Chapter 5
Age Reporting in the CLHLS: A Re-assessment

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Abstract Age reporting among respondents in the Chinese Longitudinal Healthy Longevity Survey is examined, using the first round of data collected in 1998. The sample design limits the use of traditional methods for assessing the accuracy of age reporting, and innovative methods are adopted. Only the sample aged 100+ is representative of the population at that age. The age structure of centenarians is compared with populations with good age reporting, demonstrating age exaggeration. At ages 80+, constructed estimates of age at childbearing show systematic effects consistent with age exaggeration, particularly in Guangxi and among ethnic minorities. Increasing age exaggeration with age is present in these data, which is at least partly the result of the age structure. These findings have implications for substantive analyses, and further examination of the quality of these data is needed.

Keywords Age exaggeration, Age heaping, Age misreporting, Age reporting, Age validation, Centenarian, China, Cluster sample, Data quality, Digit preference, England and Wales, Ethnic minorities, Guangxi, Han majority, Inaccuracy, Japan, Jiangsu, Large sample size, Longevity, Mean age at childbearing, Myers' Index, Non-response, Oldest-old, One Per Thousand Fertility Survey, Proportion of centenarians, Re-assessment, Regional variation, Sample design, Shanghai, Sweden, Whipple's Index, Yao, Zhuang

5.1 Introduction

The accuracy of age reporting is an important consideration for any demographic analysis, mainly because the existence of age misreporting often produces distorted results. Inaccuracies in age reporting are potentially a significant problem for studies of ageing and longevity on two counts. First, experience in many populations has

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shown that older people tend to misreport or exaggerate their age; and while the most serious problems occur in populations where literacy is low, more educated populations are not entirely free from such errors (Coale and Kisker 1986; Jeune 1995; Rosenwaike and Stone 2003). Second, the effect of misreporting at very old ages is often magnified by the shape of the age distribution.

The quality of age reporting among the majority Han population of China is generally good and is believed to be on a par with age reporting in many developed countries (Coale and Li 1991; Gu and Zeng 2004). This has been attributed to cultural factors (Wang et al. 1998). Among some ethnic minorities in China, however, age reporting at older ages has been found to be of poor quality largely because of age exaggeration (Coale and Li 1991). It is for this reason that nine provinces with sizeable minority populations were excluded from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) (see Chap. 2 in this volume). The survey population is thus mostly of Han ethnicity, but 7 percent belong to minority ethnicities. This fact alone leaves open the possibility of some degree of age misreporting in the CLHLS data, and it is important to examine the quality of age reporting in the whole dataset.

The CLHLS is a rich source of data with a sufficiently large sample size to provide the statistical power necessary to undertake detailed analyses. The data have already been used to address many research questions regarding ageing and longevity, and the papers of this volume further augment this body of research. For such analyses, the quality of age reporting is of the utmost importance. Most forms of age misreporting, and in particular age exaggeration, will tend to lead to an older age distribution and the overestimation of longevity.

The purpose of this chapter is to undertake an objective examination of the quality of age reporting in the CLHLS. We first examine the evidence previously presented by others, and then re-assess the data more comprehensively using innovative methods and addressing reporting inaccuracies that have not previously been considered. We undertake this re-assessment in the spirit of Coale and Li (1991: 300) who stressed that all data "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 proved innocent."

5.2 The CLHLS Data

Details of the CLHLS study design may be found in Chap. 2 of this volume. Only the 1998 (first wave) data are used for this study of the quality of age reporting.

5.2.1 Sample Design

The sample design is a cluster sample. For the first wave, approximately 50 percent of all counties and cities in 22 provinces were randomly selected. Among these selected clusters, 631 had centenarians, all of whom were included. For sampling purposes, the ages of the centenarians were obtained from the local ageing committees. These ages may have included some inaccuracies, particularly if based on the nominal age[1] of the person, and ages (in fact, dates of birth) were validated during the interview. Age validation resulted in a loss of 409 so-called centenarians to younger age groups, and the final number of validated centenarian respondents in the sample was 2,418.

For each centenarian, purposive sampling was used to randomly select one octogenarian and one nonagenarian from the population living nearby in such a way as to achieve approximately equal numbers of males and females at each single year of age. Thus weights are necessary in all analyses involving octogenarians and nonagenarians; these take account of (validated) age, sex and rural–urban residence (Zeng et al. 2001). After age validation, there were 3,528 octogenarian and 3,013 nonagenarian respondents in the survey.

Not all originally sampled individuals were interviewed. The 9,093 respondents[2] in 1998 represent a response rate of 88 percent. Non-responses were due to unavailability (too ill, deceased, or migrated) or refusal to participate. If those unavailable for interview are excluded, the response rate is 98 percent.

5.2.2 Reporting of Age

For all questions, every effort was taken to ensure the accuracy of responses: interviewers were extensively trained, and all training was standardized nationally. Detailed error checks and quality control mechanisms were incorporated into the interview procedure (Research Group of Healthy Longevity in China (RGHLC) 2000: 1–25; Xu 2001; Gu and Zeng 2004). In particular, respondent's age was subject to careful validation. The survey did not ask for age directly, but based this variable on date of birth. All reported dates of birth of respondents were validated by interviewers by reference to their household booklet and ID card,[3] Chinese calendar birth date and animal year, genealogical records if available, children's ages, siblings' ages, and so on (see Zeng and Gu, Chap. 4 of this volume for more detail).

5.2.3 Limitations for the Examination of Age Reporting

Conventional methods for the examination of the accuracy of age reporting rely heavily on the demographic stability of the true age distribution, often for the entire

[1] The nominal age is counted as exactly 1 year old at birth, increasing by 1 year each Chinese New Year Day. It is therefore up to 2 years greater than chronological age counted from zero at birth.

[2] This includes 134 sampled respondents whose validated age was <80.

[3] Household registration and ID cards were introduced between 1950 and 1990 and are largely based on self-reported age; they might thus be subject to age misreporting.

age range. The use of such methods for CLHLS data is severely limited by the fact that the age and sex distribution of the sample population is to a significant degree an artifact of the sample design. Only the sample population aged 100+ is proportionally representative by age of the Chinese population, that is, of the demographic processes shaping its structure. Thus, use of the age structure to examine age reporting is necessarily restricted to centenarians. Further, the examination is limited by the relatively small numbers at this age (481 males and 1,937 females) and by the restricted availability of valid and reliable distributions for comparison.

