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Cancer mortality in Russia and Ukraine: validity, competing risks and cohort effects

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Background The dramatic increase in mortality in Russia and Ukraine in the late 1980s and 1990s has been due to increases in certain causes of death, particularly cardiovascular disease and accidents and violence. In contrast, there has been a slight fall in mortality from cancer.

Methods This paper presents an analysis of trends and patterns in cancer mortality and examines four possible explanations for its recent fall: changes in data collection; cohort effects; competing mortality from other causes of death; and improvements in health care.

Results All contribute to some extent to the observed changes, with each affecting predominantly different age groups. There is evidence of a significant under-recording of cancer deaths among the elderly especially in rural areas and of significant changes in coding practices in the early 1990s. Competing mortality from cardiovascular diseases and accidents can explain some reduction in male deaths from cancer in middle age. Birth cohort effects can explain some reduction among males after early middle age and among females at all ages. The impact of changes in health care are more difficult to identify with certainty but there is evidence of reduced deaths from childhood leukaemia.

Implications Recent changes in mortality in Russia are complex and their understanding will require a multidisciplinary approach embracing demography, epidemiology and health services research.

Keywords Russia, Ukraine, demography, cohort studies, neoplasms

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Recent changes in mortality in the former USSR have attracted much international interest. Since the mid-1980s great fluctuations in population mortality have been observed in both Russia and Ukraine, countries with the two biggest Slavic populations (147.9 million and 51.6 million respectively in 1990).[1]

In Russia, after a large fall between 1985 and 1987, deaths began to increase rapidly, leading to a fall in male life expectancy at birth between 1987 and 1994 of over 7 years.[1] Earlier studies have shown how these changes were associated with an initial fall and subsequent increase in alcohol consumption before the anti-alcohol campaign of 1985 and with the socioeconomic shocks of the 1990s.[2–4] In Ukraine, a similar pattern was observed, although the increase was less marked than in Russia.[5] In both countries the increase in the overall mortality rate was due largely to increases in deaths from accidents and violence and from cardiovascular diseases in those aged between 20 and 65. The greatest increase in mortality occurred in men aged 35–45.

Throughout most of this period, trends in mortality rates from cancer remained relatively stable, with the gradual increase seen in the 1980s persisting into the early 1990s when the trend reversed in both countries and began to decline, in marked contrast to the continuing rise in deaths from other causes. This paper tries to explain this observation on the basis of in-depth analysis of mortality from cancer.

Trends in Mortality Rates from Cancer

Before considering the most recent changes in detail it is necessary to place them in the context of what is known of long-term trends in cancer mortality rates in Russia and Ukraine. The

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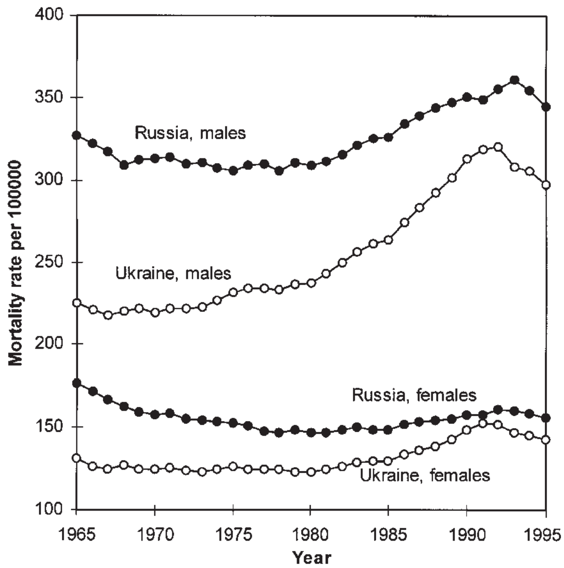

Figure 1 Standardized mortality rates for neoplasms in Russia and Ukraine in 1965–1995

Table 1 Standardized mortality rates for neoplasms by cancer site in Russia and Ukraine per 100 000

	Russia			Ukraine		
	1980	1992	1995	1980	1992	1995
Males						
All neoplasms	**308.4**	**355.3**	**344.7**	**237.0**	**320.3**	**297.3**
Aero-digestive	17.9	25.7	25.7	12.4	26.0	26.1
Oesophagus	12.6	13.9	12.2	5.7	9.2	8.6
Stomach	80.6	64.9	59.4	52.0	51.1	43.8
Intestine	12.4	17.7	17.8	9.1	16.0	15.2
Rectum	12.1	14.7	15.5	11.4	16.2	16.2
Trachea, bronchus, lung	89.4	112.2	107.3	69.9	97.3	88.0
Breast	0.5	0.7	0.7	0.5	0.9	0.8
Male genital organs	11.2	15.8	15.8	10.0	16.4	15.7
Leukaemia and other haemoblastoses	12.3	15.1	13.8	12.5	14.9	14.4
Other neoplasms	59.5	74.5	76.6	53.6	72.4	68.6
Females						
All neoplasms	**146.8**	**160.8**	**158.6**	**123.1**	**151.6**	**142.7**
Aero-digestive	2.2	2.3	2.2	1.3	2.0	1.9
Oesophagus	4.2	3.0	2.6	1.2	1.2	0.9
Stomach	36.3	28.2	25.3	22.2	21.3	17.0
Intestine	9.3	13.0	13.1	6.7	11.3	10.4
Rectum	9.0	9.4	9.4	8.1	9.5	9.5
Trachea, bronchus, lung	10.3	12.0	11.2	9.6	11.6	10.4
Breast	15.2	22.0	23.3	15.7	24.1	25.2
Female genital organs	15.5	15.0	15.2	15.4	16.5	16.2
Leukaemia and other haemoblastoses	17.0	8.6	8.4	7.1	8.7	8.6
Other neoplasms	38.0	47.3	47.9	35.8	45.6	42.7

data on which this paper is based are taken from a reconstruction of Russian and Ukrainian mortality data since 1965 that has been described in detail elsewhere.[6,7] In essence, cancer mortality trends have been rather similar to those in western nations except for the presence of a time-lag of several decades, such as the rising death rates for smoking-related cancers. In the 1960s mortality from cancer overall was much lower in Russia and Ukraine than in the west. In the 1970s, there was a slow decline in the overall mortality rate from cancer as increases in cancer of the lung, colon, and rectum for both sexes, cancer of the prostate in males, and cancer of the breast in females were balanced by a steady fall in deaths from stomach cancer. The downward trend in overall cancer mortality in both Russia and Ukraine reversed by the beginning of the 1980s.[2]

Figure 1 shows the trends in Russian and Ukrainian age-standardized mortality rates, using the WHO European standard of population between 1965 and 1995. After the period of gradual increase, a moderate decline in cancer mortality can be seen clearly since 1993 in Russia and since 1992 in Ukraine.

