Demographic Changes in North Korea: 1993–2008

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OFFICIAL POPULATION STATISTICS for the Democratic People's Republic of Korea (hereafter North Korea) were scarce until recently, resulting in very limited scientific publications analyzing national population trends. Benefiting from the release of official tables on demographic data for different years from the Central Statistics Bureau of North Korea in 1989, Eberstadt and Banister (1992a) produced the first systematic and consistent modeled reconstruction of population changes in the country from 1960 as well as a population projection up to 2050. Using the 1986 civilian age and sex structure as a benchmark, this reconstruction showed that (1) the official population data are generally reliable; (2) the mortality transition was well underway, with life expectancy at birth in North Korea at the end of the 1980s reaching levels similar to those in South Korea; and (3) total fertility remained quite high through 1970 and declined sharply thereafter, reaching about 2.5 children per woman in 1987. The reconstruction by Eberstadt and Banister remains the most comprehensive treatment of North Korea's demography to date.

Very little official demographic information was released during the 1990s. Although a population and housing census was conducted in December 1993, it did not produce any impetus for further investigation of population changes in the country because of the difficulty of accessing the results outside of the country. Living conditions deteriorated markedly during the 1990s and early 2000s as the Soviet Union began to cut economic aid, and in the wake of floods and famine in the 1990s and the collapse of heavy industry.[1] To assess the social and demographic consequences of these trends, most studies have had to rely on anthropometric measurements collected in surveys on child malnutrition (Katona-Apte and Mokdad 1998; Pak 2004; Schwekendiek 2008a, b).

Only three studies have provided a conventional demographic perspective (Robinson et al. 1999; Goodkind and West 2001; Goodkind, West, and Johnson 2011). Using data on household deaths since 1995 collected in 1998 from 440 adult North Korean migrants in 15 randomly selected sites in China, Robinson et al. (1999) showed that "mean [annual] crude death rates in the migrant households were 42.8 per 1,000 in 1995–97, nearly eight times more than the 5.5 per 1,000 derived from the 1993 census" (p. 293). Goodkind and West (2001) offered a more detailed analysis of population trends in North Korea. Based on the 1993 population census data, on the 1995 and 1998 official crude death rates released in 1999, and on mortality estimates from survey data collected from famine refugees in China (Robinson et al. 1999), Goodkind and West used a population projection model and other indirect sources of evidence (reconstructed annual age-specific death rates from the famine during China's Great Leap Forward, 1958–62, and North Korea's child malnutrition surveys) to produce estimates of famine-related deaths between 1995 and 2000. According to their estimates, famine-related deaths came to between 600,000 and one million from 1995 to 2000. Until recently these estimates represented the most plausible assessment of the human cost resulting from the social and economic deterioration that occurred during the 1990s in North Korea. Goodkind, West, and Johnson (2011) have since substantially revised downward their estimates of famine-related mortality to a total excess number of deaths between 500,000 and 600,000. Both the 2001 and 2011 estimates call into question the often-heard claims that the famine in North Korea was responsible for the loss of 3 million lives (among others, see Becker 2006: 211; Eberstadt 2007: 131–132).

In the 2000s, survey reports (the 2002, 2004, and 2006 Reproductive Health Surveys (RHS) and the 2000 Multiple Indicator Cluster Survey (MICS)) became available (DPRK Central Bureau of Statistics 2000, 2004, 2007; WHO 2007). Questions remain regarding the reliability and quality of the population data of 2000, 2004, and 2006, which do not appear to have been used in subsequent studies. In December 2009, the Government of North Korea made publicly available results of the latest national population and housing census conducted in October 2008, offering a unique opportunity to reconstruct and assess the country's recent demographic development and the living conditions that have prevailed in the preceding 15 years as well as an opportunity to evaluate the consistency of official and survey data and the estimates proposed by scholars in previous studies.

Using the 1993 and 2008 national population and housing census data, this article uses population projection to reconstruct the population trends of North Korea over the 15 intercensal years. The article is structured as follows: a brief history of North Korea over the last 60 years is provided. The 1993 and 2008 census data—population by age and sex, fertility, and

mortality indicators—are described and critically assessed. From this census-based demographic evidence and other existing demographic estimates, the population dynamics of the country is reconstructed prospectively from 1993 to 2008 through population projections testing the plausibility of different population trends. Finally, counterfactual population projections are run in order to estimate (1) the demographic impact of the famine in the 1990s and (2) the human cost of the deteriorating living conditions in North Korea that were widely reported during the 1990s and 2000s.

A brief history of North Korea

After the Korean peninsula was liberated from Japan following World War II, North Korea made advances in heavy industry, which it inherited from the Japanese, and pursued policies of autarky and import-substitution during the Cold War. This was in stark contrast to South Korea, which focused on light industrial and later semiconductor development, while opting for export orientation, all of which paved the road for its economic takeoff in the 1990s. North Korea's economy began to decline dramatically with the collapse of the Soviet bloc following the geopolitical events triggered in 1989 in East Germany with the fall of the Berlin Wall. Fraternal assistance from Russia, which included energy, mechanical spare parts, and fertilizers previously provided on a socialist concessional basis, decreased, thereby harming both industrial and food production in the country. Unable to import food at world market prices, burdened with high debt since the 1970s, and facing a series of natural disasters as a result of the El Niño weather anomaly in 1995, the nation experienced widespread famine in the decade after the end of the Cold War. In 1987, nutritional stress was relatively low in North Korea, with an estimated 3 percent of children being "severely underweight" (weight-for-age three standard deviations below the UN reference population). In 1997, however, this rate surged to 14 percent. It then decreased to 6–7 percent by 2002 (Schwekendiek 2011).

By 2002, North Korea had entered a post-famine period characterized by renewed agricultural and economic development (Smith 2009). In 1991, North Korea became a member of the United Nations and the country appealed for and received international assistance after the floods of 1995 (Lee 2010). An important impetus for the revival of the national economy was the introduction of economic reforms in 2002 (Frank 2005). These included major marketization elements such as decentralized planning, encouragement of entrepreneurial incentives, introduction of local markets to supply daily necessities and goods formerly distributed by the government, and currency reform. Another factor that helped overcome the food crisis was the activity of border peddlers who supplied the interior with goods smuggled from China. Bribery and informal market activities rose sharply with severe