The sample design also compromises the applicability of digit preference detection methods including those by Coale and Li (1991) and Wang et al. (1998). The purposive selection of 80- to 99-year-old respondents was related to age because equal numbers of male and female octogenarians and nonagenarians at each single year of age were sought. Thus, neither randomness nor representativeness can be assumed at these ages, violating the basis of digit preference measures. It is also important to note that methods for the measurement of digit preference are unable to detect systematic reporting errors such as age exaggeration, which is the most likely and potentially the most serious source of error for studies of longevity.

Other sampling and related issues must also be taken into account when assessing data accuracy because of possible age-related bias. This is particularly important for centenarians because of the very high mortality rates at these ages. Non-responses may have introduced a bias toward a slightly younger age distribution,[4] equivalent to age under-reporting; however, this effect would enhance rather than detract from the findings reported here.

5.3 Previous Assessment of Accuracy of CLHLS Respondent's Age

The 1998 CLHLS data have previously been examined in relation to the accuracy of the reporting of respondent's age and judged to be "generally reliable" (RGHLC 2000: 6–17; Zeng et al. 2001). The main focus of this examination was a sex-specific comparison of the age distribution of CLHLS centenarians with Swedish centenarians in 1984–1993 (see Fig. 5.1). The differences observed were not considered sufficiently large to bring into question the quality of age reporting among younger centenarians (aged 100–105). However, it was concluded that at ages 106+, the quality of age reporting is questionable (RGHLC 2000: 6–17). Persons aged 106+ have been excluded from most existing analyses: they number 154 (1.7 percent of those aged 80+) comprising 131 females (2.4 percent) and 23 males (0.6 percent).

[4] This would occur if unavailability for interview increased with age, which seems likely for unavailability due to ill health and migration out of the study area to a relative's residence or an institution.

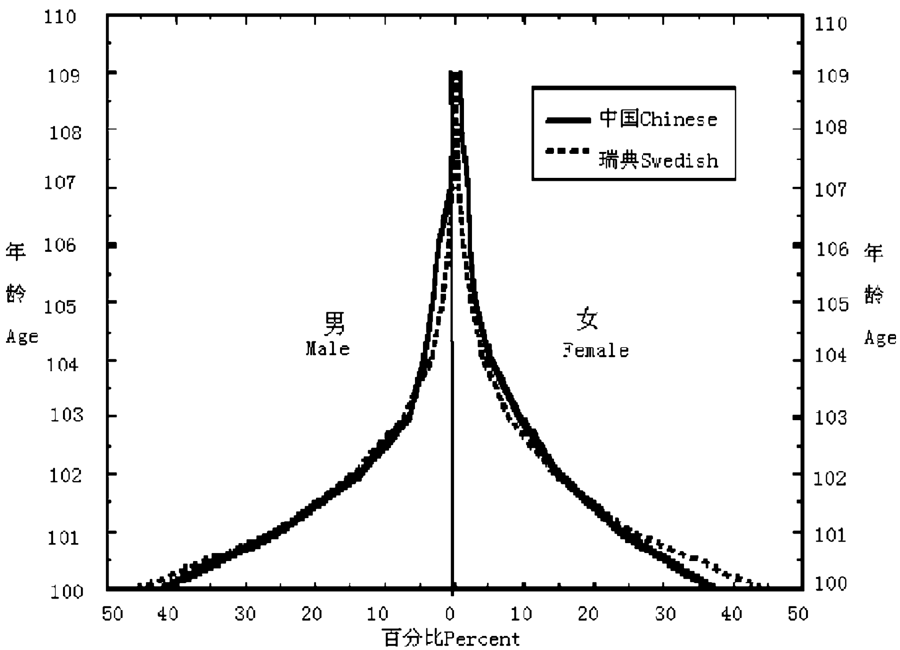

Fig. 5.1 Age distribution of centenarians, 1999 CLHLS and Sweden 1984–1993 (Reproduced with kind permission)

The choice of Sweden as a comparison population is well justified by its accuracy of age reporting, believed to be the best in the world. For centenarians, very high mortality rates dominate the shape of the age distribution, and cohort size effects are relatively small.[5] It would be expected that Chinese mortality rates would be no lower than the Swedish rates, and therefore that CLHLS centenarians would exhibit an age distribution as young as or younger than their Swedish counterparts. However, this is contra-indicated by the smaller CLHLS percentages aged 100 in Fig. 5.1, and the corresponding larger percentages aged 101+. Age misreporting in the CLHLS data is a probable explanation, and further examination is needed.

Other evidence, presented by Gu and Zeng (2004), in support of the reliability of age reporting in the CLHLS, consists of the similarity of the mortality pattern for Sweden in 1999 to the patterns derived from deaths among CLHLS respondents in 1998–2000 and 2000–2002. In fact, careful comparison of these data shows that mortality levels in the two populations are similar at ages less than 90, but at 90+ mortality is substantially higher in the CLHLS. This implies that the age distribution of centenarians will be younger for the CLHLS than for Sweden, which is again contrary to the smaller CLHLS percentages aged 100 in Fig. 5.1. Again, further examination is needed.

[5] These effects can be expected to be stable by age, and therefore not significantly influence the centenarian age distribution. In the 1890s (when these respondents were born) fertility rates were fairly stable and the age distribution of reproductive women was not subject to significant variation.

Additional supporting evidence cited by Zeng et al. (2001) and Gu and Zeng (2004) is the fact that age reporting in China's 1982 and 1990 Censuses was found to be reliable on the basis of Whipple's and Myers' indices of digit preference. However, these indices are based on all or most ages, so that accurate reporting at young ages would mask any misreporting at the oldest ages; hence no conclusions can be drawn from these indices about the oldest ages. Further, these indices measure digit preference, and do not address systematic biases such as age exaggeration or digit-neutral age misreporting.

