of a wedding invitation. Susie Elizabeth, daughter of Joseph P. Potts, was marrying James W. Gibson on November 8, 1915, in Corinth, Mississippi.

In November 2002, I called daughter-in-law Ernestine Gibson and interviewed her for background information about the family, including the names of Susie's father, mother, siblings, husband, and child; as well as information about the places where they lived. I was subsequently able to find a record in the 1920 census of a Susie Potts Gibson, who was married to James W. Gibson, but had no children yet; her only son, James Jr., was born in 1921. They lived in Sheffield, Colbert County, Alabama. The census match listed Susie as 29 years old.[23] Maybe Susie simply fudged her age in 1920?

I therefore checked the 1900 census as well. Ernestine Gibson told me that Susie's parents were Joe and Mary Potts, and lived in the town of Corinth in Alcorn County, Mississippi, when Susie was a child. Susie had other siblings, including Henry and Aileen. While the names Joe and Mary are extremely common, a search of the 1900 census found only one Joseph Potts in Mississippi, and he lived in Corinth, Alcorn County, in 1900.[24] The chance of a similar family living in the same state, county, and town, with the same names of husband, wife, and children, is so small as to not be worth considering. Therefore, I concluded that Susie Potts Gibson was born on October 31, 1890, and was 112 years old at the time.

By November 27, 2002, the GRG list[25] had accepted Susie Elizabeth (Potts) Gibson as validated and born on October, 31 1890, instead of on October 31, 1889. While not at the top of the world ranking yet, Susie continued to thrive, while those who were listed as older than she was passed away. A year later, by November 2003, Susie was up to seventh-oldest in the world. Although late age validations, such as those of Bettie Wilson, Elizabeth Bolden, and Maria Capovilla, would slow her climb on the validated living list, Susie continued to thrive in 2004, being well enough to talk to me for an hour interview in November 2004, at the age of 114. Susie would last more than a year longer, even attending an O'Charley's restaurant for her 115th birthday party in 2005. However, she began to fade shortly after that, and passed

[23] The 1920 Census lists a James W. Gibson, 34, and wife Susie Potts Gibson, 29, in Sheffield, Colbert County, Alabama, enumeration District #19. Because the 1920 census was taken in January, 1920-1-29=1890.

[24] 1. Joseph Potts, father, born Apr. 1856, 44 years old
2. Mary Potts, mother, born June 1861, 39 years old
3. Henry Potts, son, born Oct. 1886, 13 years old
4. Aline Potts, daughter, born Dec. 1888, 11 years old
5. Susie Potts, daughter, born Oct. 1890, 9 years old
6. Robert Potts, son, born May 1893, 7 years old.

[25] `http://www.grg.org/Adams/E.HTM` (accessed Oct. 16, 2006).

away on February 16, 2006, just three days after Bettie Wilson. Susie, like Bettie, ended her life as the world's third-oldest person. As I had interviewed both, I attended the funerals of both as well.

But the case of Susie Gibson was not completely finished upon her death: her tombstone, written in the 1950s, was inscribed with an 1889 birth date. Given that Susie herself always said she was born in 1889, I believe that Susie could have been 116 years old, based on the circumstantial evidence.[26] However, given that there was no birth certificate and the family Bible has not been located, we must go with the oldest documents available. Two census matches suggest that Susie was 115 years old, including the oldest (1900) census match.

2.8 Maud Farris-Luse: Aged 115 (January 21, 1887 - March 18, 2002)

I first became aware of the case of Maud Farris-Luse in early 2001, shortly after reports of her 114th birthday made the Detroit-area news, and, subsequently, the Internet. Her first 113 birthdays never made it further than the local newspaper in Coldwater, Michigan. However, in 2001 a local resident posted her 114th birthday story on a national website, where I found it. Together with Louis Epstein, we were able to verify that Maud Farris-Luse was really 114 years old by May 2001, less than a month before the death of Guinness "world's oldest person" titleholder Marie Bremont of France (April 25, 1886 - June 6, 2001). Maud was given the Guinness "world's oldest person" title on June 23, 2001. Despite being in delicate condition, Maud reached her 115th birthday in January 2002, before passing away March 18, 2002, from pneumonia.

In the case of Maud, there is ample newspaper evidence of earlier birthday celebrations: her 98th, in 1985; 100th, in 1987; 101st, in 1988; 103rd, in 1990; 105th, in 1992; 106th, in 1993; 107th, in 1994; 108th, in 1995; 109th, in 1996; 110th, in 1997 (whereupon she wrote a letter to Jeanne Calment of France, then almost 122); 112th, in 1999; 113th, in 2000; 114th, in 2001. Thus, a 115th birthday celebration in 2002 was, barring her death, totally expected. We can say with certainty that the

[26] That is, the family tombstone was made long before anyone thought that Susie would live to the year 2006. Also, her Social Security records were issued well after age 65, so there was no 'early retirement' incentive. Third, Susie herself said she was born in 1889. At it is, the census reports were made by persons other than Susie (i.e., her father or husband). Thus we have no direct self-reported age from Susie herself. Choosing the census date of 1890 is a default, based on the lack of direct evidence (i.e., birth certificate) from the birth event.

person who died in 2002 aged 115 was the same person who celebrated her 100th birthday 15 years earlier in 1987[27].

Maud Davis was born January 21, 1887, in Morley, Michigan, to parents Chester Frank and Della Davis. In 1891, the family moved to Angola, Indiana, reportedly by wagon. In 1903, she married Jason Ferris at age 16, which required parental consent. They enjoyed 48 years together, having seven children, until his death in 1951. The children were identified as Charlie (1905-1987), Ester (1907-?), Ruby (1908-?), Walter (1909-?), Clair (1911-1988), and Dale (1913-1986)—six children born in eight years, when Maud was 18 to 26 years old—then a lone child in 1928, Lucille, when she was 41. Lucille was the only one of seven children to survive Maud. In 1925, the Ferrises moved back to Michigan, settling in Coldwater. At some point, Maud decided to spell her name "Maud Farris;" it was originally "Maude Ferris." Later, a short marriage to a Mr. Luse in the early 1960's rounded out the present form, Maud Farris-Luse.

Comparing the files of family history sent to me by the family of Maud, we now take a look at the census evidence. The 1920 census for Indiana, Steuben County, city of Angola, enumeration district 160, lists Jason Ferris, head, 41; wife Maude, 32; and children Charles, 14; Esther, 13; Clair, 8; and Dale, 6. Because the 1920 census gives the age of the persons "as of January 1, 1920," and Maude wouldn't have been 33 years old until January 21, the listing here is technically correct. With four matching children (it is possible that Ruby and Walter had died early), the correct husband, town, county, and state, there can be no doubt as to the identity of the family here.

Looking at the 1910 census for Indiana, Steuben County, city of Angola, roll 380, book 2, page 95, lists Jason Ferris, husband, age 30; wife Maud, 23; son Charles, four; daughter Esther, three; and son Walter, 10 months old. Because the 1910 census was conducted in April, we would expect Maud to be 23 years old, as she is listed here. The ages of the children also match the 100th birthday record (Ruby possibly had died earlier).

The marriage license was dated June 27, 1903, well within the 20-year limit for validation by proxy. Although this document provided proof of name change (from Maude Davis to Maude Ferris), there was no age listed. Fortunately, an affidavit signed and dated June 27, 1903,

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[27] In his book Human Longevity: Its Facts and Its Fictions in 1873, William Thoms proposed the '100th birthday test' for supercentenarian claims, mostly to see if the age claim stayed consistent over time.

by the mother, Della Davis, giving parental consent to the marriage, lists Maud's age as 16 years old in 1903.

The SSA study found Maud in the 1900 census, state of Indiana, Steuben County, in Salem township. Listed are Frank Davis, 42, head of household; wife Della, 36; and children Jay, 18; an indecipherable name, 15; and Maud D., 13, born January 1887. The family had provided newspaper articles from 1920, covering the tragic murder of Frank Davis at age 62, which listed his children as Jay, May, Maud, and Essa, who died in infancy. With this, we can say we have quite a few matching points: same father, mother, brother, county, name (including middle initial), age, and month of birth. The indecipherable name appears to be Ima M. Davis, which could easily be "May" Davis (assuming she went by her middle name). Not surprisingly, the deceased infant is not listed.

The many matching points in historical records identifying the Maude Davis listed as born in January 1887 in the 1900 census as the same Maude Farris-Luse who died on March 18, 2002, at age 115 years, 56 days old, clearly validate this case.

3 False cases

3.1 Mattie Owens: Aged 119 or 105? (October 15, 1883 or 1897? - February 6, 2003)

Like so many other claims, the claim that Mattie Owens was 119 years old did not even reach major news outlets until after her death on February 6, 2003, in Long Beach, New York. It was then that the claim was made that she was born October 15, 1883, which, if true, would have made her 119 years and 114 days old-older than Sarah Knauss, the U.S. record holder, by 17 days. This was, of course, a first sign of a problem: if she had really been 119 years old, why did it take this long for the claim to be made that she was the world's oldest person? Why not submit a claim in 2000, when she would have been two years older than Eva Morris, who, at 114, was the official "world's oldest person" listed by Guinness? This case required further investigation.

Luckily, in the newspapers' eagerness to report the story, a plethora of background details were given—details which would prove important in investigating this case. The first solid indication that Mattie Owens was not actually 119 years old was that the family had thought she was "only" 117 years old, and that the birth date of October 15, 1883, came from the Social Security Administration—a source that has been notoriously unreliable when it comes to age reporting.

The local newspaper article, “Remembering Mattie Owens, 119,” by Kimberly Acevedo of the Long Island (NY) Herald, stated that Mattie Owens was born Mattie Arnold in Greenville County, South Carolina. Her children included Capers Elrod, 87; Immajean McKeeson, 79; and Alvin and Mack Elrod, both deceased. Her husband was George Owens. This suggested that Mr. Owens was not the first husband, and that a Mr. Elrod was Mattie’s husband during her childbearing years. This was subsequently confirmed by family members.

With the story laid out, it was time for background investigation. I started with the 1930 census, which immediately produced a match: in South Carolina, Anderson County, town of Williamston, district 54, page 16, image 189, was listed Mattie Elrod, 35; son David Elrod, 18; Walter Elrod, 15; Mack Elrod, 9; Capers Elrod, 7; Imogene Elrod, 5; and Alvin Elrod, 3. The names of the last four children all matched, suggesting the family had somehow lost track of the older siblings (or, at least, that the obituaries failed to mention them). For the name, Mattie, and the location, South Carolina, there were a total of six matches, far more than enough to conclude that the Mattie Owens who died in 2003 was the same Mattie Elrod listed as 35 years old in April 1930. If we assume that she was born October 15, this would suggest a birth date of October 15, 1894, and hence an age at death of ’only’ 108 years. Further, the oldest living son, Capers, was listed as just seven years old in 1930, and was, therefore, only 80 years old, not the 87 claimed, at his mother’s death. Daughter Immajean, five years old in April 1930, was likely 78 years old, not the 79 claimed. It should be noted that the Social Security records for David Elrod (November 24, 1911-1969), Mack Elrod (June 24, 1920-July 11, 1982), and Alvin Elrod (June 27, 1926-September 1969) all closely match the ages given here. It seemed that the older the person, the more years that were added to the person’s age. This also shows that the ages of the oldest children cannot be used to prove the age of the parent, unless the age of the child can also be demonstrated to be valid.

Going back a further ten years, I found another match in the 1920 census. Once again, in South Carolina, Anderson County, town of Williamston, enumeration district 65, we find a listing for Kate Elrod, 40, husband; Mattie Lee Elrod, wife, 22; David, son, 7; and Walter A., son, 5. We can assume that children Mack, Capers, Imogene, and Alvin were not born yet, as all were listed as less than 10 years old in 1930. This also points to the need for multiple census checks—the

1920 record cannot be directly matched to the 2003 obituaries, as neither the husband's unusual name, Kate, nor that of the oldest children, David and Walter, were mentioned. Yet, this can be directly linked to the 1930 census record, as it is the same location, the names of the two oldest children match (as well as the ages given), and the last name, Elrod, also matches. Once again, a family member (Dionzia Chapman) confirmed that the first husband was Kate Elrod, and that Mattie's middle name was Lee.

To be honest, I had at first passed over this match, as I had thought that "Kate Elrod" must have been a single mother listed as head of a household, without checking the possible match. Once found, however, this presented a problem: If Mattie Lee Elrod, later to become Mattie Owens, was only 22 in January 1920, then she would have been born in October 1897, and was, therefore, only 105 years old at her death in February 2003. So which age was correct: 105 or 108? Because the oldest record is closer to the actual birth event, it is more reliable. Still, another search was needed.

Going back ten more years, I found another match in the 1910 census. In the entire state of South Carolina, there was only one Mattie Arnold. She just happened to be in the right county—Greenville county. The record for South Carolina, Greenville County, roll 1461, book 2, page 70, listed the following family: Joseph Washington, 44, head; Lizzie Washington, wife, 26; Mattie Lee Arnold, 12, boarder; James Washington, 16, boarder; and Hannah Washington, 12, boarder. She was the correct race for a match, black. Her age given, 12, matched the age of 22 given 10 years later in 1920 (with a birth date in October, the discrepancy between April 1910 and January 1920 had no effect). Her middle name, Lee, matched. Finally, her next-door neighbors were the Owens! These were just too many coincidences, but I needed confirmation from the family. Once again, not just one, but two, family members confirmed that Mattie's parents had been John (or maybe Bob) and Elizabeth Arnold, that Elizabeth later married Joseph Washington, and that James Washington was a stepbrother. If Mattie's mother had been 26 years old in 1910, and Mattie was 12, then she gave birth to Mattie at age 14. If we assume that at age 26 in April 1910, Lizzie Arnold had not yet reached her birthday, she would have been born in 1883—the same year that was claimed as the birth date for Mattie Arnold in her Social Security records.

In retrospect, one can speculate that Mattie, tired of working as a servant and maid, applied for Social Security benefits using her mother's birth date. Adding 14 years to her age allowed her to collect early retirement benefits and made her less dependent on work for income. Knowing that she could possibly be caught if she revealed her true age, Mattie would, of course, have wanted to keep knowledge of her age a secret. For someone who had worked hard most of her life, the temptation of an early retirement may have been too great.

However, there appears more to the change in Mattie's age than mere money: Mattie's obituary indicated that her age was a mystery, and she liked it that way. Moreover, her first husband, Kate Elrod, either died or abandoned the family. Either way, this left Mattie with a need to fill a matriarchal role of being a strong female head of the household. In this situation, adding extra years to her age as early as 1930 may have helped enhance her status as a the "elder" in the household, just as Mr. Elrod's 40 years old in 1920 far exceeded the 22 years of his then-wife, Mattie Lee.