To understand more recent changes it is necessary to consider trends in mortality rates from specific cancers. Table 1 presents age-standardized mortality rates for common cancer sites in 1980, 1992, 1995 and the changes between these years. Between 1980 and 1992 the standardized mortality rate for neoplasms increased by 15.2% for men and by 9.5% for women in Russia, and by 35.0% and 23.2% respectively in Ukraine. By 1992 the standardized mortality rate for all neoplasms combined remained higher in Russia than in Ukraine but the gap between the two countries was substantially smaller than in 1980. The increase in cancer mortality occurred for all the leading cancer sites except cancer of the stomach in both sexes and, in women, cancer of the rectum and genital organs. Mortality from lung cancer in men and mortality from breast cancer in women are the two greatest contributors to the increase in overall cancer mortality. For almost all cancer sites both increases and decreases were greater in Ukraine than in Russia.

In the 1990s the situation changed (Table 1). Between 1992 and 1995 standardized mortality rates for many cancer sites fell. This decline is particularly striking in Ukraine. This is most marked for cancer of the stomach and lung. Mortality from other cancer sites is either declining or stabilizing. The exceptions to this pattern are cancer of the rectum in men (and cancer of the colon in Russia) and cancer of the breast in women (and cancer of the female genital organs in Russia).

Table 2 suggests that the decline in cancer mortality in the 1990s is due largely to decreases among the elderly. For males, they contribute 71% of the total decrease in male cancer deaths in Russia and 77% in Ukraine. Deaths in the age group 45–64 contribute 26% and 21% of the decrease in Russia and Ukraine respectively. Declining mortality from neoplasms at ages under 45 explains only 2% of the total decrease.

Among women, the decline in mortality from neoplasms in 1992–1995 is due exclusively to a decrease in deaths among those aged ⩾65. Unlike the situation for males, female cancer mortality is increasing in the age groups 15–44 and 45–64, offsetting the impact of mortality reduction at older ages.

The decline in deaths from neoplasms in 1992–1995 at age ⩾65 affected almost all cancer sites (with the exception of cancer of the rectum in Russia, Table 2). The changes in mortality rates

Table 2 Decomposition of changes in standardized mortality rate for neoplasms between 1992 and 1994 by age and cancer site in Russia and Ukraine (per 100 000)

	Russia					Ukraine				
	Total	0–14	15–44	45–64	65+	Total	0–14	15–44	45–64	65+
Males										
All neoplasms	**–10.5**	**–0.3**	**–0.2**	**–2.7**	**–7.3**	**–23.1**	**–0.4**	**–0.3**	**–4.8**	**–17.7**
Aero-digestive	–0.1	0.0	–0.2	0.4	–0.2	0.1	0.0	–0.1	0.5	–0.3
Oesophagus	–1.7	0.0	–0.1	–0.7	–0.9	–0.5	0.0	–0.1	–0.4	0.0
Stomach	–5.5	0.0	–0.1	–1.7	–3.7	–7.4	0.0	–0.1	–2.1	–5.2
Intestine	0.1	0.0	0.0	0.4	–0.3	–0.8	0.0	0.0	–0.5	–0.3
Rectum	0.8	0.0	–0.1	0.4	0.4	0.0	0.0	–0.1	0.8	–0.7
Trachea, bronchus, lung	–5.0	0.0	0.0	–3.1	–1.9	–9.3	0.0	–0.1	–3.5	–5.7
Breast	0.0	0.0	0.0	0.0	0.0	–0.1	0.0	0.0	0.0	–0.1
Male genital organs	0.0	0.0	0.1	0.3	–0.4	–0.8	0.0	0.0	0.4	–1.2
Leukaemia and other haemoblastoses	2.1	0.0	0.2	1.6	0.3	–3.8	–0.2	0.1	0.0	–3.8
Other neoplasms	–1.3	–0.2	–0.1	–0.2	–0.7	–0.5	–0.2	0.0	0.0	–0.3
Females										
All neoplasms	**–2.3**	**–0.1**	**0.3**	**0.7**	**–3.1**	**–8.9**	**–0.1**	**0.4**	**0.5**	**–9.7**
Aero-digestive	–0.1	0.0	0.0	0.0	–0.1	–0.1	0.0	0.0	0.0	–0.1
Oesophagus	–0.4	0.0	0.0	–0.2	–0.3	–0.3	0.0	0.0	–0.1	–0.2
Stomach	–2.9	0.0	–0.1	–0.6	–2.2	–4.2	0.0	–0.1	–0.7	–3.5
Intestine	0.1	0.0	0.0	0.3	–0.1	–1.0	0.0	0.0	–0.1	–0.9
Rectum	–0.1	0.0	–0.1	0.2	–0.2	0.0	0.0	0.0	0.2	–0.3
Trachea, bronchus, lung	–0.8	0.0	0.0	–0.2	–0.6	–1.2	0.0	0.0	–0.1	–1.2
Breast	1.3	0.0	0.0	0.7	0.6	1.2	0.0	0.3	1.0	–0.1
Female genital organs	0.2	0.0	0.3	0.3	–0.4	–0.3	0.0	0.3	0.2	–0.8
Leukaemia and other haemoblastoses	–0.2	–0.1	0.0	0.0	–0.1	–0.1	–0.1	0.1	0.1	–0.2
Other neoplasms	0.6	–0.1	0.2	0.3	0.2	–2.9	0.0	–0.1	–0.1	–2.6

in the age group 45–64 varied much more by site. The earlier decline in deaths from stomach cancer continued.

Possible Explanations

There are several possible explanations for the recent fall in recorded mortality rates from cancer. First, the quality of data collection may have deteriorated, causing deaths from cancer to be recorded erroneously as something else. Second, observed changes could be the consequence of existing historical trends, such as birth cohort effects. Third, the fall in cancer mortality could be due to competition from the large rise in mortality from other causes, in particular accidents and acute cardiovascular diseases, from which people often die at a younger age than they do from cancer. Finally, it is possible that the recent changes might be due to improvements in the health care system resulting in more effective preventive measures or treatment. Each of the explanations will be considered in turn.

