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Innocenti Working Papers
Child Mortality
and Injury in Asia

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FOREWORD

There is strong and growing evidence that child injury is a major concern throughout the world, in developing as well as industrialized countries. Research carried out by The Alliance for Safe Children (TASC), UNICEF and local partners in East and South Asia compellingly demonstrates the importance of injury as a cause of child mortality and disability in this region.

The impacts of child injury in developing countries are typically many multiples of those seen in the rich world. For example, for every 100,000 children born in industrialized countries, fewer than 135 die from injuries before the age of 18. In the Asian countries participating in the research presented here, that figure is well over 1,000. The impacts of these rates, due to higher risks, are magnified by the greater numbers of children living in developing countries.

Over the past 50 years, child deaths due to injury have decreased substantially in industrialized countries. The risk of death by injury before the age of 18 to a child born today is less than half the level of 30 years ago. Yet the reduction in the number of deaths in these countries was not merely a natural outcome of economic development. It was the result of a concerted, collective effort that began with recognition of the problem, followed by political commitment and policy change. This long process of research, lobbying, legislation, environmental modifications, public education and improvements in emergency services has saved millions of lives. Fifty years of successfully reducing child injury rates in industrialized countries has taught us that the interaction of a child and a pond, a child and a car, or a child and an animal are as predictable, and as preventable, as the encounter of a child with a virus or bacteria.

We are nearing midway in the effort initiated at the historic Millennium Summit in 2000, where world leaders adopted a set of Millennium Development Goals for the year 2015. One goal calls for reducing the under-five mortality rate by two thirds from its 1990 level. To reach this ambitious goal we will need to work harder to do what we have always done for children's survival – promoting safe motherhood, increasing immunization coverage, ensuring better nutrition, and improving the role and status of women.

To achieve sustainable reduction in child mortality we must also 'work smarter'. Focus must be given to two areas of child deaths that now make up the majority of preventable mortality, and that have not been sufficiently well addressed in the past. One area is the reduction of neonatal deaths, which has become the focus of much recent research and international public and policy attention. Another focus must be on child injury.

Almost three decades ago a child survival revolution was launched, aimed at combating infectious diseases and nutritional deficiencies as the leading killers of infants and children. The targets were a handful of diseases and conditions that were responsible for the vast majority of deaths of infants and children. Based on evidence, interventions were organized through focused, affordable and sustainable actions. Campaigns were launched for breastfeeding and growth monitoring, immunization and oral rehydration therapy. Millions of lives were saved, and the development of many millions more children was advanced.

We now need to take similarly bold steps to prevent drowning, transport injury, poisoning, and other injury-related causes of child death and disability. Experience tells us that accidents and injury are largely preventable with simple and effective interventions. Unless we include injury prevention in our programmes, we stand to lose the impact of the major investments that have been made in immunization, nutrition and maternal and child health care.

In addition, deaths due to injury are but the tip of the iceberg. For every injured child who dies, many more live on with varying degrees and duration of trauma and disability, often denied the right to be productive citizens and to live a life of dignity. Their families are burdened with expensive hospitalization or other costs of caring for them. Likewise, injury to parents may lead to a family losing its breadwinner or its caregiver, contributing to poverty and with a devastating impact on children. Society must invest in preventing injuries, to save lives but also to help ensure the quality of life for children and their families.

Child injury prevention need not compete for the same scarce resources as other actions for children. Initiatives against accidents and injuries must be made complementary to and supportive of our focus on infant and child health, early childhood care, girls' education, HIV/AIDS prevention, and other programmes for young children and adolescents.

This special Innocenti series on Child Injury, developed jointly by UNICEF and TASC, presents recently acquired evidence from surveys in five Asian countries: Bangladesh, China, Philippines, Thailand and Viet Nam. The surveys are large in scale, similar to a census. In total over half a million households and nearly 2.5 million people were surveyed. The scale of the research provides an in-depth view of child mortality from all causes, as well as of morbidity from injury throughout all the years of childhood. The results show in detail the leading contribution made by injury to child death and disability, a fact that has been insufficiently recognized to date.

The findings from this research are important to Asia, one of the most dynamic and rapidly developing regions and home to over half the world's children. However, it is likely that patterns of increasingly significant injury-related child death and disability are occurring just as silently in other regions, difficult to detect by currently available measurement methods.

The work presented here clearly shows that in Asia the efforts for child survival carried out over the past three decades have been enormously successful. In the space of less than two generations the region has been transformed into one where the epidemiology of child and adult deaths is almost comparable to that in the rich world; the rates remain high, but the patterns have evolved. The epidemiological transition is clearly well underway in the region, from infectious diseases to injury and chronic disease as the leading causes of child death and disability. We must now rise to this new challenge.

The surveys and their results are made possible by, and build upon, the development that has occurred in health systems in the region. A strong and capable public health infrastructure now exists in most countries able to provide necessary information about death and illness. This provides policymakers with a firm basis on which to formulate the interventions that will most effectively continue the downward trend in the rates of child death and disability and extend protective benefits to all children.

The realization that almost half of all child deaths after infancy are due to injury gives great pause, but it is also a cause for hope. The revolution in child injury prevention in rich countries over the last 50 years demonstrates that injury is preventable. There is a clear way forward for policymakers in the region to make Asia 'A Region Safe for Children'.

Pete Peterson
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The Alliance for Safe Children

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SYNOPSIS OF THE SERIES

The initial papers in this series present a comprehensive overview as well as an in-depth focus on the methodology, the detailed results and the policy and programmatic implications of the surveys that have been carried out on child injury in Asian countries. Papers are also presented on the association of poverty and injury, and on a community laboratory for developing effective injury interventions. A brief summary of these is as follows.

Child mortality and injury in Asia: An overview. An introduction to child injury and the issues that underlie the new data, with a summary of results. The data show child injury to be far more prevalent than previously understood. Differences in these data and those gathered earlier are explored, and implications are addressed in a non-technical fashion.

Survey methods. An explanation of the methodology used for the surveys. It provides a detailed discussion of the methodology for readers with a technical background who desire more in-depth information on the surveys and how they differ from previous work.

Survey results and evidence. Detailed presentation of the results from the series of injury surveys, particularly for readers with specific country or category interests. This paper expands upon the description in the overview paper, including the presentation of further statistical analysis.

Policy and programme implications. Implications of the new findings are explored for child health programmes within the countries surveyed. The discussion has a practical orientation, to contribute to policy discussions on the measures needed for effective child injury prevention and response.

The cost of injury and its association with poverty. Using economic methods introduced for the Jiangxi Survey in China, data are presented on the cost of injury and its association with poverty. These costs and associations have implications for the wider Asian region.

A community laboratory for child injury prevention in Bangladesh. An introduction to a new community laboratory in Bangladesh for child injury interventions. Covering over 170,000 rural and urban households, the initiative focuses on measurement of the efficacy of injury interventions and their cost-effectiveness.

Future papers in the series are planned to be devoted to key issues of child injury raised in this initial group, but which call for more detailed discussion. Additional surveys in the field, when completed, will provide coverage of additional settings. These include reports on:

1. Child injury survey findings in Cambodia, as one of the few remaining countries in East Asia with high child mortality.
2. The correlates of survival and death of children and their parents in the Asian tsunami of December 2004, and the lessons for preparation and response in relation to the annually occurring natural disasters involving water in Asia.
3. Drowning, which accounts for the majority of all child deaths from injury. The phenomenon of drowning is unique in many respects, including epidemiology and prevention; the potential exists for elimination of a significant cause of child deaths.

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Innocenti Working Paper

**CHILD MORTALITY AND INJURY IN ASIA:
AN OVERVIEW**

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Mehr Khan Williams, Christian Voumard
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1 CURRENT CHILD MORTALITY ESTIMATES

Background

In low- and middle-income countries (LMICs) in the late 1970s and early 1980s, there was little doubt that infectious diseases were the major killers of children, especially of very young children. However, the child survival community – policymakers, researchers and programme implementers alike – needed baseline data, indicators, and measurement methodologies to define levels of mortality by cause of death and serious morbidity. Child mortality in LMICs was known to be high in a qualitative sense, but representative quantitative data at national and regional levels were practically non-existent. Quantifying the problem, however, was not simple. The absence of reliable data – often the near total absence of any information at all – compounded the difficult task of counting the deaths, quantifying the disabilities and differentiating between the various causes.¹

The Declaration of Alma Ata in 1978 spurred widespread interest in developing community- and facility-level surveys that would provide cause-specific information on child deaths. However, it was clear that in LMICs most deaths were not reported to any level of the health system, were not accorded a medically established cause and occurred within the community. Early on, it was recognized that child death data from within the medical system were not representative because of the biases inherent in health facility access.²

The paucity of good mortality data limited the usefulness of initial attempts at statistical modelling to determine child death rates and causes at the national and regional levels. The models were often based on World Fertility Surveys (WFS), national censuses or compilations of health facility data. The statistical validity of the data was limited and interpretation was restricted mostly to children under five (infants plus children aged one to four years). These efforts allowed the interpretation that only a handful of causes were responsible for the vast majority of under-five deaths. The primary causes included infectious diseases such as upper and lower respiratory infections, diarrhoeal diseases, and conditions related to gestation and nutrition.³

Out of this grew a movement to assign causality to child deaths in the community through the use of standardized interviews with the deceased child's mother or caretakers.⁴ The verbal

¹ Rudan, I., et al., 'Gaps in Policy-Relevant Information on Burden of Disease in Children: A systematic review', *The Lancet*, no. 365, pp. 2031–40, 2005.

² Hill, K., et al., 'Trends in Child Mortality in the Developing World: 1960 to 1996', UNICEF ChildInfo. Accessed 4 December 2006.

³ Mathers, C. D., et al., 'Counting the Dead and What They Died From: An assessment of the global status of cause of death data', *Bulletin of the World Health Organization*, vol. 83, no. 3, March 2005, pp. 171–177.

⁴ World Health Organization, *Lay Reporting of Health Information*, WHO, Geneva, 1978; World Health Organization, *Verbal Autopsies for Maternal Deaths*, WHO, Geneva, 1995; 'The Study of Causes of Death in Developing Countries', in G. Caselli, J. Vallin and G. Wunsch (eds), *Demography: Analysis and synthesis*, vol. 2, 2005.

autopsy was thus developed and significant resources were invested into standardizing it in order to improve its sensitivity and specificity for early child deaths.⁵ Sampling surveys were subsequently developed with standardized methodologies and conducted using provincially or nationally representative samples, often as a part of Demographic and Health Surveys (DHS).⁶ The sample sizes were limited by funds and country capacity and, as a result, most early surveys included fewer than 15,000 households. These surveys initially focused primarily on women of reproductive age, and included mortality only for children under five. Despite the limited power to discriminate causes of death even within the under-five age group, these surveys provided information where previously there had been none and were used extensively to develop national and regional estimates of child mortality. The surveys provided the proportional mortality data that painted the first picture of the leading causes of under-five mortality.

In its essence, the proportional mortality method uses a variety of sources, such as community-based surveys or census data, to make an estimate of the number of under-five deaths in a district, province, country, or region. It then assigns varying proportions to the leading causes of under-five death. These proportions are derived from models developed using the available reported death statistics and adjusted by various methods, usually with extensive consultation with experts. This method is sensitive to the uncertainties inherent in defining the various proportions allocated to the largest causes. A good deal of uncertainty has always existed because reliable, representative, medically certified cause of child death information has not previously been available. Using the example of measles, the best estimates range from 1 per cent to 8 per cent of under-five deaths – an eightfold difference compounded by uncertainties in all other components of overall child mortality.⁷

The proportional mortality method is vulnerable to other uncertainties. First, estimates across countries or regions are problematic when the same diseases exist at varying incidence and prevalence rates. Ecologic factors, for instance, can cause dramatic variation in disease rates over a small geographic area. Malaria or HIV prevalence patterns, for example, reflect a host of local factors that are difficult to extrapolate to a larger setting. Second, co-morbidities (having multiple causes of illness together) are very common. In many settings, assigning a single cause of death is almost arbitrary. Co-morbidities such as malnutrition, diarrhoeal diseases, respiratory illnesses and multiple parasites are common in early childhood. Third, most of the field studies used to define the principal causes of mortality, and thus determining proportional mortality proportions, were conducted in the mid-1980s and early 1990s. It is uncertain if the common causes of death during that period continue to remain as the most common causes now. Particularly in Asia, the region where the surveys were exclusively conducted, economic and social development has been very rapid over the past two decades.

