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Demography of a man-made human catastrophe: The case of massive famine in Ukraine 1932–1933

Omelian Rudnytskyi
Nataliia Levchuk
Oleh Wolowyna[1]
Pavlo Shevchuk
Alla Kovbasiuk

Abstract

Estimates of 1932–34 famine direct losses (excess deaths) by age and sex and indirect losses (lost births) are calculated, for the first time, for rural and urban areas of Ukraine. Total losses are estimated at 4.5 million, with 3.9 million excess deaths and 0.6 million lost births. Rural and urban excess deaths are equivalent to 16.5 and 4.0 per cent of respective 1933 populations. We show that urban and rural losses are the result of very different dynamics, as reflected in the respective urban and rural age structures of relative excess deaths.

Keywords: 1932–33 Ukraine famine, Holodomor, 1932–33 famine urban-rural losses, excess deaths, lost births.

Résumé

Les estimations de 1932–1934 famine pertes directs (surmortalité) par âge et sexe et indirects (naissances perdues) sont calculées, pour la première fois, pour les zones rurales et urbaines de l'Ukraine. Les pertes totales sont estimées à 4,5 millions, avec 3,9 millions de décès en excès et 0,6 millions de naissances perdues. Surmortalité rurales et urbaines sont équivalents à 16,5 et 4,0 pour cent de 1933 populations respectives. Nous montrons que les pertes urbaines et rurales sont le résultat d'une dynamique très différente, comme en témoignent les structures d'âge urbaines et rurales respectives de surmortalité relatifs.

Mots - clés : la famine en Ukraine de 1932–1933; Holodomor; pertes dans les zones rurales et urbaines dans la famine de 1932–1933; excès de mortalité; pertes de naissances.

Introduction

Human catastrophes hold a special place in the field of population studies. Catastrophes with large-scale population consequences are of two types: *nature-induced* disasters and *man-made* disasters. Examples of nature-induced disasters are famines due to drought or pestilence, deaths from natural cataclysms like mega-volcanic eruptions, earthquakes, and pathogenic viral outbreaks like influenza

1. Corresponding author: Oleh Wolowyna, Center for Slavic, Eurasian and E. European Studies, University of North Carolina at Chapel Hill, 935 White Cross Rd., Chapel Hill, NC 27516 USA. E-mail: olehw@aol.com. Omelian Rudnytskyi, Nataliia Levchuk, Pavlo Shevchuk, and Alla Kovbasiuk—all with the Ptoukha Institute of Demography and Social Studies at the National Academy of Sciences of Ukraine, Kyiv.

pandemics. Examples of man-made disasters include wars and revolutions. A particular case of man-made disasters are those attributable to social engineering, i.e., miscalculations, failures of the system, or deliberate destructions brought by governments in their attempts to fundamentally transform a society according to a particular ideological script. Both types of catastrophe have received quite extensive coverage in the demographic literature. Besides a heavy human toll and material destruction, they often had profound long-term implications in terms of major political, geopolitical, and social transformations (Smil 2008).

The 1932–33 Great Famine, or Holodomor (extermination by hunger), is part of series of catastrophes that took place during the first half of the 20th century in Ukraine, which includes the 1921–23 and 1946–47 famines. The 1932–33 famine is an example of a social engineering type of catastrophe, while the other two were a combination of nature-induced and social engineering catastrophes. The 1932–33 famine affected several parts of the Soviet Union, not just Soviet Ukraine. It was the consequence of the harsh implementation of two policies by Stalin's regime: an extremely ambitious and accelerated industrialization program and forced collectivization of farms. The industrialization program required increased food production to feed a rapidly growing urban labour force, and to export large amounts of grain in order to obtain hard currency for importing machinery and technical resources. Peasants were forced to join collective farms in order to fulfill state controls on the food production sector, and extremely high grain quotas were imposed to satisfy industrialization and export demands. Resistance to collectivization resulted in harsh penalties. As part of the government's policy to break peasants' resistance to collectivization, wealthier farmers, branded as *kulaks* (Ukrainian: *kurkuli*), were deported to isolated areas of the Soviet Union and physically destroyed as a social class. The inability of many independent farmers and collective farms to satisfy unrealistically high grain quotas led, in many cases, to the confiscation of all grains, and in some cases to the eventual confiscation of all foods. This resulted in widespread hunger in 1932 and massive starvation during the first half of 1933 (Kulchytskyi 2007; Wolowyna 2013).

Estimates show that within the Soviet Union, Ukraine had the largest number of deaths caused by the famine, and that in relative terms, i.e., losses per population, it occupied second place, after Kazakhstan. The historical record shows that the famine in Ukraine, as well as in the Kuban, had also a national and ethnic component, as Ukraine and the Kuban region of the Russian SFSR (with a very high percentage of Ukrainians) were singled out by targeted punitive directives. There, the famine was carried out by the Soviet state with the additional purpose of subduing and eventually destroying the independent-minded Ukrainian peasantry and, by implication, the national identity of the Ukrainian people (Kulchytskyi 2007; Graziosi 2009).

Some historians divide the 1932–33 famine in Ukraine into two periods. During the first period, most of 1932, there was a generalized famine affecting several areas of the Soviet Union, as a consequence of collectivization and partial or total confiscation of the grain output. The second part, end of 1932 and first half of 1933, is characterized by an extraordinary increase of deaths due to starvation, as a result of extremely harsh measures, including confiscation not only of grain but of all food, closing of borders with Russia and Belarus to prevent peasants from travelling abroad in search of food, and total isolation of some villages and districts. These were punitive measures to force peasants to give up grain that they may have hidden, had already received from local authorities, or allegedly stolen from the State, to join collective farms, and to persecute "enemies of the State." Hunger was used as a terror-weapon (US CUF 1998, Kulchytskyi 2007; Graziosi 2009).

Although estimates of population losses caused by the Holodomor have received much attention, there is still no consensus on a definite figure. Our goal, besides trying to produce better esti-

mates, is to provide a solid demographic basis for historical evaluation of this period. We present yearly estimates of indirect losses (lost births) and of direct losses (excess deaths) by age and sex for Ukraine and for urban and rural areas, based on reconstructed populations. The quality of the data used was carefully evaluated, and adjustments were made where warranted. Estimates of direct losses are significantly improved by more accurate estimates of net migration. Separate estimations of losses for urban and rural areas show very different levels and time trends in direct and indirect losses, and the underlying dynamics responsible for these losses are quite different in each area.

Estimates of direct losses as high as 10 million are based on anecdotal evidence and are questionable (Wolowyna 2012); estimates that are derived from demographic data vary between 2.6 and 5 million (Conquest 1986; Maksudov 1989; Vallin et al. 2002).

There are several reasons for the wide range in data-based loss estimates. For many years, the Soviet government blocked access to relevant demographic information and made it very difficult for scholars to investigate the 1932–33 famine. The limited availability of data made precise estimation of losses problematic: wider intercensal periods had to be used instead of the 1932–33 famine years, researchers were not able to make separate estimates of direct (excess deaths) and indirect (lost births) losses, and it was difficult to separate the critical factor of net migration from estimates of direct losses (Kubiiovych 1996; Maksudov 1983, 1989; Conquest 1986). The quality of the data was seldom evaluated, and it was used most of the time without any adjustments.

After the opening of archives in the former Soviet Union in the late 1980s, researchers were able to access the demographic data needed for making more precise estimates of famine losses. In the next 20 years, significant advances in the estimation of the 1932–33 Great Famine losses were made (Rudnytskyi 1990; Pyrozhkov 1992; Maksudov 1991, 1992, 1995, 2010; Kulchytskyi and Maksudov 1991; Andreev et al. 1993; Wheatcroft 2001a, 2001b; Vallin et al. 2002; Meslé and Vallin 2003, 2008, 2012; Davies and Wheatcroft 2009), but reported figures still varied greatly. Problems remained with the estimation of net migration, which can lead to over- or under-estimation of excess deaths. For example, Maksudov (1989) calculated 600,000 net migrants for the 1927–38 period; in subsequent studies his estimates varied between 200,000 and −807,000 for the 1927–36 period (Maksudov 1992, 2010). Kulchytskyi and Iefimenko (2003) estimated −1.3 million net migrants for the 1927–38 period, while Vallin et al. (2002) calculated −930,000 for the same period. Separate estimates of lost births ranged from 1.1 to 1.3 million (Rudnytskyi 1990; Kulchytskyi and Maksudov 1991; Vallin et al. 2002). With the progressive availability of more detailed data, it became possible to use the population reconstruction method for estimating yearly direct losses by age and sex, and indirect losses by sex (Andreev et al. 1990 and 1998 for the Soviet Union and Russia; Vallin et al. 2002 for Ukraine).

