Global patterns of mortality in young people: a systematic analysis of population health data

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Summary

Background Pronounced changes in patterns of health take place in adolescence and young adulthood, but the effects on mortality patterns worldwide have not been reported. We analysed worldwide rates and patterns of mortality between early adolescence and young adulthood.

Methods We obtained data from the 2004 Global Burden of Disease Study, and used all-cause mortality estimates developed for the 2006 *World Health Report*, with adjustments for revisions in death from HIV/AIDS and from war and natural disasters. Data for cause of death were derived from national vital registration when available; for other countries we used sample registration data, verbal autopsy, and disease surveillance data to model causes of death. Worldwide rates and patterns of mortality were investigated by WHO region, income status, and cause in age-groups of 10–14 years, 15–19 years, and 20–24 years.

Findings 2·6 million deaths occurred in people aged 10–24 years in 2004. 2·56 million (97%) of these deaths were in low-income and middle-income countries, and almost two thirds (1·67 million) were in sub-Saharan Africa and southeast Asia. Pronounced rises in mortality rates were recorded from early adolescence (10–14 years) to young adulthood (20–24 years), but reasons varied by region and sex. Maternal conditions were a leading cause of female deaths at 15%. HIV/AIDS and tuberculosis contributed to 11% of deaths. Traffic accidents were the largest cause and accounted for 14% of male and 5% of female deaths. Other prominent causes included violence (12% of male deaths) and suicide (6% of all deaths).

Interpretation Present global priorities for adolescent health policy, which focus on HIV/AIDS and maternal mortality, are an important but insufficient response to prevent mortality in an age-group in which more than two in five deaths are due to intentional and unintentional injuries.

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Introduction

Adolescence is commonly regarded as a healthy time of life, with peaks in strength, speed, fitness, and many cognitive abilities. However, major shifts in health take place around puberty as new health risks with potentially life-threatening consequences become prominent.[1–3] Reproductive maturity brings about risks for sexually transmitted diseases including HIV, and for women, particularly in low-income and middle-income countries, risks linked to pregnancy and child birth.[4] Patterns of injury change with physical maturity, with young men in particular incurring trauma from war, violence, and traffic accidents. Puberty also indicates the onset of many mental health disorders of adulthood, which can be associated with a heightened risk of suicide.[5] Consequently, health profiles change rapidly from early adolescence to young adulthood.

Economic development typically brings about reductions in morbidity and mortality from communicable diseases, undernutrition, and maternal causes.[6] However, its effect on the health of young people might differ from that of older age-groups. For example, a long duration of education, with delays in marriage and parenthood, will probably reduce rates of early maternal death.[7] Increased availability of motor vehicles is likely to raise the risk of traffic injuries.[8] Furthermore, ease of access to psycho-active substances might heighten risks for mental health disorders and suicide.[5] The inexperience and ongoing neurodevelopment of adolescents might leave them vulnerable to some health risks associated with economic change.[9]

No comprehensive studies of death in people aged 10–24 years have been done, even though this group consists of around 30% of the world's population.[10] Reports have generally used country data to address overall mortality or specific causes of death.[11–13] Some studies have compared mortality between countries[14] or used longitudinal data,[12] but none have taken a worldwide approach. Blum and Nelson-Nmari[15] reported five leading causes of death in people aged 15–29 years (unintentional injuries, HIV/AIDS, other communicable diseases, violence, and suicide) and reported substantial regional variation in the number of deaths due to each cause. However, they were neither able to separate data into narrow age bands, nor extrapolate mortality rates to a regional or worldwide population. Similarly, studies of mortality in late childhood have grouped data for children aged 5–14 years, without scope for analysis of changes in patterns of death before and after puberty.[16]

We examined whether changes in profiles of health during adolescent development is shown in shifts in mortality between early adolescence and young adulthood. We aimed to describe international rates and patterns of mortality between early adolescence and young adulthood, differences in youth mortality patterns between middle-income or low-income countries and that in high-income countries, and regional variations.

Methods
Data collection
Data used in these analyses were derived from the Global Burden of Disease study[17] for 2004, and were separated into 5-year groups up to age 24 years. We investigated changes in mortality in young adolescence (10–14 years), late adolescence (15–19 years), and young adulthood (20–24 years). WHO member states were classified into seven groups on the basis of income and region (panel). All countries with a gross national income per head of US$10 066 or higher, estimated by the World Bank, were defined as high-income countries, irrespective of region.[18] This definition allowed some comparison of mortality patterns with economic development. Low-income or middle-income countries were grouped into regions according to WHO regional classifications, which are an indicator of an important administrative framework for international health policies (panel).

Estimates of all-cause mortality
Life tables for the 192 WHO member states in 2004 were developed from death-registration data and sample-registration systems (India and China), and data for child and adult mortality from censuses and surveys, such as the Demographic and Health Surveys and UNICEF's Multiple Indicator Cluster Surveys. Age-specific and sex-specific death rates for countries were established with one of three standard approaches:[19] routine life table methods for countries with complete vital registration, standard demographic methods to correct for under-registration of deaths, or model life tables when vital registration data were unavailable.[20]

55 countries, 42 of which were in sub-Saharan Africa, had no information available. On the basis of predicted rates of early childhood mortality in 2004, the most likely corresponding rates of adult mortality (excluding any HIV/AIDS deaths) were selected, along with uncertainty ranges, with use of regression models of child versus adult mortality from a set of almost 2000 life tables judged to be of good quality.[20]

For China, death rates recorded by age for children older than 5 years from the 2000 census were adjusted for an estimated under-reporting of 11·3% for boys and 18·1% for girls and predicted for 2004, with an assumed yearly rate of decrease in mortality of 1·5% on the basis of two intercensal periods: 1982–90 and 1990–2000.[21] This projection takes into account other sources of data such as the Child Mortality Surveillance System.[22] For India,

all-cause mortality was derived from a time-series analysis of age-specific death rates from the sample registration system for 1990–2002, after correction for under-registration (88% completeness).[23]

An early version of these life tables was published in the 2006 *World Health Report*.[24] All-cause mortality rates for age and sex were further adjusted for the revised estimates of mortality from HIV/AIDS, conflict, and natural disasters.[17] Total deaths by age and sex were estimated for each country by application of these rates to the estimated 2004 resident populations prepared by the United Nations Population Division in its 2006 revision.

Estimates of causes of death

78 countries in 2004 had complete data (coverage of 85% or more, and most were coded to the third or fourth character of the International Statistical Classification of Disease and Related Health Problems version 10 (ICD-10; table 1). We used vital registration data to estimate deaths by cause for 78 countries. However, usable death-registration data to establish cause of death were available for 112 countries, most of which were in the high-income group, and low-income and middle-income countries in Latin America and the Caribbean, Europe, and central Asia.

