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Descriptive Findings

Mortality in the Caucasus: An attempt to re-estimate recent mortality trends in Armenia and Georgia

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Table of Contents

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Abstract

With the collapse of the Soviet Union, Caucasian countries have experienced remarkable migration flows, political conflicts, and deterioration of civil registration systems. The reassessment of the populations of Armenia and Georgia after censuses carried out in the early 2000s enables researchers to re-estimate recent mortality levels in both countries. Vital statistics from the 1980s to the present are presented and discussed. Infant mortality is corrected according to sample surveys, and mortality above age 60 is estimated using model life tables. These estimates show that trends in life expectancy were similar in the two countries - unfavourable during the 1990s, especially for Georgian males for whom health progress is still low.

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1. Introduction

In light of unfavourable mortality trends observed in the region of the former Soviet Union since the 1960s, it is of particular interest to look at the specific evolution of Caucasian countries. Indeed, the consideration of the "Soviet world" as a whole has concealed the existence of different mortality patterns which may diverge from the Russian pattern characterized by high adult mortality (Meslé et al. 1996; 2003; Meslé, Vallin, and Shkolnikov 1998; Shkolnikov, Meslé, and Vallin 1996). For instance, due to different socioeconomic conditions, Albania shows divergence from other communist countries (Gjonça, Wilson, and Falkingham 1997). In order to discuss mortality patterns in the Caucasus, one must first create better estimates of mortality levels and trends. In this region, data quality has always been at issue (Kingkade 2000; Kingkade and Sawyer 2001), but since the collapse of the Soviet Union in 1991 data quality issues have increased. Not only did the region experience a failure in the control of dramatic international migration flows, along with a series of political conflicts in the Caucasian countries that disrupted many statistical series, but it seems that even the current data collection systems for births and deaths have been deteriorating (Badurashvili and Kapanadze 2003; Meslé, Vallin, and Badurashvili 2006).

In the 1990s, mortality rates provided by Armenian and Georgian statistical offices were underestimated[6] and any attempt to re-estimate them was difficult, due to the imprecision of population estimates which were still relying on the most recent Soviet census held in 1989 (Badurashvili et al. 2001; Tsuladze and Maglaperidze 2000; Yeganyan et al. 2001). However, both countries had carried out new censuses at the beginning of the 2000s. These new counts provide a much more reliable basis for re-estimating recent mortality trends in these two Caucasian countries. After summarizing the main causes of disruption in the statistical series, we present new estimated population trends (section 1) and discuss under-registration of vital events over time (section 2). Finally, new estimates of mortality trends during the last two decades in these two Caucasian countries are proposed (section 3).

[6] For example, according to Badurashvili et al. (2001), Georgian male life expectancy may have been 66.4 years in 1998 instead of the 74.2 years officially published by the Department for Statistics (DS) – an underestimation of 7.8 years. Female life expectancy ranged from 75.2 to 82.0 years, showing a 6.8-year discrepancy. For the same year, Tsuladze and Maglaperidze (2000) also pointed out important differences with respect to official estimates (5.8 years for males and 6.3 for females). For the year 1999, Yeganyan et al. (2001) estimated Armenian life expectancy levels at 68.7 years for males and 75.4 for females instead of the 72.5 and 77.2 years given by the National Statistical Service (NSS) at that time, while in Georgia the discrepancy ranged from 68.8 to 73.8 years for males and from 75.6 to 81.0 years for females.

2. Recent changes in population: post-census reassessment

2.1 Causes of dramatic changes in population numbers

The collapse of the Soviet Union had two main consequences in terms of population changes: internal migration between regions suddenly became international migration between new independent nations; and the relative peace between minorities imposed by the Soviet power degenerated into major local conflicts, including wars.

2.1.1 Migration flows across new borders

Before the collapse of the USSR, migration between Armenia or Georgia and the other republics of the Soviet Union was internal migration, undertaken mainly for economic or private purposes, and strongly regulated by the Soviet rules. When the Soviet Union collapsed, the creation of new international borders changed the situation radically and many people belonging to minorities or suffering from economic hardship felt trapped inside new independent countries and were to get out (Tishkov, Zayinchkovskaya, and Vitkovskaya 2005). Furthermore, while crossing the international borders of the former Soviet Union without special permission by authorities was forbidden, new opportunities for emigration towards Western countries or Israel emerged. Thus in both Armenia and Georgia, a sharp increase in out-migration occurred in the 1990s. Many Russians returned to Russia in the first years following the collapse. The migration out-flow became even greater after 1991 due to the social and economic crisis and the dramatic deterioration in living conditions in satellite countries, which grew substantially worse than in Russia. Later in the 1990s, international migration flows stabilized.

2.1.2 Conflicts and territory changes

Armenia was involved in a war with Azerbaijan over Nagorny Karabakh, an autonomous territory inside the former Soviet Republic of Azerbaijan, mostly populated by Armenians. The war did not affect Armenian population data substantially[7] but it led

[7] Troubles started when the newly independent Republic of Azerbaijan withdrew the autonomous status of Nagorny Karabakh. The war between Armenia and Azerbaijan resulted in Armenia's taking the control of the south-western part of the Azerbaijani territory surrounding Nagorny Karabakh. However, Nagorny Karabakh is now considered by Armenia as an independent state and its population has never been included in the Armenian statistics.

to massive inflows of Armenian refugees who used to live in Azerbaijan. The direct impact of war was much greater in Georgia (Meslé, Vallin, and Badurashvili 2006). Soon after Independence, Georgia had to face two armed conflicts resulting from the claims for independence by both the Abkhazian Republic and South-Ossetian autonomous oblast.[8] The 1993 war resulted in 10,000 deaths and around 200,000 refugees, and since the mid-1990s, the Georgian government has lost control over most of Abkhazia and a large part of the former autonomous oblast of South Ossetia (the "Tzkhinvali region")[9]. These regions were subsequently missed by the 2002 census (Meslé, Vallin, and Badurashvili 2006).

2.2 Population estimates since the last censuses

2.2.1 Collapse of the Soviet migration registration system

During the Soviet era, out-migration from the USSR was practically impossible and all changes of residence were subject to out- and in-registration. As a result, relatively good-quality migration data were available, especially for inflows.[10] The USSR Goskomstat centralized information from local authorities and established a complete matrix of inter-republic migration flows. With the collapse of the USSR, migration statistics deteriorated for three main reasons: migration outside of the former Union became possible, inter-republic collaboration to produce a general matrix ceased, and the quality of in- and out-registration declined. The phenomenon was particularly acute in Armenia (Karapetyan, Yeganyan, and Shakhnazaryan 1996; Yeganyan 2000; Yeganyan and Davtyan 2000) and in Georgia as well (Tsuladze and Badurashvili 1999). The registration of vital events (births and deaths) also deteriorated, but to a lesser extent, and with smaller consequences for population estimates.

According to current[11] official estimates, during the Soviet era, migration flows were quite regular until the late 1970s, resulting in a balance that was slightly positive in Armenia and slightly negative in Georgia (Figure 1). During the 1980s, trends

[8] Before the collapse of the Soviet Union, the socialist Republic of Georgia included two small autonomous republics, Abkhazia and Adjaria, and one autonomous oblast, South Ossetia.

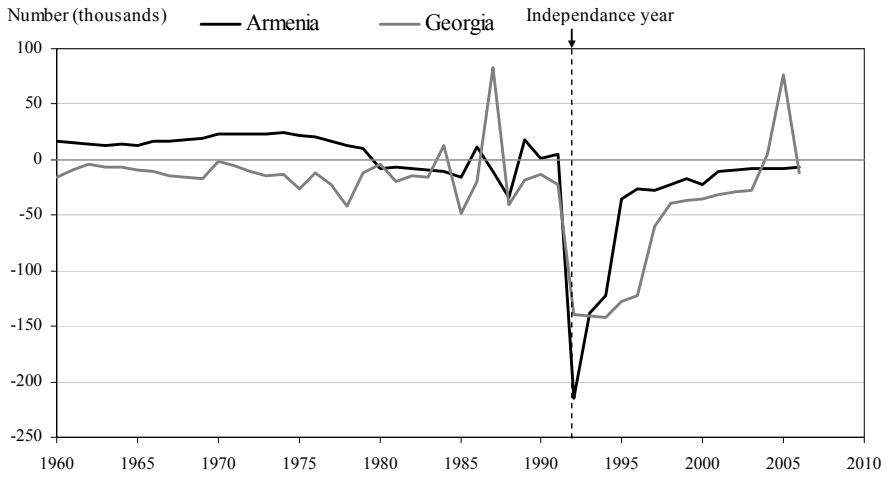
[9] The 2008 Russian intervention enlarged the area no longer controlled by the Georgian authorities while the Russian Government officially recognized Abkhazia and South Ossetia as independent states.

[10] Indeed, the migration registration system was far from perfect (Anderson, Katus, and Silver 1994). In particular, rural-rural migration was not registered. Nevertheless, it seems that it covered inter-Republic flows rather well for rural-urban, urban-rural and urban-urban migration, which makes reasonable total estimates possible.

[11] In this section, only current official estimates which were made after the last census in each country are presented. Pre-census estimates were unrealistic for the 1990s as we will see in the next section when discussing former population estimates.

became more erratic with a negative net migration in both countries. It seems that the control of movements had already slackened, making official estimates more difficult. In particular, the 1987 peak in Georgia seems unrealistic, without any specific event to explain it. On the contrary, the huge deficit observed in 1992-94 in Armenia and in 1992-96 in Georgia is obviously related to the collapse of the USSR that resulted in substantial out-migration (return migration of Russians and political and/or economic migration). Once again, more recently, the Georgian peak in 2005 is highly improbable since no explanatory events correspond this large migration inflow. More generally, consequent to all the problems described above, annual official population estimates diverged more and more from reality and age structure became less and less consistent with the actual population distribution until the most recent censuses were conducted.