Data

Table 1 summarizes all the data and their sources used in the analysis. Besides data from the 1926, 1937, and 1939 Censuses and the 1931 urban count, we had access to practically complete and detailed time series of births and deaths by urban and rural areas for the intercensal period 1927–39. We were also able to fill in a few gaps in the available data with figures found in the personal papers of the Ukrainian demographer Korchak-Chepurkivskyi. Besides complete yearly time series of total numbers of births and deaths, births by age of mother and deaths by age and sex are available for all years except 1932. Also, infant mortality is available by month of birth and month of death for all years except 1932. Efforts were made to gather all available data on urban and rural migration from official reports, archival documents, and publications by different researchers. We also analyzed

Table 1. Summary of data sources used in the analysis.

Data type	Total population	Urban	Rural
Census			
population total, by sex	1926, 1937, 1939	1926, 1931*, 1937, 1939	1926, 1937, 1939
population by sex and age	1926, 1939	1926, 1931*, 1939	1926, 1939
Births			
total, by sex	yearly	yearly	yearly
by age of mother	1926–31, 1933–39	1926–31, 1933–39	1926–31, 1933–39
by month	yearly	yearly	yearly
Deaths			
total, by sex	yearly	yearly	yearly
by sex and age	1926–31, 1933–39	1926–31, 1933–39	1926–31, 1933–39
by month	yearly	yearly	yearly
Infant mortality			
total, by sex	1926–31, 1933–39	1926–31, 1933–39	1926–31, 1933–39
by month of birth and of death	1926–31, 1933–39	1926–31, 1933–39	1926–31, 1933–39
Life tables	yearly	yearly	yearly
Migration			
total net-migration	–	yearly	–
net-migration by age and sex	–	1931, 1933–38	–
net-migration by origin-destination streams	–	1933–38	–
specific in- and out-migration streams for different years	–	–	see Table 4
Rural-urban reclassifications	–	1931, 1936, 1938	1931, 1936, 1938

Notes: All the 1926–28 data are adjusted to account for the 1928 annexation of the Myropilia region to Ukraine; * Census of urban population.

Sources: For the Census data type, census and archival data (CSA USSR 1929; Poliakov 1992, 2007; ESA UkrSSR 1933; RSAE 1562/336/604, 1562/329/279); for Births, census and archival data (CSA UkrSRR 1927–32; Korchak-Chepurkivskyi n.d.; RSAE 1562/20/41, 43, 59, 80, 121; 1562/329/20, 54, 134, 256, 260, 264); for Deaths, census and archival data (CSA UkrSRR 1927–32; Korchak-Chepurkivskyi n.d.; RSAE 1562/20/41, 46, 61, 62, 86, 88, 125, 153, 155; 1562/329/22, 23, 56, 57, 134, 256, 260); for Infant mortality, census and archival data (CSA UkrSRR 1927–32; Korchak-Chepurkivskyi n.d.; RSAE 1562/20/46, 61, 62, 86, 88, 125, 155; 1562/329/22, 23, 56, 57); for Life Tables, authors' calculations; for Migration, archival data (RSAE 1562/20) and Table 3; for Rural-urban reclassifications, government reference publications (UCEC 1933, 1936; CESA USSR 1936; SS USSR 1938, 1939; ESA UkrSSR 1933).

documents that describe data collection procedures, their evaluation and analysis by Ukrainian demographers, and attempts to falsify the 1939 Census data.

It was decided to use the administrative-territorial structure of Soviet Ukraine as specified in the 6 January 1937 Census. At that time, Soviet Ukraine was composed of seven oblasts and the Moldovan Autonomous Socialist Soviet Republic. The Crimean Autonomous Socialist Republic and the western oblasts of contemporary Ukraine are not included in our analysis, as they were not part of Soviet Ukraine during the analysis period.

Adjustment of 1926, 1927, and 1939 Censuses and the 1931 urban count

1926 Census

The 1926 Soviet Census in Ukraine (CSA USSR 1929) was executed professionally and implemented under normal conditions (Korchak-Chepurkivskyi 1928; Ptoukha 1930). It had the usual problems of censuses at that time, such as undercount of children and age heaping. The documented

Table 2. Adjustments to the 1926 and 1937 Censuses of Ukraine.

	Official civilian population	Redistribution of armed forces	Adjustment for undercount[1]	Total adjusted population (1)+(2)+(3)	Per cent total adjustment [(4)−(1)]/(1)	Per cent armed forces (2)/(4)	Per cent adjustment (5)−(6)
	1	2	3	4	5	6	7[2]
1926 Census							
Total	28,923,900	121,200	242,800	29,288,000	1.3	0.4	0.8
Urban	5,262,900	22,100	33,600	5,318,600	1.1	0.4	0.6
Rural	23,661,100	99,200	209,100	23,969,400	1.3	0.4	0.9
1937 Census							
Total	28,387,600	346,900	123,600	28,858,100	1.7	1.2	0.4
Urban	9,561,800	116,800	41,600	9,720,200	1.7	1.2	0.4
Rural	18,825,800	230,100	81,900	19,137,800	1.7	1.2	0.4

Notes: 1. Adjustment of children 0–4 years in 1926 and general adjustment for undercount in 1937; 2. differences due to rounding errors.
Sources: Korchak-Chepurkivskyi 1928; CSA USSR 1929; Andreev et al. 1990; and Poliakov 2007.

undercount of children aged 0–4 years in the 1926 Soviet Census (Lorimer 1946; Andreev et al. 1990; Zhiromskaia 2001) was analyzed for Ukraine by Korchak-Chepurkivskyi (1928), and we adopted his estimates. He compared numbers of 1-, 2-, 3-, and 4-year olds registered in the census with the respective expected survivors of births during the 1922–26 period, and estimated an undercount of 6 per cent for the age group 0–4 years.

Military personnel were registered de facto, while the civilian population was registered de jure. It was necessary to redistribute them, as military garrisons were usually located in cities and the de facto count introduced a distortion in the urban male population. It was assumed that the proportion of the Soviet Army in Ukraine was the same as the proportion of the Ukrainian civilian male population in the Soviet Union, i.e., 19 per cent. The resulting number, 121,200, was distributed proportionally to the respective civilian populations in urban and rural areas. The total population was obtained by adding the civilian and military populations with their respective age-sex structures.

Assuming that there was no underestimation of armed forces, the adjustment for the total civilian population is 0.8 per cent (Table 2, col. 7); respective adjustments for urban and rural populations are 0.6 and 0.9 per cent.

1937 Census

The 1937 Census was the first census conducted after the Great Famine, and it documented large population losses in Ukraine. It showed the total civilian population of Ukraine to be significantly lower than what had been projected by central planners (the Central Economic Survey Administration of the USSR) and actually lower than it was in 1926. Given these unexpected results, the government declared the census "defective," and its organizers were executed or imprisoned (Tsaplin 1989; Volkov 1990). Some of the 1937 Census documents were destroyed, and the remaining results discredited because of supposedly flawed methods and organizational failures.

Only in the late 1980s did the data from the 1937 Census become available, and it was shown that the 1937 Census was executed correctly (Tolts 1989; Volkov 1990; Livshits 1990). As total population by age and sex is not available for individual republics (Poliakov 2007), it was not possible to estimate undercount of children aged 0–4 years in Ukraine. Estimates of the 1937 Census total population undercount for the whole USSR, conducted by I. Kraval and M. Kurman (organizers of the census) and others, vary between almost nil and 1.2 per cent (Livshits 1990; Tolts 1995; Zhiromskaia 2001).

Andreev et al. (1990) estimated the undercount for the entire USSR, and for Russia, as 0.43 per cent, and we used Andreev's estimate for both urban and rural areas of Ukraine.

Military personnel were redistributed using the same methodology as in the 1926 Census. Persons with unreported age in the civilian population were distributed proportionally among persons with reported age in both 1926 and 1937 Censuses, and the age structures were smoothed to eliminate age heaping according to a method developed by V. Paevskii (Venetskii 1971). The estimated adjustment factor is 0.4 per cent for urban and for rural areas (Table 2, col. 7).

1939 Census

It was discovered in 1990 that the 1939 Soviet Census, considered for many years as a "model" for Soviet censuses, was actually seriously flawed. Comparison of officially published data with original data preserved in the archives showed significant discrepancies, and allowed researchers to document a sophisticated falsification plan, implemented in order to hide large population losses already documented in the 1937 Census (Zhiromskaia 1990). There were two types of major falsifications: (1) inflated undercount and control form adjustment factors; and (2) the census forms of forced labour camps, special groups, and military personnel were reassigned from their place of residence at the time of the census to their original areas of deportation or residence. The data on special groups (Simchenko 1990; Poliakov 1992) and research on undercount and control form adjustment factors (Andreev et al. 1990) allowed us to make detailed adjustments and corrections, which are described in Appendix 1. As shown in Table A1 in Appendix 1, we estimate that the total population of Ukraine was inflated by 2.6 per cent, with 1.2 per cent for urban and 3.6 per cent for rural areas.

