FULL TEXT ARTICLE

Child and Adolescent Mortality Across Malaysia's Epidemiological Transition: A Systematic Analysis of Global Burden of Disease Data

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Abstract

Purpose

A rapid epidemiological transition in developing countries in Southeast Asia has been accompanied by major shifts in the health status of children and adolescents. In this article, mortality estimates in Malaysian children and adolescents from 1990 to 2013 are used to illustrate these changes.

Methods

All-cause and cause-specific mortality estimates were obtained from the 2013 Global Burden of Disease Study. Data were extracted from 1990 to 2013 for the developmental age range from 1 to 24 years, for both sexes. Trends in all-cause and cause-specific mortality for the major epidemiological causes were estimated.

Results

From 1990 to 2013, all-cause mortality decreased in all age groups. Reduction of all-cause mortality was greatest in 1- to 4-year-olds (2.4% per year reduction) and least in 20- to 24-year-olds (.9% per year reduction). Accordingly, in 2013, all-cause mortality was highest in 20- to 24-year-old males (129 per 100,000 per year). In 1990, the principal cause of death for 1- to 9-year boys and girls was vaccine preventable diseases. By 2013, neoplasms had become the major cause of death in 1–9 year olds of both sexes. The major cause of death in 10- to 24-year-old females was typhoid in 1990 and neoplasms in 2013, whereas the major cause of death in 10- to 24-year-old males remained road traffic injuries.

Conclusions

The reduction in mortality across the epidemiological transition in Malaysia has been much less pronounced for adolescents than younger children. The contribution of injuries and noncommunicable diseases to adolescent mortality suggests where public health strategies should focus.

Across the first 25 years of life, 1- to 9-year-old Malaysian children have seen greater recent improvements in their health than 10- to 24-year-olds. National policies and strategies that target the causes of adolescent and young adult mortality are required, particularly those that address road traffic injuries in young males.

Implications and Contribution

The shift in high- and middle-income countries (HMICs) from an agriculturally based economy in the early 19th century to a more knowledge-rich economy in the later 20th century has been associated with reduced poverty and a changing burden of disease in adults that is increasingly characterized by noncommunicable diseases (NCDs) [1] . The survival of infants into childhood is also increasingly common in low- and middle-income countries [1] . With these shifts, adolescents now constitute a greater proportion of the population than in high-income countries, which is one reason why interest in the health of adolescents has recently grown [2] . However, in most low- and middle-income countries adolescent health needs remain poorly described [1 2 3] . One reason is that until recently, many countries have been focused on the high burden of fatal disease in young children. Over the past 15 years, targeted investments toward the Millennium Development Goals have resulted in many countries achieving impressive improvements in the health of infants and young children. Globally, under-5 mortality reduced by 35% in the two decades from 1990 to 2010 [3 4] , with further reduction of over a third from 2010 to 2015 [5] .

In contrast to the extensive knowledge of the causes of mortality in young children throughout the world, mortality shifts in older children and adolescents have been largely overlooked, perhaps due to the assumption that this period is the healthiest time of life [2] . Using time-trend data from 50 selected HMICs with comprehensive national death registration, Viner et al. [4] showed that mortality in 1- to 9-year-old children had improved by 80%–93% over 50 years due to steep declines in communicable disease deaths. The improvement in mortality of 15- to 24-year-olds was only half that of younger children, largely due to static or rising injury-related deaths. In most HMICs, adolescent mortality was higher than in young children [4 6] , but the contributors to these patterns of death were not reported. Viner et al. focused predominantly on middle-income countries in Eastern Europe and Latin America; there have been few reports of the changing pattern of mortality across the developmental years in Asia, Oceania, and Africa. Primary data are most notably absent or less accurate in these regions which have had rapid social, economic, and demographic changes [4 5] .

Malaysia exemplifies these changes. Its under-5 mortality rate halved from 17 per 1,000 deaths in 1990 to 7 per 1,000 deaths in 2015, an annual reduction of 3.5% [7] . This steep decline in a relatively brief period reflects the success of efforts to reduce poverty and hunger, robust public health interventions such as improved sanitation, provision of clean water to households and expanded immunization programs, as well as higher quality and more accessible medical treatments, especially in rural areas [8] . The extent to which such improvements have been experienced by older children and adolescents in Malaysia is less clear. Scarce local data reflect the application of inconsistent age bands to mortality data across childhood and adolescence [9 10] . For example, the second Malaysian burden of disease and injury study presented data for 0- to 4-year-olds, 5- to 14-year-olds, and 15- to 29-year-olds, resulting in the relative invisibility of adolescents. Although Bujang et al. [10] showed that in Malaysia all-cause mortality had reduced from 1995 to 2010 across all age groups including infants, 1- to 4-year-olds, 5- to 19-year-olds, and 20- to 39-year-olds, cause-specific mortality was not reported which limits its usefulness for prioritizing public health interventions. Furthermore, primary data from Malaysia's vital

registration system are insufficiently accurate for detailed cause of death analysis (see Box 1 (tbox1)). Hence, in this study, we use Global Burden of Disease (GBD) 2013 data to report the pattern of all-cause and cause-specific mortalities in children and adolescents in Malaysia from 1 to 24 years by age (1–4, 5–9, 10–14, 15–19, and 20–24 years) and sex from 1990 to 2013.