Incomplete registration of cancer mortality among the elderly

The first possible explanation is that the decline in mortality might be due to a deterioration in recording cause of death, with cancer deaths recorded as due to other causes. *Prima facie*, there are grounds for concern that this may be important. Comparison of age-specific mortality rates from cancer in, on the one hand, Russia and Ukraine, and on the other hand, four European countries (Figure 2) shows a strikingly different pattern. In Russia and Ukraine, the exponential mortality increase seen elsewhere does not continue beyond the ages of 70–75. Russia and Ukraine report very high cancer mortality rates in the young and middle-aged and unexpectedly low levels at advanced ages. As shown in Figure 2, the mortality rate from cancer in the age group 60–64 in Russia is similar to that in Hungary, which has some of the highest rates in Europe, but at age $\geqslant 85$ the Russian mortality rate is 2.7 times lower. This decrease at older ages is even more marked in Ukraine.

The same analysis for specific cancer sites (data available from the authors) shows that the phenomenon of decrease in mortality rate with age persists for all sites except female breast cancer.

The data from Goskomstat (State Committee for Statistics) for the year 1988[9] permits separate analysis of cancer mortality in urban and rural populations of Russia and Ukraine (Figure 3). This shows that the level of mortality rates at ages >60 or 65 differs substantially between urban and rural areas. The reported pattern of cancer mortality among rural residents, i.e. similar mortality rates at ages 50 and 85, is entirely inconsistent with the natural history of cancers and must be considered implausible. This implausibility is further supported by the observation that, although in the rural population cancer mortality is higher in the young and middle-aged, among the elderly, reported rates are lower than for the urban population.

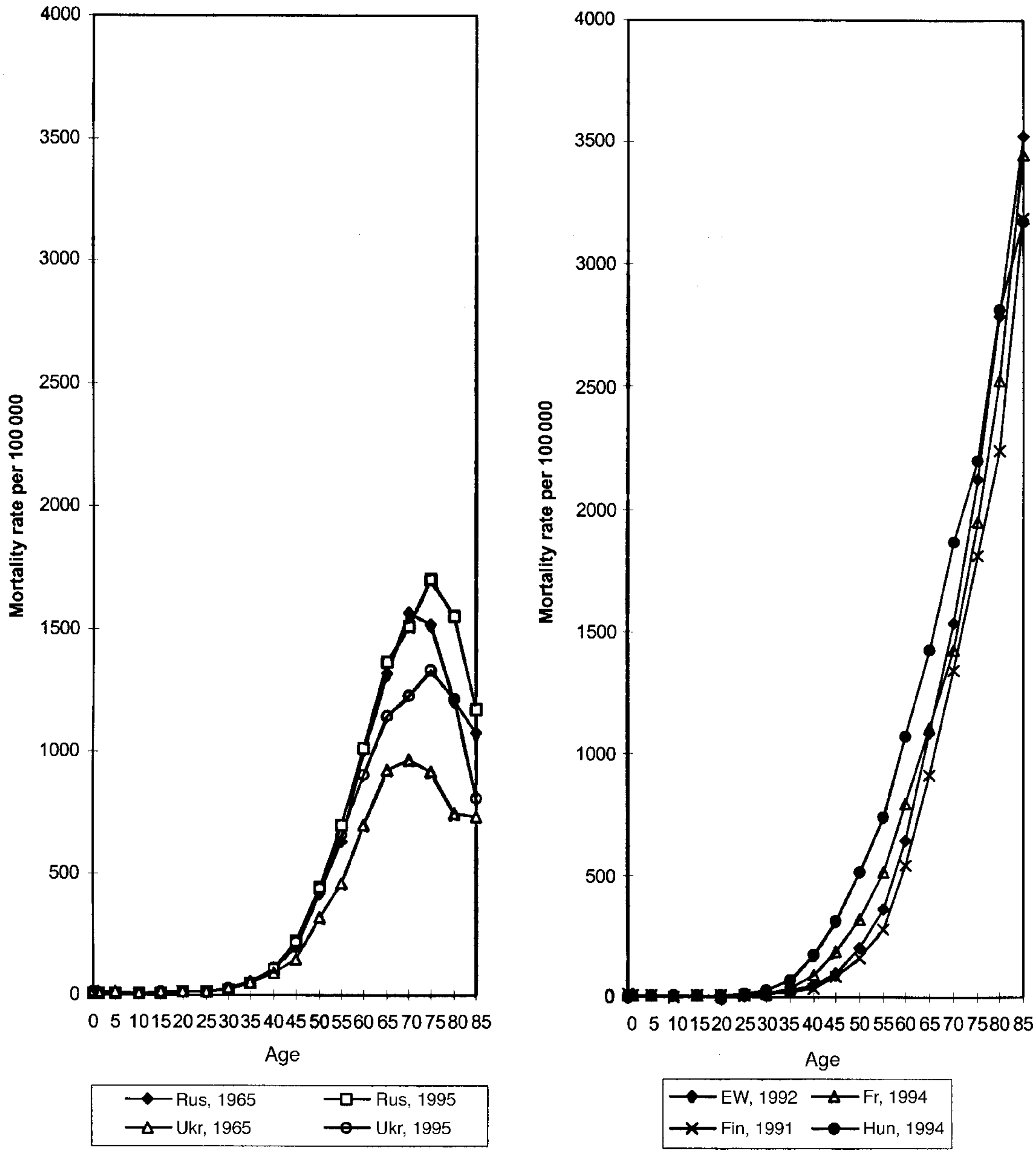

Figure 2 Age curves of mortality from cancer in Russia and Ukraine (1995), England and Wales (1992), France (1994), Finland (1991), and Hungary (1994)

The suggestion of a deficiency in data quality among the elderly in rural areas seems, at first sight, to be inconsistent with results of surveys of the quality of cause-of-death coding during the Soviet period[2] which reported only a very small level of under-recording (less than 5%). However, the quality of cause-of-death recording in the rural population has never been studied adequately as the studies were confined to urban areas. Our findings are strongly suggestive of substantial under-recording of cancer deaths at older ages, especially in rural areas. It is intuitive that this is likely in rural settlements where specialist care is less easily accessible.