1931 urban count

Two adjustments were made to the 1931 urban population data (ESA UkrSSR 1933): (1) an undercount of children aged 0–4 years; and (2) estimation of urban population by single year of age and sex (whereas in official reports, the age structure is presented in age groups). Both adjustments were taken from estimates made by Korchak-Chepurkivskyi (n.d.). After all the adjustments were made, the three censuses and the urban count were shifted forward (or backward) to the closest January 1 date.

Adjustment of vital statistics

Adjustment of vital statistics was based on a complete time series of total numbers of birth and deaths for urban and rural areas during the intercensal period, and on numbers of deaths by age and sex and numbers of births by age of mother for all years except 1932 (RSAE/1562/329/20; CSA UkrSSR 1927–32). The missing data for 1932 was estimated by linear extrapolation of respective time series for the 1927–31 period. Different adjustment methods of births and deaths were used for crisis (1932–34) and non-crisis (1927–31 and 1935–39) years. Finally, the year 1934 was added to the generally accepted 1932–33 famine period, based on the following evidence: (1) registered monthly data show levels of mortality in 1934 (measured by the crude death rate) to be significantly higher than in 1935 and 1936; and (2) as will be shown later, indirect losses (lost births) are as high in 1934 as in 1933.

The different methods used for adjusting yearly total numbers of infant deaths and of births and deaths at age one year or more are summarized in Table 3. Adjustments were done in three major steps: (1) adjustment of the three components, for urban and total populations during non-crisis

Table 3. Annual number of birth and death calculations and adjustments.

	Non-crisis years: 1927–31 and 1935–38			Crisis years: 1932–34		
	Urban	Rural	Total Population	Urban	Rural	Total Population
Infant deaths	Hungary coefficients	Difference = Total − Urban	Hungary coefficients	Hungary coefficients	Difference = Total − Urban	Adjustment factors: 1932 = 0.5 × B; 1933 = 0.66 × B; 1934 = B
Births	Adjustment factor = ID (0 mo.) + ½ ID (1 – 5 mo.)	Difference = Total − Urban	Adjustment factor = ID (0 mo.) + ½ ID (1 – 5 mo.)	Adjustment factor = ID (0 mo.) + ½ ID (1 – 5 mo.)	Difference = Total − Urban	Different methods used for 1932, 1933, and 1934
Deaths at age one year or more	Adjustment factor = ID/2.5	Difference = Total − Urban	Adjustment factor = ID/2.5	Adjustment factor = ID/2.5	Demographic equation	Sum = Urban + Rural

Notes: ID = absolute adjustment for infant death; B = absolute adjustment for births.

years, and for urban populations during crisis years; (2) adjustment of births and infant deaths for the total populations during crisis years; and (3) adjustment of deaths at age one year or more for rural populations during crisis years. During the first step, infant deaths were adjusted first, while adjustments of births and deaths at age one year or more are based on adjusted infant deaths. As part of the first step, the three adjusted components for rural populations in non-crisis years were calculated as the difference between total and urban estimates. At step two, once adjustments for total population births in crisis years are estimated, respective infant death adjustments are a function of the birth adjustment factors. As part of the second step, adjusted infant deaths and births for rural populations are calculated as the difference between respective adjusted components for total and urban populations. In step three, once rural deaths at age one year or more are estimated for the crisis years, adjusted deaths at age one year or more for the total populations are calculated as the sum of respective urban and rural estimates.

We present here a general description of the adjustment methods used; technical aspects of the different adjustment methods are presented in Appendix 2.

Adjustment of total numbers of births and deaths

Adjustment of infant mortality in step one is based on an empirical relation developed by Khomenko and Kolner (1930) for infant mortality of Ukraine compared to Hungary, a country with an infant mortality regime similar to that of Ukraine but with better statistics. Adjustments of births and deaths at age one year or more are based on infant mortality adjustments. The adjustment factor for births was derived by Korchak-Chepurkivskyi (1929); the adjustment factor for deaths at age one year or more was derived by the Central Statistical Administration of the USSR (CSAHGB 582/11).

An extra adjustment was made to the total number of registered deaths in 1937 and 1938. About 97 per cent of the 149,700 persons executed in Ukraine during the Great Terror years were killed during 1937–38 (Nikolskyi 2003). Analysis of monthly registered deaths showed that these deaths were not included in the official death statistics, and so they are added to the adjusted total of deaths at age one year or more in 1937 and 1938.

In step two, adjusted births for the total population were estimated using two different approaches, one for 1934 and one for 1932 and 1933. Adjusted births for 1934 were derived by backward pro-

jection of the four-year-olds registered in the 1939 Census. Adjusted births for 1932 and 1933 were estimated by extrapolating General Fertility Rate trends and multiplying them by the respective numbers of women aged 15–49 years. Adjustment factors used for infant mortality of the total population are based on the adjustment factors for births, as derived by Korchak-Chepurkiskyi (1929) and Khomenko and Kolner (1930).

The total number of rural adjusted deaths for 1932–34 was obtained by subtracting the number of rural deaths for the periods 1927–31 and 1935–39 from the total intercensal number of adjusted rural deaths. The difference between these estimated deaths and the actual registered deaths gives us the total number of unregistered deaths during the crisis years. The number of unregistered deaths at age one year or more was obtained by subtracting the number of unregistered infant deaths. This number of unregistered deaths at age one year or more was distributed yearly by the proportion of respective registered deaths in the three years 1932–34.

Distribution of adjusted deaths at age one year or more by age and sex

The total number of adjusted deaths at age one year or more for all years, except 1933, was disaggregated by age and sex using the age-sex structure of respective registered deaths. Then life tables for 1927 and 1939 were constructed for urban, rural, and total populations, using adjusted deaths and the respective census populations.

Given the impact of the famine in 1933, estimation of the age-sex structure of deaths for this year requires separate treatment. Having estimated the yearly demographic components (births, deaths, and net migration), we made an age-sex forward projection from 1927 to 1932, and obtained the age-sex composition for 1933. A backward projection from 1939 to 1934 gave us the age-sex population for 1934. The difference between these two populations for ages of 1 year or older is equal to the number of deaths and net migrants for the year 1933. Subtracting the net migrants (see next section), we obtained the age-sex distribution of deaths at age one year or more. These calculations were applied to the total and urban populations. The number of deaths by age and sex for rural populations was obtained as the difference between the total and urban populations.

Estimation of net migration

Urban migration

A migration registration system was in place in major cities and some industrial centers during the intercensal period, and it was improved in 1932 with the introduction of registration cards for all arrivals and departures in these cities (Popov 1995). However, the system was not implemented in medium and small cities, and the quality of the data is problematic. Thus, a mixed strategy was used for estimating urban net migration for the intercensal period: estimation of total net migration for the periods defined by the three censuses and the 1931 urban count using the demographic balance equation, and use of data from the urban registration system to disaggregate net migration for these periods by year.

Taking as our basis the adjusted numbers of urban populations in 1927, 1931, and 1939 by single year of age and sex, and of total populations by sex for 1937, net migration is estimated for three periods: 1927–30, 1931–36, and 1937–38. The difference between the final and initial points of each period is equal to the natural growth plus net migration for the period, and net migration is estimated for each period by subtracting natural growth.

Yearly disaggregation of these net migrations in each of the three periods was done proportionally to the yearly numbers of registered net migrants (RSAE 1562/20). The yearly age-sex structure of net migrants for the 1927–38 period was derived from detailed reconstructed populations as the difference between the total growth and natural growth in each year.

Rural migration

As there was no migration registration system in rural areas, the demographic balancing equation was used to calculate the number of net rural migrants for 1927–28, i.e., the difference between total rural population at the beginning and end of each year and the natural growth for that year. It is not possible to estimate yearly net migration for the 1929–34 period the same way, because adjusted deaths for 1932–34 have not been calculated at this point. The approach used is based on a comprehensive analysis of all available data sources for rural-to-urban migration within Ukraine, and out- and in-migration to and from other Soviet republics for these years (Table 4).

Table 4. Components of rural in- and out-migration in Ukraine, 1927–38.