Figure 1 shows the period of the late 1970s through to the 1990s, when most of the causality work was done. It was characterized by rapidly declining child mortality. The trend has since

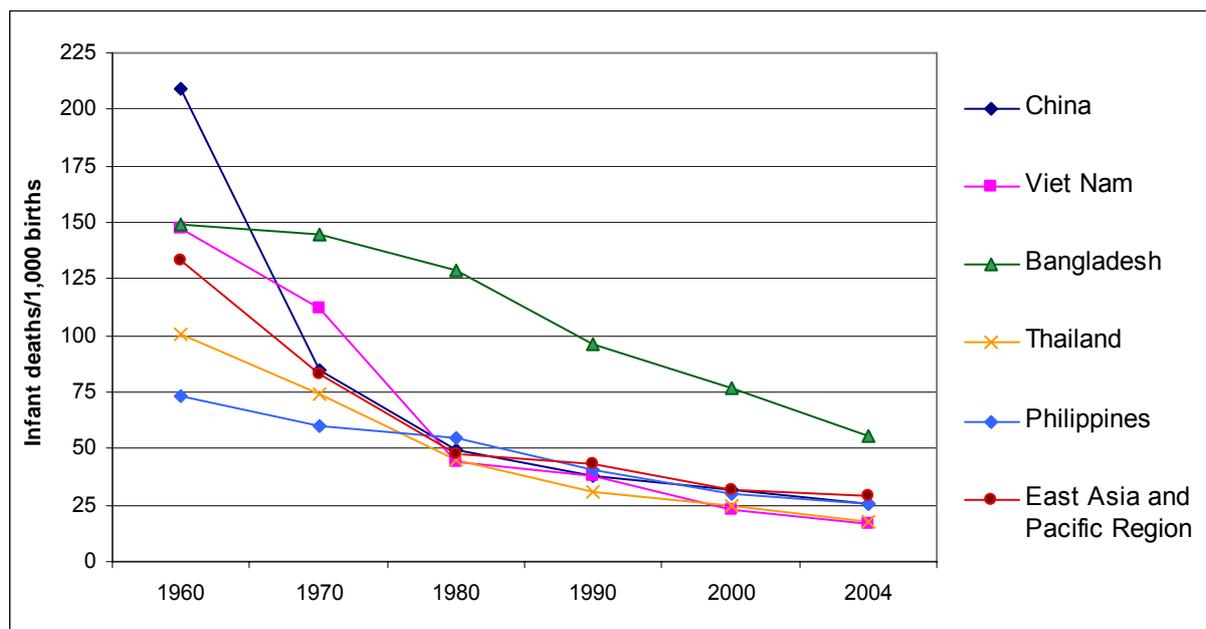
⁵ Soleman, N., D. Chandramohan and K. Shibuya, 'Verbal Autopsy: Current practices and challenges', *Bulletin of the World Health Organization*, vol. 84, no. 3, March 2006, p. 239.

⁶ See <www.measuredhs.com/aboutsurveys/>.

⁷ World Health Organization, 'WHO Measles Mortality Review Meeting Report, 22–23 January 2004'.

continued and a new pattern of childhood mortality is emerging. Between 1990 and 2004 the infant mortality rate (per 1,000 births) fell by almost 50 per cent in the countries surveyed: in Bangladesh the rate decreased from 96 to 56; in the Philippines from 41 to 19; in Thailand from 31 to 18; and in Viet Nam it declined from 38 to 17. These countries were not outliers or exceptions in any sense from the overall rapid decline within the region (as shown by the plot of IMR decline in the East Asia Pacific Region as a whole).

Figure 1: Decrease in infant mortality rate (IMR) 1960 to 2004 by country surveyed and East Asia and Pacific Region

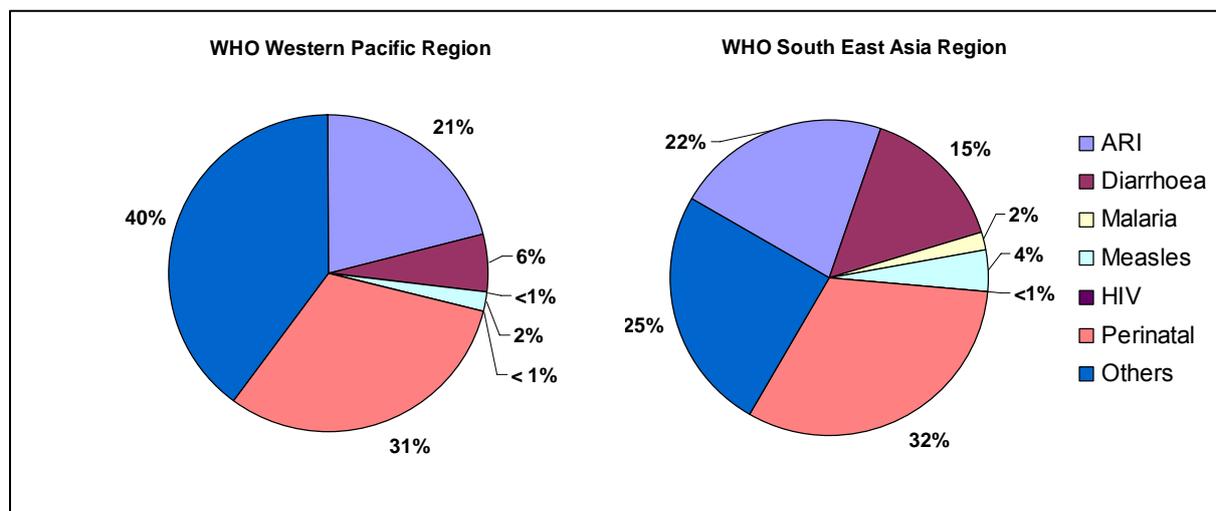


Source: World Bank; UNICEF, *The State of the World's Children*, various years.

Current estimates

Despite these limitations, the immediate need for the best available data, albeit with limitations, has made proportional mortality estimates the gold standard. The most recent version for Asia, from the World Health Organization (WHO), is presented in figure 2. The charts are very similar, with infectious and non-communicable causes accounting for between 75 per cent (South East Asia) and 60 per cent (Western Pacific). Neither lists injury, a component of the category listed as 'other'. They list causes of mortality for children under five years of age with no information for the rest of childhood, between five and 17 years.

Figure 2: Under-five child mortality estimates, WHO Western Pacific Region and South East Asia Region (2005)



2 ASIA HAS CHANGED BECAUSE OF THE CHILD SURVIVAL REVOLUTION

A great deal has been accomplished in the three decades. The rapid decline in child mortality is an indicator of progress in the child survival revolution and evidence of the development of the country-level public health capacity necessary in order to make real health gains.

Initial efforts to create the global infrastructure for delivering vaccines to children living in the most remote parts of the world involved significantly increasing the numbers of trained logisticians as well as a variety of public health practitioners who formed the necessary cadre for intracountry expansion of the child survival programme. This was bolstered by the concurrent expansion of intervention programmes for diarrhoeal disease, respiratory disease and better nutrition. By the late 1980s, the international health community had developed a systematic framework for addressing childhood mortality. This included the establishment of the Commission of Health Research for Development, which fostered programmes for Essential National Health Research, formalizing the development of public health expertise at the national level in LMICs. Since that time, additional capacity development endeavours have been undertaken through the Global Forum for Health Research. All of these activities contributed to the capacity necessary to sustain the falling rates of child mortality in LMICs and provided the necessary local capacity to undertake the surveys in this report.⁸

⁸ Rudan, I., et al., 'Gaps in Policy-Relevant Information On Burden Of Disease In Children', op. cit.

Asia is a far different place today than it was in 1974 when the need for child mortality estimates was first addressed. Reliable data was not available and the infrastructure for gathering it was non-existent. This necessitated a dependence on statistical approaches that have formed the basis of child mortality estimates needed for the child survival revolution. Today, sufficient infrastructure exists within the LMICs in Asia to allow population-based surveys counting deaths at the household level to be undertaken, demonstrating that direct measurement of child mortality is now possible. The direct counting method covers childhood comprehensively and provides a more complete picture of child mortality.

3 COMMUNITY SURVEY METHODOLOGY

To be successful, direct measurement at the community level requires large sample sizes that are representative of the country. These requirements have been seen as impossible to achieve in the past, and hence the reliance on proportional mortality estimates. However, if direct measurement is now achievable, it offers significant advantages, such as counting non-fatal events as well as deaths; counting them in all population age groups (not only in children under five, but in all stages of childhood and adults as well); and obtaining risk factor information associated with the events which allows intervention planning. These issues are discussed further below.

Rare events require large sample sizes to measure

Large sample sizes are needed to characterize injury by type in the narrow age intervals required to design successful interventions. While injury is a leading cause of death in childhood after infancy, a death from any cause is a statistically rare event. Sample sizes need to be large enough to provide the power to discriminate causes of death in the categories needed: deaths by age, sex, type and urban/rural location. Characterizing injury by these relatively narrow dimensions is necessary because the causes – and hence the prevention – differ for each. At the relatively low rates of child mortality in Asia, achieving this level of detail demands sample populations approaching 500,000 respondents. Table 1 shows the average numbers of households visited to find one death from any cause in a child according to the age of the child and the survey.

Table 1: AVERAGE HOUSEHOLD VISITS NEEDED TO FIND ONE CHILD DEATH, BY LOCATION OF SURVEY

	Age	Viet Nam	Bangladesh	Thailand	Philippines	Jiangxi, China	Beijing, China
Households visited per each death identified	0–17	386	118	254	188	1,177	4,012
	Under 1	2,077	179	344	395	7,693	14,042
	1–4	2,250	619	3,298	766	3,031	28,084
	5–9	1,227	1,462	3,853	1,773	4,546	–
	10–14	1,688	3,090	4,770	2,153	11,112	28,084
	15–17	3,857	4,132	3,853	2,206	12,501	9,361

Source: Authors' calculations based on individual survey reports.

Large sample sizes are not costly when using the local capacity

Direct measurement of the causes of child deaths had been suggested before. However, the conventional wisdom was that it would be too expensive because of the rarity of child deaths and the need for extensive external assistance to make up for the lack of local capacity. The experience of these surveys has proved otherwise. In a ‘globalizing world’, emerging markets are drawn on because of low labor costs. This is as true for the public health sector as it is for garment and shoe manufacturing. In addition, local input into reducing childhood deaths over the last 30 years has resulted in the development of a large home-grown capacity in public health.⁹ The national and subnational surveys detailed in this series have drawn on both kinds of resources to achieve their goals.

The first survey was carried out in Viet Nam through the Hanoi School of Public Health, the nation’s first modern, multidisciplinary school of public health, established in the mid-1990s. The core technical specialties needed for conducting national health and injury surveys – demographics, epidemiology, biostatistics, logistics, health administration, health economics and communications and behavioural sciences – were all present. The costs associated with the technical aspects of the survey were subsequently far less than drawing on external sources.

The subsequent five surveys reported here all used the basic methodology developed in Viet Nam. With each survey, the methodology evolved, with increased sample sizes, addition of injury risk factors, economic costing, and nested case-control and qualitative studies. These additions were made possible by the low costs of the surveys.

Table 2 presents the approximate field cost of each survey, including training, printing of instruments, transport, and data entry.¹⁰ The average cost per household was approximately \$2 and the average survey cost was approximately \$200,000. The variations in costs were related to transport and labour costs, where geography and macroeconomic factors were the main determinants. All figures are unadjusted dollars, spent in the years indicated, and the costs were shared between TASC and the individual UNICEF country office.

Table 2: Field costs of each survey

Country/Province	Year of fieldwork	Households in sample	US dollars (US\$)	Cost per household (US\$)
Viet Nam	2000	26,733	85,000	3.18
Bangladesh	2003	171,366	125,000	0.73
Thailand	2003	100,179	175,000	1.75
Philippines	2003	90,466	150,000	1.66
Beijing, China	2004	28,084	225,000	8.01
Jiangxi, China	2005	100,010	400,000	4.00

Source: Authors’ calculations based on individual survey reports.

