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Research Article

Exceptional longevity in Okinawa: A plea for in-depth validation

Michel Poulain

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Research Article

Exceptional longevity in Okinawa: A plea for in-depth validation

Michel Poulain[1]

Abstract

The topic of this article is the exceptional longevity in Okinawa. This phenomenon should be thoroughly validated at both the individual and population levels. This contribution analyzes the demographic data available for the population of Okinawa, in order to explain the presence of large numbers of centenarians. The mortality crossover obtained by comparing mortality rates in Okinawa and Japan could be attributed either to different behavior of the generations born before and after WW II, or to bad data. Arguments are presented in favor of both possible explanations. The reconstruction of the Koseki to replace the original, which was destroyed during WW II, could be a source of misreporting of age and would support the bad data hypothesis. Nevertheless, no concrete proof of invalid data has been found. Therefore, the author does not favor either of these explanations, but is calling for a more in-depth validation of longevity in Okinawa.

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1. Introduction

Okinawa is one of the 47 prefectures of Japan. It consists of a group of 44 inhabited islands that extend 800 miles south of the main Japanese islands, north of Taiwan. These islands, part of the Ryukyu Kingdom, were incorporated into the Japanese Empire in 1879. The people of Okinawa still consider themselves different from those of mainland Japan, and there are dissimilarities between some features of their cultures and traditional life styles. For 80 days in 1945 Okinawa was the site of the last and most decisive battle of WW II between Japanese and American soldiers. More than 100,000 soldiers died, as well as an equal number of civilians. The territory was subsequently under U.S. administration until 1972, when it was returned to Japan. Its population of 1.3 million inhabitants is considered to be among the less economically developed of Japan. Since the excellent contribution of Irene Taeuber (1955), no in-depth studies of the demography of Okinawa have been conducted, although these are essential in order to validate its alleged exceptional longevity.

Studies of centenarians are frequently used to investigate the determinants of healthy aging and exceptional longevity. Most of these studies involve individual centenarians and compare their behaviors and characteristics with younger members of the same population.[2] A few other studies have analyzed populations which are somewhat isolated and often ethnically distinct that experience exceptional longevity. These studies assess not only individual longevity but also the longevity of the population as a whole. The mountainous areas of Sardinia and Okinawa are the two most important regions where population longevity has been recently investigated in more detail.[3]

Verification of extreme age and exceptional longevity is crucial to the validity of all research on the oldest olds. Individual longevity and population longevity are complementary concepts that may contribute to the analysis of the determinants of longevity, but their validation process differs. For individual longevity, the age of every oldest old person is carefully checked before inclusion in the analysis, or exclusion in case of error. For population longevity, individual age validation is also required,[4] but an exhaustive enumeration of the oldest olds has to be ensured from a basic analysis of the demographic evolution of the population.

[2] For example, see the methodology followed in the EU-funded research project GEHA (Franceschi et al. 2007).
[3] For Sardinia, see Poulain et al. (2006) and for Okinawa, Willcox et al. (2001).
[4] It is nevertheless possible to validate high population longevity even if the individual longevity of some of the oldest olds cannot be validated.

A recent paper by Willcox et al. (2008) might be considered to be a direct response to the need for a complete validation of population longevity in Okinawa. It presents a battery of arguments that support the conclusion that the high prevalence of centenarians in Okinawa is valid and warrants further study of its genetic and environmental correlates. The present article intends to revisit these arguments, to assess the demographic aspects of the longevity of the population of Okinawa, and also to consider recent research by Saito (2010) on the age validation of super-centenarians in Japan.

2. Exceptional longevity in Okinawa

Population longevity is often assessed by computing the prevalence of centenarians, which is the number of centenarians reported among the total population at a given time (Table 1). Although the prevalence of centenarians is the most commonly used global index for comparing longevity, it is not necessarily the most appropriate (Canudas-Romo 2010). Important potential biases are linked to the fact that a population born a century ago and living in a particular place cannot be compared with the total population of that locale. Variations in fertility and mortality occurring over the course of a century, as well as selective migration, may profoundly influence this index and make it completely unusable for comparative purposes. Nevertheless, as shown in Table 1, the prevalence of centenarians in Okinawa is exceptionally high, especially among women. The prevalence computed for both sexes since 1963 has been consistently higher for Okinawa than for Japan as a whole (Figure 1 and Annex 1).

Period life expectancy might be a better index for comparing levels of longevity between different populations, although it describes only the current survival rates of the population and applies them to a fictitious cohort. A comparison of figures for 2005[5] reveals that the life expectancy at birth for females exceeds 86 years for Okinawa, which is higher than that of every other country shown in Table 2.

[5] Life tables are only produced every five years for Japanese prefectures; therefore the year 2005 has been selected, although later figures were available for most of the other countries.

Table 1: Number of centenarians in Okinawa, Sardinia, and other selected countries in 2008, and their corresponding prevalence expressed as the number of centenarians per one million inhabitants

	Total Males in thousands	Total Females in thousands	Male centenarians	Female centenarians	Male prevalence	Female prevalence	Sex ratio
Japan	62251	65441	5076	31200	81.5	476.8	5.85
Okinawa	674	702	94	744	139.5	1059.8	7.60
Italy	28949	30669	2287	10301	79.0	335.9	4.25
Sardinia	817	848	87	242	106.5	285.4	2.68
Austria	4054	4278	132	809	32.6	189.1	5.81
Belgium	5224	5443	144	1237	27.6	227.3	8.25
Denmark	2713	2763	103	628	38.0	227.3	5.99
Spain	22357	22926	1412	4394	63.2	191.7	3.03
France	30982	32771	4036	16213	130.3	494.7	3.80
Greece	5554	5660	854	1781	153.8	314.7	2.05
Netherlands	8112	8293	193	1293	23.8	155.9	6.55
Norway	2360	2377	106	510	44.9	214.5	4.78
Sweden	4564	4619	225	1233	49.3	266.9	5.41

Sources: Belgian National Institute of Statistics; Japanese Ministry of Health, Labor and Welfare; Japanese Statistics Bureau, Human Mortality Database, Okinawa Prefecture; StatBank Denmark; Statistics Iceland; Statistics Sweden; US Census Bureau.

Figure 1: Prevalence of centenarians in Okinawa compared with Japan 1963-2010

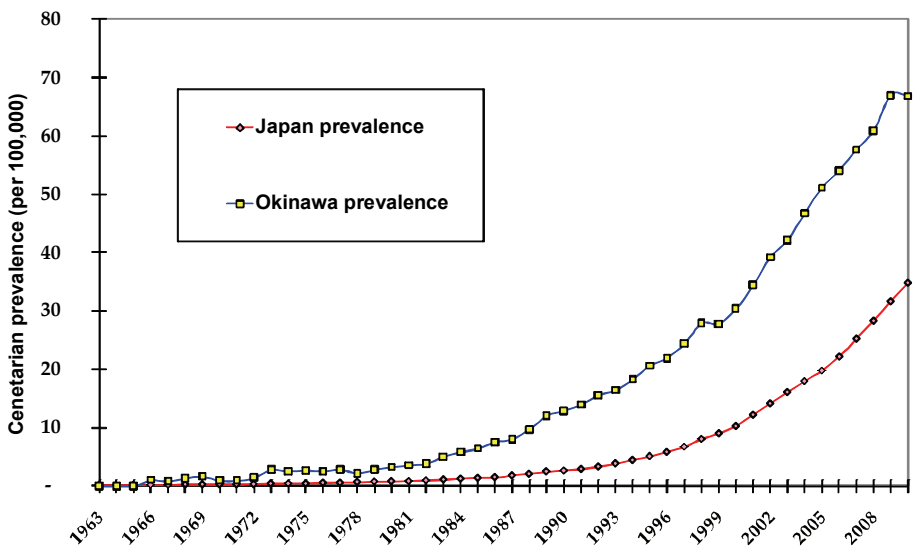


Table 2: Life expectancies for selected countries and regions in 2005

Country and regions	Males	Females
Japan	78.6	85.5
Okinawa	77.7	86.3
Italy	78.1	83.7
Sardinia	77.6	83.9
Austria	76.7	82.3
Belgium	76.2	81.9
Denmark	76.0	80.5
Spain	77.0	83.7
France	76.8	83.7
Greece	76.8	81.6
Netherlands	77.3	81.7
Sweden	78.5	82.9
Norway	77.8	82.7
Switzerland	78.7	84.0
USA	75.2	80.4

Sources: Eurostat Database; Hellenic Republic Ministry of Economy and Finance; INED; Japanese Ministry of Health, Labour and Welfare; Human Mortality Database; Italian National Institute of Statistics; Spanish Institute of Statistics; StatBank Denmark; Statistic Iceland; Statistics Sweden; and US National Center for Health statistics.

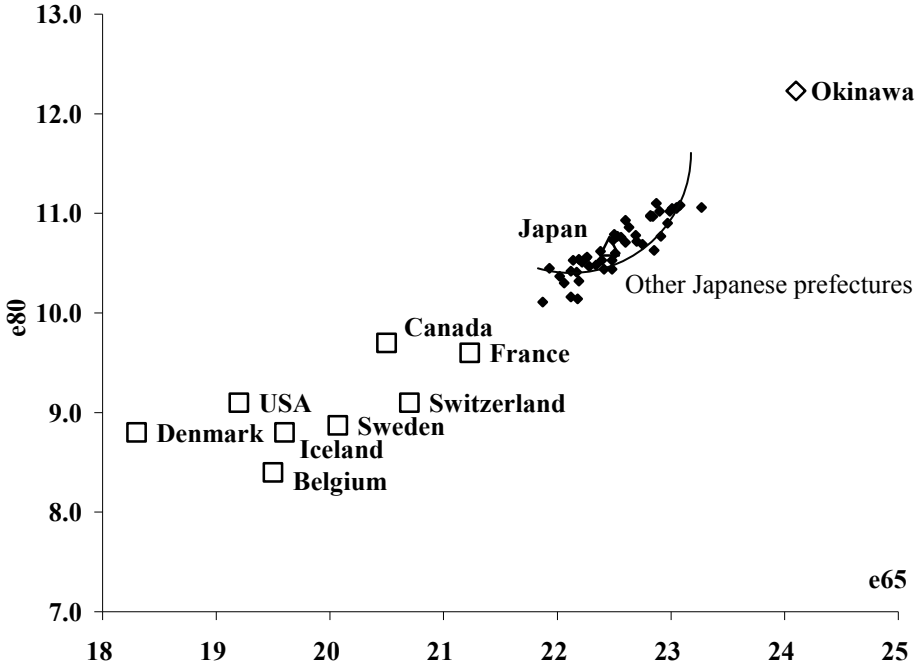
These data also show the exceptional prevalence of female centenarians in Okinawa. It is two or three times higher than for Japan as a whole and other European and North American countries, and life expectancy is also higher.