Whatever the motivation behind the exaggeration—money, a need for power, or a need to cling to myths of the past—we can unequivocally state that Mattie Owens was indeed not the age 119 claimed, but was, instead, 105 years old—old, but definitely not the world's oldest person.

3.2 Walter Hickman: Aged 116 or 99? (March. 22, 1889 or 1906 ? - August 8, 2005)

In April 2000, a story ran in Jet magazine about a man named Walter Hickman, who celebrated his 110th birthday.[28] Of note was that his son was 53, and grandson aged eight—large generational gaps that suggested that this case may be an exaggeration. In response to several queries regarding the claim that Walter Hickman had been born on March 22, 1889, I initiated an investigation.

I talked to the daughter of Mr. Walter Hickman of Martin, Tennessee, and she was able to provide enough details for me to find census matches which show that Mr. Hickman is nowhere near age 116. To start, Ebbie McGraw said she was 77; her father Walter, Jr. was born and lived in Kemper County, Mississippi. His parents were Walter Hickman, Sr., and Addie. His wife was "Corrina" (she pronounced it like Cor-een-a). It appears that Mr. Hickman was about 99 years old; not even born yet when the 1900 census was taken (I found his father there). In the 1910 census, I found Walter Hickman, aged four; his identity confirmed by the parents, location, and siblings. In addition, the 1920 census listed Walter as age 13. Finally, the 1930 census listed Walter as age 23.

[28] Jet Magazine, Apr 17, 2000. `http://www.findarticles.com/p/articles/mi\_m1355/is\_19\_97/ai\_61834865` (accessed Oct. 16, 2006).

Walter's father's age changed from 39 in 1910 to 57 in 1920, but in 1930 he was listed as 64.

The daughter, Ebbie, seemed not to know that age 116 would be the "oldest in the world." This seems to be a case where reporters took family lore seriously, and confused it with a real supercentenarian case. Clearly, with four census matches showing Mr. Hickman's family, and three showing Mr. Hickman in the context of the correct county and the correct wife, with no other possible matches, there is no doubt in my mind that Mr. Walter Hickman was 99 years old, plus or minus one year (98-100). Less than a month after my investigation, Mr. Hickman died on August 8, 2005, ostensibly 116 years old, but really only 99.

3.3 Carrie White: Aged 116 or 102? (November 18, 1874 or August 1888? - February 14, 1991)

Carrie White of the United States was declared the "world's oldest person" by Guinness World Records in 1989, and remained the titleholder until her death on February 14, 1991, allegedly at age 116. Carrie White had been, according to Guinness, the first person since Shigechiyo Izumi to reach age 115—a claim contested by scholars.

Carrie White was said to have been born Carrie Joyner on November 18, 1874, in Gadsden County, Florida. At some point after marrying, she showed signs of mental illness and was committed to the state mental hospital (Florida State Hospital) in Chattahoochee, Florida, in 1909. According to newspaper accounts, she was 35 years and one day old when committed. Some 75 years later, at the purported age of 109, she was released to a nursing home facility in 1984 in Palatka, Florida. Knowing this, I was able to locate her in the April 1930 census, listed as 55 years old and a patient of Florida State Hospital (for the Insane). Similarly, the 1920 census lists her as 45 years old and a patient of Florida State Hospital. The 1930 listing includes the middle initial, C; both listings indicate that she was "white." Thus, we can confirm the newspaper accounts of her long sojourn there, and the ages given match perfectly with a claimed birth date of November 18, 1874. Of course, as a victim of mental illness, the age was reported by the mental institution, and was based on their existing records.

Still, the issue of age verification encompasses not only proof of identity, but also proof of birth. Was she really 35 years old when admitted in 1909? Did the 1930 and 1920 census matches only mean that the same incorrect birth year was repeated over and over again—called replication of error? Of course, there is no motive for her to claim to be older than she was at that time; most age exaggerations related to financial incentives (i.e., pensions) tend to begin after age 50. However, absence of motive does not prove a case to be true.

The real problem here is that, abandoned by her family, there was no repository of family history that could answer some of the questions surrounding the case. Who, for example, were her parents? Did she have any siblings? Her husband was identified as John White. One solution was to run a search for all the Carrie Joyners in the state of Florida. A search of the 1880 census showed that there was only one Carrie Joyner listed in the state of Florida (and only five others in other states) in 1880: this Carrie Joyner was listed as born in 1873, aged seven years old. If this were the same person who died in 1991, she would have been 117 years old, not 116.

The next issue became how to prove this was the same Carrie Joyner. The supposed match found in the 1880 census was for Marion County (not the area expected). The 1880 census listed the father as Abraham Joyner, 38; the mother as 50 years old (name uncertain), and no other children. Thus, if it could be shown that Carrie's father was named Abraham, we might have a match.

The Social Security applications of individuals usually list the names of the parents. Thus, I was hopeful of finding a match when I ordered a copy of the SS-5 form. Unfortunately, the file application, issued in 1966, lists the parents as "unknown." Though the document lists Carrie C. White's birth year as 1874, and confirms that she was a patient at Florida State Hospital, without knowing the names of the parents, we cannot be certain that the Carrie Joyner listed as seven years old in 1873 is the same Carrie Joyner who married John White at an unknown date, and who was committed to a mental institution in 1909.

It should be noted that Carrie C. White is listed in the Florida Death Index as having been born on November 18, 1874, and having died on February 14, 1991, in Putnam County, Florida. Thus, we now have proof of death and proof of identity, together with two age intervals that all suggested the same thing—that she was, indeed, 116 years old. However, there were no matches in the 1910 or 1900 censuses for either a Carrie White or Carrie Joyner that could be the person who died in 1991, and thus the most important record, proof of birth, was yet to be located.

At this point, I sought outside help. The Social Security Administration, under the direction of Bert Kestenbaum, was conducting a study of American claims to age 110 and beyond for the period 1980 to 1999. Included in this group was, fortunately, the Carrie White case. As it turns out, the mystery was solved with a completely unexpected outcome. SSA researchers had information about the case that included the names of the parents, John and Sallie Joyner. Further, they had discovered a John and Sallie Joyner listed in the 1900 census in Leon County, Florida (in the area where we had expected to find the family). Listed with them was daughter Carrie, aged 11. According to the census, the couple had been married 12 years. Also of note, Carrie White's month of birth was given as August 1888.

This was a stunning reversal. With the expectation that Carrie, if born in 1874, was already married in 1900, a search for a Carrie White listed under husband John White turned up nothing. Another option was that she was not married, but that, at age 25, she would be expected to be single and residing on her own (before her illness). Again, nothing was found. Now, the answer seemed to be clear: Carrie White had been born Carrie Joyner in August 1888. After a bout of typhoid in 1909 rendered her mentally incapacitated, she was committed by her husband to the Florida State Hospital for the Insane. The fact that she was committed one day after her "birthday" may not be a coincidence: likely abandoned there, the facility probably invented both the birth date of November 18 and birth year of 1874. Moreover, the later SS-5 document was typed, the month of birth was not complete, and the parents were unknown. If we accept the 1900 census match as correct,[29] then Carrie White was only 102, not 116, years old at her death in 1991. It also means that Guinness simply copied an error which was made in 1909. In retrospect, this case never had a proof of birth, and shows why a proof of birth (from at least the first 20 years of life) is so important. Had the rules later devised for accepting "validated cases by proxy" been applied, this case would never have been accepted in the first place.

3.4 Wilhelmina Kott: Aged 115 or 114? (March 7, 1879 or 1880? - September 6, 1994)

Succeeding Margaret Skeete in the Guinness Book as the "oldest living American" was Wilhelmina "Minnie" Kott, said to be born to German parents on March 7, 1879, in Chicago, Illinois. Minnie Kott was listed as the "oldest living American" in the 1995 edition, despite having passed away on September 6, 1994 (after the publication deadline). Eight years

[29] Unlike some census matches, this match is not 100% certain. We do not know, for example, who Carrie's siblings were supposed to be. Without more information, we cannot be 100% certain that Carrie White was only' 102. However, we can be certain that no evidence within 20 years of the birth event was used to validate this case, and so it would not have been accepted using today's standards.

later, the SSA/Kestenbaum study found that Minnie Kott was listed as a two-month old (born March 1880) in the June 1880 census, which would have made her 'only' 114 years and 183 days old. Thus, this case is worth noting because Minnie Kott's age was off by only one year.

There is ample information available regarding the details needed to investigate this case. The obituary in the Chicago Tribune reported that Minnie Kott was born on March 7, 1879, in Peru, Illinois, as the "third youngest of 16 children." The obituary also mentions that her father was George Geringer, that she moved to Chicago with the family in 1881, and that she married husband Charles Kott in 1899. A personal communication with a distant relative now living in South Africa (Francois Geringer) reported that she was the 15th of 18 children of George Geringer and Sophia Seepe, and that George was born December 15, 1833, and married on September 17, 1854, in Peru, Illinois.[30]

Looking at this list, we can deduce several points. First of all, the mother, Sophia, was incredibly fecund; she was still bearing children at age 47 despite having started at 17! The average age attained by the 17 children besides Minnie was 47; if we count only the 12 who survived infancy, the average age at death was 66. No other sibling came anywhere near Minnie's age. The second point we can note is that Minnie was born about three years after the 14th child, and about three years before the twins (16th and 17th). This leaves a margin of

[30] The family was listed as follows:
George Geringer, father Dec. 15, 1833-Dec. 17, 1895 (62)
Sophia Seepe, mother Apr. 1838-fl. 1910 at 72
18 children:
1. Mary Geringer July 26, 1855-Oct. 28, 1911 (56)
2. George Geringer Mar. 29,1856-Aug. 2, 1934 (78)
3. William Geringer Feb. 10, 1857-June 28, 1928 (71)
4. Anna Geringer born 1859, died in infancy
5. Fred Geringer Dec. 29, 1861-Dec. 25, 1925 (63)
6. Amelia Geringer born 1863, died in infancy
7. Caroline Geringer Feb. 14, 1864-Jan. 26, 1915 (50)
8. Sophia Geringer Feb. 12, 1865-1896 (31)
9. Henry Geringer July 16, 1867-Sept. 28, 1935 (68)
10. Charles Geringer Oct. 24, 1869-June 18, 1955 (85)
11. Adam Geringer Oct. 12, 1871-Jan. 29, 1954 (82)
12. Jacob Geringer Oct. 28, 1873-Apr. 7, 1941 (67)
13. John Geringer May 28, 1875-Jan. 4, 1958 (82)
14. Clara Geringer 1876-Jan. 15, 1878 (2)
15. Minnie Geringer Mar. 7, 1879-Sept. 6, 1994 (115)
16. Barbara Geringer Nov. 1, 1882-died in infancy
17. Frank Geringer Nov. 1, 1882-died in infancy
18. Frank Geringer Dec. 15, 1885-May 8, 1951 (65).

error: she could have been born as early as 1877, or as late as 1881, based on this information. We can state provisionally that she must have been between 113 and 117 years old. However, assuming we did not already know the facts, we would need more information to pin down her exact age. Thus, I searched for other documents.

I was able to locate husband Charles Kott (April 28, 1877-May 1966) in the Social Security Death Index. Searching the 1900 census, I found Charles Kott, 23, living in Chicago[31]. Listed were his wife, Minie (misspelled), 21, born March 1879. Also listed were Minnie's mother, Sophia Geringer, 62 (born March 1838); Minnie's brother, Frank Geringer, 15 (likely the last child), and other relatives. From these matches, we can establish beyond doubt that the "Minie Kott" listed here in 1900 as 21 years old is the same Minnie Kott who died in 1994, allegedly 115 years old. This census record is also likely the source of Guinness' acceptance of this case as verified. Other relatives are also listed as living nearby, including brother Adam Geringer (born in October 1871) and Jacob Geringer (born in October 1873). That the ages given exactly match the family tree records attests to their veracity.

However, searching the 1910 census tells a different story.[32] Listed were Charles Kott, 33 (again matching the 1877 birthdate), wife Mamie C. Kott, 30; daughter Ruth Kott, 9; and mother-in-law Sophia Geringer, aged 72 years. While some may question the nickname difference, the presence of the exact same mother and husband proves that this is once again the same person. The age listed, 30 years old in April 1910, accords with the 1880 birth date given in the 1880 census. Also of note, Minnie's mother is listed as born in Germany. Sophia Geringer, born in 1838, married in 1854 at age 16, gave birth to 18 children in the next 30 years, having the last one at age 46, and was still alive at age 72 in 1910.

So far, we have one document (the 1900 census) that accords with the 1879 birth claim, and one document (the 1910 census) that suggests 1880 is correct.

[31] Cook county, roll 249, book 1, page 27.
[32] Chicago, roll 244, book 1, page 65A.

Because both of these are outside the 20-year standard for proxy validation, we must look further back. Fortunately, the SSA study had located Wilhelmina Geringer in the 1880 census.[33]

Comparing this list to the family tree records, we note that 12 of the 18 children listed match; there are no children listed here that are not on the family tree list. Of the six missing children, it should be noted that three were not born yet in 1880, and the oldest daughter, also missing, may be assumed to have been married off. Of the two remaining missing children, both died in infancy. Thus, we have valid reasons for the discrepancies here. We also have a chilling tangent to note: the daughter, Clara, had died in 1878, but apparently the parents, when giving the names of the children, had originally forgotten to exclude her. Her scratched-out listing as age three (she died on January 15, 1878, apparently one year old) is a reminder of her existence. Of the remaining 11 children, eight of them have an age that matches the family tree list; of the remaining three, the discrepancy is only one year. Undermining the claim that Minnie had reached age 115 was the finding that one of those three is Wilhelmina Geringer, listed as two months old as of June 1, 1880.

Aside from the fact that the record literally says that Wilhelmina was two months old as of June 1, 1880, we can be confident of this listing as accurate. Generally, the closer to the birth event, the more reliable the match is. It is hard to imagine someone mistaking a one-year-old for a two-month-old. The family must have vividly remembered the new arrival, even with so many other children; the name given, Wilhelmina, was apparently before someone shortened it to the nickname, "Minnie." It almost doesn't need to be said that this match here is one of the

[33] The 1880 census for Illinois, LaSalle County, roll 223, book 1, town of Peru (enumeration district 86, page 18) lists the following family:
George Geringer, head, 49
Sophia, wife, 43
George, son, 24
William, son, 22
Frederick, son, 18
Caroline, daughter, 16
Sophia, daughter, 13
Henry, son, 12
Charles, son, 10
Adam, son, 8
Jacob, son, 6
John, son, 5
Clara, daughter, 3 (scratched out)
Wilhelmina, daughter, 2/12 months.

strongest identifications possible from a census record: Wilhelmina is listed in the correct town, with the correct parents and 11 matching siblings. The chance of a coincidental mismatch is not there.

