Infant Mortality in Kyrgyzstan
Before and After
the Break-up of the Soviet Union

Michel Guillot
University of Wisconsin-Madison

So-jung Lim
University of Wisconsin-Madison

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Abstract

There is much uncertainty about levels and trends in infant mortality in former Soviet Central Asia. While there is consensus that the reported trends are too low, little is known about the actual extent of the underestimation and how it has changed over time. As a result, the impact of the break-up of the Soviet Union on infant mortality in the region is not known, and proper monitoring of mortality levels is impaired.

In this paper, we use a variety of data sources and methods to assess infant mortality levels and trends in one Central Asian republic, Kyrgyzstan, between 1980 and 2006. We estimate the amount of underestimation in the vital registration data and how it changed over time, and provide corrected infant mortality estimates. Patterns by urban/rural residence and ethnicity are also assessed. We find that, contrary to what the registration data indicates, infant mortality abruptly stopped declining in the 1990s. This contrasts with Russia, where infant mortality did not deviate substantially from earlier trends following the break-up of the Soviet Union. We discuss the implication of this finding for health policy and for understanding the nature of the health crisis in this understudied part of the former Soviet Union.

Introduction

Former Soviet republics have experienced a severe health crisis in recent decades. The severity of the crisis varies greatly by republic, but all of them have experienced substantial declines in life expectancy. To this day, most countries of the former Soviet Union have not recovered their 1991 life expectancy levels.

Reported trends in infant mortality are one exception to these negative patterns. In most former Soviet republics, reported infant mortality rates (IMR) have not increased substantially during the post-independence period, and today's reported levels are lower than they were in 1991. In Russia, for example (Figure 1), except for a small increase between 1992 and 1993, the reported IMR has declined during the post-Soviet period. The reported IMR value of 10.2 p.1000 in 2006 is substantially lower than the 1991 value of 18.1 p. 1000. This contrasts with life expectancy, which has declined by 2.35 years during the same period. Declines in life expectancy in Russia have been overwhelmingly due to increases in adult mortality, especially in the 20-59 age range, rather than to changes in infant mortality.

-- Figure 1 about here --

This contrast between decreases in infant mortality and increases in adult mortality has led researchers to conclude that, in Russia at least, the health crisis may not have been directly linked to a deterioration of the health care system (Anderson, 2002). Indeed, a deterioration of health facilities would have generated increases in communicable diseases, to which infants are particularly vulnerable, and would have produced IMR increases rather than declines.

The reported data indicate that a similar pattern has taken place in former Central Asian republics. Figure 1 shows the IMR trend in one Central Asian republic, Kyrgyzstan, together with Russia. Although IMR levels are higher in Kyrgyzstan, there is no sustained increase in the reported IMR since 1991. There is a small increase between 1991-93, but this increase is short term and followed by substantial declines thereafter. (The sharp increase in the IMR between 2003 and 2006 is not real but reflects Kyrgyzstan's adoption of WHO's standards with regards to the definition of live births and stillbirths. We will discuss this pattern later in the paper.)

Although the overall pattern of IMR change in Kyrgyzstan is similar to that observed in Russia (albeit at a different level), it has been regarded with much doubt in the case of Kyrgyzstan and other Central Asian republics. It has been often argued that reported IMR decreases in Kyrgyzstan in the 1990s (and in other Central Asian republics) are likely to be artifactual, due to possible declines in the completeness of vital registration during the years following the collapse of the Soviet Union (Becker et al., 1998).

In addition to uncertainty about the trends (decrease vs. increase vs. constancy), there is much uncertainty about levels of infant mortality in Central Asian republics. The consensus is that the reported rates are too low in former Soviet republics, and that the underestimation is particularly large in Central Asian republics (Anderson and Silver 1986, 1997; Velkoff and Miller 1995; Aleshina and Redmond 2005). However, there is uncertainty about the actual amount of underestimation and how it might have changed over time. This is obviously related to uncertainty about trends. If the magnitude of the underestimation was constant over time, trends in reported rates would still be informative. However, it is possible that the magnitude of the biases have changed over time, and that trends, in addition to levels, are misleading.

In this paper, we use a number of data sources and methodological approaches to assess levels and trends in infant mortality in one Central Asian republic, Kyrgyzstan. The data include detailed vital registration data, census data, and survey data. Many of these sources are not publicly available and are used for the first time in a former Soviet republic.

We focus on the period 1980-2006, which includes a number of years before and after the break-up of the Soviet Union in December 1991. This gives us ample room to assess whether the break-up of the Soviet Union coincides with a marked deviation from earlier trends. (Before 1980, the reported IMR was increasing in Kyrgyzstan and other Central Asian republics. These reported increases, which impacted IMR trends at the Soviet level, have generated a lively debate among scholars. The study of this somewhat distinct issue is beyond the scope of this paper.)

We focus on infant mortality (${}_1q_0$) rather than on child mortality (${}_5q_0$, also called under-five mortality rate), for both substantive and empirical reasons. The substantive reason is that the IMR is the measure of child health that is most reactive to rapid changes in health conditions. The empirical reason is that the national statistical office of Kyrgyzstan collects much more detailed information on infant mortality than on child mortality. Although the IMR has a long tradition in demography, the international health community now seems to prefer ${}_5q_0$, because in retrospective surveys this measure is less subject to age misreporting errors. It is also argued that the correlation between IMR and ${}_5q_0$ is very high, making ${}_5q_0$ an adequate measure. Sample surveys is only one of many data sources that we use in this paper. Thus the advantage of using ${}_5q_0$ is less clear. In response to those who argue that ${}_5q_0$ is a better measure, we also invoke the high correlation between ${}_5q_0$ and IMR.

We focus on infant mortality for both sexes combined, rather than by sex. While a study of sex-specific trends in infant mortality would be certainly interesting in the Central Asian context, we believe that, given the large uncertainty surrounding levels and trends in infant mortality in the region, the priority is to clarify such trends for both sexes combined. Moreover, international comparisons of IMRs are typically made for both sexes combined.

Assessing levels and trends in infant mortality in Central Asia has obvious policy relevance. For health policy purposes, a precise monitoring of infant mortality is paramount. The broader relevance of this assessment pertains to understanding the nature of the health crisis in former Soviet republics and how it might vary by republic.

In the case of Russia, as we said earlier, a deterioration of health services has not been identified as the most important factor of the health crisis, because of the observed decreases in infant mortality during the 1990s. The extent to which this conclusion also applies to Central Asian republics remains to be determined, due to the large amount of uncertainty regarding reported trends in infant mortality.

In this paper, we first review the errors and biases that have been identified as relevant in the former Soviet context in general, and in Central Asia in particular. Second, we present uncorrected trends in infant mortality, based on the official vital registration data, and discuss patterns that seem implausible on the basis of internal comparisons. Third, we use a variety of data sources, including census data, vital registration data, and survey data, to address possible deficiencies in reported infant mortality. Finally, we propose corrected levels and trends in infant mortality, and discuss the implication of these corrected trends for understanding the health crisis in this understudied part of the former Soviet Union.

Sources of errors in reported infant mortality in Kyrgyzstan

Levels and trends in infant mortality in republics of the former Soviet Union have been much discussed in the demographic literature. There is consensus that the reported levels are too low, and that the underestimation is particularly severe in Central Asian republics (Anderson and Silver, 1997; Aleshina and Redmond, 2005). The underestimation of infant mortality, which existed throughout the Soviet period, appeared clearly when Demographic and Health Surveys (DHS) were conducted in Central Asia, producing independent estimates of infant and child mortality. In Kyrgyzstan, for example, the 1997 DHS has estimated an average infant mortality rate of 66.2 per thousand for the period 1988-97 (Macro International, 1998: 97). By contrast, the official mortality rate for the same period was 30.8 per thousand.

There are several reasons for the underestimation of infant mortality in the former Soviet Union. The first reason stems from differences between the Soviet and the World Health Organization's (WHO) definitions of a live birth and a stillbirth (Anderson and Silver, 1986). Some births that would be counted as live births under international standards are counted as stillbirths under Soviet standards, and receive neither a birth certificate nor a death certificate. These differences in definition produce a downward bias in the infant mortality rate calculated in Soviet republics. It is estimated that infant mortality rates in Soviet republics would be higher by 22-25 percent if they were calculated according to international standards (Anderson and Silver, 1986). After the break-up of the Soviet Union, newly-independent republics progressively switched to the international standard. In Kyrgyzstan, the change occurred in 2004, creating a sudden – and expected – increase in the reported IMR, as shown in Figure 1.

Anderson and Silver (1999) and Aleshina and Redmond (2005) discuss additional sources of bias which make reported rates in the former Soviet Union too low. These sources of bias include: the misreporting of infant deaths as stillbirths, even under the

Soviet definition; the misreporting of infant deaths as deaths occurring at age one or above; and the underregistration of infant deaths by parents. These problems, which occur to some degree in all former Soviet Republics, are believed to be particularly severe in Central Asian republics.

Patterns of uncorrected infant mortality

In a first set of analyses, we examined the raw vital registration data. This analysis is made possible by a large data collection effort that we undertook in Kyrgyzstan. This data collection consisted of gathering unpublished aggregate tables of births and deaths from the archives of the National Statistical Committee, and transferring these tables from paper to an electronic format.