Statistics for cause of death are reported to WHO every year by country, year, cause, age, and sex. Deaths assigned to ICD codes for symptoms, signs, and ill-defined conditions, and some ill-defined codes in the cancer, cardiovascular disease, and injury chapters of ICD, were redistributed across defined causes. Percentages of deaths coded to these ill-defined causes varied from 4% in New Zealand to more than 30% in Sri Lanka and Thailand.[19] When the latest available year for data was earlier than 2004, death-registration data from 1980 to the latest available year were used to project cause-specific trends for 2004. When distributions for very small countries were estimated, an average of data from the most recent 3 years was used to keep random variation to a minimum. For 34 countries with less than 85% coverage, cause-of-death modelling was used to adjust proportions of deaths in the three broad groups of causes to account for likely biases in cause-of-death distribution.[19] Cause-of-death modelling for calculation of cause-of-death composition used 1613 country-years of historical death-registration data.

For the 43 countries in the African region without useable death-registration data, regional patterns for broad-cause distribution were established on the basis of information that included the South African 2004 vital registration data, the Zimbabwe National Burden of Disease study 1997,[25] INDEPTH[26] (international network of field sites with continuous demographic evaluation of populations and their health) verbal autopsy data from seven sites in Africa for 1999–2002, data from Antananarivo in Madagascar for 1976–95, and Mozambique Maputo Central Hospital Mortuary data for 1993–2004. For broad disease groups I, II, and III,

	High-income countries	Low-income and middle-income countries by WHO region						
		AFR	AMR	EMR	EUR	SEAR	WPR	World
Death registration data with coverage of ≥85%	33	3	18	..	17	1	6	78
Death registration data with coverage of <85% with CodMod	2	..	12	6	10	1	3	34
Sample registration system	..	..	..	..	..	1	1	2
CodMod, regional pattern of causes of death, and cause-specific estimates*	4	43	2	10	..	8	11	78
Total countries	39	46	32	16	27	11	21	192

AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia region. WPR=western Pacific region. CodMod=cause-of-death modelling. ..=no countries with this data type as highest level of data available. *Epidemiological estimates obtained from studies, WHO technical programmes, and UNAIDS for: AIDS, tuberculosis, diphtheria, measles, pertussis, poliomyelitis, tetanus, dengue, malaria, schistosomiasis, trypanosomiasis, Japanese encephalitis, Chagas disease, maternal conditions (including abortion), cancers, drug-use disorders, rheumatoid arthritis, and war.

Table 1: Data sources for cause-of-death estimation for 2004 Global Burden of Disease study[17]

	Population per 100 000 (%)	Number of deaths (%)	Deaths per 100 000 population (RR*)
High-income countries	189 869 (11%)	86 111 (3%)	45 (1)
LMIC	1 575 878 (89%)	2 560 220 (97%)	162 (3·6)
AFR†	243 735 (14%)	744 222 (28%)	305 (6·7)
AMR	157 273 (9%)	171 796 (6%)	109 (2·4)
EMR	166 731 (9%)	282 320 (11%)	169 (3·7)
EUR	118 428 (7%)	119 568 (5%)	101 (2·2)
SEAR†	498 093 (28%)	929 092 (35%)	187 (4·1)
WPR	391 618 (22%)	313 222 (12%)	80 (1·8)
World	1 765 746 (100%)	2 646 331 (100%)	150 (NA)

LMIC=low-income and middle-income countries. AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia region. WPR=western Pacific region. NA=not applicable. *Relative risks (RR) are estimated with high-income countries as the comparison. †No high-income countries in these regions.

Table 2: Estimated total number of deaths and all-cause mortality rates (per 100 000) in people aged 10–24 years in 2004, classified by economic and geographic groupings

the proportional distributions of total deaths (excluding those from HIV/AIDS and war) for urban populations were calculated on the basis of averages from the Madagascar urban death-registration data, South African death-registration data for 2004, the Zimbabwean 1997 estimates, and cause-of-death modelling predictions for 2004. All African INDEPTH sites were rural, and thus these data were regarded as representative of rural populations. Distributions of rural deaths were based on averages from data from the INDEPTH sites, the distribution in South African rural provinces, and distributions predicted with cause-of-death modelling.

To estimate deaths by cause for the 34 countries outside Africa without usable death-registration data, we used cause-of-death modelling to estimate proportions of deaths in broad disease groups (I–III) by age and sex. These models were based on all-cause mortality (excluding deaths from HIV/AIDS, war, and natural disasters), gross national income per head, and region.[16] For countries

	Total mortality (per 100 000)				All-cause mortality rates by sex											
					Male mortality (per 100 000 males)				Female mortality (per 100 000 females)				Risk of death for males relative to females			
	10–14 years	15–19 years	20–24 years	Total	10–14 years	15–19 years	20–24 years	Total	10–14 years	15–19 years	20–24 years	Total	10–14 years	15–19 years	20–24 years	Total
High-income countries	16	49	69	45	19	67	101	63	12	29	34	27	1·6	2·3	2·9	2·4
LMIC	103	150	244	162	103	156	275	174	104	143	211	150	1·0	1·1	1·3	1·2
AFR*	205	249	505	305	196	202	488	281	215	296	522	330	0·91	0·68	0·93	0·85
AMR	45	113	175	109	52	160	269	157	39	66	81	61	1·3	2·4	3·3	2·6
EMR	113	146	264	169	119	158	341	198	104	131	179	139	1·1	1·2	1·9	1·4
EUR	39	90	168	101	49	125	257	147	30	54	77	54	1·6	2·3	3·3	2·7
SEAR*	122	184	264	187	117	176	261	181	127	192	266	192	0·92	0·92	0·98	0·94
WPR	44	85	114	80	50	114	156	105	37	52	67	52	1·4	2·2	2·3	2·0
World	95	139	224	150	95	147	255	162	94	131	191	137	1·0	1·1	1·3	1·2

*No high-income countries in these regions. LMIC=low-income and middle-income countries. AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia region. WPR=western Pacific region.

Table 3: 2004 all-cause mortality rates (per 100 000) stratified by country classification, age-group, and sex

without complete death-registration data, 21 specific causes were further adjusted on the basis of epidemiological evidence from population-based studies, disease registers and notifications systems, and analyses by WHO programmes (more than 2700 datasets). These specific causes included HIV/AIDS, malaria, tuberculosis, cancers, drug dependence, war, and natural disasters. Almost a third of these datasets related to sub-Saharan Africa.