Figure 2 compares female life expectancy at 65 and 80 years for all Japanese prefectures and selected countries in 2000. Okinawa is clearly in the lead, followed at some distance by the other Japanese prefectures, and at an even greater distance by the European and North American countries with the highest life expectancies. We therefore conclude that the situation in Okinawa definitely appears to be exceptional. Nevertheless, such an extraordinary demographic situation needs to be fully validated. All of the other alleged cases of exceptional population longevity, e.g., the Caucasus, Ecuador, and Pakistan, have been found to be invalid (Jeune and Kannisto 1997), except for Sardinia, where males have been proven to live significantly longer in the mountainous populations (Poulain et al. 2004).

In-depth validation is therefore crucial to legitimate the findings obtained by several decades of researchers (Willcox et al. 2001). We find in the literature on individual longevity that the more exceptional the situation, the more carefully and thoroughly the validation has been developed. In-depth investigations into the extreme life spans of Jeanne Calment, who died at 122 years of age, and Chris Mortensen, who

died at 115, have found nothing that would invalidate either case (Wilmoth et al. 1996, Robine and Allard 1998).

Figure 2: Female life expectancy at 65 and 80 for all Japanese prefectures and selected countries in 2000



Because Japanese demographic data have always been considered extremely reliable, an in-depth investigation was probably never undertaken until we raised the question (Naito and Poulain 2004, Poulain and Naito 2005). Some doubt persists with regard to the absolute reliability of the Japanese data; therefore no unassailable conclusion can be reached from current research into longevity and the determinants of healthy aging in that country. Recent media reports reinforce this statement.[6] Population registration and census enumeration procedures have not been completely

[6] See, for example, Number of Registered Centenarians in Japan Gets Smaller as Records Culled The Yomiuri Shimbun - McClatchy-Tribune News Service, TOKYO, Sept 05, 2010, accessed at http://www.yomiuri.co.jp/index-e.htm/ on December 15, 2010.

free from error. It is clear that in-depth investigation is essential to legitimate all research into the exceptional longevity in Okinawa, and this study should also be viewed as a contribution toward any research using demographic data on Okinawa.

3. Validation of individual and population longevity

According to Thoms (1873), "the proof of [the age of a centenarian] should be clear, distinct and beyond dispute." With regard to the probability of finding centenarians before 1800 and supercentenarians before 1950, Hynes (1999) said that validation could face "a range of difficulties, which might be impossible to overcome." If one important piece of information is missing, we cannot conclude that there is "no doubt at all" about the validation: if one element is wrong, the whole validation process is disproved. It is definitely easier to prove that a person is not a centenarian than the opposite. In fact, a well-founded argument is sufficient to invalidate with high probability the age of an alleged centenarian, whereas an imposing set of consistent documents are required to establish a high probability of age validation (Poulain 2010).

Similar rules apply to validating population longevity. The age validation of individual centenarians or a representative sample has to be conducted very carefully. The identification of a few invalidated cases does not necessarily invalidate the longevity of the whole population.[7] These cases simply have to be eliminated or corrected when computing longevity indexes for comparative purposes. Additional rules apply for assessing the comprehensiveness of data collection – all demographic data have to be investigated, including the demographic evolution of the population going back more than a century. This is a key factor for validating exceptional population longevity. However, validating will never be as easy as invalidating individual longevity by means of well-documented arguments. Ensuring the validation of individual longevity on Okinawa is sufficient for identifying the characteristics of centenarians as compared to younger controls. However, any attempt to prove the exceptional longevity of the population of Okinawa, based on the prevalence of centenarians or the level of life expectancy, imperatively requires the validation of the longevity of the whole population.

[7] Longevity in the Sardinian Blue Zone has been validated despite the invalidation of the age of Damiana Sette, who was found to have replaced her eldest sister, and died at the age of 107, rather than 110 (Poulain et al. 2006).

4. Reliability of available data sources

Several data sources are available to support demographic studies: civil registration (Koseki), the population register (Jyuminhyo), annual lists of centenarians (Zenkoku Koureisha Meibo), vital statistics (Jinkô dôtai chôsa), and population censuses (Kokusei chôsa).

4.1 The civil registration system (Koseki)

The Japanese civil registration system is based on the Koseki*,* in which official data related to each family are transcribed, including births, deaths, marriages, and divorces. The Koseki is a family register, which records all family relationships. It gives the respondent's date and place of birth, rank in the family (e.g., first or second son, third daughter), and complete information on parents, siblings, grandparents, and spouse(s). The original Koseki – the Jinshin Koseki – was standardized as the identity register for the whole of Japan on 4 April 1871. However, Kitou (1997) noted that the system could only be considered complete and accurate as of 1886. Moreover, as the Ryukyu Kingdom, which includes Okinawa, was integrated into the Japanese Empire in 1879, the Koseki was introduced progressively starting from 1879, but Matsumoto (1977) concluded that the Koseki in Okinawa has only been fully operational since around 1900.

Due to issues of sensitivity related to the caste system, the Jinshin Koseki was replaced by the Genko Koseki according to a law (Koseki ho) enacted 22 December 1947. All of the Koseki have therefore been updated and the old versions are no longer available for validation purposes. The most important difference between the Jinshin Koseki and the Genko Koseki is that the new system groups individuals by nuclear families (parents and children), whereas the old system registered them according to family lineage, called Ié.[8] From an operational perspective, after leaving the parental home, a child establishes a new Koseki. Two types of Koseki certificates are issued: the Koseki tohon, which contains exact and complete information on all family members, and the Koseki shohon, which provides the identical information for an individual who requests this document. The latter document serves as an official birth certificate, as no birth or death register exists in Japan. The Honseki or legal domicile is the place where an individual is registered in the Koseki and where he or she may request these

[8] The translation and meaning of "Ié" is still a subject of discussion in Japan among lawyers, sociologists, and historians. The most common definition is: a large group of individuals linked by family lineage through birth or adoption. Each Ié also has economic significance, and the continuity of these groups over time is essential.

certificates; it is not necessarily the individual's usual place of residence. The situation is more complex in Okinawa, as most of the old Koseki were destroyed during WW II and a provisional Koseki was reconstructed both by American authorities in Okinawa and Japanese authorities in Fukuoka. As will be explained later, only following the return of the territory to Japan in 1972 was the new Koseki unified and can it be considered fully operational in Okinawa.

4.2 The population registration system (Jyuminhyo)

In addition to the Koseki, a population register called the Kiyori seido (literally Residence System) was created in 1914. The system was revised according to a law enacted 25 July 1967, and is now known as the Jyumin Kihon Daïcho (literally Resident Population Register). This register contains information on the date and place of birth, sex, marital status, relationship to the head of household, and address of the place of usual residence of all individuals currently living in the same household. The Jyumin Kihon Daïcho continuously updates the usual place of residence of the individual and is thereafter grouped by household rather than family. These documents are used for electoral and other administrative purposes and maintained by the administration of the place of usual residence. The Jyuminhyo serves as official proof of residence. The relationship between the Koseki and the Jyuminhyo is unidirectional: a certified copy of the Koseki has to be presented for registration in the Jyuminhyo, and the legal domicile of the Koseki is recorded in the Jyuminhyo, but the usual place of residence is not included in the Koseki. As Saito (2010) explained, there is another important difference between the Koseki and the Jyuminhyo with regard to accessing individual records. Only family members may request an extract or duplicate of the Koseki, while a certificate of residence for every individual may easily be extracted from the Jyuminhyo for research purposes. Unfortunately, the Privacy Protection Law of 2005 has largely restricted access to the Jyuminhyo. Moreover only individual information is included, limiting the usefulness of that document for age validation.[9]

[9] Individual information in the certificate of residence based on the *Juminhyo* includes name, sex, date and place of birth, usual place of residence, legal domicile, date of registration in the municipality, name of and relationship to the head of household, and, if appropriate, the date of departure or death.

4.3 Annual lists of centenarians (Zenkoku Koureisha Meibo)

Lists of the names of centenarians have been compiled by the Ministry of Health and Welfare on September 30 of each year since 1963, in order to celebrate the centenarians on Elders Day, a national holiday now known as Respect for the Aged Day, Keirō no Hi. Since 2003 this day has been celebrated on the third Monday of September. Lists based on the Jyuminhyo are prepared on September 1st and include those who are or will become centenarians from October 1st to April 1st of the following year.[10] The selection of these dates was linked to the fiscal year, which begins April 1st and ends March 31. As Robine, Saito, and Jagger (2003) explained, these lists can be used to estimate the number of centenarians on October 1st, considering that some of those listed will die before October 1st and others who are 99 years old will celebrate their 100th birthday before March 31st. The Ministry in charge of releasing these figures therefore makes some necessary corrections.

4.4 Vital statistics (Jinkô dôtai chôsa)

Vital statistics on births and deaths by age and sex have been produced annually at the local level since the end of the 20th century. At the beginning of the 20th century, the delays in reporting births and deaths were quite limited in Japan but in Okinawa births were sometimes reported late, or not at all in the event of early death (Kono 1998). This could have resulted in a lower level of registered infant mortality compared to Japan as a whole, until after WW II, as shown in Figure 3.