Infant mortality by urban/rural residence

Internal comparisons of uncorrected vital registration data largely confirm the problems mentioned in the previous section. In Figure 2 (left panel), we compare the reported IMR in urban and rural areas. Around the world, infant mortality rates are commonly higher in rural areas (United Nations 1982), due to lower standards of living and more difficult access to health facilities. This is the case in most former Soviet Republics (Kingkade and Arriaga, 1997). In Kyrgyzstan in the early 1980s, infant mortality was indeed substantially higher in rural areas. However, the urban/rural differential decreased during the 1980s, and in 1992, we observe a cross-over. While infant mortality increases in urban areas and stays more or less constant thereafter, the rural rate keeps declining. By the late 1990s, the rural IMR is substantially lower than the urban one. This is highly implausible. The sources of errors that we mentioned earlier are likely to be particularly prominent in rural areas, creating a spurious rural advantage. An additional source of error potentially affecting this trend is the misreporting of rural deaths as urban deaths. This problem, which has been raised in the literature on Soviet mortality (Anderson and Silver 1997), does not affect the trends at the national level, but it does affect trends by residence, potentially contributing to the implausible urban/rural differential observed in Kyrgyzstan since 1992.

-- Figure 2 about here --

Infant mortality ethnicity

Comparing reported IMRs by ethnicity is useful for our purpose, because Kyrgyzstan is a multi-ethnic country in which different groups have different urban/rural residence patterns, different educational levels, different standards of living, and, likely, different levels of data quality. Therefore, internal comparisons of ethnic groups can help distinguishing real trends from spurious ones.

Figure 2 (right panel) shows patterns of infant mortality by ethnicity. We show here results for two broad ethnic groups: “Central Asians” (Kyrgyz, Uzbeks, Kazakhs, Tajiks and Turkmens), and “Slavs” (Russians, Ukrainians and Byelorussians). This merging of ethnic groups is justified by the fact that ethnic groups within each broad group exhibit similar infant mortality patterns. Moreover, the merging of ethnic groups that are culturally similar allows one to limit biases arising from the potential mismatch of ethnicity in birth and death certificates. Indeed, such mismatch is more likely to occur across ethnic groups that are culturally similar and where intermarriage is more common than across groups that are culturally more distant and where intermarriage is less common. These two broad ethnic groups cover about 95% of annual births during our period of analysis.

The estimation of IMR by ethnicity also reveals some implausible patterns. In the early 1980s, Central Asians had substantially higher infant mortality. This is consistent with well-established patterns of social stratification between Russians and native ethnic groups in the region (Kahn 1993). During the 1990s, however, infant mortality among Central Asians continued declining, while it stayed constant among Slavs. As a result, by the late 1990s, the excess mortality of Central Asians has disappeared. This is implausible, given the persistent economic advantage of Russians during the 1990s, documented in several poverty surveys (Ackland and Falkingham 1997, World Bank 1999, 2007).

The pattern of infant mortality by ethnicity is related to patterns by urban/rural residence, because most Central Asians live in rural areas. These implausible patterns make us suspect that the extent of underestimation of infant mortality is particularly large among rural Central Asians. The timing of these implausible trends makes us also suspect that the extent of underestimation worsened during the 1990s.

Infant Mortality by month of age

Age patterns of infant mortality reveal some more specific deficiencies in the vital registration data. Figure 3 shows the probability that a newborn will die during a given month of age (d_x in life table notation, with *x* expressed in months) in Kyrgyzstan in 1983. Age patterns of mortality have been well studied in countries with high-quality data. We know from these countries that mortality is highest during the first months of life, and then keeps declining with age until reaching a minimum around age 10. In Kygyzstan, however, reported mortality, while highest during the first month, increases between the second and fourth months, and then increases again between the 12th and 13th months. This pattern is highly implausible. Mortality appears to be vastly underestimated during the first three months of life, generating a spurious increase in mortality between the second and fourth months. In addition, a number of infant deaths appear to be reported as deaths occurring during the second year of life, generating a spurious increase between the 12th and 13th months (Kingkade and Arriaga, 1997; Ksenofontova, 1994). Although Figure 3 presents data for 1983 only, this pattern is ubiquitous during our period of interest.

-- Figure 3 about here --

We will see later in this paper how we can use these detailed vital registration data to make adjustments. However, we first turn to alternative sources of information, some of which have never been used before in the former Soviet Union for the estimation of infant mortality.

Census-based estimates of infant mortality

The 1989 Soviet census included a question on the number of children ever born and the number of children surviving, asked to women aged 15 and above who received the census long form (25% sample). This question was also asked in the 1999 census in Kyrgyzstan (to all women aged 15 and above). This information can be used to estimate levels and trends in infant mortality, using the classic Brass method. This method converts proportions of children dead among women of a given age into life table death probabilities. The answers to these questions in the 1989 census have never been tabulated, and tabulation of these variables in the 1999 census was very limited. Fortunately, thanks to the existence of the original individual-level data bases for these two censuses, we were able to obtain detailed tabulations of this information from NSC.

This approach has many advantages for our purpose. First, the size of the census databases are considerably larger than that of sample surveys, allowing powerful analyses. Second, the availability of both the 1989 and 1999 censuses allows us to make useful pre- and post-independence comparisons. Third, this approach allows us to estimate infant mortality by urban/rural residence and by ethnicity, based on the ethnicity and residence status that the mother reported in the census. Since the variables all refer to the mother and come from a unique source (i.e., the census), no mismatch can take place.

This approach has also several drawbacks. Misreporting errors are possible. In particular, the extent to which mothers can make the distinction between live births and stillbirths on the basis of only one vague question ("How many children have you ever borne?") is not clear. Also, urban/rural residence is based on the woman's residence at the time of the census. Residence at the time of a child's birth or death could have been different. Also, the Brass method makes some assumptions about fertility patterns, mortality selection, and age patterns of mortality that can also create some bias. Nonetheless, the Brass method has been used in many instances and has generated useful estimates. To our knowledge, it is the first time that the Brass method is applied to Soviet or post-Soviet census data.

Figure 4 shows results of the Brass method at the national level. We present here results using the four different Coale and Demeny model life table systems. Although estimated infant mortality levels vary depending on the choice of model, they all confirm that the vital registration estimates are largely underestimated, both in the 1980s and the 1990s. The large gap between estimates for the 1980s (based on the 1989 census) and estimates for the 1990s (based on the 1999 census) is difficult to interpret. It is important to note, however, that the Brass method provides overall levels of mortality and is not precise to the point of indicating year-to-year changes with confidence. With this in mind, we see that the estimated infant mortality levels of the 1980s are higher, on average, than the estimated mortality levels of the 1990s. This is somewhat consistent with the reported trends and does not support the existence of a surge in infant mortality in the 1990s. From these data, however, it is difficult to draw the precise annual trends in infant mortality since 1991.

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Figure 5 shows results of the same procedure, applied to urban and rural areas separately. These results are based on the West model, which is most neutral model in the Coale and Demeny system. According to these estimates, infant mortality in urban areas is systematically lower than in rural areas, both before and after 1991. This is consistent with expectations of urban/rural differentials, and gives support to the fact that the urban/rural cross-over in the registered data is artifactual. Similarly, these results indicate that the underestimation of infant mortality in the reported data is much larger in rural areas. This is also consistent with expectations.

-- Figure 5 about here --

Figure 6 presents census-based estimates of infant mortality by ethnicity (Slavs vs. central Asians). Here also, we find that infant mortality among Slavs is consistently lower than among Central Asians. There is no evidence that the ethnic differential has narrowed over time. The amount of underestimation in the registration data appears larger among Central Asians.

-- Figure 6 about here --

One interesting pattern in Figures 5 and 6 is that the gap between estimates for the 1980s and 1990s, which we observed at the national level, is larger in rural areas and among Central Asians. In urban areas and among Slavs, the two sets of estimates are more consistent. This could imply that the quality of the census data and/or the validity of the method's assumptions are higher in urban areas or among Slavs.

Overall, these census-based estimates of infant mortality support a number of important facts about infant mortality in Kyrgyzstan: (1) there is no evidence that infant mortality levels in the 1990s were higher, on average, than during the 1980s; (2) contrary to what the reported data indicates, infant mortality appears to be systematically higher among Central Asians and in rural areas. These patterns are more plausible, and imply that the underestimation of infant mortality in the reported data is particularly large among these two subpopulations.

Sample surveys

Sample surveys, such as the Demographic and Health Surveys (DHS) and the Multiple Indicator Cluster Surveys (MICS) are a common source of information for the estimation of infant and child mortality in developing countries. They have already been used to estimate levels of infant and child mortality in Central Asia, including Kyrgyzstan (Macro International, 1998). In fact, most international estimates of infant and child mortality for Kyrgzystan come from such surveys.

Sample surveys are widely available and have revolutionized knowledge of infant and child mortality in developing countries. One needs to realize, however, that these sources are not free of bias. Lack of representativeness and misreporting errors can affect mortality estimates derived from these sources. Also, sample sizes are usually too small to detect annual changes in infant mortality or allow useful comparisons of population subgroups with confidence. Because of these drawbacks, it is useful to rely on several independent sources, whenever possible, rather than on sample surveys exclusively. In this paper, sample surveys are one of several sources of information that we use.

