

50-year mortality trends in children and young people: a study of 50 low-income, middle-income, and high-income countries

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Summary

Lancet 2011; 377: 1162–74

Published Online

March 29, 2011

DOI:10.1016/S0140-

6736(11)60106-2

See Comment page 1128

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Background Global attention has focused on mortality in children younger than 5 years. We analysed global mortality data for people aged 1–24 years across a 50-year period.

Methods The WHO mortality database was used to obtain mortality data from 1955 to 2004, by age-group (1–4, 5–9, 10–14, 15–19, and 20–24 years) and stratified by sex. To analyse change in mortality, we calculated mortality rates averaged over three 5-year periods (1955–59, 1978–82, and 2000–04) to investigate trends in deaths caused by communicable and non-communicable diseases and injury.

Findings Data were available for 50 countries (ten high income, 22 middle income, eight low income, seven very low income, and three unclassified), grouped as Organisation for Economic Co-operation and Development (OECD) countries, Central and South American countries, eastern European countries and ex-Soviet states, and other countries. In 1955, mortality was highest in the 1–4-year age-group. Across the study period, all-cause mortality reduced by 85–93% in children aged 1–4 years, 80–87% in children aged 5–9 years, and 68–78% in young people aged 10–14 years in OECD, Central and South American, and other countries. Smaller declines (41–48%) were recorded in young men (15–24 years), and by 2000–04, mortality in this group was two-to-three times higher than that in young boys (1–4 years). Mortality in young women (15–24 years) was equal to that of young girls (1–4 years) from 2000 onwards. Substantial declines in death caused by communicable diseases were seen in all age-groups and regions, although communicable and non-communicable diseases remained the main causes of death in children (1–9 years) and young women (10–24 years). Injury was the dominant cause of death in young men (10–24 years) in all regions by the late 1970s.

Interpretation Adolescents and young adults have benefited from the epidemiological transition less than children have, with a reversal of traditional mortality patterns over the past 50 years. Future global health targets should include a focus on the health problems of people aged 10–24 years.

Funding None.

Introduction

Global mortality trends in children and young people have been little studied, even though more than two-fifths of the world's population is aged 5–24 years. A strong international focus on reduction of mortality in children younger than 5 years (Millennium Development Goal 4)¹ has reduced early childhood mortality by 35% since 1990,^{1–3} resulting in increased population sizes in later childhood (age >5 years) and adolescence. By comparison, mortality in later childhood and adolescence has been neglected, with the assumption that this period is the healthiest time of life.⁴ However, during the past 50 years, global social, economic, and political changes have adversely affected patterns of health and disease in adolescents and young adults.⁵

In the 2007 World Development Report,⁶ the World Bank concluded that adolescent health has substantial long-term effects on development and deployment of social and economic capital. Yet international data on mortality in children aged 5 years and older and young people are largely limited to cross-sectional data,^{5,7} or inclusion within studies of adult mortality.⁸ In a systematic review done on Jan 17, 2011, we did not identify any longitudinal studies of global mortality in people

Key messages

- In 2000–04, mortality in people aged 15–24 years was higher than that in children aged 1–4 years in most countries studied, with the exception of some very low-income countries. Mortality in young men (15–24 years) was two-to-three times higher than that in boys (1–4 years).
- Mortality in children aged 1–9 years declined by 80–93% in the 50 years up to 2004, due largely to steep declines in mortality from communicable diseases.
- Improvements in mortality in young people aged 15–24 years were half that in children, due largely to static or rising injury-related mortality, particularly in young men.
- Violence and suicide became increasingly important causes of death in young people in the second half of the 20th century, together making up a quarter to a third of mortality in young men aged 10–24 years in all regions by 2000–04.
- The changing patterns of mortality suggest that future global health targets should have an increased emphasis on the health of adolescents and young adults.

aged 5–24 years. In the past 40–50 years, mortality from transport injuries, suicide, and homicide has risen in adolescents and young adults in high-income countries.^{5,9–12} Mortality in young people aged 15–24 years in the UK has exceeded that in children aged 1–4 years since the 1970s, a reversal of the traditional understanding of mortality in children and youth.¹⁰

A scarcity of data disaggregated by age has been a barrier to understanding mortality in people aged 5–24 years because these people are typically included in age-groups of 0–14 or 15–44 years. The WHO mortality database now collates historical registration data disaggregated by age. We used these data to examine international mortality trends in mortality from communicable and non-communicable diseases and injuries in children and young people during the 50 years from 1955 to 2004. We limited our study to people aged 1–24 years because infant mortality has already been extensively studied.

Methods

Study design

The WHO mortality database records numbers and causes of death (International Classification of Diseases 7–10) registered by WHO member states from 1950. We accessed the WHO mortality database on March 26, 2010, and obtained data aggregated in the age-groups of 1–4, 5–9, 10–14, 15–19, and 20–24 years, stratified by sex. We used a modified global burden of disease classification of causes of death¹³ (panel 1).

Few countries had contiguous data from 1950 onwards and data varied in completeness between years within countries. WHO assessments of completeness of death registration data were used to reject unreliable data. We selected a cohort of countries according to three criteria: country recruitment to the WHO mortality database started in 1955 and continued until the midpoint (1980); countries were permitted to have only 2 successive years of missing data; and datasets had to have at least 70% completeness.

Countries were categorised by their gross national income per person at purchasing power parity in 1980, or the first year thereafter when data were recorded, as high income, middle income, low income, or very low income according to World Bank data and cutpoints. We chose not to use a strict classification of country income for analytical purposes because of a substantial category shift during the 50 years of the study; such an approach would have classified the UK and Japan as middle-income countries. Instead we chose to use a semi-regional approach; we categorised all 21 countries that were members of the Organisation of Economic Co-operation and Development (OECD) by 1980 as a separate group, irrespective of actual income. Countries outside the OECD in 1980 were classified as middle, low, or very low income, and were then classified by region. Data for all eastern European countries were

Panel 1: Global burden of disease classification of causes of death

Communicable and non-communicable diseases

Group 1

- Communicable (infectious), perinatal, and nutritional disorders, excluding maternal disorders
- Maternal disorders—eg, eclampsia or haemorrhage leading to maternal death

Group 2

- Non-communicable disorders—eg, diabetes, epilepsy, cardiovascular disease, asthma, and mental health disorders

Injury

Group 3: unintentional injury

- Transport injuries; this category is more inclusive than, but is substantially attributable to, road traffic injuries
- Other unintentional injury

Group 3: intentional injury

- Self-inflicted injury—ie, suicide
- Violence, including assault and war, though substantially assault

For more on the **WHO mortality database** see <http://www.who.int/healthinfo/mortables/en>

included in analyses from 1980 onwards, the year that Russia entered the study cohort, as few data were available before this.

Ethics committee approval was not required for these secondary analyses of national registration data.

Statistical analysis

We calculated the proportion of deaths per 100 000 population or per 100 000 person-years of observation in each age-group with population data from the WHO mortality database, or where missing, from UN estimates.¹⁴ To analyse change in mortality, we calculated mortality rates averaged over 5-year periods at baseline (1955–59), the study midpoint (1978–82), and the study endpoint (2000–04). Separate analyses are shown for children (1–9 years) and young people (10–24 years) according to WHO age categorisation. Analyses were done with Stata (version 10.0).