BOX 1

- At least 85% of deaths in Malaysia are registered. The Registration of Birth and Death Act (1957) states that all deaths must be registered no later than 3 days before burial permits being issued. Death registration has improved since the completion of online vital registration in 2000.

- Under-registration is more likely in Sabah and Sarawak due to the historic lack of requirement for burial permits in East Malaysian states.

- The system allows deaths in the community to be certified by police officers, who code deaths according to the Code Book for Uncertified Causes of Deaths. This was developed by the Department of Statistics based on discussions with the Ministry of Health, National Registration Department, Royal Malaysia Police, and Kuala Lumpur City Hall [9] . The validity of this process has not been assessed.

- Medically certified cause of death follows verification by a medical officer or coroner, who code deaths using the International Statistical Classification of Diseases and Related Health Problem, 10th Revision. Approximately 80% of deaths of 1- to 24-year-olds are medically certified [11] .

- Lack of coding training for medical officers and police officers will result in suboptimal data.

- The cause of death for uncertified deaths is almost certainly less reliable for stigmatized conditions than for unintentional injury deaths. A robust coronial system that is respectful of the sensitivity of these deaths will improve the accuracy of certification.

Summary of Malaysia's vital registration system

Methods

Global Burden of Disease

GBD 2013 includes an annual assessment covering 188 countries from 1990 to 2013. It covers 306 diseases and injuries, 1,233 sequelae, and 79 risk factors. Detailed descriptions of the methodology and approach of GBD 2013 have been published elsewhere 12 13 14 15 16 17 18 . Key methodological advances from GBD 2010 are the inclusion of new data through updated systematic reviews and through the contribution of unpublished data sources from many collaborators, together with improvements in data processing and estimation methods including modification of garbage coding algorithms and revised modeling strategies. Garbage coding refers to the practice of assigning untenable, unspecified, and improbable causes of deaths (e.g., cervical cancer in males) to other categories. There are four categories of “garbage codes”: causes that cannot serve as underlying causes of death (R codes or all codes under chapter 18 of the International Statistical Classification of Diseases and Related Health Problem, 10th

Revision); intermediate causes of death (heart failure, septicemia, peritonitis, osteomyelitis, or pulmonary embolism); immediate causes of death that are the secondary rather than primary causes on a disease pathway leading to death (e.g., disseminated intravascular coagulation or defibrination syndrome [D65]); and unspecified causes within a larger cause grouping such as an unspecified site for neoplasms [19] . The methodology of Wang et al. [13] was used to generate the child mortality rate and adult mortality rate under the influence of natural disasters and armed conflicts. GBD 2013 uses a hierarchy of causes that organizes 306 diseases and injuries into four levels of classification, the rationale for which has been described previously [20] . Level 1 distinguishes three broad categories: first, communicable, maternal, neonatal, and nutritional disorders; second, NCDs; and third, injuries. Level 2 has 21 mutually exclusive and collectively exhaustive categories, which are each subcategorized so that level 3 has 163 categories, and level 4 has 254 categories. In this study, we present level 3 findings.

To augment the reporting framework and identify the leading causes of child and adolescent mortality, causes of deaths were regrouped from the 306 causes into 3 categories, 11 major groups and 52 minor subgroups (see Appendix 1 (appsec1)). This categorization, similar to that used within the Lancet Commission on Adolescent Health and Well-being, reflects the changing disease burden that is associated with progression through the epidemiological transition [2] .

From a review of the published literature on the leading causes of death of children and young people in Malaysia [9 10] and Southeast Asia [4 6 21] , a review of national policy targets and indicators for Malaysia [22 23] , and in the context of identified global indicators and health strategies [24] , we maintained communicable diseases and chronic physical conditions (e.g., neoplasms, renal diseases, and asthma) and defined nine other distinct major groups. These are HIV-related diseases, neonatal, nutritional, sexual reproductive health, self-harm, assault, alcohol and drug overdose, and transport and unintentional injuries (nontransport injuries). Mental disorder was not included as it is not modeled in GBD to cause of death other than self-harm and eating disorders. Transport injuries were defined as distinct from the unintentional injuries subgroup categorization because this condition is of particular relevance to adolescents and young adults in Malaysia [25] .

Statistical analysis

Age-specific mortality rates were calculated from the proportion of deaths per 100,000 population or per 100,000 person-years of observation in each age group in 1990 and 2013 using population data from the Institute for Health Metrics and Evaluation mortality database. To analyze trends in mortality rates over time, linear regression models were fitted to annual data points and the beta coefficient used to estimate the percent annual change. Analyses were undertaken using Stata (Stata Statistical Software, Release 14; StataCorp, College Station, TX).

Ethical oversight

Ethics committee approval was not required by the Royal Children Hospital Human Ethics Committee for these secondary analyses of openly available national registration data.

Results

All-cause mortality

All-cause mortality was highest for 20- to 24-year-old young men across the study period (Figure 1 (fig1)). All-cause mortality for 20- to 24-year-old males was 166 per 100,000 per year in 1990 and 129 per 100,000 per year in 2013. In 1990, all-cause mortality for females and males aged 1–4, 5–9, 10–14, 15–

19, and 20–24 years was 102, 39.5, 38.2, 87.5, and 116.3 per 100,000, respectively.