An examination of age reporting in the 1982 Census by Coale and Li (1991) has been cited (Wang et al. 1998; Gu and Zeng 2004) as evidence of good age reporting in China with the exception of Xinjiang province[6]. However, the Coale and Li study concentrates on male mortality patterns at ages less than 100, and is thus unable to illuminate the evaluation of age reporting among centenarians or among females. Further, its reliance on the comparison of mortality patterns may not provide entirely solid evidence; this is due to the facts that age exaggeration produces underestimated mortality rates, and that an association between age exaggeration and relatively high mortality is likely to hinder the detection of age exaggeration. Similarly, if a proportion of the population reports their nominal age, the mortality curve will show no irregularity.

None of the above previously cited evidence is sufficiently convincing to establish without qualification the good quality of age reporting in the CLHLS. Indeed, some of the evidence would appear to indicate the presence of age misreporting, rather than its absence. The accuracy of age reporting thus remains open to question. It is therefore important to undertake further assessment of age reporting in the CLHLS.

5.4 A Re-assessment

This re-assessment of the accuracy of respondent's age in the CLHLS data adopts two approaches. The first focuses on centenarians, comparing the CLHLS with selected comparable populations. The second examines age reporting for the whole sample using unconventional methods that make use of age differences between respondents and their children. For both approaches, regional variation is also examined.

5.4.1 Age Reporting Among Centenarians

This examination of the accuracy of age reporting among reported centenarians involves a comparison with three populations: Sweden 1943–1952, England and Wales 1950–1955, and Japan 1962–1966. These countries were selected because

[6] Inaccurate age reporting among the Wei (or Weiwuer or Uyghur) ethnic minority was found responsible; the evidence included digit preference at ages 40–80 and age exaggeration at 110+. No evidence was provided to show that other provinces or ethnic minorities do not also exhibit age reporting inaccuracies.

of their known accuracy of age reporting (Kannisto 1994), and the specific periods were chosen to match on average China's 1998 life expectancy at birth of about 70 years and to provide sufficient numbers to reduce random fluctuation to an acceptable level. These populations span the age structure of the 22 provinces of China covered in the CLHLS, referred to here as China-22, as reported in the 2000 census. For China-22, the proportion aged 65+ is 7 percent; this is compared with 10, 11 and 6 percent for Sweden, England and Wales and Japan respectively. The proportion aged 90+ in China-22 is 8 per 10,000, compared with 11, 10 and 4 per 10,000 for Sweden, England and Wales and Japan respectively. The study population, that is the 22 provinces of China, is thus within the comparable population range.

The first question considered is: how many centenarians do we expect to find in a population? The exact number depends on both longevity and the overall population structure, but broadly similar numbers of centenarians per million are expected in populations with similar life expectancies at birth and similar structures. Given similar life expectancies and the above proportions aged 65+ and 90+ in the selected populations, it would be expected that China-22 in 2000 would have fewer centenarians per million than Sweden and England and Wales, but more than Japan in the selected years. Table 5.1, which shows the number of centenarians per million in these four populations, suggests that China-22 has relatively more centenarians than all three comparison populations: twice as many as Sweden and England and Wales, and seven times as many as Japan. Similarly, differentials of between 2 and 7 are found for the centenarian proportions among those aged 90+ and 65+ (Table 5.1). A likely explanation for such large centenarian proportions is age exaggeration, including reporting based on nominal age, among the very old in the Chinese census. The magnitude of these proportions is such that age exaggeration in the census must exist not only among the ethnic minority populations but also among the Han majority, as the size of the ethnic minority populations is too small to produce the differentials found.

Table 5.1 also shows centenarian proportions estimated from the 1998 CLHLS by using the 2000 Census to provide population data.[7] The much lower CLHLS

Table 5.1 Centenarians in the 1998 CLHLS and selected comparable populations

Population	Period	Centenarians per million population	Centenarians per million aged 90+	Centenarians per million aged 65+
Sweden	1943–1952	7	5,975	66
England & Wales	1950–1955	7	6,914	62
Japan	1962–1966	2	4,427	28
China (22 provinces)	2000	13.5	16,441	184
CLHLS	1998	4.5	5,475	62

Selected comparable populations cover periods when life expectancy averaged 70 years. CLHLS proportions are based on population data from the 2000 Census and assume that the selected clusters include half of the population of their respective provinces

[7] These estimates are based on the assumption that the selected clusters cover half of the population of their respective provinces.

proportions than in the 2000 Census for China-22 can be attributed to the better quality of age reporting in the CLHLS. The estimated CLHLS proportions fall within the range of the three comparison populations. It should be noted, however, that CLHLS centenarians per population aged 90+ and 65+ will be underestimated to the extent that the 2000 Census overestimates the size of these two age groups through age exaggeration. Further examination in greater detail is required.

A useful approach is to examine differences within the CLHLS data. Considerable variation in centenarian proportions is found among the provinces. This variation cannot be easily explained, except in terms of greater age exaggeration in certain provinces. The highest proportion of centenarians in the population[8] (14.9 per million) is found in Shanghai where mortality rates have been relatively low for at least 50 years and fertility began to decline earlier; this is not unexpected. However, equally as high (14.9) is Guangxi, a relatively undeveloped province in the south of China, where the centenarian proportion is expected to be comparatively low; it is suspected that age exaggeration is responsible. The third highest centenarian proportion is 9.8 in Jiangsu, which is one of the most developed provinces, located close to Shanghai in the east of China; Guangxi would not be expected to exceed this proportion. Age exaggeration and increasing age exaggeration with reported age are expected to be particularly marked in Guangxi because of its worldwide reputation for longevity. In contrast, age exaggeration is expected to be relatively limited in Jiangsu and Shanghai because of their higher socio-economic development for a longer period. These expectations are confirmed by the 1990 Census which recorded 64 centenarians per million aged 65+ in Shanghai and 62 in Jiangsu, while in Guangxi as many as 407 were recorded.