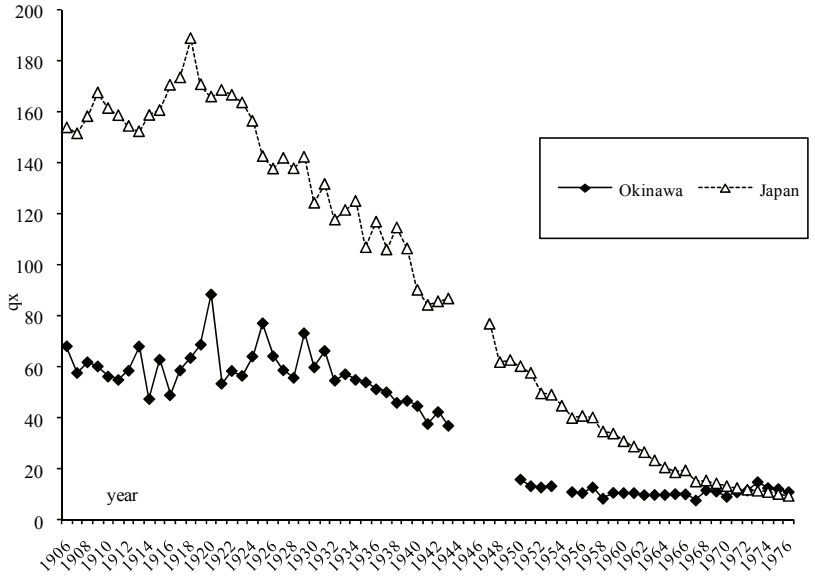
4.5 Population censuses (Kokusei chôsa)

In Japan, censuses have been conducted on October 1st every five years since 1920,[11] except in 1945. Up until 1940 the de facto population was considered; starting from 1950 it has been the de jure population. U.S. authorities in cooperation with the Government of Okinawa carried out censuses from 1950 to 1970. The reliability of the 1985, 1990, and 1995 Japanese censuses is considered very high, but a more thorough investigation by Iibuchi and Kato (1987) for the Prefecture of Okinawa and two similar

[10] The list for 2010 is accessible at http://www.mhlw.go.jp/stf/houdou/2r9852000000roq6-img/2r9852000000rorn.pdf (accessed on April 4, 2011).
[11] Some figures based on the Koseki, including the structure of the population by sex and five-year age groups, have been available every five years starting from 1890 to 1915 (see Annex 2).

prefectures identified some discrepancies. They compared two successive censuses – 1975 and 1980 – and the deaths registered between them, but only for birth cohorts up to 30 years of age. The UN joint score index can be used for checking age heaping up to age 75. Figure 4 shows opposite trends for Japan as compared with Okinawa, where levels have remained relatively high without signs of recent improvement. With regard to the reliability of the censuses, it is worth mentioning that the number of individuals of unknown age enumerated was higher for Okinawa than for Japan as a whole, except for 2005 (Figure 5).

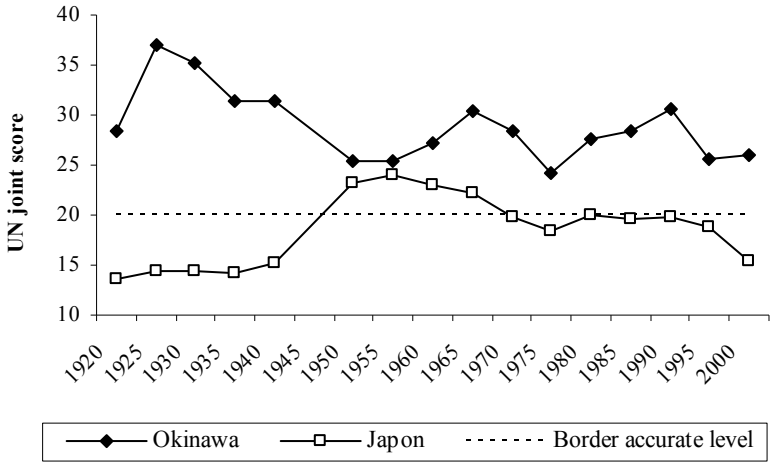
Figure 3: Infant mortality rates for Okinawa compared with Japan, 1906-1976



Sources: Okinawa Prefecture and the Japanese Statistics Bureau

The 2005 census results were the first to include data on age and sex structure by single years above age 100. While the proportion of the 80-89 age groups relative to the total population is larger in Japan than in Okinawa, the situation is reversed for older ages. The levels are similar for ages 90-94, but above 95, and especially after 100, the figures are clearly higher for Okinawa: the proportion of centenarians is twice as high for men and three times higher for women (Figure 6).

Figure 4: Comparative reliability of censuses for Okinawa and Japan, using the UN joint score index for age heaping up to age 75



Source: Japanese Statistics Bureau

Figure 5: Proportion of enumerated individuals of unknown age in Okinawa and Japan from 1975 to 2005 (per thousand)

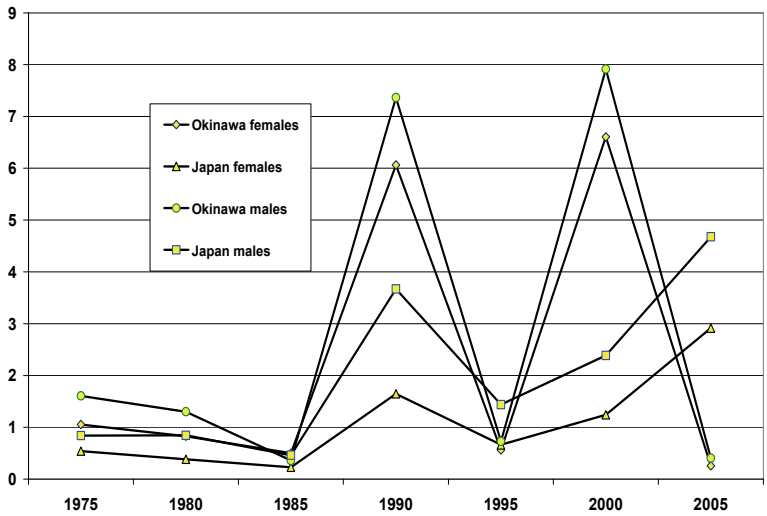
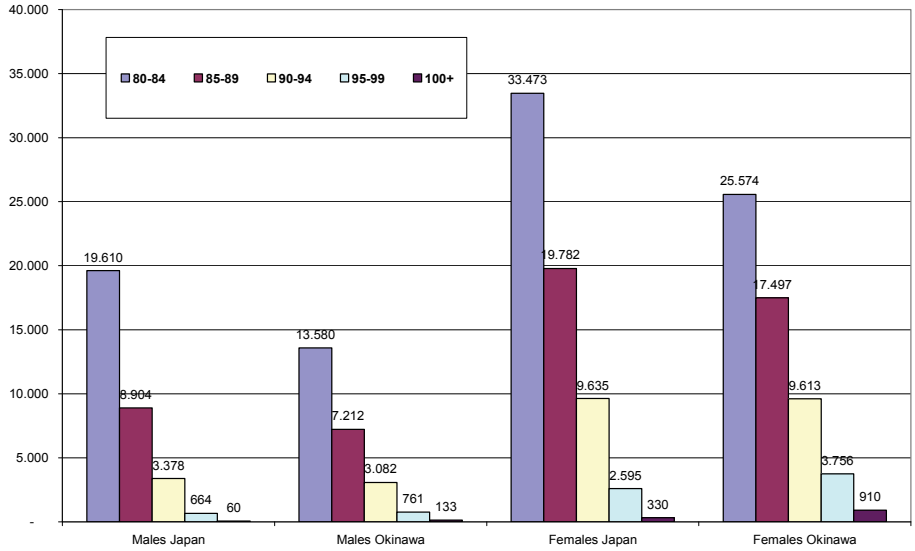


Figure 6: Comparative proportions of oldest olds in Okinawa and Japan as of the 2005 census (per one million inhabitants)



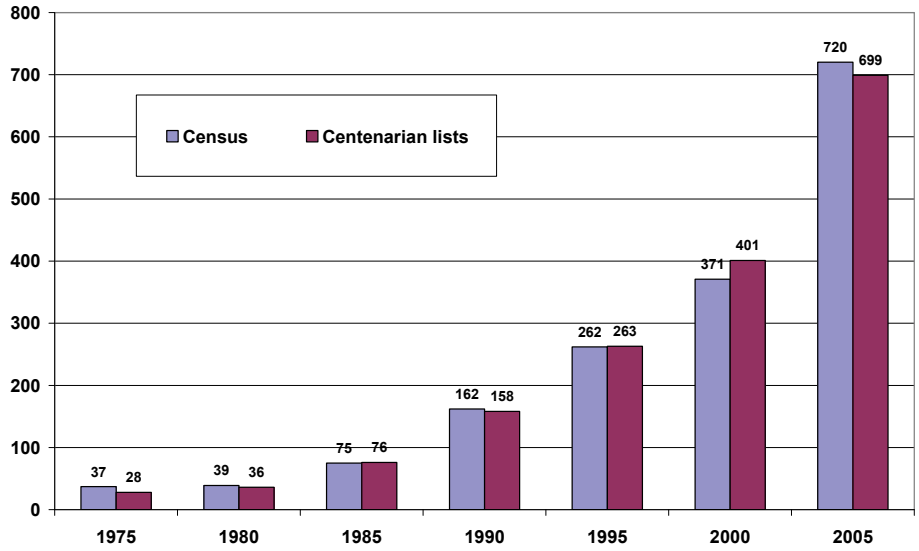
4.6 Compatibility of data sources with regard to the number of centenarians

Age is self-reported on censuses, but the annual lists of centenarians are based on administrative records (Jyuminhyo). The compatibility of these two data sources should be checked, even if it can be assumed that most individuals have reported their age as stated in their Koseki. Figure 7 compares these figures for Okinawa. The figures are extremely consistent, except for the last two censuses. The likely reason for these differences is the correction methodology applied by the Ministry for issuing annual figures on centenarians.

The numbers of deaths of centenarians according to vital statistics may also be contrasted with figures obtained by comparing successive annual lists of centenarians. The annual lists do not report the number of centenarians who have died. These lists are dated October 1st, whereas death statistics are produced on an annual basis. A method of approximation was therefore developed to ensure comparability by assuming no

migration after age 100.[12] The result of this procedure is applied to Okinawa in Figure 8. It shows a slight overestimation for the data obtained by comparing successive annual lists of centenarians.