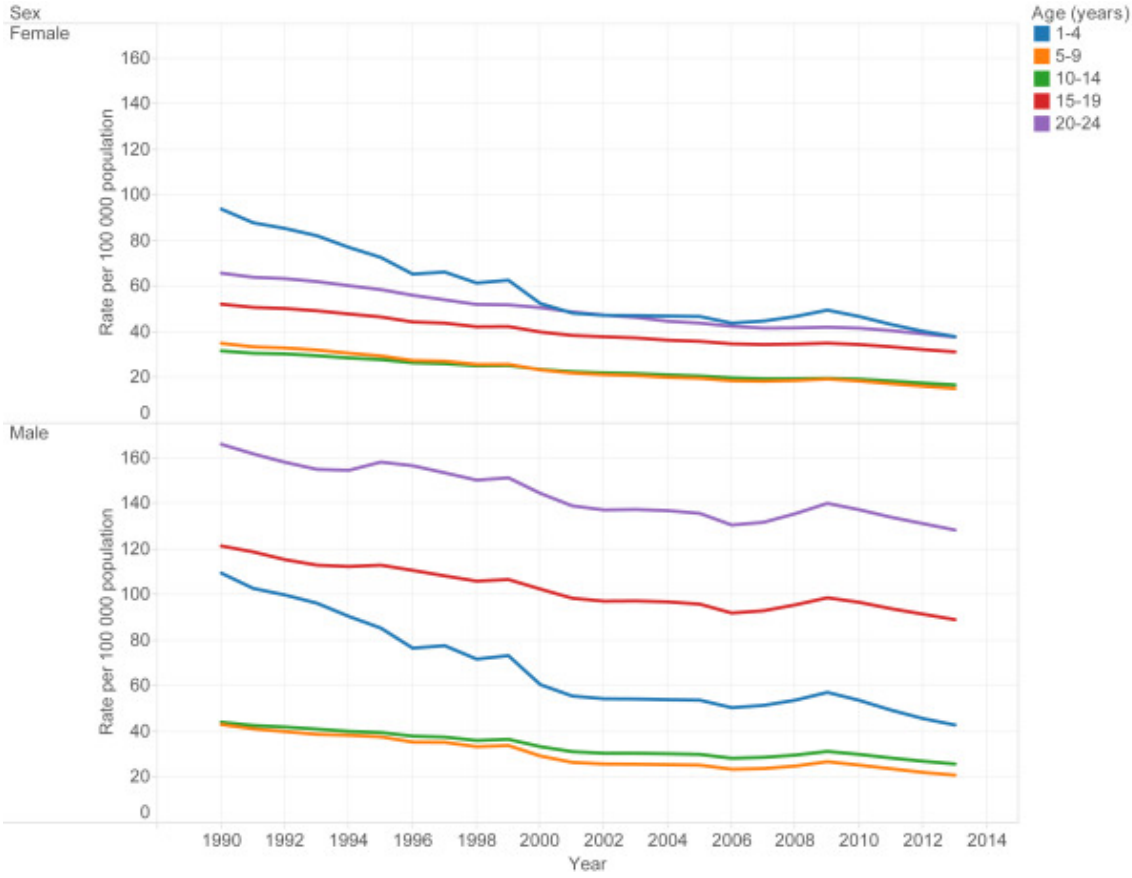


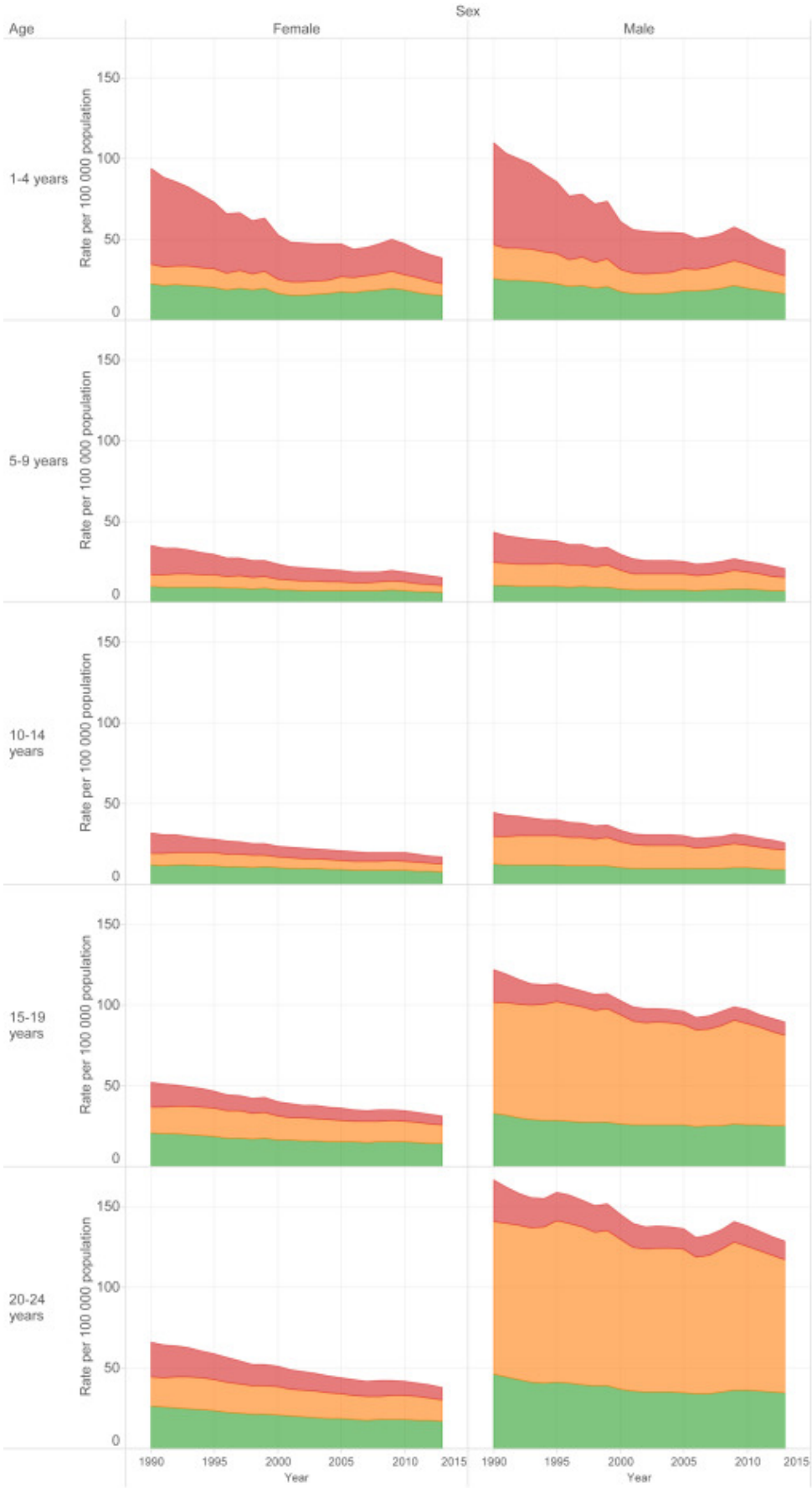
Figure 1

All-cause mortality by year (1990–2013) and age.

A trend of decreasing all-cause mortality was apparent for males and females across all age groups. By 2013, the mortality rate in each age group had reduced (40.7, 18.2, 21.4, 59.6, and 82.0 per 100,000 for 1- to 4-, 5- to 9-, 10- to 14-, 15- to 19-, and 20- to 24-year-olds, respectively). The greatest reduction was in 1- to 4-year-olds, which decreased by 2.4% per year from 1990 to 2013. The least reduction was in 20- to 24-year-old males, which decreased by .9% per year. Although there were no significant sex differences in the extent of reduced mortality in younger age groups, a greater reduction in mortality was seen in 15- to 19- and 20- to 24-year-old females than in males from 1990 to 2013. In 1990, males had over double the mortality rate of females (122 vs. 52 per 100,000 in 15- to 19-year-olds; 166 vs. 66 per 100,000 in 20- to 24-year-olds). By 2013, the difference in mortality rate by sex had increased to more than threefold for 15- to 19- and 20- to 24-year olds. Thus, in 2013, the mortality rate for 15- to 19-year-old males and females was 89 and 32 per 100,000 per year and for 20- to 24-year-old males and females was 129 and 38 per 100,000 per year, respectively.

Cause-specific mortality

Figure 2 (fig2) shows the mortality rate per year by the three types of cause of death, age groups, and sex from 1990 to 2013. In 1990, communicable diseases were the major contributor to deaths in 1- to 4- and 5- to 9-year-old children of both sexes and in 10- to 14-year-old females. By 2013, NCDs had become the major cause of death for these groups. Injuries were the principle cause of death for males aged 10–14, 15–19, and 20–24 years through 1990 and remained so in 2013. Meanwhile, NCDs were the principle cause of death in females aged 15–19 and 20–24 years across the study period.