shortages: based on information gathered from refugees departing from North Korea between 1997 and 2004, some four-fifths of total household income was generated through private-plot farming, stockbreeding, and the like (Kim and Song 2008). In the mid-2000s, fearing too much marketization and facing new forms of corruption, Pyongyang began to curb liberalization by limiting market activities (Schwekendiek 2011). In a similar vein, in 2009 the government introduced a currency reform that replaced older bills, and in the process destroyed a substantial part of household savings that were mostly held by traders (Frank 2010). Although the famine of the mid-1990s was overcome with international assistance, economic reforms, and informal market growth, severe food shortages have continued. In 2008, half of North Korean households interviewed in a rapid food security assessment conducted by the United Nations said that they ate only two meals per day while also consuming a reduced quality diet (WFP/FAO 2008). However, because the last nutritional survey based on reliable anthropometric measurements dates back to 2004, the current extent of nutritional stress in North Korea remains undocumented.
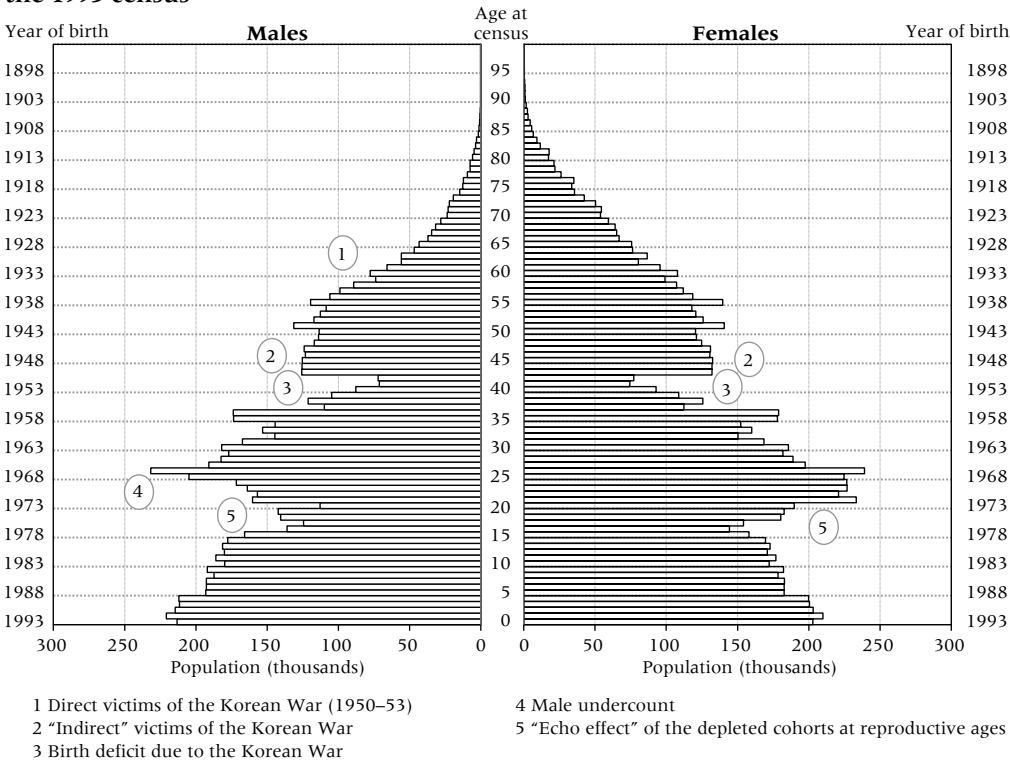
Census data, data quality, and adjustment

This study uses data from the 1993 and 2008 national population and housing censuses (DPRK Central Bureau of Statistics 1995, 2009). The first of these was conducted with technical and financial assistance from the United Nations Population Fund (UNFPA) in late 1993–early 1994 with a reference date of 31 December 1993. The second was conducted with technical and financial assistance from UNFPA and the South Korean government between 1 and 15 October 2008 with a reference date of 1 October 2008. While technical assistance was limited for the 1993 census, as international observers had restricted access and were not present in the country during the fieldwork, the later census was conducted following international standards (United Nations 2008) and is considered to be of high quality (Engracia 2010).[2] Both the 1993 and 2008 censuses covered all households and institutional living quarters (i.e., institutions such as dormitories, nurseries, boarding houses, homes for the elderly, military camps, penal colonies, etc.) (DPRK Central Bureau of Statistics 1995: 1; 2009: 3; Engracia 2010).
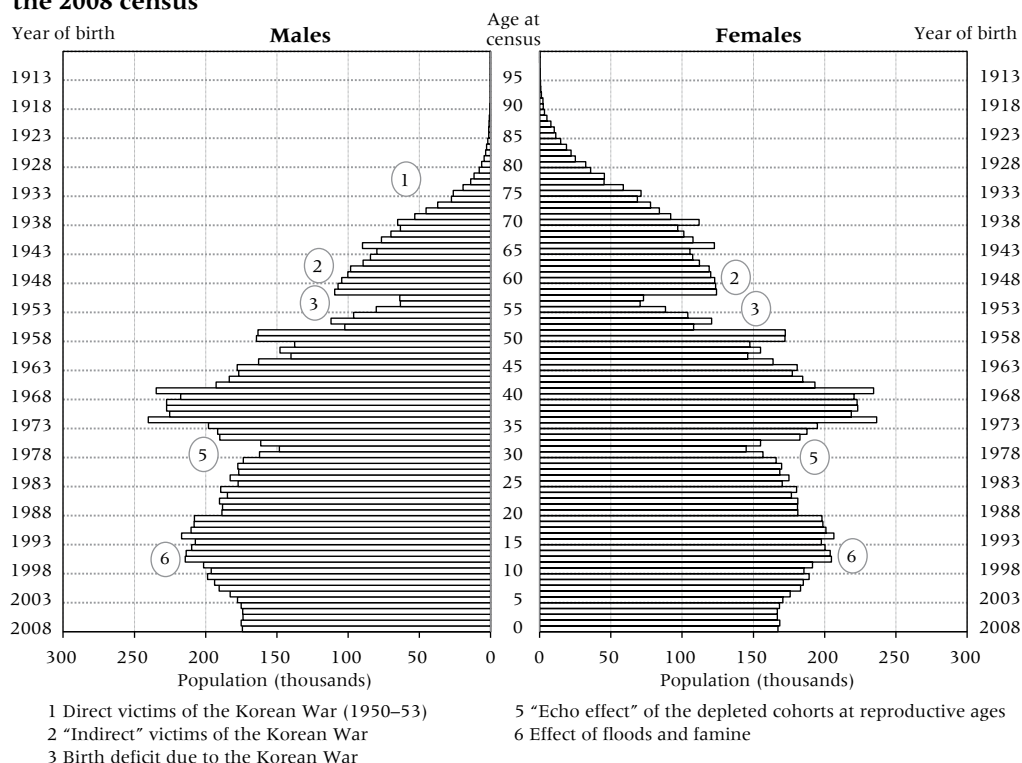
Population by age and sex

Figures 1 and 2 show the population by single year of age and sex enumerated by the 1993 and 2008 censuses. The two series are remarkably consistent. Both figures illustrate the long-term demographic legacy of the twentieth-century history of North Korea. The direct and indirect consequences of the Korean War (25 June 1950–27 July 1953) on the population age distribution

FIGURE 1   The population of North Korea, by age and sex, according to the 1993 census

1 Direct victims of the Korean War (1950–53)
2 "Indirect" victims of the Korean War
3 Birth deficit due to the Korean War
4 Male undercount
5 "Echo effect" of the depleted cohorts at reproductive ages

of North Korea are clearly visible (indicated by circled numbers on Figures 1 and 2). First, as a direct consequence of the war, the male population aged 60 and over in 1993 (i.e., men who were aged 17 and over in 1950) was much smaller than the female population of the same age, indicating a heavier male death toll during the war (as well as higher female survival at older ages).[3] The birth cohorts that reached childhood ages during the Korean War were the "indirect" victims of the conflict. The cohorts born in each year between 1947 and 1950 were almost identical in number in the 1993 census, indicating that deteriorating living conditions in wartime increased child mortality. The conjunction during the conflict of factors that reduce a woman's ability to conceive and maintain a healthy pregnancy (spouse separation, depleted cohorts at reproductive age, reduction in food intake, stress) resulted in a birth deficit among cohorts born between 1951 and 1953 (and to a lesser extent in 1954). The larger cohorts born in 1957 and 1958 represent a classic process of recuperation of births averted during the war and in the immediate postwar period.