The age distribution of centenarians is also examined, using age ratios and the three comparable populations. It was first verified that there was negligible heaping on age 100 in the three comparable populations, as this would have resulted in age ratios that are too low. The possibility of heaping on age 100 in the CLHLS data was also considered. As digit preference measures could not be used, this was examined by calculating age ratios using ages 101 and 102 as the base instead of age 100. The results are generally consistent with those derived using 100 as the base (see Appendix 1, Tables 5.4 and 5.5), indicating minimal age heaping. The age ratios based on age 100, seen in Table 5.2, show that there are relatively more centenarians at each age above 100 in the CLHLS than in the commensurate mortality regimes. In other words, for each sex the CLHLS data exhibit an older centenarian age distribution than expected. Furthermore, the relative differentials between the CLHLS ratios and those for each of the three comparable populations are shown to increase with age. These ratios are consistent with increasing age exaggeration with reported age. At ages 101–104, the relative differentials are mostly greater for females than males, but at older ages they are more marked for males, as the ratio of ages 105+ to 100–104 also shows. Again, provincial comparisons show ratios for Guangxi to be particularly high: ratios for both sexes are 474 at age 102, and 105 at age 105.

[8] Again, these proportions are based on total population data from the 2000 Census and CLHLS centenarians.

Table 5.2 Age ratios for centenarians by sex, CLHLS and comparable populations

Age	Male				Female			
	Sweden 1943–1952	E&W 1950–1955	Japan 1962–1966	CLHLS 1998	Sweden 1943–1952	E&W 1950–1955	Japan 1962–1966	CLHLS 1998
100	1, 000	1, 000	1, 000	1, 000	1, 000	1, 000	1, 000	1, 000
101	382	518	532	605	506	534	467	654
102	221	273	286	335	265	292	242	398
103	88	142	143	160	123	152	142	255
104	59	65	91	115	62	79	64	143
105	15	21	0	75	31	41	39	80
106	0	3	0	60	12	20	27	60
107	0	0	0	10	6	10	21	52
108	0	0	0	10	0	3	15	27
109	0	0	0	15	0	1	9	21
110+	0	0	0	20	0	0	15	24
105+/ 100–104	8.4	12.4	0.0	85.8	25.2	36.3	66.5	107.5

Age ratios are expressed as the number of respondents aged 101, 102, etc. per 1,000 respondents aged 100. The ratio $105+/100-104$ is also per 1,000

Thus far, it has been demonstrated that there are more centenarians than expected in the CLHLS data, and that their age distribution is older than expected to an increasing extent with age. Both findings are much more marked in Guangxi. It has been suggested that the most likely explanation is increasing age exaggeration with reported age.

5.4.2 Age Reporting at Ages 80+

The suggestion of age exaggeration among centenarians raises the possibility that age misreporting also exists among younger respondents. As already noted, at ages less than 100, sample design limitations necessitate the use of unconventional methods for the assessment of age reporting accuracy. The approach used here is to examine the age difference between female respondents and their children, or the age at which the mothers bore their children,[9] by age of respondent. This approach is based on two underlying assumptions (note that no assumptions are made about reporting). The first assumption is that age at childbearing is constant across age: as female respondents bore their children during 1905–1970, before fertility restrictions were introduced and when fertility patterns were stable, this assumption is justified. The second assumption is that age at childbearing is unrelated to the survival of the mother. Accordingly, if the ages of mothers and their children were both reported accurately, mean age at childbearing would be constant across age. If some mothers over-reported their age, but their children's ages were better reported, the

[9] There was no direct question on age at childbearing. Male data were not examined; male reporting of offspring and their ages is usually of poorer quality than female reporting.

mother–child age gap would be artificially widened. Further, if mother's age exaggeration were more pronounced at older reported ages, the age gap would increase with age. If mothers accurately reported their own age, but under-reported their children's ages on average, a similarly widened age gap may appear.

The CLHLS obtained data on the ages of respondent's children, whether alive or dead. For deceased children, the age they would have been at the time of interview (had they survived) was reported. Mother's age at the birth of each child was calculated as the difference between the female respondent's age and the age of the child. The mean age at childbearing was calculated for all births (by averaging the average age for each individual mother), and for first and last births. These measures are shown by age of respondent[10] in Fig. 5.2. The trends so produced are highly sensitive to age misreporting in respondent's age, facilitating the detection of reporting error. Because any age exaggeration in an individual respondent's age will produce an equally exaggerated age at childbearing (by virtue of the method of calculation), a positive slope will result. The higher the proportion in any age group with exaggerated age, the steeper the slope. Thus, under the two assumptions, the trends in Fig. 5.2 are consistent with increasing proportions of respondents at age 90+ with exaggerated age.

It is also possible that an increasing age gap could be produced by increasing under-reporting of children's ages with respondent's age. However, the uniformity of the trends for different birth orders strongly suggests that they are influenced by the exaggeration of respondent's age, rather than by the under-reporting of

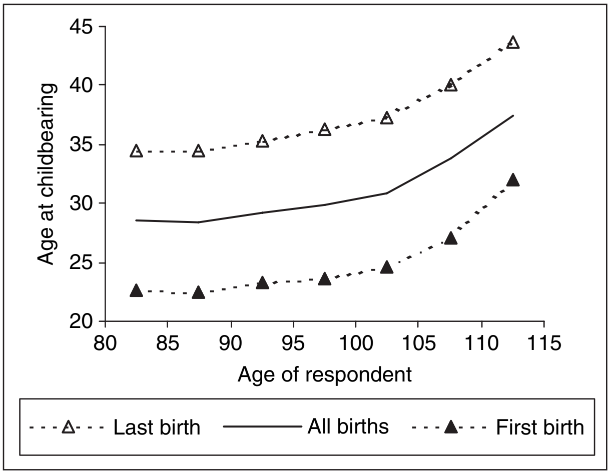

Fig. 5.2 Estimated mean age at childbearing by age of respondent by birth order. See Appendix 2 Table 5.6 for standard errors associated with these estimates

[10] As 94 percent of female respondents reported a least one child, conclusions drawn from these data about age reporting can be generalized to all female respondents.

children's ages, because only respondent's age is common to the calculation of all three measures.