Figure 1: Armenian and Georgian annual migration flows according to official estimates since 1960



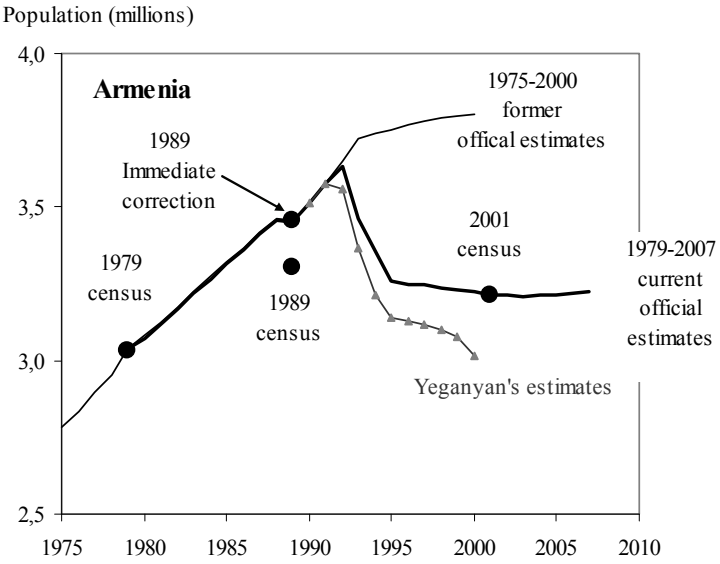
Sources: for Armenia: NSS 2007; for Georgia: European Population Committee 2006 (until 1989) and Tsuladze, Maglaperidze, and Vadachkoria 2007 (from 1990).

2.2.2 Reassessment of population estimates after 2001 and 2002 censuses

New censuses conducted in 2001 (Armenia) and 2002 (Georgia) allowed statistical offices to reassess inter-census population counts and to provide more reliable estimates for recent years. Indeed, inter-census estimates had been more difficult in Armenia

where the 1989 Soviet census was dramatically disrupted in the aftermath of the 1988 earthquake.[12] Figures 2 and 3 show the large difference between official estimates used before the last censuses and the after-census official estimates. They also display alternative estimations made by various authors.

Figure 2: Armenian population trends according to different estimates



Sources: censuses: 1979, 1989, 2001; current official estimates: NSS 2007; former official estimates: NSS 2002; Yeganyan's estimates: Yeganyan et al. 2001.

[12] The earthquake occurred on 7 December 1988. At that time, the Armenian authorities were faced with substantial population displacement. Authorities asked for a postponement of the census but were obliged by the central power to conduct it at the same time as the rest of the Soviet Union. Consequently, the census significantly underestimated the population. A correction was made immediately afterwards, increasing the enumerated population from 3,304,000 to 3,450,000.

In Armenia, the new census reported 3.2 million inhabitants, much less than the 3.8 millions reported in 2001 by official statistics (NSS 2002), but significantly higher than the only 3 millions estimated by Yeganyan, et al. (2001).[13] Following the census, NSS produced new annual population estimates for the period of 1989-2001.[14] The readjustment took into account the post-independence emigration wave that resulted in a dramatic population decline between 1992 and 1995. Current population estimates after 2001 are probably less problematic than in the early 1990s, since migration flows are thought to have stabilized. Population trends based on these new official estimates appear realistic[15] and they will serve as a basis for calculating Armenian mortality rates.

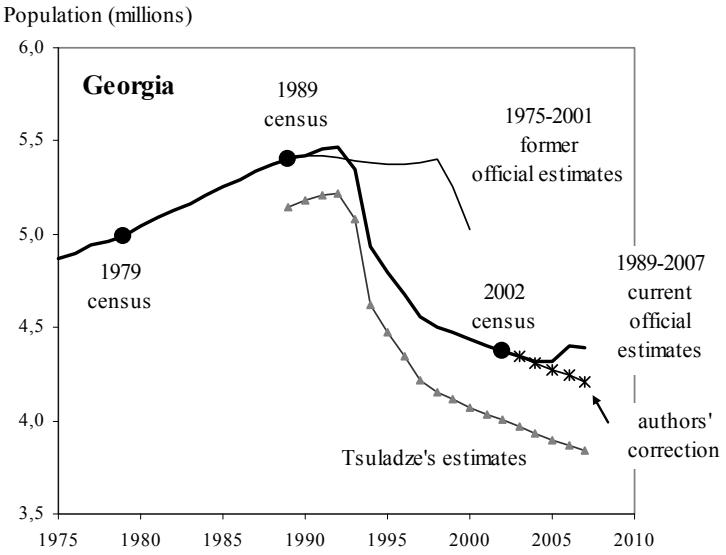
In Georgia too, population estimates varied a lot prior to the 2002 census (Figure 3). For 2001, official estimates indicated 4.9 million inhabitants while Tsuladze proposed 4.0 million, a difference of close to 25%, like in Armenia. The gap was even larger in 1999, since the official estimates during the 1990s continued to include the populations of Abkhazia and Tzkhinvali which were excluded de facto from the Georgian population after 1993, while Tsuladze excluded Tzkhinvali in 1993 and Abkhazia in 1994. The new census gave an intermediate result: 4.4 million. The new official estimated trends include a short period of continued growth (1989-92) followed by a dramatic fall resulting from the loss of the Ossetian (1993) and Abkhazian (1994) populations and positive out-migration flows (1992-96). After checking that territories involved are the same for population and vital events, 1989-2002 official inter-census estimates will be used hereafter to compute mortality rates, as in the case for Armenia. However, more recent estimates for Georgia seem quite unreliable since they are largely influenced by the artificial peak of in-migration already discussed, even if a positive natural growth rate is taken into consideration. Consequently, we correct population estimates for 2005-2007 based on linear population trends beginning in 1998.

[13] The main cause of such a divergence was the method used to estimate migration flows. While official population estimates relied on migration registered through the regional passport offices of the Police of RA, a system which did not capture migration completely, Yeganyan et al. (Yeganyan 2000; Yeganyan and Davtyan 2000)attempted to re-assess migration (Yeganyan 2000; Yeganyan and Davtyan 2000), on the basis of various sources, including migration surveys (Karapetyan, Yeganyan, and Shakhnazaryan 1996; Yeganyan and Shakhnazaryan 1999).

[14] The Armenian statistical office decided to take the corrected value from the 1989 census as the starting point for the recent reassessment. However, slight changes have also been made for the previous inter-census period from 1979 to 1989.

[15] The first results from the last migration survey, performed in 2007, suggest that migration flows are still larger than the official estimates used to assess post-census population counts (MLSI and NSS 2008). Consequently, there could be some remaining overestimation of the Armenian population in the most recent years, at least among young adults. Forthcoming analysis on the survey data could provide a more precise estimate of annual migration flows in the 2000s. However, as the current overestimation of the population concerns mainly young adults, with rather low mortality, it should not have a big impact on life expectancy.

Figure 3: Georgian population trends according to different estimates



Sources (official and Tsuladze estimates are both published in the Demographic Yearbooks of Georgia): censuses and current official estimates and Tsuladze's estimates: Tsuladze, Maglaperidze, and Vadachkoria 2007; former official estimates: Tsuladze, Maglaperidze, and Vadachkoria 2001.

3. Incomplete birth and death registration

During the last decade of the Soviet era, problems of reliability in death registration remained for deaths in infancy and above age 60, and had greater impact in specific regions such as Central Asia and Caucasus (Anderson and Silver 1989). The under-estimation of infant deaths in Caucasian countries (Ksenofontova 1994; Velkoff and Miller 1995), was thus probably much more significant than in Russia (Meslé et al. 2003) or in the Ukraine (Meslé and Vallin 2003) where the problem was only related to the definition of live birth.[16] Since independence, however, the registration system has deteriorated in both Georgia and Armenia, mainly because administrative control of the

[16] The WHO definition, which is less restrictive than the Soviet one, was officially adopted in Armenia in 1994 and in Georgia in 1993 (Aleshina and Redmond 2005). However, in Armenia, it seems that the impact of this change was limited by a progressive adoption of the new definition (Hakobyan, Mkrtchyan, and Yepiskoposyan 2006). The new definition of live birth according to WHO was confirmed by RA Government Decree in 2005.

population has weakened, but also for other reasons, such as the establishment of registration fees in Georgia[17] or the centralization of civil registration services.[18] More recently, health and statistical authorities have tried to reverse this negative trend, by implementing recovery measures.

Furthermore, in Georgia, the Abkhazian and Ossetian conflicts resulted in more specific difficulties. First, vital statistics no longer cover the "Tzkhinvali region" as of 1991, or Abkhazia as of 1992. The only way to calculate rates is thus to refer to the population of Georgia without these territories. Second, in 1993, while mortality climbed due to the conflict, the civil registration system was disrupted and no regular data are available for that year. Georgian Statistical Office gives only a rough estimate of death numbers.

3.1 Recent reforms to improve civil registration

3.1.1 In Armenia

The first steps for improving the Armenian registration process were taken in 1999 with a decree introducing a social allowance for women giving birth to a live child. Its amount was increased considerably in 2003,[19] and, since 2005, specific allowances are available to families receiving social aid.[20] The Demographic and Health Survey (DHS), conducted in 2005, revealed that 96% of births in the five years preceding the survey were registered (NSS, Ministry of Health, and ORC Macro 2006), suggesting that the government measures were effective despite the centralization of the registration system. Under-registration of deaths is less problematic, except for the very young and the very old. Concerning neonatal deaths, the RA law "On Acts of Civil Status" states that any infant death occurring in the first four weeks of life must be registered by the Medical service where the death certificate was issued. Since 1996, funds are also allocated to families for the death registration of a pensioner, and the amount was also increased in 2003.[21]

[17] The fees were rather high for Georgian people who were facing a severe social and economic crisis. At that time burial could take place without a death certificate, especially in rural areas, many people no longer registered death. Registration of births deteriorated much less but completeness of birth statistics was also affected because child benefits for women were abolished.

[18] In Armenia, the centralization of services at regional level in 1996 made the registration difficult for people living in villages far from the regional capital.

[19] 35,000 Dram or AMD (69€ in mid-2009) whereas it was previously 5,900 AMD.

[20] The allowance is twice more important for thoses families and since 2007, families under social aid received an allowance of 200,000 AMD from the third child.

[21] Effective 1996, families received the equivalent of one year's pension for registering the death of a pensioner, and as of 2003, the amount increased to 15 times the determined base pension.

3.1.2 In Georgia

A first improvement occurred in Georgia when, in 1998, fees for birth and death certificates were abolished, first in the capital city of Tbilisi, and then in the countryside.[22] In 2005, a reorganization of the civil registration system was implemented, with the establishment of an independent agency, the Georgian Civil Register, to centralize the civil registration process. If the reform improved the availability and the quality of services for Georgians, the centralization of services discouraged many people in rural areas from registering events. Consequently, there were 18% fewer deaths registered in 2005 than in 2004 and the Department for Statistics (DS)[23] re-estimated the number of deaths in rural areas in 2005 based on the rural/urban ratio observed in 2004. Nevertheless, an advertising campaign about the usefulness of registration and the accessibility of services played a positive role. Recent official statistics show an increase in the number of registered events, especially births and marriages. In 2006, the number of deaths increased slightly, but remained less than before the reform. At the same time, in order to improve vital statistics, a dual system of data collection was organized in 2004. The "old" system (the traditional process of civil registration) was duplicated by a "new" one, based on data available from medical facilities. The comparison between the two sources should result in a better estimate of actual number of deaths.