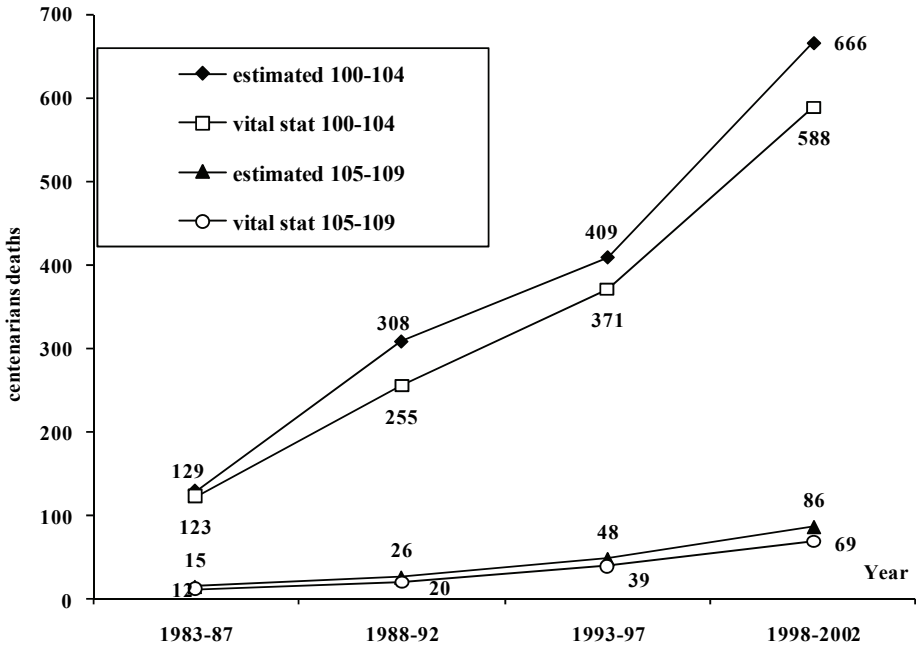
Figure 7: Compatibility of census figures and annual lists of centenarians for Okinawa



Source: Japanese Statistics Bureau

[12] According to the methodology, a centenarian who was on the list in a given year but does not appear on that of the succeeding year is considered to have died between September 1st of the first year and September 1st of the second, with a uniform distribution of deaths over the twelve month period.

Figure 8: Number of centenarian deaths according to vital statistics and by comparing successive annual lists of centenarians



Sources: Japanese Ministry of Health, Labor and Welfare, and Okinawa Prefecture.

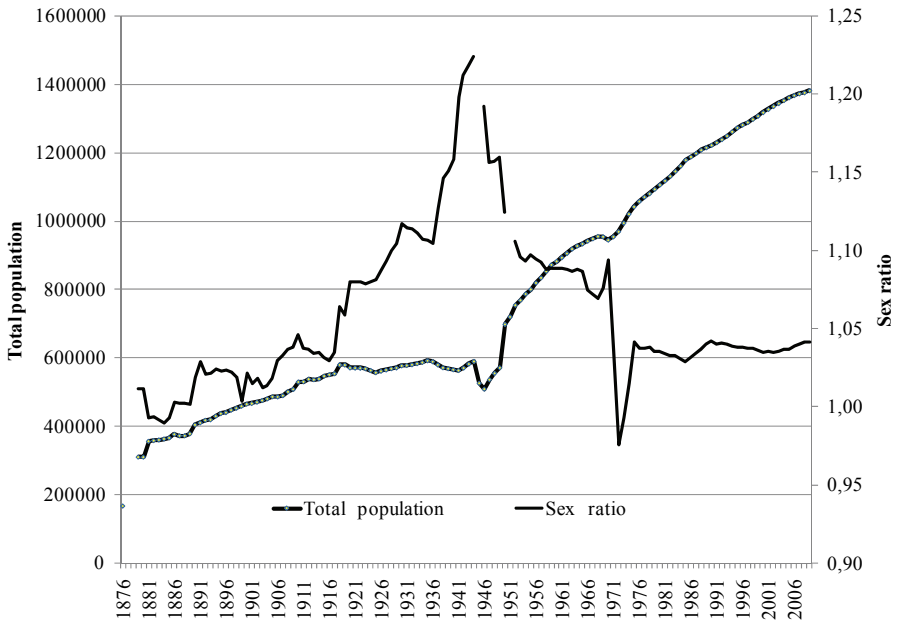
Death registration is considered to be exhaustive; therefore this overestimation should be investigated more thoroughly. A possible explanation is that annual lists might include individuals who survive "administratively" in the Jyuminhyo because their deaths were not registered. The names of these individuals were later removed when the administrative error was found, but they were not included in the death records of that year.[13] Access to individual data would be required in order to test this hypothesis.

[13] The problem of the "administrative survival" of the oldest olds has been observed in most countries that have population registers (Oblak Flander 2009).

5. Evolution of the population of Okinawa

The long-term population trends of Okinawa and the evolution of its age and sex structure have been affected by considerable emigration during the first half of the 20th century and large human losses during WW II (Figure 9).

Figure 9: The global evolution and sex ratio of the population of Okinawa (F/M) (1876-2009)

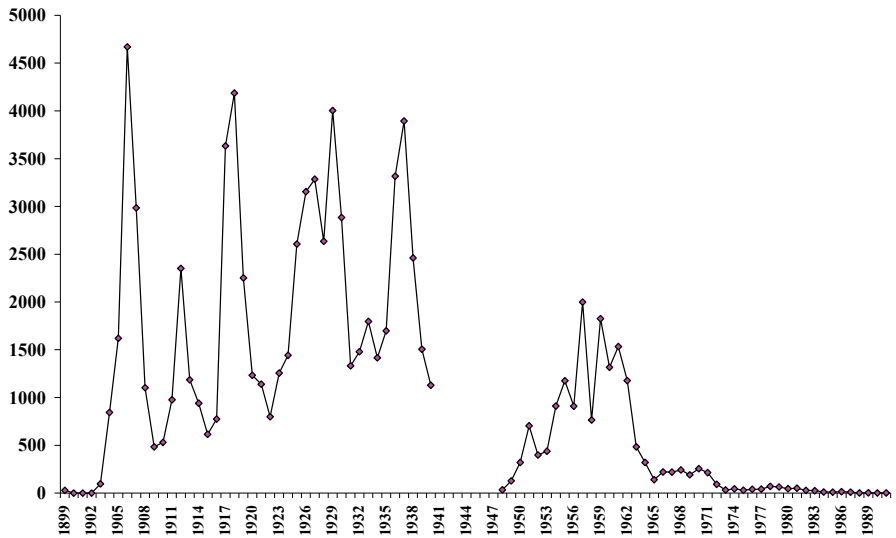


5.1 Age and sex structure of the population

The increase in the population and changes in the sex ratio have both been affected by large-scale, mainly male, emigration before WW II (Figure 10). A pattern of migration from Okinawa to Hawaii started in 1900, 15 years later than from mainland Japan.

A large number of Okinawans left in a short period of time.[14] The emigration rate was among the highest in Japan: by 1940, one out of ten Okinawans had emigrated. The reasons were economic – Okinawa was poor and has natural disadvantages because of its geological location, socio-political – the Ryukyu Kingdom land allocation system was replaced by individual ownership, and personal – emigrants' success stories and emigration agencies encouraged individuals to leave.

Figure 10: Emigration from Okinawa (1899-1993) (absolute figures)



Source: *Ryukyu Shimpo* Journal (http://ryukyushimpo.jp/variety/page-31.html).

The population of Okinawa experienced extreme suffering during WW II, especially during the Battle of Okinawa in 1944. Of the 240,000 casualties listed in the Okinawa Prefectural Peace Memorial Museum, approximately 150,000 were native civilian Okinawans.[15] The Peace Memorial and the Okinawa Prefecture tabulated the comparative age structure of the population in 1940 (Japanese census) and 1945

[14] From 1900 to 1940, 20,000 Okinawans left for Hawaii, 17,000 for the Philippines, 14,000 for Brazil, and 11,000 for Peru, according to data published on the Okinawa Prefectural Government web site (accessible at www.pref.okinawa.jp/english/).

[15] See the website of the Okinawa Prefectural Peace Memorial Museum at www.peace-museum.pref.okinawa.jp.

(American estimates) (Figure 11). The losses were exaggerated by the fact that many civilians had been evacuated to mainland Japan and had not yet returned in 1945.

Figure 11: The comparative age and sex structure of the population of Okinawa in 1940 (Japanese census before WW II) and 1945 (US estimates after WW II)

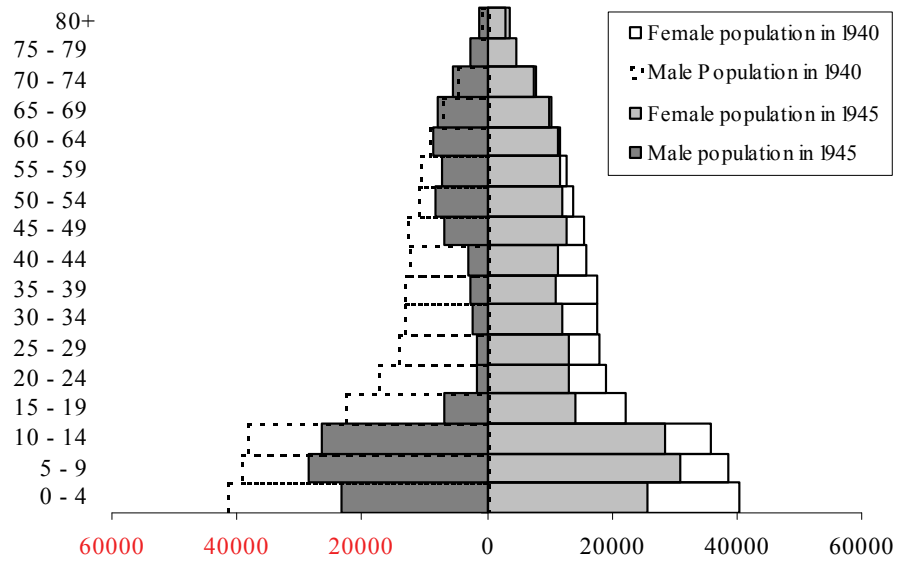
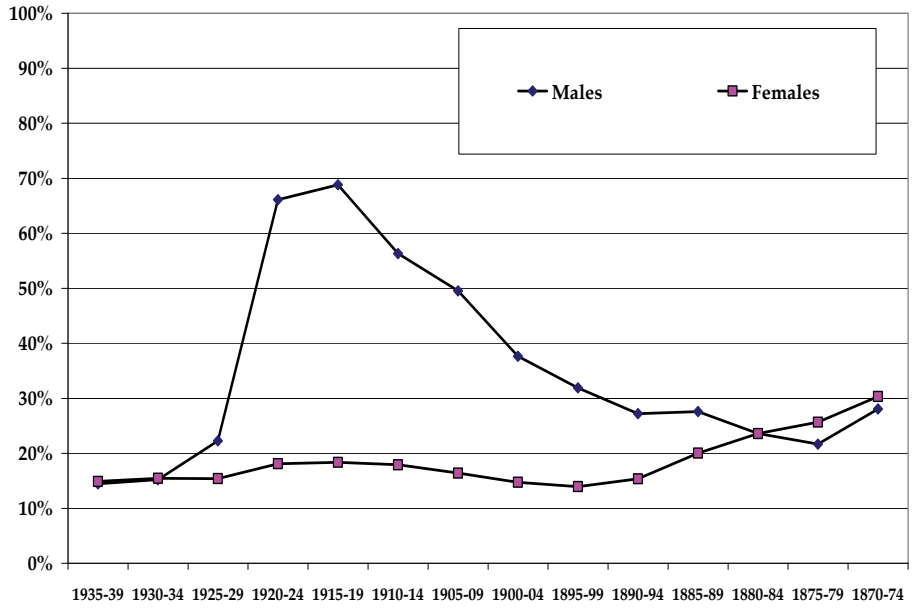


Figure 12 shows an estimate we developed of the WW II Okinawa population losses, based on individual information collected by the Peace Memorial. One fourth of the population was lost – three men for every two women. 60% of males in the cohorts born on the island between 1910 and 1924 died. The significant gender gap as well as the sex differential in the 1920s' and 30s' wave of migration are responsible for the sudden increase in the female/male sex ratio after WW II, and also for the current high sex ratio among the older olds.