The costs are considerably less than the current population-based surveys that are designed to provide trends in child health indices, such as the Demographic and Health Surveys. Most

⁹ The Global Forum for Health Research, www.globalforumhealth.org. Accessed 4 December 2006

¹⁰ Unless otherwise indicated, all costs presented in this paper are in US dollars.

DHS surveys cost several million dollars each with costs per household in the hundreds of dollars. The surveys described in these papers feature much larger sample sizes which allow direct measurement of mortality. The survey methodology has been standardized to achieve one major goal, which is to allow direct comparison of results from the different countries surveyed.

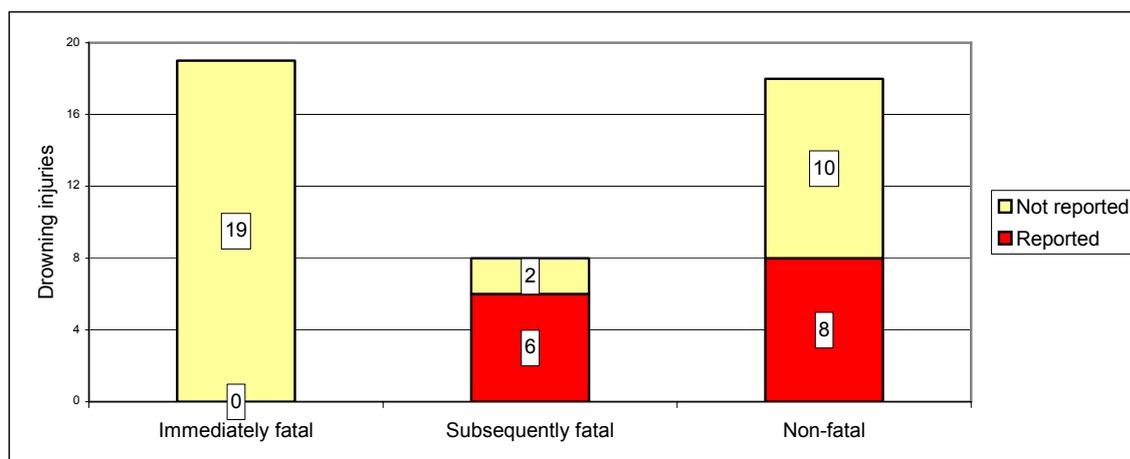
A second goal has been to develop the methodology to make it sufficiently extendable and scalable to be incorporated into census and inter-censal subsamples. These are done at five-year intervals in most countries, and incorporating the survey methodology would allow for a low-cost way of dividing the crude mortality rate of all causes obtained by the census into cause-specific mortality. This would provide health policymakers with key trend information regarding child deaths by cause, with additional information on serious morbidity and associated risk factors. This is further detailed in the second paper in the series, Survey Methods (IWP 2007-05).

Most deaths occur in the community and not in hospitals. Deaths occurring in or known to hospitals and health facilities are fundamentally different.

It was anticipated that the rates, proportions and patterns of injury would be different when measured in the community compared with measurement in hospitals. Nonetheless, the magnitude of the difference was astonishing. Hospital or clinic-based national information systems grossly underestimate the true burden of injury in developing countries, especially for children. The surveys showed that issues of access biased the reported data, as had been expected. What was surprising was the finding that many immediately fatal injuries were never reported even when there were facilities in close proximity and families had the means to pay any fees.

In the case of Bangladesh, less than 10 per cent of cases were seen at government health facilities for some injury types. For most child injuries, well under half the identified cases were seen in government health facilities. Similar findings were present in all the national-level surveys. The data reflect a very strong survival bias: to be seen at the hospital requires that you survive long enough to be admitted to the hospital. The data from Thailand in figure 3 clearly demonstrate this.

Figure 3: Child drownings, reported and non-reported, in the Thailand national survey 2003



Source: Authors' calculations based on Thailand National Injury Survey (2003)

Within the Thai survey (100,179 households, 389,531 respondents), there were a total of 45 child drownings and near drownings (27 fatal and 18 non-fatal) recalled over the previous three years. Less than one quarter of the fatal drownings (six subsequently fatal, 22.2 per cent) were reported to a hospital. Of the immediately fatal drownings none were reported to a hospital. These represented over two thirds of all fatal drownings (19 of 27, 70.3 per cent). Respondents also reported that a quarter (two of eight, 25 per cent) of non-immediately fatal drownings (survival of at least 24 hours before dying) were never reported to a hospital. In addition, less than half (eight of 18, 44.4 per cent) of non-fatal drownings were reported to a hospital.

These findings were representative of each country surveyed. In Bangladesh, drownings were virtually never reported to a hospital or alternative institution for inclusion in the health information system. This single cause of death from injury accounts for about half of all child deaths from injury in the 1–17 year age group, and the lack of reporting is the fundamental reason for the relative invisibility of drowning within the national health systems in the countries surveyed. For the countries surveyed, injury surveillance systems relying on hospital reporting or other health service delivery points for the health information systems greatly underestimate drownings, and consequently the total of all child deaths from injuries.

This local phenomenon has enormous implications for the issue of child mortality at the global level as well as for the estimates of child mortality cited from the WHO. The invisibility of drowning at the regional and global levels is a consequence of the composition of the reporting system. The WHO global disease database is made up of reports from the health ministries of member countries of the World Health Assembly. The local systems that are blind to the exclusion bias for drowning are the primary sources of the national reports making up the WHO database, and it is the WHO database that is one major input into WHO child mortality estimates.¹¹

¹¹ Bryce, J. et al. and the WHO Child Health Epidemiology Research Group, 'WHO Estimates of the Causes of Death in Children', *The Lancet*, vol. 365, no. 9465, March 2005, pp. 1147–1152.

Focus on mortality in the previous data

While mortality is measured by dichotomous outcomes, i.e. being alive or dead, morbidity is much more challenging to assess due to its variation in severity. It has a continuous distribution of severity: from insignificant bumps or bruises, through increasing severity resulting in loss of school or employment, the need for ambulatory medical care, hospitalization for major surgery, and the most severe level of permanent disability. This spectrum renders injury morbidity very difficult to define and measure in a standardized way across populations.¹² This is the primary reason why indicators of child health available at the regional and global levels have traditionally utilized mortality measures.

Comparative measurement has been addressed in the surveys through the use of indicators defining the severity of an outcome by the resulting economic or social cost – the loss of school days or work, number of days hospitalized, and the expenditure of resources as a result of the injury. This is not an ideal scheme as the outcomes are confounded by factors related to the measures themselves (e.g. for there to be hospitalization, the hospital has to be accessible and different levels of accessibility mean a varying impediment to this measure). However, it is a practical response to a complex issue that is of paramount importance and allows the issue to be considered, however imperfectly, rather than ignored. Ultimately, most questions of variability are related to infrastructure and economic development. While most evident in LMICs, they are also equally present in rich countries and addressed under the rubric of access and inequity.

The difficulties inherent in injury morbidity measurement are separate from its impact on child health. These country and provincial level surveys have shown that the social and economic burden of serious and severe injury morbidity far outstrips that of fatal injury. In addition, they show that differences in the socio-economic burden of injury can be vast depending on whether it resulted in the loss of a day of school or whether it caused permanent disability.

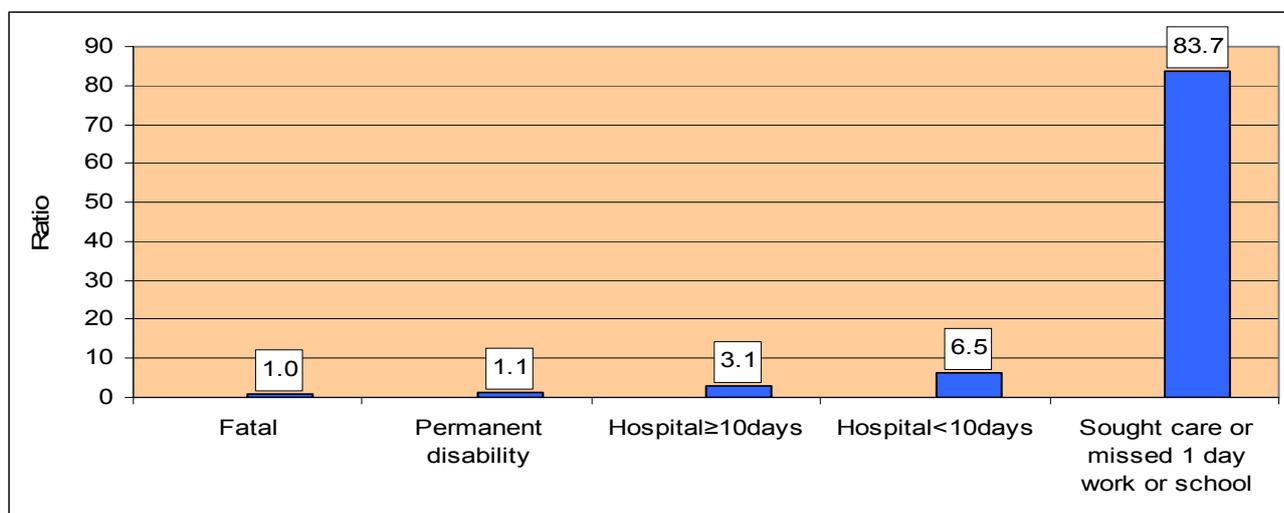
Using the Jiangxi Injury Survey, for example, the proportion of children moderately injured (losing one day of school) was 75 times greater than those permanently disabled.

A separate report (Innocenti Working Paper, forthcoming in 2008) details the economic costs of the injuries in Jiangxi Province, China, as well as the association of injury and poverty. However, the issues involved do not require precise data here to be appreciated. It is clear that injury has enormous costs. The medium levels of severity, with associated hospitalization

¹² Bartlett, S. N., 'The Problem of Children's Injuries in Low-Income Countries: A review', *Health Policy and Planning*, vol. 17, no. 1, 2002, pp. 1–13.

and treatment costs place a substantial economic burden on the family. However, these costs are time-limited as the child recovers, even when the rehabilitation period is quite lengthy.

Figure 4: Ratio of non-fatal to fatal injury, by degree of severity, Jiangxi Province, China 2005



Source: Authors' calculations based on Jiangxi Injury Survey (2005).

The highest costs, social and economic, are associated with permanent disability. The lives of these children are profoundly altered, often with severe economic consequences for their families. The surveys defined permanent disability as loss of a physical sense (sight, hearing), loss of mobility (loss of arm, hand, leg or foot) or loss of the ability to speak. It did not include emotional or psychiatric causes because of difficulty in measurement. The classification of permanent disability as 'severe' is due to the extraordinary social and economic cost associated with permanent disability (see figure 4 for severity ratio in injury).