Only one DHS survey was conducted in Kyrgyzstan, in 1997. The key element of the survey for the estimation of infant mortality is full birth histories, in which interviewed women report the date of each of their births. For children who died, women are asked to report their age at death. These data can be converted into period estimates of infant and child mortality. Because of age heaping and other misreporting errors in ages at death, infant mortality estimates based on retrospective histories can be biased. In fact, the IMR found in the DHS is too high relative to what we would expect on the basis of ${}_5q_0$. Given the estimated ${}_5q_0$ value of 75.8 for the period 1987-1996 in the DHS, the estimated ${}_1q_0$ value of 66.2 is outside the range predicted on the basis of Coale and Demeny or United Nation model life tables. (Problems with the estimation of ${}_1q_0$ on the basis of birth histories is one reason why ${}_5q_0$ is usually a preferred mortality measure when using survey data.) In order to address this problem, we first calculated child mortality (${}_5q_0$), and then converted these estimates into infant mortality estimates using the relationship between ${}_5q_0$ and ${}_1q_0$ found in the human mortality database (HMD). This produces an average value of 55.8 for the period 1987-1996. This value is more in line with the range predicted by model life tables.

The MICS survey was conducted in 2006. Rather than full births histories, MICS collected summary birth histories (number of children ever born and number of children surviving). This information is similar to that collected in the 1989 and 1999 censuses and allows the use of the Brass method.

Figure 7 shows estimates of infant mortality at the national level, based on these two sample surveys. (The DHS estimates presented in Figure 7 are two-year moving averages.) These estimates confirm many of the results we found using the census data. The DHS results confirm the extent of underestimation in the registration data and confirm that there was no obvious surge in infant mortality in the early 1990s. Nonetheless, in spite of the random fluctuations, the DHS estimates do seem to indicate that the important declines observed in the 1980s have stalled in the 1990s. Estimates for the period 1991-97 fluctuate around a value of 50 p. 1000, contrasting with the important declines of the 1980s, from 80 to 50 p. 1000.

Levels produced by the MICS data are comparable to those produced by the DHS. They do also indicate a stalling of the decline, but starting at a later date, around 1998. While DHS estimates are calculated directly on the basis of full birth histories, MICS estimates are based on the Brass method which, as we said earlier, is not particularly precise for detecting short-term changes in mortality over time.

-- Figure 7 about here --

Survey-based estimates for urban and rural areas are shown in Figure 8. (The MICS Brass estimates use the West Coale and Demeny model.) In spite of large fluctuations due to small samples sizes in the DHS urban data, these estimates confirm that, overall, mortality is higher in rural areas. The DHS data also indicate that the stalling of mortality declines occurs in both urban and rural areas.

-- Figure 8 about here --

The survey-based estimates by ethnicity shown in Figure 9 are even more subject to random fluctuations than the estimates by residence, due to small sample sizes for Slavs. In spite of these random fluctuations, these sources do indicate that infant mortality remains lower among Slavs, and that the amount of underestimation in the registration data is larger among Central Asians.

-- Figure 9 about here --

Overall, the survey information confirms the broad patterns found when using census data. The overall infant mortality levels are comparable to those estimated using the census data. The amount of random fluctuation, however, remains too large to detect annual variations in IMR with precision. One contribution of the survey data, however, is the finding that the large declines of the 1980s appear to have stopped in the 1990s. This contrasts with the information from the registration data which show no major deviation from the earlier trend.

Using detailed information by month of age

In this section, we use an alternative procedure based on vital registration data, taking into consideration the patterns of error by month of age that we observed in Figure 3.

Indeed, in Figure 3, two major problems can be detected: (1) underestimation of mortality at ages 0-2 months, relative to ages 3-11 months. This is due to a combination of misclassification of live births as stillbirths and incompleteness of registration of deaths below 3 months; (2) over estimation of mortality during months 12-23, relative to months 3-11. This appears to be due to a misclassification of deaths occurring during the later months of the first year as deaths occurring during the second year of life.

An interesting aspect of these two sets of errors is that they do not affect the reported probability that a baby aged 3.0 months will die before age 24.0 months. Indeed, a death below age three months, if not registered, does not affect the reported number of survivors at age 3.0 months if the corresponding birth was not registered either. Therefore the denominator of the death probability will be unbiased. Similarly, a death occurring between ages 3.0 and 12.0 months, if misreported as occurring between age 12.0 and 24.0 months, will not affect the numerator of the death probability between 3.0 and 24.0 months. We term the probability that a baby aged 3.0 months will die before age 24.0 months "${}_{21}q_3$", using traditional demographic notation. (The subscripts here refer to months rather than years of age).

${}_{21}q_3$ is not totally free of data errors either. In particular, undercount of deaths in the age range 3.0-24.0 months will bias ${}_{21}q_3$ downwards. Nonetheless, in light of the patterns of errors shown in Figure 3, we believe that the most serious errors occur during the first three months and during the second year of life, and that ${}_{21}q_3$, as reported in the vital registration data, is less biased than the traditional IMR. (Also, undercount of deaths below the age of 3.0 months, if the corresponding births were recorded, would bias ${}_{21}q_3$ downwards. Such undercount affects the denominator, rather than the numerator, of the probability, and has a small impact compared to undercount of deaths in the age range 3.0-24.0 months.)

Levels and trends in ${}_{21}q_3$ are useful for our purpose, because there is a very strong correlation between ${}_{21}q_3$ and the IMR. Figure 10 shows the relationship between ${}_{21}q_3$ and IMR in Sweden, a country known for the high quality of its data. The linear relationship is positive and very strong ($r = .9934$). Other countries with high-quality data, such as England & Wales and France, follow a similar relationship.

--Figure 10 about here --

Figure 10 also presents points based on Kyrgyzstan's registration data. In Kyrgyzstan, the reported IMR is much lower than what we would expect on the basis of the reported level of ${}_{21}q_3$. This illustrate the extent to which the main sources of errors discussed above (misclassification of live births as still births, undercount of deaths below 3 months, and misclassification of deaths occurring during the later months of the first year as deaths occurring during the second year of life) contributes to the underestimation of the reported IMR.

Because ${}_{21}q_3$ is not affected by these two major problems and is thus a more reliable indictor of mortality levels and trends, we propose to use it as a basis to calculate corrected estimates of IMR in Kyrgyzstan. The correction is made using the linear relationship between ${}_{21}q_3$ and IMR as observed in Sweden. Mortality across different ages during the first few years of life is very strongly correlated, and these correlations hold in a number of settings. Although the specific correlation between ${}_{21}q_3$ and IMR has not been systematically studied in countries with good data, we believe that it is highly likely that the patterns observed in Sweden reflect general patterns. It is thus reasonable to use this relationship for correcting the data in Kyrgyzstan. In any case, even if the relationship is somewhat different in Kyrgyzstan, higher levels of ${}_{21}q_3$ will still be associated with higher levels of IMR. Our corrected IMR will still be indicative of trends, even if the levels do not correspond exactly. (This procedure is similar to one followed by Kingkade and Arriaga (1997), except that they did not take into account observed mortality during the second year of life. Instead, they used the relationship between 6q4 and IMR. Therefore, they do not correct for reporting of infant deaths as child deaths, and their corrected estimates are likely to be underestimated.)

Figure 11 shows the results of this correction procedure for Kyrgyzstan as a whole. Here also, the reported IMR appears significantly underestimated. Interestingly, the amount of underestimation appears to have changed overtime. During the 1980s, we see a progressive diminution of the gap between the two indicators, indicating a decline in the extent of underestimation in the registration-based IMR. During the 1990s, however, the reverse is true: the gap between the two indicators increases, indicating an increase in the underestimation of the registration data. A consequence of this change in the extent of underestimation is that the trend in the adjusted IMR is quite different from the trend in the reported IMR. While the reported IMR does not depart substantially from the earlier trends and continues to decline during the 1990s, the adjusted IMR abruptly stops declining in the 1990s, contrasting with the large declines of the 1980s. Only in 1999 does the adjusted IMR reach again the level observed in 1991, resuming its decline thereafter. Given that this corrected IMR is based on ${}_{21}q_3$, a much less biased mortality indicator which did not decline in the 1990s, we believe that the trend in the adjusted IMR is closer to truth than the trend in the reported IMR. The apparent decline in the reported IMR appears to be spurious, due to a deterioration of data quality following the break-up of the Soviet Union.

-- Figure 11 about here --

The application of this correction procedure to urban and rural areas, shown in Figure 12, confirms that the amount of underestimation is much larger in rural areas. As a result, the corrected IMR remains consistently higher in rural areas, and the cross-over disappears. This pattern is much more plausible than that observed in the reported IMR. We also observe that, although the IMR stops declining in the 1990s in both urban and rural areas, the stalling is particularly striking in rural areas. (Deaths by month of age is not available by ethnicity, so we are not able to calculate corrected IMRs by ethnicity using this approach.)

-- Figure 12 about here --

The impact of the change of standard for classifying live births

In 2004, Kyrgyzstan's Ministry of Health decided to abandon the Soviet standard for classifying live births and stillbirths, and to adopt the more inclusive definition of a live birth determined by WHO. As expected, this generated an sharp increase in the reported

IMR. As shown in Figure 1, between 2003 and 2005, the reported IMR increased by 42%, from 20.9 to 29.7 p.1000.

One premise of our correction based on ${}_{21}q_3$ is that it should largely correct for the bias arising from differences in the definition of a live birth. Therefore, if the increase in the IMR between 2003 and 2005 is due to this change of definition, and if the premise of our correction is adequate, no increase in the ${}_{21}q_3$-based IMR estimates should be observed, and differences between reported and corrected IMRs should decrease during that period.