Figure 12: Author's estimate of the proportion of the Okinawa population who died during WWII, by sex and birth cohort



5.2 Evolution of mortality in Okinawa

Comparative life tables are available for Japan and Okinawa every five years at the time of each census, beginning in 1920. A comparison of mortality levels by five-year age groups reveals a clear mortality crossover, as previously discussed (Poulain and Naito 2005, Naito and Poulain 2004). Figure 13 shows the mortality crossover for the 2000 life table; the mortality rates for Okinawa are higher before and lower after age 60, relative to Japan.

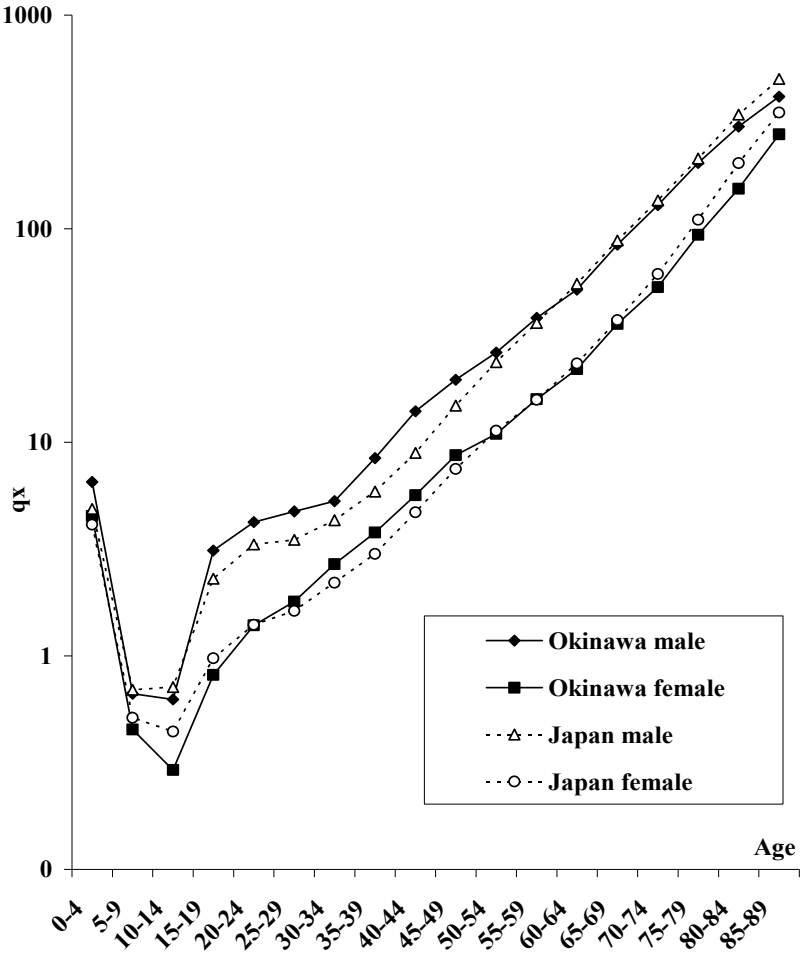
Coale and Kisker (1986) made an in-depth study of the possible reasons for mortality crossovers. The two main explanations are (i) a selection effect and (ii) age misreporting or bad data. In the case of Okinawa as compared with Japan, all life tables since 1975 show this phenomenon, but the point of the crossover moves progressively over time, in such a way that the same groups of cohorts – those born before and those born after 1945, the end of WW II – are systematically contrasted. The ratio between

the mortality rates in Okinawa and Japan are provided in Table 3. Kaneko (1987) and Takahashi (1993) have previously drawn attention to this contrast between the two groups of cohorts. According to Coale and Kisker's hypothesis, these two groups of cohorts should have experienced different selection effects or differences in the reliability of their data. More precisely, according to the first hypothesis we might suppose that those born before 1945 experienced more difficult life conditions than the succeeding cohorts, as compared with Japan as a whole. The second hypothesis might be that the age reporting is less reliable for cohorts born in Okinawa before 1945 than in Japan as a whole. The first hypothesis has been supported by several studies that demonstrated the positive impact of caloric restriction on the first group of cohorts (Willcox et al. 2006) and the negative effects of "westernization", which mainly applies to the younger generations (Kagawa 1978). More recently, Hokama and Binns (2008) attributed this contrast to lower birth weights among the post WW II cohorts.

Even if the first group of factors is acknowledged to have a significant impact on longevity for nutritional reasons, the possible lower quality of the data cannot be excluded because of the sizable impact of the crossover. This impact is more obvious in Tables 4 and 5 where, using data from life tables, the cumulated number of deaths up to age *x* (Table 4) and life expectancy at age *x* (Table 5) have been compared for Okinawa and Japan as a whole.[16] These data confirm the large differences between the two groups of generations. The Okinawa life tables show more deaths for both sexes of the generations born after 1940, and higher life expectancy for the generations born before that year. The magnitude of these differences for women is two times greater than it is for men.

[16] Age *x* has been moved from one life table to the next in order to contrast the two groups of cohorts, as mentioned above.

Figure 13: Mortality crossover between Okinawa and Japan in 2000



Sources: Japanese Ministry of Health, Labor and Welfare, Okinawa Prefecture and Human Mortality Database.

Table 3: Corresponding mortality rates for Okinawa and Japan (both sexes)

Age groups	1980	1985	1990	1995	2000	2005
0-4	1.010	1.131	1.196	1.111	1.218	0,932
5-9	0.900	0.922	1.073	0.798	0.920	1.170
10-14	1.200	0.836	1.198	0.895	0.767	1.120
15-19	1.497	1.349	1.179	1.233	1.096	0.840
20-24	1.274	1.316	1.196	1.009	1.133	1.008
25-29	1.344	1.283	1.425	1.132	1.232	1.087
30-34	1.297	1.247	1.356	1.255	1.224	1.288
35-39	1.076	1.116	1.209	1.246	1.345	1.275
40-44	0.929	1.008	1.215	1.187	1.386	1.226
45-49	0.945	0.841	1.033	1.180	1.243	1.385
50-54	0.891	0.818	0.909	1.044	1.039	1.185
55-59	0.932	0.903	0.890	0.937	1.032	1.061
60-64	0.838	0.911	0.882	0.879	0.940	1.059
65-69	0.811	0.806	0.852	0.891	0.959	0.993
70-74	0.743	0.769	0.785	0.866	0.908	0.914
75-79	0.742	0.719	0.785	0.796	0.902	0.873
80-84	0.750	0.710	0.757	0.775	0.819	0.852

Sources: Japanese Ministry of Health, Labor and Welfare and Okinawa prefecture.

Table 4: Ratio of deaths for Okinawa and Japan, cumulated up to age *x*, as per life tables

Year	Age *x*	Males Okinawa	Females Okinawa	Males Japan	Females Japan	Ratio males	Ratio females
1975	35	5196	3124	3925	2505	1.324	1.247
1980	40	4854	2508	3880	2341	1.251	1.071
1985	45	5128	2812	4372	2540	1.173	1.107
1990	50	6827	3292	5358	3034	1.274	1.085
1995	55	8603	4479	7434	4125	1.157	1.086
2000	60	12472	5558	10448	5238	1.194	1.061
2005	65	16343	7538	14336	6923	1.140	1.089
Average						1.216	1.107

Table 5: Ratio of life expectancy at age *x*, for Okinawa and Japan

Year	Age *x*	Males Okinawa	Females Okinawa	Males Japan	Females Japan	Ratio males	Ratio females
1975	35	40.23	46.04	39.04	43.52	1.0305	1.0579
1980	40	37.25	43.35	35.52	40.21	1.0487	1.0781
1985	45	34.04	40.45	31.98	36.95	1.0644	1.0947
1990	50	29.95	36.35	28.19	33.51	1.0624	1.0848
1995	55	25.84	32.33	24.42	29.60	1.0583	1.0922
2000	60	22.37	28.52	21.44	26.85	1.0434	1.0622
2005	65	18.34	24.40	18.13	23.19	1.0119	1.0522
Average						1.0460	1.0750

6. The reliability of demographic data for Okinawa

The key data source for age validation is the Koseki, in which the date of birth is originally recorded. However, a large majority of original Koseki was destroyed at the end of WW II. The particulars of the reconstruction of the Koseki in Okinawa after 1945 are therefore crucial to assessing the reliability of the current sources of age data.

6.1 Reconstruction of the Koseki after WW II

According to Nishihara (1977), almost all of the Okinawa Koseki were destroyed during WW II – original documents as well as copies. Maeda's more recent research (2004) found that only 5 of the 41 municipalities, constituting less than one tenth of the population of Okinawa, had intact original documents.[17] Six other municipalities had some original Koseki.

Nishihara (1975, 1977), a jurist and sociologist from Okinawa, undertook an in-depth analysis of the difficult circumstances under which the Okinawa Koseki were reconstructed during the American occupation, from 1945 to 1972. He concluded that the task was extremely difficult due to the lack of documents, original Koseki or other official documents, resource persons, and poor coordination between the U.S. and Japan. The reconstruction of the Koseki was undertaken by American authorities in Okinawa, and by their Japanese counterparts in the Prefecture of Kagoshima (south of

[17] The municipalities were Gushikawa Son, Izena, Nakazato, Tonaki, and Zamami.

mainland Japan), for all individuals born in Okinawa who were evacuated to mainland Japan during or after WW II.