For more on **estimated completeness of data** see <http://apps.who.int/whosis/database/mort/table3.cfm>

Role of the funding source

There was no funding source for this study. The corresponding author had full access to all the data in the study and had final responsibility to submit the report for publication.

For more on **World Bank cutpoints** see <http://data.worldbank.org/about/country-classifications>

Results

50 countries conformed to the eligibility criteria, and 95% of the country datasets for each year had at least 80% completeness. Of the 21 OECD countries, ten were high income and 11 were middle income. The remaining 29 countries were middle, low, or very low income or unclassified, of which 15 were from eastern Europe (including ex-Soviet states in Asia), ten were from

For more on **OECD** see <http://www.oecd.org>

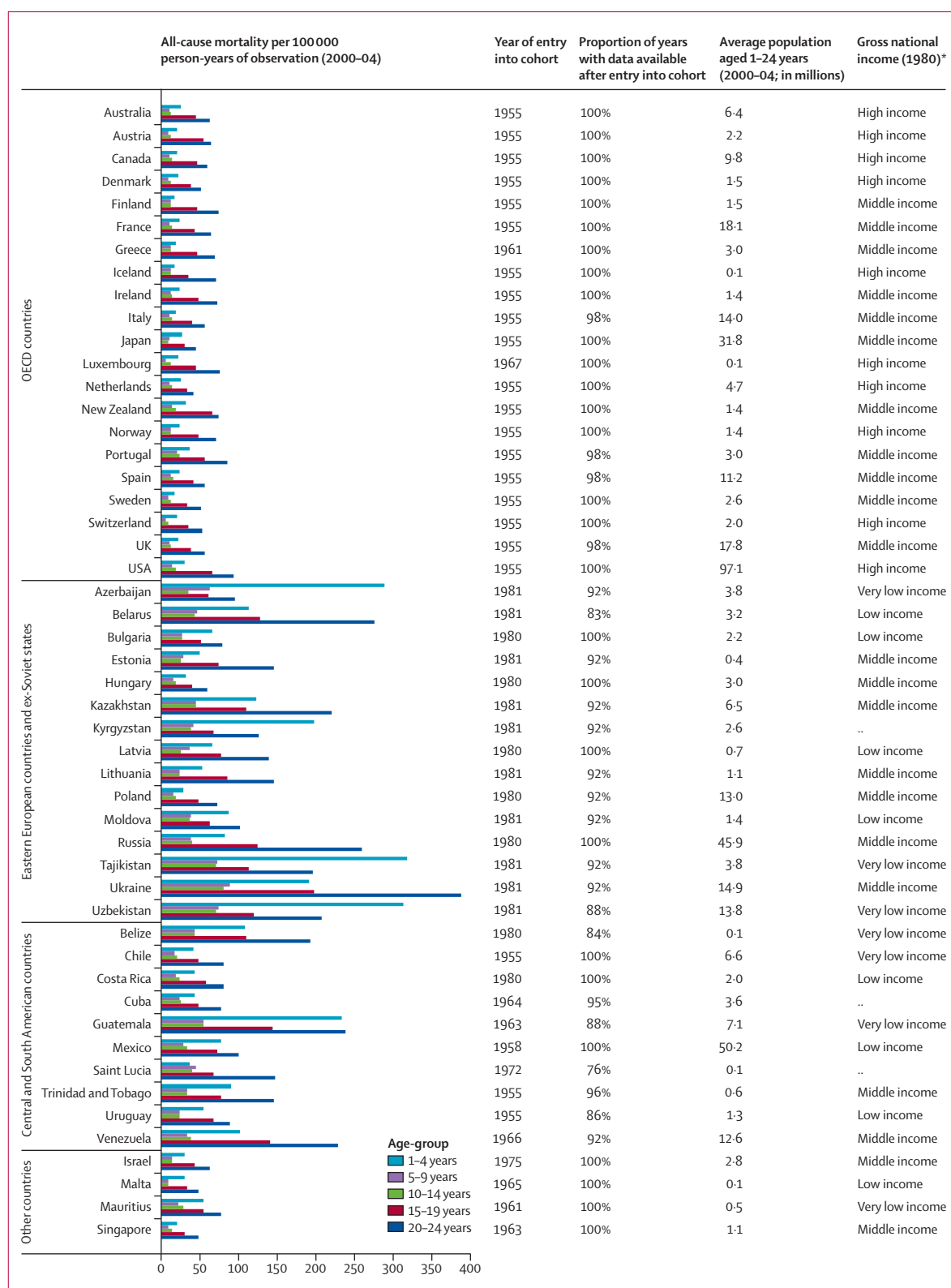


Figure 1: Characteristics of countries included in the cohort by region

OECD=Organisation of Economic Co-operation and Development. ..=unclassified. *Countries were categorised according to gross national income per person at purchasing power parity in 1980 or the first year thereafter when data were recorded.

Central and South America, and four from disparate regions (other countries) were small nations that have undergone very rapid economic development in the past 25 years (figure 1). The three unclassified countries (Kyrgyzstan, Cuba, and Saint Lucia) were almost certainly low income or very low income. In the 50 countries, the combined population aged 1–24 years in 2000–04 was 436 million, representing 15% of the global population of this age.¹⁴ In all but one country (Saint Lucia), all-cause mortality in 2000–04 was lower in children aged 1–4 years than in those aged 5–9 years, was lowest between 5 and 14 years, and rose sharply from 15–19 years onwards (figure 1). In OECD and most middle-income countries, mortality was higher in young people aged 15–24 years than in children aged 1–4 years. In low-income countries, mortality in children aged 1–4 years was substantial, resulting in a U-shaped histogram, but did not surpass mortality in young people aged 20–24 years. In the very low-income eastern European countries, children aged 1–4 years had the highest mortality.

In 1955, all-cause mortality was highest in children aged 1–4 years, lowest in the age-groups of 5–9 and 10–14 years, and then increased with age in both sexes (figure 2). Childhood mortality (1–9 years) was highest in 1955–60 and declined steadily over the next 50 years, with no substantial difference between sexes. Mortality in young people aged 15–24 years declined slightly across the 50 years, with secondary peaks in the early 1980s and again in the late 1990s that were most obvious in young men. Mortality in boys aged 1–4 years reduced below that of young men aged 20–24 years from the mid-1970s and young men aged 15–19 years from the early 1990s. By 2000–04, mortality in young men aged 15–19 years and 20–24 years was, respectively, two and three times higher than that in boys aged 1–4 years. Mortality in young girls aged 1–4 years decreased to be equivalent to that in young women aged 20–24 years from 2000 onwards.

The study period began with large differences in all-cause mortality between regions for both children (1–9 years) and young men (10–24 years), and ended with similar mortality rates across regions (figure 3). Mortality trends in children were similar across regions and sexes whereas mortality trends in young people differed between regions and sexes. Proportional reductions in mortality were much lower in young people than in children in all regions (figure 3, table). Mortality in eastern European countries had a bimodal distribution, with a second peak during the 1990s in both sexes.