However, an alternative hypothesis can also be proposed. It could be argued that older generations were less exposed to certain risk factors and have genuinely lower cancer mortality rates. There are many examples of cohort effects in cancer epidemiology, most notably for lung cancer due to variation in prevalence of smoking across birth cohorts.[10]

If the decrease in period (or cross-sectional) mortality rates with age is due to a cohort effect then it should not be observed in age-specific mortality rates in birth cohorts. Figure 4 shows the age distribution of cancer mortality in Ukraine for selected cohorts born between 1895 and 1920. In the majority of cohorts the decline at ages over 70–75 remains.

Figure 5 shows age distributions for the same birth cohorts for smoking-related and breast cancer; cancers which can experience the strongest cohort effects. Declines at older ages are

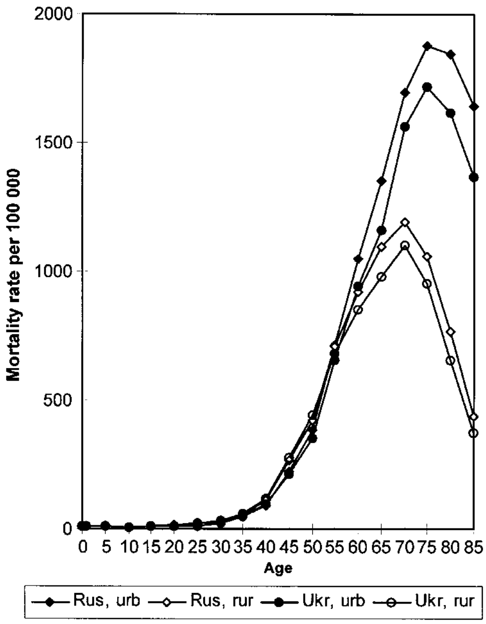

Figure 3 Age curves of mortality from cancer in Russia and Ukraine in 1988: urban and rural populations

characteristic of lung cancer, but are not seen for aero-digestive cancer and for cancer of the female breast (except for the oldest cohort born in 1895–1900).

The cohort born in 1905–1910 (labelled '1907' in Figures 4 and 5) is an important exception from the general regularity. This cohort reached age 80–84 around the year 1990 when the Soviet death certification practice was considerably modified, with particularly important implications for the elderly (see below).

Although significant cohort effects are observed (in particular, for aero-digestive and breast cancers) they do not eliminate the decline with age for leading cancer sites. This suggests that the phenomenon of decline in older-age mortality from cancer cannot be attributed to lower cancer risks among the elderly.

In summary, there are considerable grounds for concluding that cancer deaths are really under-recorded among the elderly. Looking more precisely at recent trends in order to understand if there were any changes in this under-recording in the early 1990s, the special behaviour of '1907' cohort suggests that something probably happened around the year 1990. To confirm this we should look at temporal changes in age-specific mortality at older ages.

In Russia during the 1980s mortality rates from cancer at ages ⩾75 increased more rapidly than at younger ages (Figure 6, upper charts). By 1989–1992 this had stabilized and by 1993–1995 had declined. In Ukraine a steep increase in cancer mortality rates at ages ⩾70 was also observed until 1989 (Figure 6, lower charts). In 1989–1990 a sudden sharp increase occurred. This was especially great among those aged ⩾85, for whom the mortality rate approximately doubled. In 1992–1993 a symmetrical decrease occurred, which continued (at a much slower rate) in 1994 and 1995.

Fluctuations such as these raise the possibility of changes in coding practice. Interpretation of these findings necessitates a review of what is known about procedures for coding cause of death in the Soviet Union. In the late 1970s and the early 1980s the Soviet Ministry of Public Health and Goskomstat had turned their attention to the problem of cause-of-death registration. The Ministry conducted systematic checks of medical documentation and death certification. These built on earlier studies that had some known weaknesses.[11,12] For example, contrary to official guidance, the immediate cause was often recorded rather than the underlying one.[6] This leads, for example, to the over-registration of cardio-respiratory diseases in elderly people who die following a fall.[2]

In November 1984 the Ministry of Public Health of the USSR issued Order N1300 which enacted measures to improve the system of cause-of-death registration. Further improvements also occurred in completeness of cancer registration following development of a territorial network of cancer dispensaries. It is highly plausible that this intensified attention could have improved the reliability of cause-of-death statistics and, specifically, cancer registration at older ages, thus contributing to the accelerating increase in cancer mortality in the 1980s seen in Figures 6.

The gradual pace of change did not, however, meet the expectations of the Ministry of Public Health and more drastic action was taken. In March 1989 the Ministry issued a directive in respect of cause-of-death registration which was primarily intended to reduce registration of deaths from cardiovascular diseases in older ages. The directive led to a huge rise in deaths from 'senility' in Russia from 300 per year to 30 000–40 000 per year between 1988 and 1990–1991.[6]

According to paragraph 11 of the directive, where malignant neoplasms co-existed with circulatory disorders, the former was to be registered as the primary (underlying) cause of death. It seems likely that the dramatic rise in cancer mortality at older ages in Ukraine in 1989–1990 was due to this directive (Figure 4b), possibly reinforced by the greater attention to cancer rates following the explosion at Chernobyl in Ukraine. The subsequent sharp fall in cancer mortality at older ages in Ukraine could then be explained by a return to the previous registration customs.

Unlike Ukraine, an accelerating increase in cancer mortality in 1989–1990 was not seen in Russia. This could be due to differences between Soviet republics in the practice of death certification[6] and, in particular, the slower diffusion of policies on registration among the many territories of the Russian Federation, which stretches from the Baltic to the Pacific. It can also be noted that the size of the rural population is greater in Ukraine than in Russia (33% against 26% according to the census of 1989).

In summary, this section of the analysis suggests that changes in the practice of death registration can explain a substantial part of the increase in cancer mortality among the elderly in the 1980s and its decline in the 1990s.

Cohort effects among those under age 70

It has been already shown that some decline in cancer mortality had occurred not only at older ages, but also in middle age among men (Table 2). This could be due to cohort effects, whereby generations with different lifetime risks of cancer lead to temporal fluctuation in mortality rates.