The demographic effects of the Korean War were devastating and continue to affect the population dynamics of the country. The depleted cohorts

FIGURE 2   The population of North Korea, by age and sex, according to the 2008 census

1 Direct victims of the Korean War (1950–53)
2 "Indirect" victims of the Korean War
3 Birth deficit due to the Korean War

5 "Echo effect" of the depleted cohorts at reproductive ages
6 Effect of floods and famine

resulted in a lower number of births 20–25 years later in the 1970s (number (5) on Figures 1 and 2). This decline in the birth rate can, however, also be attributed to the government's promotion of one- or two-child families in the late 1970s and early 1980s (Eberstadt and Banister 1992a: 136; Yonhap 1996 cited in Adlakha and West 1997: 4). According to North Korean defectors, families were told to raise at most two children during this time (Hunter 1999: 104–105). The decline in births in 2000 and later may reflect the poor and deteriorating economic conditions that discouraged couples from having children, as well as the small size of the birth cohorts of the 1970s reaching childbearing age (Figure 2).
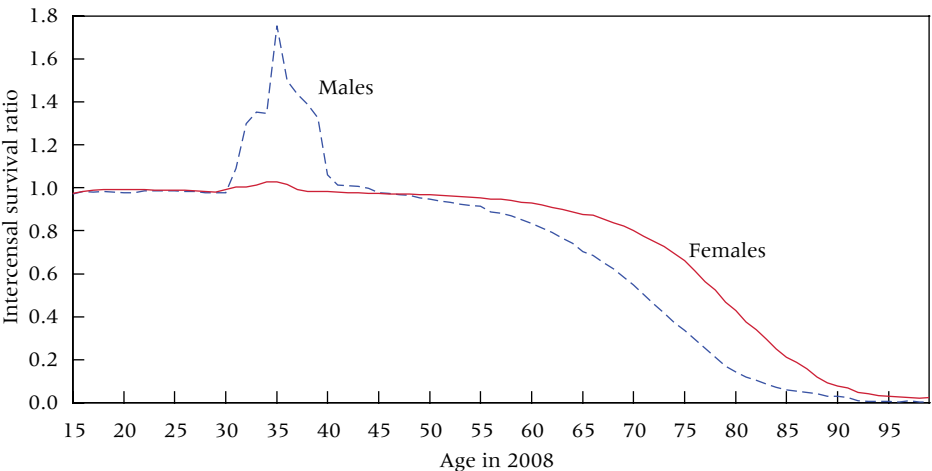
The 2008 census does not show a famine-related cohort dip among men and women born between 1993 and 2000 like the noticeable one for China during the Great Leap Forward (1958–61). The large number of women reaching peak childbearing ages between 1993 and 2000 would tend to increase the cohort size for children born between these years. At the same time, the famine would likely have raised mortality (and/or lowered fertility), reducing the cohort size for those born between 1993 and 2000. The effects of these two demographic forces would offset each other.

Problems with the 1993 census data by age and sex

Given the long-term demographic disturbance caused by the Korean War, most of the classic measures devised by demographers to assess data quality (age-heaping index, successive age ratio, age-accuracy index, sex ratio score, age-sex accuracy index) are not appropriate. However, because the country has remained closed for decades and international migration can be considered non-existent, the quality of the two censuses can be assessed using intercensal cohort analysis. Intercensal cohort analysis allows patterns of under-enumeration to be detected by considering the proportion of a cohort of a given sex reported in a census that is counted in a later census. In a closed population where both censuses are of good quality, intercensal cohort survival cannot exceed 1. The intercensal survivorship estimates in Figure 3 indicate serious problems in the census age and sex data. Intercensal survivorship estimates higher than 1 for some ages show that the 1993 census data are problematic. Figure 3 indicates a major under-enumeration of the male population aged 15–25 in the 1993 census (i.e., those reaching ages 30–40 15 years later in 2008). Indeed, according to the 1993 census tabulations, the total population of North Korea was 21.213 million at that time. This total population differs, however, from the 1993 total population obtained from the population age and sex structure, which indicates a lower total population of 20.522 million, a difference of 691,000 persons. It is likely that the difference was primarily the result of the exclusion of the (mainly male) military population in the 1993 enumeration.[4] As Adlakha and West (1997: 8) note,

> The presentation of data in this manner [(i.e., exclusion of the military population in the age distribution, but inclusion in the total population)] is the same

FIGURE 3   Intercensal survivorship estimates by single year of age, 1993 and 2008 censuses of North Korea

as China published for its 1982 and 1990 population census results. China footnotes and explains that the difference is the military population. China's State Statistical Bureau provided technical assistance to North Korea on the 1993 census and may have influenced the presentation of the results […], but no specific explanation of the differences is available from DPRK sources.

The intercensal cohort analysis demonstrates that the 1993 census population age and sex data need to be corrected before being used for intercensal comparisons.

Like the 1993 census report, the 2008 census report published two different total populations: a total population (24.052 million) that is different from the total population computed from the data by five-year age groups and sex (23.350 million), the difference, 702,000, indicating a likely exclusion of the military population. However, unlike the 1993 census, the 2008 census data by single year of age and sex *include* the military population, since the total population computed from these data matches the published total population.

Estimate of the 1993 census population age and sex structure

To estimate the "true" 1993 population age and sex structure, we used the 2008 census data to compute, for each sex, the percentage distribution of the difference between the published population by five-year age groups and sex and the computed population by five-year age groups and sex from the single-year age and sex distribution. We then applied the 2008 census percentage distribution of the 662,000 male and 40,000 female differences to the 1993 census difference of 652,000 males and 39,000 females between the published total population and the computed total population from the five-year age groups data. By applying the percentage distribution of the difference between the published and computed population age and sex structure from the 2008 census to the 1993 census, a no-change assumption is made on the age and sex characteristics of the military population. Adlakha and West (1997: 9–10, Table 9) provide the only available alternative estimate for the 1993 population structure based on a reconstruction of the population from the sex ratios. The difference between the present adjustment based on the 2008 census data and the Adlakha–West reconstructed population was, however, very small.[5]

Neither the 1993 nor the 2008 census collected data on total children born and surviving children, making it impossible to apply Brass-type methods to derive indirect fertility and mortality estimates. However, both censuses did record the number of live births in the 12 months preceding the census to women 15–49 years of age, as well as the number of deaths in the 12 months preceding the census by age group and sex of the deceased. Coupled with
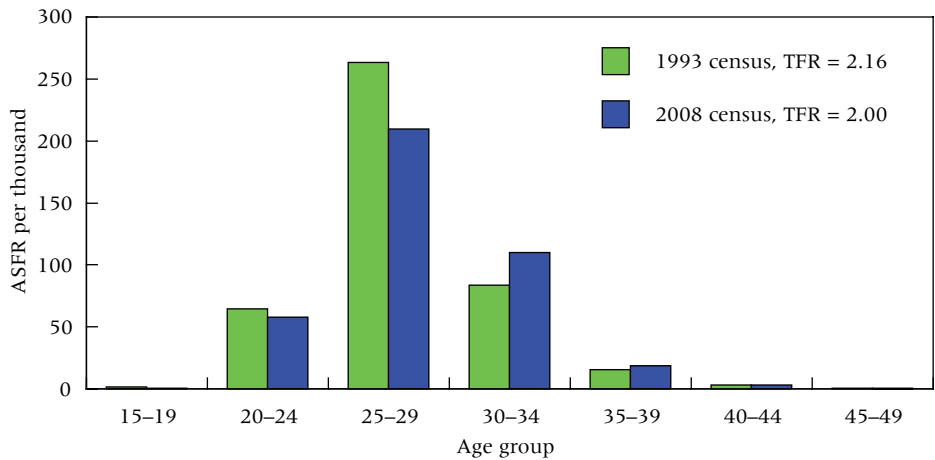
the population by age and sex, we could thus compute classic fertility and mortality indicators—that is, age-specific fertility rates and total fertility, and age-specific death rates and life tables.

Fertility

We computed the estimates of total fertility from the number of births in the 12 months preceding each census and the female population by age and sex. Because the women were on average one-half year younger at the time of childbirth than their reported age at the time of the census, we adjusted the age-specific fertility rates (ASFRs) for one-half year of age.