Figure 11 confirms that this is indeed the case. Most of the difference between the reported and corrected IMRs disappears. This means that, as Kyrgyzstan adopted the international definition of a live birth, the relationship between the reported ${}_{21}q_3$ and the reported IMR moved closer to the one observed in Sweden. Indeed, looking back at Figure 10, the data points for Kyrgyzstan towards the lower part of the ${}_{21}q_3$ range (which correspond to the years 2003-2006) move progressively towards the high-quality Swedish data.

There is still a small gap between the reported IMR and corrected one. This is because our procedure, in addition to correcting for differences in definition, also corrects for live births who died during their first three months but for whom neither a birth certificate nor a death certificate was reported. It also corrects for the underestimation of the IMR due to misclassification of deaths occurring during the later months of the first year as deaths occurring during the second year of life. Nonetheless, these errors appear somewhat secondary in comparison to the role played by definitional differences. It is also possible that the enforcement of the new standard improved the quality of reporting overall, beyond differences in definition.

A puzzling pattern following the change in definition, though, is that the reported increase is much larger in urban areas than in rural areas, as shown in Figure 2 (left panel). This is puzzling, because in theory the impact of the change in definition should not be so different in various population subgroups. Interestingly, in Figure 2 (right panel), Slavs and Central Asians happen to be equally affected by this definitional change. This makes the urban/rural comparison even more puzzling; since Slavs live predominantly in urban areas and Central Asians live predominantly in rural areas, there should be some parallel between the patterns by urban/rural residence and the patterns by ethnicity. In this case, patterns by ethnicity are consistent with expectations, while patterns by residence are not.

We mentioned at the beginning of this paper that urban/rural comparisons are likely to be confounded in part by misreporting of residence on birth and death certificates. It has long been suspected that many rural deaths are reported as urban (Anderson and Silver 1997), perhaps because they sometimes occur in urban hospitals and might lack information about the deceased person's actual place of residence. The extent of this phenomenon, however, has never been fully explored.

The comparison of reported and corrected IMRs in urban and rural areas for the period 2003-2005, shown in Figure 12, confirms the existence of this problem in the case of Kyrgyzstan. Following the change of definition, the reported IMR in urban areas exhibits a large increase, to the point that it reaches a level *above* the one that we predict on the basis of ${}_{21}q_3$. In rural areas, however, the reported IMR increases only slightly and remains significantly below the corrected ones. At the national level, however, no such pattern occurs – the increase in the reported IMR is large but remains below the corrected level, which is exactly what we would expect given the change of definition. A plausible explanation for this *overreporting* of infant mortality in urban areas (relative to what is predicted on the basis of ${}_{21}q_3$), while underreporting remains large in rural areas, is that many rural deaths are misreported as urban deaths.

It is likely that this misreporting of residence in the registration data occurred before 2004 as well. It does not appear as clearly during these years, because, with the old standard of live births vs. stillbirth, the reported IMR is sufficiently underestimated to appear lower than the corrected IMR, even with the additional misclassified rural deaths. In fact, given the role played by differences in definition, we would expect the gap between reported and corrected rates to be somewhat larger, in the absence of this misreporting of residence, before 2004 in urban areas (Figure 12). Interestingly, the gap between reported and corrected IMRs suddenly decreases in urban areas during the early 1990s (a pattern that does not appear in the national data). It is quite likely that the misclassification of rural deaths as urban deaths worsened in the early 1990s, contributing to the observed cross-over and the implausible excess infant mortality in urban areas during the post-Soviet period.

Using data for the year 2006 (the most recent year for which we have data), we estimate that up to 30% of actual rural deaths are misclassified as occurring in urban areas. This estimate is based on the assumption that, in the absence of misclassification, the rural/urban IMR ratio in the reported data would be equal to the rural/urban ratio in the corrected IMR for that year (1.135). (In reality, the actual percentage of misclassified deaths is likely to be somewhat lower, because even if there was no misreporting of residence, the observed rural/urban ratio would be somewhat less than 1.135 due to lower completeness of vital registration in rural areas. But even if, in the absence of residence misreporting, the observed urban/rural IMR ratio was equal to 1.00 (a value allowing for lower completeness in rural areas), the proportion of misclassified deaths would still be about 28%.)

Comparing estimates

Figure 13 compares national-level estimates from all the different sources and approaches used in this paper. Although these estimates use completely different data, methodologies and assumptions, they fall within a comparable range. The DHS estimates are somewhat higher than the ${}_{21}q_3$-based IMR estimates for the years when they overlap. This is perhaps due to the fact that ${}_{21}q_3$ is still somewhat underestimated as a result of possible undercount of deaths in the age range 3.0-24.0 months. Conversely, the DHS estimates are probably over-estimated during in the early 1980s, due to the increasing selection of lower-order births for these years (a bias that is well-documented in the literature describing this approach). The three sets of estimates based on the Brass method (1989 and 1999 census, and MICS) provide average levels that are consistent with the other two sets of estimates, but they provide less precise information about trends.

-- Figure 13 about here --

This overall agreement between the different sources and approaches increases our confidence about real trends in infant mortality in Kyrgyzstan. Since the IMR estimates based on ${}_{21}q_3$ give us the longest time series and the smallest amount of random variation, we find it reasonable to privilege this series over the others. However, we recognize that ${}_{21}q_3$ is probably still underestimated to some extent due to undercount in the age range 3.0-24.0 months. We also recognize that the DHS estimates are less likely to be affected by such undercount. Therefore, we perform a final adjustment, such that the average corrected IMR for the period 1987-1996 matches the DHS-based IMR average for that period (10-year period prior to the survey). This produces an adjustment factor of 1.135, which we apply to entire series of ${}_{21}q_3$-based IMR estimates. This appears to be a good combination of the useful information respectively contained in these two sources. This adjustment produces our final and preferred adjusted IMR estimates for the period 1980-2006. These final estimates are shown, along with other IMR estimates, in Table 1.

-- Table 1 about here --

Discussion

We can summarize our findings as follows:

1) We confirm the large underestimation of IMR in the registration data due to a combination of errors. The reported IMR is systematically lower than the adjusted one. We estimate that for the 1980-2006 period, the reported IMR is 44% lower, on average, than the actual IMR.

2) The amount of mortality underestimation appears to have changed overtime. While we detect improvements in the registration data in the 1980s, we find a deterioration in the 1990s.

3) We find that the reported decreases in infant mortality in the 1990s are spurious, and that in reality, infant mortality abruptly stalled following the break-up of the Soviet Union. We estimate that actual decreases in infant mortality resumed only in 1999. However, we find no evidence for a large surge in infant mortality in the 1990s.

4) The amount of underestimation in the reported data appears to be disproportionately large in rural areas and among Central Asian ethnic groups.

5) We find that the reported cross-over between urban and rural areas is spurious, due to greater undercount in rural areas, as well as misreporting of residence. In reality, we find that the actual IMR stays consistently higher in rural areas during the period.

6) We find that the reported decrease in the gap between Slavs and Central Asians is spurious. Our estimates indicate that the actual IMR stays consistently higher among Central Asians.

7) The quality of the reported data appears to have improved recently, following the adoption in 2004 of the international standard for classifying live births and stillbirths. Nonetheless, some underestimation is still taking place. We estimate that, in 2006, the reported IMR is still lower than the true values by about 22%.

8) In spite of these improvements, misclassification of urban/rural residence continues to generate spurious urban/rural comparisons. We estimate that, in 2006, up to 30% of rural deaths are misclassified as occurring in rural areas.

The implication of these findings is that health policy would be largely misled if it was based on the reported trends. With a corrected value of 37.5 p. 1000 in 2006, infant mortality remains relatively high in Kyrgyzstan, even though it appears to have resumed its decline in the 2000s. This value is comparable to values observed recently in countries such as Iran or Egypt. It is lower, however, than recent assessments made by the UN population division (55 p. 1000 in 2007) or the Population Reference Bureau (50 p. 1000 in 2008). Our corrected value is more in line with estimates produced for the year 2006 by the WHO (35.6 p.1000) or by the international division of the US Census Bureau (34.5 p.1000). Children of Central Asian ethnicity and born in rural areas remain considerably more at risk, contrary to what the reported levels indicate. Resources should be allocated or reallocated to address these differentials.

In light of these findings, it is useful to contrast mortality patterns in Kyrgyzstan with those observed in Russia. As we said in the introduction, the health crisis in Russia has been characterized by a large surge in mortality at adult ages, while infant mortality remained low and continued declining. These patterns, together with information on causes of deaths, have led researchers to emphasize the role of adult behaviors, such as alcohol consumption and violence, and to relate these behaviors to the stark decline in the country's economic and social conditions (Shkolnikov et al., 1998). In the case of Kyrgyzstan, a much poorer country where the economic crisis has been even more severe than in Russia, adults have paradoxically resisted better, in part because cultural differences influencing patterns of alcohol consumption (Guillot, 2007). However, this comparison does not hold for children. Our corrected estimates show that, in Kyrgyzstan, children have been more affected than in Russia. In fact, contrary to what the reported data indicate, we find a divergence between the two countries during the 1990s. This divergence could be related to the observed divergence in the macro-economic situation of these two countries. In 1990, the gross national income per capita in Russia was about 6.5 times greater than in Kyrgyzstan. In 2006, it was about 11.5 times greater (World

Bank, 2008). In Kyrgyzstan and other Central Asian republics, access to health care (which was virtually free during the Soviet period), became more expensive during the 1990s, due to increases in both official costs and under-the-table costs. This happened during a period when poverty levels have increased dramatically, leaving many unable to afford health care (Falkingham 2002). At the same time, quality of care has declined substantially (McKee, Healy and Falkingham 2002). In view of these changes, it is not surprising that infant mortality stalled, rather than declined, in the 1990s.