Data from the Jiangxi survey demonstrate the burden of permanent disability attributable to injury, by type. The gender-specific rates highlight the distinct pattern according to injury type (see figure 5).¹³ Three things become immediately apparent:

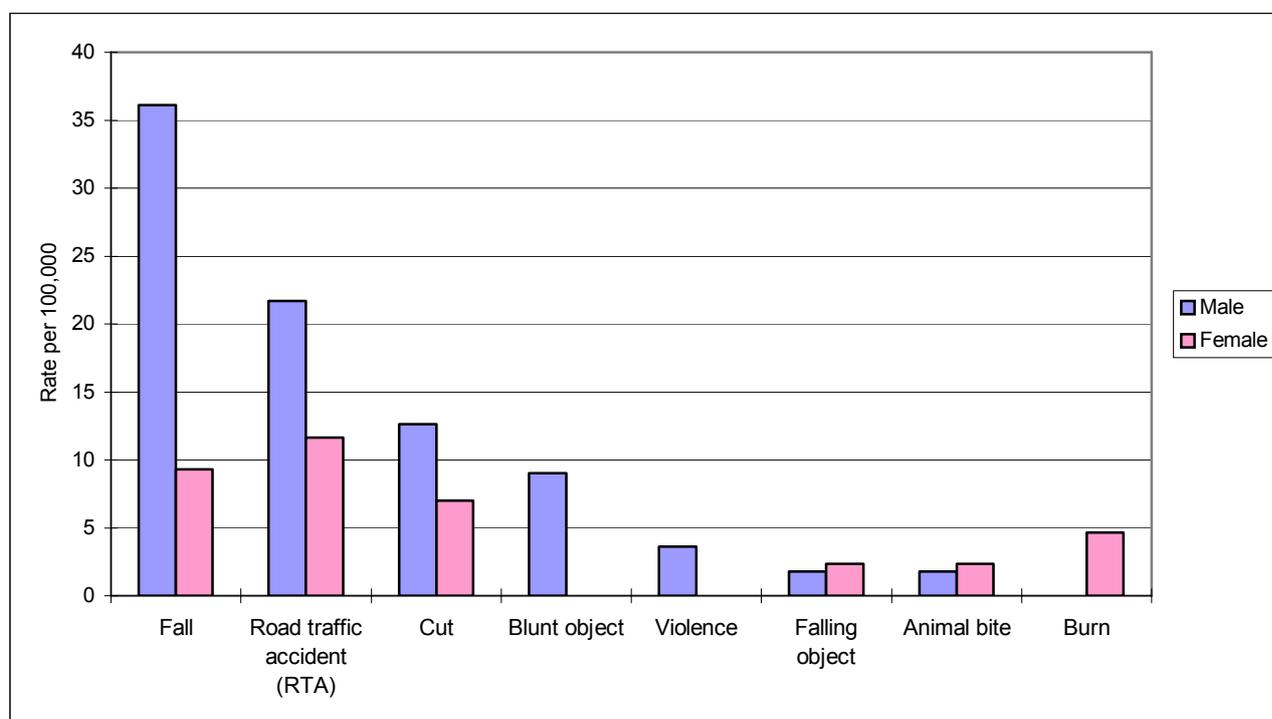
- 1 Falls and RTA (road traffic accidents)¹⁴ account for half of all permanent disability in children;
- 2 Traumatic injuries such as falls, RTA and cuts had high permanent disability rates; and

¹³ Where no male or female rate is shown for certain types of injury it is due either to lack of injuries or to unavailability of information.

¹⁴ 'Road traffic accidents' was preferred to 'road transport injuries' in the countries. Moreover, the acronym RTI has been used for respiratory tract infections as well as reproductive tract infections. For the purposes of this definition, accident means lack of intent.

- 3 Males had higher rates of permanent disability than females. This was seen in all high-frequency categories (falls, RTA, cuts and blunt objects). Burns were the only category with a large proportion of female disability.

Figure 5: Permanent disability in children 0–17 years old, by type of injury and gender, Jiangxi Province, China 2005



Source: Authors' calculations based on Jiangxi Injury Survey (2005).

4 CHANGING EPIDEMIOLOGIC TRENDS

The bulk of proportional cause mortality research was done in the mid-1980s, and under-five mortality rates (U5MR) have been over 40 per cent less on average in the last 15 years since then – a child's lifetime. It is no surprise that the surveys presented reflect the rapid development of the region and highlight the change that has occurred over the past three decades.

At least two potential explanations exist for the differences between the estimates of death produced by modelling techniques described above and those produced in this set of surveys:

- One mechanism – 'replacement mortality' – would suggest that as the former leading causes of death have declined, new causes (such as injury) have replaced them. These did not exist before and now exist with the changing patterns that have occurred through the introduction of new risk factors.

- Another explanation – ‘concurrent mortality’ – is that the additional causes now noted and measured were always there, concurrent with the former leading causes of death. The fact that the additional causes of death were not previously observed, even when present, could be due to a variety of reasons: insensitivity of the measurement tools; overshadowing by the other causes of death; or simply that they were not expected and therefore not looked for.

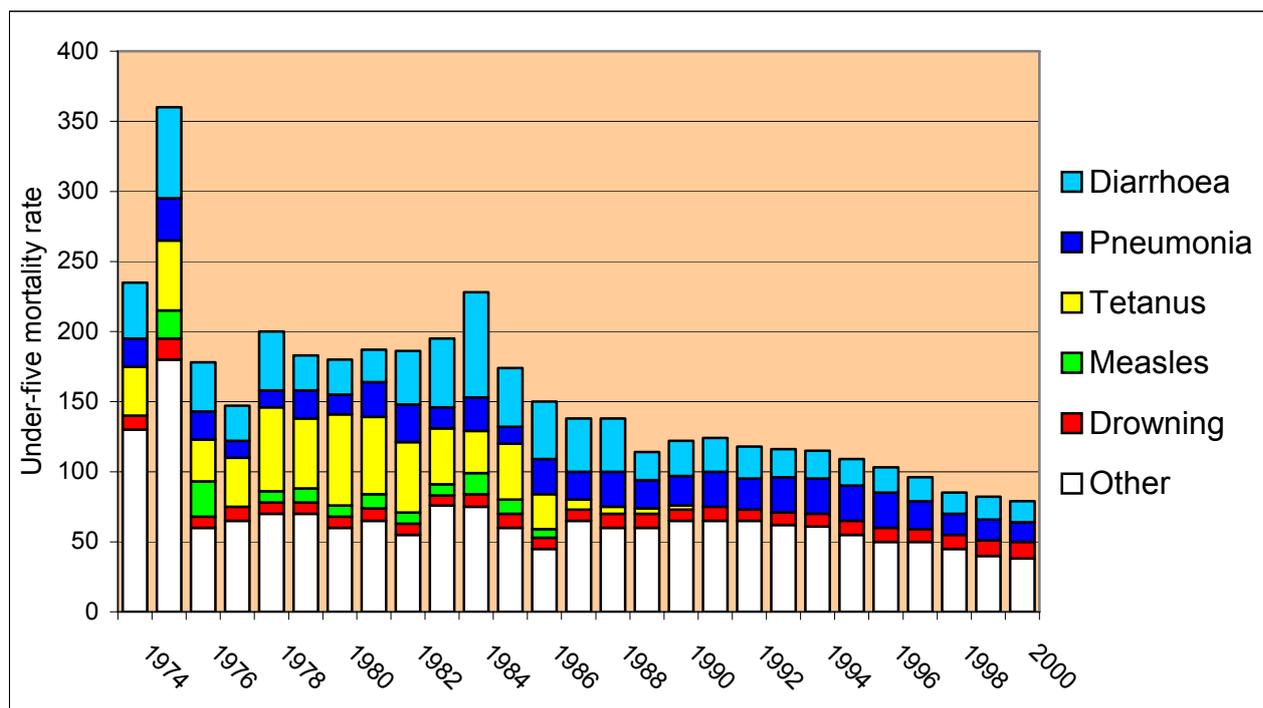
This point is significant because of the changes noted in this rapidly developing Asian region. If child injury is an entirely new phenomenon, not previously existing, then injury as a cause of child death may be unique to the Asian region and not be expected to be present in other regions with similar indices of child mortality.

However, if injury as a cause of child death and serious morbidity was always there but simply not measured, then it is likely that it is a customary part of child mortality generally, whether U5MR is high, as it was in the region previously, or much lower, as it has become in the last three decades. If so, once it is sought out in other regions, it is likely to be found there as well.

This issue can be explored by examining cause of death data for relevant geographic areas that cover a long period of time. The world-renowned Matlab community laboratory in Bangladesh is known for pioneering virtually all of the child survival interventions currently in use. It has operated the Demographic Surveillance System (DSS) and tabulated monthly reports of child deaths by cause since first becoming operational in the early 1970s.

Figure 6 below shows the trend in under-five mortality by cause over the period 1974–2000. It demonstrates that ‘concurrent mortality’ is clearly at work. Drowning has always been a leading child killer from the earliest period recorded in the surveillance system. In the pre-immunization era it killed about the same number of children under five as measles. When measles and other vaccine-preventable causes of under-five deaths were eliminated as significant causes of death, drowning did not increase in absolute numbers. It did, however, rise substantially as a proportion of under-five deaths.

Figure 6: Decrease in under-five mortality rate over time, Matlab, Bangladesh, 1974-2000

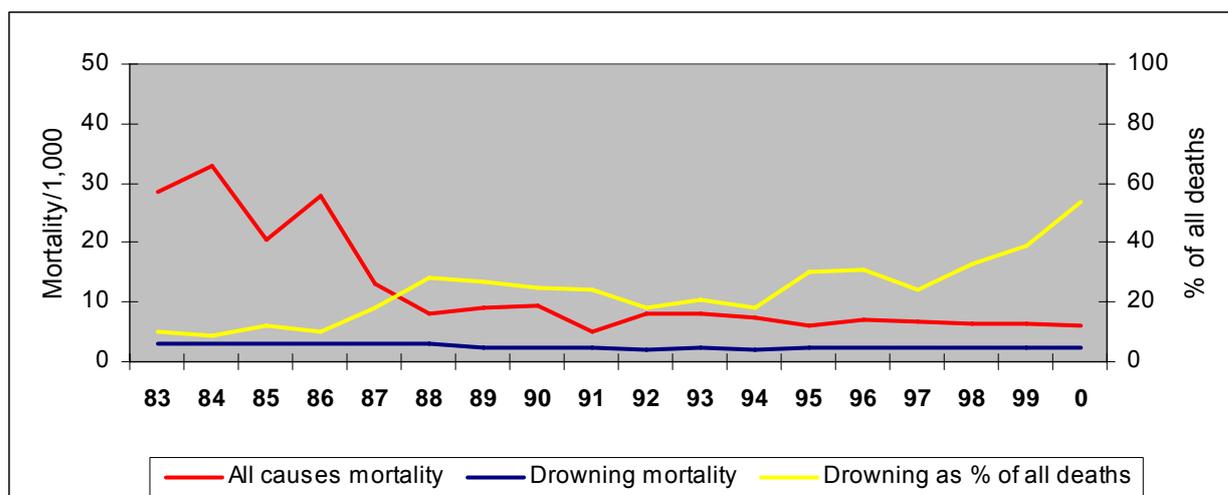


Source: Reports from the International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh, 2003.

Figure 7 below shows the proportional increase in drowning in Matlab over time as interventions have been directed at the other causes of death.¹⁵ Drowning has been the persistent killer in early childhood in Matlab from the inception of the surveillance programme. This is indicated by the blue line on the chart, which shows the drowning mortality rate. As other causes of mortality have decreased due to effective interventions, the relative proportion of drowning mortality has increased, as shown by the yellow line. While it was responsible for 9 per cent of deaths in 1–4 year olds in 1983, it claimed 53 per cent in 2000.

¹⁵ 'The Emergence of Drowning as a Principal Cause of Childhood Death in Bangladesh', ICDDR, B (International Centre for Diarrhoeal Disease Research, Bangladesh) Periodicals, *Health and Science Bulletin*, vol. 1, no. 1, November 2002.

Figure 7: Proportional mortality by cause in 1–4 year olds, Matlab, Bangladesh, 1983–2000



Source: Reports from the International Centre for Diarrhoeal Disease Research, Dhaka, Bangladesh, 2003.

Given this clear picture from Matlab, the emergence of drowning as a leading cause of death in the countries surveyed is most likely explained by the insensitivity of previous methods of measurement, and an inability to recognize the importance of the drowning deaths combined with the changing epidemiologic pattern of child mortality. Thus, it is probable that the same phenomenon is occurring in other regions of the developing world such as Latin America, the Middle East and Africa.

Changing patterns bring a change in association

One of the most striking findings of the research is that death rates and changes in death rates appear disconnected from economic development. The countries in the sample represent a spectrum of GDP measures, often used as a major proxy measure of development. Bangladesh, with a GDP per capita of \$400 in 2003, the year of the survey, was the lowest. Thailand, with a GDP per capita of \$2,190 in 2003, the year surveyed, was the highest. Despite the fivefold difference in GDP across the countries surveyed, there is clear convergence in their epidemiologic patterns – from poorest to richest. This suggests the epidemiologic transition marking the shift from infectious to non-infectious mortality has already occurred throughout the region.¹⁶ There is widespread corroborating evidence from a range of sources, with classic harbingers such as childhood obesity and non-insulin dependent diabetes mellitus diagnosed in late childhood with increasing frequency.¹⁷

¹⁶ Salomon, J. and C. J. L. Murray, 'The Epidemiologic Transition Revisited: Transitional models for causes of death by age and sex', *Population and Development Review*, vol. 28, no. 2, June 2002, pp. 205–228.