The age-specific fertility data from North Korea contain some incongruities, however (Figure 4). The shape of the age rates is quite unusual, showing a highly concentrated age distribution of fertility. More than half of the births are concentrated among women aged 25–29. By contrast, fertility is extremely low among younger (15–19) women. These age profiles raise questions about the quality of data collected in the 1993 and 2008 censuses. However, the concentration of fertility in the late 20s was probably the result of the long military draft.[6] The government does not give individuals permission to marry early on the grounds that this would lower the morale of military recruits (Schwekendiek 2011). After completion of military service, young couples marry and start a family. Further, the government enforces abortions and provides free contraceptive devices for women to prevent unwanted births and to stem population growth (ibid.). The fertility rate of older North Korean women (ages 40–49) is very low. Contributing factors are the government pressure on families to have only one or two children and the high female

FIGURE 4   Age-specific fertility rates and total fertility rates (TFR), North Korea, 1993 and 2008 censuses

labor force participation in the socialist economy. In addition, there are indications that a significant proportion of North Korean women are infertile, in part perhaps as a result of malnutrition (ibid.). Age distributions of fertility collected in the 2002, 2004, and 2006 Reproductive Health Surveys (RHS) present similar age patterns (DPRK Central Bureau of Statistics 2004, 2007; WHO 2007), providing further evidence of and confidence in the plausibility of the census data. Furthermore, although at a much lower fertility level, a similar age pattern can be found in South Korea.
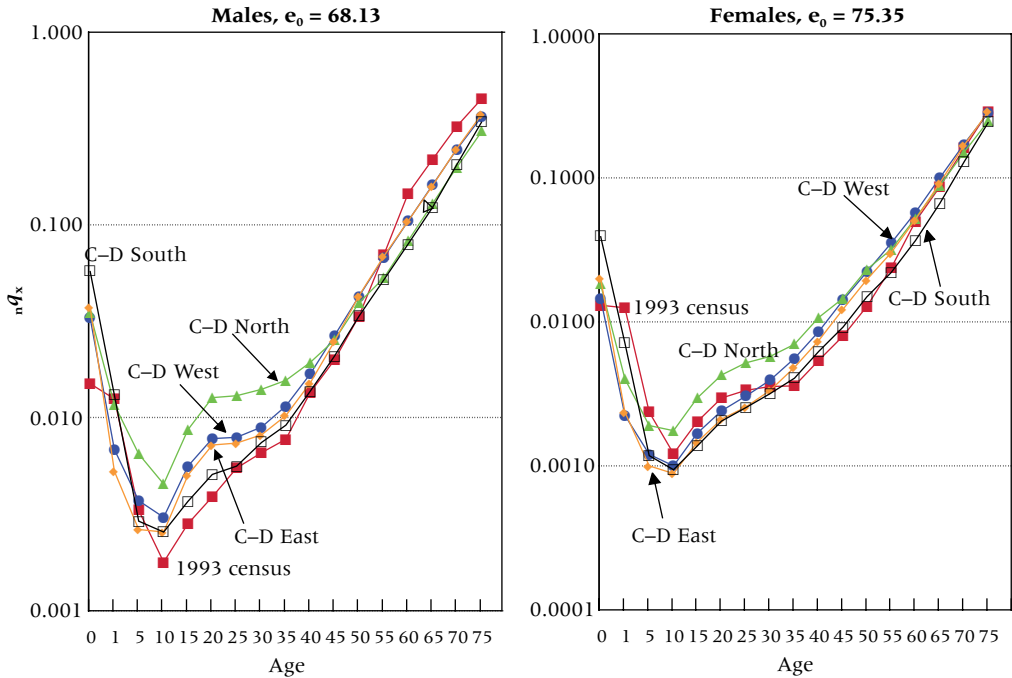
According to the number of births tabulated in the 1993 and 2008 censuses and the female population by age and sex, the total fertility rate appears to have remained relatively stable over the last 15 years: 2.16 children per woman in 1993 and 2.00 children per woman in 2008. However, the census data show fertility only at both ends of this 15-year period and do not allow assessment of the effect of famine on fertility. It has been widely reported that women bear fewer children in times of famine, but once the crisis passes, fertility peaks as a result of recuperation (Dyson and Ó Gráda 2002). Such a demographic response seems to be evident in North Korea as well. According to the 2000 MICS report and the 2002 RHS data (DPRK Central Bureau of Statistics 2000: 19; WHO 2007), the total fertility rate declined to 2.00 children per woman in 1999 at the end of the famine before increasing in the early 2000s to 3.06 children per woman, followed by a decline to 2.23 children per woman in 2004 and a slight rise to 2.35 children per woman in 2006 (DPRK Central Bureau of Statistics 2000, 2004, 2007).

Mortality

Based on the 1993 and 2008 census data, we computed abridged life tables using the number of deaths in the 12 months preceding the census and the population by age and sex. The civilian population was used in the case of the 1993 census.

Comparison of the age-specific probabilities of dying ($_nq_x$) computed from the 1993 census data and the Coale–Demeny model life tables at corresponding levels of life expectancy at birth (e_0) revealed several inconsistencies in the 1993 census data (Figure 5). First, the difference between $_1q_0$ and $_4q_1$ was unusually small. At a corresponding level of e_0 (68.13 for men; 75.35 for women), a striking difference was apparent between the mortality patterns at young ages recorded in the 1993 census and the Coale–Demeny model life tables. In the 1993 census data, $_1q_0$ is almost equal to $_4q_1$, whereas in the mortality models, $_1q_0$ is considerably higher than $_4q_1$. Such a mortality pattern at young ages can potentially be the result of (1) medical termination of high-risk pregnancies, contributing to artificial reduction of infant mortality, and/or (2) comparatively high child mortality. Besides questionable data quality, the evidence from North Korea indicates that the first explanation (specific medi-

FIGURE 5   Comparison of age-specific probabilities of dying ($_nq_x$) by sex computed from the 1993 North Korean census with the Coale–Demeny (C–D) model life tables at corresponding levels of life expectancy at birth (e_0)
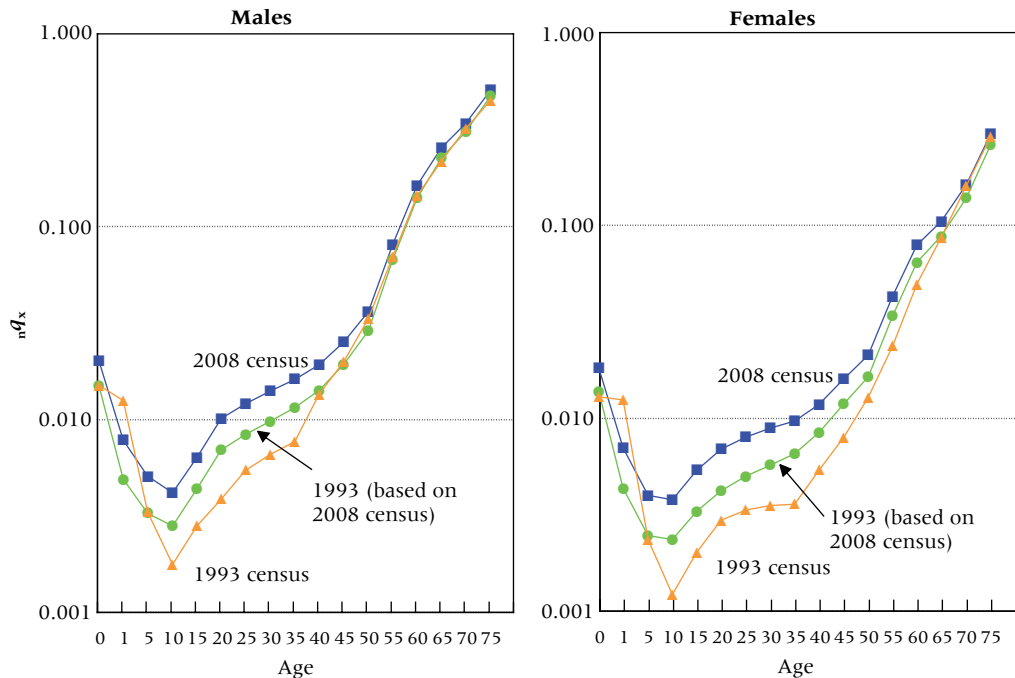

NOTE: For illustrative purposes, the distance between ages 0–1 and 1–4 years is shown as equal to the other five-year age groups. Vertical axis is on logarithmic scale.

cal intervention) is more likely to have contributed to the mortality pattern at young ages. According to Eberstadt and Banister (1992a: 137), high-risk pregnancies were closely monitored in North Korea, and deformed fetuses were aborted based on the results of ultrasonic examinations at six months of pregnancy. Moreover, $_4q_1$ computed from the male 1993 census data is slightly more consistent with $_4q_1$ observed in each Coale–Demeny model life table at a corresponding level of e_0, thus giving less credit to the second explanation (high child mortality). However, while specific medical intervention could play a role in the small difference in mortality in the first years in life, the most likely explanation is certainly to be found in the deficient quality of the 1993 census mortality data. Supporting this hypothesis is the fact that the small difference in mortality at young ages is larger for girls than for boys, suggesting that more female fetuses were aborted and that female child mortality was higher (compared to infant mortality), although parental discrimination against daughters is believed to be largely absent in North Korea (Goodkind 1999; Schwekendiek 2010b).