Further evidence of age exaggeration is found in the regional variation in mean ages at childbearing. If age exaggeration is present, provinces with greater reported proportions of centenarians, such as Guangxi, would be expected to have higher estimated mean ages at childbearing. Table 5.3 is consistent with this expectation: the mean age at childbearing in Guangxi is 2.3 years greater than in Jiangsu and 3.8 years greater than in Shanghai. Similarly, the mean age at first birth in Guangxi is 1.4 and 2.0 years greater than in Jiangsu and Shanghai respectively, and the mean age at last birth is 2.6 and 4.8 years greater. That such differences are not genuine is supported by the fact that all respondents bore their children before the introduction of fertility restrictions when regional variation in fertility behavior was relatively low. This has in fact been shown by data in the 1982 One Per Thousand Fertility Survey, except for lower fertility in large cities such as Shanghai where fertility decline began earlier than elsewhere.

Figure 5.3 shows mean ages at childbearing by age of respondent for these three provinces and for the whole sample. The consistent patterns of increasing age at childbearing for Guangxi and Jiangsu indicate increasing age exaggeration with age, and the generally higher mean ages for Guangxi would appear to indicate a greater extent of age exaggeration at all ages in this province (given similar expected fertility behavior). For Shanghai, the patterns are neither consistent nor increasing, and there is no observable age exaggeration.

Why is age exaggeration more serious in Guangxi? A possible contributing factor is the high proportion of the Guangxi population who belong to the province's ethnic minorities, as most minorities report age less accurately than the Han majority. This possibility is examined in Fig. 5.3 with respect to two ethnic minorities, the Zhuang and Yao. The Zhuang are China's largest ethnic minority and comprise approximately one third of the population of Guangxi; the Yao are much smaller in number but reported a relatively large number of centenarians. Though minority numbers are relatively small, especially for the Yao, the three mean age at childbearing patterns are fairly consistent indicating age misreporting effects. For both minorities, mean ages at childbearing are generally higher than for Guangxi, suggesting a greater degree of age exaggeration at all ages especially among the Yao. Again, actual fertility behavior is not expected to differ appreciably between these populations.

Table 5.3 Estimated female mean age at childbearing and first and last birth, CLHLS 1998

Province	Number of respondents	Mean age at childbearing	Mean age at first birth	Mean age at last birth
Guangxi	708	31.46 (0.22)	24.53 (0.23)	38.11 (0.30)
Jiangsu	650	29.16 (0.20)	23.16 (0.19)	35.47 (0.28)
Shanghai	229	27.63 (0.32)	22.56 (0.31)	33.30 (0.50)
Total	4943	29.73 (0.08)	23.66 (0.08)	35.95 (0.11)

Based on respondents aged 80+. Standard errors in parentheses

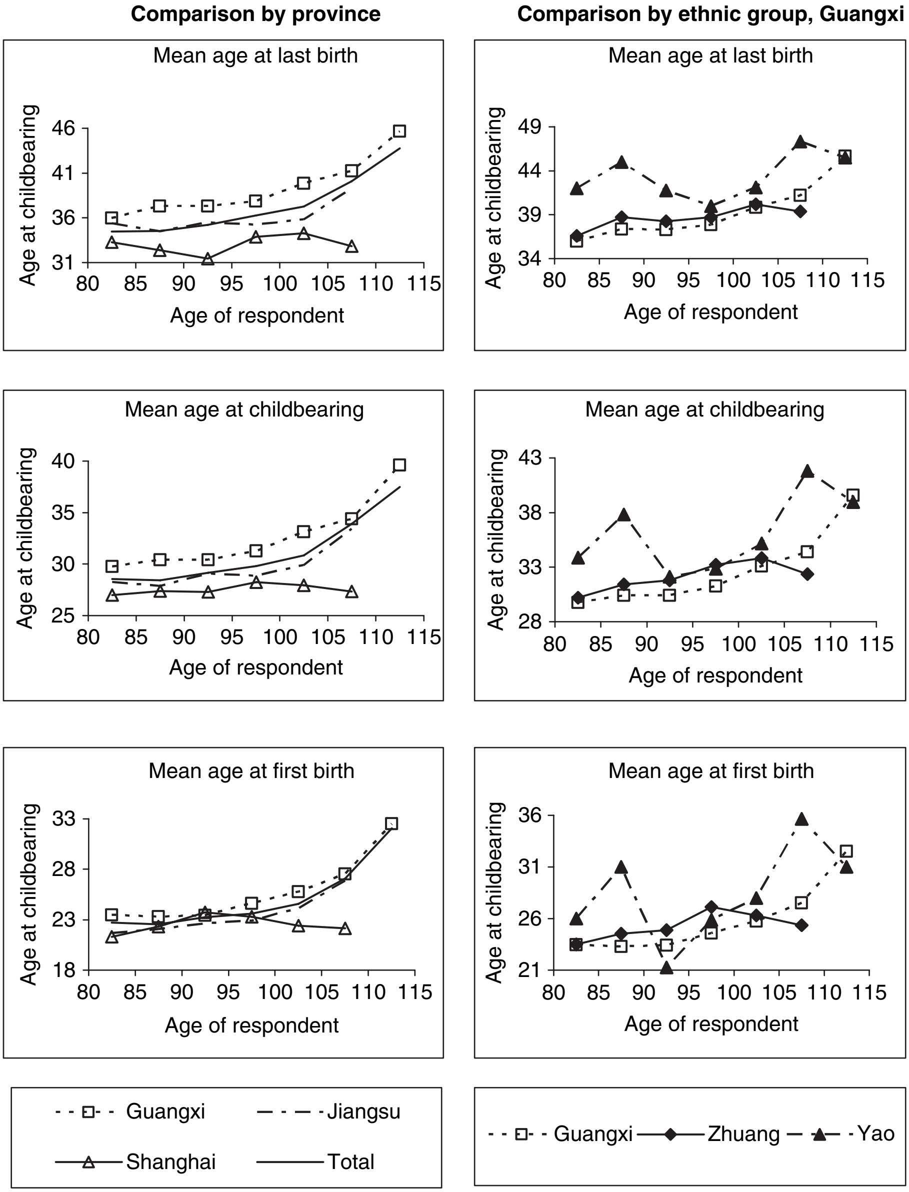

Fig. 5.3 Estimated mean age at childbearing by age of respondent by province and ethnic group. See Appendix 2 Tables 5.6 and 5.7 for standard errors associated with these estimates