Deaths were categorised with the framework of three broad-cause groups from previous burden-of-disease studies, but with maternal mortality as a distinct group to allow comparison between sex in group I causes of death.[16] The four groups of death were: group IA, maternal mortality; group IB, communicable disease mortality including nutritional disorders; group II, non-communicable disease; and group III, injury including traffic accidents, fires, drowning, self-inflicted injury, and violence and war. Deaths assigned to ICD codes for symptoms, signs, and ill-defined conditions were proportionately redistributed to causes within groups I and II.

Role of the funding source

WHO funding allowed age-disaggregation of data. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Of a worldwide population of 1·8 billion people aged 10–24 years, all-cause mortality was estimated at about 2·6 million deaths in 2004 (table 2). More than a third of deaths were in southeast Asia, with Africa having the next highest mortality (table 2). Relative risks (RR) for death in Africa were higher than in any other region, and nearly seven times higher than in high-income countries

(table 2). Table 3 shows rates of all-cause mortality by the three age-groups for both sexes.

Relative risk of death in countries of low and middle income, compared with those of high income, was greatest in young adolescents, but the absolute difference was greatest in young adulthood (table 3). Males died at higher rates than did females in all age-groups and regions apart from Africa and southeast Asia (table 2). Risk in poor countries compared with high-income countries was higher for females than for males (RR 5·6 *vs* 2·8), largely because of the low rates for young women in high-income countries.

Worldwide mortality rates were 2·4-fold higher in young adults than in young adolescents. High-income countries had the steepest relative rise in mortality from young adolescence to young adulthood (table 3). In low-income and middle-income countries, all-cause mortality in young adults was 2·4-times higher than in young adolescents (table 3). In the African region, all-cause mortality was high for all age-groups, with a female predominance most evident in the 15–19 year age-group. In low-income and middle-income countries in the American region, male mortality rose more than five-fold between early adolescence and young adulthood, and brought about a pronounced difference between sexes (RR 3·3; table 3).

Low-income and middle-income countries in the eastern Mediterranean region had fairly high mortality in young adolescents, but did not have the pronounced rise that was noted for women aged 15–24 years in Africa and southeast Asia. In low-income and middle-income countries in the European region, mortality in young adolescents was low, but in males increased more than five times by young adulthood, with a resultant mortality gap compared with females. In the southeast Asian region, females died at greater rates than did males in all age-groups. Mortality in
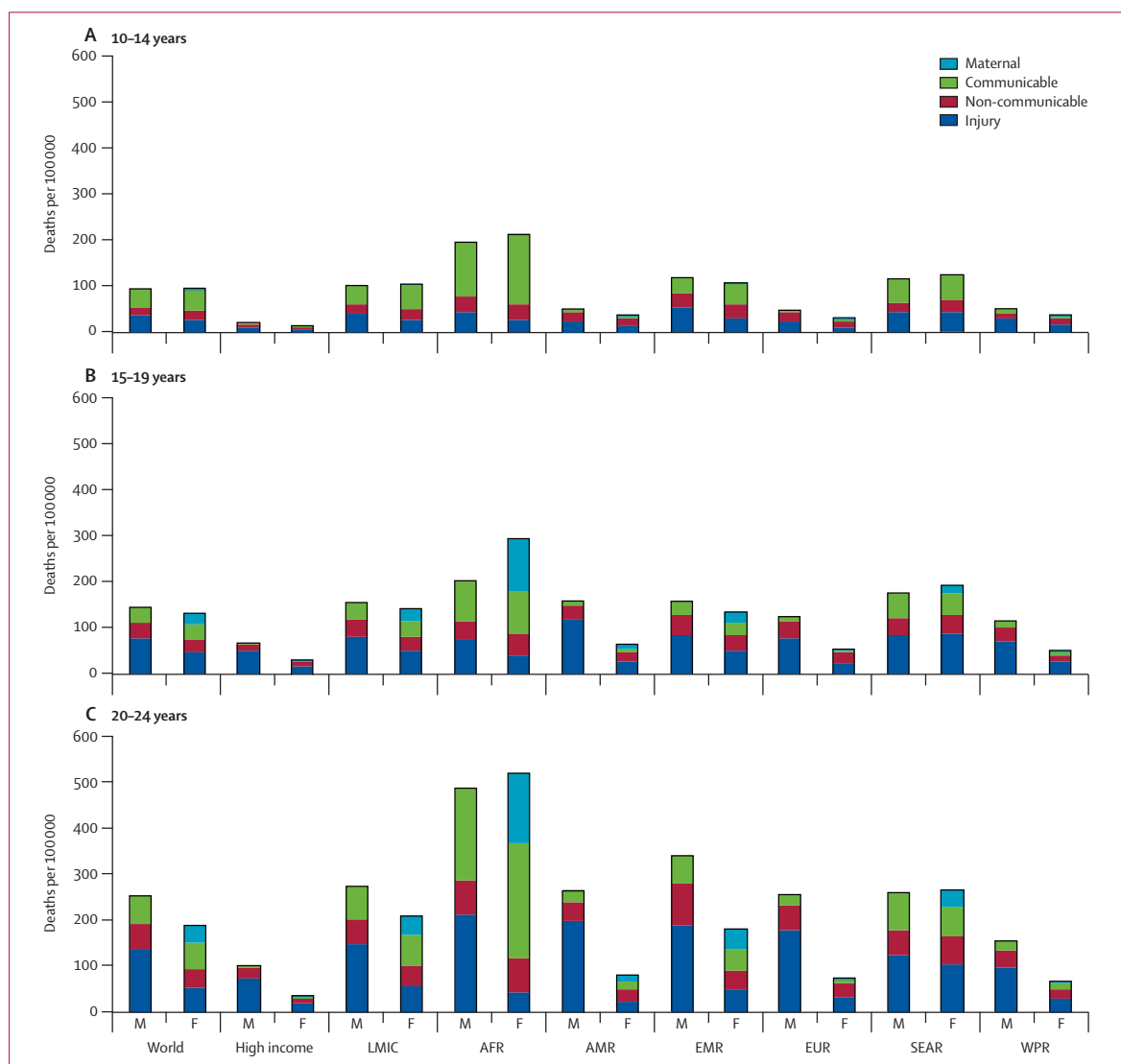
Figure 1: Mortality rates (per 100 000) due to maternal, communicable, non-communicable, and injury causes
Mortality rates shown by sex, country classification, and age-group: 10–14 years (A), 15–19 years (B), and 20–24 years (C). Maternal=group IA.
Communicable=group IB. Non-communicable=group II. Injury=group III. M=male deaths. F=female deaths. High income=high-income countries. LMICs=low-income
and middle-income countries. AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia
region. WPR=western Pacific region.

young adolescents varied from a high of around 22% in southeast Asia, Africa, and the eastern Mediterranean to a low of 13% in eastern Europe. Low-income and middle-income countries in the western Pacific region had the lowest regional mortality and an overall pattern similar to that of high-income countries (table 3).