We analysed the data by cause of death (table)—communicable and non-communicable diseases and injury—and separated the data for children (1–9 years, figure 4) and young people (10–24 years, figure 5). In the late 1950s, communicable and non-communicable diseases caused the overwhelming majority of childhood deaths in all regions for which data were available (figure 4). However, by 1978–82, deaths from

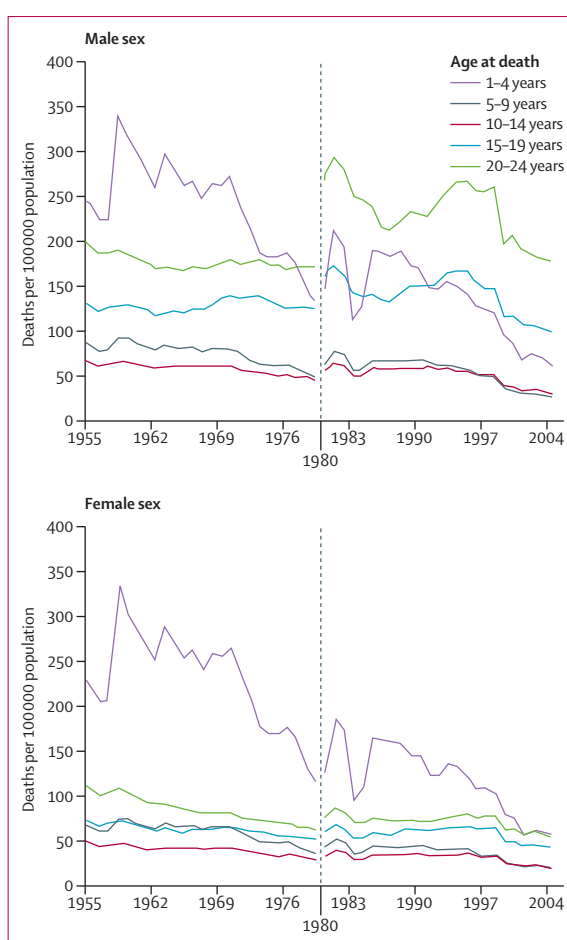


Figure 2: All-cause mortality per year from 1955 to 2004 by sex and age-group for all participating countries

A discontinuity is shown at 1980 because of entry of eastern European countries and ex-Soviet states into the cohort.

communicable diseases had reduced by ten to 30 times in these regions. By contrast, mortality from non-communicable diseases declined little in OECD and other countries and rose slightly in Central and South American countries. In the second half of the study period, mortality from communicable and non-communicable diseases reduced in all four regions, however, the proportion of childhood mortality due to these diseases remained steady at about 65% in OECD and eastern European countries, and 75% in Central and South American and other countries (figure 4).

In the late 1950s, communicable and non-communicable diseases, including maternal disorders, caused 70% of all deaths in young women (10–24 years) from OECD countries and nearly 90% in those from Central and South American and other countries, but only 40–60% of mortality in young men except in other countries (70%; figure 5). Maternal disorders caused 9% of deaths in young women in Central and South American

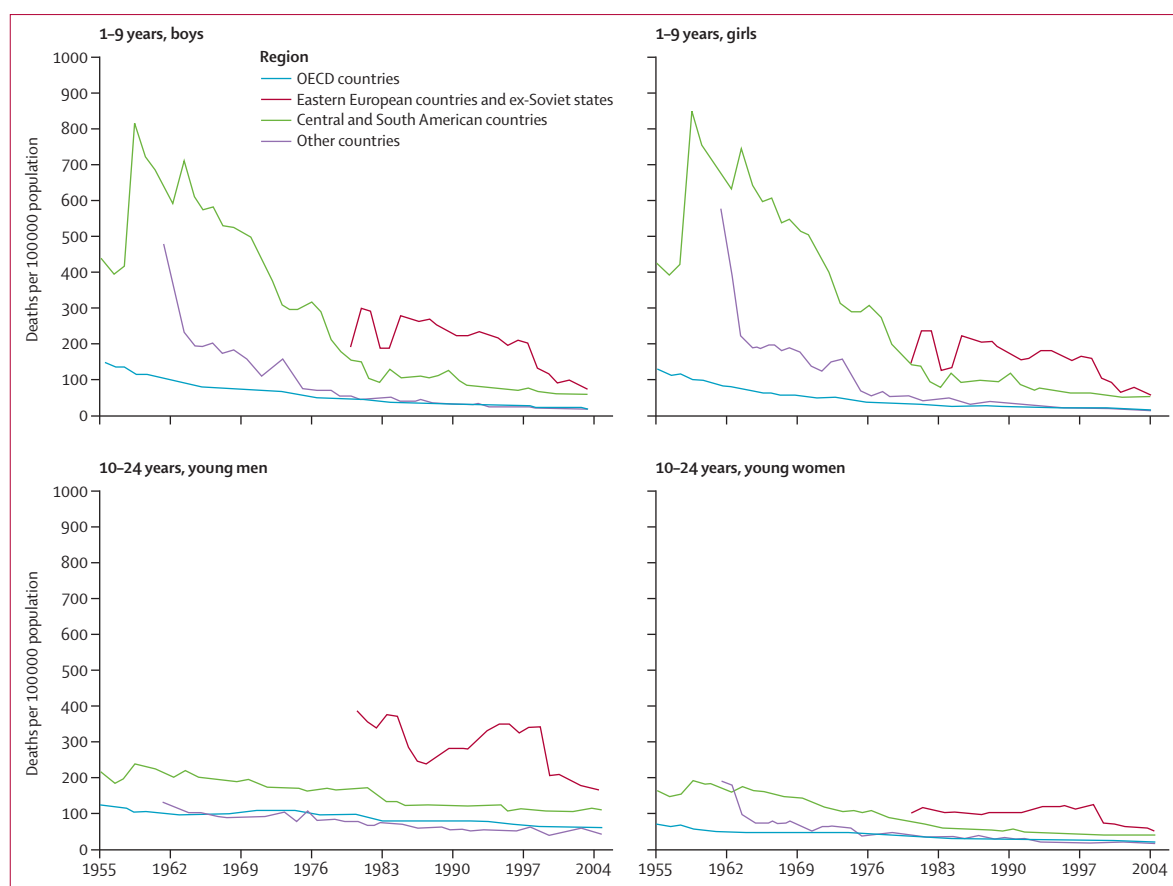


Figure 3: All-cause mortality per year from 1955 to 2004 in children aged 1–9 years and young people aged 10–24 years by region and sex
OECD=Organisation of Economic Co-operation and Development.

countries, 5% in other countries, and 4% in OECD countries. Mortality from communicable and non-communicable diseases then declined substantially across the study period in both sexes, largely because deaths due to communicable diseases reduced by 20–50 times. By 1978–82, communicable and non-communicable diseases caused around a third of deaths in all regions in young men, although it continued to be the dominant cause of mortality in young women. Across the study period, maternal mortality reduced by 12 times in OECD countries, seven times in Central and South American countries, and 40 times in other countries, accounting in 2000–04 for 6% of mortality in young women in Central and South American countries but only 1% in other regions (figure 5).