In spite of this divergence between Russia's and Kyrgyzstan's IMRs, we find no evidence for a large surge in infant mortality in Kyrgyzstan. Like in Russia, life expectancy declines in Kyrgyzstan are mostly due to mortality increases at adult ages, even after accounting for the underestimation of infant mortality.

While this paper deals with data from Kyrgyzstan only, we believe that our findings have some applicability for other Central Asian republics as well. Indeed, many of the patterns found in the registration data in Kyrgyzstan are also present in the reported data in other Central Asian republics. For example, reported infant mortality has declined in all Central Asian republics during the 1990s. It is quite possible that similar explanations hold in these rather similar environments, even though the extent of errors will likely vary substantially by republic.

This paper also has some methodological implications. In spite of the deficiencies in the vital registration sources, the most useful and precise findings of this paper come from a procedure that uses vital registration data. Indirect methods and survey data are useful and provide broad indications of levels, but they often fail to provide precise information on short-term trends and differentials. Vital registration data remains underused in many developing countries, in part because they are more difficult to access, but also because of the premise that they are too unreliable to be used as a basis for mortality estimation. This premise, while true in many populations, does not necessarily apply to all situations. Our study of the different data sources in Kyrgyzstan demonstrates that, while the registration data has a number of deficiencies, the extent of errors vary substantially by age and population subgroups. With this more nuanced evaluation, we believe that much can be learned about real mortality patterns from the official registration data.

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Table 1: Reported and adjusted IMR estimates, Kyrgyzstan, 1980-2006

Year	Registration	${}_{21}q_3$-based adjustment	Final estimates
1980	43.3	*	*
1981	40.3	70.8	80.4
1982	38.6	61.1	69.3
1983	39.7	66.3	75.3
1984	40.3	65.0	73.7
1985	41.6	65.3	74.2
1986	37.6	59.9	68.0
1987	37.5	60.8	69.0
1988	37.0	58.5	66.4
1989	32.4	48.7	55.3
1990	30.2	45.8	52.0
1991	29.7	42.9	48.7
1992	31.6	45.8	52.0
1993	32.9	49.6	56.3
1994	29.6	47.4	53.8
1995	27.7	45.7	51.9
1996	26.6	43.5	49.4
1997	28.6	48.0	54.5
1998	26.0	45.9	52.1
1999	22.7	42.1	47.8
2000	23.0	40.2	45.6
2001	21.6	37.0	42.0
2002	21.1	35.1	39.8
2003	20.7	34.1	38.7
2004	25.6	32.8	37.3
2005	29.7	33.2	37.7
2006	29.2	33.0	37.5

* Deaths by month of age were not available in 1980. Therefore our adjusted series start in 1981.

Figure 1: Registration-based IMR in Russia and Kyrgyzstan, 1980-2006

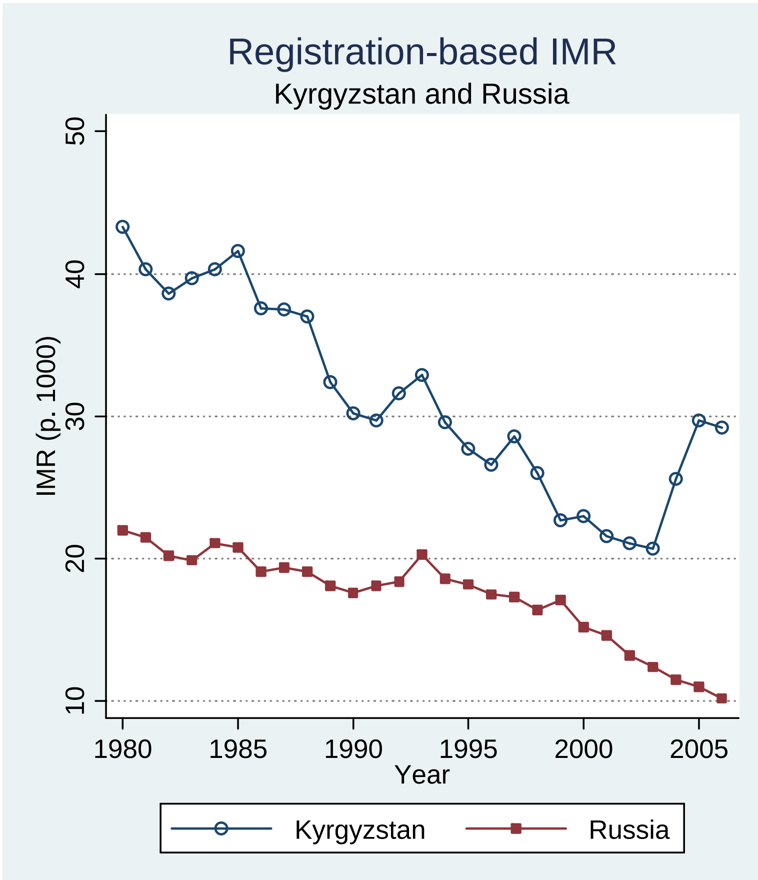

Figure 2: Registration-based IMR by residence and ethnicity, Kyrgyzstan, 1980-2006