3.2 Available data on births and deaths

3.2.1 Births counts

In Armenia and in Georgia, both statistical offices and Ministries of Health publish routine annual birth counts (Figure 4). In addition, in Georgia, the statistical office has published corrected estimates since 1996, while the new data collection system and its cross-matching with the old system gives slightly different results for the years 2004-06. Tsuladze has also published his own yearly estimates since 1998.

In Armenia, except for the last two years of Soviet rule, the Ministry of Health used to register significantly fewer births than the Statistical office through civil registration, but since 2000, it has counted slightly more births at hospitals than total births registered through civil registration. Nevertheless, NSS and the Ministry of

[22] However, people still have to pay medical doctor to issue the medical certificate they need to register a vital event.

[23] Since 2004, the department is part of the Ministry for the Economic Development of Georgia; it was previously called the State Department for Statistics (SDS) of Georgia.

Health give similar trends throughout the period. The situation is quite different in Georgia, where the annual birth counts provided by the Ministry of Health are much higher than those produced from civil system since the late 1990s. For this reason, DS also published an adjusted series, which is almost the same, but slightly higher, than that of the Ministry until 2003. After that year, official data rely totally on the results of the cross-matched data from the dual-collection system.[24] In both countries, the dramatic drop observed around the independence year is obviously due to the corresponding population decline mentioned above, which is much larger in Georgia because of territory losses. This phenomenon is exacerbated by an actual fertility decline in the two countries.[25]

The almost-perfect match between official statistics and Ministry of Health data in Armenia suggests that birth registration is quite good. However the increase in birth numbers starting in 2003, observed from the two sources, is probably due to improvement of the registration system. In Georgia, given the large discrepancies beginning in the mid-90s, the quality of civil registration data seems questionable. Nevertheless, official estimates, which take into account both better recent estimates from the Ministry of health and the cross-matching of data in 2004,[26] provide more realistic series.

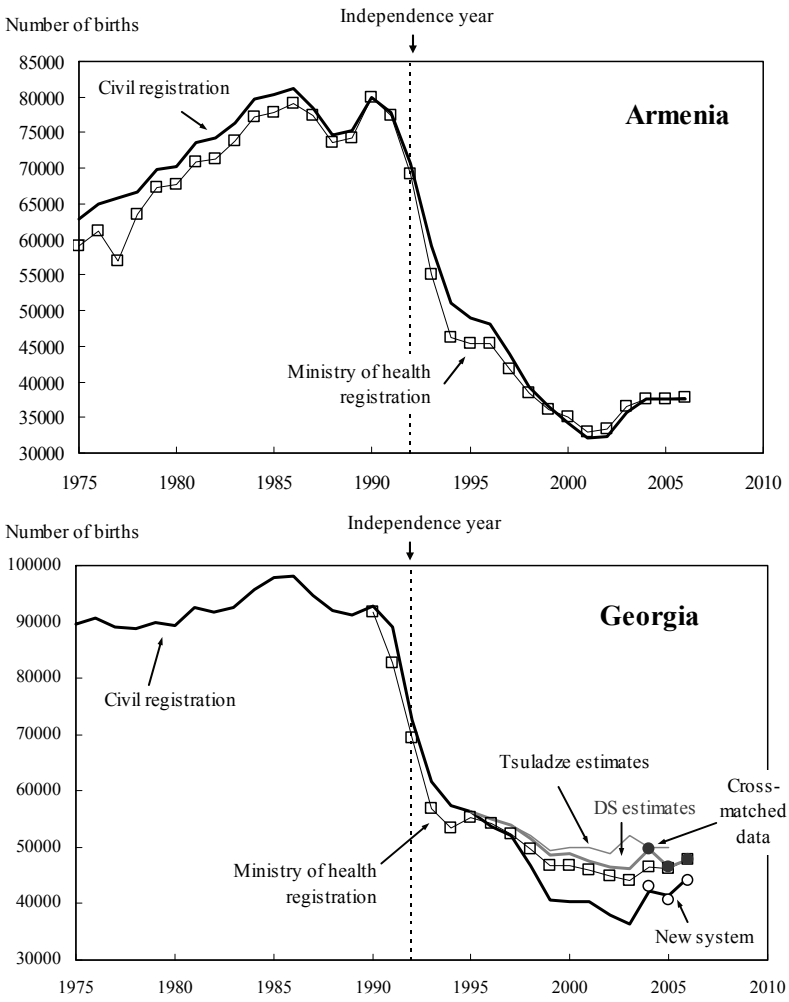
3.2.2 Deaths counts

While only one annual death series is available in Armenia, four different estimates can be found for Georgia. Indeed, Georgian series of registered deaths published by the Statistical Office have been much more irregular since Independence than those of Armenia (Figure 5), with a first dramatic drop in 1994-1995 and a second in 2005. As for births, the first drop correlates to a certain degree with the population decrease, but is much more pronounced than in Armenia and probably also reflects a deterioration of death registration. Georgian crude data certainly needed more adjustment than Armenian data. The series adjusted by DS from 1989, which is much higher than the registered death series for the 1990s, seems to take into account the first drop, but for the second, it relies entirely on the cross-matched data without any correction. The Tsuladze series adopted much higher numbers of deaths for the years 2005 and 2006.

[24] It is interesting to note that both the "old" and "new" systems, upon which the dual collection system is based give very similar total birth counts, but the births registered by each system are not the same. This explains why data cross-matching gives a significantly higher number of births.
[25] For the period 2005-2010, the Total Fertility Rate is 1.7 in Armenia and 1.6 in Georgia, compared to 3 and 2.6 in 1970-1975 respectively (United Nations 2009).
[26] The double-data collection experiment started in 2003 but the first year seems to have been incomplete.

Before concluding discussion of these data, let us have a look at crude death rates which take into account the population size.

Figure 4: Available estimates of annual numbers of births in Armenia and Georgia



Sources: for Armenia: NSS 2002; 2007, Ministry of Health 2008 (unpublished tables); for Georgia: Tsuladze, Maglaperidze, and Vadachkoria 2001; 2007; counts from each system since 2004 are from unpublished tables

3.3 Crude mortality rates

In Armenia, a decrease in the crude mortality rate is still observed in the years following Independence (Figure 6). This could be related to deterioration in death registration that was not clear from the death series. But the quality of mortality statistics is even lower in Georgia when only registered deaths are considered. Official estimates seem to give a more realistic view for the 1990s. If we take into account the 1993 mortality peak due to the Abkhazian conflict, this correction removes the unexpected gap in 1995-96 by increasing observed mortality rates differently over time. However, it does not abolish the sharp drop of 2004-05 as Tsuladze's estimates do. For all these reasons, we think that further adjustments are needed. But examining the overall under-registration of deaths is not enough to solve the problem. It is very probable that under-registration varies with age. In particular, infant mortality and mortality above age 60 deserve special attention.

4. Re-estimating life expectancy

4.1 Infant mortality

There are specific causes for under-registration of infant mortality (Aleshina and Redmond 2005; Anderson and Silver 1986), but fortunately sources of information totally independent from routine registration are available to make comparisons. In Armenia, two Demographic and Health Surveys (DHS) were carried out in 2000 and 2005 (NSS, Ministry of Health, and ORC Macro 2001; 2006), while Georgia also produced results from two Reproductive and Health Surveys (RHS), very similar to DHS, conducted in 1999 and 2005 (Serbanescu et al. 2001; 2007).

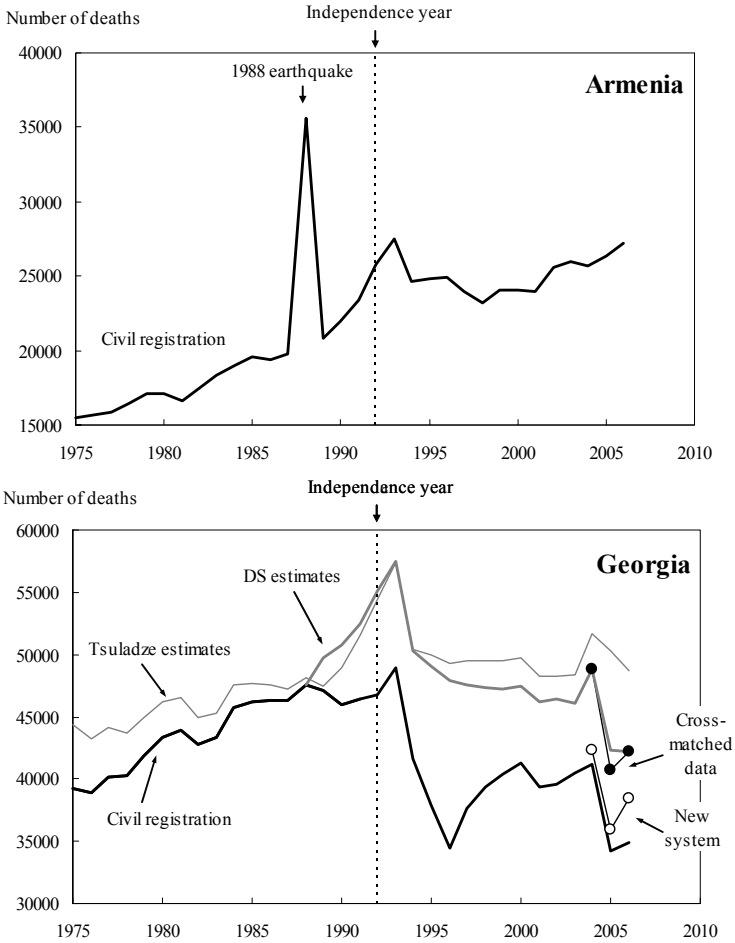
In Armenia, Ministry of Health[27] data show infant mortality rates slightly higher than statistical office data (Figure 7), which probably means that infant deaths are significantly under-registered by the civil registration system. Four measures from each DHS[28] are reported in Figure 7 and whatever the period, both 2000 and 2005 DHS show significantly higher rates than those of the civil registration system, as do those

[27] From this source, we obtained two unpublished series for 1996-2003 and 2003-2006, but infant death counts for the common year (2003) are different. We therefore plotted two series on Figure 8. This difference reveals that infant deaths registered through the health system should also be considered carefully.