Causes of death were grouped into four broad categories. Figure 1 shows cause-specific mortality groups for high-income countries, low-income and middle-income countries by region, and the world. For worldwide deaths, group IA (maternal causes) and IB (communicable, perinatal, and nutritional causes) accounted for the highest proportion (48%) of mortality in young women aged 10–24 years. Overall group I deaths were almost 50% greater

(RR 1·47) in females than in males, but this excess was attributable to maternal deaths. Worldwide mortality for group IB in the 10–24 year age-group was very similar for females and males (1·01). Early adolescent rates of deaths for group II (non-communicable diseases; 21 per 100 000 deaths per year) and group III (injuries; 26 per 100 000 per year) doubled by young adulthood (41 per 100 000 per year and 53 per 100 000, respectively).

For males, 28% of deaths were group I and 21% were group II. Worldwide, group III deaths were the most prominent and accounted for 51% of all male mortality. Group II deaths in males increased 2·6-fold (from 20 to 51 per 100 000 per year) and group I 1·7-fold (from 39 to 63 per 100 000 per year) between early adolescence and
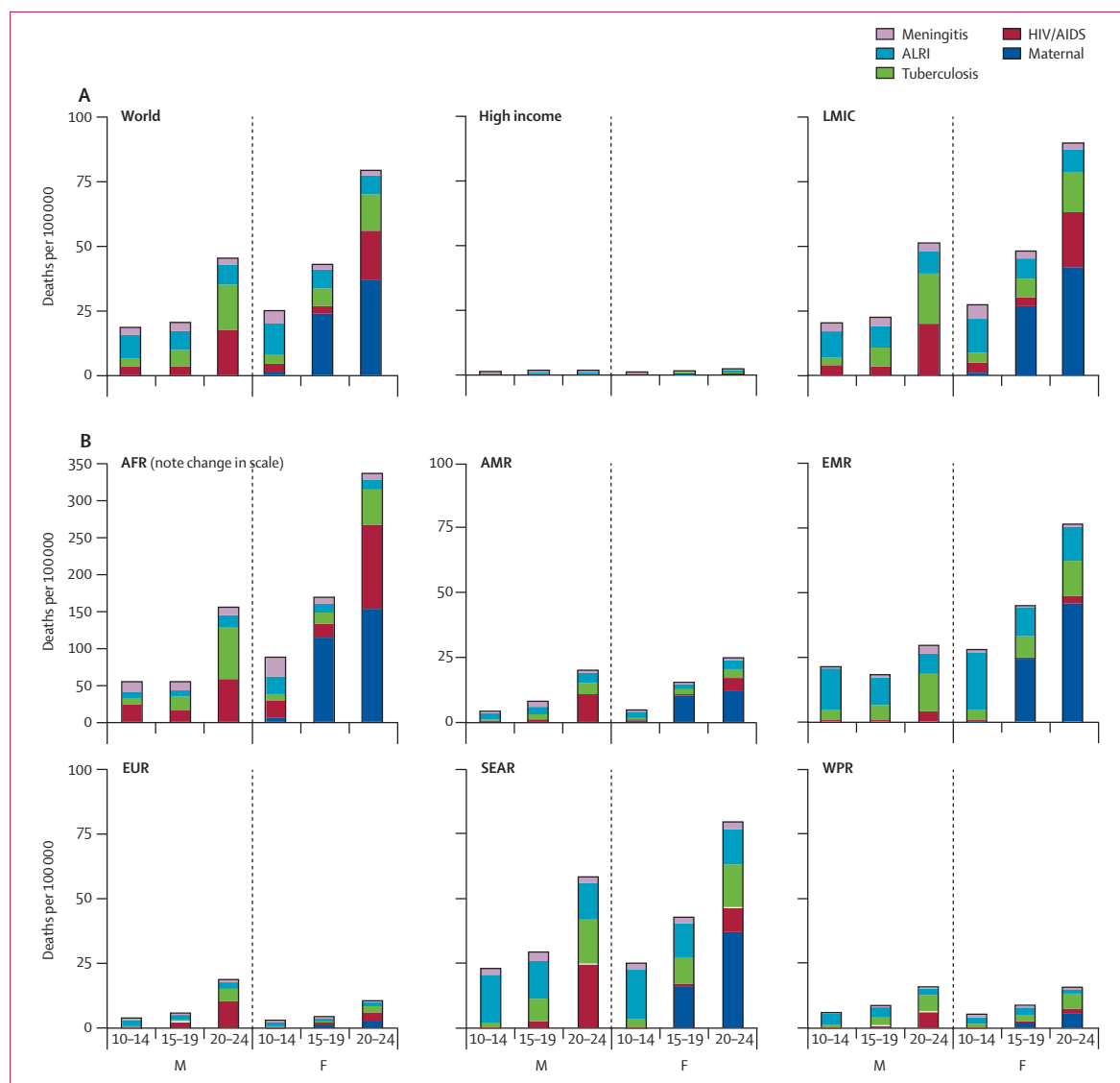
Figure 2: **Specific group I causes of death stratified by sex, age-group, and region**
Specific group I causes of death are tuberculosis, HIV/AIDS, acute lower respiratory infection (ALRI), and maternal deaths. M=male deaths. F=female deaths. (A) Data for world, high-income countries, and low-income and middle-income countries (LMICs). (B) LMICs grouped by WHO region. AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia region. WPR=western Pacific region.

young adulthood. An almost four-fold rise in male deaths in group III was reported between early adolescence and young adulthood (from 36 to 141 per 100 000 per year). Mortality rates in all categories were lower in high-income countries than in other countries, and the largest differences were in group I deaths (figure 1). Both group IA and IB deaths were uncommon in high-income countries, and accounted for only 4% of mortality.

The African region had the highest rates for both sexes and had high rates in each category (figure 1). Of note were the large numbers of group I female deaths, which grew 2·6-fold (from 155 to 402 per 100 000) between early adolescence and young adulthood. In low-income and middle-income countries in the American region, the

increase in male mortality between early adolescence and young adulthood was largely from an eight-fold rise in group III deaths, which accounted for 72% of all male deaths and 52% of all deaths in adolescents and young adults in the region. In the eastern Mediterranean region, mortality was moderately high for both sexes in each age-group, but a pronounced rise in group III male deaths was noted between early adolescence and young adulthood (figure 1).