Migration stream	Period	Direction of stream	Migrants
Rural to urban internal migration[1]	1927–38	rural to urban within Ukraine	−3,388,000
Eviction of kurkuls to settlement areas[2]	1930–33	rural to outside Ukraine	−364,000
Prisoners to concentration camps[3]	1929–38	rural to outside Ukraine	−285,000
Forced emigration of peasants[4]	1929–33	rural to outside Ukraine	−576,000
Deportation of Poles to Kazakhstan[5]	1936	rural to Kazakhstan	−60,000
Emigration of Jews[6]	1929–38	rural to outside Ukraine	−57,000
Resettlement of peasants from Russia and Belarus to Ukraine[7]	1933–34	Russia and Belarus to rural	138,000
Organized resettlement of peasants[8]	1929–30	rural to outside Ukraine	−80,000
Resettlement of kurkuls from Central Asia to Ukraine[9]	1931	Central Asia to rural Ukraine	16,000
Labor emigration from rural areas[10]	1935–38	rural to outside Ukraine	−170,000
Total net rural migration	1927–38		−4,826,000

Sources: 1. RSAE 1562/20/22, 29, 30, 38, 73, 76, 77, 118, 147; 2. SARF 9414/1, 9479/1; 3. Zemskov 2005; Nikolskyi 2001, 2003; Mazokhin 2004; 4. Vynnychenko 1994; RSAE 1562/20/22, 29, 30, 73; 5. Vynnychenko 1994; Rybakovskii 1990; Zemskov 2005; Stronskyi 2011; 6. Weitsblit 1930; Hirshfeld 1930; Vynnychenko 1994; Leskova 2005; Rudnik 2006; 7. CSANO 1/2; 8. Platunov 1976; Hirshfeld 1930; Rybakovskii 1990; Stronskyi 2011; 9. Vynnychenko 1994; Zemskov 2005; Smolii 2003; 10. Kozin 1936; Vynnychenko 1994; RSAE 1562/20/73, 75, 76, 118, 143, 145.

With one exception, data for all out-migration streams were estimated directly from archival sources and publications. The emigration stream of Jews was estimated using the ethno-demographic balance method, which assumes very little assimilation among members of a nationality between censuses, i.e., the same nationality is reported by a person from one census to another. The change in the ethnic population during the intercensal period was estimated and decomposed into natural growth and net migration. First, the number of Jews living in rural areas of Ukraine, as registered in the 1926, 1937, and 1939 Censuses, was adjusted the same way as the total rural population in each census, then the average natural rate of growth of Jews during the 1929–38 period was estimated, and this rate was used to estimate the hypothetical number of Jews expected at the beginning of 1939. The difference between the actual number of Jews according to the 1939 Census and this hypothetical number gives the number of Jews who emigrated from Ukraine during 1929–38. This number was disaggregated by year, using sources listed in Table 4. Besides urban-to-rural internal migration, the two in-migrations listed in Table 4 are: resettlement of peasants from Russia and Belarus to villages decimated by the famine, and resettlement of kulaks from Central Asia to rural areas of

Table 5. Yearly total reconstructed populations for Ukraine by urban and rural areas.

Year(s)	Population on 1 January	Total growth	Births	Deaths	Urban-rural reclassification	Net migrants
Urban						
1927	5,322,400	271,700	165,200	79,300	0	185,700
1928	5,594,100	268,600	156,800	81,600	0	193,400
1929	5,862,700	306,200	155,000	89,300	0	240,600
1930	6,168,900	413,200	149,200	96,700	0	360,700
1931	6,582,100	336,800	154,000	109,000	−245,600	537,500
1932	6,918,900	393,800	172,400	152,400	0	373,700
1933	7,312,700	4,700	126,000	300,100	0	178,700
1934	7,317,400	481,500	153,100	146,700	0	475,200
1935	7,798,900	640,900	199,400	104,600	0	546,200
1936	8,439,800	1,277,000	242,000	111,900	615,800	531,100
1937	9,716,800	489,300	408,000	187,000	0	268,300
1938	10,206,100	835,700	382,200	191,400	427,800	217,200
1939	11,041,800					
1927–38		5,719,500	2,463,200	1,650,000	798,000	4,108,300
Rural						
1927	23,994,000	384,800	1,056,300	514,400	0	−157,200
1928	24,378,700	368,000	1,014,000	473,800	0	−172,200
1929	24,746,700	69,500	956,000	507,900	0	−378,600
1930	24,816,100	−177,100	898,400	500,300	0	−575,200
1931	24,639,100	−170,000	841,400	467,900	245,600	−789,100
1932	24,469,000	−484,900	698,400	642,500	0	−540,900
1933	23,984,100	−3,530,200	516,100	3,815,800	0	−230,500
1934	20,453,900	−327,700	443,900	381,900	0	−389,800
1935	20,126,200	−202,500	569,800	257,700	0	−514,500
1936	19,923,700	−793,200	663,800	271,100	−615,800	−570,100
1937	19,130,500	197,900	820,700	341,900	0	−280,900
1938	19,328,400	−256,600	743,200	344,400	−427,800	−227,500
1939	19,071,800					
1927–38		−4,922,200	9,221,800	8,519,600	−798,000	−4,826,400
Total						
1927	29,316,300	656,500	1,221,500	593,700	0	28,600
1928	29,972,800	636,600	1,170,800	555,400	0	21,200
1929	30,609,400	375,700	1,110,900	597,200	0	−138,100
1930	30,985,100	236,100	1,047,600	597,000	0	−214,500
1931	31,221,200	166,800	995,400	577,000	0	−251,600
1932	31,388,000	−91,100	870,800	794,800	0	−167,100
1933	31,296,800	−3,525,600	642,100	4,115,900	0	−51,800
1934	27,771,300	153,800	597,000	528,600	0	85,400
1935	27,925,100	438,500	769,100	362,300	0	31,700
1936	28,363,500	483,800	905,800	383,000	0	−39,000
1937	28,847,300	687,200	1,228,700	528,900	0	−12,600
1938	29,534,500	579,100	1,125,300	535,900	0	−10,300
1939	30,113,600					
1927–38		797,300	11,685,000	10,169,600	0	−718,100

Source: Authors' calculations, based on the results of the study.

Ukraine (as relatively well-off farmers, the kulaks were declared to be "class enemies" by the Soviet regime and subjected to repressions).

Population reconstruction

As shown above, due to errors, omissions, and falsifications of the official data, as well as the extraordinary levels of under-registration of births and deaths during the crisis years, in order to have a more accurate picture of the population during the 1927–39 period, it is necessary to make adjustments to the original data and re-estimate yearly populations using adjusted demographic parameters.

Total reconstructed populations

In order to complete all the necessary elements for calculating total yearly reconstructed urban and rural populations for 1927–38, it is also necessary to take into account the several urban-rural reclassifications implemented during the intercensal period. In 1931, many urban areas were reclassified as rural, and some rural areas were reclassified as urban (ESA UkrSSR 1933; UCEC 1933). The net result is a loss of 245,600 persons for the urban population (Table 5). Two additional reclassifications were made in 1936 and 1938 (CESA USSR 1936; UCEC 1936; SS USSR 1938, 1939); in both cases all reclassifications were from rural to urban areas, with respective urban gains of 615,800 and 427,800 (Table 5).

Yearly urban and rural total yearly reconstructed populations were calculated using the demographic balance equation with yearly adjusted births, deaths, and net migration, and taking into account the urban-rural reclassifications. This yearly time-series of adjusted births, deaths, net migration, and urban-rural adjustments, together with the resulting populations, is called the *population balance*. Table 5 shows very different urban and rural population dynamics during the 1927–39 period. The urban population more than doubled during this period, from 5.3 to 11.0 million, thanks to steady and high positive net migration and rural-to-urban reclassification. Demographic effects of the famine in urban areas are observed mainly in 1933, with a relatively small decline in births and a fairly significant increase in deaths, resulting in a very small total population increase for that year. By contrast, the rural population experienced a 20 per cent decline between 1927 and 1939, from 24.0 to 19.1 million. Compared to the yearly average for the five pre-crisis years, rural deaths increased by 30 per cent in 1932 and a staggering 674 per cent in 1933. In terms of migration, urban areas gained more than 4.1 million population during 1927–39, while rural areas lost 4.8 million persons. Overall, the population of Ukraine increased by less than three per cent during this 12-year period, and the total net migration during this period was −718,100. During the non-crisis years, natural growth varied between 418,000 and 628,000, it was about 70,000 in 1932 and 1934, while in 1933 there were close to 3.5 million more deaths than births.