[28] From retrospective questions to women aged 15-49 related to their delivery and children, the number of live births reported can be calculated for specific periods as can the number of children reported deceased before age 1. Infant mortality can be thus calculated dividing the number of infant deaths by the number of births for each period (0-4, 5-9, 10-14 and 15-19 years before the survey) associated with Wald confidence intervals.

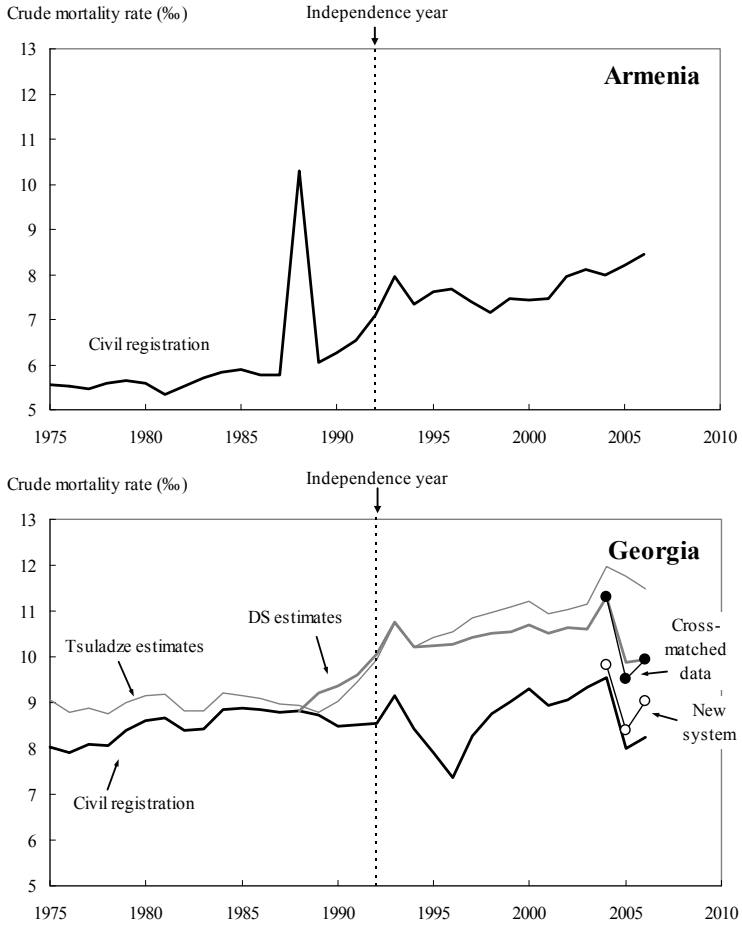
from health services. The two DHS also confirm a steady decrease in infant mortality over the past three decades.

Figure 5: Available estimates of annual numbers of deaths in Armenia and Georgia



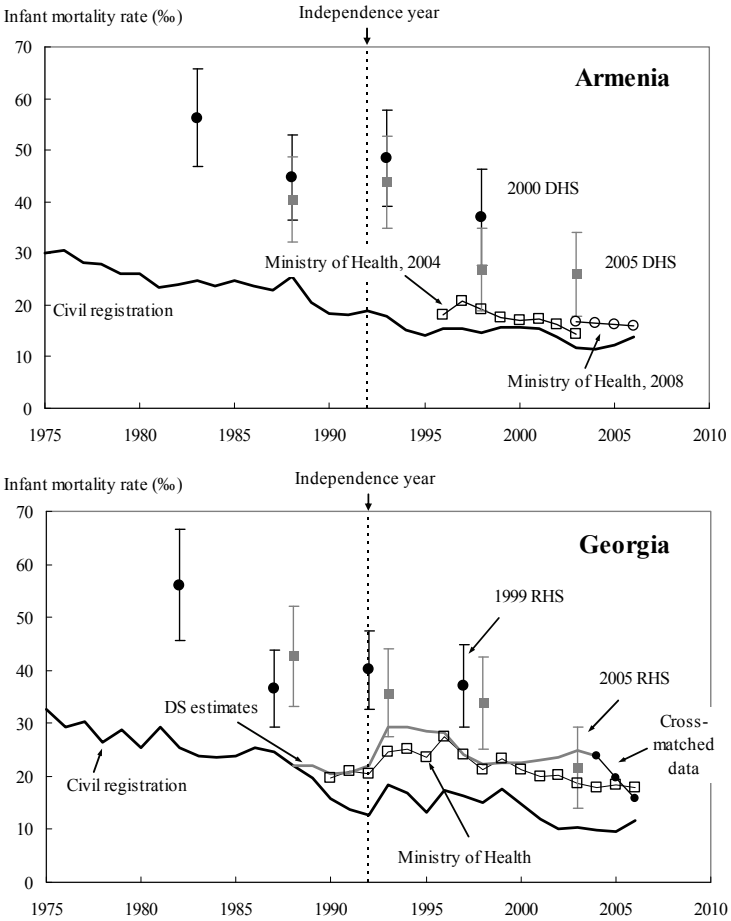
Sources: for Armenia: NSS 2002; 2007; for Georgia: Tsuladze, Maglaperidze , and Vadachkoria 2001; 2007; counts from each system since 2004 are from unpublished tables.

Figure 6: Available estimates of crude death rates in Armenia and Georgia



Sources: for Armenia: NSS 2002; 2007; for Georgia: Tsuladze, Maglaperidze , and Vadachkoria 2001; 2007; deaths counted since 2004 in each system are from unpublished tables.

Figure 7: Available estimates of infant mortality rates in Armenia and Georgia



Sources: for Armenia: NSS 2002; 2007; Ministry of Health 2004; 2008 (unpublished tables); 2000 and 2005 DHS (authors' calculation for 5-year periods with confidence interval); for Georgia: Tsuladze, Maglaperidze , and Vadachkoria 2001; 2007; unpublished tables; 1999 and 2005 RHS (author's calculation for 5-years periods with confidence interval).

The same phenomenon is observed in Georgia, when comparing rates based on civil registration to survey data. However, for the 2000-2004 period (the five-year period preceding the survey), the second survey shows a mean infant mortality rate which is very close to the Ministry of Health data (slightly lower) and official estimates (slightly higher).

We assume that the survey results give a better view of general levels and trends than current vital statistics. However, different biases are linked to such surveys and despite a standardized method, results for a similar period are not systematically equal. In Armenia, for instance, Figure 7 shows that for the period 1996-2000, IMR was estimated at 37 per thousand according to the first DHS, compared to 27 according to the second one. Different reasons may explain this gap. First, the sample is not the same in the two surveys, because the last census carried out in between. There are also some well-known limits to questioning women about their birth histories: problems of recollection, underestimation of early neonatal mortality, reliability of children's ages as well as that of those who died (Potter 1977; Institute for Resource Development 1990). In addition, there are specific limits due to low fertility levels which lead to small numbers of infant deaths in the DHS samples (UNICEF 2003; 2006; Aleshina and Redmond 2005; Redmond 2007). For these reasons, it is certainly better to rely on estimates based on current statistics to capture the actual short-term changes in infant mortality.

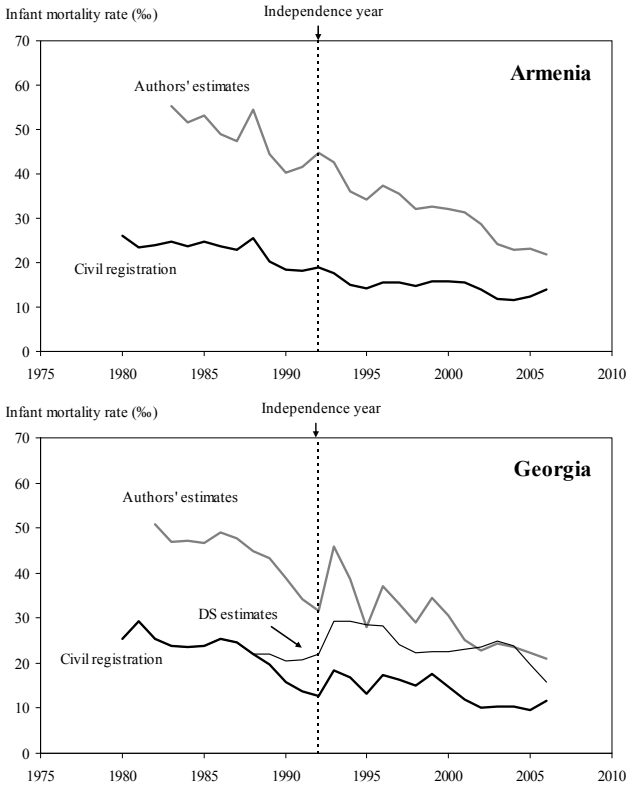
In order to estimate annual IMR, we proceeded in four steps (details in annex 1). First, we estimated linear IMR on the basis of a linear regression of the eight points given by the two surveys. Second, we used these linear estimates to calculate five-year coverage rates of the "civil registered IMR". Those IMR are calculated on the basis of births and infant deaths counted through civil registration.[29] Third, we estimated annual IMR by applying these coverage rates to annual "civil registered IMR". Fourth, for the most recent years, trends in annual estimated IMR were extrapolated through 2006.

Figure 8 compares our IMR estimates to official estimates. For Armenia, in the last step, we assume not only that the general decrease in IMR is ongoing, but also that the recent reforms in the civil registration system substantially improved the measure and led to the artificial increase observed in official IMR. For Georgia, according to the RHS, our estimates are very close to official estimates for years 2003 and 2004. Indeed, the new dual-collection system seems to have been effective. Compared to other estimates, the correction gives higher levels than those provided by Kingkade and Sawyer (2001), the Georgian IMR estimated by SDS, NCDC, and UNICEF (2008) and

[29] For Georgia, we decided to use civil registered data and not the official data. These estimates rely on a very questionable distribution of births and deaths by sex which will be discussed in the next section.

the Armenian official IMR adjusted by Ministry of Health and UNICEF (2002), but we assume that their methods still underestimate infant mortality rates.[30]

Figure 8: Infant mortality rates in Armenia and Georgia according to official statistics and authors' estimates



[30] First, Kingkade and Sawyer broke down infant deaths into three age groups (0-3, 4-9 and 10-11 months) and estimated infant mortality on the basis of that of Germany and United States, with the same level of mortality observed for the middle age group 4-9 months. There is no evidence that infant deaths in Armenia and Georgia between four and ten months are as well registered as they assume. Second, in order to estimate IMR in Georgia, SDS, NCDC, and UNICEF (2008) used an indirect method based on Brass's model to estimate IMR in Georgia which has already been discussed by Aleshina and Redmond (2005). Finally, in Armenia, according to a survey carried out by the Ministry of Health and UNICEF in 2000, 24% of infant deaths with a medical death certificate would not have been registered in the civil system (2002). They propose an adjusted official IMR but it does not take into account infants who die at home without any medical certification, nor intentional and unintentional under-registration of infant deaths by health personnel.