There are enough pieces of the puzzle already laid out to conclude that Wilhelmina "Minnie" Kott was likely born in March 1880, not 1879, and was only 114 years old, not the age 115 claimed. This is an example of the most common of all age misreporting errors: adding one year. While more cases have been off by one year than any other margin, most of them have been exaggerated by one year, not understated. While these cases are often the hardest to detect (because they're so close to the truth), a level of scrutiny approaching a case like Jeanne Calment's would almost certainly expose such an error.

3.5 Edna Oaks and her mother, Macy Bare, aged 115 or 107?

The Edna Oaks case is an important example because it shows that wild age misreporting (as opposed to being off by one year) in the United States is not limited to African-Americans, nor is it limited to the past. This case is also a good example of how hearsay and testimonial fallacy can blow a story out of proportion. Even today, the lack of a central government database, combined with the sheer size of the U.S. population (the third largest in the world; the largest centenarian population in the world), makes it easy for age myths to thrive, especially in rural, isolated communities in the South (the last U.S. region, overall, to institute mandatory birth registration). The state of Georgia did not institute state-wide birth registration until 1919; the Federal government did not require universal birth registration until 1933, when the high costs of the "New Deal" made personal age identification an imperative to controlling and calculating future costs, such as Social Security.

Following the death of the oldest living American titleholder, Mary Christian, 113, on April 20, 2003, I was contacted by a number of people claiming they knew of someone who was even older, including a claim relating to Edna Oaks of Roan Mountain, Tennessee, said to be aged 115 (born on November 13, 1887). This was one of the more glaring false cases I've seen (not in terms of the age claimed, but in terms of the relative veracity of the initial report) and thus I use it as an example here of age misreporting due to a certain recklessness that tends to occur in hearsay reports.

The case was reported by a nephew of Edna's, living in Florida. Calling the family, I discovered that Edna Oaks was, in fact, 84 years old. The source of the "115-year-old" myth was Edna's mother, Macy

E. Bare, who, unbeknownst to the nephew, had died in the latter half of 2002, allegedly at age 114. While this resolves the issue of the claim of being the oldest "living" American—she was in fact deceased—if she had been born when she said she had (November 13, 1887), and died when reported (October 26, 2002), she would, in fact, have been the oldest living American from March 18, 2002, until her death October 26, 2002, at just a few days shy of age 115.

The claim that Macy Bare had lived to be 114 years old does not, however, appear to be true, either. The family mentioned that Macy Bare lived almost her entire life in Elk Park in Avery County, North Carolina. Knowing this, I ran a search in the Social Security Death Index's online database for all deaths of people with the last name of "Bare" in North Carolina. This yielded one possible match: Macy E. Bare of Avery County, North Carolina, born on October 15, 1894, and died on September 6, 2002. Considering that this was the only possible match, that the name and middle initial, town, and name of the county all matched, I concluded that this was most likely the Macy E. Bare who died, allegedly aged 114, in 2002.

The point of this story is that many exaggerated claims are not the result of outright lies, but errors on the part of the family. Knowing this, a researcher merely has to ask the family details about the claimant unique to the individual, and then attempt to verify them. An initial verification would lead to further investigation, but in a case like this, it seemed that the correct answer has already been deduced: Macy Bare was 'only' 107 years old. Why would someone report themselves as seven years younger than they really are, which would delay collection of Social Security benefits by the same amount? In this case, the claim to be 114 years old appears not to be motivated by financial gain, but is merely the result of family pride in the matriarch, coupled with inattention to details. These factors combined to produce an errant age report.

This case also points to the maxim, once again, that claims from rural, isolated areas warrant extra skepticism, because people living in these areas tend to be less educated, and are thus more susceptible to age exaggeration. Indeed, the family of Macy Bare is Caucasian (white), which shows, like many other cases, that the higher-than-national-average number of false and exaggerated cases in the U.S. South is not entirely due to the African-American population, though they do remain the largest source of false and fictitious American longevity claims.

4 Conclusion

Of the almost twenty cases of individuals considered to be validated at age 115 or older (see chapter by Jeune et al. in this monograph), eight were born in the United States and one in Puerto Rico (in addition, a tenth person, Christian Mortensen, migrated to the U.S. at an early age). With a population of 300 million and the largest centenarian population in the world[34], the U.S. also comprises the largest component of verified cases aged 115 and older. However, when compared to Western Europe (records are generally lacking for Eastern Europe), the relatively new system of recordkeeping ensures that false and exaggerated cases will continue to thrive in the U.S. until at least 2053. Thus, it is imperative that we separate the real 115-year-olds from the pretenders to extreme longevity.

As of October 2007, I have listed 55 claims worldwide to age 115 or beyond[35] that were shown to be false or exaggerated; of these, 52 could conclusively be shown to be less than 115 years old; only two (Maggie Barnes, Susie Gibson) were still 115 or older (even if not 116 as claimed). Moreover, of the eight U.S.-born persons (nine, including Puerto Rico) validated to have reached their 115th birthday by October 2006, only three have been verified to have reached age 116 (one of whom was still living). Including only the seven deceased U.S.-born cases, five died at 115; one, at 117; and one, at 119. When non-validated cases are factored out, the U.S. data falls in line with expectations. The relatively large number of U.S. claims is mostly due to age inflation.

For the eight shown to have reached 115 or older, all have turned 115 since 1990, suggesting that living to age 115 is a recent phenomenon. While there have been two 'batches' of cases (in the mid-1990's and in 2005, there were three 115+-year-olds living at the same time), this appears to be an anomaly. Looking at the numbers of remaining validated U.S. centenarians, the year 1892 already has no U.S.-born cases left, while the year 1893 has a single frail person,[36] making it unlikely that another U.S. age bubble of more than one living 115-year-old will emerge before 2009.[37] Thus, the recent trio of Elizabeth Bolden, Bettie

[34] Japan is a distant second, at 28,395 as of Sept 2006. `http://mdn.mainichi-msn.co.jp/national/news/20060917p2a00m0na013000c.html` (accessed Oct. 16, 2006).
[35] My personal database.
[36] This is Edna Parker (born Apr 20, 1893), alive as of Feb 26, 2008.
[37] There remains a small but unlikely chance of a claim to age 115 or older to emerge and subsequently be validated; we have seen this with both Maria Capovilla of Ecuador and Maggie Barnes of the USA.

Wilson, and Susie Gibson in 2005, and the past trio of Sarah Knauss, Chris Mortensen, and Maggie Barnes in 1997-1998, appear to be 'age bubbles,'[38] not the start of a sustainable trend. If anything, the only observable trend is that increased life expectancy and cohort size, together with lower death rates for persons aged 80+ (Robine and Vaupel, 2002) have allowed for the occasional 115+ outliers (higher peaks),[39] as well as higher valleys,[40] and perhaps a slowly increasing frequency of 115th birthdays.[41] With evidence for this occasional population firmly established, reaching age 115 may be less of a feat in the future, but we should not expect a flood of new cases in the short term. As of February 2008, we find the oldest validated American to be 114; the oldest validated European to be 114; and the oldest validated person in Japan to be 113.

We can thus conclude that the numbers of alleged cases of 115-year-olds are wildly inflated by age exaggeration, making age verification for this elite age category especially necessary. Sufficient systems of recordkeeping exist to validate or invalidate the ages of many, but not all, U.S. cases. If we err on the side of caution and include only the validated cases, the U.S. data only slightly exceeds that of Western Europe, but given the larger U.S. centenarian and supercentenarian population, that is to be expected. That the verified numbers fall in line with what can be expected suggests that the methodologies of age validation as given in this chapter are sufficient to produce reliable U.S. data for the elite 115+ age category (even if the sample size is too small, individual cases may be of interest). Additional biographical

[38] Like the stock market or an overheated housing market, significant positive deviations from the expected are usually followed by a 'correction' or 'bubble burst.' In 1998, two of the three 115-year-olds died, and by the end of 1999, the U.S. 115+ population was back down to zero.

[39] As Bernard Jeune noted (personal communication), "115+ years old people emerged first after 1990 - that's a new phenomenon, a new trend." The point here is that we are seeing higher 'peaks' but the evidence for the emergence of a stable 115+ population is not yet conclusive.

[40] In the 1980's, persons as young as 112 held the "world's oldest person" title. Since 1990, there has been at least one verified person aged 114 at all times. Hence, the low points or valleys are also increasing, not simply the high points or peaks.

[41] The U.S. is the only nation to maintain a continuous 113+ population since 1986. In Japan, France, and the UK, the sustainable population has been 111+. For example, the UK's 'oldest person' has been at least 111 since 1988, and the current titleholder is 111 (showing no improvement). France's 'oldest person' has been at least 111 years old at all times since 1985, last dipping to 111 in 2003. Japan's oldest person has been at least 111 since 1987 (dipping to 111 in 1995 and 1999). Since 1986, however, the oldest person in the U.S. has ranged from 113 to 119 years old, never dipping below 113.

details about the verified European cases are given in the chapter by Jeune et al. in this volume.

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Jeanne Calment and her successors. Biographical notes on the longest living humans

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Abstract. The vast majority of 115+-year-olds reported around the world have not, in fact, attained the age claimed. However, we are fairly certain that, since 1990, nearly 20 persons worldwide have reached the age of 115 years or more, among them the longest-living person, Jeanne Calment, who reached age 122. We have attempted to validate the stated ages of these people through the collection of available genealogical information, and through detailed evaluations of this information. This chapter attempts to paint a picture of these true long-livers based on insights about them gleaned from various sources, including interviews with some of them conducted by aging researchers. The life journeys of these very old people differed widely, and they are almost without common characteristics, aside from the fact that the overwhelming majority are women (only two are men), most smoked very little or not at all, and they had never been obese. Still, they all seem to have been powerful personalities, but decidedly not all were domineering personalities. They are living examples of the fact that it is possible to live a very long life while remaining in fairly good shape. Although these people aged slowly, all of them nonetheless became extremely frail in their final years. Their physi-

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cal functions declined markedly, especially after their 105th birthdays. They spent their last years confined to wheelchairs, virtually blind and very hard of hearing. But they did not fear death, and they appeared to be reconciled to the fact that their lives would soon end.

1 Introduction

One of the pioneers of modern research on aging, Leonard Hayflick, writes in his book How and Why We Age (1994): "There is no evidence that the maximum human lifespan has changed from what it was about hundred thousand years ago. It is still about 115 years." At the time this was written, Jeanne Calment had already exceeded the 115-year limit. Today we have reasonably good evidence that, during the 1990s, others reached the same age (Jeune and Vaupel 1999, Robine and Vaupel 2001). We can thus confidently reject the claim that 115 is the absolute limit for longevity.

Since the beginning of the 1990s, effort has been made to validate the ages of reported exceptional long-livers (Jeune and Vaupel, 1995). It seems that most of the alleged exceptional long-livers reported from all over the world cannot be documented, and the greater part of these reports may be false (Jeune and Vaupel, 1999). However, a few cases of people reaching the age of 115 years or more have been fairly well documented. There seem to have been more than 15 genuine long-livers 115 years or older since 1990. The following is a list of the longest living documented humans in the long history of human beings:

- Jeanne Calment, who reached the age of 115 on 21 February 1990;
- Charlotte Hughes, who reached the age of 115 on 1 August 1992;
- Margaret Skeete, who reached the age of 115 on 27 October 1993;
- Tane Ikai, who reached the age of 115 on 18 January 1994;
- Marie Meilleur, who reached the age of 115 on 29 August 1995;
- Sarah Knauss, who reached the age of 115 on 24 September 1995;
- Maggie Barnes, who probably reached the age of 115 on 6 March 1996;
- Chris Mortensen, who reached the age of 115 on 16 August 1997;
- Annie Jennings, who reached the age of 115 on 12 November 1999;
- Marie Bremont, who reached the age of 115 on 25 April 2001;
- Maud Farris-Luse, who reached the age of 115 on 21 January 2002;
- Kamato Hongo, who reached the age of 115 on 16 September 2002;
- Maria Esther Capovilla, who reached the age of 115 on 14 September 2004;
- Hendrijke van Andel-Schipper, who reached the age of 115 on 29 June

2005;
- Elizabeth Bolden, who reached the age of 115 on 15 August 2005;
- Bettie Wilson, who reached the age of 115 on 13 September 2005;
- Susie Gibson, who reached the age of 115 on 31 October 2005;
- Emiliano Mercado del Toro, who reached the age of 115 on 21 August 2006; and
- Julie Winnifred Bertrand, who reached the age of 115 on 16 September 2006.

Although there may still be some doubt about a few of them, these cases have at least been validated by independent researchers, i.e., researchers other than those connected with Guinness World Records, which bases its validation exclusively on documents sent by the families of the long-livers, or on government records. Others have probably have reached the age of 115, but their cases have not been validated by independent researchers. In the years 1997 and 1998, i.e., just before and after the death of Jeanne Calment, four documented long-livers age 115 were alive. Not until the end of 2005 has an equivalent number of living 115+-year-olds existed.

Apart from all the genealogical data which have been collected about 115+-year-olds for the purposes of validating their extremely high ages, we do not know very much about their life courses and life conditions, their past history of diseases, and their functional status and health characteristics as very old people. On most of them we have some biographical notes from interviews in newspapers. However, a few of them have been interviewed by aging researchers (including ourselves) who have reported their knowledge and observations in journals and books, with the informed consent of the long-livers studied.

The following accounts of the best-documented 115-year-olds are based on information that they themselves, or their relatives, gave in interviews published in newspapers, journals, and books, including information about their health. The information is therefore mainly based on written sources that have already been published (see the references). We have not included references from the many features in newspapers (they can be found, for example, by searching the respective names on Google). We report their names, as they all are famous and known from newspapers and online information published all over the world.

2 Jeanne Calment - a modern Methuselah

"I'm starting to think I must be a phenomenon." (Jeanne Calment)

Jeanne Calment is probably the longest-lived human being to date. She died on August 4, 1997, in the southern French town of Arles. She was born in the same place on February 21, 1875. She thus lived to the age of 122 years, five months, and 14 days. This made her not only a media celebrity to whom journalists from all around the world made pilgrimages, but also a phenomenon for researchers on old age, for she had exceeded what had long been considered the absolute limit for longevity.