Another inconsistency was found in mortality at young adult ages. Whereas at a corresponding level of e_0, female mortality between ages 5 and 29 corresponded to the Coale–Demeny model life tables, male mortality between ages 10 and 24 was considerably lower than all of the model life tables. Furthermore, the mortality crossover between sexes at age 20 was very unusual. This can be explained by (1) the underestimation of male mortality between ages 10 and 24 and/or (2) an unexplained plateau in female mortality between ages 25 and 39. On the one hand, the underestimation of male mortality at ages 10–24 could result from exceptionally incomplete reporting of deaths at these ages (underestimation of the numerator) and/or the overcounting of the male population at these ages (overestimation of the denominator). On the other hand, a plateau in female mortality at reproductive ages could be related to low maternal mortality resulting from both age-specific reproductive patterns and the practice of (late) induced abortion noted above.

A further indication of problems with the 1993 mortality data can be gained from comparison with the 2008 census data. Figure 6 compares the

FIGURE 6   Comparison of age-specific probabilities of dying ($_nq_x$) by sex computed from the 1993 and 2008 North Korean census with $_nq_x$ obtained by applying the mortality age pattern observed in 2008 to the value of e_0 recorded in 1993

NOTE: For illustrative purposes, the distance between ages 0–1 and 1–4 years is shown as equal to the other five-year age groups. Vertical axis is on logarithmic scale.

age-specific probabilities of dying ($_nq_x$) computed from data from each census with probabilities produced by applying the mortality age patterns recorded in the 2008 census to the level of e_0 computed from the 1993 census data. The age- and sex-specific mortality patterns recorded in the 2008 census are generally more consistent with empirical mortality patterns that have been observed across populations and do not exhibit atypical variations in either infant (under age 1) and early childhood (ages 1–4) mortality or in adult mortality. The 2008 mortality pattern by age is indeed more consistent with various Coale–Demeny model life tables at a corresponding level of e_0 (not shown here). Yet, compared to the model life tables, both $_1q_0$ and $_4q_1$ are still lower in the 2008 North Korean census data. However, the 2008 census data yield a distinctly different mortality age pattern from that of the 1993 census data. It is not clear how the two mortality age patterns only 15 years apart could be so different.[7]

Changes in e_0 give a first overall perspective on the performance of North Korea between 1993 and 2008. According to the 1993 and 2008 census mortality data, life expectancy at birth declined during the intercensal period from 68.1 years to 65.3 years for men and from 75.4 years to 72.0 years for women. Among the few other available official data, the 2000 MICS report indicated an e_0 for both sexes of 66.8 years in 1999 at the end of the famine (a decline of 6.4 years from the 1993 e_0 of 73.2 years) and increases of 1.6-fold and 1.8-fold in infant and under-five mortality, respectively, between 1993 and 1999 (DPRK Central Bureau of Statistics 2000: 27).[8] Furthermore, the same report noted that both infant and under-five mortality dropped between 1998 and 1999, indicating that the mortality levels in the preceding years were higher.

The analysis of single-year intercensal cohort survival ratios could theoretically shed further light on the age-specific mortality effect of the deteriorating living conditions in North Korea. Yet, data quality issues make such analysis difficult. The underreporting of infants and young children and/or the undercounts or overcounts at specific ages could affect any conclusion based on the intercensal cohort survival ratios. This bias, common in many censuses, could be more important in the 1993 census given that technical assistance was much more limited than for the 2008 census, as noted above. Furthermore, the 1993 census data by single year of age do not include the military population, making any analysis of single-year intercensal cohort survival ratios even more tentative.

Despite these shortcomings, we made several attempts to reconstruct the population by single year of age in 1993. Two series of corrections were tested. A first series of corrections sought (1) to distribute the female military population down to single year of age under different assumptions and (2) to apply several different sex ratios (from the 2008 census and from other countries at similar life expectancies—e.g., Sweden in 1955; the United States in 1975

(Human Mortality Database 2011)) to the 1993 female population to obtain a corrected male population by single year of age for ages 15 and over. The resulting single-year intercensal cohort survival ratios still exceeded 1 at ages 20–24 and exhibited erratic variations at other ages. The second series of corrections applied standard interpolation methods maintaining the given value by five-year age group (Karup-King, Sprague, Beers "ordinary") to the 1993 population adjusted to include the military population (as described earlier). For purposes of comparison, the 2008 data also had to be interpolated using the same methods. The resulting intercensal cohort survival ratios were more satisfactory. The spliced intercensal cohort survival ratios (i.e., from ages 0–14 in 1993 the survival ratios were computed based on the original census data, and from ages 15 and over in 1993 the survival ratios were computed using the interpolated data) indicate that the deteriorating living conditions in the country affected men more than women. While the possible underreporting of infants and young children in the 1993 census complicates any definitive conclusion on the level and sex-specific pattern of intercensal mortality of the young birth cohorts, the interpolated data indicate higher intercensal male mortality at other ages, especially among men between ages 25 and 34 in 1993. Finally, male intercensal survival ratios decreased much more abruptly, indicating that men suffered higher mortality during the famine in North Korea. These results corroborate the findings of previous studies showing (1) that women biologically are more resistant to nutritional deprivation (Macintyre 2002) and (2) that biological and not behavioral factors were responsible for differentials in survival ratios during the famine (Goodkind 1999; Schwekendiek 2010b). Contrary to the situation in many other traditional Asian societies, this second result provides further confirmation that sex-specific intra-household resource allocation is not an issue in North Korea.

Reconstructing population trends in North Korea, 1993–2008

Based on the census data, additional available official estimates, and the estimates of previous scholars, we reconstructed population trends in North Korea between 1993 and 2008 using the cohort component method of population projection (George et al. 2004). The 1993 census population by age and sex was projected prospectively to 2008 under specific fertility and mortality assumptions in order to find the best match to the population by age and sex enumerated in the 2008 census. While reconstructing population trends in North Korea, we assumed that international migration was nonexistent[9] and that the sex ratio at birth stayed constant at 1.05 (Goodkind 1999; Schwekendiek 2010b). The reconstruction used the 1993 base-year population by age group and sex, adjusted for the inclusion of the military population and the computed fertility and mortality indicators.

Fertility

The census data indicate relatively similar levels of fertility at both ends of the intercensal period, but according to the survey figures (2000 MICS and 2002, 2004, and 2006 RHS), total fertility declined slightly during the famine and increased in the early 2000s. The different attempts to reconstruct the country's population to account for such a fertility trend have remained unsuccessful, however. With the mortality scenarios tested (see below), if the rebound of total fertility to 2.4 or 3.0 children per woman in 2001–02 was real, the population in the 5–9 age group would be well above that indicated by the 2008 census data. Therefore, and accounting for a lagged effect of the famine on fertility, we assumed that total fertility declined to 2.14 children per woman in 1994, 2.1 in 1995, 2.0 in 1996, and 1.8 in 1997 and 1998 and returned to 2.0 children per woman by 1999 and remained at this level during the rest of the projection period. The age pattern of fertility used to project the 1993 population to 2008 took the 1993 and 2008 adjusted age-specific fertility rates as starting and final points; the ASFRs for the intermediate years were linearly interpolated with respect to the corresponding total fertility rates.