¹⁷ Deen, J. L. et al., 'Injuries and Noncommunicable Diseases: Emerging health problems of children in developing countries', *Bulletin of the World Health Organization*, vol. 77, no.6, 1999, pp. 518–524.

As infectious diseases diminish in significance as causes of child death after infancy, the countries surveyed are showing the classic pattern of the compression of mortality in infancy to be concentrated increasingly within the neonatal period. Coale and Demeny identified this as the hallmark of the transition to new epidemiologic patterns associated with injury and non-communicable diseases predominating in childhood in their classic study which quantified this trend as different European regions developed.¹⁸

5 EXAMINING THE FULL SPAN OF CHILDHOOD

A significant feature of the previous estimates of child mortality is that they addressed only the first five years of childhood, less than a third of the total, excluding the remaining 12-year period. This was due to practical limitations of the methodology. However, it had unintended consequences which can be seen in the findings of surveys which cover all of childhood, from birth to 17 years.

Rapidly changing causes of death over the first five years of life make it misleading to treat the five-year period as a single stage

The category of “children under five” is insufficiently specific to guide policy in relation to child mortality. The first five years are in fact two distinctly different stages, infancy and early childhood, each with its own characteristic epidemiology. This is a key issue as prevention programmes differ according to causes.

Figure 8: Proportional mortality of children under five, all surveys

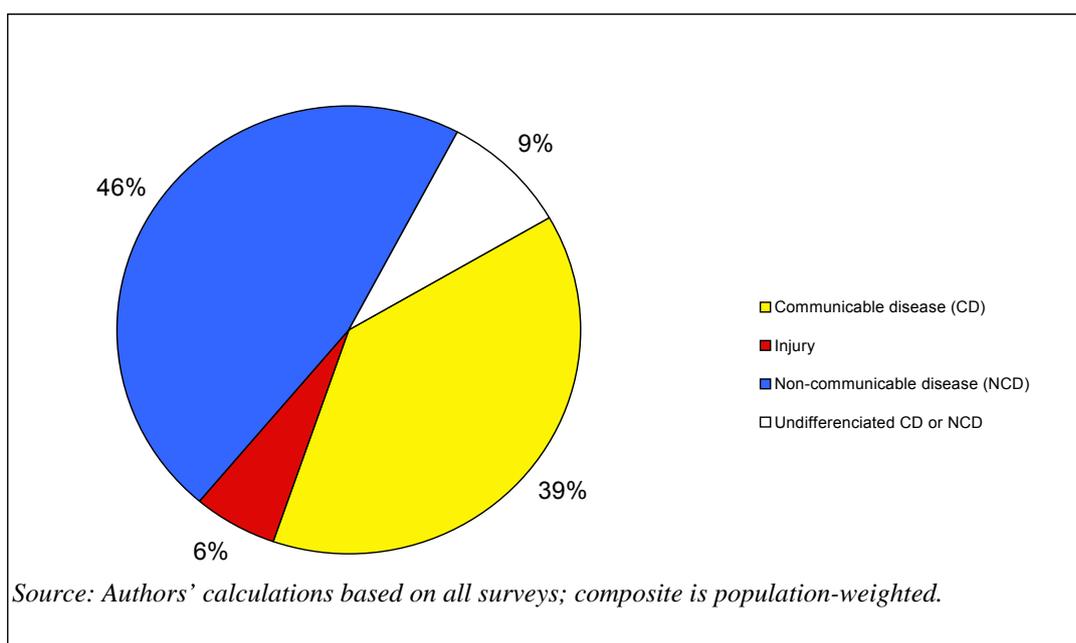
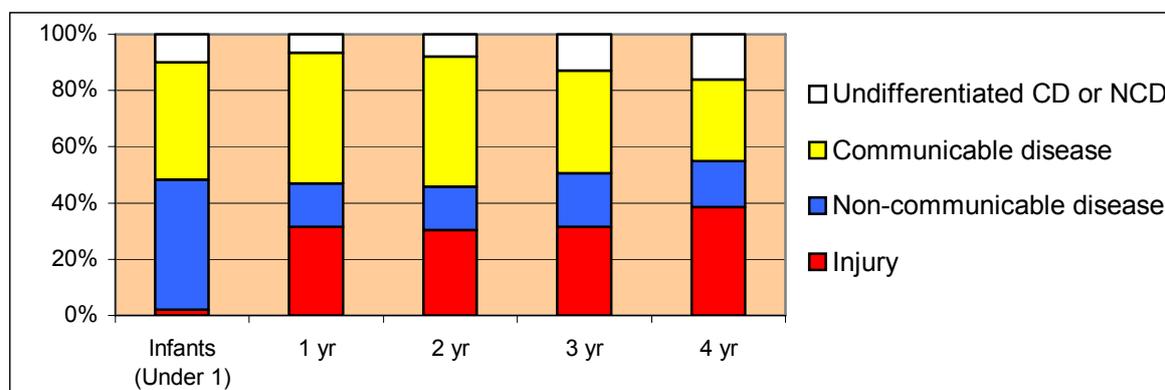


Figure 8 shows a composite of all under-five deaths found in all the surveys presented, by major cause categories. Injury causes 6 per cent of all under-five deaths and appears to be much less a factor in child mortality than communicable or non-communicable diseases for the five-year period measured.

¹⁸ Coale, A. J. and P. Demeny, with B. Vaughn, *Regional Model Life Tables and Stable Populations*, 2nd ed., Academic Press, New York, 1983.

However, quite a different picture emerges when the all-inclusive under-five category is divided into the actual age and developmental intervals that constitute the broad category, as seen in figure 9.

Figure 9: Proportional mortality of children under five by age, all surveys



Source: Authors' calculations based on all surveys; composite is population-weighted.

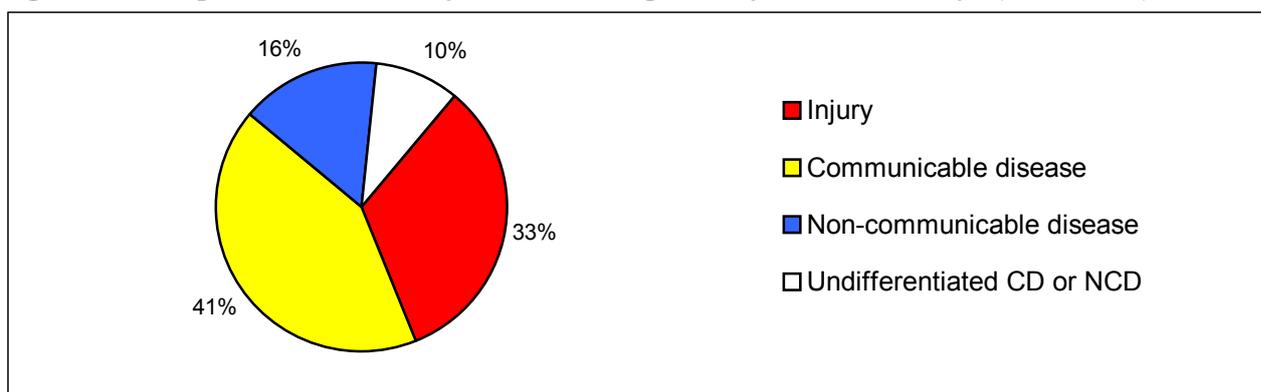
The rates and patterns of the main causes of child death change rapidly over the five-year period. Infancy is epidemiologically distinct from the four years following because the majority of infant deaths occur in the first month of life. These deaths, termed neonatal deaths, are mostly related to the pregnancy, birth and the immediate aftermath. Neonatal deaths only occur in infancy, and do not repeat in later years. Infancy is also unique in childhood in that the child, not being able to walk, is kept particularly close to the caregiver, who is a protective influence. Thus, infancy is a singular period of life, when the leading causes of death relate to events that do not occur again (pregnancy and childbirth), and when the child is also likely to be uniquely protected from injury as a cause of death.

In beginning to walk (on average at the first birthday), the child starts to determine its own environment, and throughout the rest of early childhood, injury is a major cause of death. Lumping all ages and all causes into one classification category of under-five mortality masks this fundamental epidemiologic issue.

Proportional mortality models are unable to refine the characterization of child deaths into cause of death by each year of life because the necessary data are unavailable. The surveys reported here provide these data for the first time and unmask the unrecognized epidemiology of mortality in early childhood after infancy. They clearly show the causal importance of injury in this crucial early development period of childhood: 'toddlerhood'.

With this divide clearly shown, it is possible to look at this period of 'toddlerhood', at children aged one through four years (see figure 10). Here, there is a sharp increase in deaths due to injury, accounting for 33 per cent of all deaths.

Figure 10: Proportional mortality of children ages 1–4 years, all surveys (2000-2005)



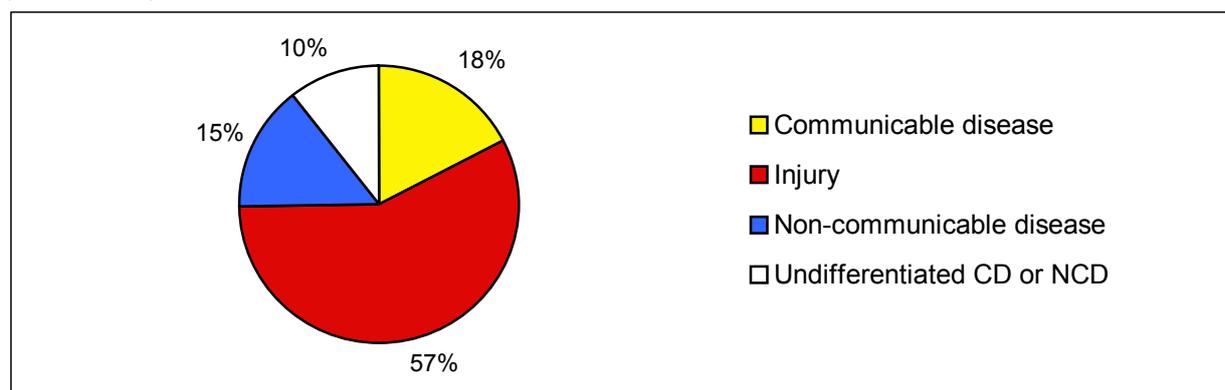
Source: Authors' calculations based on all surveys; composite is population-weighted.

Of equal significance to the unique epidemiology of infancy is the finding that almost all (>90 per cent) of the injury deaths were attributed to a single cause: drowning. The identification of this problem permits public health intervention to begin. This is also true for infants (under age one), since almost all of the injury to this group was caused by asphyxia – either drowning or suffocation. Both are preventable causes, as has been conclusively proven over the last 50 years in developed countries.

If current child mortality estimates include only the first five years of childhood, a large number of child deaths are excluded

While current child mortality estimates stop at age five, the six surveys discussed here were able to show the causes of death of children throughout childhood, in the middle and adolescent portions as well as the first five years. Following the Convention on the Rights of the Child, the surveys used the definition of childhood as infancy through 17 years. The causes of death in the children who were five years and older are seen in figure 11, which shows that well over half of all deaths are caused by injury in these children, previously unrepresented in child mortality estimates.

Figure 11: Proportional mortality of children aged 5–17 years of age for all surveys (2000-2005)



Source: Authors' calculations based on all surveys surveys; composite is population-weighted.

The principal indicator of child mortality, the under-five mortality rate (U5MR), cannot address the deaths of any children aged 5–17

About one-half of all child deaths (0–17 years) occur after infancy (0–1). About half of these occur after the age of five years. Yet the under-five mortality rate (U5MR) remains the single most important yardstick of child health in global discussions of development. As shown by the surveys, the under-five mortality rate masks very important prevention issues even for the small child in the 1–4 year age group.