mortality due to communicable diseases reduced fourfold in 1- to 4-year-old children of both sexes from 1990 to 2013. Reduction in deaths from communicable diseases in 5- to 9-, 10- to 14-, 15- to 19-, and 20- to 24-year-old females and males ranged from twofold to threefold. Mortality from injuries and NCDs reduced slightly in 15- to 19- and 20- to 24-year-old males and females between 1990 and 2013 (57 vs. 51 per 100,000 deaths for injuries in young men; 19 vs. 13 per 100,000 deaths for NCDs in young women).

Figure 3 (fig3) details cause of death by 11 major causes, disaggregated by age and sex in 1990 and 2013. In 1990, the leading cause of death for 1- to 4- and 5- to 9-year-olds was communicable diseases. Communicable disease deaths were highest in 1- to 4-year-olds (59 per 100,000 males and 56 per

100,000 females) in comparison to other age groups. In 1990, the principle causes of death for males and females aged 15–19 and 20–24 years were transport injuries and chronic physical conditions, respectively. By 2013, chronic physical conditions had become the main cause of death in 1- to 4- and 5- to 9-year-old children of both sexes. The main cause of death for young men and women aged 15–19 and 20–24 years remained unchanged at that time. Ten- to 14-year-olds had the lowest overall mortality rate. In 1990, the leading cause of death in this age group was communicable diseases. By 2013, chronic physical conditions had overtaken communicable diseases as the leading cause of death in 10- to 14-year-olds. There were no sex differences in the cause of death for younger adolescents in 1990 and 2013.