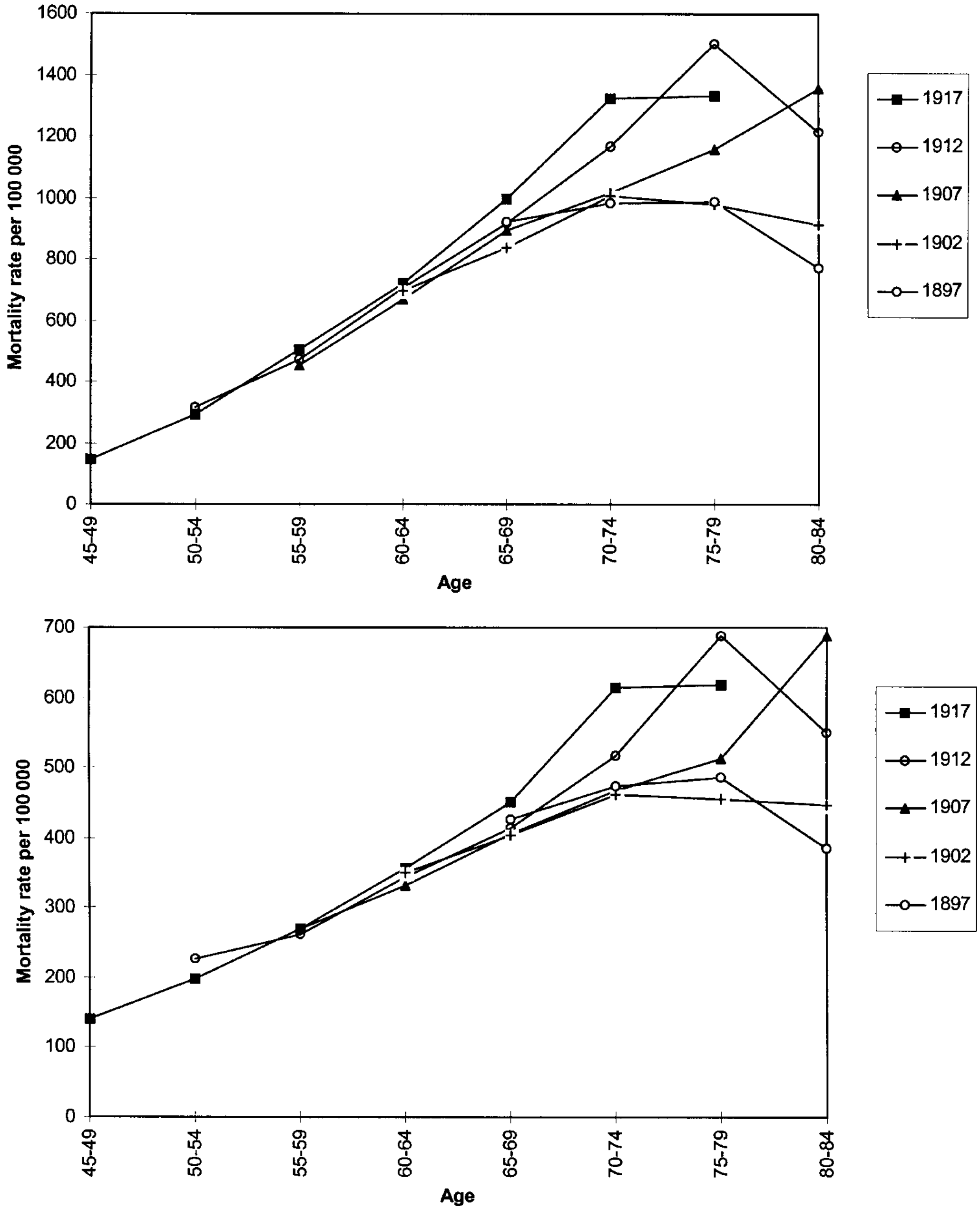

Figure 4 Mortality age curves for selected older birth cohorts: all neoplasms combined. Birth cohorts are labelled according to their 'central' years of birth (for example, '1907' corresponds to people born in 1905–1910)

Age, period, and cohort effects on Russian mortality from neoplasms can be estimated from age-specific mortality rates for neoplasms for 1965–1995.[6] In the present analysis, certain data have been excluded to provide a comparability over time. These are data relating to those <5 years, due to small numbers, and to ages >75 due to the possible changes in completeness of cancer registration noted above.

A linear regression model has been applied, similar to that used by Anderson and Silver to analyse Soviet all-cause mortality[13] (Appendix 1).

Estimation of cohort effects according to this model permits examination of the expected impact of changes in the cohort composition of the population on cancer mortality rates. Figure 7 presents the observed changes in age-specific mortality rates for neoplasms between 1992 and 1995 and those expected from estimated cohort effects in Russia and Ukraine. For males above early middle age and females at all ages there are marked similarities in the patterns of observed and expected changes. This indicates that cohort effects also contribute to the temporal trends in cancer mortality rates. Clearly these need to be