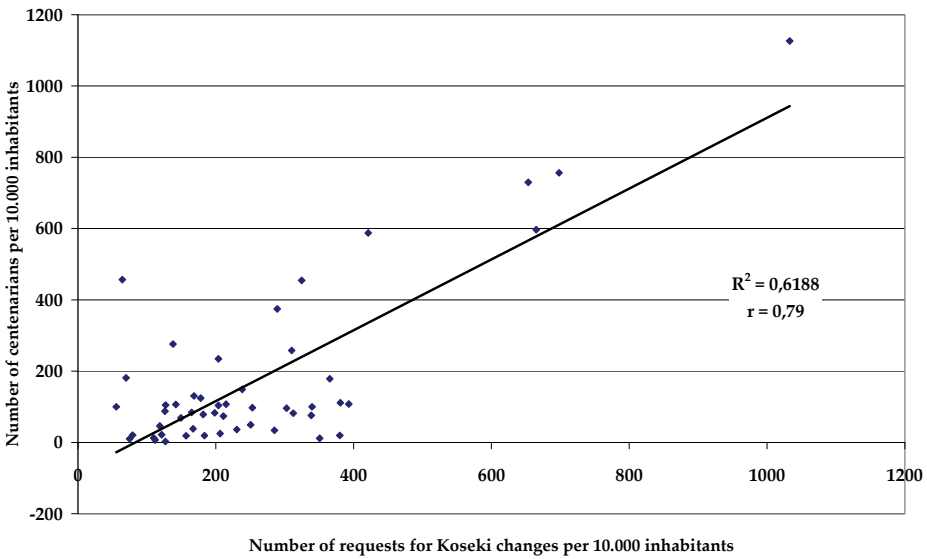
In the first few months following the end of WW II, no method of documentation existed to estimate the surviving population as support for re-establishing social order. In September 1946 the U.S. administration issued guidelines for establishing a temporary Koseki. The development of this Koseki began in early 1947 with a limited amount of information.[18] The principal aim of the temporary Koseki was to distribute food and manage migration (internal migration, emigration, and repatriation). Another important function was the organization of compulsory work for Okinawans assisting the U.S. administration. The reliability of the data from these temporary Koseki was rather poor, due to the circumstances under which they were collected. It is important to analyze these circumstances in order to assess the reliability of the data. The reconstruction was based on personal interviews with acquaintances or family members. Classmates were sometimes interviewed because the whole family had died in the war. Some discrepancies may also have resulted from the confusion and shock occasioned by the war. "It is evident that this state of shock affected the reliability of the reporting system, and although Okinawans considered age very sacred, there were genuine reasons for unwillingness to participate."[19] The extreme fatigue of the interviewees made them appear older than they were, the American interviewers probably encountered language barriers, and they also had difficulty interpreting birth dates based on the calendar in use during the Meira era, from 1868 to 1911. In March 1954 the Ryukyu government under U.S. administration finally passed a law instituting a provisional Koseki. The temporary Koseki continued to be used, with the result that errors remained even if further information was added. Consequently, numerous inconsistencies arose between the information in the provisional Koseki and the Koseki developed by the Japanese administration in the Prefecture of Kagoshima, for individuals born in Okinawa but who were living or had lived on mainland Japan. This duplication of the Okinawa Koseki persisted up to reunification in 1972. Many juridical actions have been initiated requesting changes in the registered information, even after reunification. The actions resulted in changes of surname, given name, filiations, birth date, etc. These types of juridical actions were 30 times more numerous in Okinawa as compared with the Japanese average. Their number varied at different times, but according to Nishihara (1975) certain peaks of activity may be linked to the adoption of particular laws.[20] The first such law concerned the welfare of the elderly, and it brought

[18] The temporary Koseki included the following information: head of the Koseki or head of household, marital status, address, and members of the household who had died or disappeared during the war.
[19] Personal communication of David ITOKAZU, Chairman of the Okinawa International Collaboration on Longevity, 2003.
[20] See more details at http://www.pref.okinawa.jp/syakaihosho/V.html.

substantial improvements for those aged 65 years and over. The second, enacted in 1969, instituted a welfare pension for all individuals born before 1899. The third, adopted in 1968 but only operationalized in 1970, granted a welfare pension and a national pension to all male workers above the age of 60 and to female workers above the age of 55 if they had worked more than 20 years. Nishihara reported that the relative number of changes requested during these years was higher for Okinawa compared with the national average, and he did not exclude the possibility of false declarations.

In order to assess the reliability of the local Koseki, we examined the number of legal actions for changes in the Koseki in the 1950s and 60s, as reported by Nishihara (1975, 1977). The number of requests for changes for each municipality was compared with the number of inhabitants, and then with longevity. To assess longevity we divided the total number of centenarians in each municipality born between 1863 and 1903 by the number of inhabitants enumerated in the 1990 census. As shown in Figure 14, the correlation between the number of legal actions and apparent longevity by village is significant ($R^2 = 0.62$).

Figure 14: Correlation between the number of requests for changes in the Koseki and the number of centenarians born between 1863 and 1903 (both figures are reported to the size of the population of each municipality)



Data source: Nishihara 1975.

6.2 Can demographic data afford misreporting of age?

In a situation where misreporting of age is plausible, it is worth checking whether the demographic data can support such a hypothesis. Four types of errors can be identified with regard to misreporting of age. The first is inadvertent and can be considered as randomly distributed around the actual age, following a Gaussian distribution. In the second type the reported ages are also randomly distributed, but exhibit an innate tendency toward overestimation. The third type of error is an intentional exaggeration of age in order to gain financial benefit; however, as discussed above, this situation is less common. The last situation could be caused by the fact that some reported ages might be exactly 12 years older, due to the twelve signs of the Japanese zodiac.

Preston, Elo, and Stewart (1999) demonstrated that misreporting of age always involves the underestimation of mortality rates at old ages, even if the reported ages are randomly distributed around the actual ages. Consequently, in the instance of any of the above-mentioned types of errors, life expectancy as well as the number of centenarians is overestimated.

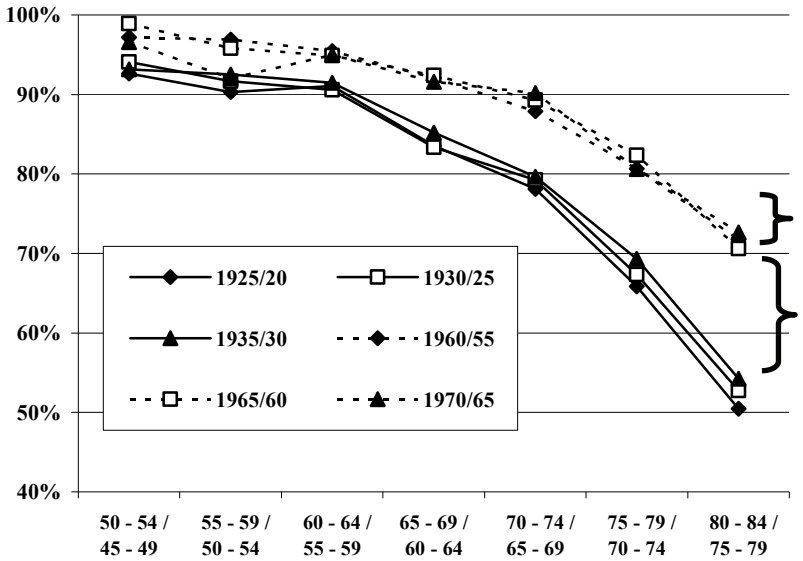
By comparing successive censuses we verified whether the evolution of the age and sex structure is compatible with the consequences of possible misreporting of age. We limited our analysis to females, as longevity in Okinawa is primarily a female phenomenon. We used the census data in Annex 2 to calculate the probability of survival from one five-year census to the next, assuming that emigration has not been considered for the population above 50 years of age, and that the probabilities reflect survival between the two censuses. Figure 13 includes all censuses between 1920 and 1970, except for those from 1940 to 1950, as these are more questionable and less comparable, according to Taueber (1955). The six curves are grouped into two sets: censuses before WW II (with a lower likelihood of age misreporting), and those after WW II (with a greater probability of age misreporting). This analysis clearly seems to support the incidence of age misreporting.

The second exercise consisted of comparing the two age structures before and after the misreporting is supposed to have occurred. The two most appropriate censuses would therefore be those of 1935 and 1955. However, those generations experienced considerable emigration and return migration, and significant war casualties. The rates of survival between 1935 and 1955 are therefore only partly due to normal mortality regimes. We therefore used only the post-WW II censuses. The method we followed examined the survival rates between 1955 and 1970. The 13,017 women in Okinawa aged 65-69 in 1970 were compared to the 15,773 aged 50-54 in 1955. If we apply the survival rate for Japan as a whole (0.8253), the survivors would number only 15,457, and we may therefore suppose that part – "p" – of this group was actually aged 45-49 and had experienced a higher survival rate (0.8830) than the average survival rate for

Japanese women. The following basic equation allows us to estimate that this "*p*" would be 30%, assuming that the mortality profile of Japan is applicable and that net migration was negligible.

$$(15,773 - p) \cdot 0.8253 + (p) \cdot 0.8830 = 13,107$$

Figure 15: Probability of survival for females in Okinawa between two successive censuses before and after WWII



Sources: Japanese Ministry of Health, Labor and Welfare, and Okinawa Prefecture.

A third exercise focused on women born at the beginning of the 20th century. Our intent was to estimate the impact of possible misreporting to explain the high number of females aged 100-104 in 2005 (574 according to the last census) and 105-109 in 2010 (91 according to the list of centenarians[21]). We assume that, due to misreporting, part of a given five-year age group was actually born in the following cohort. Therefore a proportion of women reported to be born in 1900-1904 were actually born in 1905-1909. In order to avoid the period of U.S. administration and to limit the possible

[21] Accessed at http://www3.pref.okinawa.jp/site/contents/attach/12406/H22roujin.pdf.

impact of migration, the starting date of this exercise is the 1975 census, and we assume that among women born in 1900-1904 aged 70-74 years, a proportion – "*p*" – was born in 1905-1909 and was actually 65-69 years of age. For example, let us suppose that this proportion is successively 10%, 20%, and 30% of the 12,125 women reported to be 70-74 years of age at the time of the 1975 Okinawa census. In Table 6 we use Japanese life tables to estimate the number of these women who will survive between each pair of censuses, up to 2005. The results show that the number of women who would be 100-104 years of age in 2005 in Okinawa would only be 246, had the population experienced the same mortality rates as Japan as a whole. If we assume that 10% of women declared to be aged 70-74 at the time of the 1975 census actually belonged to the cohorts born in 1905-1909, and apply the survival rates for the younger age group, 318 would be alive in 2005. If 20% misreporting is assumed, 389 of these women would be alive in 2005, and a 30% age misreporting assumption would yield a figure of 461, of whom only 173 are centenarians (37%).