Over the course of several years, Michel Allard, a doctor from Paris, who had initiated the French study of centenarians; her own doctor, Victor Lèbre; and Jean-Marie Robine, demographer from the University of Montpellier; conducted a number of interviews with Jeanne Calment, and collected her witticisms and aphorisms in a book about her (Allard et al. 1994, 1998) which is the source for the following discussion of her life.

"Every age has its happiness and its troubles"

Together with the local archivist, Caroline Boyer, Robine has researched Jeanne Calment's entire genealogical table (see their chapter in Jeune and Vaupel 1999). The documents about her in the city archives of Arles are situated in the old building of the psychiatric hospital where Van Gogh was treated. The archives in Arles, an ancient city with roots going back to Roman times, are exceptionally well kept. The births and deaths for each year are recorded in chronological order in yearly books, with a table of entries in alphabetical order in an annex. Special volumes list all entries in alphabetical order for each 10-year period. Censuses at that time were taken every five years. It was therefore possible to follow Mme Calment's trajectory over the years, tracing her to the various (not very numerous) addresses in Arles where she had lived, and seeing with whom she had lived at different stages of her life. Altogether, Jeanne Calment's name appeared in 16 different censuses between 1875 and 1975.

Robine and Boyer have assembled 23 certificates and documents showing the dates of birth, christening, marriage, and death of her closest relatives, from her parents' marriage certificate to her grandson's death certificate. Jeanne Louise Calment (this was also her maiden name) had had an elder brother, Antoine, who was born in 1862, but lived only five years; and an elder sister, Marie, born in 1863, who died in infancy. Since Jeanne herself was born in 1875, she never knew these siblings; the only sibling she knew was her brother, Francois, ten years her senior (born in 1865). Her parents were both 37 years of age when she was born as their last child. There was also a marriage certificate showing that she was married in 1896, at the age of 21, to her second cousin, Fernand Nicolas Calment (their paternal grandfathers were brothers).

The American demographer, James W. Vaupel; the Finnish demographer, Vaino Kannisto; and the Danish epidemiologist, Bernard Jeune; visited Jeanne Calment the day after her 120th birthday. Together they formed an unofficial committee whose purpose was to look through the documents that Robine and Boyer had found in the city archives. There was a good deal of speculation at the time as to whether Mme Calment really was as old as reported. If the comprehensive documentation that Robine and Boyer had dug up could conclusively rule out all error and confusion, then she would indeed be "la doyenne de l'humanitè" (the elder of humankind), as her compatriots called her. It was, therefore, of great importance that impartial experts examine the original documents.

The only errors this team of researchers found were minor—for example, a wrong middle name in some of the censuses. They tried to find out whether any other children had been born in the Calment family between Francois and Jeanne, or after the latter's birth. There were, of course, other Calment children, since the family had several branches in the town, but the documents proved that they were born of parents other than Jeanne's. There were, at any rate, no data on the parents of any of these children suggesting that any names had been swapped. The facts thus appeared extremely convincing and far better established than the cases of other long-lived people known to us.

Robine had undertaken a thorough investigation, going back five generations, into the ages to which Jeanne Calment's forebears lived. Her 62 direct ancestors (two parents, four grandparents, eight great-grandparents, 16 great-great-grandparents, and 32 great-great-great-grandparents) appeared to have lived longer, on average, than a control person from each period in question. A large proportion of them, moreover, had lived beyond age 80, especially among her father's ancestors. Living in Arles in the period from 1700 to 1900, these generations had survived the plague of 1721, two major famines during the hard winters of 1708/9 and 1788/89, and four epidemics of cholera in 1832, 1835, 1854, and 1884. But Jeanne Calment was the only one to live into her hundreds. She herself wished that her brother, Francois, had lived to 100 (he died in 1962 at the age of 97), but as she put it: "God didn't want there to be two hundred-year-olds in the same family, so it fell to me".

"I have lost my husband, my daughter, my grandson"

Since the age of 88, Jeanne Calment had been without close relatives, since her husband and second cousin, Fernand, had died in 1942 at the age of 74; her only child, Yvonne, had died at the age of 36 in 1934; and her only grandchild, Frédéric, died likewise at the age of 36, as a result of a motorcycle accident in 1963. Although he was married, he had no children. Her brother, Francois, had married and had a daughter, who died at the age of 21.

Jeanne Calment spoke reluctantly of her sorrow at these losses. When she moved to the nursing home at the age of 110 she had not wanted to hang up pictures of her daughter and grandson, as these would only have awakened sad memories. She had always looked forwards rather than backwards. But they were included in her wishes for the future: "When I'm laid in my coffin, I want you to put a picture of my grandchild to the right of me and a picture of my daughter to my left. That way they will be buried with me." It seems that this wish was carried out (Allard and Robine, 2000).

"God has given me all I have asked of Him"

She was much more willing to talk about her father, who had been a shipbuilder in the town. She had loved him greatly and listened to him "like an oracle." She told the authors eagerly about the launching of his last wooden ship, which was named after her; about her meeting with van Gogh when she was 13 years old; about the clothes she wore for her confirmation and her wedding; about her husband, with whom she loved to go hunting, though she never helped him in his manufacturing business; about her pleasure in painting, playing the piano, and going to the opera in Marseilles-in other words, about her enjoyment of life: "I had fun; I am having fun."

Mme Calment allowed herself one glass of port and one cigarette a day. She liked good food and wine, including cakes and chocolate, which she ate every day. But she didn't care much for social life: "I didn't enjoy visiting, I didn't like the fashionable world, but I loved being out in the fresh air." Like her husband, she was a great walker, and ran rather than walked about her everyday business. She liked to get things done swiftly, as happened when she gave birth for the first and only time: it "happened of its own accord, like everything else I've done. Straight away, it had to be done quickly." She thus offered little support for the dictum that taking things slowly is the best guarantee of long life. From childhood onwards she had lived without material worries and had never needed to work, either in the home or outside. Asked how she had managed her household tasks, she answered in best upper-class style: “With spit my dear; I just needed to command”.

Altogether, the book on Jeanne Calment presents her as a decisive, strong-willed woman. She herself stressed this repeatedly: “I had a damn strong will;” “I was physically strong;” “I had character;” and, “I wasn’t afraid of anything. I was often reproached for that.” She was also full of curiosity, but not especially passionate: “I’m interested in everything but passionate about nothing.” Her strong will never deserted her, as the following stories testify.

Mme Calment first moved to a nursing home at the age of 110. Before this she had more or less managed on her own at home. A lawyer who wanted to buy her house arranged an advance contract for the purchase when she was roughly 90 years old. Under the French system, this involved an annual payment. The lawyer paid up for 30 years, in the end predeceasing her in 1995, at the age of 77. Mme Calment’s eventual move to the nursing home was not due to illness, but to the fact that she almost burned the house down one cold January day. The water in the boiler in the cellar had frozen solid, so she fetched a candle, climbed up on a table, and attempted to melt the water with the heat of the candle flame. This set fire to the insulating material, which went up in flames. Neighbors noticed the smoke and summoned the fire brigade, who put out the fire. Very reluctantly, Jeanne Calment was moved to the nursing home.

There she became friends with one of the nurses, who smoked the strong, dark French cigarette, Gauloise. Mme Calment herself smoked a milder brand, but through her acquaintance with the nurse she acquired a taste for the strong French cigarettes. One evening she was going upstairs to the nurse’s room to have a smoke, but fell downstairs and ended up with a broken hip at the age of 115. Despite her age, she underwent an operation, which proved successful. Warned that she might not be able to walk again, she replied laconically: “I’ll wait, I’ve got plenty of time.” She steadily improved, and within a few days was able to get out of bed. She succeeded in standing, but thereafter was more or less confined to a wheelchair. To survive for over seven years after undergoing such an operation at such an advanced age does indeed require a considerable will to live.

“I’m not asleep, I’m reliving the good times of my life and I never bore myself.”

At the end of her life she was virtually blind, hard of hearing, and confined to a wheelchair. However, apart from moderate heart failure, a chronic cough, and rheumatism, she did not suffer from any serious illness (Allard et al., 1994, 1998). Among her past ailments were migraine headaches. At her retirement age she had broken her ankle. At the age of 100 she had broken her leg and elbow during a fall, but had recovered and learned to walk again. As mentioned above, she did not regain the use of her limbs after breaking her hip at the age of 115, but she survived the operation at an age at which no one else has undergone such major surgery. A couple of years later she suffered a bout of flu which everyone believed would be the end of her, since it left her greatly weakened and depressed. But this too she survived.

During her final years Mme Calment was examined on several occasions for signs of incipient dementia. Over a number of years the neuropsychologist, Karen Ritchie, tested her memory every six months, and reported the results in a scientific journal (Ritchie, 1995). In fact, she improved over time, not least in arithmetic, showing that it is never too late to learn mathematics. She enjoyed contributing to the study by recalling the poems, fables, and songs she had learned as a child. These visits by researchers, which helped compensate for the lack of visits from relatives, together with the evident pleasure she took in them, may well have helped to prolong her already long life.

Considering that she was confined to a wheelchair, none of this would have been possible, of course, had she not been able to find consolation in her own inner life. As she herself put it: “My sight is bad, my hearing is bad, I feel bad, but I don’t suffer, I don’t complain.” And she went on to say: “I don’t lack for anything. I have everything I need. I’ve had a good life. I live in my dreams, in my memories, beautiful memories.” Although she no doubt had secrets that she didn’t share, there was one secret, at least, that she wanted to pass on: “Always keep your sense of humor. That’s what I attribute my long life to. I think I’ll die laughing. That’s part of my program.” One of her witticisms in particular was known to every fellow in town: “I’ve never had more than one wrinkle, and I’m sitting on it.”

“I’m waiting for death and the journalists.”

Jeanne Calment was a legend in the town where she had lived her whole life. She was very well aware of this herself, and enjoyed her fame: “I’ve waited 110 years to be famous. I intend to make the most of it for as long as possible.” She awaited not only death, but also the journalists who had faithfully turned up for all her recent birthdays. But, unlike many others in their hundreds, she did not feel completely abandoned by God: “I’m God’s little angel.” At the very least, she required some explanation for his forgetfulness: “He’s forgotten me. He can't be in any hurry to see me. He knows me all too well." She knew her own historical worth: "I am a modern Methuselah."

3 Jeanne Calment's successors in the 1990s

3.1 Charlotte Hughes: "A stiff brandy, bacon and eggs"

The next person to exceed the 115-year limit was most probably Charlotte Marion Hughes from England. She was interviewed in the press and appeared on television, but was never interviewed by researchers on aging. However, the now deceased Peter Laslett, a historian from Cambridge University, did have the opportunity to go through the documentation pertaining to her case (biographical notes by Laslett). Her birth registration has been found.

Charlotte Hughes was born on August 1, 1877, and died on March 17, 1993. She grew up in Middlesborough in Yorkshire, where her father ran a music shop. Until the age of 63 she worked as a teacher in a religious school. While employed there she was not permitted to marry, so she married for the first time only after her retirement. Her husband, Noel Hughes, was a retired army captain and was younger than she. They lived together for 40 years until he died at the age of 88, when Mrs. Hughes herself was 103.

At the age of 107, Mrs. Hughes received a visit from the Queen. At her 108th birthday, she took the express train to London for the first time in her life and had tea with Margaret Thatcher at 10 Downing Street, having declared on the radio the previous day that she supported the Labour Party. "I told her I was Labour when she cuddled up to me in Downing Street. I said 'Don't cuddle me I'm Labour.' She said: 'Never mind, come and let us have a cup of tea.'" Two years later, aged 110, Mrs. Hughes flew on a Concorde over the Atlantic, traveling in her wheelchair. She was received by the mayor of New York and appeared on television. At the age of 111 she took part in a BBC program on longevity, and by her 112th birthday she had become the oldest person in England. She still lived at home, staying most of the time in her wheelchair, receiving daily home help and regular visits from the district nurse. At the age of 113, she was moved to St. David's Nursing home in Redcar, Cleveland, due to her increasing frailty and poor eyesight. She died at the nursing home from bronchopneumonia, having reached the age of 115 years and 228 days.

According to newspaper accounts, Charlotte Hughes retained her mental faculties to the last, although she complained of not being able to remember her grammar properly. Relatives described her as extremely domineering, outspoken, and sharp; but also as friendly and witty. Asked what she considered to be the secret of her long life, she replied: "A healthy lifestyle, a stiff brandy, and bacon and eggs." On another occasion she answered: "A good honest life" and adherence to the 10 Commandments.

3.2 Margaret Skeete: "I guess that's something, but it doesn't buy me anything."

The next person who reached the age of 115 was probably the American woman Margaret Skeete. She was born on October 27, 1878, in Rockport in Aransas County, Texas. Her age has been validated by Robert Young (see his chapter in this monograph). He found her registered in the 1880 census. A two-year-old child named Mattie was listed in the correct county and town as the last of six children (the oldest was 14 years old) of R. H. Seward, aged 39, and his wife, Margaret, aged 39.

Mrs. Skeete married her husband, Renn Skeete, before 1910. They lived in Brazoria County, Texas, and had three children: Verne, a daughter, born before 1910; and two sons, Seward and Charles, both born after 1910 and before 1920. She lived in Texas until 1953, when her husband died. Then she moved to Rockport in Virginia, where she lived with her daughter, Verne Taylor.

She first attracted national media attention in 1993, when she was included in the Guinness Book of Records as the oldest living American at age 114. In an interview with a local newspaper, her daughter said that she never could put her mother in a nursing home. "It would break her heart. She had to be where she could see me and call me." At her 115th birthday party, Margaret Skeete was unimpressed by her longevity: "I guess that's something, but it doesn't buy me anything."

Taylor said that her mother was feisty and insisted on trying to walk with her walker even after the last, most serious fall. "She was always like that. She went camping with us when she was 75—you'd have thought she was about 40." She was bedridden after this serious fall, which occurred just three weeks before she died. Mrs. Skeete died in her sleep on May 7, 1994, at the age of 115 years and 192 days.

3.3 Tane Ikai: A Japanese woman who survived her four children

The next person who reached the age of 115 was probably the Japanese woman, Tane Ikai. She was born on January 18, 1879, in the former village of Kansei, Aichi Prefecture, which is now part of Nagoya, 170 miles west of Tokyo. She was the third daughter of six children of a farming family. Her grandfather and father died in their nineties. She married her husband at the age of 20, and they had three sons and a daughter. She separated from her husband at the age of 38. She lived with her daughter until the daughter died at the age of 47.