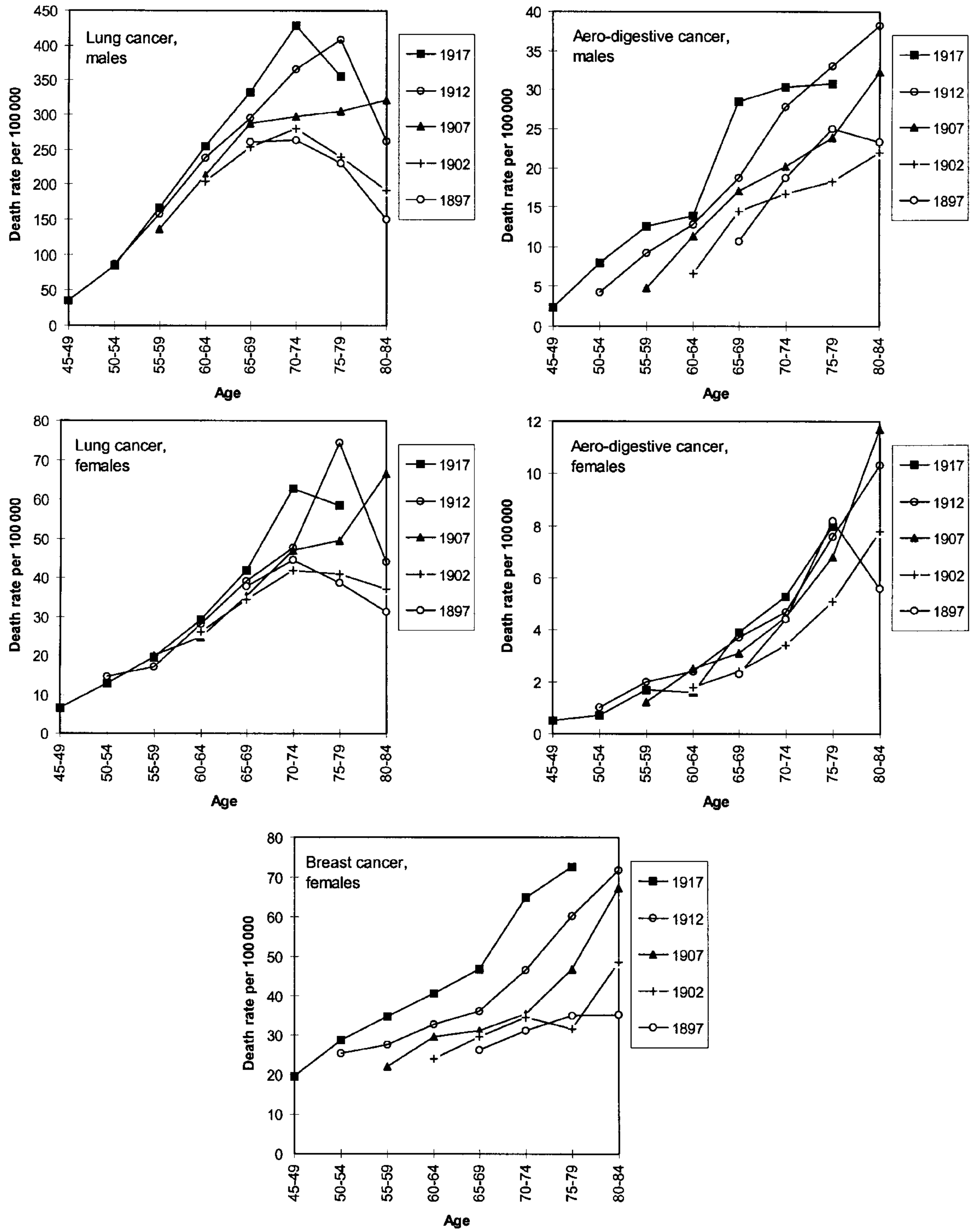

Figure 5 Mortality age curves for selected older birth cohorts: cancer of the bronchus and lung and cancer of the aero-digestive tract, cancer of breast for females

examined in more detail for specific sites but this is outside the scope of the present paper.

Competing risks

The dramatic increase during the early 1990s in deaths at an early age from cardiovascular diseases and from accidents and violence raises the possibility of competition among causes of death. Some of the decline in reported cancer mortality in the 1990s could have been caused by those who would otherwise have died from cancer dying earlier from these other causes.

This can be studied using the approach developed by Chiang.[14] This permits estimation of age-specific probabilities of

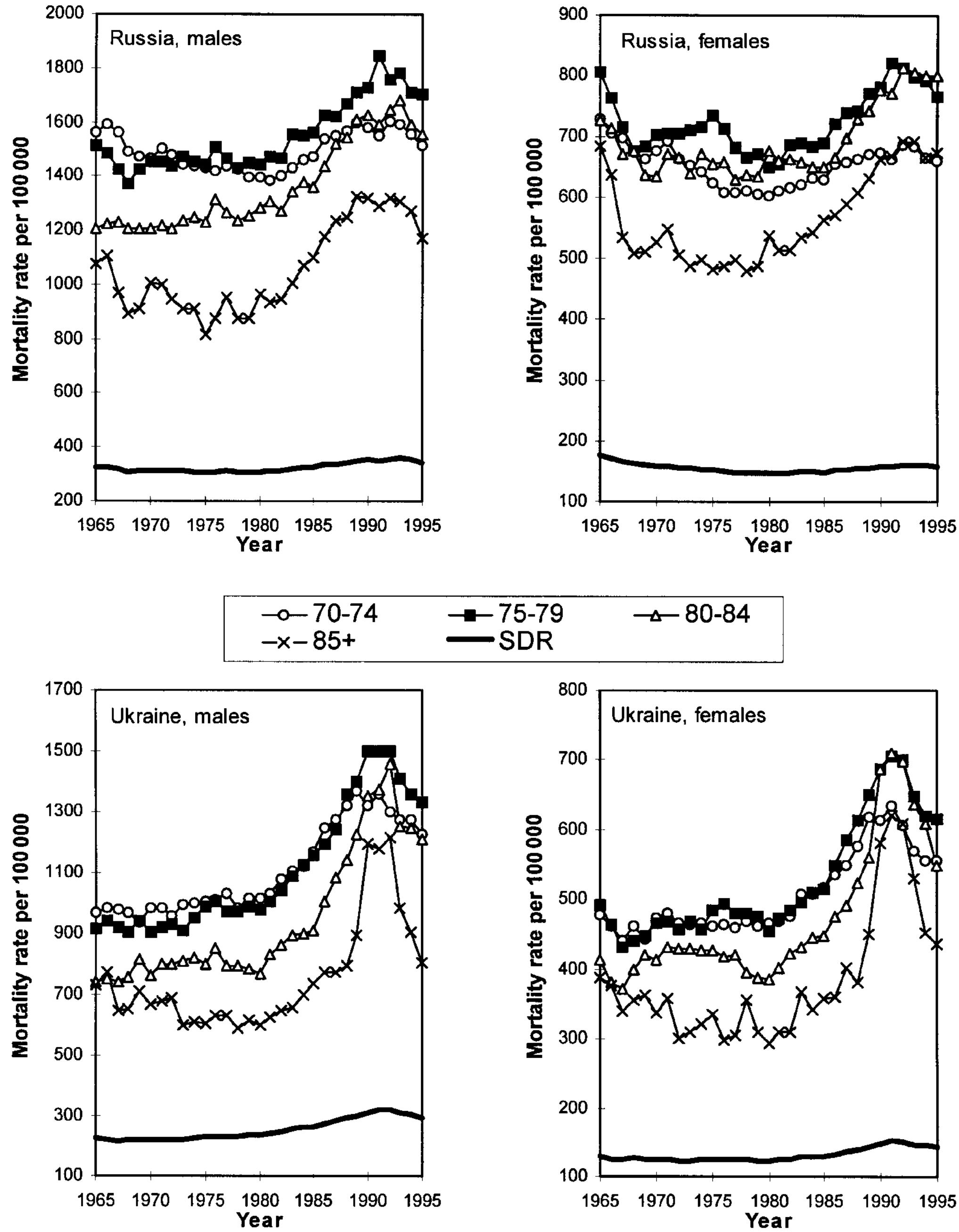

Figure 6 Trends in Russian and Ukrainian mortality rates from neoplasms since 1965 for selected age groups and in standardized death rate for age 0–69

death from a specific cause following removal of other causes (Appendix 2). It involves calculation of the hypothetical crude age-specific probabilities of dying from cancer in men in 1995 following removal of the increase between 1992 and 1995 in the probabilities of dying from the residual causes. The resulting hypothetical probabilities are compared with the observed probabilities of death from cancer in 1992. Figure 8 depicts the ratio of observed age-specific probabilities of death from cancer in 1992 to those in 1995 and the ratio of hypothetical probabilities of death from cancer in 1995 to the real probabilities of death from cancer observed in 1995. It shows that, in Russia, in middle age, a substantial proportion of the fall in mortality could be due to changes in competing causes. It can explain a lower proportion of the changes among the elderly and this would be consistent with the evidence presented earlier that a deterioration of the quality of data on cause-of-death is more important in this age group. Competing mortality appears less able to explain the observed changes in Ukraine, although again the marked divergence at older age groups seems likely to reflect changes in registration of cancer deaths.