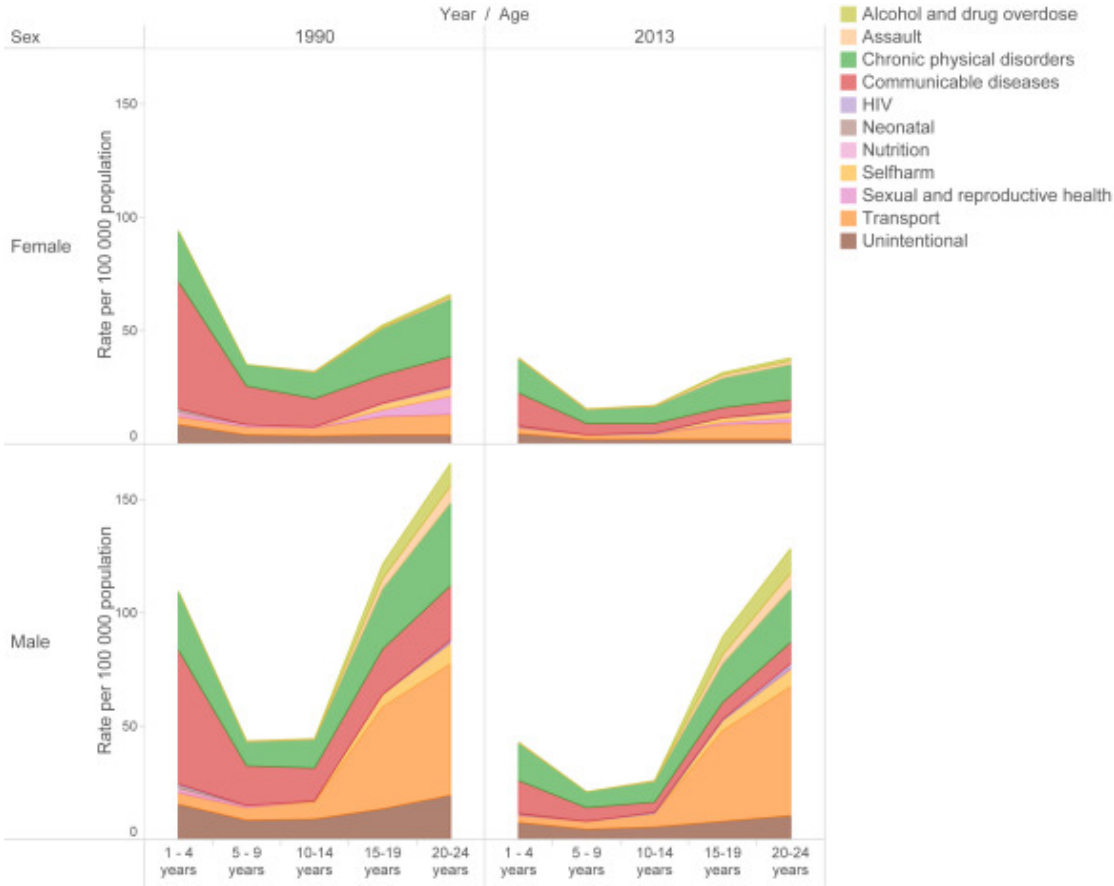
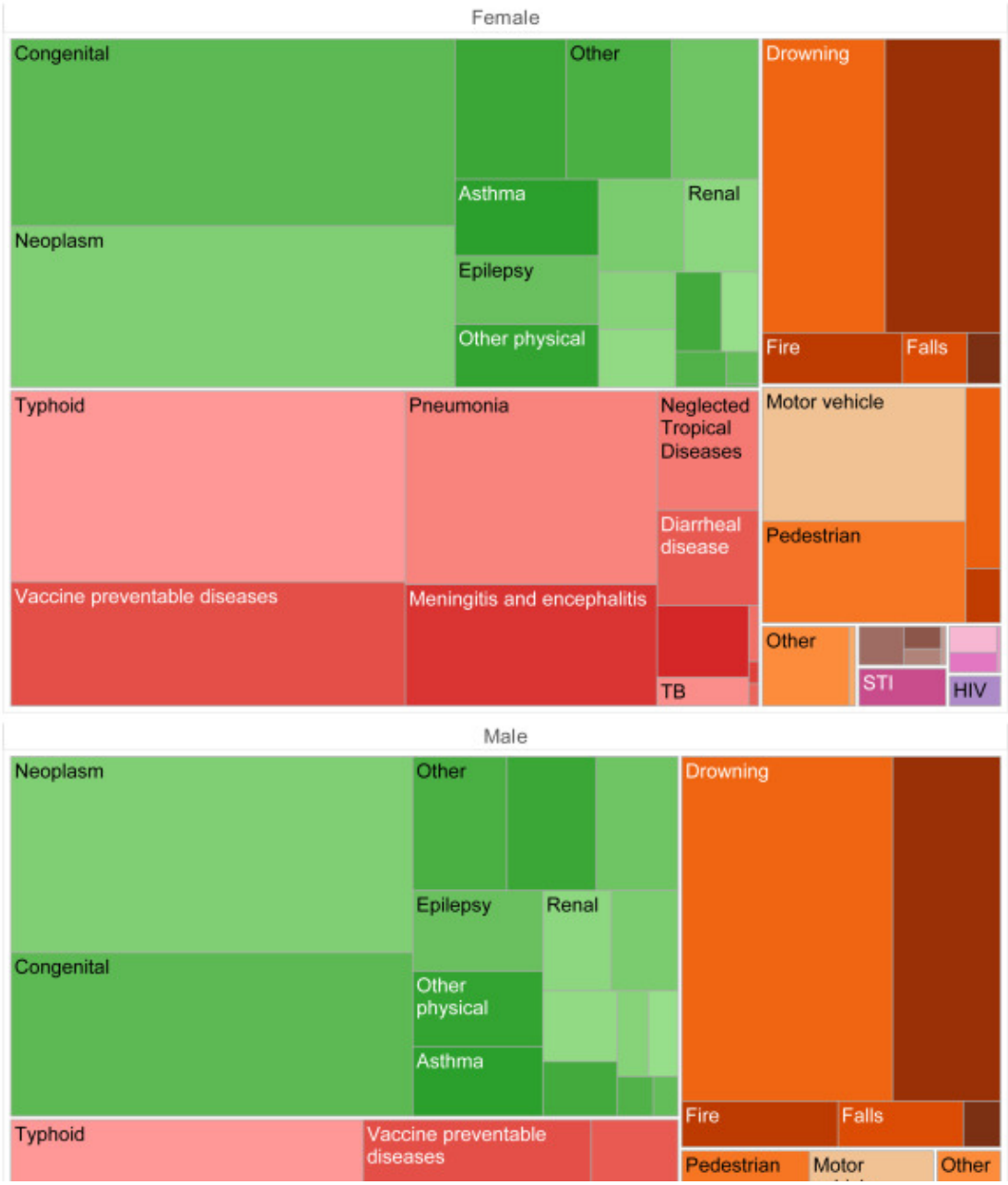