In low-income and middle-income countries in the European region, the male predominance of deaths was largely due to more than a seven-fold rise in group III deaths between early adolescence and young adulthood (from 24 to 179 per 100 000), which accounted for 65% of
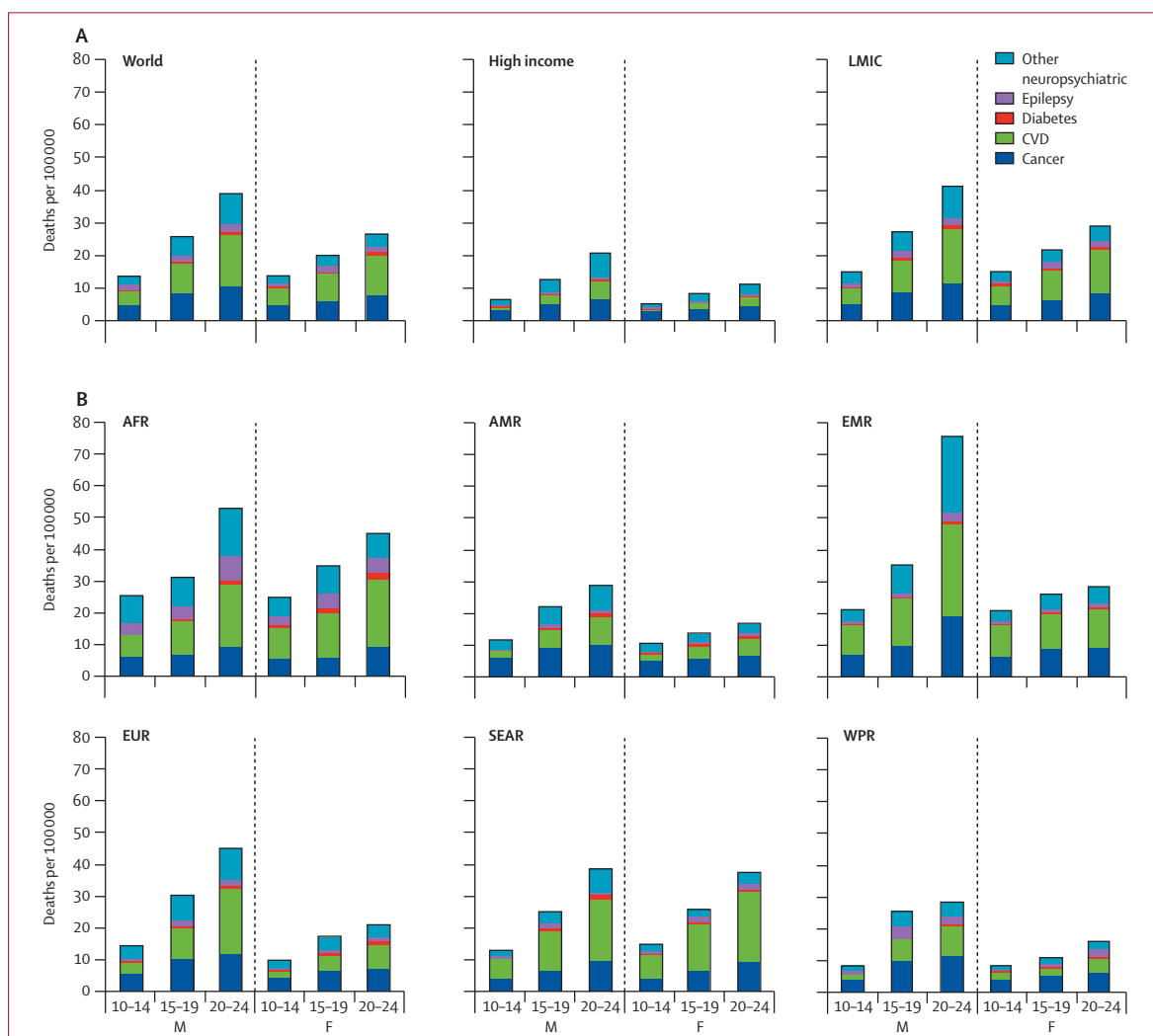
Figure 3: Specific group II causes of death stratified by sex, age-group, and region

Specific group II causes of death are cancer, cardiovascular disease (CVD), diabetes, epilepsy, and other neuropsychiatric causes. M=male deaths. F=female deaths. (A) Data for world, high-income countries, and low-income and middle-income countries (LMICs). (B) LMICs grouped by WHO region. AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia region. WPR=western Pacific region.

male deaths and 48% of all deaths. In the southeast Asia region, group III causes were predominant (43%), with many deaths in groups I (36%) and II (21%). In western Pacific countries of low and middle incomes, 62% of male deaths and 42% of all deaths were due to group III causes.

Figure 2 shows specific causes of group I deaths. Worldwide, maternal mortality accounted for 15% of all female deaths and 7% of all deaths in people aged 10–24 years. 11% of deaths were due to HIV/AIDS and tuberculosis, and rates of death from these diseases rose around five-fold between early adolescence and young adulthood (from 6·5 to 34 per 100 000 per year). However, mortality from lower respiratory tract infections was lower in young adults than in young adolescents (figure 2). Figure 3 shows specific causes of group II deaths. Cardio-vascular-related deaths were the largest subgroup within group II, accounting for 6% of all deaths in 10–24-year-olds.

5% of all deaths were from cancer, and 5% were attributed to neuropsychiatric disorders and epilepsy.

Figure 4 shows specific causes of group III deaths. Traffic accidents were the largest contributor to group III in all age-groups and caused 14% of male and 5% of female deaths. 9% of young males died from violence and 6% of both sexes from suicide. Fire-related death was the third most common group III cause, accounting for 4% of female deaths. Drowning was common in both sexes and accounted for 5% of male and 2% of female deaths.