In the late 1950s, injuries accounted for 24% of mortality in children (1–9 years) in OECD countries and less than 10% of childhood mortality in Central and South American and other countries (figure 4). Although injury-related deaths reduced by three-to-five times across the study period in all regions, they increased as a proportion of childhood mortality, accounting by 2000–04 for 36% of mortality in OECD and eastern European countries, and 25% of mortality in Central and South

American and other countries. The dominant causes of injury deaths in children were transport and other non-intentional injuries in all regions. Violence was a negligible cause of childhood deaths at the beginning of the study period ($\leq 1\%$ in all groups), but increased by 2000–04 to account for 5% of mortality in OECD and eastern European countries, 2% of mortality in Central and South American countries, and 3% of mortality in other countries. Deaths due to suicide were extremely uncommon during childhood across the study (figure 4).

Injury became a dominant cause of mortality in young men (10–24 years) during the study period, and contributed substantially to mortality in young women across all regions by 2000–04 (figure 5). In the late 1950s, injuries accounted for a third of mortality in young men in other countries, two-fifths in Central and South American countries, and three-fifths in OECD countries. Proportions were lower in young women. Injury-related mortality rose across the first half of the study period in both sexes in OECD, Central and South American, and other countries, and by 1978–82 was established as the main cause of death in young men in all regions and in young women in OECD and eastern European countries. This pattern changed little thereafter.

	Change in mortality from 1955–59 to 1978–82						Change in mortality from 1978–82 to 2000–04						Change in mortality from 1955–59 to 2000–04					
	Communicable and non-communicable causes		Injuries		All causes		Communicable and non-communicable causes		Injuries		All causes		Communicable and non-communicable causes		Injuries		All causes	
	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex	Male sex	Female sex
OECD countries by age-group (years)																		
1–4	75%	77%	36%	40%	66%	70%	53%	52%	60%	58%	56%	54%	88%	89%	74%	75%	85%	86%
5–9	64%	67%	34%	27%	53%	58%	51%	48%	66%	57%	59%	52%	82%	83%	78%	68%	81%	80%
10–14	55%	59%	22%	3%	41%	47%	40%	39%	51%	40%	46%	39%	73%	75%	62%	41%	68%	68%
15–19	50%	60%	–24%	–23%	7%	33%	32%	32%	38%	27%	37%	29%	66%	73%	23%	10%	41%	52%
20–24	52%	67%	–6%	–4%	16%	47%	23%	26%	32%	29%	30%	28%	63%	76%	28%	27%	41%	61%
Eastern European countries and ex-Soviet states by age-group (years)*																		
1–4	..	..	..	..	..	..	60%	61%	59%	59%	60%	61%	..	..	..	..	..	..
5–9	..	..	..	..	..	..	59%	59%	65%	60%	62%	60%	..	..	..	..	..	..
10–14	..	..	..	..	..	..	55%	57%	54%	48%	54%	53%	..	..	..	..	..	..
15–19	..	..	..	..	..	..	60%	52%	46%	31%	51%	41%	..	..	..	..	..	..
20–24	..	..	..	..	..	..	46%	42%	40%	18%	42%	32%	..	..	..	..	..	..
South and Central American countries by age-group (years)																		
1–4	80%	81%	16%	29%	78%	80%	67%	69%	46%	44%	64%	67%	94%	94%	55%	60%	92%	93%
5–9	71%	74%	–5%	5%	61%	68%	62%	62%	58%	59%	61%	61%	89%	90%	56%	61%	84%	87%
10–14	63%	65%	–12%	–25%	44%	55%	47%	49%	50%	45%	49%	48%	81%	82%	44%	31%	71%	76%
15–19	61%	62%	–25%	–20%	25%	51%	37%	50%	25%	37%	29%	46%	75%	81%	7%	25%	47%	73%
20–24	60%	65%	–26%	–28%	19%	56%	33%	54%	33%	43%	33%	51%	74%	84%	16%	27%	46%	78%
Other countries by age-group (years)†																		
1–4	81%	95%	42%	34%	61%	66%	63%	69%	53%	49%	61%	66%	93%	95%	73%	67%	91%	93%
5–9	74%	84%	19%	41%	59%	58%	56%	59%	64%	54%	59%	58%	87%	89%	71%	73%	85%	87%
10–14	60%	69%	27%	21%	51%	57%	52%	59%	50%	52%	51%	57%	81%	81%	63%	62%	76%	78%
15–19	56%	41%	–21%	–32%	37%	47%	58%	57%	20%	31%	37%	47%	75%	85%	3%	8%	48%	73%
20–24	64%	51%	–7%	2%	22%	47%	45%	56%	8%	34%	22%	47%	74%	90%	2%	36%	44%	83%

Positive values indicate improvement in mortality. OECD=Organisation of Economic Co-operation and Development. *No data were available until 1980. †Data from 1961 to 1965 used for the earliest phase.

Table: Improvement in mortality person-years of observation from 1955–59 to 1978–82, from 1978–82 to 2000–04, and from 1955–59 to 2000–04, expressed as percentage of mortality in people aged 1–34 years in 1955–59, 1978–82, and 1955–59, respectively, by age-group and sex

Transport injuries caused the greatest proportion of injury-related deaths in young people (10–24 years) of both sexes across most of the study period in all regions, except in Central and South American countries, in which violence caused most injury-related deaths in young men. Mortality from transport injuries increased across the first 25 years of the study to peak in the 1970s in OECD, Central and South American, and other countries, declining thereafter in these regions and in eastern European countries. Violence-related mortality increased in young men and women across all regions during the study period, both in absolute rate and as a proportion of overall mortality. In the late 1950s, violence accounted for 8% of deaths in young men from Central and South American countries, but only 1% of deaths in young women from these countries, and only 1% of deaths in young people of both sexes from OECD and other countries. By 2000–04, violence accounted for a third of deaths in young men in Central and South American countries, two-fifths of deaths in young men in eastern

European countries, and 8–15% of mortality in other groups of young men and women.

Suicide was a negligible cause of death ($\leq 2\%$) in the late 1950s except in OECD countries where it accounted for 10% of mortality in young men and women (10–24 years). In young men, deaths from suicide rose steadily across the study period in Central and South American and other countries, rose from the 1970s onwards in OECD countries, and peaked in eastern European countries in the late 1990s. By 2000–04, suicide accounted for 14–16% of deaths in young men in all regions except Central and South American countries (7%). By contrast, suicide rates in young women declined across the study period in OECD and Central and South American countries and declined across the second half of the study period in eastern European countries, but nearly doubled in other countries between the early 1960s and 2000–04. By 2000–04 suicide was responsible for 11% of deaths in young women in OECD countries, 6% in Central and South American countries, 8% in eastern