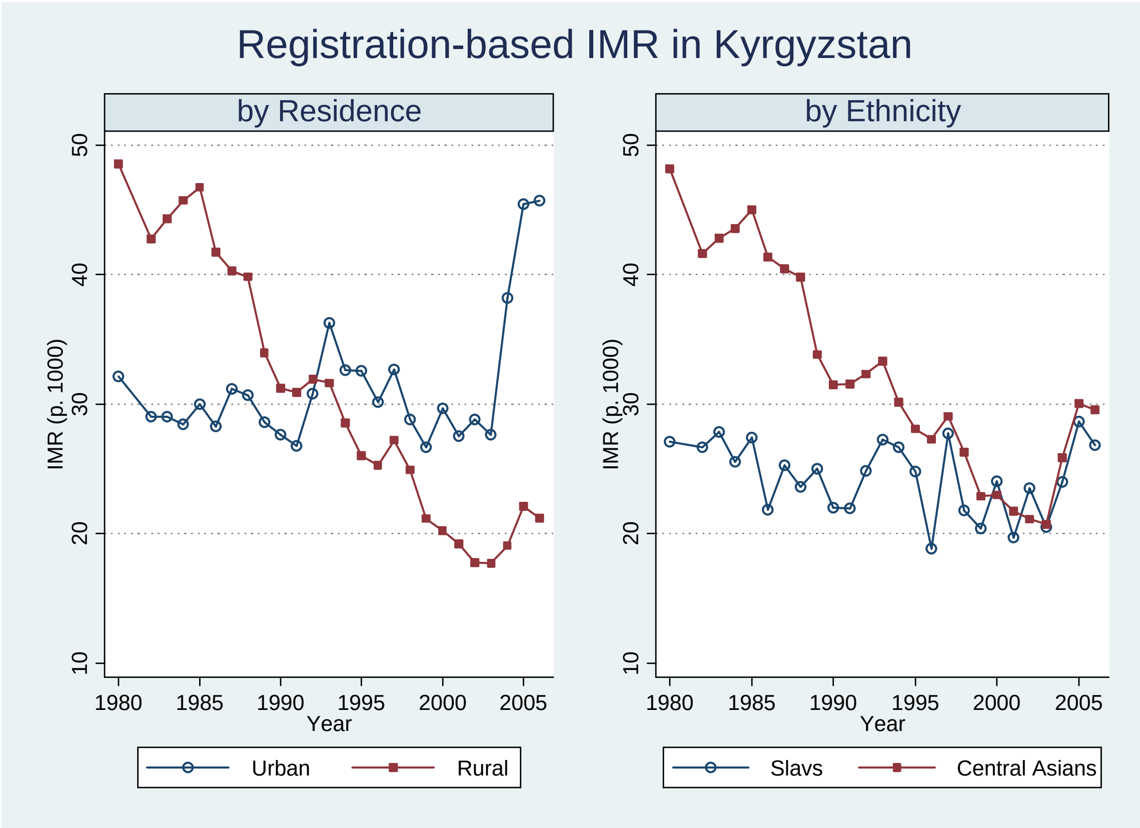

Figure 3: Reported death probabilities (d_x) by month of age, Kyrgyzstan, 1983

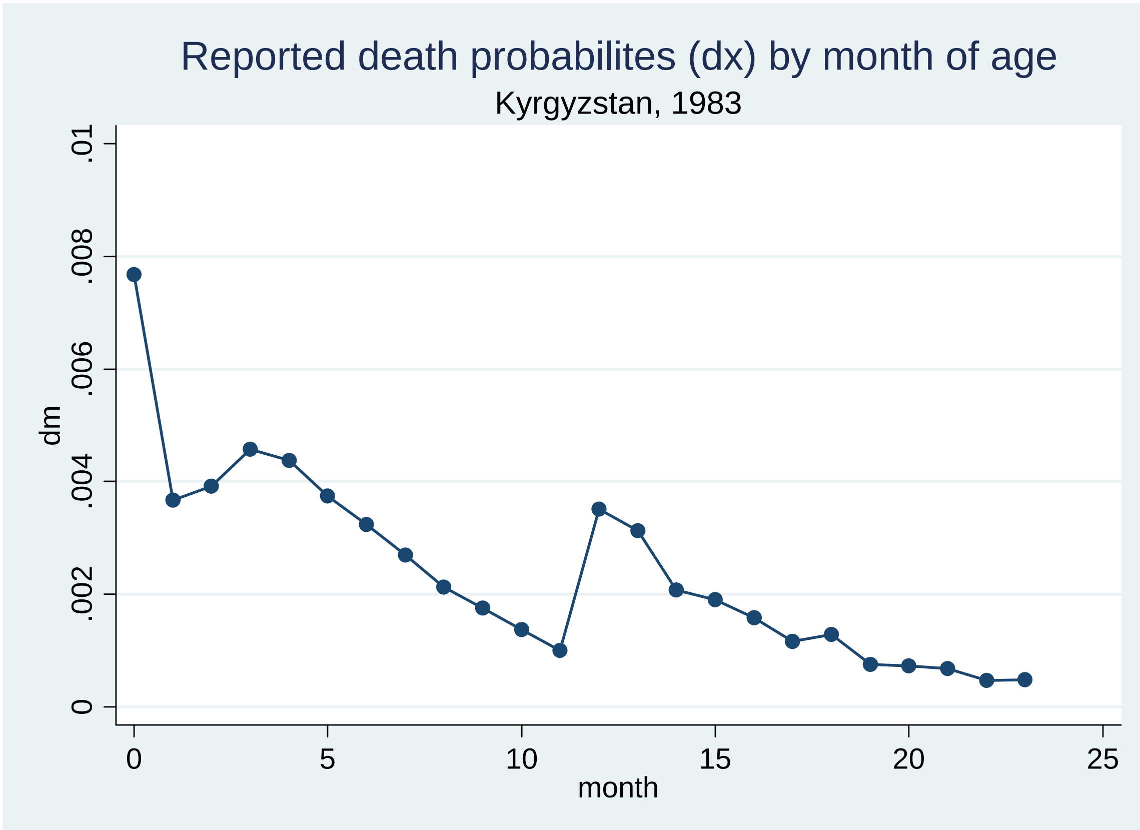

Figure 4: Census-based vs. reported IMR estimates, Kyrgyzstan, 1980-2006

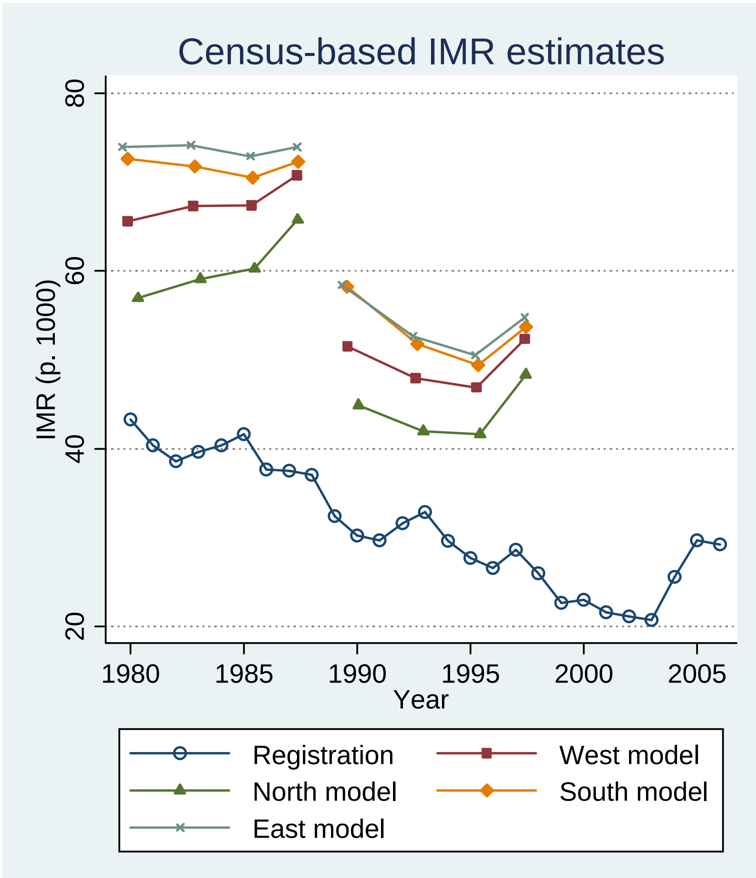

Figure 5: Census-based vs. reported IMR estimates by residence, Kyrgyzstan, 1980-2006

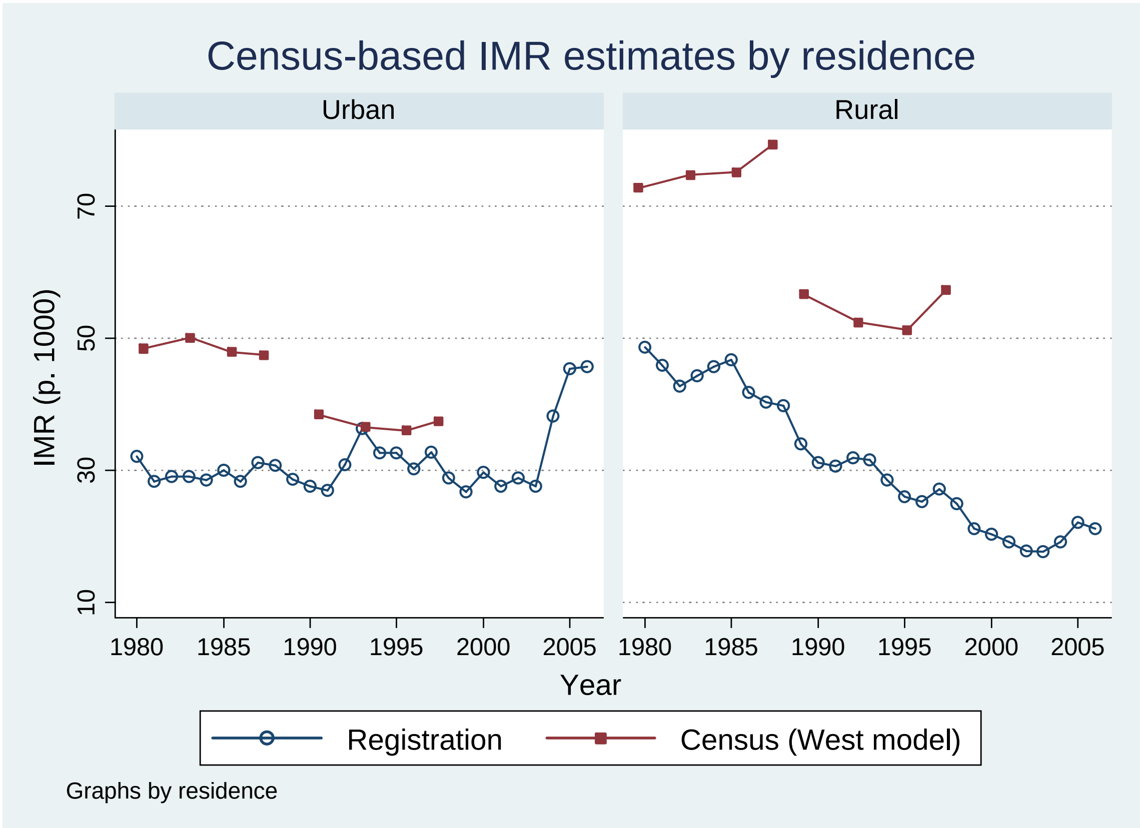

Figure 6: Census-based vs. reported IMR estimates by ethnicity, Kyrgyzstan, 1980-2006