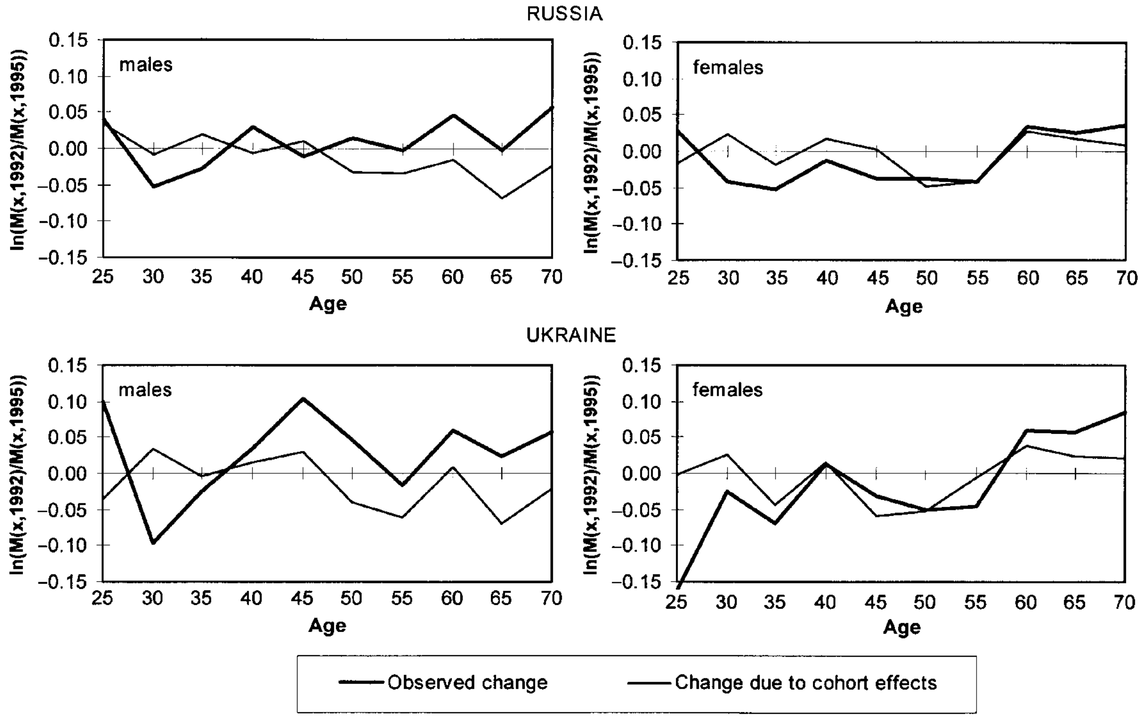

Figure 7 Observed proportional changes in logarithms of age-specific mortality rates by neoplasms and proportional changes expected from cohort effects between 1992 and 1995 in Russia and Ukraine, by gender

Changes in the health care system

Examination of the reasons for the observed decline in cancer mortality would be incomplete without considering the possibility that improvements in the health care system might have led to more effective treatment, even though it seems unlikely in this period of socioeconomic transition and of widespread reports of financial crises facing the health care system. This impression is supported by the few studies that have examined quality of care in Russian hospitals and reported important shortcomings in the field of cancer treatment.[15] In contrast to the overall decline in cancer mortality, there have been some increases, such as for cancer of the breast and uterus. It is possible that these could be due to deterioration in care for these conditions but this would be more plausible had there been effective screening programmes in place that subsequently collapsed.

For other cancers, the impact of health services is even less clear, as many of the cancers that have contributed most to the overall decline in mortality, such as lung cancer, respond poorly to treatment[16] so even major changes in treatment regime or quality of care would be unlikely to have a significant effect. There is, however, some evidence of improvements in one highly specific area. The reduction in deaths from cancer among children in 1992–1995 can be explained almost entirely by a fall in deaths from childhood leukaemia. A plausible explanation is that this reflects improved survival due to the introduction of new therapeutic regimes, involving previously unavailable chemotherapeutic agents and improved nursing care since 1991.[17] It is consistent with statistical reports of a substantial improvement in survival among Russian patients with haematological malignancies between 1992 and 1995.[18,19] For example, expected survival (on the basis of cross-sectional life tables) at age 10 for a newly diagnosed patient was 10 years for males and 13.5 years for females in 1992 but this increased to 16.8 years and 19.5 years respectively by 1995.

Conclusions

Interpretation of trends in cancer mortality is inevitably complex due to the impact of underlying trends in cancers at differing sites, the possibility of changes in data collection, and the many other factors that may influence them. It is especially problematic in countries such as Russia and Ukraine that are undergoing major social and economic transitions leading to dramatic fluctuations in deaths from many causes and possible breakdown of previous systems for health care and data collection. Understanding such trends is, however, important as they have important implications for health and social policy. At first sight, the observed fall in cancer mortality in 1992–1995 seemed counterintuitive and there was little information from which to decide whether it was real and, if so, what were its causes. This analysis has begun to correct this situation.