Detailed reconstructed populations

In order to estimate detailed reconstructed populations by age and sex, complete yearly life tables were calculated for Ukraine and total urban areas for the 1927–39 period using an iterative process; rural age-sex-specific deaths were calculated as the difference between total and urban deaths. Starting with the initial 1927 population by age and sex, yearly detailed populations were estimated using the 1927 and 1939 Census populations and the 1931 urban count as pillars. During the first iteration, populations by age were calculated by subtracting cohort-specific deaths for each age, assuming zero net migration for each year. For urban populations this was done in two steps: first, from 1927 to 1931, and then to 1939, taking the 1 January 1931 population as the starting point. The differences between the 1939 adjusted census population and the values obtained by the iteration provide an estimate of net migration by age and sex for the whole period. This total net migration was distributed uniformly cohort-wise from 1939 to 1927. Next, the age-sex-specific yearly net migrants obtained by

this distribution were adjusted to the respective total net migration values given by the total reconstructed population (TRP). Finally, the resulting age-sex structures were adjusted to the respective TRP's total populations. Yearly life tables were recalculated using the final adjusted populations.

Estimation of losses

Given the available data, it is not possible to apply strict definitions of Holodomor-related direct and indirect losses, i.e., losses caused by famine; this would require death statistics by cause of death, and detailed information about pregnancies and fetal and infant mortality. Such data are incomplete and their quality is problematic (Boriak 2008). The following operational definitions are used instead: *direct losses* are defined as the difference between actual deaths during the famine years and deaths that would have occurred had there been no famine; and *indirect losses* are defined as the difference between births that would have occurred had there been no famine and actual births.

Yearly direct and indirect losses

Actual deaths during the famine years have been estimated; deaths that would have occurred without the crisis can be estimated multiplying non-crisis age-sex-specific death rates by the respective non-crisis populations. Hypothetical non-crisis mortality is specified by linear interpolations of age-sex-specific mortality rates between 1931 and 1935; the initial year captures pre-crisis mortality, while the compensation of mortality after the crisis is fairly stabilized by 1935. The main difficulty in estimating the hypothetical non-crisis population by age and sex lies in the specification of yearly non-crisis net migration by age and sex. As the number of non-crisis deaths is affected by the size and age-sex structure of non-crisis populations, different specifications of non-crisis net migration are reflected in the level and age-sex structure of non-crisis populations, and thus in different numbers of non-crisis deaths. Even with lower non-crisis mortality levels, it is possible that the number of non-crisis deaths may be higher for some age groups, thus distorting the estimation of direct losses. This is especially the case for infant deaths, as infant mortality was quite high even in non-crisis years. Given these considerations, it was decided to use detailed reconstructed populations instead of hypothetical detailed non-crisis populations as the basis for calculating non-crisis age-sex-specific deaths. This eliminates the need to arbitrarily specify non-crisis net migration, and avoids distortions in the estimation of age-specific non-crisis deaths due to the interaction between the level and age-sex structure of non-crisis populations (the implications of this assumption for the estimation of losses are described in the discussion section).

Crisis births have been already estimated, and non-crisis births are estimated by applying linearly interpolated age-sex-specific fertility rates between 1931 and 1935 to estimated numbers of non-crisis women in childbearing ages for the 1932–34 period. This non-crisis subpopulation was estimated by adding the respective number of women who died due to the famine to the reconstructed women of childbearing age. Interpolation of age-sex specific fertility rates through the 1931–35 period takes into account the pre-crisis fertility decline and avoids the disruption in fertility caused by the prohibition of abortions in July 1936.

The total number of direct losses during 1932–34 for Ukraine is 3.9 million, with 90 per cent of them occurring in 1933. Urban direct losses for this period are 287,600, with 67 per cent in 1933, while total rural losses are 3.7 million, with 91 per cent in 1933 (Table 6). In relative terms, the number of direct losses per 1,000 population for the famine period is 133.5 for Ukraine, with 39.3 in urban and 164.5 in rural areas. The total number of excess deaths in rural areas is 12.7 times

Table 6. Direct (excess deaths) and indirect (lost births) 1932–34 famine losses in Soviet Ukraine by urban-rural areas: absolute numbers and per 1,000 population.

	Losses				Per 1,000 population			
	1932	1933	1934	1932–34	1932	1933	1934	1932–34[1]
Direct losses								
Total	250,000	3,529,200	163,300	3,942,500	8.0	119.5	5.9	133.5
Urban	43,100	193,900	50,600	287,600	6.1	26.5	6.7	39.3
Rural	207,000	3,335,300	112,700	3,654,900	8.5	150.1	5.6	164.5
Indirect losses								
Total	67,100	267,700	251,200	586,000	2.1	9.1	9.0	19.8
Urban	−10,000	46,200	30,700	66,900	−1.4	6.3	4.1	9.1
Rural	77,100	221,500	220,500	519,100	3.2	10.0	10.9	23.4

Note: 1. Summary indicator: total number of direct (or indirect) losses in 1932–34/mid-year 1933 population.
Source: Authors' calculations.

the number in urban areas, and for losses per 1,000 population this factor is 4.2. Levels of relative direct losses in 1932 and 1934 have different patterns in urban and rural areas. In urban areas, this ratio is slightly higher in 1934 than in 1932—6.7 and 6.1, respectively—while in rural areas the relative number of excess deaths is significantly higher in 1932 than in 1934—8.5 and 5.6, respectively. If we compare relative direct losses between urban and rural areas during the first and last years of the famine, in 1932 rural areas had relatively more excess deaths than urban areas, while we find the opposite relationship in 1934. This shows that the initial effects of the famine were felt more in rural areas, while cities were proportionally more affected in 1934.

The number of indirect losses in Ukraine is 586,000 for the whole 1932–34 famine period, with 67,000 in urban and 519,000 in rural areas. In contrast with the direct losses, with most of them occurring in 1933, the number of indirect losses is similarly high in both 1933 and 1934. This is probably due to the fact that a large number of lost births in 1934 were conceived in 1933 to mothers with extreme levels of starvation. The negative number of indirect losses in urban areas in 1932 is probably an artifact of the high level of in-migration in 1931 (Table 5), resulting in an increase in the number of births in 1932 that overcompensated the decrease in births that year due to famine. Indirect losses per 1,000 population in Ukraine are 2.1 in 1932 and about 9.0 in 1933 and 1934, for a total of 19.8 over the whole period; respective total ratios for urban and rural areas are 9.1 and 23.4. Relative numbers of lost births in 1933 and 1934 have different patterns in urban and rural areas; in urban areas they drop from 6.3 to 4.1 lost births per 1,000 population, while in rural areas they are very similar. Thus, the fact that many births conceived in 1933 died in 1934 seems to apply only to rural areas.

Life tables calculated as part of the population reconstruction process provide an indicator, *life expectancy at birth*, which further illustrates the impact of the Holodomor in Ukraine. Before the crisis, life expectancy at birth for urban populations varied between 40 and 46 years for males and between 47 and 52 years for females; respective ranges for rural populations were 42 to 44 and 45 to 48. A significant decline in life expectancy at birth is observed in 1932 for all four subpopulations, with life expectancies at birth of about 30 years for urban and rural males, and about 40 years for urban and rural females, and extremely low levels in 1933: 26.0 and 18.7 years for urban females and males, and 6.6 and 4.2 years for rural females and males, respectively. Extreme life expectancy at birth values for the peak year of the 1932–34 famine have been documented by other researchers. Vallin et al. (2002) estimated 1933 values for Ukraine at 7.4 for females and 10.8 for males; our estimates, 5.0 for males and 8.0 for females, are somewhat lower due our higher estimates of direct losses. Andreev et al. (1998) also documented low values of life expectancy at birth in 1933 for Russia: 15.2 for males and 19.5 for females.

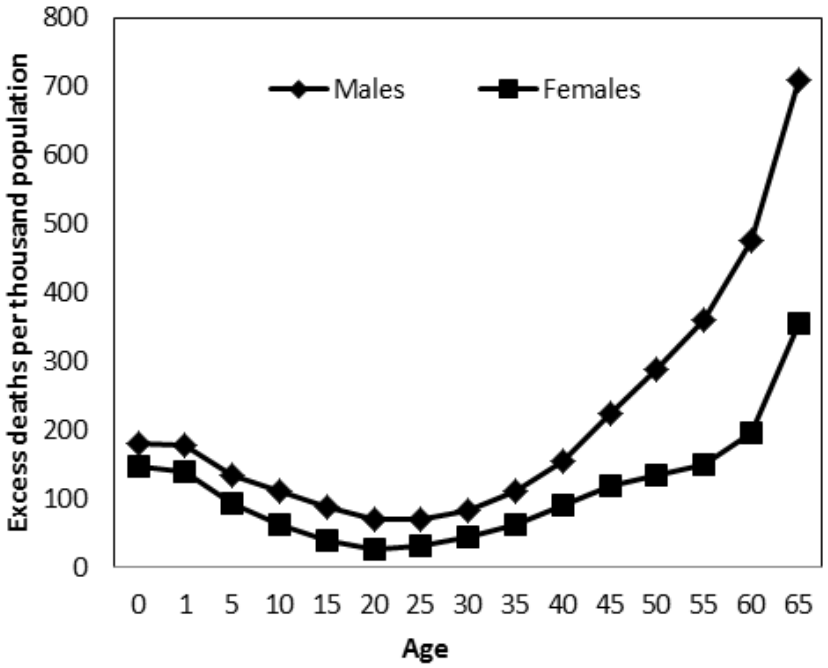

Figure 1. Direct losses in 1933 by age and sex.
Source: Authors' calculations, based on the results of the study.