Table 6: Estimating the effect of possible age misreporting: third exercise (see preceding text)

Newborn cohorts	1975	1980	1985	1990	1995	2000	2005	2010
	Japan survival rates							
1900-1904	81.7%	73.1%	61.3%	53.7%	45.7%	22.6%	10.4%	
1905-1909	89.8%	84.7%	77.0%	65.1%	53.6%	38.9%	23.9%	
	Number of those surviving, assuming no age misreporting							
1900-1904	12125	9910	7248	4445	2387	1090	246	26
	Number of those surviving, assuming 10% misreporting as of the newborn cohorts							
1900-1904	10192	8919	6523	4001	2149	980	222	23
1905-1909	1213	1088	922	710	462	248	96	23
Total	12125	10007	7445	4711	2611	1228	318	46
	Number of those surviving, assuming 20% misreporting as of the newborn cohorts							
1900-1904	9699	7928	5798	3556	1910	871	197	20
1905-1909	2426	2176	1844	1420	924	496	192	46
Total	12125	10104	7462	4976	2834	1367	389	66
	Number of those surviving, assuming 30% misreporting as of the newborn cohorts							
1900-1904	8486	6937	5073	3112	1671	762	173	18
1905-1909	3639	3264	2766	2310	1386	744	288	69
Total	12125	10201	7839	5242	3057	1506	461	87

7. Discussion

A classical individual validation of the age of alleged centenarians is not sufficient to validate the exceptional longevity of the population of Okinawa. Validating population longevity requires several types of demographic analysis, as well as verification of the accuracy of the demographic data.

Saito (2010) has confirmed that individual age validation of the oldest olds in Japan is quite difficult because of limited access to original data sources. Certificates of residence (Juminahyo) may be obtained quite easily, but these are secondary sources that do not provide enough information for age validation purposes, and, furthermore, such data can be discarded five years after death. The Koseki tohon contains more information, but the authorization of the family is required to access this data. Only copies of the original Koseki in which the birth of the person was initially recorded can be obtained. However, a full reconstruction of the family cannot be achieved on the basis of that document. The situation in Okinawa is even more problematic, as almost all the original Koseki have disappeared, and the existing Koseki were reconstructed after WW II under very difficult conditions.

Nevertheless, we have attempted to validate the individual longevity of 25 of the oldest olds alive at the time of the study (January 2004). We succeeded in obtaining copies of all of their Koseki tohon. Unfortunately conclusive validation was not possible because these copies did not include all the pertinent information: there were no data on children who had already left the household, or on parents or siblings of the alleged centenarians. A complete individual validation would require copies of Koseki not only for the centenarian but also for his or her parents, siblings, and children. We were also only able to obtain information on the last marriage, which means that age at marriage may be biased. For the 7 males and 11 females ever married, we calculated an average age at marriage of 31 years for men and 26 for women; the corresponding average ages for Japan during that period were 29 and 24 respectively. Moreover, we were able to find only 15 children of the 18 married centenarians. The main conclusion from this limited study is that the conditions for developing a complete individual age validation are difficult to meet in Okinawa. In addition, any future attempts at individual age validation would have to include a larger representative sample of centenarians in order to reach significant conclusions. As explained elsewhere (Poulain 2010), checking birth records or linking death and birth records cannot be sufficient to ensure individual age validation beyond doubt. The family history should also be verified. In the case of Okinawa, if age misreporting occurred when the Koseki were reconstructed in the 1950s, checking the compatibility of the Koseki with the reported age or age at death is not sufficient: the original birth record would be required. In the absence of such records, alternative methods of age validation must be developed.

We compared the longevity of the population of Okinawa with one of the other Japanese prefectures and the best examples of longevity from European and North American countries. The use of centenarian prevalence (the number of centenarians relative to the population) should be avoided, as it is not a valid index for comparing longevity between different populations. By presenting life expectancies at 65 and 80 years of age, based on official life tables, we demonstrate that Okinawa is in the lead, followed at a considerable distance by all the other Japanese prefectures and selected countries. According to the life tables longevity in Okinawa definitely appears to be exceptional, and validation of the longevity of the population is required.

The demographic analysis conducted to validate the exceptional longevity of the population of Okinawa exhibits a mortality crossover when comparing Okinawa and Japan. According to Coale and Kisker (1986) this crossover could result from a selection effect or bad data. We think that both could apply to the findings for Okinawa. The differences in behavior and nutrition between the two groups of generations in Okinawa and Japan have been established (Kagawa 1978), and caloric restriction only affected those born before WW II (Willcox et al. 2006). Nevertheless, the impact of nutrition would have to be enormous to justify the survival rates, and such a hypothesis would have difficulty explaining the considerable difference between males and females. Therefore, the "bad data" hypothesis has to be thoroughly investigated.

The circumstances in which the Koseki in Okinawa was reconstructed after WW II, up to the reunification with Japan in 1972, support the hypothesis that the age of a significant number of persons born before 1945 could have been misreported. We believe that, although there were reasons for overstating age, most of the errors were probably inadvertent. Longevity can be compared between areas where the Koseki were reconstructed and others where they remained intact, but the differences are not statistically significant. In order to assess the possible effect of the reconstruction of the Koseki on reported longevity, we preferred to consider the number of legal actions initiated in the 1950s and 60s for changes in the Koseki, as reported by Nishihara (1975, 1977). As shown by his research, the correlation between the number of legal actions and longevity by village is significant. This conclusion contradicts that proposed by Willcox et al. (2008) and confirms the necessity of considering the bad data hypothesis.

Despite the arguments presented above there are some demographic features that could indirectly support exceptional longevity in Okinawa. The strongest argument is the absence of centenarians at extreme ages (above 115 and 120), as this would be compelling evidence of age exaggeration. Other demographic characteristics such as the increase in the number of centenarians over time, some internal age structural indicators (110+/105+ and 105+/100+), and the possibility of age heaping, have also been investigated. The range of figures is within the realm of reasonable values and supports

the validity of the longevity of the population. However, such arguments are necessary but not sufficient for validating population longevity, as random misreporting and overstating of age may easily meet all these requirements. For example, the observation that the maximum reported age at death is 112 for both men and women is not sufficient to validate longevity. We must bear in mind that local authorities usually scrutinize more closely the data for the oldest olds, and any error discovered would therefore be immediately corrected. The high female/male sex ratio among the oldest olds also cannot be regarded as validating longevity in Okinawa, because it has been proven that, for regions of Italy, higher longevity is associated with a lower ratio (Robine et al. 2006).

The two simple theoretical exercises we have proposed in this article lend credence to the assumption that misreporting, e.g. overstating of the age of some individuals born before WW II, has influenced the age and sex structure of the population of Okinawa. These results do not prove the existence of bad data, but point to the need for in-depth validation.

In conclusion, we think that the evidence that has so far been presented is necessary but not sufficient to validate the longevity of the population. We advance some arguments in this paper showing that there were opportunities for age misreporting and exaggeration immediately following WW II when the Koseki was reconstructed. Recent figures on the number of centenarians in Okinawa did not increase in 2010, and that prefecture lost its top ranking for female life expectancy in Japan. This could support our hypothesis. Nevertheless, we must admit that we did not find proof that the age of any centenarian had been exaggerated. We believe that the apparent longevity of the population of Okinawa is so remarkable that it should continue to be regarded as an example of exceptional population longevity. Despite the difficulties of gaining access to individual data, we recommend that an in-depth individual validation be conducted, which will require the development of innovative methods. Our research did not cast doubt on the findings of longevity determinants in Okinawa. However, in-depth validation would give them greater credibility. In closing, we would like to quote Coale and Li (1991) on age validation in China: "The major lesson to be learned from this research is that data on ages listed in censuses, surveys, or registers of a population must be scrutinized critically, even when there are reasons to suppose that the data are accurate. Accuracy of most of the data does not mean that all of the data are accurate; as William Brass said, all data are guilty until proven innocent."

8. Acknowledgments

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Annexes

Annex 1: Evolution of the number of centenarians by sex in Okinawa and Japan 1963-2010

YEAR	OKINAWA M	OKINAWA F	JAPAN M	JAPAN F	Okinawa prevalence	Japan prevalence	Sex ratio F/M Okinawa	Sex ratio F/M Japan
1963			20	133	-	0.1591		6.65
1964			31	160	-	0.1965		5.16
1965			36	162	-	0.2015		4.50
1966	0	10	46	206	1.06	0.2544		4.48
1967	0	8	52	201	0.84	0.2539		3.87
1968	1	12	67	260	1.36	0.3244	12.00	3.88
1969	3	13	70	261	1.68	0.3244	4.33	3.73
1970	2	7	62	248	0.95	0.3006	3.50	4.00
1971	3	6	70	269	0.96	0.3249	2.00	3.84
1972	5	9	78	327	1.46	0.3830	1.80	4.19
1973	5	23	91	404	2.82	0.4580	4.60	4.44
1974	8	18	96	431	2.55	0.4817	2.25	4.49
1975	5	23	102	446	2.68	0.4926	4.60	4.37
1976	5	22	113	553	2.55	0.5924	4.40	4.89
1977	2	29	122	575	2.89	0.6141	14.5	4.71
1978	5	19	132	660	2.22	0.6916	3.80	5.00
1979	8	23	180	757	2.83	0.8115	2.88	4.21
1980	6	30	174	794	3.25	0.8322	5.00	4.56
1981	8	32	202	870	3.58	0.9146	4.00	4.31
1982	10	34	233	967	3.89	1.0169	3.40	4.15
1983	12	46	269	1085	5.06	1.1399	3.83	4.03
1984	11	57	347	1216	5.85	1.3077	5.18	3.50
1985	11	65	359	1381	6.45	1.4468	5.91	3.85
1986	22	68	361	1490	7.55	1.5304	3.09	4.13
1987	19	78	462	1809	8.07	1.8686	4.11	3.92
1988	18	100	562	2106	9.75	2.1864	5.56	3.75
1989	21	126	630	2448	12.07	2.5135	6.00	3.89
1990	19	139	680	2618	12.93	2.6874	7.32	3.85
1991	25	147	749	2876	13.99	2.9447	5.88	3.84
1992	30	163	822	3330	15.58	3.3626	5.43	4.05
1993	34	172	943	3859	16.49	3.8792	5.06	4.09
1994	40	191	1093	4500	18.31	4.5080	4.78	4.12
1995	47	216	1255	5123	20.66	5.1312	4.60	4.08
1996	50	232	1400	5973	21.98	5.9122	4.64	4.27
1997	54	261	1570	6921	24.40	6.7948	4.83	4.41
1998	66	297	1812	8346	27.90	8.1101	4.50	4.61
1999	61	304	1973	9373	27.82	9.0455	4.98	4.75
2000	57	344	2158	10878	30.42	10.3779	6.04	5.04
2001	55	402	2541	12934	34.42	12.2907	7.31	5.09
2002	58	467	2875	15059	39.24	14.2324	8.05	5.24
2003	64	505	3159	17402	42.18	16.1112	7.89	5.51
2004	77	558	3523	19515	46.79	18.0426	7.25	5.54
2005	84	615	3760	21593	51.14	19.8430	7.32	5.74
2006	74	666	4150	24245	54.09	22.2217	9.00	5.84
2007	75	717	4613	27682	57.68	25.2757	9.56	6.00
2008	94	744	5076	31200	60.90	28.4090	7.91	6.15
2009	107	821	5447	34952	66.97	25.2757	9.56	6.00
2010	113	809	5869	38580	66.84	28.4090	7.91	6.15