Figure 3

Causes of death by type, age group, and sex, in 1990 and 2013.

Figures 4 (fig4) and 5 (fig5) are tree maps of cause-specific mortality in 2013 for 1- to 9-year-olds (Figure 4 (fig4)) and 10- to 24-year-olds (Figure 5 (fig5)), by sex. Both girls and boys aged 1–9 years died largely from NCDs, with neoplasms and congenital anomalies the two leading causes of deaths. The mortality rate from these conditions was similar in girls and boys (3.2 and. 3.1 per 100,000 for congenital anomalies; 2.7 and 3.7 per 100,000 for neoplasms in girls and boys, respectively). In 2013, pneumonia and typhoid were also important causes of deaths for 1- to 9-year-old children of both sexes. Although drowning and other unintentional injury were other important causes of deaths for both young boys and girls, boys had over double the injury mortality rate than girls (3.5 vs. 1.4 per 100,000).



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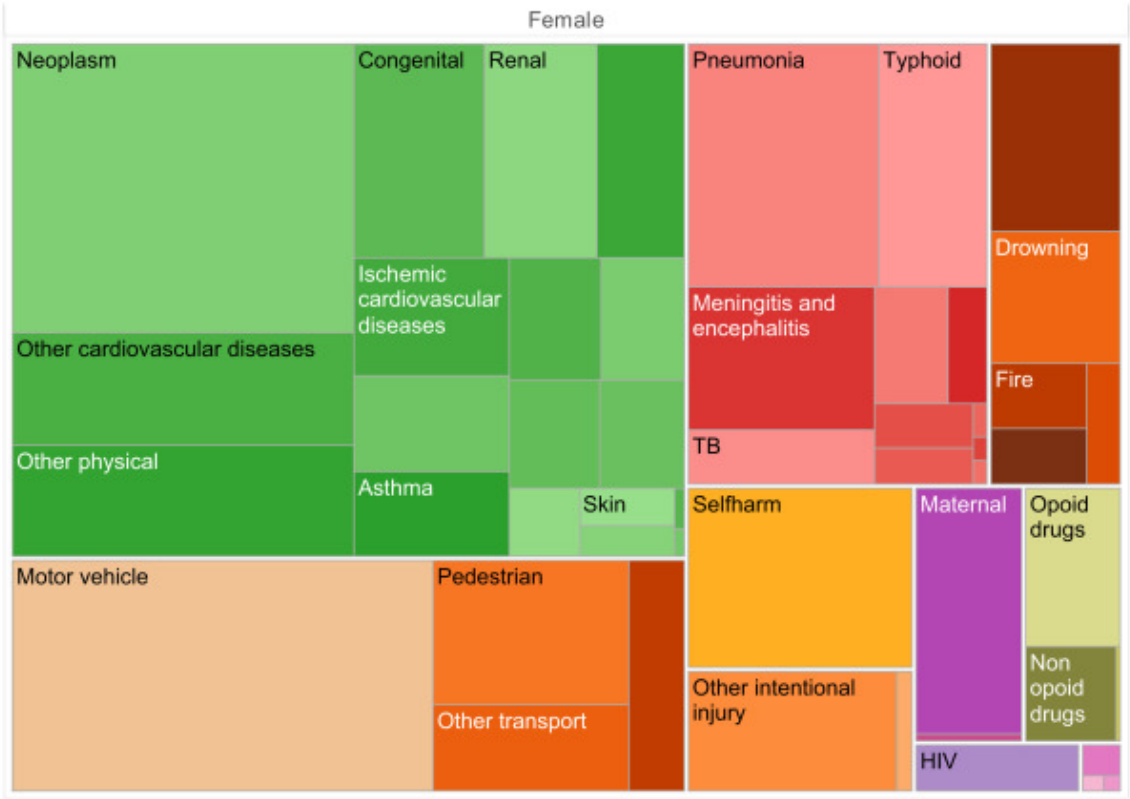