Age structure of direct losses by sex and by urban-rural areas

Losses by sex. Men suffered higher direct losses than females, both in absolute and relative terms. For the 1932–34 period, there are 2.4 million excess deaths among men and 1.5 million among women, with 90 per cent for each sex occurring in 1933. Excess deaths per 1,000 population in 1933 are 153.5 for men and 88.6 for women. For both males and females, the age pattern of relative direct losses is similar up to the 35–39 age group, i.e., respective maximums of 181 and 146 for the 0–4 age group, with a steady decline to minimums of 69 and 27, respectively, for the 20–24 age group, and then a rapid monotonic increase with age starting at the 25–29 age group (Figure 1). The male-female differential experiences an accelerated widening starting at the 40–44 age group, resulting in respective maximums of 711 and 356 at age 65 or older.

Urban-rural losses. The age pattern of relative excess deaths in urban areas is quite different from the rural pattern (Figure 2). The number of excess deaths per 1,000 population in urban areas is 122 for children aged 0–4 years; it declines gradually to a value of <10 at the 10–14 age group, and remains practically constant until age group 30–34. Starting at the 35–39 age group, this ratio increases rapidly with age, to a maximum of 178 for ages 65 or older. In rural areas this ratio is 175 for children aged 0–4 years; it declines rapidly to a minimum of 64 for the 20–24 age group, and then experiences a steep increase to a maximum of 591 per 1,000 population at ages 65 or older. Excess deaths for children under ten years of age comprise about 25 per cent of all deaths in 1933, both in urban and rural populations.

Discussion

Before discussing the results, we will examine a couple of data issues and comment on some aspects of the estimation methods used.

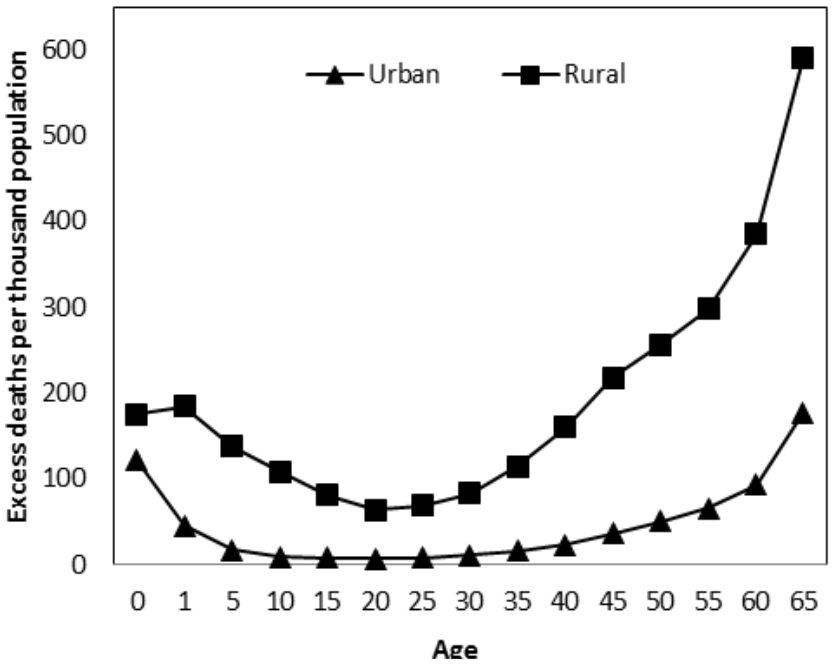

Figure 2. Direct losses in 1933 by age for urban and rural populations.
Source: Authors' calculations, based on the results of the study.

Some data issues

Collectivization was followed by extreme famine conditions in rural areas, forcing rural inhabitants to seek food in cities, where many of them died. With the sudden increase in urban deaths in early 1933, city vital statistics officials were ordered not to register *deaths of non-urban inhabitants* (Wheatcroft and Garnaut 2013). As the standard practice was to register vital events by place of occurrence, it seems that the vital statistical officials decided to unofficially keep two sets of statistics—numbers of deaths with and without residency papers—in order to be able to make valid comparisons with death statistics from previous years. According to recently discovered documents, of all the 1933 urban deaths registered in Ukraine, 17.6 per cent were tabulated as being non-urban residents (Wheatcroft and Garnaut 2013). Although technically these are urban deaths, it may be argued that actually they are rural deaths. These deaths of non-urban residents translate to 21 per cent of direct urban losses in 1933. This does not necessarily mean that the actual number of direct urban losses in 1933 should be lowered by 21 per cent, as it is not clear to what extent these deaths were registered, and how many of them were correctly classified as deaths of non-urban residents. This example illustrates how newly discovered data, as well as the use of data without critical evaluation, can affect loss estimates.

As explained above, it is very difficult to accurately estimate non-crisis populations, as it is practically impossible to specify migration trends had there been no crisis. Nevertheless, in order to have some idea of how the decision to use reconstructed populations instead of hypothetical non-crisis populations to estimate non-crisis deaths may have affected the estimation of direct losses, an approximate estimation of the hypothetical non-crisis population for 1932–34 was made. Non-crisis mortality levels were estimated by linear interpolation of age-specific mortality rates between 1931 and 1935, and non-crisis fertility rates by linear interpolation of fertility rates by mother's age for the same interval. Non-crisis populations for 1932–34 were estimated by taking the reconstructed 1

January 1932 populations and applying each year the demographic balance equation with non-crisis deaths and births, and net migration estimated in the population balance.

Non-crisis deaths and births are calculated by multiplying respective mortality and fertility rates by the non-crisis populations. The total number of excess deaths obtained is 3,884,000, instead of the original estimate of 3,943,000, a reduction of 1.5 per cent; in urban and rural areas the respective reductions are 5.9 and 1.2 per cent. For age-specific estimates of direct losses the largest deviations are found in the 0–4 age group: 15.1 per cent for Ukraine overall, with 18.4 per cent in urban areas and 14.7 per cent in rural areas. For most age groups the deviations vary between 0.4 and 3.0 per cent in urban and rural areas, with larger differences in older age groups. For the 65-year or older age group, the deviation for Ukraine overall is 8.9 per cent, with 7.8 per cent in urban areas and 9.0 per cent in rural areas.

These two examples illustrate the fact that it is very difficult, if not impossible, to make exact estimates of direct (as well as indirect) famine losses, and it is more reasonable to assume that actual numbers of losses can be found within a certain probability interval. A precise estimate of these intervals would require a sophisticated simulation analysis—also not without its own problems. The analysis presented above suggests that at the national level, it is likely that the actual number of direct losses falls within a ±5 per cent interval, with a smaller interval for rural areas. The situation in urban areas is more complicated and requires more research; our estimates should be considered as a first approximation.

Comparisons with previous estimates

Among the numerous attempts to estimate famine losses in Ukraine, only one study used the population reconstruction method (Vallin et al. 2002; Meslé and Vallin 2003, 2008, 2012). Their results are quite different from ours: 2.6 million direct losses and 1.1 million indirect losses, compared to our 3.9 million and 600,000, respectively. The detailed data provided in Meslé and Vallin (2012) allow us to make a population reconstruction for Ukraine based on their estimates, and to determine the reasons for these differences. There are four major differences between our and Meslé and Vallin's studies. First, Meslé and Vallin made only one correction to the 1926 and 1939 Census data—smoothing for age heaping—and they used the official data of total populations without any additional corrections. Second, they did not include 140,000 deaths of persons executed during the 1937–38 terror campaign that were not registered by the vital statistics system. Third, we had access to more detailed vital statistics and did not have to use models to estimate some of the data needed for the population reconstructions. Fourth, our estimates of net migration are based on more detailed and comprehensive data.