5.5 Discussion

The examination in this chapter of the CLHLS centenarian age distribution appears to provide evidence consistent with increasing age exaggeration. This is somewhat different from the verdict of "generally reliable" at ages up to 105 (RGHLC 2000: 6–17). That verdict was based on a comparison of the CLHLS data with a single population, Sweden 1984–1993. However, this population does not provide a valid comparison: life expectancy is 77 years, the percentage aged 65+ is ten percentage points greater than for China-22 in 2000, and the proportion of centenarians in the population is 63 per million (see Table 5.1). The comparison presented in this chapter is with three populations that are considered comparable with the CLHLS data: they have equivalent life expectancies and their age structures (as measured by proportions aged 65+ and 90+) are similar to and span the Chinese age structure in 2000. The use of three populations broadens the comparison; and the inclusion of Japan provides an example of a population that has undergone a more recent and more rapid demographic transition, which is closer than the European populations to China's experience. Further, we base our analysis on age ratios because they are a more sensitive indicator than the percentage distribution. For these reasons, we consider our examination to be both more valid and more reliable than that presented in RGHLC (2000) and Zeng et al. (2001).

While increasing age exaggeration may be apparent in reported age, this does not necessarily indicate increasing age exaggeration when related to true age. This is because of the effect of the (true) age distribution. At the oldest ages, rapidly increasing mortality dominates the shape of the age distribution rendering cohort effects negligible and producing a concave distribution that tapers to zero. With such a distribution a constant rate (at true age) of age exaggeration will tend to have an increasingly large inflationary effect with age, giving an older observed age distribution. Wang et al. (1998) used this effect to support their argument that age reporting among the Han in the 1990 Census is generally good despite questionable numbers at ages 105+. If age exaggeration is present in the CLHLS data, the increasing differentials between the CLHLS age ratios in Table 5.2 and those for the three comparable populations can at least in part be attributed to this age distribution effect. However, this effect cannot exist without age exaggeration.

Neither does the older age distribution necessarily indicate that the data are affected only by age exaggeration. The concavity of the age distribution also means that the same constant rate of age under-reporting will have a smaller deflationary effect that decreases slightly with age. For equal under and over-reporting, the net effect is increasing inflation, and the degree of misreporting imbalance determines the degree of inflation (a modest imbalance toward under-reporting may also produce inflation). Thus the older centenarian age distribution in the CLHLS than in comparable populations could in theory be due to statistically symmetrical age misreporting (or slight net under-reporting). However, to produce the same effect on the age distribution, the extent of such age misreporting would have to be much greater than the extent of pure age exaggeration. Symmetrical but extensive age misreporting would have additional implications for the substantive analysis of these data, particularly if the direction of age misreporting were associated with other variables.

One irrefutable piece of evidence in support of age exaggeration is the fact that age under-reporting cannot have occurred across the upper limit of the age distribution. Thus the inflated age ratios at the oldest ages can only be the result of age exaggeration. It is highly likely that age exaggeration also extends to younger centenarians. Indeed, the smooth decline in the CLHLS ratios in Table 5.2 gives no indication of other patterns of age misreporting at younger ages. Thus, while it is impossible to determine from these ratios the exact extent and balance of age misreporting, it can be determined that age exaggeration is present, and that while this is not necessarily increasing with true age, it increasingly affects reported age at ages 101+.

The arguments related to the effect of the concavity of the (true) age distribution are also relevant to the evidence based on the age gap between female respondents and their children.[11] Thus, in part at least, the increasing trends in Fig. 5.2 could be produced by a constant rate of age exaggeration by true age. It might also be argued that because under-reporting of respondent's age will produce an under-estimated age at childbearing, this will also appear as a positive slope in Fig. 5.2.[12] However, the increasing slope would imply increasingly improved reporting with increasing age, to a theoretical limit of no under-reporting at the upper age limit, which is not only unlikely but could not produce the larger effects at older ages because of smaller numbers. (Again, any counterbalancing of misreporting would imply a much higher overall level of misreporting.) Further, under-reporting would imply higher (true) mean ages at childbearing; this issue is now addressed.

Comparison with directly reported ages at childbearing for the same cohort[13] of women in the 1982 One Per Thousand Fertility Survey shows that the CLHLS estimate of the mean age at first birth is too high. This could be the result of respondent's age exaggeration or child's age under-reporting or the omission of low-order births at younger childbearing ages. The same comparison shows the CLHLS estimated mean age at last birth to be too low, which could arise from respondent's age under-reporting or child's age exaggeration or the omission of higher order births at older childbearing ages. Clearly, if the reporting of respondent's age is responsible, age at first and last birth must exhibit a common direction of misreporting, which is not the case. If the reporting of first and last children's ages is responsible, the comparisons imply that the estimated childbearing period has been compressed at both ends. This is indistinguishable from the effect of omissions. Comparison with data in the 1982

[11] The age distribution effect does not apply to children's ages. Thus (increasing) under-reporting of children's ages is unlikely to explain the large increases in age at childbearing. The alternative explanation of over-reporting of children's ages to a decreasing degree with age is similarly flawed.

[12] If mother's and children's ages were equally misreported, there would be no effect in Fig. 5.2 because age at childbearing would be correct.

[13] The only cohort for which this comparison is possible is women aged 64–67 in the 1982 survey and 80–83 in the CLHLS.

One Per Thousand Fertility Survey suggests that around one child per woman has been omitted in the CLHLS. In addition, a high proportion of reported higher birth order children have missing age, which has the same effect as omissions of births per se. Thus omission is (at least partly) responsible for the relatively low age at last birth, and is likely to also be a factor in the high age at first birth.

There thus seems to be a contradiction between the explanations for the patterns observed. While omissions could explain the early age at last birth, found on average for CLHLS respondents, they cannot lead to the overestimated age at last birth found at very old ages (Fig. 5.2). Further, omissions are unlikely to produce the pattern observed in the mean age at childbearing. Thus, it is likely that the high level of omission for last births overwhelms the effect of respondent age exaggeration on age at last birth, in which case the late age at first birth found in the CLHLS can be at least partly attributed to age exaggeration.