Tane Ikai entered a nursing home in Nagoya in 1968 at the age of 89, for which she had to pay a small fee. Four years later, she moved to a special nursing home, which was free of charge. She moved slowly, but was able to walk and use the toilet independently until she was 107 years old. In 1988, at the age of 109, she suffered a stroke and was moved to the hospital affiliated with the nursing home. She lived her last years bedridden, but had three meals of rice gruel a day, and spoke to hospital staff when she felt good. At the age of 113, she became the oldest Japanese person.

When once asked for her advice on living a long life, she said: "You should not insist on saying you want to eat this and that. You should live naturally." Her children passed away before she died, but at the end of her life she was blessed with two grandchildren, five great-grandchildren, and seven great-great-grandchildren. She died on July 12, 1995, at the age of 116 years and 175 days. From an article in a Japanese medical journal we know that an autopsy was carried out. She had cancerous cells in different organs (metastases) and had changes in her brain indicating Alzheimer's dementia, but she died of kidney failure.

3.4 Marie-Louise Meilleur: A French-Canadian woman with 300 descendants

When Jeanne Calment died on August 4, 1997, many newspapers in various countries published reports of people who were even older than she, but none of these alleged successors could be documented. Proper evidence could, however, be found in the case of 117-year-old Marie-Louise Meilleur, who lived at a nursing home in the province of Ontario in Canada. The demographer Bertrand Desjardins from the University of Montreal examined the documentation supporting her case (see his chapter in Jeune and Vaupel, 1999). Desjardins and his colleagues had established a comprehensive genealogical archive, going back to the early 17th century, on the families of French immigrants and their descendants. Since Mme Meilleur was a French Canadian, her genealogical table could be established from this archive. No evidence was found to suggest she was of different parentage than stated, or that she had adopted the name of an older sibling or some other member of the family. Records of her could be traced through various censuses, as well as from her marriage certificate and the birth certificates of her many children.

She was born Marie-Louise Fébronie Chassé on August 29, 1880, in Kamouraska, a small village in Quebec on the south coast of the St. Lawrence River. She was one of eight children and attended a Catholic convent school. She married her first husband, Étienne Leclerc, a widower and ship's mate, on November 26, 1900, when she was 20 years old. They had six children: three girls, two of whom died in infancy, followed by three boys. Her husband died of pneumonia in 1911, leaving Marie-Louise a widow at the age of 30 with four children under the age of ten. Around the same time, she lost both her parents, who died at the ages of 61 and 59. She moved in with her sister, who ran a hotel for forestry workers on the Ottawa River. Here she helped in the kitchen.

In 1915 she married again, this time to a carpenter, Hector Meilleur, a widower with four children. They moved to a log cabin in a little village on the Ottawa River. She had a further six children with her second husband, of whom four were still alive at her death. Mme Meilleur lived in the village until her husband's death in 1972 at the age of 92, when she herself was 91. Thereafter she lived for sixteen years with her youngest daughter, until the age of 107. In 1988, she moved to a nursing home. At her 115th birthday, when her relatives sang, "Happy Birthday to you;" she sang, "Happy Birthday to me." When they told her that she was the oldest living in Canada she said, "Poor Canada." On the occasion of her 117th birthday a journalist wrote: "Today she does not speak much, but when she does, she can be pretty humorous." According to her doctor, she was completely demented at the end of her life. She died on April 16, 1998, at the age of 117 years and seven months.

Thus, for eight months after Jeanne Calment's death, Marie-Louise Meilleur was the oldest documented person in the world. Unlike those who left no direct descendants, Marie-Louise was survived by about 300 descendants stretching over five generations. She succeeded in being the eldest of six generations. According to reports, she had always worked hard and remained active.

The above-mentioned genealogical archive allowed Bertrand Desjardins to follow the same procedure as in Jeanne Calment's case and investigate the lifespans of Marie-Louise Meilleur's relatives. In Mme Meilleur's case, however, the average lifespan of her 62 direct ancestors over five generations was found to be no higher than the average for their contemporaries; nor was the percentage of 80+-year-olds among them any higher than the average for each period.

3.5 Sarah Knauss: The great-great-great-grandmother who "hated vegetables"

Marie-Louise Meilleur was succeeded by the American woman Sarah Knauss, who was the world's oldest documented person for almost two years. She died on the penultimate day of 1999 at the age of 119 years and three months, and is probably the second-longest-lived person ever. In an attempt to gain Guinness recognition after the death of Jeanne Calment, the genealogical data of Sarah Knauss was documented and researched by Edith Rodgers Moyer from the Phoebe Ministries when Mrs. Knauss was 117 years old (Moyer 1997). This documentation provides a good example of validation in absence of a birth record (see the summary of the documentation in Robine and Vaupel, 2001). Her case has been re-validated by Robert Young (see his chapter in this monograph). She has also been interviewed by the American geriatrician Tom Perls.

Together with Tom Perls and the American demographer, John Wilmoth, from Berkeley University, Bernard Jeune and Jean-Marie Robine visited Mrs. Knauss in November 1998, when she was 118 years old. She lived in a nursing home, Phoebe Home, in Allentown, Pennsylvania. Her 95-year-old daughter had just moved to sheltered housing next door. Mrs. Knauss received us sitting in her wheelchair. She was still partially sighted, but almost completely deaf, which made conversation nearly impossible.

Mrs. Knauss was born and grew up in the coal-mining area of Luzerne County, first in the tiny hamlet of Hollywood, then later in South Bethlehem, Pennsylvania. Her father, Walter Clark, worked as an engineer; her mother, Amelia Clark, was the daughter of German immigrants. Her mother died at the age of 68, and her father at age 85. They had seven children born between 1876 and 1893, of whom only four survived childhood. Sarah Clark was the third child. Her eldest brother, Albert, died as a child; the second brother, Charles, died at the age of 78; her younger brothers, Walter and Edward, died as infants; and her younger sister, Emily, died at the age of almost 90.

She was married at the age of 21 to Abraham Lincoln Knauss, aged 23, on August 28, 1901. He was a tanner, and died in 1965 at the age of 86. They had the above-mentioned daughter, Kathryn, who, in turn, had a son, Robert. There were, at the time of her death, three great-grandchildren, five great-great-grandchildren, and a newly-born great-great-great-grandchild. Like Mme Meilleur, Mrs. Knauss thus succeeded in being the eldest of six generations. Her family was featured in Life magazine in February 1999, with a photo of her together with her 95-year-old daughter, her 73-year-old grandson, a 49-year-old great-granddaughter, a 27-year-old great-great-granddaughter, and the latter's child sitting in Sarah Knauss's arms.

She did not move to a nursing home until she was 111, due to her general frailty and failing eyesight. She had lived with her great-granddaughter since she was 96, and had, for many years, been a babysitter for the latter's children. At the age of 117, she was given a blood transfusion because of low haemoglobin. She took medication for her heart, but otherwise had no recognized illnesses. She was thought to be of sound mind right up to her death, although towards the end she had difficulty recognizing her 96-year-old daughter, who visited her every day. But it was hard to judge whether this was simply due to her poor eyesight and hearing. Her daughter had real conversations with her when she was 118 years old. However, during the six months prior to her death she was not very responsive in conversation.

A member of staff at the home described her as the friendliest person she had ever met among the home's residents. None of her relatives could remember her ever scolding anyone or appearing stressed in any way. She laughed easily and often good-humoredly brushed aside conflicts. She never allowed herself to be rocked by adversity or bad news, and never appeared worried on any score. She was a housewife throughout her life, but kept herself busy with knitting, crocheting, and sewing.

Unlike Jeanne Calment, Mrs. Knauss had never smoked, but, as noted above, she shared Mme Calment's love of chocolate and all kinds of sweets, while, according to her great-granddaughter, she "hated vegetables." Even at the nursing home, she preferred to go directly to the dessert, leaving aside the chicken, potatoes and carrots. Asked how she had survived to such a great age, she replied that you had to "keep yourself busy, work hard, and not worry about how old you are."

Sarah Knauss died, apparently peacefully, on December 30, 1999. An autopsy was performed, but the cause of death has never been officially published. Her daughter, Kathryn, died five years later at the age of 101.

3.6 Maggie Barnes: An African-American woman with 15 children

The date of birth of the African-American woman, Maggie Barnes, is uncertain, but, according to the obituary in a local newspaper in

Raleigh, North Carolina, she died on January 19, 1998, at the age of 117. Robert Young's documentation (see his chapter in this monograph) about her age at different censuses, the reported age of her husband, and the ages of her children, most of whom died before her, make it probable that she at least attained the age of 115.

She lived her entire life in Wilson and Johnson counties in North Carolina. At the age of 19, she married William Barnes, aged 22, who was a sharecropper. She gave birth to 15 children in the bedroom in her home, and lost seven of them at childbirth or shortly thereafter. The oldest, Lilian, was born in 1900. Over the years, four other children died before her own passing. At her death, the remaining living children were her daughters, Clara Barnes, 92; Gladys Robertson, 90; Ruth Revell, 75; and Mildred Finch, 71.

According to the local newspaper, Mrs. Barnes's four daughters cared for her during the 10 years prior to her death in the small, white frame house she and her husband had purchased in the 1950s after he retired from sharecropping. She died from gangrene in her foot, which grew from a minor infection. She was treated with antibiotics in October 1997 at the Wilson Memorial Hospital, but she was apparently too frail to survive surgery. Then she was sent home again. Her daughter Ruth Revell told the local newspaper that, although her mother seemed lucid at times in her last months, she seldom spoke: "She was doing fine until January 6, and then stopped eating. When we took her to the hospital again, they said there was nothing they could do. So we decided to bring her home and let her die in her own house. She never wanted to leave that house anyway. But I didn't expect her to go so fast. She was in her own bed. She took one last breath. Then she was gone."

What amazed her four living children the most was that she didn't outlive them. "She always said she would bury all of us," said Ruth Revell. "Her funeral is already paid for, because we thought we would die before she did." It almost happened: the longest living of her children died soon after she did; Gladys, at the age of 90, on September 7, 1998; and Clara, at the age of 93, on September 8, 1998. Her last surviving child, her daughter Mildred, was interviewed by Robert Young. When he asked Mildred how old her mother really was when she died, Mildred replied, "116." Maggie Barnes may have been born on March 6, 1881.

3.7 Chris Mortensen: World's oldest man, who still smoked cigars

Of the nearly 10 individuals so far known to have lived to over 115 in the 1990s, all were women, apart from a Danish-American man named Chris Mortensen, who died on April 25, 1998, at the age of 115 years and eight months. He was probably the longest-lived man of all time.

When he reached age 112 while living at a Danish-American nursing home in San Rafael, north of San Francisco, an article about Mr. Mortensen appeared in a Danish newspaper. This was an extraordinary age for a man, so it was clear that this case was worth investigating. Bernard Jeune and his colleague, Axel Skytthe, at the University of Southern Denmark, therefore contacted Paul Ørberg, then archivist at the Regional Archives in Viborg, Denmark, who, together with other local genealogists, had already been interested in the case, and had found the birth registration indicating the birth of Chris Mortensen on August 16, 1882. Nevertheless, there was still the possibility that this Chris Mortensen died at a much younger age, and that his name was adopted by another member of the family, as has been documented in several cases of reported long-livers. Since Chris Mortensen was still alive at that time, it was possible to obtain further information directly from him. Jeune and Skytthe therefore asked their colleague, John Wilmoth, from the University of Berkeley to contact him at the nursing home in San Rafael, and request permission to interview him about his childhood and subsequent history.

During Wilmoth's interviews Mr. Mortensen accurately described a number of incidents that could subsequently be documented in the written sources at the archive of Viborg. This conclusively confirmed his age and identity. Together with Jeanne Calment and Marie Louise Meilleur, his case is the best documented among the 115+-years-old individuals studied (see Wilmoth et al., 1996, and the chapter by Skytthe and al. in Jeune and Vaupel, 1999). Chris Mortensen was born on August 16, 1882, in the village of Skaarup near Skanderborg, Denmark, as the youngest of six children, of whom two died in infancy. His mother was 40 years old at the time of his birth. His three older brothers died at the ages of 31, 72, and 92. As a boy, he worked as a farm hand, but moved to Skanderborg at the age of 16 to train as a tailor. He completed his apprenticeship in 1903, and the same year he emigrated to the United States, arriving there in September 1903. He obtained his immigration permit on Ellis Island and made his way to Chicago, where he lived with relatives.

From 1908 to 1918, he traveled as an itinerant tailor in the western and southern parts of the U.S., spending periods of six months to a year in Kansas City, Denver, Salt Lake City and Sacramento; eventually moving to Los Angeles, where he remained for about four years. He then returned to Chicago, where he worked first as a milkman, and, subsequently, from 1929 to 1950, as a worker in a canned goods factory. He was married for four years in the 1920s, but the marriage ended in divorce. He never re-married and remained childless. After his retirement in 1950, he lived for many years in southern Texas, where he built his own sailboat and enjoyed sailing in Galveston Bay, just as he had enjoyed rowing on Skanderborg Lake as a boy. He also reported visiting Denmark a couple of times in his retirement, which was confirmed by his relatives in Denmark. In 1978, at the age of 96, he moved to the Danish-American nursing home in San Rafael, California, where he lived until his death at the age of 115 on April 25, 1998.

Together with John Wilmoth, who had interviewed him several times, Bernard Jeune, Axel Skytthe, and Jim Vaupel visited Mr. Mortensen on his 113th birthday. He was sitting in a wheelchair, but was able to stand and walk a couple of steps. He was almost blind, but was still able to hear a certain amount, especially with the help of a hearing microphone. He was small in stature (less than 160 cm). As a young man, he had been exempt from military service in both Denmark and the U.S. because of his diminutive size. He appeared to be in good humor on his birthday and was happy about the good wishes and gifts he received. He was especially pleased with the large box of Danish cigars that we brought him. We knew that he enjoyed smoking a couple of mild cigars a week. In honor of his birthday and his guests from Denmark, he was allowed to light one of the cigars indoors. He would have liked to have smoked every day, but was not permitted to do so. He had smoked since the age of 20: mainly a pipe and later on cigars, but almost never cigarettes. For a short while he had also chewed tobacco. Earlier he had smoked several pipes a day, but had never inhaled.

Mr. Mortensen emphasized the need to "eat well and eat properly." He had always had oatmeal for breakfast, and had otherwise eaten every kind of food, though for a while he had been a vegetarian. Asked why, in his view, he had lived to such a great age, he replied: "I live differently from most people and I have a strong heart, a strong body." Asked whether he still enjoyed life, he replied: "Well, enjoying and living are two different things. I'm 113 years old. What pleasure can there be for such an old man? I eat every day. I listen to the radio."