The U5MR was selected as a key child health indicator, reflecting the period of childhood with the highest mortality rates. A key reason that coverage stopped at the fifth year of life was the technical limitations of proportional mortality measurement methods two decades ago which made it very difficult to measure child mortality in middle and late childhood. Limiting child mortality measurement to children under five was thus a practical response to a difficult technical issue. However, with direct counting of all child mortality, it can be seen that *an exclusive focus on under-five mortality misses a large part of the one-half of child mortality that occurs after infancy*. The surveys show that limiting child mortality estimation to children under five lacks sufficient breadth to be an effective summary indicator of mortality throughout childhood. There is a clear need to develop a more comprehensive indicator for childhood as a single age group, such as a childhood mortality rate (U18MR), where children are defined as aged 0–17 years.

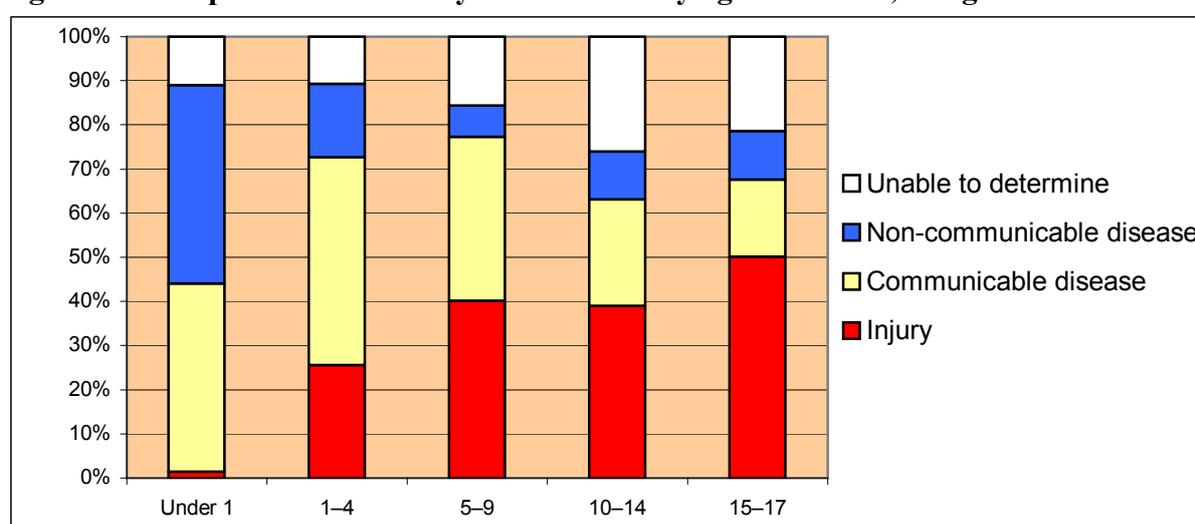
The U5MR measures the probability of surviving the period from birth to the fifth birthday, which ties the death of the child from any cause to the moment of its birth. The denominator for U5MR is per 1,000 live births. It is possible to extend the period to the 18th birthday, creating a U18MR to cover all of childhood using this concept. Alternatively, the U5MR could remain for early childhood, with the addition of a 5–17MR indicator to address the other 12 years of childhood. The combination of these would cover all of childhood. Another

alternative would be to use standard demographic principles to create a childhood mortality rate where the numerator is the number of child deaths from birth to 17 years in a given year and the denominator is the population under 18 years old at the mid-point of the year. Either approach would give the comprehensive measure of all deaths in childhood that programmes currently lack.

Injury risk increases with age

When proportional childhood mortality is analysed by age group and the three broad categories of injury, communicable diseases (CD) and non-communicable diseases (NCD), it becomes clear that injury claims an increasing proportion as age increases. As the example of Bangladesh shows in figure 12, CD and NCD causes dominate infant mortality but steadily decrease as a relative proportion of all deaths in childhood as injury increases.

Figure 12: Proportional mortality in childhood by age and cause, Bangladesh 2003



Source: Authors' calculations from Bangladesh Health and Injury Survey (2003).

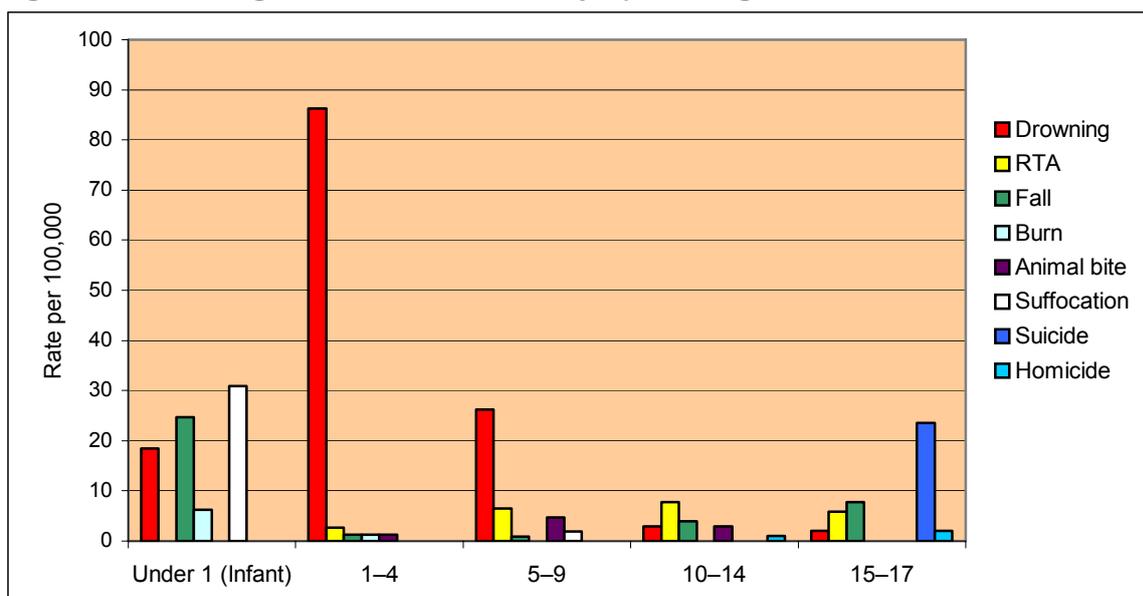
Injury type changes with age

The leading causes of injury death and serious morbidity differ by age group. To fully characterize the different patterns, childhood should be divided into five groups:

- 1 infancy, under age 1;
- 2 'toddlerhood' or preschool; early childhood 1–4 years of age;
- 3 middle childhood 5–9 years of age;
- 4 early adolescence 10–14 years of age;
- 5 late adolescence 15–17 years of age.

These five groups account for the different exposure patterns to external hazards in each group, and consequently, the different patterns of injury epidemiology.¹⁹

¹⁹ This age classification is the standard used in the TASC survey methodology. It is based on the United Nations Statistical Classification and further extended to cover the full span of the childhood as defined by the Convention on the Rights of the Child.

Figure 13: Leading causes of fatal child injury in Bangladesh, 2003

Source: Authors' calculations from Bangladesh Health and Injury Survey (2003).

Figure 13 once again shows the results of the survey in Bangladesh as an example. The same age-specific pattern was found in all the localities, regions and countries surveyed. For infants, the leading cause of death from injury was suffocation. For toddlers (1–4 age group) the overwhelming cause of injury death was drowning (up to 90 per cent). The burden from drowning was so high that it was the leading or a leading cause of death of 1–4 year old children in each survey. Drowning remained the leading injury cause of death in the 5–9 age group, although at a diminished rate. In subsequent age groups, drowning was overtaken by road traffic accidents (RTA), which became the leading unintentional cause of death for children in late adolescence.

The age dependence of injury type is a function of the different exposure to risk at each stage of childhood. Similar patterns can be observed in other regions of Asia surveyed.

- Infants have little exposure to injury as they are protected by their mothers. However:
 - in the first third of infancy, the infant cannot even raise its head to clear obstructions around its nose and mouth. It is especially vulnerable to suffocation from adult overlaying, and most families sleep all together, in one bed;
 - in the middle third of infancy, mothers often begin weaning by introducing hard foods such as peas and beans, not knowing they are choking hazards;

- in the last third of infancy, infants begin to take their first steps. Most homes are rural, and lack plumbing. There are buckets and other means of storage filled with water. Drownings predominate in late infancy.
- Toddlers, or preschool children are exposed to hazards in and around the home, where they spend the majority of their time.
 - Most people live in rural areas. Wells, ponds and animal watering troughs are the predominant water hazards and are generally unfenced. Drownings are the overwhelming cause of fatal injury in this age group.
- School-aged children spend increasing amounts of time outside the home, in school and in social activities with peers, and they are exposed to community hazards specific to the environments where they live.
 - There are no school buses and most children walk or ride bicycles to and from school. Pedestrian and bicycle-related RTA deaths are common.
 - Most children cannot swim, but they play in the many ponds and lakes in their areas. Drowning is the most common fatal injury in this age group.
- Adolescents, navigating the difficult transition to adulthood, are exposed to hazards that are a function of their own risk-taking behaviour, with further exposure to violence from themselves and others.
 - Risk-taking commonly involves motor vehicles, especially motorcycles. RTA deaths are the leading cause of unintentional injury.
 - In late adolescence, while bodies are physically developed, brain development lags and inhibitory functions remain underdeveloped. Intentional injury (homicide and suicide) equals or surpasses RTA as a leading cause of fatal injury.

The issue of intentional injury and children

Intentional injury (homicide and suicide) was among the leading causes of death in children in adolescence in most surveys. Experience suggests that household surveys are not ideal for characterizing intentional injury because of the under-reporting of these highly sensitive types of death. The literature on intentional injury highlights the under-reporting bias from non-confidential, single-contact household surveys such as these. Elucidation of an intentional injury death requires privacy, the need for the establishment of rapport and trust between the interviewer and family, and ways of ascertaining intentional injury that ensure confidentiality.²⁰

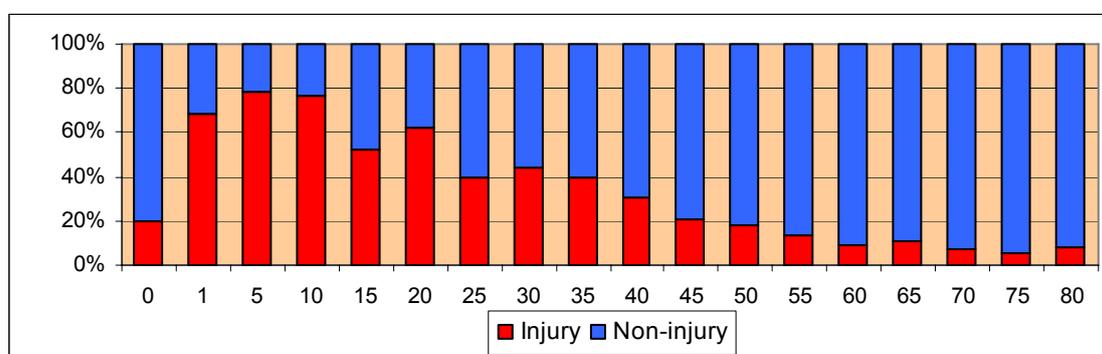
Despite the absence of all the prerequisites for best practice in ascertaining intentional injury in the surveys, it was found to be a leading cause of child death in the adolescent group. This highlights the fact that the figures reported are likely to be significant underestimates of the true magnitude of the problem. While most policymakers do not associate terms such as homicide and suicide with child injury, these surveys have demonstrated that they are real and significant issues with levels ranking among the leading causes of mortality and morbidity for over a third of childhood.

²⁰ Hawton, K. and K. Van Heeringen (eds.), *International Handbook of Suicide and Attempted Suicide*, John Wiley & Sons, Chichester, 2000.

The impact of injury to parents on children

Children do not have to be injured themselves to be the victims of injury. The loss of a father, mother or, most tragically, both father and mother has a devastating impact on a child's future health and social well-being. Figure 14 shows that injury is a leading cause of death for parents during most of the child-raising years. Given children's physical and emotional dependence on their parents, they are affected when a parent is seriously injured. The more serious the injury to the parent, the more serious is the impact on the children in the family. Death and permanent disability in a family always have a severe impact on dependent children, and the younger the child, the greater the ultimate impact. Figure 14 uses Jiangxi Province data to show the general case for injury being a leading cause of death in parental age groups.