In high-income countries, traffic accidents caused 32% of deaths in males aged 10–24 years. Violence and suicide accounted for 10% and 15% of male mortality, respectively. Young adults had higher rates of death due to traffic accidents (RR 7·7), suicide (16), and violence (18) than did young adolescents. In females, traffic accidents (27%) and suicide (12%) were the main causes of death.
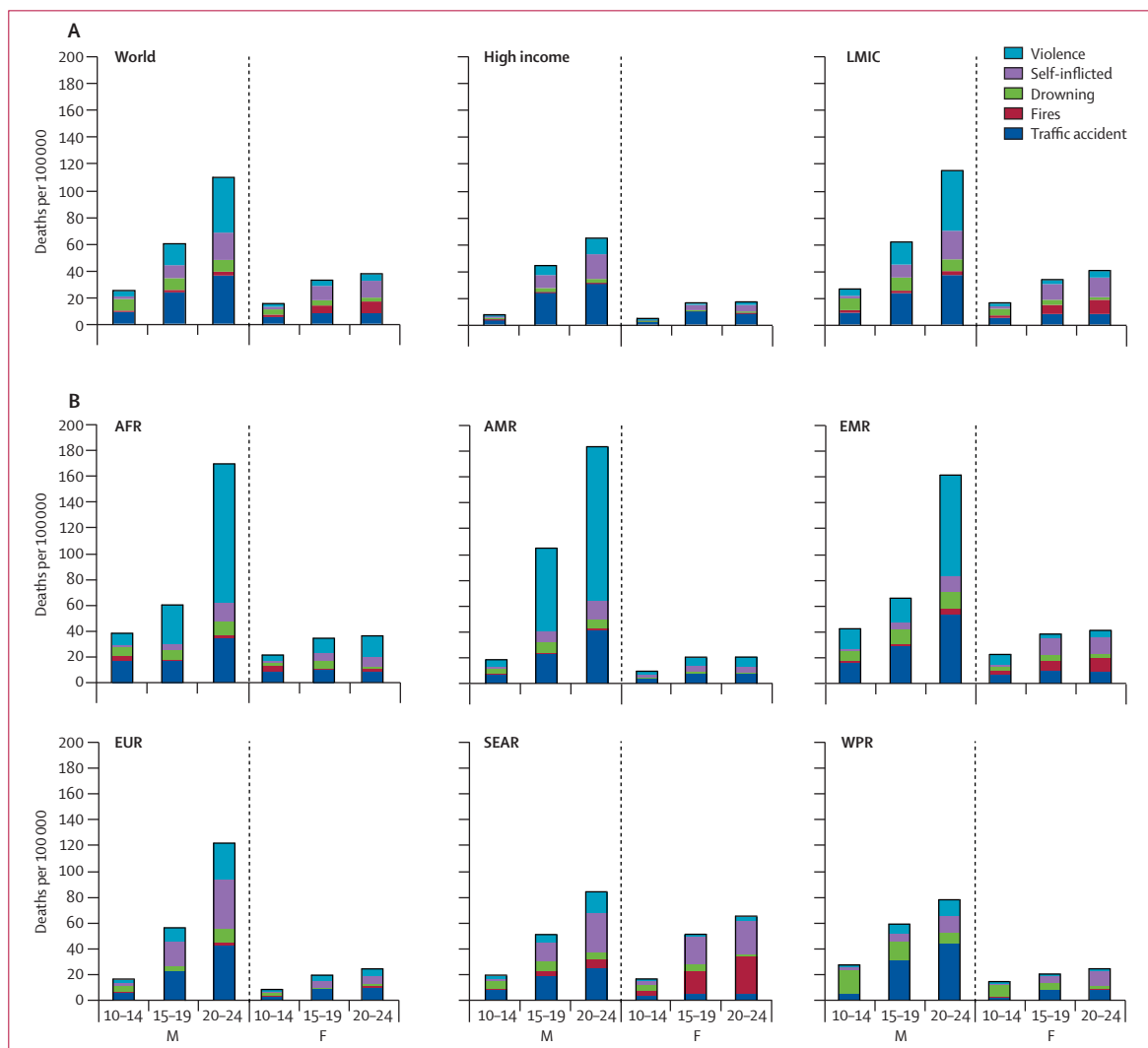
Figure 4: Specific group III causes of death stratified by sex, age-group, and region
Specific group III causes of death are traffic accidents, fire-related deaths, drowning, self-inflicted injury, and violence. Violence refers to deaths from both violence in and outside of war. M=male deaths. F=female deaths. (A) Data for world, high-income countries, and low-income and middle-income countries (LMICs). (B) LMICs grouped by WHO region. AFR=African region. AMR=region of the Americas. EMR=eastern Mediterranean region. EUR=European region. SEAR=southeast Asia region. WPR=western Pacific region.

Traffic accidents, violence, and suicide accounted for almost 80% of group III deaths in both sexes and more than half of all-cause mortality.

In low-income and middle-income countries, group I mortality was largely due to HIV/AIDS and tuberculosis, and in females, due to maternal causes. In group III, violence and traffic accidents were most prominent in males, and suicide and fire-related deaths in females. Cardiovascular-related mortality was the most common group II cause, with rates in low-income and middle-income countries 3·4-fold higher in males and 4·7-fold higher in females than in high-income countries. Mortality rates for epilepsy (RR 4·3) and diabetes (3·4) were also higher in countries of low and middle income. In the African region, maternal mortality caused 26% of female deaths in those aged 10–24 years, with a clear rise

in mortality with age (figure 2). Deaths due to HIV/AIDS and tuberculosis also increased with age, accounting for more than one in five of all deaths between early adolescence and young adulthood. The largest subgroup of group III causes in males was violence and war (16% of all deaths), followed by traffic accidents (8%), drowning (3%), and suicide (2%).

In countries of low and middle income in the American region, high mortality rates for boys in late adolescence and young men were mainly due to violence. Such deaths were 26-fold higher in young men than in young adolescent males, and accounted for more than 42% of all deaths in those aged 15–24 years and for 9% of female deaths. Additionally, a rise of almost six-fold in traffic deaths and nine-fold in suicide was recorded for males between early adolescence and young adulthood.