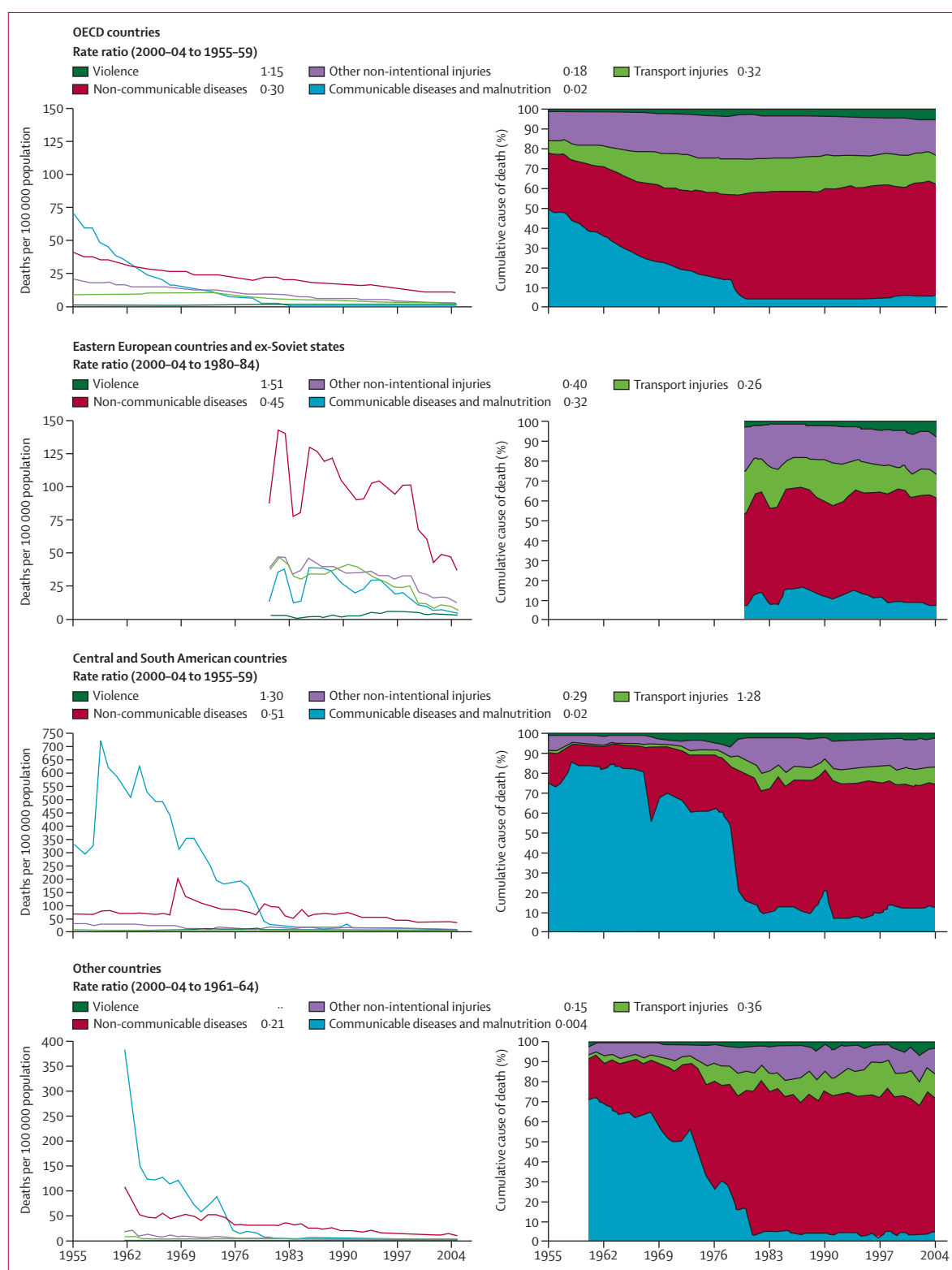


Figure 4: Causes of death in children aged 1–9 years from 1955 to 2004 by region

The scale for deaths per 100 000 population differs between regions. Data begin for eastern European countries and ex-Soviet states in 1980, and for other countries in 1961. Suicide and maternal deaths are not included because of very low occurrence. Data are shown for both sexes combined because we recorded no substantial differences in mortality between the sexes. OECD=Organisation of Economic Co-operation and Development. ..=data could not be calculated because of very low occurrence.

European countries, and 13% in other countries. Other non-intentional injuries were the only type of injury-related death to decrease across the study period both in absolute rate and as a proportion of overall mortality in young men, accounting for about 15% of overall mortality in 2000–04 across region. In young women, reductions in rates of non-intentional injuries also decreased across the study period, although the contribution of these injuries to overall mortality remained largely stable at 7–13% (figure 5).

Discussion

This report presents a unique international overview of mortality trends in children after infancy, adolescents, and young adults in 50 countries of high, middle, and low income between the mid-20th century and the first years of the 21st century (panel 2). Overall mortality declined substantially between 1955 and 2004 in children and young people aged 1–14 years, and young women (15–24 years), but improvement in mortality was much lower in young men (15–24 years).

In the 1950s, mortality in early childhood (1–4 years) greatly exceeded that of all other age-groups in all regions. Early childhood mortality subsequently declined substantially in each region, with annualised yearly declines of 1.7–1.8% in Central and South American and OECD countries, and 2.0% in other countries. Eastern European countries had a 2.4% annual decline in mortality between 1978–82 and 2000–04. These data are similar to Rajaratnam and colleagues³ report of annual decline in global mortality of 2.2% in children aged 1–4 years between 1970 and 2010. We did not include data for infant mortality (<1 year) in our study because most causes of death in infancy are unique to that period (eg, prematurity, birth asphyxia, and neonatal sepsis), and we believe that children and young people (5–24 years) have been neglected in mortality studies. However, in 2000–04, infant mortality continued to exceed mortality in all other age-groups assessed in our study in all regions (data not shown).

The 5–14-year age-group had the lowest mortality across the study period, and we recorded large yearly declines in mortality in children aged 5–9 years (1.6–2.0%) and young people aged 10–14 years (1.4–2.0%). By contrast, improvements in mortality in young men (15–24 years) were much lower, with yearly declines of 0.8–0.9%. We recorded intermediate improvements in mortality in young women (15–24 years), with reductions of 1.2–1.7% per year. These differentials in mortality reductions drove a reversal of historical mortality patterns, with mortality in the 1–4-year age-group falling to below that of young men aged 20–24 years from the mid-1970s and young men aged 15–19 years from the early 1990s, and to become equal to that of young women (20–24 years) by the end of the 20th century.

For both children and young people in OECD, Central and South American, and other countries, all-cause

mortality declined steadily across the study period, with greater gains in the first half of the study period than in the second half. However, mortality in young people (10–24 years) in eastern European countries showed a clear peak in the last 15 years of the 20th century, which is probably due to well described rises in mortality in the aftermath of the fall of communism.¹⁵

The differences in mortality trends between children and young people resulted largely from differing trends in injury mortality, because all age-groups had precipitous declines in mortality from communicable diseases and slight declines in mortality from non-communicable diseases. The only exceptions were temporary peaks in mortality from communicable and non-communicable diseases in the mid-1990s in eastern European countries. Maternal mortality was an important cause of death in young women (10–24 years) in the mid-1950s but reduced substantially in the first half of the study period to become a negligible cause of death ($\leq 1\%$ of overall mortality) in OECD, eastern European, and other countries and a minor cause (6%) in Central and South American countries by 2000–04. Although maternal mortality remains high in many low-income and middle-income countries, particularly in sub-Saharan Africa, our data are consistent with global trends of substantial reductions in maternal mortality across all regions in the past 20 years.^{16,17}