A reviewer of this chapter questioned the validity of the above comparison on the grounds that the CLHLS did not go into the same level of detail in recording fertility histories as the 1982 survey, and moreover that the "memory capacity of women aged 80–83 [in the CLHLS] was certainly substantially weaker as compared to those aged 64–67 [in the 1982 survey]." This is precisely the point that we are making: the CLHLS data are not consistent with the much better quality 1982 data because of reporting inaccuracies, and that these inaccuracies relate in part to age reporting in the CLHLS. Moreover, the reviewer's observations and additional comment that "the reliability of the age at births reported by these extremely old women is certainly questionable" raise important further issues. First, given that the CLHLS age validation process was largely based on recall of personal events including marriage and childbearing (Xu 2001, and Chap. 4 of this volume), the weaker memory capacity and unreliable age at birth reporting of CLHLS respondents actually call into question the accuracy of validated age. Second, this dependence between age at childbearing and respondent's age invalidates the use of these data for the study of the relationship between longevity and age at childbearing, because reporting errors will result in their correlation. Third, the unreliability of reported fertility in the CLHLS (e.g., the omission of births) would have a considerable impact on the relationship between longevity and age at childbearing, again invalidating its study based on these data. As already noted, the CLHLS data likely omit around one child per woman.

The evidence supporting the increasing extent of age exaggeration in reported age is particularly strong for Guangxi. Centenarian proportions for Guangxi far exceed expectations, and their reported age distribution is exceptionally old. Further, the higher than average mean ages at childbearing suggest a greater extent of age exaggeration, which is in evidence from age 80. The significance of this higher level of age exaggeration in Guangxi for substantive analyses of the CLHLS data cannot be ignored. Indeed, preliminary analyses indicating that mortality rates of CLHLS centenarians between survey rounds are lower in Guangxi than in other provinces could be entirely an artifact of age exaggeration. Further, the variation in the degree of age exaggeration by province clearly has implications for the sample weights. The higher level of age exaggeration in Guangxi results in this province comprising

14 percent of CLHLS centenarians, and by virtue of the sample design 14 percent of the whole sample, when it comprises only 4 percent of the total population of China-22. The significance of age misreporting among particular ethnic minorities (e.g., Coale and Li 1991) should similarly be carefully considered.

In order to give some idea of the variability in the data, Tables 5.6 and 5.7 in Appendix 2 provide standard errors for the mean ages at childbearing shown in Figs. 5.2 and 5.3 respectively. It must be emphasized, however, that high variability (such as for the Zhuang and Yao ethnic minority populations of Guangxi) does not detract from the analysis and the validity of the conclusions drawn. Our concern is to demonstrate the quality of the CLHLS sample per se. The fact that the high mean ages for the Yao in Guangxi have relatively large standard errors does not detract from these observed means, nor from the fact that this group forms part of the sample and contributes to the inaccuracies in the data. It is noted, however, that in all but one cases standard errors are smallest for the age group 100–104, giving confidence in the patterns observed.

These conclusions about age reporting at ages 80+ are based on the assumption that age at childbearing is unrelated to the survival of the mother. This assumption is open to question: research findings show a positive relationship between late childbearing and longevity at the population level. However the exact nature of this relationship has yet to be determined. Several studies found no relationship between age at first birth and subsequent survival at ages 50+ (Smith, Mineau, and Bean 2002; Dribe 2004; Alter, Dribe, and van Poppe 2004), though Doblhammer (2000) found a significant positive association when comparing first births at age <20 (which accounted for only 7–12 percent of first births) with those at 20+. On the other hand, most of these studies found a significant positive relationship between age at last birth and survival at ages 50+, as have other studies (e.g. Perls, Alpert, and Fretts 1997; Müller et al. 2002).

Would relaxing this assumption lead to a different conclusion? A relationship between longevity and age at childbearing could in part explain the increasing mean ages at childbearing by age in Fig. 5.2. If there is a relationship in the CLHLS data between longevity and age at last birth, but not age at first birth (or a stronger relationship for age at last birth), its effect would be to widen the childbearing interval with increasing respondent's age. Such widening is in fact found for the whole sample (the interval increases from 11.8 years at age 80–84 to 13.0 at 105–109) and for Guangxi, but it is not found for Shanghai or Jiangsu where age reporting is more accurate, suggesting the absence of such a relationship. It is noted that the widening of the childbearing interval cannot be attributed to increasing omissions with age, as this would have the opposite effect. Thus the increasing means with age seen in Fig. 5.2 are attributed to age exaggeration and the effects of the concavity of the age distribution.

Using CLHLS data, Zeng and Vaupel (2004) found a statistically significant positive association between number of births after age 35 or 40 and the risk of survival as measured by deaths between the 1998 and 2000 waves of the survey. The number of births after age 35 or 40 is dependent on the respondent's age and on the age of each child because age at childbearing depends on these two ages. If, as suggested by this examination of data quality, age exaggeration exists among female respondents this finding could be spurious. The increasing level of significance of Zeng and Vaupel's finding with increasing number of children (2004: table 3) is also consistent with the effect of age exaggeration because each additional child must have been borne at an older age. The same is true of the increased significance at higher ages (2004: table 4a). Here, as in the above discussion, the effect of the age distribution comes into play to magnify the strength of the association at older ages.

In conclusion, careful examination of the CLHLS data has demonstrated the presence of age exaggeration in reported age as seen in the older than expected age distribution. The extent of exaggeration in the data appears to be low at the youngest ages, but increases with age especially after age 100. Much of the age exaggeration can be attributed to Guangxi and in particular Guangxi's ethnic minorities. However, the extent of exaggeration found in the data cannot be entirely accounted for by the minority populations. It must therefore be concluded that age misreporting or exaggeration at very old ages also exists among the Han majority, especially at ages 100+, even though age reporting is generally reliable in this population. While increasing age exaggeration may be due to the effect of the age distribution, it is nevertheless present in the data. Thus substantive analyses, especially those concerning longevity, must take age exaggeration into account. In particular, analyses using constructed variables based on respondent's age may well be open to spurious relationships with age. The recommendation that respondents aged 106+ be omitted from analyses only partially addresses this issue: though the largest biases will be removed by this means, biased results may still be obtained. Analyses of the effects of age exaggeration on substantive results based on the CLHLS data are beyond the scope of this chapter, but have subsequently been undertaken by others (Chap. 4 in this volume).