	Males		Females		Total	
	Cause	Total deaths (×1000) (%)	Cause	Total deaths (×1000) (%)	Cause	Total deaths (×1000) (%)
10–24 years						
1	Road traffic accidents	202 (13·9%)	Low RTI	77 (6·7%)	Road traffic accidents	259 (10·0%)
2	Violence	133 (9·2%)	Self-inflicted injuries	71 (6·2%)	Self-inflicted injuries	164 (6·3%)
3	Self-inflicted injuries	93 (6·4%)	HIV/AIDS	71 (6·1%)	Violence	157 (6·0%)
4	Drownings	77 (5·3%)	Tuberculosis	66 (5·8%)	Low RTI	153 (5·9%)
5	Tuberculosis	76 (5·2%)	Road traffic accidents	57 (5·0%)	Tuberculosis	142 (5·5%)
6	Low RTI	76 (5·2%)	Fire-related	50 (4·3%)	HIV/AIDS	142 (5·5%)
7	HIV/AIDS	71 (4·9%)	Maternal haemorrhage	36 (3·2%)	Drownings	106 (4·1%)
8	War	41 (2·8%)	Abortion	31 (2·6%)	Fire-related	67 (2·6%)
9	Leukaemia	28 (1·9%)	Drownings	28 (2·5%)	Meningitis	53 (2·0%)
10	Meningitis	26 (1·8%)	Meningitis	27 (2·3%)	War	46 (1·8%)
10–14 years						
1	Low RTI	30 (10·1%)	Low RTI	36 (13·3%)	Low RTI	66 (11·7%)
2	Road traffic accidents	27 (9·4%)	Meningitis	15 (5·3%)	Road traffic accidents	41 (7·2%)
3	Drownings	26 (9·0%)	Malaria	13 (4·9%)	Drownings	38 (6·7%)
4	Malaria	13 (4·5%)	Road traffic accidents	13 (4·9%)	Malaria	27 (4·7%)
5	HIV/AIDS	11 (3·9%)	Drownings	12 (4·4%)	Meningitis	24 (4·2%)
6	Meningitis	9 (3·2%)	HIV/AIDS	11 (4·1%)	HIV/AIDS	23 (4·0%)
7	Tuberculosis	8 (2·8%)	Diarrhoeal diseases	10 (3·5%)	Tuberculosis	17 (3·1%)
8	Diarrhoeal diseases	7 (2·4%)	Tuberculosis	9 (3·4%)	Diarrhoeal diseases	17 (2·9%)
9	War	7 (2·2%)	Protein-energy malnutrition	7 (2·7%)	Protein-energy malnutrition	13 (2·3%)
10	Self-inflicted injuries	6 (2·2%)	Fire-related	7 (2·6%)	Self-inflicted injuries	11 (2·0%)
15–19 years						
1	Road traffic accidents	72 (16·2%)	Self-inflicted injuries	31 (8·2%)	Road traffic accidents	96 (11·6%)
2	Violence	42 (9·3%)	Road traffic accidents	23 (6·2%)	Self-inflicted injuries	60 (7·3%)
3	Self-inflicted injuries	29 (6·5%)	Low RTI	21 (5·6%)	Violence	51 (6·2%)
4	Drownings	29 (6·4%)	Tuberculosis	20 (5·2%)	Low RTI	45 (5·4%)
5	Low RTI	24 (5·3%)	Fire-related death	17 (4·7%)	Drownings	40 (4·8%)
6	Tuberculosis	20 (4·4%)	Maternal haemorrhage	13 (3·4%)	Tuberculosis	39 (4·8%)
7	Leukaemia	11 (2·6%)	Abortion	12 (3·2%)	Fire-related	22 (2·7%)
8	HIV/AIDS	10 (2·3%)	Drownings	11 (2·9%)	HIV/AIDS	19 (2·3%)
9	Meningitis	9 (2·1%)	Hypertensive disorders	10 (2·7%)	Leukaemia	18 (2·1%)
10	Falls	8 (1·8%)	Violence	10 (2·5%)	Meningitis	16 (1·9%)
20–24 years						
1	Road traffic accidents	102 (14·4%)	HIV/AIDS	51 (10·1%)	Road traffic accidents	122 (10·1%)
2	Violence	85 (12·0%)	Tuberculosis	37 (7·4%)	HIV/AIDS	101 (8·3%)
3	Self-inflicted injuries	58 (8·2%)	Self-inflicted injuries	35 (7·0%)	Violence	96 (8·0%)
4	HIV/AIDS	50 (7·0%)	Fire-related	25 (5·0%)	Self-inflicted injuries	93 (7·7%)
5	Tuberculosis	48 (6·8%)	Maternal haemorrhage	24 (4·7%)	Tuberculosis	85 (7·1%)
6	War	28 (4·0%)	Road traffic accidents	21 (4·1%)	Low RTI	42 (3·5%)
7	Drownings	22 (3·2%)	Low RTI	20 (4·0%)	Fire-related	34 (2·8%)
8	Low RTI	22 (3·1%)	Abortion	19 (3·7%)	War	29 (2·4%)
9	Poisonings	14 (1·9%)	Hypertensive disorders	12 (2·4%)	Drownings	28 (2·3%)
10	Leukaemia	11 (1·5%)	Maternal sepsis	11 (2·3%)	Maternal haemorrhage	24 (2·0%)

Low RTI=lower respiratory tract infections.

Table 4: **Ten most common causes of death by sex and age-group**

In low-income and middle-income countries in the eastern Mediterranean region, deaths due to violence and traffic accidents (17% and 16% of all male deaths, respectively) largely accounted for the rise in group III mortality with age. The main group III causes of female deaths were suicide (6%), traffic accidents (6%), fire-related (5%), and violence (4%). Maternal mortality contributed to the rise in group I deaths with age,

accounting for 16% of all female deaths. For males, infectious diseases, especially tuberculosis, accounted for the rise in group I deaths with age.

In European countries of low and middle income, the major group III causes of deaths in males aged 10–24 years were traffic accidents (17%), suicide (14%), and violence (9%), which largely contributed to the reported rise with age. In southeast Asian countries, male deaths in group I increased partly due to HIV/AIDS and tuberculosis, which constituted 10% of deaths in males aged 10–24 years. For females, the rise in group I deaths was largely the result of maternal mortality, with some contribution from HIV/AIDS and tuberculosis. For males, traffic accidents (9%), suicide (8%), and violence (4%) were the most common cause of group III deaths in this region. Fires (8%) and suicide (8%) contributed to the high group III mortality in females.

In low-income and middle-income countries in the western Pacific, the main causes of group III deaths in males were traffic accidents (24%), drowning (14%), suicide (6%), and violence (6%). Increased mortality by age was mostly from traffic accidents (RR 9·2), which accounted for almost half of group III deaths. However, rates of drowning halved between early adolescence and young adulthood. For females, suicide (12%), road traffic accidents (11%), and drowning (11%) were the main group III causes of death. Cancer accounted for 9% and cardiovascular disease around 5% of all deaths.

Table 4 shows the ten most common ICD-10 causes of mortality by age-group. Traffic accidents were the most frequent cause in all male age-groups and were the most common cause in young people overall. Suicide increased in both sexes in people aged 15–24 years, and was overall the second most common cause. Violence was common in males aged 15–24 years, and was the third most frequent cause overall.