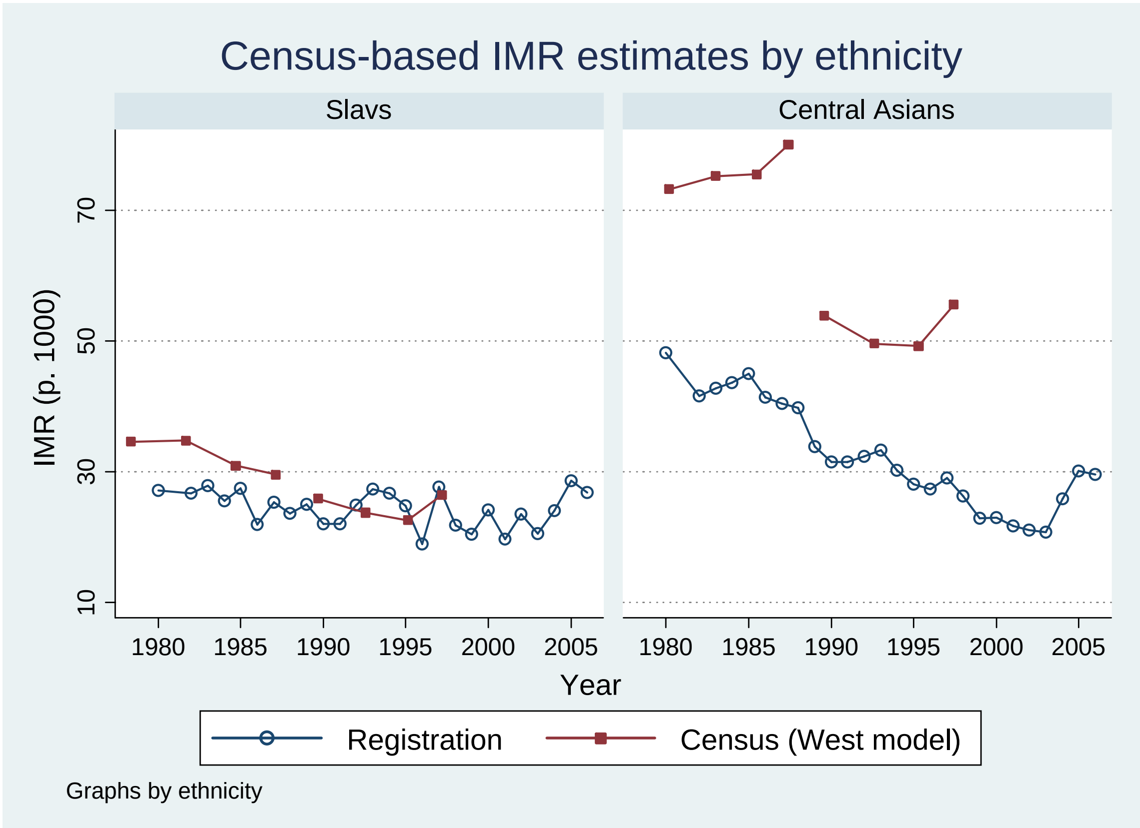

Figure 7: Survey-based vs. reported IMR estimates, Kyrgyzstan, 1980-2006

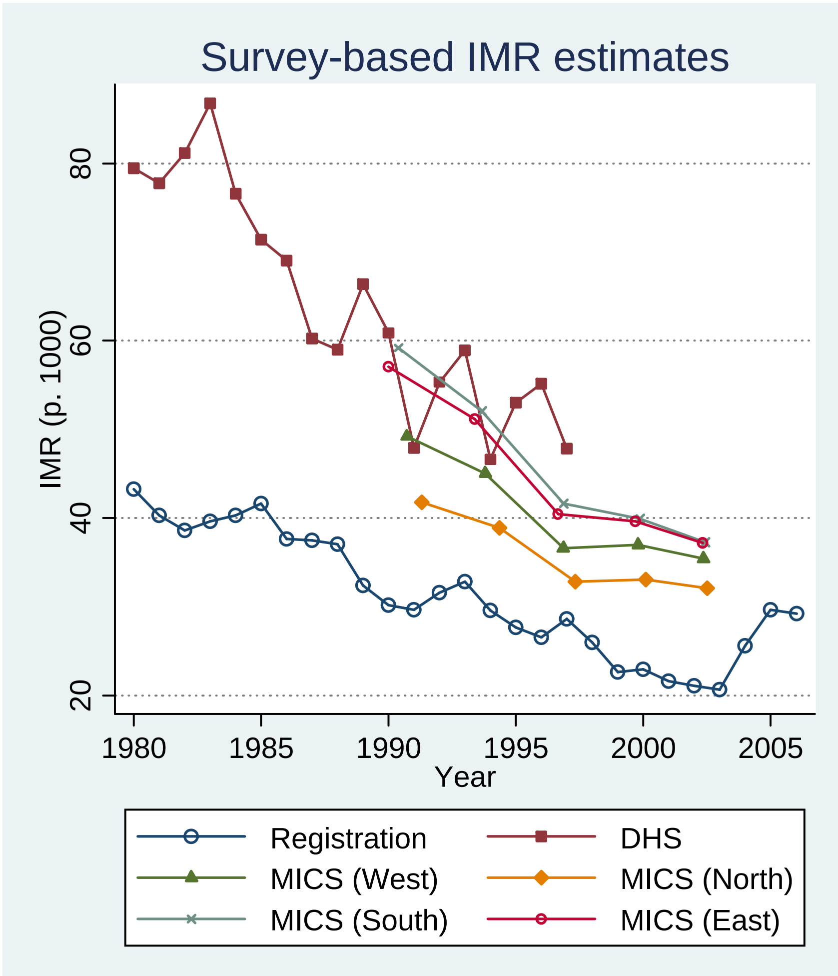

Figure 8: Survey-based vs. reported IMR estimates by residence, Kyrgyzstan, 1980-2006

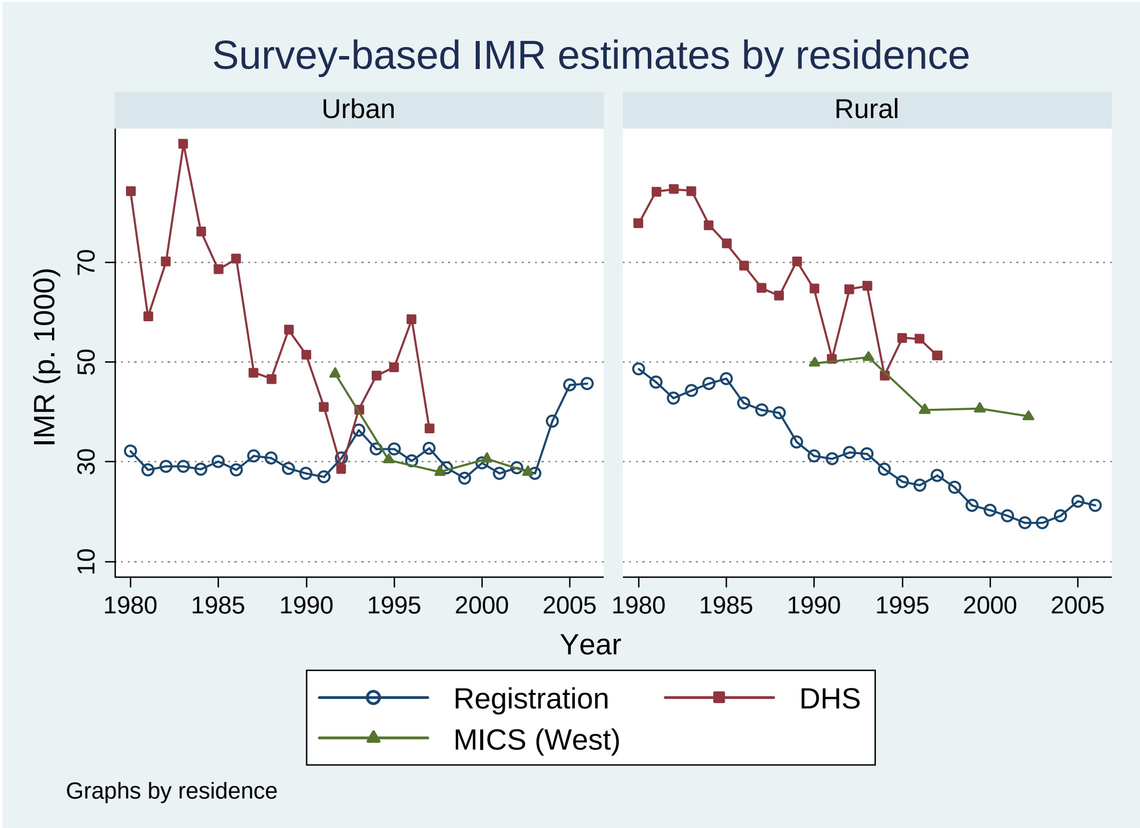

Figure 9: Survey-based vs. reported IMR estimates by ethnicity, Kyrgyzstan, 1980-2006

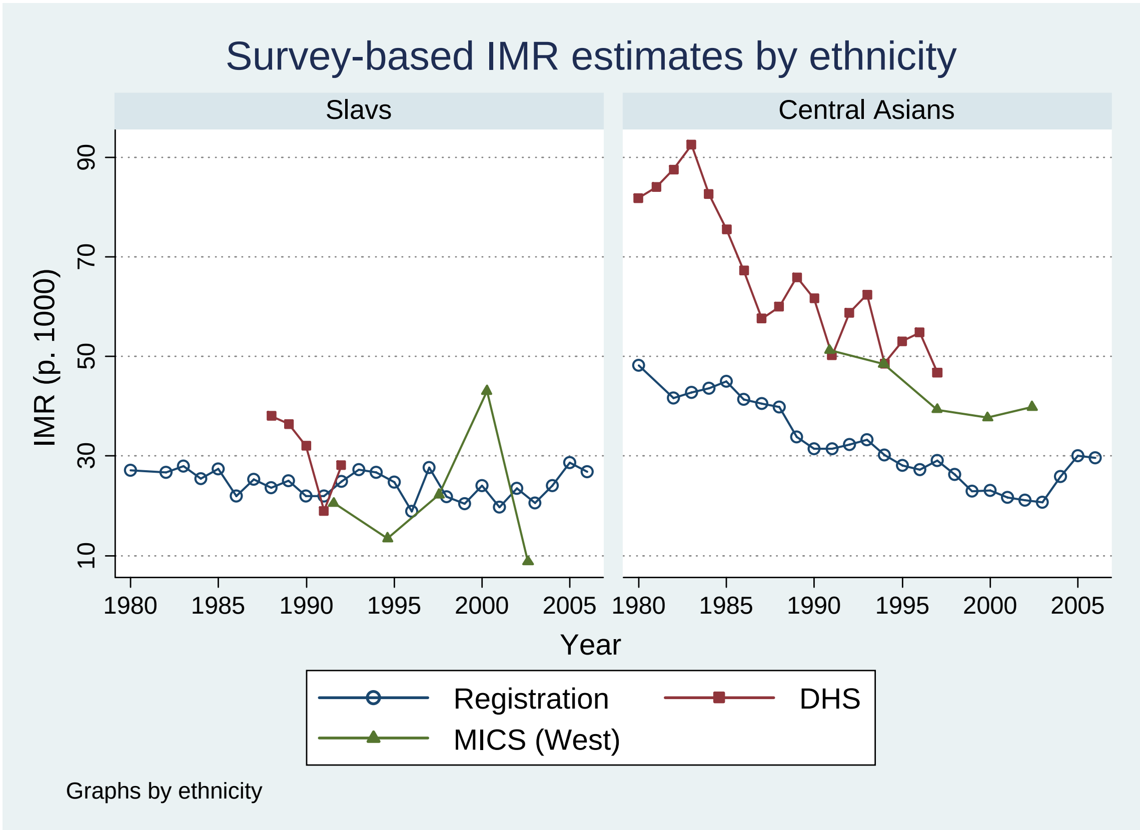

Figure 10: Relationship between ${}_{21}q_3$ and IMR in Sweden and Kyrgyzstan (registration data)