In summary, there is clear evidence of weaknesses in cause-of-death registration, especially among those aged >70 which has, historically, led to underestimation of cancer mortality, especially in rural populations. Against this background, the rapid increase in cancer mortality among the elderly in Russia and Ukraine in the late 1980s and its striking further rise in Ukraine in 1989–1990 seem to be due, in large part, to an increase in completeness of registration of cancer as an underlying (or primary) cause of death. The decline in cancer mortality at older ages in the 1990s, which is particularly striking in Ukraine,

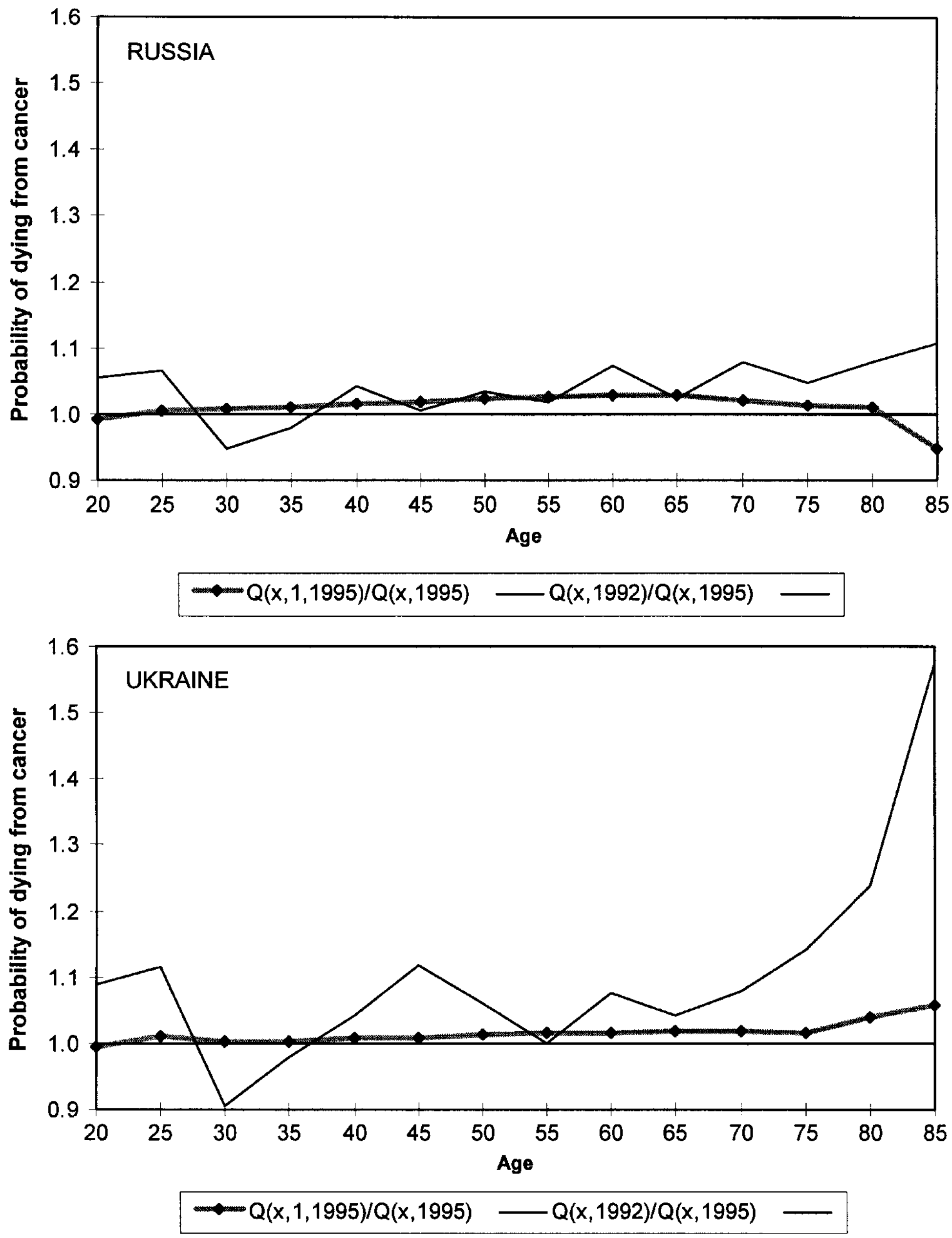

Figure 8 Proportional changes in male probability of dying from cancer between 1992 and 1995 and hypothetical increase in probability of dying from cancer due to elimination of excess mortality from other causes of death

seems likely to represent a return to previous approaches to registration.

The moderate decline in cancer mortality among middle-aged men in the 1990s seems likely to reflect a combination of cohort effects and a simultaneous extraordinary rise in mortality from competing causes of death.

In addition, there is evidence that changes in the delivery of health care have had small, but specific effects, most notably with regard to childhood leukaemia. The many reports of a decline in the quality of care provided to other patients may have contributed to the observed increase in mortality from cancer of the uterus and the breast but, on the basis of evidence currently available, this must remain speculative.

These analyses have only been able to explore these issues superficially. There remain many important gaps in our knowledge of the current trends in mortality in the countries of the former Soviet Union. These have important implications for policy and there is an urgent need for further detailed epidemiological and health services research, examining cancers at specific sites, and involving researchers from a broad range of disciplines.

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Appendix 1

Model used to evaluate cohort effects

The model is defined by the following equation:

$$\ln(M_{ijk}) = a_i + b_j + c_k + e_{ijk}$$

where M_{ijk} is the central mortality rate for age group i, calendar year j, and cohort k, a_i is the age effect, b_j is the period effect, c_k is the cohort effect, and e_{ijk} is the stochastic error. (Age x_i, calendar year t_j, and year of birth T_k are obviously linked by expression: $T_k = t_j - x_i$.) In practice 5-year age groups corresponding to 6-year cohorts were used. For example, age 20–24 in 1970 corresponds to cohorts born in 1945–1950. It is thus easier to identify a cohort by its central year, namely, 1947.

Effects of age, period and cohort are estimated by the ordinary least square method as coefficients of a linear regression of logarithms of standardized mortality rates on dummy (dichotomous) variables representing age groups, calendar years and birth cohorts. For example, for the year 1970 the corresponding dichotomous (dummy) variable is 1 for all observations in 1970 and it is 0 for all the residual observations. The method of constructing the dummy variables for age groups and cohorts is the same.

Appendix 2

Method used to measure effect of competing mortality

$$Q_{x\delta} \bullet 1 = \frac{Q_{x\delta}}{q_x - Q_{x1}} [1 - p_x^{(q_x - Q_{x1})/q_x}], Q_{x\delta} \bullet 1$$

= the crude probability of death from a cause δ at age x in the absence of risk of death from the cause 1, $Q_{x\delta}$ = the probability of death from a cause δ at age x, Q_{x1} = the probability of death from a cause 1 at age group x, q_x = the probability of death at age x, $p_x = 1 - q_x$.