Mortality

We used the values of e_0 for both sexes computed from the census data together with other mortality estimates and model life tables. The mortality assumptions are based on changes in e_0 and the use of the Coale–Demeny and United Nations model life tables (Coale and Demeny 1983; United Nations 1982), as well as the mortality patterns from the 2008 census data (the deficient 1993 mortality patterns were omitted). Six different mortality scenarios were explored: (1–4) the four series of estimated changes in e_0 between 1993 and 1999 proposed by Goodkind and West (2001) were tested using the nine model life tables and the 2008 census-based mortality patterns while applying the sex ratio between male and female e_0 values observed in the 1993 data to both sexes; (5) the absolute difference in e_0 between each year during the Great Leap Forward in China (1958–62) and the year just before the onset of the famine (1957) was applied to the North Korean level of e_0 starting from 1994; and (6) the absolute increase observed in the age-specific death rates in China between each successive famine year and 1957 was applied to North Korea's 1993 (unadjusted and adjusted) age-specific death rates.

Based on the degree of consistency between the reconstructed and observed populations in 2008, we selected three mortality scenarios from this exploratory analysis (Table 1). The first scenario is based on the reconstruction of the trend in e_0 made by Goodkind and West (2001: 226) from official data from North Korea. The second scenario, also taken from the estimation by

TABLE 1 Changes in life expectancy at birth (e_0) in three mortality scenarios selected to reconstruct the 2008 population of North Korea by age and sex

Year	Scenario 1 (based on official North Korean data)		Scenario 2 (based on reconstructed data from the Chinese famine, with adjusted infant mortality rates)		Scenario 3 (based on reconstructed data from the Chinese famine)	
	Males	Females	Males	Females	Males	Females
1993	68.13	75.35	64.66	71.51	68.13	75.35
1994	67.22	74.35	64.66	71.51	67.92	74.77
1995	67.22	74.35	59.24	65.52	55.60	63.61
1996	60.85	67.30	54.67	60.47	46.48	59.30
1997	60.85	67.30	50.78	56.16	48.25	62.51
1998	60.85	67.30	50.78	56.16	61.57	69.84
1999	67.22	74.35	56.86	62.89	68.11	74.79
2000	68.13	75.35	64.66	71.51	68.13	75.35
…	…		…		…	
2008	65.32	72.00	65.32	72.00	65.32	72.00

NOTE: See text for full description of the scenarios. Between 2000 and 2008, the values of e_0 are linearly interpolated.

Goodkind and West, is based on the changes in e_0 computed from the reconstructed mortality patterns of the famine during the Great Leap Forward in China (Luo 1988), adjusted for the implied infant mortality rates from a North Korean child malnutrition survey and international data (Goodkind and West 2001: 230, Table 3). The last scenario, based on the reconstructed mortality patterns during the famine in China (Luo 1988), applies the absolute difference in e_0 for each sex between each famine year (1958–62) and the year just before the onset of the Great Leap famine in China (1957) to the North Korean level of e_0 starting from 1994. All scenarios assume that e_0 returns to its 1993 level in 2000 and then rises or falls linearly between 2000 and 2008.

We identified the most consistent 2008 reconstructed population by comparing the 2008 reconstructed population with the 2008 census population using a goodness-of-fit statistic computed as the absolute average deviation (AAD) between the 2008 observed and projected populations:

$$AAD_a^b = \frac{\sum_a^b \left(\left(\left| P_{x,x+5}^{obs} - P_{x,x+5}^{proj} \right| \cdot 100 \right) / P_{x,x+5}^{obs} \right)}{n}$$

where a and b indicate the lower and upper age groups being considered; $P_{x,x+5}^{obs}$ is the 2008 observed population in age group x, $x+5$; $P_{x,x+5}^{proj}$ is the 2008 projected population in age group x, $x+5$; and n is the number of age groups.

We computed the AAD for the age ranges 0–14 (AAD_0^{14}) and 0–84 (AAD_0^{84}). We selected the most consistent mortality model and scenario on the basis of the lowest AAD values and graphical examination. For all three mortality scenarios, the values of AAD_0^{14} and AAD_0^{84} were the lowest for women, indicating higher consistency with the 2008 census population by age and sex (Table 2). The mortality models that best reproduced the 2008 enumerated population are (1) the 2008 pattern, (2) the UN Far Eastern, and (3) Coale–Demeny East. According to the AAD values and graphical examination, the mortality model based on the 2008 pattern under scenario 1 most consistently reproduced the 2008 population by age and sex. Some other mortality patterns under different scenarios gave lower values for AAD_0^{14} or AAD_0^{84}, but not for both indicators. For example, the 2008 pattern in scenario 2 gave the smallest AAD_0^{84} for men (2.44), but the population in age group 10–14 was 5.0 percent lower than in the 2008 census data. In contrast, the same mortality pattern in scenario 1 returned a higher AAD_0^{84} (5.48), but the fit for the 10–14 age group in 2008 was much closer (only 1.3 percent lower than the 2008 census data). The population reconstructions based on scenarios 2 and 3 systematically gave too low a number of people in the age group 10–14 in 2008 (i.e., children who were born during the famine), likely indicating that these scenarios assumed levels of infant and child mortality that were too high.

Table 3 compares the 2008 observed population by age and sex with the reconstructed population using the 2008 pattern under scenario 1. The reconstructed male total population was 0.8 percent higher than the observed male total population (a difference of 94,000 persons), whereas the reconstructed female total population was lower by only 0.08 percent than the observed female total population (a difference of 10,000 persons). The percentage difference by age group between the two populations in 2008 remains under 5 percent for men until age group 65–69, and does not exceed 2 percent for women until the age group 75–79.

The percentage differences in Table 3 are instructive regarding the selected mortality pattern and scenario. For a given age group, a negative difference points to a reconstructed population that is too high compared to the observed population and, thus, age-specific mortality that is too low; a positive difference points to an overly low reconstructed population and, thus, an overly high age-specific mortality. For both sexes, the negative figures for the 0–4 and 5–9 age groups indicate that the assumed infant and child mortality was too low in the early 2000s. Similarly, the negative percentage differences at older age groups (starting from age 55 for men) indicate that the mortality pattern selected reproduced these age groups less satisfactorily. Further, the adult mortality assumed by the 2008 pattern of mortality was too high, as shown by the mainly positive values among the 35–49 age group (especially for women). Despite these caveats, we found that the population of North Korea could be consistently reconstructed using straightforward demographic

TABLE 2 Absolute average deviation between ages 0 and 84 (AAD_0^{84}) and 0 and 14 (AAD_0^{14}) between the 2008 observed and projected population of North Korea, by sex

Mortality model	Scenario 1 (based on official North Korean data)				Scenario 2 (based on reconstructed data from the Chinese famine, with adjusted infant mortality rates)				Scenario 3 (based on reconstructed data from the Chinese famine)			
	Male		Female		Male		Female		Male		Female	
	AAD_0^{84}	AAD_0^{14}	AAD_0^{84}	AAD_0^{14}	AAD_0^{84}	AAD_0^{14}	AAD_0^{84}	AAD_0^{14}	AAD_0^{84}	AAD_0^{14}	AAD_0^{84}	AAD_0^{14}
UN Latin American	27.22	4.14	4.57	2.13	24.63	7.66	4.76	5.33	26.19	6.26	4.61	3.14
UN Chilean	23.23	3.01	4.41	2.16	20.16	6.33	4.69	5.29	21.79	5.04	4.51	3.17
UN South Asian	24.15	4.89	3.72	2.37	21.14	8.67	3.44	5.82	22.89	7.24	3.54	3.45
UN Far Eastern	13.36	1.14	3.63	0.74	10.75	3.25	4.74	2.71	12.14	2.48	3.68	1.10
UN General	21.56	2.71	3.64	1.26	18.48	6.11	4.09	4.30	20.18	4.78	3.84	2.24
C–D West	19.20	1.99	2.71	0.93	17.39	5.82	3.79	3.33	18.37	4.32	2.93	1.51
C–D North	27.59	3.11	3.73	0.80	25.48	6.76	4.37	4.12	26.56	5.20	4.00	1.88
C–D East	18.24	2.28	2.19	0.82	16.46	6.42	3.00	4.04	17.72	4.94	2.34	1.68
C–D South	25.08	4.92	4.76	2.81	22.25	8.59	3.46	6.29	24.11	7.19	4.61	3.92
"2008 pattern"	5.48	1.08	2.75	0.59	2.44	2.96	3.71	2.86	4.59	1.91	2.91	0.96

NOTE: See text for full description of the scenarios.
C–D = Coale–Demeny.