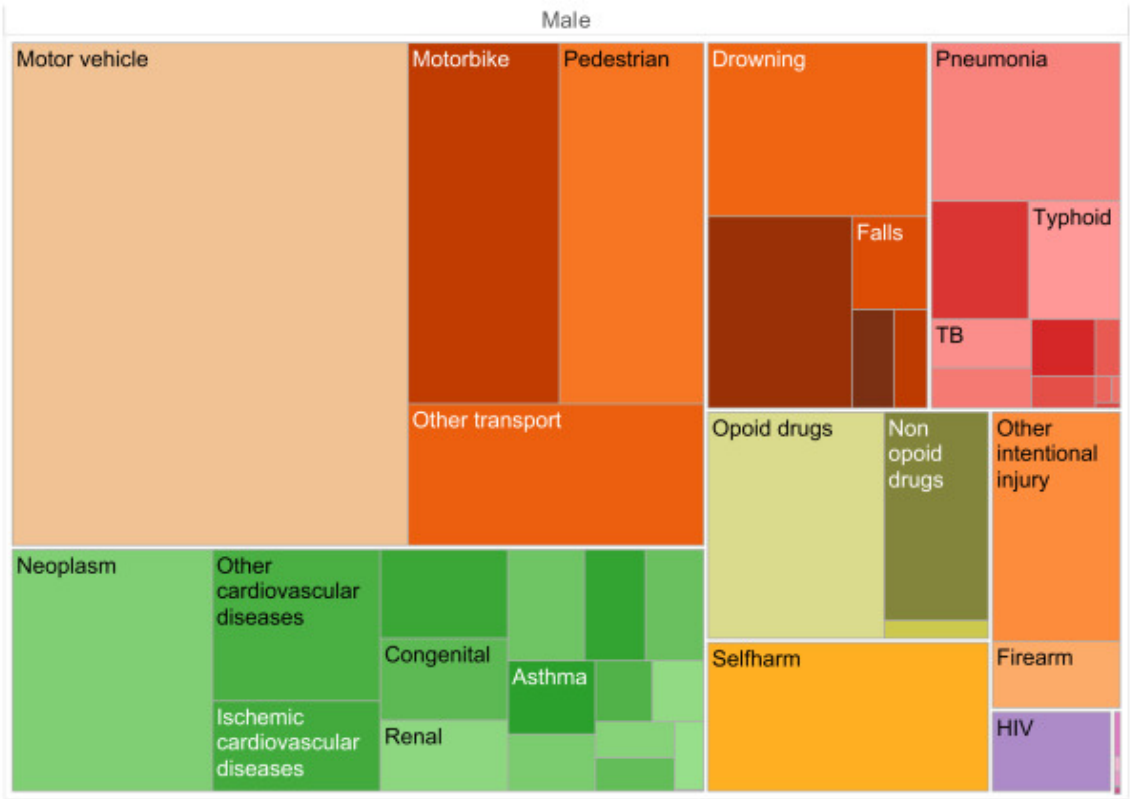

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In 20- to 24-year-old males, the age group with the highest mortality rate in 2013. Road traffic injuries were a significant cause of death in 20- to 24-year-olds males, with far less improvement over time than for communicable diseases. These data highlight that substantial reductions in death from communicable diseases have occurred across the epidemiologic transition. Over this same period, road traffic injuries are contributing to a greater proportion of deaths, especially in young men, and the contribution of NCDs to mortality in young children and in females of all ages is substantial.

Our findings on the impact of communicable diseases for under-5 mortality rate are similar to those reported elsewhere [26] . In addition to improvements in the conditions of daily living including water and sanitation, specific public health interventions in Malaysia such as a national expanded program of immunization, promotion of breast feeding, and micronutrient supplementation will have contributed to this relatively low level of communicable diseases [27] . Focused on young children, these actions will

also have benefited 5- to 9-year-olds and 10- to 14-year-olds, in whom there was also a significant reduction in mortality from communicable diseases across this period. In 2013, pneumonia was the leading cause of death within the communicable diseases category for 1- to 9-year-olds and 10- to 24-year-olds, followed by typhoid. The prevalence of pneumococcal disease is slightly higher than in several other countries in Southeast Asia, but detailed information is lacking about which serotypes are responsible [28] . This study affirms the importance of obtaining pneumococcal seroprevalence data which would inform cost-benefit ratios and pneumococcal vaccine policy for Malaysia. It also highlights the value of efforts to improve typhoid vaccine uptake through strategies to raise awareness and enforce laws that mandate immunization in food handlers. Beyond these, more distal social and structural determinants, such as reduced poverty and improved maternal and adolescent education, are expected to have contributed to reduced communicable disease in less specific ways [29] .