Until about the age of 115, he was still capable of long conversations with John Wilmoth. However, the conversations were very slow, and the interviews demonstrated that Mr. Mortensen was having good and bad days. At the last meeting, about the one week before he died, he was confused and delirious. He had been treated for different diseases during the latest years at the nursing home, but the physician's notes, which we have seen, are confidential and have never been officially published.

Chris Mortensen's successors as the world's oldest man included Antonio Todde, an Italian from the island Sardinia, who died aged 112 years in January 2002; Yukichi Chuganji, a Japanese man from the island of Kyushu, who died aged 114 years and 189 days on September 28, 2003; Joan Riudavets-Moll, a Spaniard from the island of Minorca, who died aged 114 years and 81 days on March 5, 2004; Fred Hale of the United States, who died aged 113 years and 354 days on November 19, 2004, and finally Emiliano Mercado Del Toro of Puerto Rico, who died aged 115 years and 133 days on January 24, 2007.

3.8 Annie Jennings: Living at home until her death

Annie Jennings was born in Wales (UK) on November 12, 1884, and died at the age of 115 and eight days on November 20, 1999. She has been validated by the Office of National Statistics, which has sent a copy of her birth registration to the International Database on Longevity.

Mrs. Jennings worked as a schoolteacher at different schools in the district of Chesterfield. She married a Nottinghamshire clergyman and former missionary, who died after catching black water fever in the 1940s. They had no children. With some help from carers, she lived alone at home in the village Wingerworth, District of Chesterfield, County of Derbyshire, until her death. She was known in the village as a bit of a recluse. She shunned and disliked media attention, and refused to be interviewed by newspapers. "You had to be there to appreciate her wit and understanding. She was a remarkable woman," said a friend to a newspaper. When she was 100 she didn't want a telegram from the Queen. Being old was, she said, "nothing to shout about."

At the age of 108, Mrs. Jennings still attended the church services on Sundays, but, at the age of 109 she decided not to attend church any more as a protest at the ordination of women priests. At the age of 110, she had a fall and was admitted to a hospital with a broken leg. After that she was physically incapacitated. She was certainly in full possession of all her cognitive functions at that time. She had a stroke around the age of 115, from which she later died.

4 Jeanne Calment's successors in the period 2000-2004

Jeanne Calment was a phenomenon, but as we have seen, she was not unique, for she was succeeded by others who lived to an extremely old age during the same period. Throughout the 1990s, there was always at least one person—and sometimes two, three, or four people—who had reached the age of 115 or more. When, however, Sarah Knauss died on December 30, 1999, the maximum lifespan dropped by more than five years. The British woman Eva Morris from Staffordshire was probably the longest-living person after the death of Sarah Knauss. She was born on November 8, 1885, and she died on November 2, 2000, just a week before she reached the age of 115.

4.1 Marie Bremont: A gourmet fond of chocolate

More than one year after the death of Sarah Knauss on December 30, 1999, another woman reached the age of 115. This was Marie Bremont, a French woman born as Marie Marthe Augustine Mesange on April 25, 1886, in Noëllet, in the *départment* Maine-et-Loire in the western part of France. Jean-Marie Robine has found her birth registration and her family book (*livret de famille*). We have some biographical information from a few French newspapers.

Mme Bremont's father was a lumberjack, and she grew up in a family with eight children. She began working at the age of seven on a farm: "When I was seven I guarded cows. Life was hard and we had to get up at four o'clock in the morning." At the age of 20, she moved to join one of her brothers in Versailles. She married her first husband, Constant Lemaitre, in Paris at the age of 24. He worked at the railway. "We bought a little house with three rooms. We didn't have much for a living but we lived quietly." Her husband died during World War I. Over time, she worked as a nanny, as a worker in a pharmaceutical factory, and as a seamstress. As a widow she went twice on pilgrimage to Lourdes, although she told a journalist that she was not devout. "When I was widow, I was very well considered, you never saw me with anybody, except when I married again." That was in 1936, when she married Florentin Bremont, who was a taxi driver. "He was a good man and besides he was handsome." In 1959, they moved to the village of Vritz near the city Candé in the *départment* Loire-Atlantique. Her second husband died in 1967. “I had two good husbands. I have always been happy,” she once said to the local newspaper. “I like all people.” The same newspaper reported that she was a “gourmet” and fond of chocolate.

Mme Bremont lived independently at home until the age of 105, very often walking the eight kilometers from her small village to the nearest city, Candé. At the age of 103, she was hit by a car and broke her arm. At the age of 105, she was admitted to the nursing home of the local hospital, Aimé Jallot in Candé. She would have liked to have stayed longer in her home, but her sight and hearing were deteriorating. According to the nursing home staff she was “a rebel.” She refused to wear a hearing aid—like Jeanne Calment—because, according to her, she could hear the nurses perfectly.

When, at the age of 111, she was told that she now was the oldest person in France (which turned out not to be true) after the death of Jeanne Calment, she said: “You know I have worked all my life. I don’t have anything to reproach myself.” For her 113th birthday, the nursing home prepared a public party without asking her permission. Consequently, she refused to come to her party. For the following birthdays, the staff asked her opinion and organized more intimate parties. Mme Bremont’s 115th birthday was officially celebrated in the nursing home in Candé, where she passed her final years. After her 115th birthday, she worried about how she could answer the emails received for her birthday. According to the staff of the nursing home, meaningful exchanges took place until her death, although she had good days and bad days. She died, apparently peacefully, shortly after her 115th birthday on June 6, 2001.

4.2 Maud Farris-Luse: Outlived six of her seven children

Marie Bremont’s successor was probably the American woman Maud Farris-Luse. She has been validated by Louis Epstein and Robert Young (see his chapter in this monograph) on the basis of census records, her marriage certificate, the birth records of her children, and newspaper evidence of earlier birthday celebrations since she was 98. She was born on January 21, 1887, in Morley, Michigan, about 40 miles north of Grand Rapids.

In 1891, her family moved to Angola in the county of Steuben, Indiana. On June 27, 1903, at age 16, she married Jason Ferris, a farmer and laborer, which required parental consent. They had seven children: four sons and three daughters. Six of the children were born in an eight-year period from 1905 to 1913, when she was 18 to 26 years old; while the last, a daughter, Lucille, was born in 1928, when she was 41. Lucille was the only one of her children to survive her. The oldest, the son, Charlie, died in 1987 at the age of 82; the fifth, the daughter, Clair, died in 1988 at the age of 77; and the next-youngest, the son, Dale, died in 1986 at the age of 73. The other children probably died at younger ages.

In 1923, she and her husband moved back to Michigan, settling in Coldwater, a southern Michigan city about 100 miles southwest of Detroit. At some point hereafter, she decided to spell her name "Maud Farris," instead of "Ferris." Her husband died at age 72 in 1951 after 48 years of marriage, and she became a widow at the age of 64. In the early 1960's, she married Walter Luse and called herself Maud Farris-Luse. Her new husband died three years into their marriage, when she was still in her sixties. She was in good shape at age 100, and was still fishing, a sport she had enjoyed since she was young. She lived on her own until the age of 104. In 1991, she fell in her home, breaking her hip. This forced her to leave her home for a nursing home, The Laurels of Coldwater, where she lived for more than a decade. In 1997, when she reached the age of 110, she was still able to write a letter, and she wrote to Jeanne Calment, then almost 122. However, during her last years she was mostly confined to bed.

Mrs. Farris-Luse was accepted by the Guinness World Records as the "world's oldest person" on June 23, 2001, a few weeks after the death of Marie Bremont. When she celebrated her 115th birthday, one of her grandchildren, Susie Crandall, age 53, told a local newspaper that her grandmother could no longer speak, hear, or understand what was going on, but she loved visiting. "I hold her hand and give her kisses and tell her that I love her, but she doesn't understand what's going on. If I could turn out to be half the woman that she's been, I'd consider myself lucky." She outlived all but one of her seven children and had a dozen offspring, including one great-great-great-grandchild. She died from pneumonia on March 18, 2002, almost two months after her 115th birthday.

4.3 Kamato Hongo: "Just an ordinary life"

Maud Farris-Luse was succeeded as the world's oldest person by the Japanese woman Kamato Hongo, who was reportedly born on September 16, 1887, and apparently reached the age of 115 years on September 16, 2002, six months after the death of Maud Farris-Luse, or more than one year after the death of Marie Bremont. But the Belgian demographer, Michel Poulain, who has tried to validate her age, has questioned her birth date (see his chapter in this monograph). She was born on the small island of Tokuno-Shima to the south of Japan's main islands, also the home of the alleged 120-year-old man, Shigechiyo Izumi, who is still mentioned by Guinness World Records as the longest-living man, but whose age never has been, and never can be, verified due to lack of documents. In Japan, Mrs. Hongo is officially still considered to have been the oldest of the Japanese long-livers.

According to information her daughter provided to a local newspaper, Mrs. Hongo grew up in a farming family; a very warm family from which she inherited her "warm character." She married and had four sons and three daughters. Her husband produced sugar cane. When her husband died in 1964, she moved to Osaka, and later, in 1983, she moved to Kagoshima on Kyushu, Japan's main southern island, where she lived with her daughter, grandchildren, and great-grandchildren. Her daughter said that "she's just lived an ordinary life," without doing anything special. She did not eat much processed food, but preferred natural foods. She had a very sharp sense of taste. She drank mainly green tea, and she also used to drink two or three cups of herb wine.

At the age of 110, she had a surgery for a hip fracture. The operation went well and she recovered, but she thereafter began to sleep for an entire day or two, followed by a day or two of being awake. She spent the end of her life listening to music from a tape recorder. Her hearing was fading away, and, during the last year of her life, her mind was not clear. Mrs. Hongo's daughter refused to place her mother in a nursing home, preferring instead to have her at home until she died. From her 115th birthday until her death, a banner hung from the second floor of her daughter's house declaring that this was the house of Kamato Hongo, aged 115, the oldest person in the world. It had been put up by the local municipality. She died, apparently peacefully, at the age of 116 years and 45 days, on October 31, 2003.

4.4 Maria Esther Capovilla: "Only a small cup of wine with lunch and nothing more."

Maria Esther Capovilla was publicly recognized by Guinness World Records as the oldest living person, based on documents provided by her family, including baptismal and marriage certificates. She had been regularly featured in the Guayaquil newspaper since her 100th birthday in 1989. Robert Young visited her in March 2006, and Bernard Jeune, Jean-Marie Robine and the Chinese demographer Siulan Cheung visited her in April 2006. They interviewed her children and some of her grandchildren, and have collected copies of several certificates from the parish registers and other relevant documents. As Maria Capovilla has lived all her life in the city Guayaquil in Ecuador, it is possible to carry out a thorough validation at the same level as for Jeanne Calment and Chris Mortensen, although this has not yet been done.

She was born September 14, 1889, in the large sea port of Guayaquil in southwestern Ecuador. Her father was of Spanish descent and was a colonel in the Ecuadorian army. She grew up in an affluent home, the third of five children. She was a frail child who had to be raised outside the town by an aunt at a farm where she drank plenty of milk, both goat milk and donkey milk. She did not start school until she was 11 years old in 1900, when the first school opened. In her youth, she liked to embroider, paint, play the piano, and dance the waltz. As an adult she always ate three meals, but she never smoked or drank strong alcoholic drinks—"just one small glass of wine with lunch and not more."

She was married at a relatively late age, when she was 27 years old in 1917, to Antonio Capovilla, a man of Italian descent who was born in 1864 in the Austrian-occupied part of northern Italy. He was an engineer and an officer. After a stint in the Chilean army, he came to Ecuador in 1910, where he had a significant position in the Ecuadorian fleet as a mine and torpedo specialist. He died in 1949. They had five children, of whom the oldest, a son born in 1918, died in 1920. The second oldest, Emma, was born in 1920 and died in 1999 at the age of 79. The three youngest were still living in 2007: Hilda, 82 years old, who was born in 1924; Irma, 80 years old, who was born in 1926; and Annibal, 78 years old; who was born in 1928. For the last 20 years of her life, she lived with her oldest daughter and her son-in-law.

When we visited her in April 2006 at her oldest daughter's house, she was dressed in a noble blue-black dress, and was sitting with an impressive fan in her hand in the middle of a sofa between her oldest and second-oldest daughters. She was sitting majestically and erect, but she had a tendency to lean to one side when she sat without support for a long time. She was able to see us and greet us. She was still able to read headlines in newspapers, but was no longer able to read ordinary text in newspapers. She watched television, but had difficulties keeping up with a TV program, possibly due to a hearing impairment, as she was able to see the photos which we took in a digital camera. Even though she had trouble hearing, we managed, with the aid of a hearing microphone, to have a conversation with her.

She was able to remember many details from her long life, and seemed, on the whole, of sound mind. According to her daughters, however, she had become less communicative, especially since her 116th birthday. Her memory was not bad, because she remembered many things, but not everything. Her hearing impairment may, however, have contributed to this, as it was necessary to speak very loudly and close to her ear to be able to make yourself understood. She was fond of receiving guests, however, and smiled at them and nodded communicatively with her head while sitting in her sofa.

She was still able to walk indoors when she was assisted, but had not been outdoors for about two years. She slept a lot, got up late, took a long time to get ready in the morning, but managed on her own. She also had an afternoon nap and went to bed early in the evening. She was always present at all family meals: for breakfast she drank coffee with warm milk and ate bread with cheese and jam; for lunch she liked lentils and chicken; in the afternoon she enjoyed something sweet, like cakes, jelly, and ice cream; and for supper she ate whatever the family was having. She could eat on her own if the food has been prepared. While we were there she ate a cake with ice cream on her own, holding the small plate with her left hand and the spoon with her right hand.

Around the time of her 116th birthday, Maria Capovilla developed a stomach ailment which required hospitalization. This almost claimed her life and left her quite frail, with a considerable loss of weight. Until that time, she was able to move around with a walker on her own in the house. She managed without a walker until the age of 111 years. When she was 103 years old, she felt so unwell after an infection that the vicar had to administer last rites. She recovered, but was somewhat frail thereafter. As a 20-year-old, she had almost died as the result of a serious illness, most probably the Spanish flu. But, aside from a gall bladder operation as a 60-year-old, her health as an elderly person was good. She took very little medication.

According to the family, Maria Capovilla's calm disposition might have been the secret to her longevity. She had always had a calm mind and never got upset by anything. She seldom smiled or laughed, nor did she cry. She had always been a person of few words; polite and reserved. She took things as they came and she had been like that all her life. Every day she thanked God for still being alive. In this way, she had also taken every death in the family with fatalistic equanimity. She prayed to God every morning and night.

She died on August 27, 2006, two weeks before her 117th birthday, after being hospitalized for a severe flu. She left three children, 12 grandchildren, 20 great-grandchildren, and two great-great-grandchildren.