Trends in injury-related mortality diverged between children (1–9 years) and young people (10–24 years) during the study period. Injury-related mortality reduced by three-to-five times in children and was responsible for 25–36% of childhood mortality in 2000–04, similar to previous estimates.¹⁸ By contrast, injuries dominated mortality in young men (10–24 years) by the start of the 21st century in all regions, causing 70–75% of overall mortality. Injuries also became the dominant cause of mortality in young women in OECD and eastern European countries (53–55%), but played a lesser role in Central and South American (35%) and other (46%) countries. These shifts were indicative of the substantial reduction in mortality caused by communicable and non-communicable diseases, and the small declines or, in some cases, rises in mortality from violence, suicide, and transport injuries. These trends are consistent with individual country data from the USA,¹² UK,¹⁰ and Israel.¹¹

In children, non-intentional injuries, including transport injuries, were the most common causes of injury-related deaths, with violence and suicide responsible for few deaths in all regions. The early growth and later decline in transport injuries in all regions is indicative of similar international changes across all age-groups, and probably relates to the introduction of road safety measures in mature economies.¹⁹ In young people, transport mortality dominated injury-related mortality across the study period in both sexes in OECD, eastern European, and other countries and in young women in Central and South American countries, whereas violence dominated

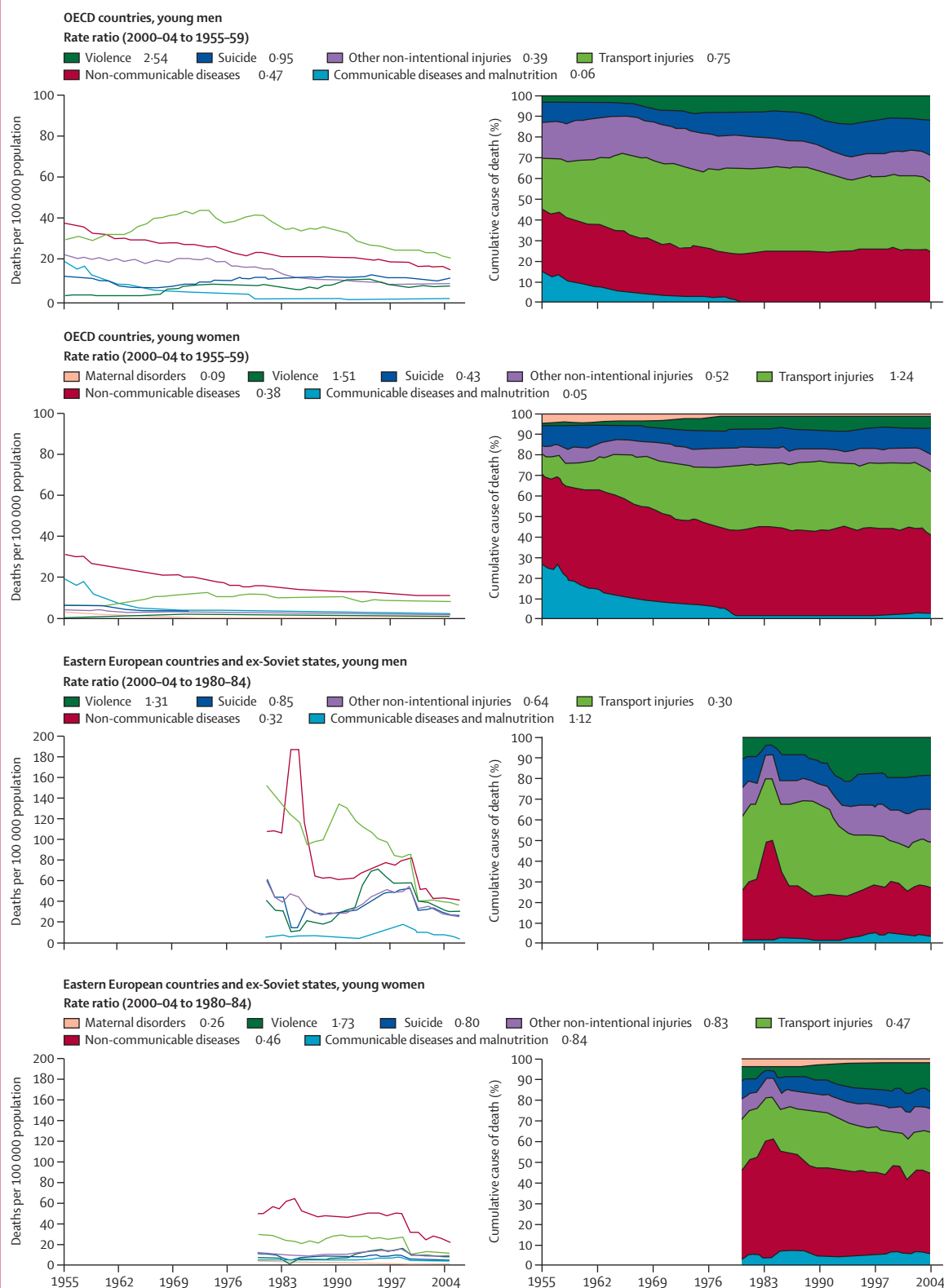
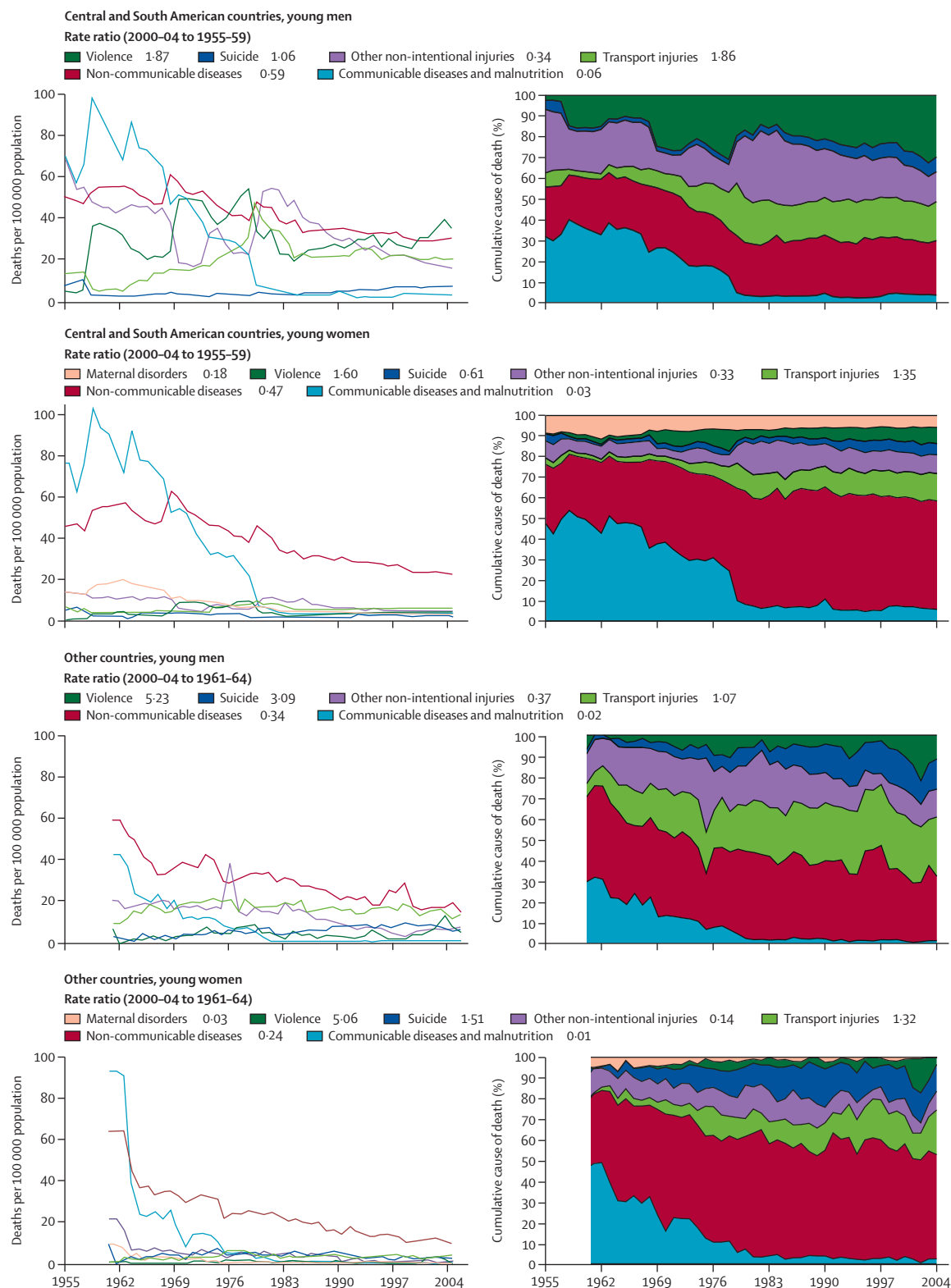