Finally, it must be emphasized that this chapter has sought to evaluate the quality of age reporting in the CLHLS through an objective examination of the data, including reporting problems that had not previously been investigated. The aim has been to identify whether age misreporting is present in the data, rather than to rank the CLHLS among various data sources according to the quality of age reporting. This initial analysis has demonstrated that the data are subject to the effects of age misreporting, and further evaluation of the quality of the data and the effect of age misreporting on analyses is still needed. Our ultimate interest is in the reliability of the conclusions about longevity based on CLHLS data.

Appendix 1: Examination of Evidence on Heaping at Age 100 in CLHLS Population

Age ratios for centenarians based on 101 and 102 give similar results for females as for ratios based on 100: the CLHLS distribution is older than any of the three comparable populations. Thus age heaping at age 100 does not affect the finding. For males, ratios based on 101 and 102 do not show an older age distribution at ages 102 and 103 suggesting that the extent of inflation (relative to 100) at ages 101, 102, and 103 does not increase; an older distribution is observed at ages 104 and above for all ratios.

Table 5.4 Age ratios based on age 101, CLHLS 1998

Age	Male				Female			
	Sweden 1943–1952	E&W 1950–1955	Japan 1962–1966	CLHLS 1998	Sweden 1943–1952	E&W 1950–1955	Japan 1962–1966	CLHLS 1998
101	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
102	577	527	537	554	524	547	519	608
103	231	274	268	264	244	284	305	390
104	154	125	171	190	122	148	136	218
105	38	41	0	124	61	78	84	122
106	0	7	0	99	24	37	58	92
107	0	0	0	17	12	18	45	79
108	0	0	0	17	0	6	32	41
109	0	0	0	25	0	1	19	32
110+	0	0	0	33	0	0	32	36

Age ratios are expressed as the number of respondents aged 102, 103, etc. per 1,000 respondents aged 101

Table 5.5 Age ratios based on age 102, CLHLS 1998

Age	Male				Female			
	Sweden 1943–1952	E&W 1950–1955	Japan 1962–1966	CLHLS 1998	Sweden 1943–1952	E&W 1950–1955	Japan 1962–1966	CLHLS 1998
102	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
103	400	519	500	478	465	520	588	641
104	267	237	318	343	233	271	263	359
105	67	78	0	224	116	142	163	201
106	0	13	0	179	47	68	113	151
107	0	0	0	30	23	33	88	130
108	0	0	0	30	0	11	63	67
109	0	0	0	45	0	2	38	53
110+	0	0	0	60	0	0	63	60

Age ratios are expressed as the number of respondents aged 103, 104, etc. per 1000 respondents aged 102

Appendix 2: Standard Errors for Figures 5.2 and 5.3

Table 5.6 Standard errors of mean ages at childbearing of total sample

	Respondent's age						
	80–84	85–89	90–94	95–99	100–104	105–109	110–114
Age at last birth							
Mean	34.48	34.52	35.22	36.25	37.26	40.08	43.75
SE	0.24	0.29	0.27	0.28	0.19	0.66	2.10
Age at childbearing							
Mean	28.55	28.41	29.15	29.82	30.85	33.89	37.52
SE	0.17	0.20	0.18	0.20	0.14	0.48	1.61
Age at first birth							
Mean	22.71	22.52	23.26	23.58	24.59	27.07	32.08
SE	0.17	0.19	0.18	0.20	0.15	0.52	2.26

Table 5.7 Standard errors of mean ages at childbearing by province and ethnic minority

Province/ ethnic group		Respondent's age						
		80–84	85–89	90–94	95–99	100–104	105–109	110–114
Age at last birth								
Shanghai	Mean	33.27	32.39	31.43	33.90	34.27	32.83	–
	SE	1.41	1.42	1.26	1.12	0.78	2.98	–
Jiangsu	Mean	35.35	34.48	35.49	35.20	35.81	39.29	–
	SE	0.73	0.83	0.83	0.78	0.41	2.16	–
Guangxi	Mean	35.97	37.33	37.29	37.84	39.85	41.22	45.67
	SE	0.66	0.80	0.70	0.80	0.52	1.59	2.46
–Zuang	Mean	36.60	38.71	38.28	38.71	40.20	39.38	–
	SE	1.07	1.12	1.12	1.49	0.81	2.81	–
–Yao	Mean	42.00	45.00	41.75	40.00	42.08	47.33	45.50
	SE	2.00	2.86	2.66	2.01	2.04	0.88	3.31
Age at childbearing								
Shanghai	Mean	27.00	27.37	27.28	28.24	27.95	27.33	–
	SE	0.88	0.92	0.90	0.76	0.46	1.89	–
Jiangsu	Mean	28.24	27.85	29.08	28.86	29.90	33.43	–
	SE	0.52	0.59	0.56	0.48	0.29	1.49	–
Guangxi	Mean	29.76	30.39	30.42	31.27	33.11	34.39	39.59
	SE	0.47	0.53	0.49	0.59	0.41	1.33	0.62
–Zuang	Mean	30.19	31.43	31.78	33.22	33.84	32.38	–
	SE	0.79	0.79	0.77	1.10	0.67	1.69	–
–Yao	Mean	33.88	37.84	32.11	32.86	35.15	41.81	38.98
	SE	2.62	3.45	2.77	2.50	1.58	3.12	0.76
Age at first birth								
Shanghai	Mean	21.30	22.33	23.76	23.27	22.43	22.16	–
	SE	0.59	0.86	0.95	0.86	0.47	1.91	–
Jiangsu	Mean	21.68	22.07	22.64	22.88	24.14	26.86	–
	SE	0.45	0.57	0.49	0.45	0.30	2.12	–
Guangxi	Mean	23.46	23.30	23.42	24.60	25.75	27.52	32.50
	SE	0.45	0.49	0.46	0.58	0.45	1.51	2.28
–Zuang	Mean	23.52	24.54	24.88	27.13	26.31	25.38	–
	SE	0.65	0.90	0.86	1.13	0.71	2.16	–
–Yao	Mean	26.00	31.00	21.25	25.88	28.00	35.67	31.00
	SE	4.00	5.05	2.78	2.50	2.49	5.92	2.38

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