Annex 2a: Age and sex structure of the population of Okinawa 1890-2005, females

	1890	1895	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945
Females												
0 - 4	23192	27586	23996	24948	33393	30886	40450	40518	41965	42352	40234	
5 - 9	21965	23233	26464	23140	28412	31711	34401	36440	37641	38997	38791	
10 - 14	21276	22114	22887	25549	24972	28015	32307	31008	33991	35116	35723	
15 - 19	21366	21419	22048	22687	25115	24929	28429	21654	25105	24894	22075	
20 - 24	19436	20985	20928	21816	22764	26154	23144	20965	21902	21312	19061	
25 - 29	16064	19087	20720	20781	21466	22784	21793	19461	20175	19871	17862	
30 - 34	14327	15317	18487	19299	20074	21107	18566	18553	17875	19032	17674	
35 - 39	12004	13714	14523	17299	18007	19270	17304	16806	15755	16949	17638	
40 - 44	10861	11215	12987	13733	16353	17274	15981	15766	15775	16610	15784	
45 - 49	11266	10319	10622	12088	13083	15651	15112	14812	14933	14865	15624	
50 - 54	7847	10518	9627	9728	11279	12142	13818	14002	13934	13915	13974	
55 - 59	6556	7188	9457	8623	8827	10061	10578	12477	12836	12892	12723	
60 - 64	6577	5923	6248	8359	7697	7820	8788	9634	11304	11744	11683	
65 - 69	4603	5409	4766	5224	6588	6166	6335	7343	8030	9633	9890	
70 - 74	3761	3474	3862	3564	3928	4844	4719	4950	5819	6395	7683	
75 - 79	1982	2447	2093	2349	2445	2488	3323	3108	3333	4033	4346	
80 - 84	980	1025	1138	1123	1430	1362	1238	1676	1639	1808	3088	
85 - 89	365	329	358	475	517	660	388	428	591	610		
90 - 94	54	82	56	89	182	191	58	81	99	155		
95 - 99	4	5	11	16	41	67	10	6	10	14		
>= 100				1	8	29	1	1		1		
Unreported											3	
Total	204486	221389	231278	240891	266581	283611	296743	289689	302712	311198	303856	

Annex 2a: (Continued)

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005
Females												
0 - 4	56170	65675	59209	52933	50146	54896	50945	49249	45266	41805	40151	39824
5 - 9	38038	55467	66259	59645	53141	51719	56368	51945	49602	46128	42569	41247
10 - 14	42332	37797	55220	65941	59207	53661	51867	56417	51592	49417	46128	42683
15 - 19	39398	41797	35044	47094	52075	50031	46496	47392	52162	48915	46741	44005
20 - 24	32826	37425	37702	31158	35424	44240	39828	39984	40334	48171	43000	42191
25 - 29	26518	31409	35654	36865	30550	40127	48360	45405	42231	43861	49817	46852
30 - 34	22593	25775	30746	33872	35217	32295	41519	50233	45747	43938	45117	52381
35 - 39	19974	22532	25443	29495	32826	36167	32505	41586	49813	46211	44249	46274
40 - 44	17707	19497	22041	24643	28626	33005	35863	32100	40829	49358	45808	44506
45 - 49	15915	17233	19099	21375	23944	28732	32871	35556	31457	40555	48646	45934
50 - 54	13414	15457	16751	18889	20647	23358	28504	32439	35027	31407	39674	48558
55 - 59	12224	12791	14980	16051	17387	19989	23190	28041	31914	34918	30745	39911
60 - 64	10373	11773	12208	14212	15241	17255	19807	22835	27477	31615	34463	30753
65 - 69	8001	9236	10839	11281	13017	14670	16707	19183	22185	27002	30795	33918
70 - 74	5870	7014	8117	9679	10175	12125	13878	15846	18242	21457	25929	29786
75 - 79	3684	4578	5658	6683	7804	8602	10801	12636	14668	16987	19772	24342
80 - 84	2390	2515	3283	3994	4855	5982	7006	9039	10747	12761	14856	17725
85 - 89		933		1886	2386	3055	4019	4988	6745	8298	9909	12127
90 - 94		-	1953	621	831	1121	1537	2244	2951	4098	5337	6663
95 - 99		-		135	219	200	298	513	811	1221	1889	2603
>= 100		-		4	18	28	32	65	145	215	318	631
Unreported		24	73	27	0	560	466	299	3784	365	4430	178
Total	367427	418928	460279	486483	493736	531818	562867	597995	623729	648703	670343	693092

Sources: Japanese Statistics bureau, Japanese Ministry of Health, Labor and Welfare and Okinawa prefecture.

Annex 2b: Age and sex structure of the population of Okinawa 1890-2005, males

	1890	1895	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945
Males												
0 - 4	23563	27688	25059	21013	34022	32465	40032	40238	42492	42314	41474	
5 - 9	22459	23507	26738	24628	29764	31948	34572	36461	38319	40189	39467	
10 - 14	22084	22597	23303	25824	25752	29469	32130	33052	34708	36567	38154	
15 - 19	21750	22021	22268	22761	25685	25809	28209	26165	26672	28149	22691	
20 - 24	20086	21581	21588	21886	22675	25825	20553	18766	17899	18434	17436	
25 - 29	16668	19604	21169	21160	21709	22492	20758	15799	15564	16161	14204	
30 - 34	13778	16013	18793	20104	20642	20679	16314	16063	14098	14895	13120	
35 - 39	11953	14009	14974	17784	18552	19460	16179	13685	14627	13569	13281	
40 - 44	10990	11203	12935	14225	16142	17892	15296	14010	12554	13843	12536	
45 - 49	10949	10106	10358	11862	13015	15223	14409	13644	13030	11792	12869	
50 - 54	7308	9732	9031	9137	10847	11737	12448	12669	12461	12007	10871	
55 - 59	5795	5498	8176	7680	7817	9327	8851	10601	10990	10994	10604	
60 - 64	5141	4702	4969	6367	6394	6210	6543	7243	8768	9351	9227	
65 - 69	3206	3660	3358	3722	4779	4686	4031	4839	5289	6731	7129	
70 - 74	2300	1996	2279	2237	2677	3043	2581	2573	3177	3609	4628	
75 - 79	989	1235	1006	1273	1342	1463	1384	1431	1413	1814	2000	
80 - 84	422	436	496	485	617	580	411	552	570	633	942	
85 - 89	122	131	122	199	210	245	111	118	142	187		
90 - 94	11	21	15	27	60	72	13	21	22	26		
95 - 99	1	-	1	4	8	17	4	3	2	1		
>= 100				-	1	4	0	0		-		
Unreported											1	
Total	199575	215740	226638	232378	262710	278646	274829	267933	272797	281266	270634	

Annex 2b: (Continued)

	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005
Males												
0 - 4	58575	68096	61186	55191	51599	57413	53301	51631	47619	44026	42443	41975
5 - 9	39749	57956	68247	61183	54948	53581	59125	54576	52037	48535	44631	43530
10 - 14	43557	39756	57432	68155	60281	55268	53787	58705	53720	51391	48357	44944
15 - 19	38705	41759	36091	49014	51371	51735	48144	48970	53200	50697	48771	46038
20 - 24	27767	35286	34830	27672	31894	46299	40597	39763	38271	48122	43467	41843
25 - 29	19787	27342	34510	34533	28532	42975	51440	46584	40955	42127	48895	46053
30 - 34	16917	19915	27142	33715	34089	32791	44593	54600	46480	43646	43743	51493
35 - 39	15461	17031	19662	25963	33104	36850	33322	45424	52829	47497	44259	45398
40 - 44	13717	15679	16776	18976	25054	34794	36665	33357	43767	52813	47132	44799
45 - 49	12145	13587	15155	16146	18137	25907	33855	36068	31887	43353	51829	47122
50 - 54	10727	11832	13063	14584	15292	18051	25053	32920	34442	31254	42325	51718
55 - 59	9854	10057	11189	12074	13080	14869	17375	24265	31505	33755	30335	41993
60 - 64	7427	9190	9183	9957	10996	12645	14187	16597	22960	30539	32810	30224
65 - 69	5291	6344	8049	7874	8690	10010	11533	13115	15406	21641	28707	31460
70 - 74	3590	4303	5106	6378	6435	7346	8725	10224	11735	13927	19604	26264
75 - 79	1865	2414	3061	3540	4471	4917	5760	7146	8548	9856	11889	16821
80 - 84	831	1049	1455	1804	2176	2938	3337	4099	5264	6378	7465	9078
85 - 89		285		710	901	1111	1666	1959	2502	3273	4056	4821
90 - 94		-	650	171	272	369	438	742	897	1133	1613	2060
95 - 99		-		28	68	56	75	138	219	273	365	509
>= 100		-		1	3	9	7	10	17	47	53	89
Unreported		19	56	24	0	820	707	209	4409	454	5128	270
Total	325965	381900	422843	447693	451393	510754	543692	581102	598669	624737	647877	668502