5 The increasing number of successors in 2005/2006

5.1 Hendrikje van Andel-Schipper: A herring and a glass of orange juice every day

The Dutch woman Hendrikje van Andel-Schipper, called “Aunt Hennie,” who reached the age of 115 on June 29, 2005, was recognized as the longest-living person in the world for more than one year, until Guinness World Records in December 2005 publicly recognized that Maria Esther Capovilla had reached the age of 115 almost one year previously (on September 14, 2004). Hendrikje van Andel-Schipper was visited and interviewed by journalists from the local and the national press, and was also interviewed by RTL television. Her birth registration has been found in the archives of her birth town (Wikipedia 2005).

She was born in a small village, Smilde, near Drenthe in Holland. Born prematurely and weighing just three pounds, her mother believed that the infant would not survive. However, thanks to the continuous care of her grandmother during her first four weeks of life, she recovered. But she remained a frail and ailing child. At the age of five, on her first day of school, she was sick again and was removed from school on the advice of a local doctor. She was not allowed to go to school and was tutored by her parents at home. Her father, who was the head of the local school, taught her to read and write. “My mother taught me arithmetic, as she found that to be extremely important,” she once recalled. “Because I didn’t go to school, I usually took to the land with the farmers. I was allowed to sit on the hay wagon. That was great.”

Hendrikje lived with her parents until she was 47 years old. At the age of 46, she met her husband, Dick van Andel, a tax inspector who worked in Amsterdam. She left her parent’s home to marry Dick at age of 49 in 1939. From then on, her name was van Andel-Schipper. She was too old to have children. She had loved the theater from a young age, but, after her mother objected, she decided not to pursue a career in acting. She became a needlework teacher instead, and drama remained a hobby. During World War II, she and her husband moved to Hoogeven, where she had to sell jewelry to help pay for food during the German occupation. Her husband died of cancer in 1959.

“I was 49 when I married him,” She said in an interview. “My mother was dead-set against it; she thought I was too old to get married. But I held my ground and had twenty wonderful years with my husband. Then he died. My husband suffered for months before he passed away. That’s why I always tell people who ask me how I’ve lived to be 113: Don’t smoke and don’t drink too much alcohol. What else have I done to reach this old age? Continue to breathe, nothing more. But I hope that people will stop asking me this question; the answer is becoming increasingly monotonous." In another interview, she has stated that her secret was a raw Dutch herring and a glass of orange juice every day. She was a good cook and took her time to prepare meals. She never smoked, and she very much enjoyed riding a bicycle. Although she told Time magazine that the greatest advance in her lifetime was the automobile, she never learned to drive.

When she turned 106, Mrs. van Andel-Schipper went to live in a nursing home, De Westekim in Hoogeven. "Yes, I am very satisfied here in De Westerkim. The staff is very kind and friendly. I couldn't have wished for better." On a table of her room in the nursing home was a picture of Queen Beatrix, and an Ajax pennant hung on the wall. She visited Queen Beatrix in 2001: "Who can honestly say that they've visited with the queen for tea? Very few people, if I'm not mistaken. It was a great honor. The Queen was very kind and I let her ask the questions. Then, in turn, I could respond, it was simpler that way. It was a wonderful afternoon, and on our way back in the evening, we were treated to a delicious dinner in Staphorst. I hope to live to 114. I feel fine, so that shouldn't be a problem." In another interview she said: "If I continue to feel as I do now, I will become a 120;" however, she added, "the Great Manager decides when my end is to be."

She had been a fan of the football club Ajax Amsterdam since she attended a match in 1918. It was her favorite football club: "Even if they shoot down to the bottom rung, I will still remain an Ajax fan. I've only been to an Ajax match once in my life, when I was 28. Now I'm nearly 114 years, how is that possible?" Once, when the Ajax team visited her, she complained that the other residents of her nursing home were "hicks who don't understand football."

For her 115th birthday, she received visits from many prominent and local guests: the daughter-in-law of the Queen of the Netherlands, Princess Laurentien; a delegation from her favorite football club, Ajax; a representative from the Dutch association of housewives who declared her an honorary member; the mayor of Hoogeven; the regional tourist board; and many other guests. The inhabitants of the town waved their flags, and banners reading "Hoogeven feliciteert Hennie van Andel 115 Jaar" hung several places in the municipality. She left the celebration after one hour; very tired, but also very grateful. "I had a great time," she said afterward. "When you get as old as I am, you have few distractions left. That's why I so enjoy having people visit me."

Apparently, she had not suffered of major diseases until her nineties, when she was diagnosed with a breast cancer and went through a mastectomy at the age of almost 100. Afterward, she remained fairly well, although her hearing was poor and she was almost blind. At the age of 113, she was treated for a bladder infection. The director of the nursing home told a newspaper that "she was very clear mentally right up to the end, but physically ailments were increasing." She was socially engaged and was "really interested in what's going on in the world and listens to the news on the radio most days,"—at least until the age of 113, when her hearing became too poor. "I sit all day long. That comes with the territory of age. Besides, my former contemporaries are no longer amongst the living." However, her standing reply whenever anything went wrong was: "There's no point in moaning."

At the end, she was waiting for death. "Ultimately you wait for death," she said. "It's been nice, but the man upstairs says it's time to go." Mrs. van Andel-Schipper died peacefully in her sleep very soon after her 115 years celebration on August 30, 2005. She had decided some years previously that her body should be donated to an anatomist at the University of Groningen, Gert Holstege, who had visited her and interviewed her several times. As planned, she was autopsied. She died of stomach cancer (Science, 2005).

5.2 Elizabeth Bolden: A religious woman with 10 great-great-great grandchildren.

Two weeks before the death of Mrs. van Andel-Schipper, the African-American woman Elizabeth Bolden probably reached the age of 115 on August 15, 2005. Her claim has been accepted by Guinness World Records without a birth or a marriage certificate due to registrations from census reports and her seven children's documents. After the death of Maria Esther Capovilla, she was probably the oldest person in the world. Her case has been validated by Robert Young (see his chapter in this monograph) with the help of a local genealogist, Jeff Knight.

Elisabeth Bolden was probably born on August 15, 1890 (it may have been one year later), on a cotton farm in Fayette, Tennessee. Both her parents were former slaves. She grew up with her mother, Annie Jones, and her four siblings. She was married to a tenant farmer, Lewis Bolden, in 1909. They had seven children, the oldest of whom, the son, Ezell, was born in 1908; while the youngest was born in 1920. Two of these children were still living in 2007: an 89-year-old daughter, Queen Rhodes, who was born in 1917, and a 86-year-old daughter, Mamie

Brittmon, who was born in 1920. Her husband died in the early 1950s. She grew up on the cotton farm where later she also worked. Her main job was processing the cotton after it had been harvested. Remembering the days on the farm when, in addition to chopping cotton, her mother would take in washing and ironing, her daughter Mamie said to the local newspaper: “In the summer we’d build a fire outside. We had the big smoothing irons and we’d heat the irons and in the winter we’d use a fireplace in the stove.” Throughout her life she was a keen Baptist, and was a verger at the local Baptist church until she entered a nursing home at the age of 109.

Bernard Jeune, Jean-Marie Robine, and the Chinese demographer, Siulan Cheung, visited Mrs. Bolden on April 4, 2006, the 31st anniversary of the murder of Martin Luther King in Memphis. She was living in a nursing home, MidSouth Health and Rehabilitation Center, in Memphis (Tennessee). She was sitting in her wheelchair in her room, which was completely decorated with pictures of her very big family and a large number of newspaper cuttings showing her latest birthdays. It was very difficult to communicate with her as she was deeply affected by the impact of a stroke, but she could communicate with her eyes.

On her 112th birthday, she was allegedly completely mentally fit and was able to remember all details. But, on her 114th birthday, she did not speak much any more. Shortly after her 115th birthday, she had a stroke; thereafter she clearly had significant memory problems. The family believed she was not able to recognize them any more when they came to visit her. But the nursing staff closest to her said they were convinced she could recognize them, and that she could also hear what they said to her.

After she had suffered the stroke, it became difficult for her to eat, and she did not get enough nutrition. She was then fed artificially through a stomach tube. She therefore got abundant amounts of nutrition. Her face seemed full without many wrinkles.

When, prior to her stroke, Mrs. Bolden was asked by a local journalist why she believed she had lived to such a high age, she answered laconically, “I don’t know.” According to her youngest daughter, her mother was deeply religious: “She always asked us to read the Bible, be honest, go to church, and treat others in the way we would like to be treated. She raised us well.” Her grandson added, “She has always been a spiritual person. She prays when she wakes up and she prays when she goes to bed.”

She passed away on December 11, 2006, from respiratory distress. When she died, she had 34 grandchildren, 124 great-grandchildren, more than 100 great-great-grandchildren, and more than 10 great-great-great-grandchildren.

5.3 Bettie Wilson: Survived a major surgery at the age of 114

Another African-American woman, Bettie Wilson, reached the age of 115 on September 13, 2005. She was featured in the local Mississippi newspaper and was interviewed for NBC news. She has also been interviewed several times by Robert Young, who has validated her case (see his chapter in this monograph).

She was born as Bettie Antry Rutherford on September 13, 1890, in Benton, Mississippi, the daughter of ex-slaves Solomon and Delia Rutherford. Her mother was 45 years old when she delivered Bettie as the last child of 12. Her mother, who was from South Carolina, was sold to a Mississippi plantation owner. Her parents were freed by Union soldiers and settled as farmers in the north of Mississippi. She remembers as a little girl picking cotton in the fields, and the dinner bell ringing when it was time to eat. As a young girl, she was a servant. She had her first child in 1910; a son, Willie Rogers, who was still living at the age of 96 in 2007, although in a wheelchair like his mother. She married Rufus Rogers in 1919 who died soon after, and, in 1922, she married Dewey Wilson, a clergyman. They were married for 72 years, until Dewey Wilson died in 1994, aged 95. They had two daughters who are deceased.

Bettie Wilson was a very spiritual person, giving God the glory for her long life. She was in good health until the age of 100, when she went to the hospital for the first time. She apparently could walk with the aid of a cane until the age of 114, when problems with her gall bladder put her in the hospital again. She survived gall bladder surgery in September 2004, after which she was on oxygen for a period months. The doctors didn't think she would make it. Before her 115th birthday, she tended to sit most of the day in a big easy chair, but sometimes used a wheelchair, although she could not sit up in the chair and had to lay back. She could not walk, but she could still read and talk coherently. She remembered her age and birth year, and she knew the name of the current president. However, after her 115th birthday, her vision, hearing, and memory declined, and she suffered from bed sores as a result of being more bedridden than before. During the last months of her life, she was declining. She died on February 13, 2006, at the age of 115 years and 153 days.

Prior to her death, Mrs. Wilson lived in a new home with her great-granddaughter and caregiver Della Shorter in New Albany, about 70 miles southeast of Memphis. When it was believed that she was the oldest American woman (i.e., before Elizabeth Bolden was officially accepted by Guinness), Della told the local newspaper that her mother wouldn't mind not being the oldest: "She didn't want people feeling that she was higher than anybody."

5.4 Susie Gibson: Still going out to eat at the local restaurant to the very end

A little more than one month later, Susie Gibson reached the age of 115 on October 31, 2005. Her case has been validated by Robert Young (see his chapter in this monograph). He also interviewed her several times in 2004 and 2005.

She was born as Susie Potts on October 31, 1890, in Corinth, Mississippi. Her grandfather owned a plantation, and her father was said to have owned just about the whole town. She said that her father owned so much land you couldn't reach the end of it in a day, riding a horse. She remembers when she as a child in the 1890s picking up leftover shells from the Civil War battlefield of Shiloh.

When she was a girl, she became sick and her family thought she was going to die. She remembers an angel that came to her. The town doctor, the first person in town to own an automobile, promised her a ride if she got better. She got better, but the doctor didn't keep his promise. As a young woman she went to dictation school, and was educated as a typist. In 1912, she won a trip to San Francisco. While at theater in that city, she remembers that the movie was interrupted to announce that the Titanic was sinking. She also said that she had to "wait a long time to vote;" not until 1920, when she was 30, were women first allowed to vote.

In 1915, she married James Gibson, Sr., and they moved to Sheffield, Alabama, shortly thereafter. He died in 1955, aged 71. They had one child, James Jr., who was born in 1917. He was a pharmacist and lived to the age of 70. After the birth of her child, she did not work away from home. Instead, she operated an inn and made neckties. She was an avid fisher, and claims to have rescued a child from drowning.

Mrs. Gibson still drove until the age of 95, and she fished into her low one hundreds. At the age of 104, she moved into a nursing home in Tuscumbia, Alabama, due to declining vision. She walked unassisted until age 109, and, though confined to a wheelchair, was still able at 115 to wheel herself around. In November 2005, at the last interview, she wheeled herself to her closet to look through her many fine dresses. She was able to sit erect in her wheelchair. She loved to tell stories, and her memory at age 113 was very good; at 114, she was still a loquacious talker, able to be interviewed for one hour.

Her memory gradually declined in her final years, and she had her ups and downs, but she still had the ability speaking coherently when she was feeling well. She had become a bit forgetful. When she was asked in September 2005 when she was born and how old she was, she said “I was born in 1889;” and, “I am 118.” She also did not know who the current president was. Even so, she lit up when you talked to her. Her sight and hearing were not good, but she was not given a hearing aid until 2005. She could no longer sign her name. She still had her purse, and went out to eat at the local O’Charley’s restaurant once a month. She enjoyed the frequent visits of an 88-year-old man, and the visits of her nearest relatives, including her granddaughter, who lived about two hours away, and her daughter-in law, Ernestine Gibson, who was 84 years old. She had a bout of pneumonia in February 2005, and the doctors were worried, but she recovered. However, her condition declined gradually thereafter. In January 2006, she suffered from heart failure, and died on February 16, 2006.

5.5 Emiliano Mercado Del Toro: “I never damaged my body by liquor”

The American, Emiliano Del Toro from Puerto Rico, is probably the second man who has reached the age of 115, about nine years after Chris Mortensen, on August 21, 2006. He was acknowledged by the Guinness World Record as the longest living man based on documents which the family provided. Robert Young has independently validated his case (see his chapter in this monograph), having found his birth certificate and his baptismal record listing him as having been born on August 21, 1891. The following biographical information about him is taken from a few local newspapers and a feature in the New York Times.