These differences have several important implications. First, adjustments of the 1926 and 1939 Census total populations, representing an increase of 242,800 and decrease of 803,600, respectively, reduce the intercensal difference by about one million persons. Second, our estimate of net migration for the intercensal period (which includes both forced and voluntary migration) is −718,100 (Table 4); Vallin et al. (2002) estimated forced net migration for the 1927–38 period at −930,000 and assumed a voluntary net migration of zero. (As shown in Table 7, the net migration derived from the reconstructed population based on Meslé and Vallin's data is actually −1,265,762.)

Comparing the two reconstructed populations, we observe the following differences (Table 7). First, there is little difference between the two time series of reconstructed births in non-crisis years, and our estimates are somewhat higher for 1932–34. Second, yearly reconstructed deaths are also similar, except in 1933, 1937, and 1938. The differences in 1937 and 1938 are mainly due to the addi-

Table 7. Comparison of estimated yearly population balances for Ukraine.

Year	Population as of January 1		Net migration		Births		Deaths	
	Authors' calculations	Meslé and Vallin	Authors' calculations	Meslé and Vallin	Authors' calculations	Meslé and Vallin	Authors' calculations	Meslé and Vallin
1927	29,316,340	29,000,081	28,579	−1,441	1,221,535	1,228,226	593,662	579,000
1928	29,972,791	29,647,866	21,222	900	1,170,800	1,178,355	555,438	548,000
1929	30,609,375	30,279,121	−138,083	−270	1,110,917	1,115,139	597,151	585,000
1930	30,985,058	30,808,990	−214,486	933	1,047,580	1,052,510	596,991	581,000
1931	31,221,161	31,281,433	−251,625	258	995,402	1,000,771	576,951	553,000
1932	31,387,986	31,729,462	−167,132	225	870,828	800,965	794,841	746,000
1933	31,296,842	31,784,653	−51,757	−1,397,189	642,096	576,454	4,115,890	2,584,000
1934	27,771,291	28,379,918	85,421	236,127	596,984	561,602	528,619	508,000
1935	27,925,077	28,669,646	31,652	−21,652	769,111	770,446	362,303	362,000
1936	28,363,537	29,056,440	−38,972	17,260	905,758	904,617	383,021	380,000
1937	28,847,302	29,598,317	−12,568	−71,672	1,228,691	1,226,645	528,896	450,000
1938	29,534,530	30,303,291	−10,345	−29,241	1,125,331	1,123,168	535,878	451,000
1939	30,113,638	30,946,218						
1927–38			−718,094	−1,265,762	11,685,032	11,538,899	10,169,640	8,327,000

Sources: Meslé and Vallin (2008) and authors' calculations based on the results of the study.

tional unregistered 140,000 deaths (executions) included in our calculations; the large difference in 1933 deaths is related to very different estimates of net migration for that year.

Although there are significant differences between our and Meslé and Vallin's yearly estimates of net migration in all years, we will comment only on the 1933 values, as this is directly related to the estimation of direct losses for that year. Our estimate of net migration for 1933 is −52,000, while Meslé and Vallin's estimate is −1.4 million. This extremely large number of net out-migrants is directly related to their estimate of 2.6 million reconstructed deaths, i.e., the larger the number of net out-migrants, the smaller the number of reconstructed deaths. We have not found any evidence of a massive voluntary out-migration in 1933 that can justify Meslé and Vallin's implicit estimate of −1.4 million net migrants. Furthermore, Directive No. 65 of the Central Committee dated 22 January 1933, "On the prevention of a mass exodus of starving peasants," closed the borders to any voluntary emigration (CC ACP 2001).

This analysis illustrates the difficulties inherent in estimating 1932–33 famine losses in Ukraine (and other Soviet republics), and the effect that more complete data can have on such estimates. It also underlines the importance of making a thorough evaluation of the quality of the data and applying relevant adjustments *before* proceeding with the estimations.

Principal results

We estimate the toll of the Great Famine at 4.5 million, with 3.9 million in direct and 0.6 million in indirect losses. Using the indicator *losses per 100 population* instead of per 1,000 population, this translates into a total loss (direct plus indirect losses) equivalent to 15.3 per cent of the overall population of Soviet Ukraine in 1933. Total losses in rural areas are equivalent to 19 per cent of the total 1933 rural population, while corresponding relative total losses in urban areas are close to 5 per cent (Table 6). Thus, the mortality impact of the famine in urban areas, although much smaller than in rural areas, was nevertheless significant. Most of the direct losses occurred in 1933—about 91 per

cent in rural areas and 67 per cent in urban areas. Actually, the majority of excess deaths in 1933 occurred within a six-month period, between March and August, with 77.5 per cent in urban areas and 90.0 per cent in rural areas (Wolowyna 2013).

The 586,000 lost births are distributed as 11.5 per cent in urban areas and 88.5 per cent in rural areas. In relative terms, the ratios per 1,000 population are 20 for Ukraine and 9 and 23 for urban and rural areas, respectively. The yearly distribution of lost births is quite different from the distribution of excess deaths. While direct losses are mostly concentrated in 1933, both in urban and rural areas, the majority of lost births is evenly distributed between 1933 and 1934 in rural areas; in urban areas the number of lost births, both in absolute and relative terms, is significantly lower in 1934 than in 1933. Also, the ratios of relative rural-to-urban lost births are very different for direct and indirect losses. For the overall three-year period, the relative number of excess deaths in rural areas is 4.2 times the number in urban areas, and the factor for 1933 is 5.7; for lost births the overall factor is 2.6, with 1.4 in 1933 and 2.7 in 1934. Thus, compared to excess deaths, the relative weight of urban lost births is much closer to those in rural areas.

An original contribution of this study is the estimate of relative age-specific excess deaths by sex and by urban-rural area. The age structures for males and females are as expected; the age structures for urban and rural areas, on the other hand, are surprisingly different, and they seem to reflect the different conditions in rural and urban areas during the famine years, especially in 1933. In rural areas, the high mortality for children aged 0–4 years reflects the vulnerability of small children to high levels of starvation of the mother and of the children themselves. The rapid decline in mortality during the adolescent years probably reflects inherent biological resilience at these ages. The very rapid increase in mortality with age, after the minimum value for the 20–24 age group, is the result of specific restrictive conditions on movement in rural areas during the Holodomor.

The great majority of the rural population in Soviet Ukraine consisted of farmers, who were the targets of Stalinist collectivization policies. This entailed economic blacklisting of non-compliant collective farms, villages, and whole districts at the collective level, and the imposition of drastic grain requisitions, with additional confiscation of meat and potatoes, and in some cases all foodstuffs, at the individual level (Pyrih 2007). A decree dated 22 January 1933, prohibiting Ukrainian peasants to travel to Southern Russia and Belarus in search of food (CC ACP 2001), the domestic "passports" for city residents introduced in December 1932, and the subsequent expulsion of rural residents from cities eliminated the option of searching for food in neighbouring countries or in the cities of Ukraine. Thus, once all the food was taken away and it was impossible to search for food outside the village, peasants were literally condemned to death by starvation (Kulchytskyi 2007). These events are consistent with the rapid increase in rural mortality starting at age 25.

The situation in cities was quite different. Stalin's policy of extremely accelerated industrialization required a large labour force in cities, with growing industrial complexes and attendant bureaucratic cadres. A comprehensive food rationing program was implemented to provide adequate levels of nutrition for these important groups. The very low, almost constant values of urban relative excess deaths for the prime working age groups from 15–19 to 35–39 suggests that food assistance for industrial workers and government bureaucrats in urban areas was likely instrumental in keeping excess deaths at relatively low levels for these age groups (Osokina 1999; Boriak 2012). The much lower levels of urban than rural mortality for infants and school-age children may be related to the implementation of special food programs for these children. Thus, rationing programs may have been an important factor in the relatively lower levels of excess deaths in cities compared to rural areas, and may also provide an explanation for the very different age structure of relative excess deaths in urban areas.

However, not all urban inhabitants were covered by these rationing programs; a certain proportion of the urban population did not receive any food assistance. There were six categories of food rations, from normal to bare minimum levels. People outside the food rationing system were as helpless as the rural inhabitants left with little or no food; moreover, the food rations in the lower categories were barely enough for survival. The distribution of the urban population in these different categories varied from city to city, with smaller cities having, in general, a larger proportion of people without food assistance. Also, these food rations were gradually reduced, due to the overall food shortages in the country.