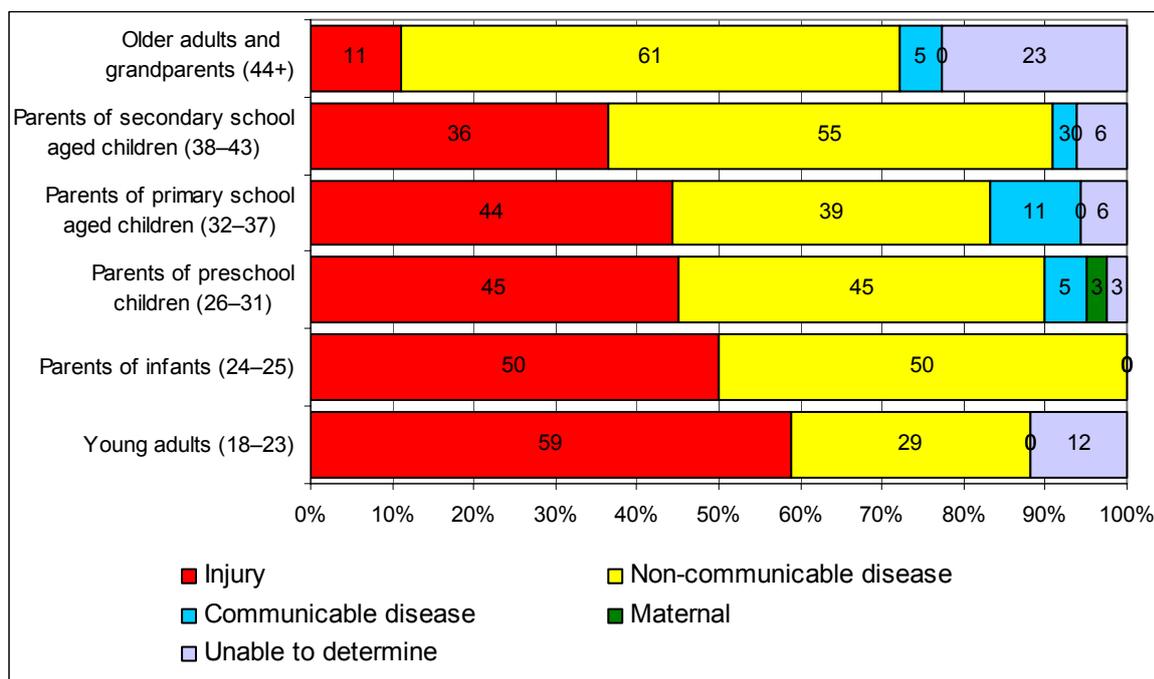
Figure 14: Mortality from injury and non-injury causes, by age, Jiangxi Province, China, 2005



Source: Authors' calculations from Jiangxi Injury Survey (2005).

Because the roles and relationships in all household members are defined at the time of interview in the surveys, it is possible to identify the cause of death for each of the parents and link those to any children residing in the household. Figure 15 shows the different causes of death for parents as classified by the different stages of their children in Jiangxi Province, China.

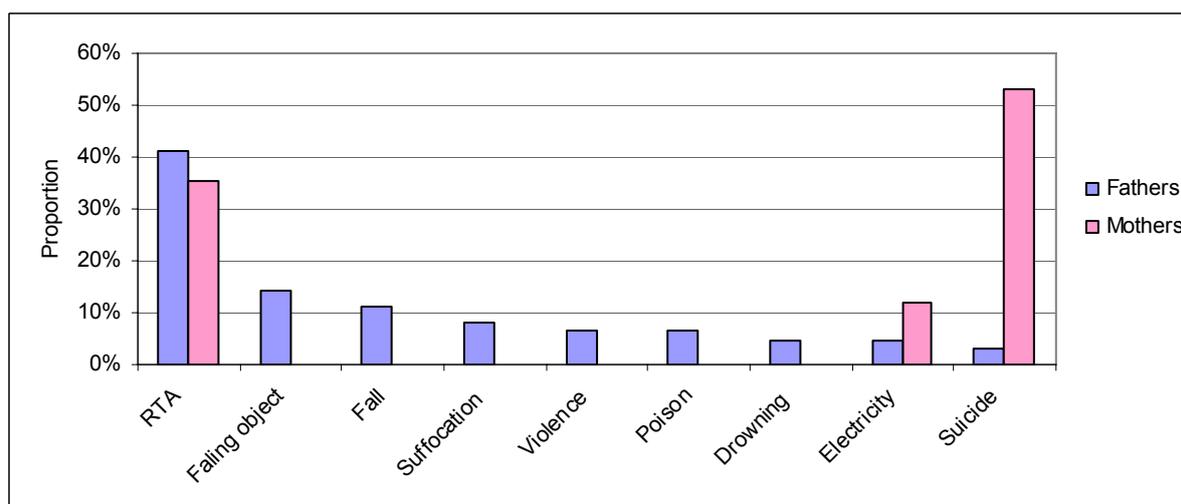
Figure 15: Causes of death among parents by relationship to child, Jiangxi Province, China, 2005



Source: Authors' calculations from Jiangxi Injury Survey (2005).

Injury is the leading cause of death for parents of children from infancy through secondary school. Figure 16 shows the actual causes of death from injury by sex of the parent.

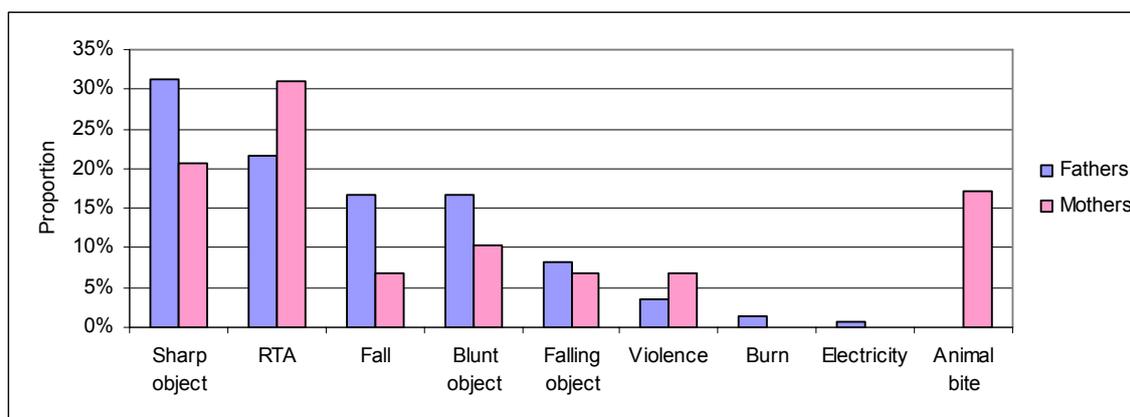
Figure 16: Causes of parental death from injury by sex of parent, Jiangxi Province, China, 2005



Source: Authors' calculations from Jiangxi Injury Survey (2005).

Orphanhood because of injury is extremely common. The leading cause of loss of a parent was suicide. Almost 90 per cent of parental suicides involved the mother. The second leading cause of parental death was RTA, leaving almost equal proportions of paternal orphans²¹ and maternal orphans from injury. Fathers had a broader range of causes of injury death than mothers. Mothers died exclusively from suicide, RTA and electrocution. While the permanent disability of a parent does not leave the children orphaned, it often renders the disabled parent incapable of fulfilling the parental role. In doing so, it can place the health and survival interests of the disabled parent in conflict with those of the children in the family (see figure 17).

Figure 17: Causes of parental permanent disability from injury by sex of parent, Jiangxi Province, China, 2005



Source: Authors' calculations from Jiangxi Injury Survey (2005).

Injury robs children of their parents in large numbers, irrespective of gender and socio-economic status. However, the impact of the loss of the primary caregiver or the primary economic earner is dramatically different depending on the socio-economic status of the family involved. Financially secure families have options unavailable to poorer families. Poor families often cease to exist as a nuclear family when the father is killed or disabled. The health outcomes for infants and young children are markedly poorer when they lose their mother, and are no longer breastfed or cared for. For older children, loss of a mother or father often means that they have to leave school and take on the economic or care-giving role for the family. In either case, whether in early or later childhood, their physical health and continued development are placed in jeopardy.

6 DISCUSSION

As the child survival revolution approaches its 30th anniversary, more and more children live past infancy thanks to its success.²² Communicable and certain non-communicable causes

²¹ 'Injury orphans' are defined using the same definitions as HIV orphans. Loss of a father due to injury results in a paternal orphan, and loss of a mother due to injury results in a maternal orphan.

²² Ahmad O.B., A.D. Lopez and M. Inoue, 'The Decline in Child Mortality: A reappraisal', *Bulletin of the World Health Organization*, vol. 78, no. 10, 2000, pp. 1175–1191.

have been targeted and reduced, so that more children survive longer.²³ These surveys show that injury, not yet targeted, claims a significant share of the 10.5 million annual deaths generally reported in *The Lancet* as occurring in children under five.²⁴ In the Lancet series injury deaths were among the category of ‘other’. The articles in *The Lancet* did not report on those over five, because the current child mortality estimates used in the series do not include children older than four years.. For the Asian countries surveyed and analyzed in this series of working papers, between a quarter and a third of child deaths occurred after the first five years and before adulthood at the 18th birthday. Well over half of these were due to injury.

Injury insidiously undermines progress in child survival by lurking beneath the view of normal public health surveillance mechanisms. A child who benefited from proper antenatal care, whose birth was attended by a trained birth attendant, who was exclusively breastfed during infancy and who was fully immunized at the transition to early childhood may drown: this is a tragedy in its own terms, as well as representing a loss of the full potential benefits – to the child, to the family and to the society – of those earlier health investments. Similarly, if a girl of 10, having attended primary school and progressed to secondary school, dies as a pedestrian struck by traffic on her walk to school, that is both a great tragedy and a loss of the potential represented by the full range of investment made in her by society. In each example the tragedy is compounded for the parents as well in view of the complex interplay of their personal, financial and emotional engagement which must always be taken into account.

Injury is closely related to the respective stage of childhood. In Bangladesh, for instance, the survey found proportional infant mortality from injury was 2 per cent – about one twenty-seventh of those caused by infection and a similarly small fraction of those caused by non-communicable diseases. But beyond infancy, an astonishing 29 per cent of classifiable child mortality in the 1–4 age group was caused by injury. Injury’s share of overall mortality where cause was known increased in every child age cohort studied in Bangladesh, accounting for 48 per cent of classifiable deaths in the 5–9 group, 52 per cent in the 10–14 group, and 64 per cent among 15–17 year olds. Bangladesh was not unique – the same pattern prevailed in each country surveyed.

Most injury deaths in all age groups after infancy were caused by drowning. Because drowning is such a rapid cause of death, the surveys found that victims were almost never brought to a hospital. Therefore the cause of death went unreported in health statistics. This renders them invisible in most health information systems in developing countries, which rely on health facility reporting because of a lack of vital registration systems. Most of these deaths are preventable with simple, inexpensive, low-technology interventions. They represent a significant lost opportunity for reduction in child deaths from a cause which is a

²³ UNICEF, 'Progress since the World Summit for Children: A statistical review', UNICEF, New York, 2001, http://www.unicef.org/publications/files/pub_wethechildren_stats_en.pdf.

²⁴ Black, R. E., S. Morris and J. Bryce, 'Where and Why Are 10 Million Children Dying Every Year?' *The Lancet*, vol. 361, no. 9376, 2003, pp. 2226–2234.

leading killer in early childhood after infancy, continuing into middle and later childhood. This involves a substantial number of child deaths, as the numbers of children dying after the age of five is similar to the numbers dying after infancy and before five.

In all the countries surveyed, injury is the leading cause of child death after infancy. None of the countries surveyed had significant intervention programmes in place to target this cause of death. The scope of injury across all the developmental stages of childhood and the magnitude of the numbers involved are powerful arguments for its inclusion in under-five child survival programmes and its addition to the programmes for those aged between five and 17.