Both parents, his father, Delfin Mercado, and his mother, Gumersinda Mercado, were born in Puerto Rico, and lived in 1910 in Pedernales, Cabo Rojo, Puerto Rico. He remembered the U.S. seizure of Puerto Rico from Spain in July 1898, when he was nearly seven years old. He also remembered the hurricane San Ciriaco, which swept across Puerto Rico in 1899, killing more than 3,000 people. He grew up among the sugar cane plantations in the southwestern part of Puerto Rico. He attended a public school in the town of Cabo Rojo through the sixth grade. As a young man, he worked for 50 cents a day driving animals loaded with sugar cane to processing centers. At the age of 27, he was drafted into the U.S. Army, but was still at a training camp in Panama when the armistice ended World War I on November 11 of that year. According to a certificate that his niece has preserved in a plastic envelope, he was discharged on December 4. In this certificate, he is described as having chestnut eyes, chestnut hair, and a good character. After the war, he returned to working in the sugar cane fields. He had several love affairs, but, for reasons of fate, never married. He retired at the age of 80, and quit smoking after 75 years at the age of 90.

He lived in the northwestern coastal town of Isabela (70 miles from San Juan) with his 85-year-old niece, Tomasita Ruiz. At the age of 111, he was the grand marshal of the Veterans Day parade, which he attended in his wheelchair and with a navy-and-gold garrison cap on his head. He told a local journalist that he felt satisfied with the honor. At the age of 112, he survived gangrene of the foot, which nearly killed him. After that he was described in the New York Times as frail, almost blind with unseeing eyes ringed with dark circles, and nearly deaf. He spent most days in bed with a cool washcloth over his eyes, but his memory was good. His fingers were in constant motion, but he was able to grasp a visitor's hands. At his 115th birthday, an ambulance drove him to an outdoor plaza for at party with his family. His favorite singer, Iris Chacon, sang a birthday tune set to mariachi music. "I feel happy," he said after the party. "I never thought I would last so long." He attributed his longevity to a healthy diet of boiled cornmeal, cod, and coconut milk; and to avoiding alcohol: "I never damaged my body by liquor." His favorite drink was coffee. When he died on January 24, 2007, at the age of 115 and 133 days, he was the second-oldest validated male ever, after Chris Mortensen.

5.6 Winnefred Bertrand: Never hospitalized for a serious disease before the age of 112

Almost one month later than Emiliano Mercado del Toro, the Canadian woman, Julie Winnefred Bertrand, reached the age of 115 on September 16, 2006. At the end of her life, she lived in a long-term care facility, Résidences Berthiaume Du Tremblay, in Montreal, Quebec. Together with two demographers from the University of Montreal, Robert Bourbeau and Bertrand Desjardins, who thoroughly validated her case, Jean Marie Robine and Bernard Jeune visited her on October 1, 2006. Desjardins found her baptismal certificate, which constitutes in Quebec her birth registration, as well as census registrations and several biographical notes from different public sources. She was mentioned in different newspapers after her 105th anniversary, although she only rarely accepted interviews, and never agreed to have photos taken. But her 75-year old nephew, André Bertrand—who, together with his sister, Elaine Saucier, received us when we visited their aunt—has talked about her to different newspapers.

She was born on September 16, 1891, in Coaticook, which was, at the time, a small rural community near the U.S. border, some 140 kilometers east of Montreal. Her father, Napoléon J. Bertrand, was born in 1862 and died at the age of 82; and her mother, Julia Agatha Mullins, was born in 1864 and died at the age of 85. As adults, they both had diabetes, and her mother underwent the amputation of one of her legs. Her parents were married in 1886 and had seven children: five sons and two daughters, the oldest born in 1887 and the youngest in 1911. Winnefred Bertrand was number three of the seven children. The longest living of her siblings were her sister Irene, who died at the age of 92, and her brother Maurice, who died at the age of 85. Two of her brothers died at young ages, one of the Spanish flu.

Winnefred Bertrand never married, but as a young woman she had some lovers ("*j'ai eu quelques flammes*"), including a young lawyer, Louis-Stephen Saint-Laurent, who later became prime minister of Canada in the period 1948-1957. Until the age of 112, she was in very good health and "*une force de la nature*," her sister-in-law, Germaine Bouchar-Bertrand (married to her youngest brother) told a journalist. During all of her life, "she stood five-foot-eight and weighed 150 pounds in her fighting days," said her nephew André Bertrand to another journalist. He also said that she has always been "a strong lady, fiercely independent and self-sufficient." She spent most of her working life (35 years) as a shop assistant in the store Lajoie-Lajoie in Coaticook, where she was responsible for the sales of women clothes. This store was situated about half a mile from her parent's farm. When her parents sold their farm, she cared for them in her apartment just above the store. She took care of her parents well into their eighties. At the age of 105, she told a journalist that the periods following the deaths of her parents "were the most difficult in her whole life."

In 1974, at the age of 83, she entered the above-mentioned nursing home, not because she was sick or dependent on help with daily activities, but because she wished to live with other people. Apart from a short hospitalization for a collar bone fracture after a fall at the age of 95, she had never been hospitalized or treated with medications before she had a stroke when she was 112 years old.

At the age of 105, she still performed most tasks independently: cleaning her room, washing her clothes, going to the dinner room to take her lunch and dinner, going to the bank to manage her finances, etc. She was particularly engaged in keeping her wardrobe with her elegant clothes in order. Nobody was allowed to touch her clothes. She very much liked to read books and newspapers, and to watch the news on the TV. She was well-informed about what was going on around her, and in the world. However, at that age she was starting to have difficulties with her sight and her hearing.

At the age of 110, she did not allow anybody to interview her, and she did not want a party (she didn't appreciate the party which was held at her 105th birthday), although she was still in relatively good shape: in spite of her decreasing sight and hearing, she still went to the dining room with help of a walker (*marchette*) and her cognition was intact (she was still very "*lucide*"). But she was more tired and rarely left her room. At the age of 111, and until her stroke, she was still able to walk around, and was still communicative and had an excellent memory.

After the stroke, she was no longer capable of holding a conversation, although it seemed that she could give some adequate answers and comments, and expressed her wishes with gestures. Her nephew said that his aunt still recognized him and his sister when they visited her. Some days she slept for most of the day, as she did when we visited her.

Not long before her death, her nephew said to a journalist that "she would say that she was tired and praying for the good Lord to come down and fetch her." He believed that, if she were to go to sleep and not wake up, it would be a relief to her: "She's is like a great general. She won't die. She's just fading away." At the age of 105, she told a journalist that she considered "moderation" to be the secret of her long life. Her faith may have contributed to her longevity, as she was a devout Catholic throughout her life. Julie Winnefred Bertrand died on January 18, 2007, at the age of 115 years and 124 days.

6 Did they have something in common?

As can be seen from Jeanne Calment's successors, none came near her record of 122 years. In fact, since the death of Sarah Knauss at the age of 119 on December 30, 1999, no one has reached the age of 118. However, the appearance of several new long-livers reaching the age of 115 years in 2005 and 2006 may indicate a new trend; a future in which such longevity would become the norm. Do they have anything in common that would explain their extreme longevity?

If God isn't simply playing dice with our fates and deciding who should be spared the longest, then presumably Jeanne Calment and her successors must have possessed something that most of us more mortal creatures do not have. As we shall see, it is not easy to determine what these special qualities might be. However, being born a woman definitely seems to be a great advantage, as only two of those who reached the age of 115 or more were male.

Jeanne Calment evidently descended from long-lived stock: her forebears lived longer than the average. Susie Gibson was the daughter of a 102-year-old mother. But this was not true in the other cases. Most had at least one relative who had lived beyond age 90, but that would also be true for many people who have died at younger ages. Jeanne Calment, Susie Gibson, and Maria Capovilla grew up in a well-to-do family. But others came from a working class or a farmer family, or even from slaves, and were busy during most of their lives.

About half of them had no children or only one child. Emiliano Del Toro and Winnefred Bertrand never married and had no children. Charlotte Hughes bore no children, but she did marry late in life; similarly, Hendrikje van Andel-Schipper married too late to have a child. Annie Jennings married, but had no children, and Chris Mortensen remained childless, though he was married for a brief period. Marie Brémont had two good husbands but no children. Both Jeanne Calment and Sarah Knauss had only one child, but the lineage of Jeanne Calment died out when she was 88 years old, while Sarah Knauss succeeded in becoming the oldest of six generations. Susie Gibson had only one child; but Bettie Wilson had three children; Tane Ikai had four; Maria Capovilla had five; Maud Farris-Luse, Kamato Hongo, and Elizabeth Bolden each had seven; Marie-Louise Meilleur had 12; and Maggie Barnes 15 children. Most of those with children also had great-great-grandchildren, and Marie Louise Meilleur, Sarah Knauss, Maud Farris-Luse, Bettie Wilson, and Elizabeth Bolden all had great-great-great-grandchildren.

There is nothing to suggest that most of them ate what we would nowadays regard as a healthy diet. It is, of course, noteworthy that three of the longest-lived women were all great consumers of chocolate, and others liked to eat sweets. Along with vegetables, fruit, tea, and red wine, good chocolate contains antioxidants that appear to protect against hardening of the arteries and cancer. But in other respects, their diets varied greatly, and none had been vegetarian or had been on a special weight-reducing diet. Nor was there any indication that any of them had at any point been overweight.

There is no doubt that smoking shortens life, albeit to a varied extent, depending on how much one smokes and inhales. Indeed, tobacco is one of the most powerful known factors in reducing a person's lifespan. It is, therefore, noteworthy that both Jeanne Calment and Chris Mortensen had smoked for almost 100 years, and Emiliano Del Toro quit smoking at the age of 90, after having smoked for 75 years. However, it is questionable how much harmful smoke they actually inhaled. Jeanne Calment smoked only two cigarettes a day, and possibly did not inhale at all. Chris Mortensen smoked much more, but stuck to pipes and cigars and never inhaled the smoke. However, the majority did not smoke.

The most amazing fact is, however, that Hendrijke van Andel-Schipper, who was born prematurely with a weight of only three pounds, survived to such a high age. According to the programmed fetal origin hypothesis, low birth weight is a strong risk factor for later chronic diseases. Nevertheless, Mrs. van Andel-Schipper avoided major life-threatening diseases until her nineties, when she got a breast cancer and ultimately died of a stomach cancer. As she stressed herself, she avoided smoking, she loved to bike and seems to have lived a very quite life.

Perhaps their long lives would not have been possible without the life-prolonging effects of the modern medical treatments that have become available in recent decades. Hendrijke van Andel-Schipper was successfully treated for breast cancer just before she turned 100 years old. Bettie Wilson survived surgery for a gall bladder disease at the age of 114. At the age of 115, Jeanne Calment survived surgery for a hip fracture. Just after her 120th birthday, moreover, she was treated with antibiotics for pneumonia arising from a particularly severe bout of flu. Kamato Hongo survived a hip fracture at the age of 110. Sarah Knauss was given a blood transfusion to treat low haemoglobin at the age of 117. The other long-lived successors had survived pneumonia or stroke or other illnesses, such as moderate heart failure at an advanced age. Although our official knowledge of their past diseases is scanty (the notes of their physicians are confidential), and they were not thoroughly examined at the end of their lives, it seems that none of them had suffered from severe heart disease, and most of them avoided serious forms of cancer, unlike many less long-lived centenarians (see Andersen-Ranberg et al., 2001).

It is also striking that Jeanne Calment, Charlotte Hughes, Sarah Knauss, Maggie Barnes, Chris Mortensen, Marie Bremont, Hendrijke van Andel-Schipper, and Bettie Wilson all apparently avoided dementia, at least until shortly before they died. Although this was not the case with Tane Ikai, Marie-Louise Meilleur, Maud Farris-Luse, Kamato Hongo, and Elizabeth Bolden, it provides evidence in itself that dementia is not an inevitable corollary even of extreme old age.

Another striking feature of Jeanne Calment and her successors was their will to live and their sense of humor. A recurring point in relatives' descriptions of all these centenarians was that they were strong personalities who were able to combine strength of will with friendliness. By definition, of course, a person who has withstood the loss of numerous family members and endured many years of frailty—progressively losing mobility, sight, and hearing—must possess a certain will to live. Yet they all exhibited their strong personalities in different ways. Some were considered domineering, e.g., Jeanne Calment and Charlotte Hughes; while others were described as quite the opposite, e.g., Sarah Knauss and Maria Capovilla. The descriptions given by younger relatives may, in part, of course, have been rationalizations after the event, or reflected their perception of personality traits more generally prevalent among an older generation.

Provisionally, however, we may conclude that Jeanne Calment and her successors did not reveal any particular secrets that could serve as straightforward explanations for their extraordinarily long lives. They therefore remain a complex phenomenon. Nonetheless, they offer exceptional examples of the fact that certain people can age extremely slowly, although we do not as yet know why the aging process is slowed down in certain cases, or how this happens when it does.

Although these people aged so slowly, all of them nevertheless became extremely frail in their final years. Their physical functions declined markedly, especially after their 105th birthdays. They walked very slowly and had increasing difficulty in performing daily tasks. Their sight and hearing weakened, so that in the last years of their lives they were virtually blind and very hard of hearing. They spent their last years confined to wheelchairs and slept most of the time. Most of them entered a nursing home between the ages of 105 and 110, but a few lived at home to the very end of their lives (Maggie Barnes, Annie Jennings, Kamato Hongo, and Bettie Wilson).

Although they retained their youthful personalities and were able to live on their memories, none of them could escape the effects of old age. But nor, on the other hand, did they fear death, and they appeared to be reconciled to the fact that they were approaching the end of life. They never expressed any wish to recover their youth. “Enjoying and living are two different things,” as Chris Mortensen put it.

Whether Jeanne Calment and her successors were exceptional, one-off cases, or the first examples of a new trend, their stories, together with recent discoveries in biology, have given rise to new reflections. For concurrently with the survival of several 115-year-olds, a number of biological experiments were conducted which proved that changes in genes involved in fundamental biological mechanisms, and changes in environmental factors, such as dietary restriction and improvement of anti-oxidant capacity, can increase the lifespan of yeast cells, round-worms, fruit flies, and mice. These results have contributed to a far greater understanding of the aging process than we have had up until now. Along with Jeanne Calment and her successors, these findings have shaken the hitherto widespread assumption that aging and lifespan are unalterable.

However, Jeanne Calment and her successors also show that life must eventually come to an end, whether that end is the conclusion to a long period of suffering, or the culmination of a lifetime of fulfillment. It is, therefore, understandable that some have maintained an unshakable belief in the inexorable decline that comes with old age. Lone swallows such as Jeanne Calment and her successors, who went beyond the presumed absolute limit of 115, have not succeeded in dislodging the idea that there is an absolute limit to the human lifespan. Nevertheless, they give us a more nuanced picture of aging and longevity. Neither aging nor longevity can be reduced to simple causes.

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