Annual coverage rates applied to "civil registered IMR" are used to estimate annual IMR for males and females, as well as for both sexes combined (Annex 1). This assumes that there is no sex difference in birth and infant death registration. For 2001 in Georgia, sex ratio at birth (SRB) calculated on the basis of registered live births was 1.18 boys born per girl, whereas DS data present a constant SRB from 1996 to 2002 (1.11). The latter is actually higher than the usual 1.05 but lower than 2005 RHS estimates. A higher actual level is thus consistent with the sharp increase in the sex ratio at birth observed in the Caucasus (Meslé, Vallin, and Badurashvili 2007). In Georgia, births registered through the civil system along with DS estimates lead to a similar level of male and female IMR since 2004, contrary to the 2005 RHS results (excess male infant mortality is about 1.5 over the period 2000-05). The excess male infant mortality was 1.36 on average according to events recorded in the civil registries over the 10-year period 1994-2003. We thus decided to apply this ratio in order to estimate male and female IMR since 2004.

4.2 Mortality at old ages

The above correction of infant mortality gives a solid basis for re-estimating life expectancy. If infant deaths are under-registered, then registration of deaths after age one is also likely to be incomplete. No survey gives any reliable estimate of adult mortality or provides reliable and detailed data on completeness of registration of deaths over age 1.[31] Actually, in the former USSR countries, the burden of cardiovascular diseases and external causes of death leads to adult mortality rates that are much higher than predicted by any model life table (Shkolnikov, Meslé, and Vallin 1996). Using such model life tables is thus not very relevant for estimating young adult mortality in Caucasian countries.

Nevertheless, model life tables can be used as a reference to assess mortality at old ages, not on the basis of 1-59 mortality, but according to the level of infant mortality. For this reason, we have examined the relationship between corrected infant mortality and life expectancy at age 60 from official statistics[32] (Annex 2). The comparison with

[31] Only the 2006 Georgian Gender and Generation Survey (GGS) inquired regarding deaths that occurred in the household during the five preceding years (Badurashvili et al. 2008). However, it produced quite unreliable levels of mortality, with a life expectancy at birth estimated at 72.2 years for males and 78.5 years for females for the period April 2001- March 2006. Regarding registration in the civil system, the question about registration of declared deaths has been asked to respondents, and according to the answers, around a quarter of deaths over age 1 were not registered, but low frequencies do not allow a detailed analysis by sex and age group.

[32] Official statistics refer to civil registration for Armenia; and civil registration until 1988 and DS estimates from 1989 for Georgia.

levels given by Coale and Demeny Regional Life Tables (Coale, Demeny, and Vaughan 1983) reveals an overestimation of life expectancy at age 60 in both countries through the early 1990s. In Armenia, the 1980s[33] are characterized by relatively high life expectancy at age 60 according to the infant mortality rate, compared to regional life table models (the East and the West ones for males; the North and the East ones for females). By contrast, e_{60} is relatively low in the most recent years, lower than the West model for males, and lower than the East model for females. In Georgia, a similar phenomenon can be observed in the 1980s: life expectancy at age 60 seems too high for the IMR level. From 1991, the relationship between e_{60} and IMR is very close to the West model for males, and varies from the North model to the East model for females. Again, in 2005 for both sexes and 2006 for females, e_{60} appears to be overestimated. Thus, we decided to correct life expectancy at age 60 through 1991 in Armenia and in Georgia[34] according to the West regional model for males and the North model for females. As in Georgia, the years 2005 and 2006 are also questionable and were corrected in the same way.

4.3 Life expectancy at birth

For both countries, age-specific mortality rates from age 1 to 60 were computed from official data. Life tables were then built on the basis of these age-specific rates plus our estimates of IMR and life expectancy at age 60. It then became possible to compare official statistics of life expectancy at birth with those obtained after applying the corrections proposed above.

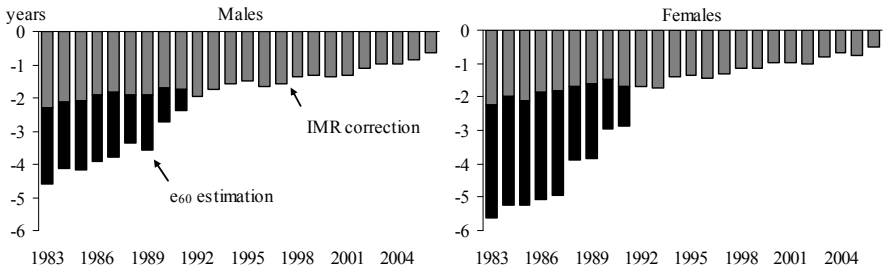
4.3.1 Armenia

In Armenia, the correction of infant mortality rates led to a reduction of life expectancy at birth of more than two years for both sexes in 1983. The discrepancy with respect to official statistics has decreased over the period and in 2006 the reduction is less than one year (0.6 for males and 0.5 for females). Taking into account estimated life expectancy at age 60 until 1991 has resulted in a second reduction in estimated life expectancies with respect to official statistics. This has also decreased over time, however, with a greater impact on female mortality, resulting in a loss of 3.4 years in 1983. At the beginning of the period, the global correction reduces the official life

[33] Except for 1988, the year of the earthquake.
[34] For 1991, male life expectancy at age 60 has not been corrected because the observed level is similar to the model life table.

expectancy at birth by 4.6 years for males and by 5.6 years for females. The gap between official statistics and proposed estimates has decreased regularly over time (Figure 9). For the most recent years, those estimates are certainly a minimum correction.

Figure 9: Respective effects of (i) infant mortality correction (in grey) and (ii) old age mortality re-estimation (in black) on official Armenian life expectancy at birth

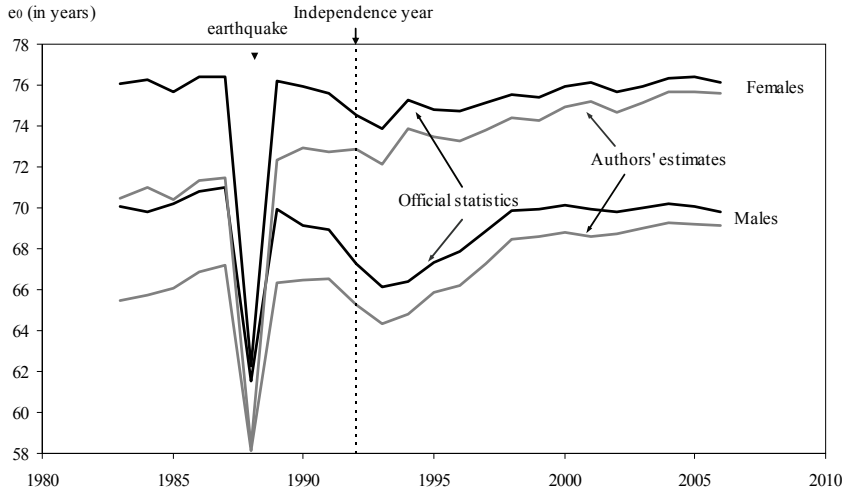


According to those estimates, Armenian male and female life expectancies were 65.5 and 70.4 years, respectively in 1983, whereas current official estimates suggest 70.0 for men and 76.0 years for women. In 2006, they are estimated at 69.2 and 75.6 (Figure 10), with a gain of less than 4 years for males but more than 5 years for females over the two decades.

The impact of the 1988 earthquake is obviously massive[35]. Life expectancy at birth fell to just 58.2 years for males and 58.3 years for females; and the sex difference almost vanished given the greater impact of the earthquake on females than on males. Apart from the earthquake, female life expectancy increased slowly over the period, except for some short interruptions just after Independence. Since 2006, progress has stopped but it is too early to know if this is a sustainable trend. For males, the downtrends were much sharper and the up trends have levelled off since the end of the 1990s.

[35] It could be even more dramatic if we took into account a probable underestimation of deaths due to the earthquake. Different sources estimate the number of deaths at around 25,000 (Demoscope Weekly 2004; Ria Novosti 2008) i.e. 10,000 more than official statistics used here.

Figure 10: Trends in Armenian life expectancy at birth from 1983 according to official statistics and authors' estimates

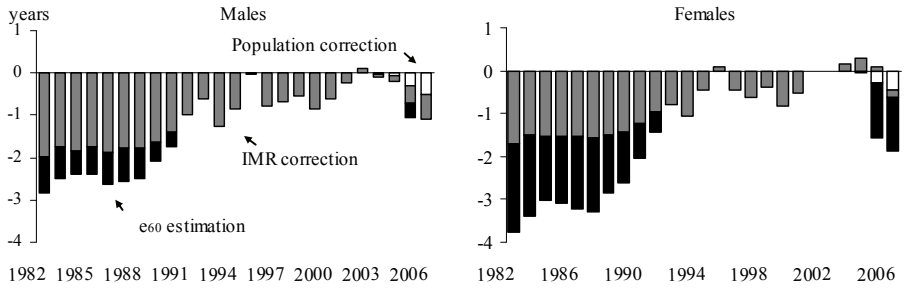


Sources: for official statistics: NSS 2002; 2007.

4.3.2 Georgia

Georgian official data already include a large correction for the last decade, even bigger for some years (1995 and 2004 for females) than our own. For these years, the IMR correction has an irregular impact, never exceeding one year of life expectancy reduction and in 2005-2006, the correction of population counts has little influence on life expectancy levels. Before 1989, official statistics were not revised and the IMR correction decreased life expectancy levels substantially. IMR correction has resulted in a life expectancy reduction of around two years among males in 1982, slightly less among females while e_{60} re-estimates produce an additional loss of one more year for males, and two more years for females, showing a larger under-registration of female deaths at old ages in the civil system. The recent correction for females after the centralization of the system in 2005 suggests that this sex differential remains over time (Figure 11).