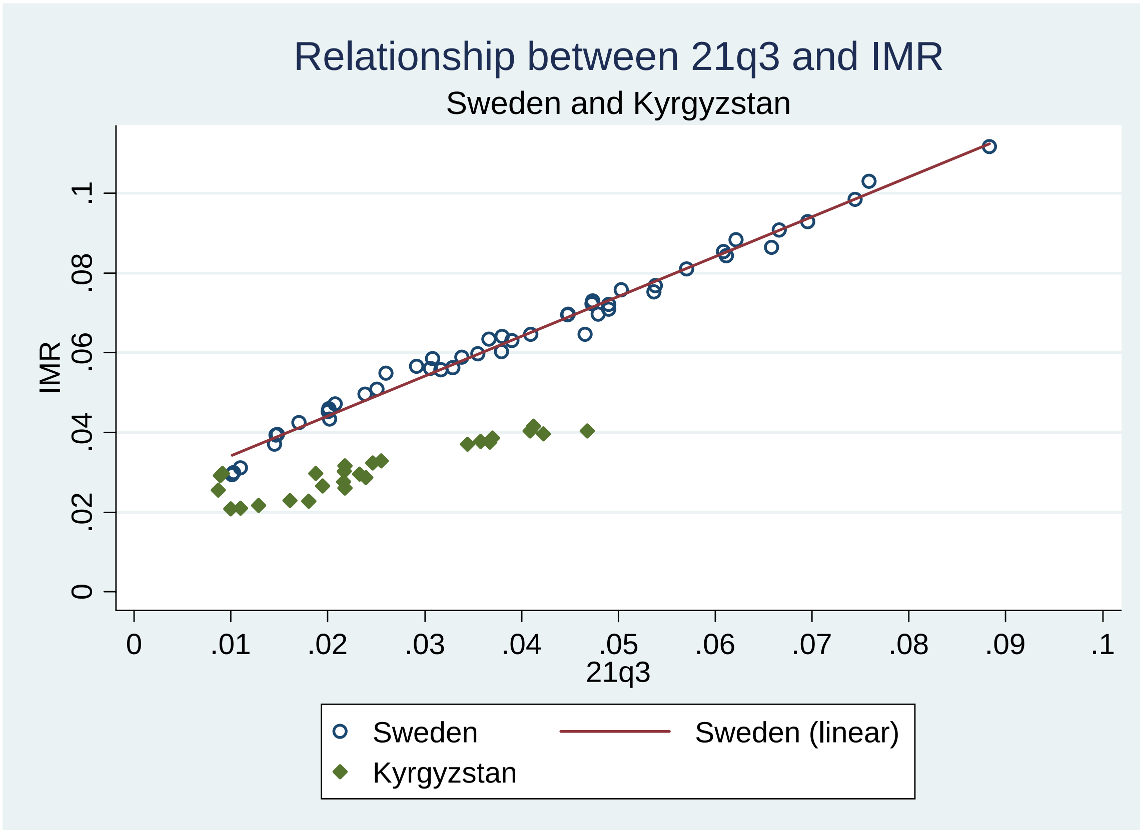

Figure 11: Adjusted vs. reported IMR estimates, Kyrgyzstan, 1980-2006

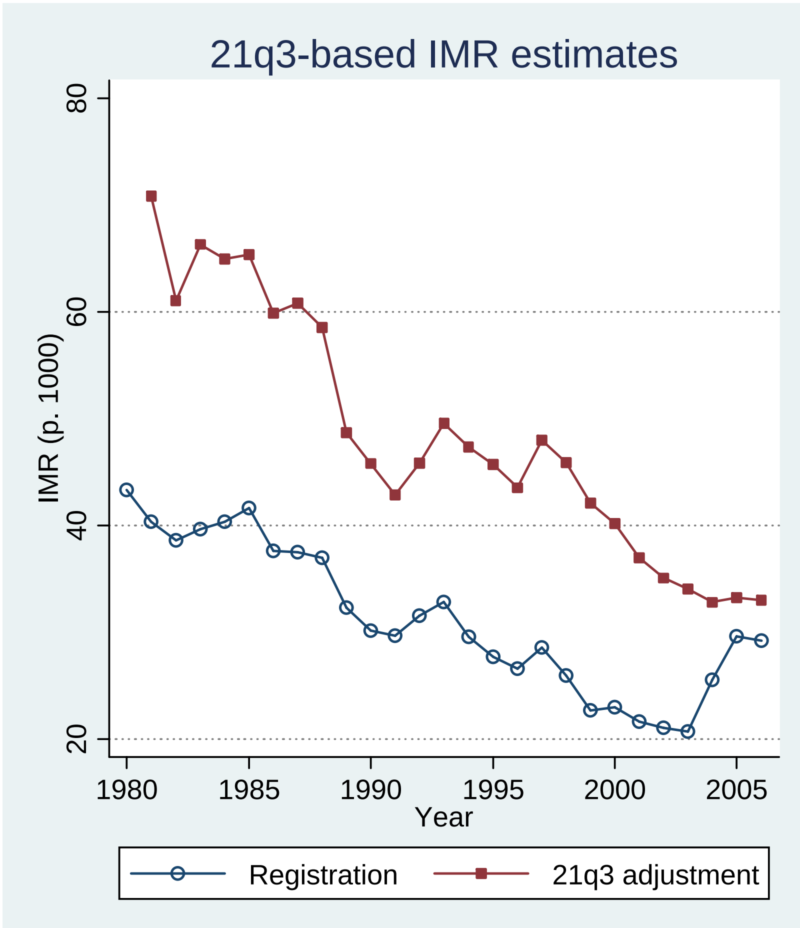

Figure 12: Adjusted vs. reported IMR estimates by residence, Kyrgyzstan, 1980-2006

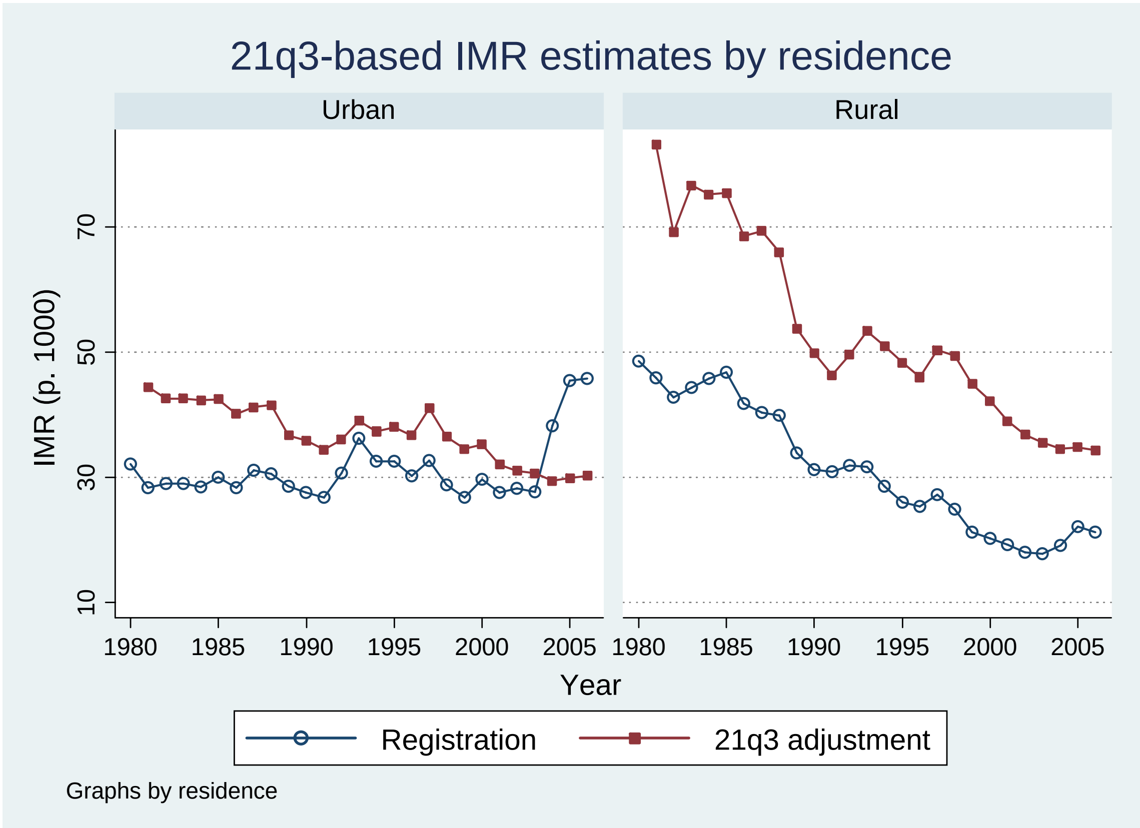

Figure 13: Comparison of various IMR estimates, Kyrgyzstan, 1980-2006