Figure 5: Causes of death in young people aged 10–24 years from 1955 to 2004 by region and sex
The scale for deaths per 100 000 population differs between regions. Data begin for eastern European countries and ex-Soviet states in 1980, and for other countries in 1961.
OECD=Organisation of Economic Co-operation and Development.



injury-related mortality in young men in Central and South American countries.

Violence and suicide became increasingly important causes of death in young men during the study period, together making up a quarter to a third of mortality in all regions by 2000–04. These causes of death might have been under-reported 50 years ago, but we believe these trends to be genuine. In our study, violent deaths far outweighed suicide in young men (10–24 years) from Central and South American countries, although findings from other studies show that the extent to which suicide deaths are misclassified in Latin American countries is unclear.²⁰ These findings are consistent with country-level reports of rises in youth mortality related to suicide^{20,21} and violence²² in high-income and middle-income countries during the second half of the 20th century.

Our data are consistent with previous suggestions that children aged 1–4 years, and girls and women benefit

most from the epidemiological transition from mortality predominantly caused by communicable diseases to that predominantly due to non-communicable diseases and injury.²³ Young men (15–24 years) benefited least from this transition for several reasons. First, their mortality from communicable diseases was low at baseline and so reductions in infectious disease had little benefit. Second, CNS developmental issues related to increased sensation seeking during adolescence place young people at heightened risk of injury-related deaths, particularly transport injuries and violence.^{24,25} Third, high injury-related mortality at baseline in young men (15–24 years) meant that they had increased exposure to rises in injury mortality associated with economic development, urbanisation, and globalisation.^{18,22} The transition of young people into the workforce introduces new risks of occupational, transport, and violence-related injury, together with mental health risks related to suicide.²⁶ Indeed, young men (15–24 years) transitioning into the workforce might be particularly vulnerable to the effects of economic disruption on mortality, as seen in our study in eastern European countries in the 1990s.¹⁵ Employment of adolescents and young adults is most vulnerable to economic downturns, and the associations of unemployment with suicide and violence seem to be greatest in young people.²⁷ Increasing youth cohorts in developing countries might also increase youth unemployment and its attendant health problems in the absence of economic disruption.^{6,28} Additionally, in failing states, both young men and young women are particularly vulnerable to violent mortality related to conflict and black economies.

We used the best available international longitudinal data for mortality from 50 countries, containing about 15% of the global population aged 1–24 years and including countries with a range of incomes. The dataset also included several OECD, eastern European, and South and Central American countries, which have had substantially different social and economic trajectories during the past 50 years.

Our study was limited to countries with accurate mortality data for at least 24 years. Thus we could not include very low-income countries in Africa and Asia, in which the burden of mortality is greatest,²⁹ or large low-income countries, such as China and India, which contain the largest populations of adolescents and young adults. Therefore, generalisability was restricted, but we did include 15 countries of low and very low income, and a further three countries that were almost certainly low or very low income. Because some of the greatest improvements in mortality in children younger than 5 years have been made in very low-income countries,²⁶ further work is needed to examine the extent to which trends that we have identified are also apparent in these countries. Notably, many very low-income countries in sub-Saharan Africa have had rapid social, economic, and demographic changes, which have a profound effect

Panel 2: Research in context

Systematic review

In a systematic review with the search terms “mortality”[MeSH] AND (“adolescent”[MeSH] OR “young adult”[MeSH]) AND “longitudinal studies”[MeSH] AND (“internationality”[MeSH] OR “world health”[MeSH]), we did not identify any previous studies of global trends in all-cause and cause-specific mortality in people aged 5–24 years. Although mortality in children younger than 5 years has been studied extensively, global mortality data for children aged 5 years and older, adolescents, and young adults are limited to cross-sectional data or inclusion within studies of adult mortality. In studies from high-income countries, mortality from transport injuries, suicide, and homicide has risen in adolescents and young adults in the past 50 years.^{5,9–12}

Interpretation

This international study is the first to examine trends in cause-specific mortality in people aged 1–24 years from countries of high, middle, and low income across the second half of the 20th century, with the aim to inform policy action to improve health in young people. We showed that, in 2000–04, mortality in people aged 15–24 years was higher than that in children aged 1–4 years in most countries studied, with the exception of some very low-income countries. Mortality in children aged 1–9 years reduced by 80–93%, largely because of very steep declines in mortality from communicable diseases, whereas improvements in mortality gains in young people aged 15–24 years were half that in children, due largely to static or rising injury-related mortality, particularly in young men. The high injury burden in young people means that they are particularly affected by the persistent low global investment in non-communicable diseases and injury relative to the global disease burden. The changes in traditional mortality patterns seen in our data support the need for a new focus on the health of adolescents and young adults.

on young people's health;³⁰ however, the HIV epidemic and the scarcity of mortality data mean that our findings cannot be generalised to these nations.

Death registration might be incomplete, and we only included country years judged to have at least 70% completeness. Differences in coding practices impose limitations in cross-national comparisons, particularly for suicide and ill-defined causes. Entry of high-mortality countries after 1955 could have led to some artifactual effects. To keep these effects to a minimum, we averaged data in 5-year periods and interpreted trends conservatively. However, the entry of high-mortality eastern European countries from the late 1970s almost certainly led to the rise in global mortality in the 15–24-year age-group.