A better understanding of population losses caused by the Holodomor can be obtained by further research in several areas. First, although significant advances have been made in the development of methods for estimating direct losses, estimation of indirect losses needs further elaboration. Research on the relationship between hunger and fertility (Frish 1978; Bongaarts 1980; Menken et al. 1981) needs to be adapted to the specific characteristics of the 1932–34 famine. Second, most of research on the Holodomor has focused on Soviet Ukraine as a whole and on rural areas, with relatively less attention to urban areas. We have shown that the famine also had a significant effect in urban areas, but the role of the different factors related to urban losses is not yet well understood. Third, preliminary research has shown that there is great variation in direct and indirect famine losses in Ukraine (and in Russia) at the regional level (Kulchytskyi 2007; Davis and Wheatcroft 2009; Levchuk 2013; Rudnytskyi and Savchuk 2013; Wolowyna 2013), and different hypothesis have been suggested to explain this variation (Plokhii 2013; Wheatcroft and Garnaut 2013), but a comprehensive analysis of these variations and their causes is lacking. Finally, the 1932–34 famine had very uneven effects on the different Republics of the Soviet Union (Rudnytskyi et al. n.d.). Comparative analyses at the national level among republics, and sub-national levels within republics, would greatly enhance our understanding of the Holodomor in Ukraine in particular, and the 1932–34 famine in the Soviet Union in general.

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Appendix 1. Adjustment of the 1939 Census

For many years, the 1939 Census was considered a "model" for Soviet censuses. In 1990 it was discovered that there were significant discrepancies between the officially published census results and the original data preserved in the archives (RSAE 1562/329, 1562/336). Namely, following on the officially discredited "defective" Census of 1937, the 1939 Census had once again actually documented a significantly smaller population than had been predicted by Stalin, and so it was subjected to a string of sophisticated falsifications (Zhiromskaia 1990). Undercount adjustments were inflated in the regions most affected by forced collectivization and the famine. The census forms for subpopulations such as prisoners in forced labour camps (gulags) were reassigned to their original areas of deportation, and home addresses in the census forms of military personnel were also changed. Archival documents show that addresses in 795,000 census forms of labour camp inmates were changed, and 383,600 of them were reassigned to specific rural areas in Ukraine (Simchenko 1990; Tolts 1995). Inflated factors for allocating control forms were also applied (as part of the census procedure, a list of all residents per household was compiled, and adjustments were made for persons missed during the census count); disproportionate numbers of these forms were allocated to subpopulations and areas that suffered most from the famine, i.e., males and rural areas (Andreev et al. 1990; Maksudov 1995; Tolts 1995; Zhiromskaia 2001).

Table A1. Adjustment steps implemented for the 1939 Census of Ukraine.

	Official civilian population	Army	Civilian population related to the NKVD[1]	Groups A, B, and C[2]	Correction for undercount	Correction for control forms	Correction for the "unknown difference"	Adjusted census population (sum of cols. 1–7)	Official total population	Per cent adjustment [(8)−(9)]/(9)/100
	1	2	3	4	5	6	7	8	9	10
Total	29,269,200	380,700	8,000	194,300	82,400	113,400	94,600	30,142,600	30,946,200	−2.6
Urban	10,678,400	138,900	5,900	143,800	8,100	41,700	34,700	11,051,600	11,190,400	−1.2
Rural	18,590,800	241,800	2,100	50,500	74,300	71,800	59,800	19,091,000	19,755,800	−3.4

Notes: 1. Narodnyi komissariat vnutrennikh del (People's Comissariat for Internal Affairs); 2. A=NKVD; B=prisoners; C=forced settlements.
Sources: CSA USSR 1956; Simchenko 1990; Poliakov 1992; Kokurin and Petrov 2000; and authors' calculations.

Our adjustments of the 1939 Census data are presented in Table A1. We start with the original count of the civilian population without falsifications (col. 1; RSAE 1562/329/279; Simchenko 1990), and then progressively add different subpopulations and corrections, as follows.

Armed forces were distributed in the same manner as in previous censuses (col. 2). Adjustments of civilians related to the NKVD (People's Commissariat for Internal Affairs, or the Soviet political police; col. 3) and special groups (NKVD, prisoners, and forced settlers; col. 4) are based on data from Simchenko (1990) and Poliakov (1992). They are available only for Ukraine, and their urban-rural distribution was estimated using data from the 1937 Census (Poliakov 2007). The adjustment factors of 1.0 per cent for undercount and 0.68 per cent for control forms, proposed by USSR State Plan Director N. Voznesenskii and Head of the Central Economic Survey Administration (CSA) I. Sautin, are considered to be too high and suspect, especially considering that they were determined before analysis of the control forms was completed. Andreev et al. (1990) estimated the control forms factor for the 1959 Census to be 0.38 per cent, and used this figure for the 1939 Census for the Soviet Union overall and for the Russian SFSR, arguing that both censuses were implemented using the same procedures. We also applied this factor in the present study (col. 6). Assuming that the

undercount for the whole population was due mainly to an undercount of children aged 0–4 years, the undercount factor for both urban and rural areas is estimated at 0.3 per cent, by comparing births during 1934–38 with infant deaths during their first five years of life (col. 5).

In 1956, the Central Statistical Administration (CSA) discovered 414,800 persons missing from the initial official count of the 1939 Census, and this was labeled the "unknown difference" (CSA USSR 1956). A fraction of this figure proportional to Ukraine's population (94,600) was distributed proportionally between the urban and rural populations (col. 7). Final adjusted populations are shown in column 8, and relative per cent differences with the official census figures in column 10. The inflation factor for Ukraine is 2.6 per cent, with 1.2 per cent for urban and 3.4 per cent for rural populations.

The age-sex structure of the corrected population is based on the age-sex structure of urban and rural populations found in archives (RSAE 1562/336/604), which contained the 383,600 individual census records of prisoners living outside of Ukraine that were arbitrarily redistributed in rural areas of Ukraine (Simchenko 1990; Kokurin and Petrov 2000).

Appendix 2. Adjustment of Births and Deaths

Urban and total births and deaths during the non-crisis years (1927–31 and 1935–39) and urban births and deaths during crisis years (1932–34)

Adjustment of infant deaths. Khomenko and Kolner (1930) developed an adjustment method for infant deaths using a factor based on a relationship with a referent country with an infant mortality regime similar to that of Ukraine's but with better quality statistics, such as Hungary. Assuming that most of infant mortality under registration is concentrated in the first six months of life, the ratio of infant mortality during the first six months of life in Ukraine and Hungary is considered to be equal to the respective ratio of infant mortality during the second half of the first year of life. The adjustment factors were estimated using Hungarian total and urban monthly infant mortality rates for the period 1904–26 (CSO Hungary 1904–26).

Adjustment of births. Estimation of undercount of births is based on a relationship between the undercount of births and the undercount of infant deaths. Korchak-Chepurkivskyi showed that the number of unregistered births is equal to the number of unregistered infant deaths during the first month of life, plus half of the number of unregistered infant deaths during the next five months of life (Korchak-Chepurkivskyi 1929; Khomenko and Kolner 1930).

Adjustment of deaths at age one year or more. Research by the Central Statistical Administration of the USSR (CSA) in the 1950s showed that the number of unregistered deaths at age one year or more is equal to the number of unregistered infant deaths divided by 2.5 (CSAHGB 582/11). This relationship was used to make the adjustment.

Adjustment of births and infant deaths for the total population during 1932–34

Adjustment of births. Different adjustment methods were used for 1934 and for 1932–33. Adjustment of 1934 births was based on a backward projection from 1939 to 1934 of persons aged four as registered in the 1939 Census, using adjusted infant deaths for 1938, 1937, 1936 and 1935; net migration was assumed to be zero in each year. The number of unregistered births was obtained as the difference between the projected and registered births in 1934. This method cannot be applied to 1932 and 1933 births, as the adjusted number of deaths for crisis years has not been calculated yet. The

absolute number of adjusted births for 1932 and 1933 was derived from general fertility rate (GFR) values by multiplying the GFR by the number of females aged 15–49 years. Analysis of birth trends in pre-crisis years shows that the relative decline in GFR to be twice as large during 1931–32 as in 1930–31, and again twice as large during 1932–33 as in 1930–31; the respective declines are 5.4 per cent, 10.6 per cent and 21.3 per cent. As fully reconstructed populations for the intercensal period have not been calculated yet, we used estimates from preliminary population projections based on 1927 and 1939 life tables and a linear interpolation of age-specific mortality rates between these two years.

Adjustment of infant deaths. The following proportions of the undercounts of births were taken to equal the undercount of infant deaths: 50 per cent in 1932, 66.6 per cent in 1933 and 100 per cent in 1934. These adjustments are based on studies by Korchak-Chepurkivskyi (1929) and Khomenko and Kolner (1930).

(See the main text for adjustment of rural deaths at age one year or more during 1932–34, and the distribution of adjusted deaths at age one year or more by age and sex).