TABLE 3   Comparison of the 2008 observed and projected population (thousands) of North Korea by age and sex

Age group	Male observed	Male projected	Female observed	Female projected	Percentage difference (obs.−proj.) Male	Female
0–4	872.2	883.1	837.9	842.3	−1.25	−0.53
5–9	943.0	949.7	903.7	906.8	−0.70	−0.34
10–14	1,035.3	1,021.9	986.1	977.3	1.29	0.89
15–19	1,050.1	1,049.7	1,002.2	997.4	0.04	0.48
20–24	941.0	939.1	900.4	893.8	0.20	0.73
25–29	887.6	880.6	849.6	843.9	0.78	0.67
30–34	853.3	853.9	827.0	832.4	−0.08	−0.65
35–39	1,118.4	1,098.4	1,096.5	1,080.8	1.79	1.43
40–44	1,005.1	1,013.2	1,010.4	994.3	−0.81	1.59
45–49	766.1	753.4	793.5	785.7	1.65	0.98
50–54	637.7	633.4	677.4	663.8	0.68	2.00
55–59	423.6	440.0	479.3	481.5	−3.87	−0.46
60–64	476.7	500.1	581.5	577.4	−4.91	0.72
65–69	379.5	413.1	533.8	527.3	−8.88	1.23
70–74	228.3	259.8	434.3	429.5	−13.82	1.12
75–79	79.2	98.7	256.2	272.4	−24.58	−6.30
80–84	18.9	24.1	113.3	143.5	−27.84	−26.69
85+	5.8	3.5	47.3	70.1	40.40	−48.34
Total	11,721.8	11,816.0	12,330.4	12,320.0	−0.80	0.08

assumptions. Indeed, the consistency between the reconstructed population and the 2008 census population by age and sex is remarkable.

The most consistent reconstructed population was obtained from the "2008 pattern" mortality model under scenario 1. Both the mortality model and scenario are based on the official data from North Korea, suggesting that the government did not try to conceal the mortality impact of the famine of the mid-1990s. The results from the present population reconstruction substantiate the conclusion of Eberstadt and Banister (1992a: 11, 68) that the official population data from North Korea are in general consistent and reflect reality.

Based on the present population reconstruction of North Korea, between 1993 and the peak of the famine, infant mortality ($_1q_0$) doubled for boys and girls; male and female under-five mortality ($_5q_0$) increased 2.3-fold (2.29 for boys and 2.32 for girls); and male and female adult mortality increased 2.09- and 2.64-fold. These increases should be interpreted cautiously, keeping in mind that these mortality changes are the result of the selection of both a mortality pattern and scenario that reproduce less satisfactorily the male population by age and sex in 2008 (Table 2) as well as in some age groups (Table 3).

Estimates of the demographic impact of famine and the human cost of deteriorating living conditions in North Korea

We used counterfactual population projections to estimate the demographic impact of the famine in the 1990s and the human cost of the deteriorating living conditions in North Korea between 1993 and 2008. Counterfactual projections allow us to demonstrate what would happen to a population if a series of changes occur or do not occur. By holding constant all demographic parameters in the population projection model and changing the assumption for only one parameter, we can estimate the demographic impact of a change or intervention. For North Korea, we ran five different counterfactual population projections with alternative mortality scenarios to obtain low and high estimates of the demographic impact of the famine as well as an estimate of the human cost of the deteriorating living conditions over the intercensal period.

The first counterfactual projection estimates what the population of North Korea would have been in 2008 if the famine had not occurred but in presence of the deteriorating living conditions during the 2000s. Specifically, the level of e_0 for both sexes was held constant from 1993 to 2000 and then allowed to decline linearly until 2008. The result of this first projection can be taken as a new low estimate of the demographic impact of the famine in the 1990s. The second and third counterfactual projections provide two high estimates of the demographic impact of the famine and estimate what the population of the country would have been had e_0 in North Korea recorded the same annual increase between 1993 and 2000 as (a) in South Korea and (b) in China, and had declined linearly thereafter from its 2000 level to the 2008 census level. The last two counterfactual projections tested what would have happened if e_0 in North Korea had increased at the same pace between 1993 and 2008 as (a) in South Korea and (b) in China. These fourth and fifth projections produced demographic estimates of the total human costs of the deteriorating living conditions during the 15 intercensal years, including the famine. China and South Korea, both neighboring countries, were chosen in order to assess the sensitivity of the counterfactual population projections. South Korea was a natural choice since the country has demographic trends comparable to those of North Korea, especially regarding mortality levels in the late 1980s and early 1990s, despite 40 years of different socioeconomic development paths (Eberstadt and Banister 1992b; Larivière 1995). China was selected because its life expectancy at birth in 1993 was comparable to, although somewhat lower than, the values observed at the same period in North Korea.[10]

The results of the five counterfactual population projections are given in Table 4. According to the first projection, the population of North Korea

TABLE 4   Implied total population of North Korea in 2008 resulting
from five counterfactual population projections (thousands)

Counterfactual population projection	Total population in 2008 (000)		Difference (proj.−recon.) (000)
	Population reconstruction	Counterfactual projection	
First	24,136	24,373	237
Second	24,136	24,553	417
Third	24,136	24,454	318
Fourth	24,136	24,970	834
Fifth	24,136	24,724	588

NOTE: Population reconstruction refers to the 2008 population reconstructed through population projection and serves as a reference to assess the demographic effect of the counterfactual population projections (see preceding section). See text for description of the five counterfactual population projections.

would have reached 24.373 million on 1 October 2008 if the famine had not occurred and life expectancies for each sex had remained constant at their 1993 levels between 1993 and 2000 (against 24.136 million at the same date according to the population reconstruction that includes the famine). The results of the second and third counterfactual population projections indicate that the country would have counted a total population of 24.553 million on 1 October 2008 if e_0 had recorded the same annual increase as e_0 in South Korea between 1993 and 2000, and a total population of 24.454 million if e_0 had increased annually as in China between 1993 and 2000. Based on these figures, we can revise the demographic impact of the famine in the 1990s to include between 240,000 and 420,000 total excess deaths, accounting for 1–2 percent of the country's population. These revised estimates are well below the previous and widely accepted range of estimates of 600,000 to one million (Goodkind and West 2001) and well below the claims by Jasper Becker and others of 3 million victims of the famine in North Korea.

Alternatively if e_0 had increased annually by the same amount as in South Korea over the 15 intercensal years (as in the fourth counterfactual projection), the total population of North Korea would have reached 24.970 million on 1 October 2008. Similarly, had e_0 increased annually as in China between 1993 and 2008 (fifth counterfactual population projection), the total population of North Korea would have been 24.724 million on 1 October 2008. Compared to the 2008 reconstructed total population, the fourth and fifth counterfactuals produce a range of estimates of the human cost of the deteriorating living conditions over the 15 intercensal years of between almost 600,000 and 850,000 total excess deaths. According to these figures, the number of total excess deaths caused by the deterioration of living conditions in the 2000s is as high as or higher than the number attributed to the famine in the 1990s.