Mortality in adolescents and young adults in many countries spanning categories of high to very low income is now greater than is childhood mortality after the first year of life. Mortality in young adults aged 10–24 years has proved less responsive to the epidemiological transition, and to alliances and interventions, than has early childhood mortality (1–4 years). These trends are likely to continue because mortality in children younger than 5 years is expected to decline further, and injury-related mortality is expected to increase in the next 25 years with the continuation of the epidemiological transition in developing countries.²⁹ The high burden of injury in young people means that they are particularly affected by the persistent low global investment in non-communicable diseases and injury relative to the global disease burden.³¹ This health disadvantage has increased in the past 50 years because injury has become responsible for an increased proportion of mortality in adolescents and young adults.

Signs that global policy is starting to focus on youth are encouraging. The 2007 World Bank report on development⁶ recognised the economic benefits from improvement of the health and survival of the world's young people as they enter the workforce, particularly the nearly 90% that live in low-income and middle-income countries. Rajaratnam and colleagues⁸ warned that focusing on mortality in only young children is “no longer defensible”, and argued for an increased focus on older groups. The changes in traditional mortality patterns seen in our data support the need for a new focus on the health of adolescents and young adults worldwide. Future global health targets should include the causes of death in people aged 10–24 years, and should extend beyond HIV infection and maternal mortality to include injury and mental health. Global and national health information systems will need to be extended to include young people, capacity will need to be increased in research and policy implementation, and broad-based global alliances, such as those that have successfully reduced child and maternal mortality, will need to be developed.³²

Contributors

RMV and GCP had the idea for the study. Data were obtained from CM, cleaned by CC and CM, and summarised by CC. RMV, CC, and GCP

prepared the data for publication. RMV led writing of the report, and GCP, CC, JS, PB, CM, and AC contributed to writing of the report. RMV guarantees the report and is the corresponding author.

Conflicts of interest

RMV has received consultancy fees from Esai. GCP was a member of a technical steering committee for WHO Department of Child and Adolescent Health, for which he received travel, living, and accommodation expenses. CC, CM, PB, AC, and JS have no conflicts of interest to declare.

Acknowledgments

We are grateful to Doris MaFat and other members of the team led by CM in the Department of Health Statistics and Informatics, WHO, Geneva, Switzerland, for their work providing the data for these analyses.

References

- 1 WHO. Countdown to 2015 decade report (2000–2010): taking stock of maternal, newborn and child survival. Geneva: World Health Organization and UNICEF, 2010.
- 2 You D, Wardlaw T, Salama P, Jones G. Levels and trends in under-5 mortality, 1990–2008. *Lancet* 2010; **375**: 100–03.
- 3 Rajaratnam JK, Marcus JR, Flaxman AD, et al. Neonatal, postneonatal, childhood, and under-5 mortality for 187 countries, 1970–2010: a systematic analysis of progress towards Millennium Development Goal 4. *Lancet* 2010; **375**: 1988–2008.
- 4 Kleinert S. Adolescent health: an opportunity not to be missed. *Lancet* 2007; **369**: 1057–58.
- 5 Blum RW, Nelson-Mmari K. The health of young people in a global context. *J Adolesc Health* 2004; **35**: 402–18.
- 6 World Bank. World development report: development and the next generation. Washington, DC: World Bank, 2007.
- 7 Patton GC, Coffey C, Sawyer SM, et al. Global patterns of mortality in young people: a systematic analysis of population health data. *Lancet* 2009; **374**: 881–92.
- 8 Rajaratnam JK, Marcus JR, Levin-Rector A, et al. Worldwide mortality in men and women aged 15–59 years from 1970 to 2010: a systematic analysis. *Lancet* 2010; **375**: 1704–20.
- 9 Heuveline P, Slap GB. Adolescent and young adult mortality by cause: age, gender, and country, 1955 to 1994. *J Adolesc Health* 2002; **30**: 29–34.
- 10 Viner RM, Barker M. Young people's health: the need for action. *BMJ* 2005; **330**: 901–03.
- 11 Wilf-Miron R, Nathan K, Sikron F, Barrell V. Trends in youth mortality in Israel, 1984–1995. *Isr Med Assoc J* 2001; **3**: 610–14.
- 12 Sells CW, Blum RW. Morbidity and mortality among US adolescents: an overview of data and trends. *Am J Public Health* 1996; **86**: 513–19.
- 13 Mathers CD, Lopez AD, Murray CJL. The burden of disease and mortality by condition: data, methods and results for 2001. In: Lopez AD, Mathers CD, Ezzati M, Murray CJL, Jamison DT, eds. Global burden of disease and risk factors. New York, NY: Oxford University Press, 2006: 45–240.
- 14 UN Population Division. World population prospects: the 2006 revision population database. United Nations, 2007.
- 15 Shkolnikov V, McKee M, Leon DA. Changes in life expectancy in Russia in the mid-1990s. *Lancet* 2001; **357**: 917–21.
- 16 WHO, UNICEF, UN Population Fund, World Bank. Trends in maternal mortality: 1990 to 2008. Geneva: World Health Organization, 2010.
- 17 Hogan MC, Foreman KJ, Naghavi M, et al. Maternal mortality for 181 countries, 1980–2008: a systematic analysis of progress towards Millennium Development Goal 5. *Lancet* 2010; **375**: 1609–23.
- 18 Peden M, Oyegbite K, Ozanne-Smith J, et al, eds. World report on child injury prevention. Geneva: World Health Organization, 2008.
- 19 Kopits E, Cropper M. Traffic fatalities and economic growth. World Bank Policy Research Working Paper 3035. Washington, DC: World Bank, 2003.
- 20 Pritchard C, Hean S. Suicide and undetermined deaths among youths and young adults in Latin America: comparison with the 10 major developed countries—a source of hidden suicides? *Crisis* 2008; **29**: 145–53.

- 21 Rutz EM, Wasserman D. Trends in adolescent suicide mortality in the WHO European Region. *Eur Child Adolesc Psychiatry* 2004; **13**: 321–31.
- 22 Blumstein A, Rivara FP, Rosenfeld R. The rise and decline of homicide—and why. *Annu Rev Public Health* 2000; **21**: 505–41.
- 23 Omran A. The epidemiologic transition: a theory of the epidemiology of population change. *Millbank Q* 1971; **49**: 509–38.
- 24 Steinberg L. A behavioral scientist looks at the science of adolescent brain development. *Brain Cogn* 2010; **72**: 160–64.
- 25 Patton GC, Viner R. Pubertal transitions in health. *Lancet* 2007; **369**: 1130–39.
- 26 Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: a reappraisal. *Bull World Health Organ* 2000; **78**: 1175–91.
- 27 Gunnell D, Lopatzidis A, Dorling D, Wehner H, Southall H, Frankel S. Suicide and unemployment in young people. Analysis of trends in England and Wales, 1921–1995. *Br J Psychiatry* 1999; **175**: 263–70.
- 28 Brenner MH, Mooney A. Unemployment and health in the context of economic change. *Soc Sci Med* 1983; **17**: 1125–38.
- 29 Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006; **3**: e442.
- 30 Blum RW. Youth in sub-Saharan Africa. *J Adolesc Health* 2007; **41**: 230–38.
- 31 Stuckler D, King L, Robinson H, McKee M. WHO's budgetary allocations and burden of disease: a comparative analysis. *Lancet* 2008; **372**: 1563–69.
- 32 Patton GC, Viner RM, Linh LC, et al. Mapping a global agenda for adolescent health. *J Adolesc Health* 2010; **47**: 427–32.