Figure 11: Effects of (i) population correction (in white), (ii) infant mortality correction (in grey) and (iii) old age mortality re-estimation (in black) on annual official Georgian life expectancy rates



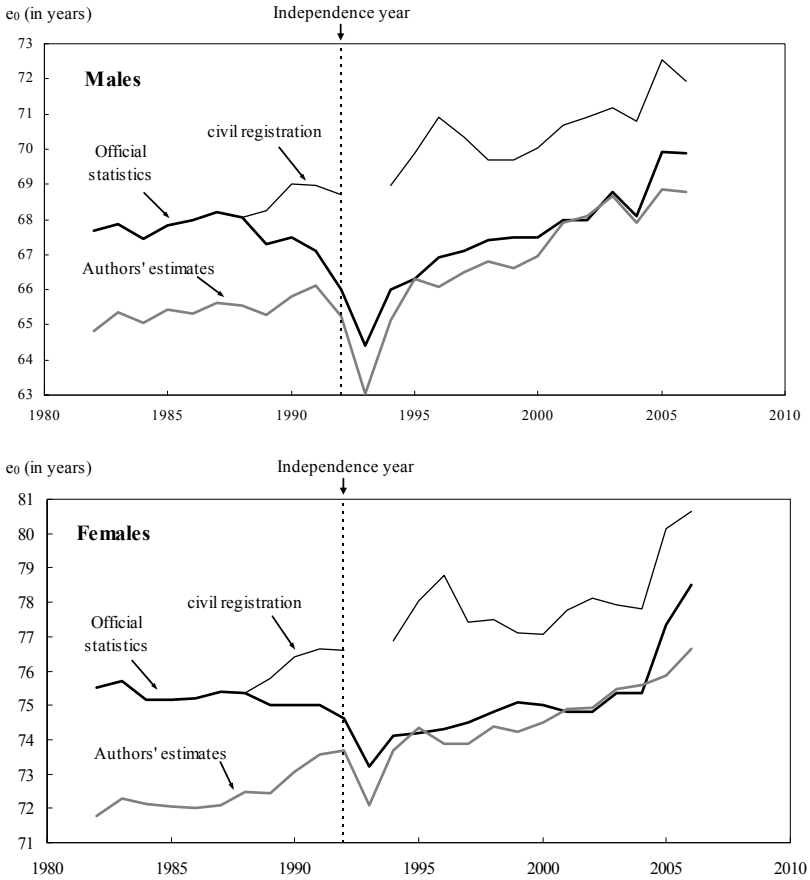
Unlike in Armenia, the difference between those estimates and civil registered data[36] did not decrease with time (Figure 12). They are nevertheless closer to official statistics which already took into account the poor reliability of the data source. Finally, according to our estimates, life expectancy at birth is 68.8 and 76.7 years for Georgian males and females in 2006. This is 4 and 5 years more than levels estimated for the year 1982.

As in Armenia, health progress has stagnated starting from the first year of independence, but the crisis is more pronounced with the strong impact of the 1993 war, especially among males. In 1995, life expectancies recovered the years lost during this difficult period, and from that year, global trends started to increase. However, a divergence between sexes is observed for 2004: whereas female life expectancy goes on increasing at the same pace, for males it decreased before returning to a similar level in 2005. The IMR correction smoothed this discontinuity for females, but not totally for males.[37] Nevertheless, these estimates reduce the suspicious sharp increase in official life expectancies.

[36] They are missing in 1993 because of the war. More recently, deaths registered through the civil system are no longer published since the implementation of the new system (cross-matched data) in 2003. Those data are thus from unpublished tables.

[37] For Georgian males, life expectancy at age 60 appears quite low compared to other years (Annex 2). A problem with DS data can thus be suspected here.

Figure 12: Trends in Georgian life expectancy at birth from 1982 according to official statistics and authors' estimates



Sources (for official statistics and registered data): Tsuladze, Maglaperidze, and Vadachkoria 2001; 2007; since 2004, data from civil registration are from unpublished tables.

5. Discussion-Conclusion

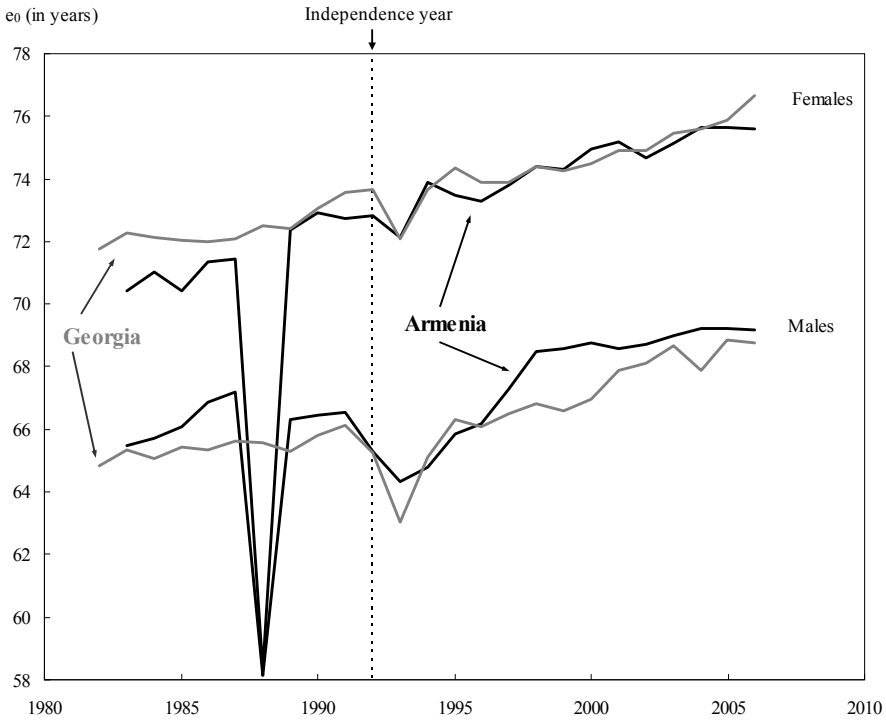
In this paper, a special attention has been paid to infant and old age mortality. Concerning mortality over age 1 and below age 60, available information was insufficient to permit a reliable correction. Even though results from retrospective surveys such as DHS have to be interpreted cautiously, especially because of large confidence intervals (Redmond 2007), corrected trends confirm that infant mortality sharply decreased in the last decades of the twentieth century (Hakobyan, Mkrtchyan, and Yepiskoposyan 2006). In both countries, the correction doubles official figures in the 1980s. In the most recent years, the correction is still 40% in Armenia. In Georgia, official estimates can be considered reliable at the beginning of the 2000s but sex ratio at birth and estimates of infant deaths remain doubtful. Moreover, the recent deterioration in the registration system has led to a new divergence of official statistics from reality. This is also true for mortality at old ages which was corrected in the two countries before independence, but also in the two most recent years in Georgia.

Figure 13 compares recent trends estimated for Armenia and Georgia (Annex 3). In spite of various differences in the way crude data are adjusted, the results are quite comparable, apart from the very specific impact of the 1988 earthquake in Armenia. Changes in life expectancy appear to be similar in both countries for females since 1994, whereas life expectancy was previously a bit higher in Georgia than in Armenia. For males, the opposite is true: despite a recovery in 1994 and 1995, Georgian life expectancy has remained lower than that of Armenia throughout the period, with a strong effect of the war in 1993.

The sex difference is lower in Armenia than in Georgia. At the beginning of the 1980s, the IMR correction led to an Armenian female IMR higher than that of Georgia. Although DHS and RHS are similar, the quality of the surveys can be different, resulting in various IMR trends. However, with large proportion of Russians in Georgia compared to Armenia during the Soviet period (10% and 1%, respectively in 1979), Georgian mortality may correspond more closely to a *Russian pattern.* By contrast, Armenian mortality seems to be less favourable to women, corresponding to a *Mediterranean pattern*; though this Armenian female pattern disappeared after Independence while Georgian males still experienced relatively high mortality.

These corrected trends in life expectancy provide a more reliable basis for comparison with recent mortality trends in European republics of the former USSR (Meslé 2004). They pave the way for a deeper analysis of mortality trends and patterns in these two Caucasian countries relying on cause-of-death statistics, from which coherent time series are under construction.

Figure 13: Trends in Georgian and Armenian life expectancy at birth since the early 1980s according to authors' estimates



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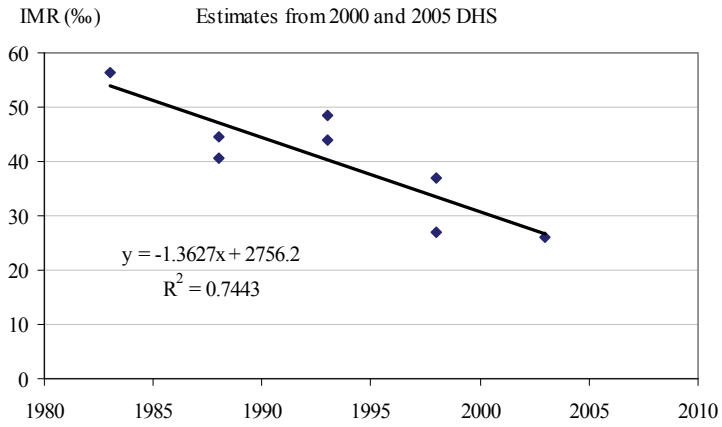
Annex 1: Method for estimating annual infant mortality rates in Armenia and Georgia