Infectious diseases were frequent in both sexes in all age-groups. Deaths from lower respiratory tract infections were the most common cause in young adolescents, and although rates fell somewhat with age, it was the fourth most frequent cause of mortality overall. Rates of HIV/AIDS and tuberculosis increased substantially between early adolescence and young adulthood, and accounted for 17% of female and almost 14% of male deaths in young adulthood. Overall, tuberculosis and HIV/AIDS were ranked fifth and sixth, and accounted for more deaths than did traffic accidents. Maternal causes of death (maternal haemorrhage, sepsis, and abortion) were common in females aged 15–24 years.

Discussion

Findings from this study have shown that only 3% of deaths were in high-income countries, even though 11% of young people live in these settings. Mortality rates in low-income and middle-incomes countries were almost four-fold higher than were those in high-income countries, a difference that was particularly pronounced for young

women. Rates were highest in Africa and southeast Asia; these regions accounted for around two-thirds of worldwide deaths in young people, but constituted only 42% of the population. Female death rates were generally lower than were those for males, apart from in African and southeast Asian regions, where the increased number of female deaths was largely from maternal mortality, with deaths from suicide, fire, HIV/AIDS, and tuberculosis also contributing. High rates of death from injury in young women in southeast Asia and Africa contrasted greatly with low rates in low-income and middle-income countries of Central and South America, western Pacific, and eastern Europe.

Major barriers exist to presentation of an adequate worldwide profile of mortality in any age-group.[27] Less than a third of the world's populations have complete national registration data for cause-specific deaths. Countries with the lowest life expectancies have the greatest scarcity of data.[16,28] Sample registration systems provide a source of cause-specific mortality data for some countries with low and middle incomes.[29] However, for many poor countries, including most of sub-Saharan Africa, verbal autopsy within recent surveys was the main source of data.[29]

We included estimates of cause-specific deaths for regions with scarce death-registration data and wide uncertainty ranges, because exclusion of these regions would result in a potentially biased picture of worldwide mortality. In an early analysis of the 2001 Global Burden of Disease study,[30] researchers estimated that uncertainty in all-cause mortality ranged from 1% for high-income countries to 15–20% for sub-Saharan Africa. Uncertainty ranges were generally large for deaths from specific diseases. Uncertainty for deaths from traffic accidents ranged from 3% for high-income countries to 25% for sub-Saharan Africa, and for stroke from 10% for high-income countries to 30% for sub-Saharan Africa.[24] In our analyses, uncertainty ranges are almost certainly larger than are those from the Global Burden of Disease study[31] for all ages combined. Improved registration of deaths and development of alternative research methods for study of mortality in this age-group remains important.[27] Since progress towards civil registration in many low-income countries will probably be slow, attainment of valid data for young people from these sources will be essential in the foreseeable future.[32,33]

Some caution is needed when regional mortality estimates are extrapolated to a country level. For example, in the western Pacific all-cause rates of death were low and cause-specific mortality was similar to that in high-income countries. However, these estimates are dominated by China—the most populous country in the region. Small countries in this region, such as Papua New Guinea, have patterns of death similar to those in regions of high mortality.[34]

Regional differences in age of onset of sexual activity and availability and accessibility of condoms, contraception, safe abortion, antenatal and obstetric care, and

HIV testing are some of the reasons for the rise in female mortality with age.[4,35] High maternal mortality rates in some low-income and middle-income countries have been previously described,[36] and are the target of the fifth Millennium Development Goal. Prominence of maternal death in this young age-group should be a further incentive for promotion of developmentally appropriate sexual and reproductive health services for young people.[35] In view of the high number of deaths due to abortion, to ensure not only that contraception is available but also that all abortions are safe would do much towards reduction of mortality in young women.[37] In regions without substantial maternal mortality, rates of female deaths generally remained low throughout adolescence and young adulthood.

In males, injury deaths contributed most to the rise in mortality with age worldwide, but rates and patterns of causes varied substantially across regions. Injuries account for around 10% of worldwide mortality for all ages, but in people aged 10–24 years they accounted for more than 40% of all deaths and about half of male deaths.[16,38] The importance of injury deaths in young people in high-income countries has been recognised.[12,13] However, injury mortality was most prominent in low-income and middle-income countries. This finding emphasises the need for heightened investment in injury-prevention programmes for this age-group.[39] Diverse responses are needed because patterns of injury deaths varied substantially between regions. An increase in traffic-related deaths in many high-income countries up until the 1980s resulted in coordinated intersectoral policy responses, with a subsequent fall in mortality.[9,40] Typical preventive measures include investments in road infrastructure, compulsory seatbelts and helmets, and enforcement of legislation for use of alcohol and other drugs when driving.

Further regional differences in priorities exist for prevention. In the western Pacific region, drowning caused most injury deaths in children aged 10–14 years.[41] Simple policy responses such as improved availability of swimming lessons in childhood and teaching about the hazards of water could prevent many deaths.[42,43] For deaths caused by violence, suicide, and accidental injury, policy responses will probably need to be complex and target a wide range of ages, but with particular benefits for this young age-group.[44] In Central and South America, violence was the major cause of injury deaths in young men. Firearms are responsible for up to 97% of homicide deaths in countries in this region, making a strong case for strengthened gun control.[45] However, without policies to address the illicit drug industry, few employment opportunities, urban segregation, and a culture of machismo, gun control alone is unlikely to be effective.[46]

In eastern Europe, patterns of injury deaths in young men were complex, with homicide, traffic injuries, and suicide all common. The emergence of a large black or underground economy with a so-called criminological transition and exposure to violence might be one reason why rapid socioeconomic transition affects mortality in young men.[47,48] Furthermore, heightened alcohol misuse has been linked to changes in rates of suicide, accidental injury, and homicide, and could be a further target for prevention.[49–51] In southeast Asia, the number of injury deaths in young women, particularly from fire-related death and suicide, was pronounced. Previous reports[16,52,53] from India have attributed these deaths to suicide and accidents, but the role of violence from family members is important in many cases. Restricted access to pesticides in rural India will probably be an important element of suicide prevention.[43,54,55]

Increases in mortality between early adolescence and young adulthood suggest major underlying shifts in health status that have so far attracted little attention from policy-makers. In some regions, including Africa and southeast Asia, group I causes of death rise in adolescence and young adulthood and thus are of major importance. Present global health policies for the prevention and management of HIV, and provision of access to information and services for sexual and reproductive health, will probably have major benefits.[56] However, even in these regions, tuberculosis and lower respiratory tract infections cause more youth deaths than does HIV/AIDS, but have not yet attracted a similar response in policy. Importantly, group I causes of death were not prominent in most low-income and-middle-income countries. In the western Pacific and eastern Europe, although overall death rates were increased, patterns of death resembled those reported in high-income regions, suggesting a need for very different strategies.

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