The contribution of road traffic injury to deaths in 15- to 19- and 20- to 24-year-old males is a striking feature of this study. Estimates of road injury fatalities by the International Traffic Safety Data and Analysis Group for Malaysian adolescents aged 15–24 years were similar to our report [30] . In our analysis, road traffic injury deaths constituted over 40% of deaths for males aged 15–19 years and 20–24 years and 20% of deaths for 15- to 19-year-olds and 20- to 24-year-old females, which were predominantly due to motor vehicle accidents. In contrast, the World Health Organization and International Traffic Safety Data and Analysis Group showed motorcyclists accounted for nearly 60% of all transport deaths in Malaysia [25 30] ; however, neither of these reports present age-disaggregated data. Overestimation of road traffic injuries in Organisation for Economic Co-operation and Development countries with good primary data has been previously noted, with a possibility that GBD methods reassign too many deaths with partially specified causes to road injuries [31] . It is possible that redistribution of unspecified transport-related injury deaths may have led to an underestimation of the proportion of death due to motorcycles [32] . Nonetheless, there remains an essential need for Malaysia to address road traffic injuries as a public health priority in young adult males. Policies that directly seek to reduce high-risk scenarios for young and inexperienced road drivers have been found to be successful in developed countries [33 34] . There are calls for existing laws that address key elements of road safety (including the enforcement of speed limits, drink-driving, helmet, and seat-belt use and prohibiting the use of mobile devices while driving) to be more tightly enforced as compliance with speed limits, safety-belts, and helmet use is reportedly declining in Malaysia [30] .

Cancer is a major contributor to female mortality, both in children and adolescents, which suggests an important role for health services, including specialist services for children and adolescents. The Malaysian National Cancer Registry (2007–2011) reports that the incidence of cancer has increased in both sexes, more so in females than in males, in whom the incidence rate exceeds males of all ages except in those older than 60 years [35] . The relatively high incidence of cancer and cancer-related deaths in adult women in more developed Asian countries, such as Malaysia, is believed to be due to breast cancer [36] . However Malaysian cancer registry data are not well disaggregated by age. Although increasing urbanization, changes in reproductive patterns and diet, obesity, tobacco and alcohol use, and increasing longevity contribute to an increasing cancer burden of a different pattern in adults in Asian countries [37] , the contribution of these factors to cancer in children and adolescents is less prominent as lifestyle factors uncommonly contribute to cancer in young people [38] . In Malaysia, a National Cancer Control Program focuses on strategies to reduce the incidence and mortality from cancer and to improve the quality of life for cancer sufferers through access to pain relief and palliative care. It is important that such strategies are equitably accessible to children and young people as well as older Malaysians.

In contrast to other parts of Southeast Asia where maternal causes significantly contribute to high rates of mortality in adolescent females [4 6] , our analyses revealed that maternal death rates were relatively low in Malaysia, both in 1990 and 2013. This may follow the adoption of effective strategies to reduce maternal death that have been implemented over the 2 decades before 1990. A particular benefit of using modeled data is that some maternal deaths are likely to be under-reported in Malaysia, whether using certified or uncertified deaths, due to the extent of stigma attached to teenage pregnancy which results in illegal and unsafe abortion [39] . Nevertheless, our estimates are constrained by the accuracy of the primary data sources due to particular issues around misclassification within maternal deaths and under-reporting of deaths of specific maternal causes (e.g., data related to abortions are not available for Malaysia) [40] .

Limitations

The usual limitations of the GBD study also apply to this study. The precision of mortality estimates depends on the quality of the stated cause of death. The dual death certification process in Malaysia, with reduced diagnostic accuracy from nonmedically certified deaths, will influence these estimates. Error and bias will be more pronounced for stigmatized causes of death, such as suicide, than for unintentional injury deaths. Although redistribution of ill-defined or intermediate causes to specific causes using global or regional algorithms improves the validity of cause of death data, this approach is less optimal than having country specific algorithms [15] . National statistical authorities' efforts to improve medical and nonmedical certification of causes of death in Malaysia could reduce the fractions of deaths assigned to different types of garbage codes. Although the present study points to a steady decline in mortality rates in 1- to 24-year-olds over this period, Bujang et al. documented increased mortality rates for under five children between 1999 and 2010 [10] . Improvements in Malaysia's vital registration system was achieved following implementation of online vital registration was completed between 1999 and 2000, which is widely believed to have improved registration of deaths in young children.

The high mortality burden from injury and NCDs in Malaysia, especially in adolescents and young adults, underscores the urgent need for national investment in a new suite of public health strategies involving coordination across sectors and beyond those that have historically targeted the major causes of death in young children [2] . Furthermore, the current contribution of pneumococcal disease and typhoid to communicable disease mortality in children and adolescents suggests that consideration is warranted around expanding Malaysia's National Immunization Program beyond its current focus. To support the intersectoral and multilevel public health strategies that Malaysia will require to address these issues will also need greater investment in technical capacity around policy implementation and research [2] . Finally, better understanding of the nonfatal burden of disease from communicable diseases, NCDs, injuries and disabilities, risk factors, and health determinants in young Malaysians is also required.

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Supplementary Data

Appendix 1 (/ui/service/content/url?section=static%2fimage&eid=1-s2.0-S1054139X17302197&path=1054139X%2FS1054139XXXXXXXXX%2FS1054139X17302197%2Fmmc1.docx)

Conflicts of Interest: The authors have no conflicts of interest to disclose.

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