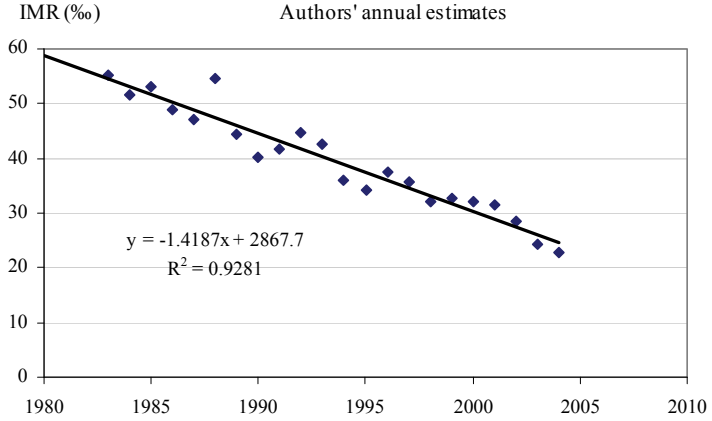
Armenia

Year	IMR Civil registration (1) ‰	IMR 2000 DHS (2) ‰	IMR 2005 DHS (3) ‰	IMR linear estimates (4) ‰	coverage rate estimates (5)	IMR annual estimates (6) ‰
1980	26.2					
1981	23.4					
1982	24.1					
1983	24.7	56.3		54.0	0.45	55.2
1984	23.6			52.6	0.46	51.5
1985	24.7			51.2	0.47	53.1
1986	23.6			49.9	0.48	48.9
1987	22.8			48.5	0.48	47.2
1988	25.6	44.6	40.5	47.2	0.47	54.5
1989	20.4			45.8	0.46	44.4
1990	18.3			44.4	0.46	40.2
1991	18.0			43.1	0.43	41.6
1992	18.9			41.7	0.42	44.8
1993	17.8	48.5	43.8	40.3	0.42	42.6
1994	15.1			39.0	0.42	36.1
1995	14.2			37.6	0.41	34.3
1996	15.5			36.3	0.41	37.5
1997	15.4			34.9	0.43	35.6
1998	14.7	37.0	26.9	33.5	0.46	32.0
1999	15.7			32.2	0.48	32.7
2000	15.8			30.8	0.49	32.1
2001	15.5			29.4	0.49	31.4
2002	14.0			28.1	0.49	28.6
2003	11.8		26.0	26.7	0.49	24.2
2004	11.5			25.3	0.50	22.9
2005	12.3				**0.53**	**23.2**
2006	13.9				**0.64**	**21.8**

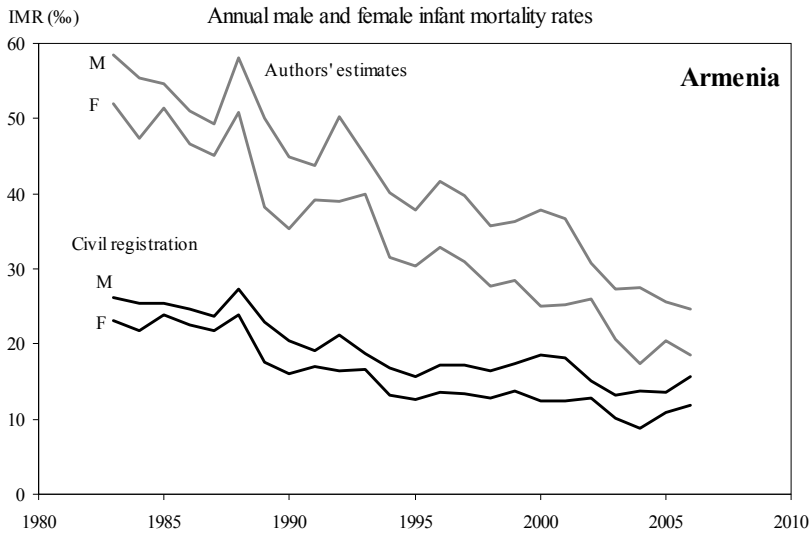
a) Column (4) gives linear estimates for IMR resulting from linear regression on the eight points given by the two surveys.



b) Column (5) is the coverage rate computed as the ratio between 5-year civil registration IMR (moving average) and linear estimated IMR (column 4).
c) Column (6) estimates annual IMR obtained by applying the coverage rate (column 5) to annual civil registration IMR (column 1).
d) For the last two years (in bold in column 6), the estimates result from a linear progression made from all previous estimates. Final estimates are deduced from the corresponding coverage rates.



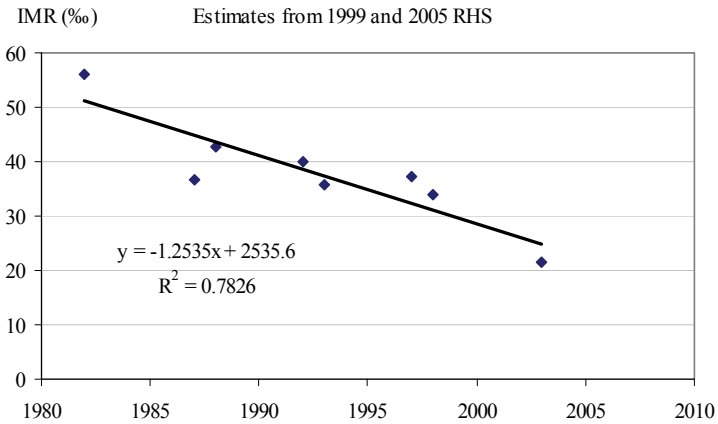
e) Same coverage rates have been applied to infant mortality by sex.



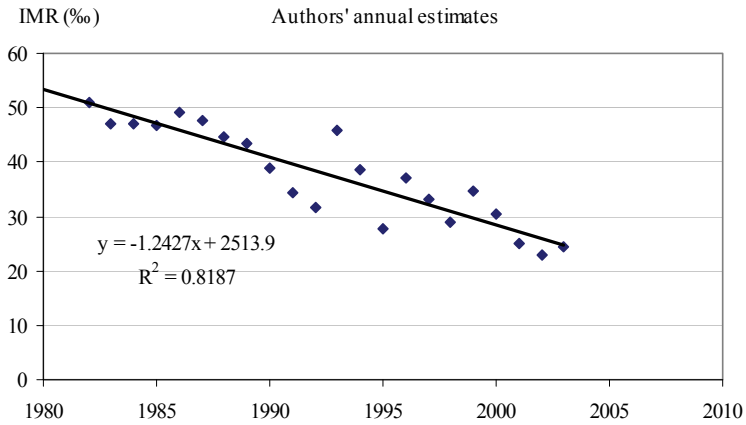
Georgia

Year	IMR Civil registration (1) ‰	IMR 1999 RHS (2) ‰	IMR 2005 DHS (3) ‰	IMR linear estimates (4) ‰	coverage rate estimates (5)	IMR annual estimates (6) ‰
1980	25.4					
1981	29.4					
1982	25.4	56.1		51.2	0.50	50.9
1983	23.8			49.9	0.51	47.0
1984	23.7			48.7	0.50	47.2
1985	23.9			47.4	0.51	46.7
1986	25.5			46.1	0.52	49.1
1987	24.5	36.5		44.9	0.51	47.6
1988	22.0		42.7	43.6	0.49	44.8
1989	19.6			42.4	0.45	43.4
1990	15.8			41.1	0.41	38.8
1991	13.8			39.9	0.40	34.2
1992	12.6	40.1		38.6	0.40	31.6
1993	18.3		35.8	37.4	0.40	45.9
1994	16.7			36.1	0.43	38.6
1995	13.1			34.9	0.47	27.9
1996	17.4			33.6	0.47	37.2
1997	16.3	37.1		32.4	0.49	33.2
1998	15.2		33.9	31.1	0.52	29.0
1999	17.5			29.9	0.51	34.5
2000	14.9			28.6	0.49	30.6
2001	11.8			27.3	0.47	25.1
2002	10.1			26.1	0.44	22.9
2003	10.2		21.6	24.8	0.42	24.4
2004	10.4			23.6	0.44	23.6
2005	9.6				**0.43**	**22.3**
2006	11.8				**0.56**	**21.0**

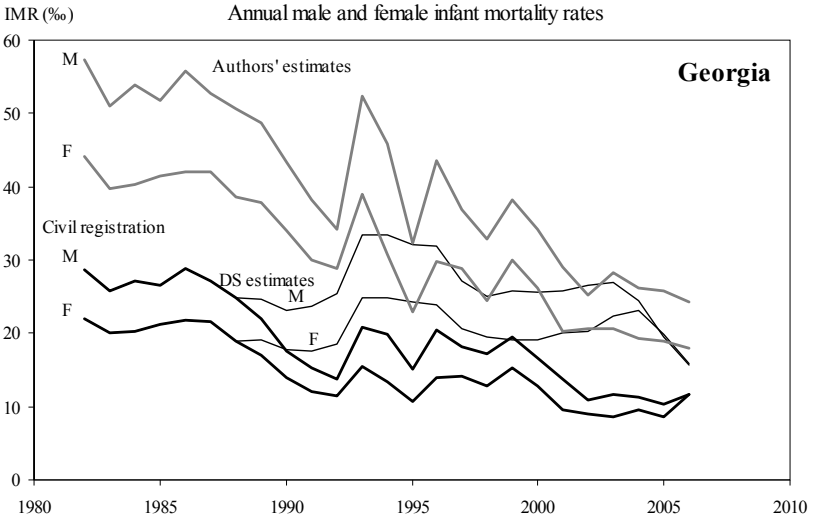
a) Linear regression on the eight points given by the two surveys



d) Linear regression on the annual IMR estimates from 1980 to 2003



e) Annual IMR estimates by sex



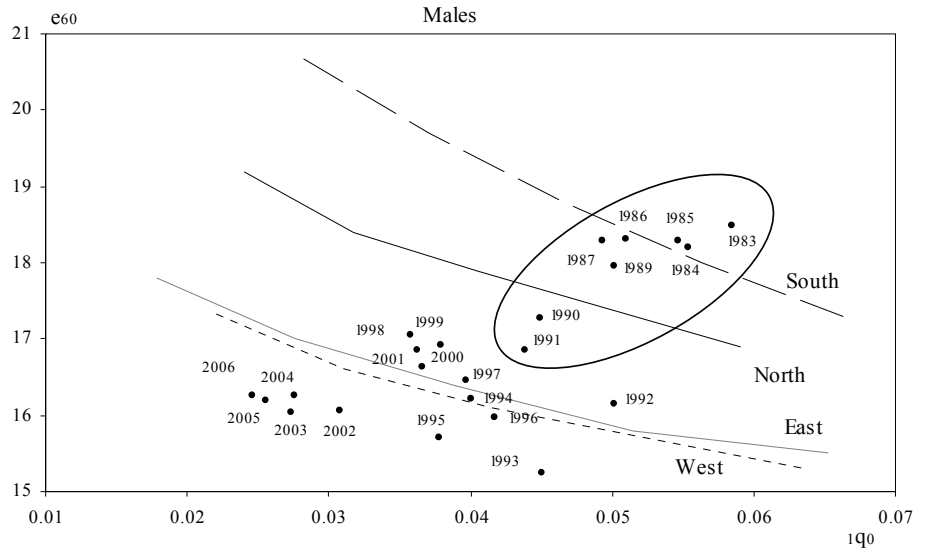
Annex 2: Relationship between corrected infant mortality rate and life expectancy at age 60

In the following figures, dots correspond to crude data and lines correspond to the four Coale and Demeny Regional Life Tables (South, North, East, and West). Years for which life expectancy at age 60 is clearly overestimated compared to other points have to be corrected. This led us to construct a coherent period which is 1983-91 in Armenia (excluding 1988 because of the earthquake). For Georgia, 1982-90 also corresponds to a period of overestimated life expectancy, along with 1991 for females, 2005 for both sexes and 2006 for females. For all these years, we estimate life expectancies according to the closest regional model: West model for males and North model for females.