Conclusion

Publication of the results of the 2008 population and housing census of North Korea offers an opportunity to examine recent population trends in that country. The 2008 population by age and sex was reconstructed using the 1993 and 2008 census data to test the plausibility of different fertility and mortality scenarios. Despite evidence from survey reports, a classic fertility rebound after the famine was unlikely in North Korea. Such a rebound would have to have been accompanied by a substantial mortality increase in order to reproduce the 2008 population in the young age groups. Among the different mortality scenarios we tested, the 2008 population by age and sex was most closely reproduced under straightforward mortality assumptions derived from official data. It is evident that the selected age pattern of mortality and mortality scenario better reconstructed some age groups than others, giving further information on the likely age-specific mortality changes during the intercensal period that the population projection model could not account for. All in all, the consistency between the reconstructed population using prospective population projections with simple demographic assumptions and the 2008 census population by age and sex is remarkable.

The finding that the 2008 population by age and sex was best reproduced under mortality assumptions derived from official data supports the conclusion that the government of North Korea did not try to minimize the demographic impact of the famine for the outside world. Although this conclusion is based on one possible and consistent reconstructed version of what could have happened during the last intercensal decade in the country, it contradicts many judgments on the doubtful quality of the official social and demographic statistics from North Korea.

Using counterfactual population projections, we reappraised the demographic impact of the famine. According to the first three counterfactual mortality scenarios, the total number of excess deaths caused by the famine in the 1990s came to between 240,000 and 420,000, a range well below the widely accepted previous estimates of 600,000 to one million total excess deaths or the recent revision that set the number between 500,000 and 600,000 (Goodkind, West, and Johnson 2011: 12). While the new estimates proposed here indicate a substantially lower number of deaths, they still point to a high number of deaths that could have been avoided.

Finally, assuming that life expectancy at birth in North Korea experienced the same increases as observed in South Korea and in China between 1993 and 2008, we proposed a range of estimates of the human cost of the deteriorating living conditions in North Korea over those 15 years. According to these estimates, if the famine and general deterioration in living conditions had not occurred, the population of North Korea would have been larger by about 600,000 to 850,000. These last estimated figures suggest that the num-

ber of deaths attributable to the deterioration in living conditions in the ten years following the famine is as high as and probably higher than the number of deaths attributable to the famine.

A number of the assumptions made here could be called into question. The premise that North Korea is a society closed to migration might not necessarily be true and could bias the intercensal figures estimated here. For instance, North Koreans have worked in Russian lumber camps since 1967 (Schwekendiek 2011: 143); however, these migrant workers were probably outside of North Korea during both the 1993 and 2008 censuses. More importantly, while it is likely that some 100,000–400,000 North Koreans fled to China during the famine around the mid-1990s, the majority had returned to North Korea by 2008 when the census was conducted. Most of them were sojourners and children working or looking for food, and they returned home after the famine. About 70,000–80,000 North Koreans were believed to have stayed permanently in China in the mid-2000s, and about 15,000 had relocated to South Korea by 2008 (Schwekendiek 2010a). Further, these North Korean refugee figures often include children resulting from mixed unions of North Korean women and Chinese men (because North Korean refugees reside illegally in China, their children of mixed parentage cannot be registered in either China or North Korea). Hence, this does not affect the internal population of North Korea. Yet, emigration is likely to bias the 2008 census of North Korea by some 70,000–80,000 persons fleeing to China permanently, although these refugee figures for China remain highly speculative. According to Goodkind, West, and Johnson (2011: 6, citing Robinson 2010), fewer than 40,000 people left the country between 1993 and 2008. But because of the illegal status of North Koreans escaping to China, it is very difficult to measure actual emigration rates. Undoubtedly, accounting for international migration in the prospective reconstruction of the intercensal population changes in North Korea would to some degree reduce the total excess deaths estimated in this analysis.

Another concern is that the intercensal cohort survival ratios derived from the 1993 and 2008 censuses might not be only a result of higher mortality during that observed period. Further possible explanations include underreporting of infants. For instance, infant deaths were reclassified as stillbirths up to 10 days after birth by the North Korean government (Eberstadt and Banister 1992a: 116). Similarly, the differences between the 2008 population projection and the 2008 census might be due to problems in the original 1993 census counts, including undercounts or overcounts at various ages. Hence, further technical explanations might account for a fraction of the excess mortality rates. However, while these are common concerns with any census, the more important finding is that North Korea's government does not seem to adjust its demographic data based on political considerations.

The reconstructed population trends reflect continuing deterioration in the living conditions in North Korea since the early 1990s, with potentially far-reaching social, economic, and political consequences.

Notes

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1 On these points, see Eberstadt, Rubin, and Tretyakova 1995; Natsios 2001; Eberstadt 2007; Haggard and Noland 2007 and 2011; Schwekendiek 2011.

2 The results of the post-enumeration survey indicate nearly 100 percent completeness for the 2008 census. No post-enumeration survey seems to have been conducted after the 1993 census (Engracia 2010).

3 As a rough quantification of the impact of the Korean War, the sex ratio of the population aged 60 and over in the 1993 census reached 0.53 (i.e., 53 men per 100 women). In comparison, in other countries with similar life expectancies (according to the 1993 census data, the life expectancy at birth for both sexes was 72.6 years in North Korea), the sex ratio of the population aged 60 and over is 0.70 in the Czech Republic, 0.78 in Argentina, 0.84 in Thailand, and 0.90 in Syria in 1995 (United Nations 2011) or 0.74 in the United States in 1975 and 0.88 in Sweden in 1955 (Human Mortality Database 2011). These numbers suggest that men aged 60 and over are 30–70 percent less numerous in North Korea than in countries cited here for comparison.

4 Accepting the difference between the published total population and the total population computed from the age and sex distribution as an estimate for the military population of North Korea implies a decrease in the size of the army by some 40 percent from an estimated 1.2 million in 1986 (Eberstadt and Banister 1992a: 86–97).

5 For males, the difference between our adjusted series and the Adlakha–West reconstruction reaches a maximum of +3.31 percent

in age group 20–24 and –3.24 percent in the age group 30–34. For females, the largest difference between the two series is observed at age groups 15–19 and 20–24 with –1.64 and +1.33 percent respectively.

6 Males in North Korea were conscripted for a period of ten years in 1993; length of conscription was raised to 14 years in 1996 and reduced to ten years in 2003. Women are not drafted by law but unmarried women often join the army voluntarily. In the late 1990s, the legal age for marriage was 27 years for women and 30 for men (Schwekendiek 2011).

7 The different attempts to use the observed 1993 mortality age patterns and the different scenarios regarding the change in e_0 (see below) to reproduce the 2008 population as closely as possible to the 2008 census population by age and sex were not successful.

8 As noted in the MICS report, the figures for infant and under-five mortality are direct estimates "based on data on population collected through unified system of CBS (Central Bureau of Statistics) instead of an indirect estimation technique (the Brass method)" (DPRK Central Bureau of Statistics 2000: 27).

9 Official estimates from the Ministry of Unification, Republic of Korea, put the number of North Korean nationals living in China at 100,000 in October 2010 (Haggard and Noland 2011: 2). According to a count of North Korean refugees through a network of community contacts in the border between the two countries, between 5,000 and 15,000 North Korean nationals were residing in the three Chinese provinces bordering North Korea (Robinson 2010 cited in Haggard and Noland 2011: 2). On the migration of North Korean nationals to China, see also Smith (2005) and Lee (2006: 17–20). For a meta-analysis of North Korean migration to China and South Korea, see Schwekendiek (2010a).

10 The annual data for China and South Korea are taken from United Nations (2011). Ideally, this sensitivity analysis would have

used life expectancy at birth for the Chinese provinces bordering North Korea (i.e., Jilin and Liaoning). While such estimates are available for 1990 and 2000, more recent Chinese province-level estimates of life expectancy at birth could not be found.

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