For the year 1988 in Armenia, the estimation has been done in different steps for each sex: First, using the linear trends of observed life expectancy at age 60 from 1983 to 1987, we calculated an expected life expectancy which would have been observed in the absence of the earthquake ($e'_{60\ obs}$). Second, using the linear trends of estimated life expectancy at age 60 from 1983 to 1987, we calculated an expected level life expectancy which would have been estimated in the absence of the earthquake ($e'_{60\ est}$). Third, we assume that the difference between the expected observed level ($e'_{60\ obs}$) and the actual model ($e_{60\ obs}$) is due to the earthquake and we estimated life expectancy at age 60 ($e_{60\ est}$), reporting this difference in the expected estimated model.

Estimation of life expectancy at age 60 in Armenia in 1988		**Males**	**Females**
Observed level	$e_{60\ obs}$	17.0	20.7
Expected level without earthquake before correction (linear trends 1983-1987)	$e'_{60\ obs}$	18.2	21.9
Expected level without earthquake after correction (linear trends 1983-1987)	$e'_{60\ est}$	15.9	18.4
Final estimation with earthquake	$e_{60\ est} = e'_{60\ est} + (e_{60\ obs} - e'_{60\ obs})$	14.7	17.1

Armenia


Males
e60
21
20
19
18
17
16
15
0.01
0.02
0.03
0.04
0.05
0.06
0.07
1q0
1986
1985
1983
1987
1989
1984
1990
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2006
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1994
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1995
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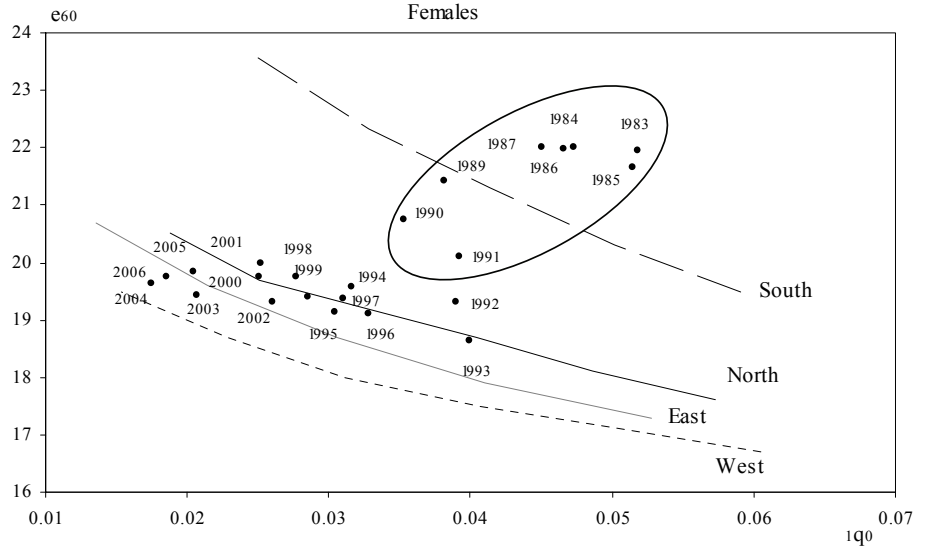
2002
1993
South
North
East
West


Females
e60
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0.02
0.03
0.04
0.05
0.06
0.07
1q0
1984
1983
1987
1989
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1985
1990
2001
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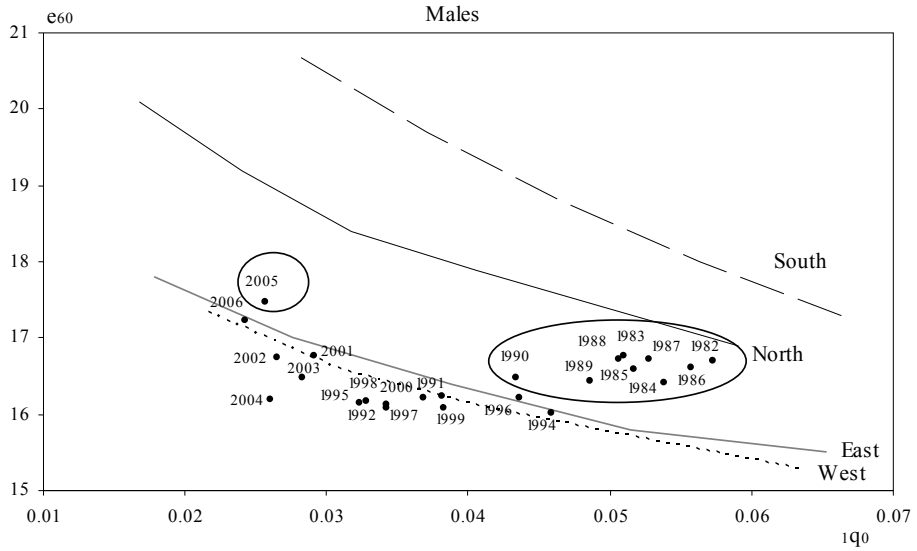
2002
1995
1996
1993
South
North
East
West

Georgia


e60
Males
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0.07
1q0
South
North
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West
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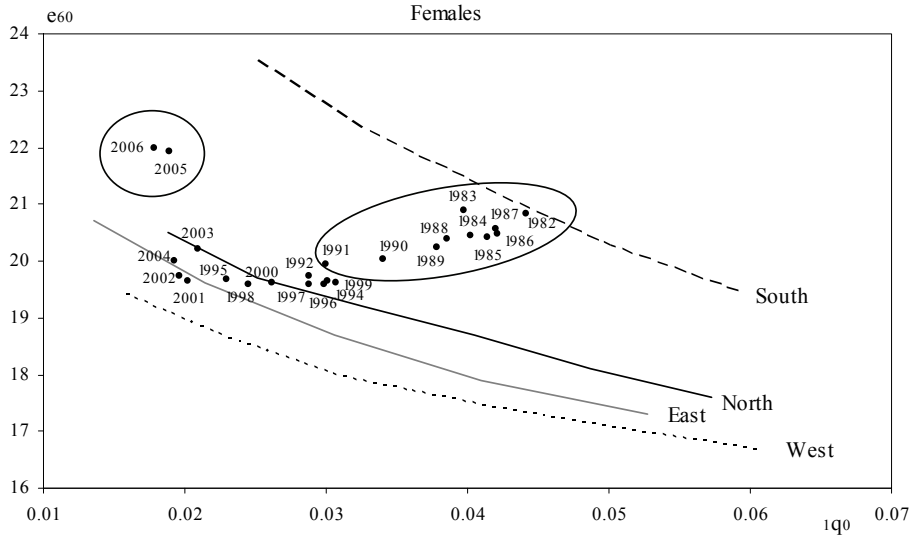
e60
Females
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1q0
South
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2006
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1986

Correction of life expectancy at age 60 in both countries

e_{60}	Armenia				Georgia			
(in years)	Official data		Authors' correction		Official data		Authors' correction	
	Males	Females	Males West	Females North	Males	Females	Males West	Females North
1982					16.7	20.8	15.5	18.4
1983	18.5	21.9	15.5	18.0	16.8	20.9	15.7	18.7
1984	18.2	22.0	15.6	18.2	16.4	20.4	15.6	18.7
1985	18.3	21.6	15.6	18.0	16.6	20.4	15.7	18.6
1986	18.3	22.0	15.7	18.3	16.6	20.5	15.6	18.6
1987	18.3	22.0	15.8	18.4	16.7	20.6	15.7	18.6
1988	17.0	20.7	14,7	17,1	16.7	20.4	15.8	18.8
1989	18.0	21.4	15.8	18.8	16.4	20.2	15.8	18.9
1990	17.3	20.7	16.0	19.0	16.5	20.0	16.0	19.1
1991	16.9	20.1	16.0	18.7	16.2	19.9		19.4
1992	16.1	19.3			16.1	19.7		
1993	15.2	18.6			12.3	15.1		
1994	16.2	19.6			16.0	19.6		
1995	15.7	19.1			16.2	19.7		
1996	16.0	19.1			16.2	19.6		
1997	16.4	19.4			16.2	19.6		
1998	17.1	19.8			16.2	19.6		
1999	16.9	19.4			16.1	19.6		
2000	16.9	19.8			16.1	19.6		
2001	16.6	20.0			16.8	19.6		
2002	16.1	19.3			16.7	19.7		
2003	16.0	19.4			16.5	20.2		
2004	16.3	19.6			16.2	20.0		
2005	16.2	19.8			17.5	21.9	17.0	20.5
2006	16.3	19.7			17.2	22.0		20.6

Annex 3: Life expectancy at birth in Armenia and Georgia according to authors' estimates

e_0 (in years)	Armenia		Georgia	
	Male	Female	Male	Female
1982			64.8	71.8
1983	65.5	70.4	65.4	72.3
1984	65.7	71.0	65.0	72.1
1985	66.1	70.4	65.4	72.1
1986	66.9	71.3	65.3	72.0
1987	67.2	71.5	65.6	72.1
1988	58.2	58.3	65.6	72.5
1989	66.3	72.3	65.3	72.4
1990	66.4	72.9	65.8	73.1
1991	66.6	72.7	66.1	73.6
1992	65.3	72.8	65.2	73.7
1993	64.3	72.1	63.0	72.1
1994	64.8	73.9	65.1	73.7
1995	65.8	73.5	66.3	74.4
1996	66.2	73.3	66.1	73.9
1997	67.3	73.8	66.5	73.9
1998	68.5	74.4	66.8	74.4
1999	68.6	74.3	66.6	74.2
2000	68.8	74.9	66.9	74.5
2001	68.6	75.2	67.9	74.9
2002	68.7	74.7	68.1	74.9
2003	69.0	75.1	68.7	75.5
2004	69.2	75.7	67.9	75.6
2005	69.2	75.7	68.9	75.9
2006	69.2	75.6	68.8	76.7