The evidence provided by the surveys demonstrates that directly counting child mortality is practical in Asia (and highly likely to be practical in most LMICs elsewhere). This new method covers all of childhood, providing a more complete and more comprehensive picture of child mortality than the proportional mortality method. When used in conjunction with a national census or intercensus, it would be a sustainable mechanism for ongoing measurement of child mortality which captures under-fives and older children, provides morbidity information as well as mortality and paints a more precise picture that can be used with confidence when generating trend data. The enormous progress made in capacity and infrastructure development as a consequence of three decades of the child survival revolution has made these direct mortality and morbidity surveys possible. Coupled to the already developed and funded capacity for the national census or intercensus in a country, they would provide a low-cost way of developing the needed information to follow trends in causes of mortality, as well as additional data on morbidity and risk factors. Using data on child mortality collected in this way would inform policy-makers about all child deaths, with complete information on all causes. The current mechanism informs them on children under five years, and misses drowning, which is the leading single cause of death after infancy.

A number of methodological lessons related to the measurement of injury mortality and morbidity warrant elaboration. The experience of the surveys highlights the importance of large sample size, long recall periods and standardized definitions for morbidity. However, virtually all the available research on child injury in LMICs exhibits small sample sizes (often fewer than 500 children in total), uses short recall periods (often less than one month), has different definitions of severity for non-fatal injury (often measured in a subjective manner), and usually uses 14 years as the upper limit of childhood (often lumping several developmental ages together). This may explain why the current literature has failed to provide the evidence base for child injury to be included in proportional causality models. The surveys also found that the most significant underestimates correspond to the more severe levels of injury, with injury causing permanent disability and death the most underestimated. This is a possible reason why injury has seemingly been overlooked in past causality models, even when community-based surveys were considered when developing statistical models.

Looking beyond the technical estimation of child mortality, these lessons may explain the lack of visibility for child injury at the policy level in national and international institutions. Insufficient statistical power is a technical explanation often overlooked by health policymakers. Most health policymakers have little or no technical training in epidemiology. To most, the absence of evidence for fatal injury in early child mortality would be evidence that it was absent and not a reflection of insufficient statistical power or a facility bias. The policies of the past 30 years, with injury excluded from child survival programmes, seemingly are testimony to this.

Another policy of the child survival revolution has been a focus on measurement. It has served policymakers and programme implementers well, and has guided the stepwise introduction of each of the major interventions, such as oral rehydration therapy, immunization and prevention of acute respiratory infections (ARI). Along with the proportional mortality estimation of child deaths, a related measure, the under-five mortality rate (U5MR) has been a key metric in the revolution.

As a key child indicator the U5MR reflects events in the period of childhood with the highest mortality rates. However, an exclusive focus on U5MR misses a large part of the one-half of all child mortality that occurs after infancy. Can the death of a six year old child be any less important to count than that of a four year old child? The answer clearly is no. The surveys show that limiting child mortality estimation to children under five does not represent an effective summary indicator of mortality throughout childhood. There is a clear need to develop a more comprehensive indicator for childhood as a single age group, such as a childhood mortality rate or U18MR, where children are defined as aged 0–17 years.

The surveys themselves constitute injury interventions at the national level and have been potent agents of policy change. Sample size requirements mean that the injury surveys have been the single largest national health surveys ever undertaken in the countries concerned (other than China). Since they show the relative proportion of each age group dying from injury compared to communicable and non-communicable disease, the data effectively communicate key general health policy issues. In each country where the surveys have been done, the government has made a significant commitment to injury reduction, especially among children. Often, this has been due to the involvement of the UNICEF country office, which has multiple counterparts in the different social and health sectors and has used the survey to advocate across sectors.

Innocenti Working Paper

**CHILD MORTALITY AND INJURY IN ASIA:
SURVEY METHODS**

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Special Series on Child Injury No. 2

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1 INTRODUCTION

The surveys presented in this series of papers show that for children in Asia, mortality and morbidity from injury is far more common than had been previously known. The first paper, IWP 2007-04, reviewed the methodology of the current estimates and limitations inherent in them. It also briefly described the alternative methodology used in the surveys presented in these papers, which is the direct measurement and classification method.

This paper presents the direct measurement and classification method in greater detail. The paper addresses various statistical and epidemiologic issues related to the surveys. Therefore it has a more technical orientation than other papers in the series. Every attempt has been made to keep the presentation and discussion sufficiently broad and accessible to generalists interested in this paper. Technical specialists in epidemiology and other readers interested in further detail are directed to the full reports on the individual surveys available through the UNICEF country offices concerned and at the TASC website at <www.tasc-gcipf.org>.

2 BACKGROUND

Present estimates

The standard method used to measure child mortality in low-and middle-income countries (LMICs) first determines the total number of children under five years old dying from all causes. Then, it allocates mortality shares of this total number based on the leading killers of young children in a given region. Typically, these leading causes have been determined by health facility data, statistical models, and expert opinions.²⁵

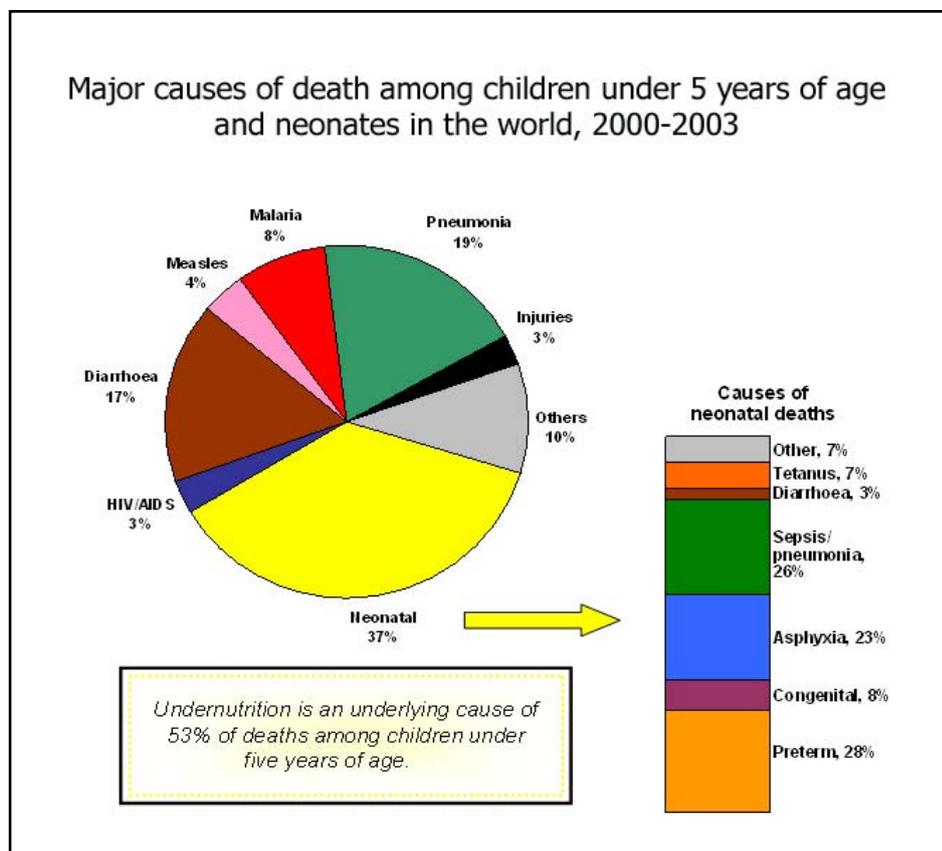
In 2001, the World Health Organization (WHO) formalized this general process with the establishment of the Child Health Epidemiology Reference Group (CHERG). The group began a process to develop estimates of child mortality by determining the proportions of child deaths caused by the leading recognized killers of children under five years of age: pneumonia, diarrhoea, malaria, measles and the major causes of neonatal deaths (in the first month of life).

The group started with the WHO database of mortality-by-cause as reported by WHO member States. Acknowledging the serious quality issues inherent in the reported data, the group used the distribution by cause of child deaths in 72 countries where there was agreement on soundness of the data. These were from high- and middle-income countries. For countries without similar data, epidemiological studies and statistical modelling were used extensively to fit proportional mortality by cause to the numbers of child deaths in a two-step process. In the first step, a statistical model was used to assign deaths to one of three broad categories by cause: communicable diseases, non-communicable diseases and injuries or deaths from external causes. The second step used the proportional mortality estimates and various natural history models devised by the CHERG to assign the distribution of specific

²⁵ Bartlett, S. N., 'The Problem of Children's Injuries in Low-Income Countries: A review', *Health Policy and Planning*, vol. 17, no. 1, 2002, pp. 1–13.

causes of death. These were then published as global, regional and country-level, cause-specific child mortality estimates.²⁶ The global level estimate is shown in figure 1 for illustrative purposes.

Figure 1: Global mortality of under-fives and neonates (0–28 days) by cause, 2000–2003



Source: Bryce, J., et al and the WHO Child Health Epidemiology Reference Group, 'WHO Estimates of the Causes of Death in Children', *The Lancet*, vol. 365, no. 9465, March 2005, pp. 1147–1152.

This global level figure includes injury and estimates that it was responsible for about 3 per cent of under-five deaths in 2005. The regional estimate for the WHO Western Pacific Region, which includes Viet Nam, does not contain estimates of injury contribution to under-five deaths. The official estimates available at the time of the initial Viet Nam survey in 2000 lumped them into a category labeled 'other', which accounted for 25 per cent of under-five deaths in the Western Pacific.²⁷

Initial work on child injury in Viet Nam

At the same time, work was underway at a new institution in Viet Nam, the Hanoi School of Public Health (HSPH). In developing the strategic research agenda for the school, one fundamental question was to ask what the major killers of children in Viet Nam were. Consultation with the country offices of UNICEF, WHO and others indicated that infectious and nutritional causes were the leading killers.

²⁶ Bryce, J., et al. and the WHO Child Health Epidemiology Reference Group, 'WHO Estimates of the Causes of Death in Children', *The Lancet*, vol. 365, no. 9465, March 2005, pp. 1147–52.

²⁷ <www.who.int/child-adolescent-health/OVERVIEW/CHILD_HEALTH/map_00_region.jpg> accessed 8 December. 2006.

However, several community-level studies contradicted the information reported by UNICEF and WHO country offices. An assessment of child mortality in 20 villages comprising a demographic research site in northern Viet Nam showed injury, almost entirely drowning, as the leading cause of death in children after infancy.²⁸ A similar study undertaken in southern regions of the country showed similar results, with injury, predominantly drowning, being the leading child killer after infancy.²⁹ A study of the major urban areas throughout the country showed a similar pattern.³⁰ Efforts to reconcile the different findings of the leading causes of death of children from the field studies to those reported by WHO and UNICEF led to an effort to understand the striking differences seen from the sample surveys.

For its part, UNICEF Viet Nam undertook to validate the numbers of deaths reported as due to diarrhoeal and respiratory diseases. Programme managers were asked to count the individual deaths for each cause. They reported the actual numbers counted rather than the sum predicted by the proportion-based models as deaths from that particular cause. When actual numbers were counted, they were substantially fewer.³¹ As a result of these findings, UNICEF Viet Nam, in collaboration with the US Embassy, the Centers for Disease Control and Prevention in the United States (CDC) and the HSPH, undertook a community-based survey with a nationally representative sample which was large enough to directly count deaths and establish cause of death for Vietnamese of all ages.

The HSPH created a collaborating network of public health institutions in eight regions of the country and undertook the Viet Nam Multi-Center Injury Survey (VMIS).³² While named an injury survey, VMIS actually looked at all causes of mortality in 27,000 households selected as a nationally representative sample from all areas of Viet Nam. When completed in 2001, the results confirmed that the epidemiologic transition had already occurred in Viet Nam. Injury was the leading cause of death after infancy, with drowning being the leading cause of death in the 1–4 age group, as well as in older age groups until late adolescence. While controversial in Viet Nam at the time, particularly because the findings differed greatly from the WHO estimates, the VMIS findings have since been validated in other studies.³³

The divergence of the findings in Viet Nam from those in the models and predictions by WHO and UNICEF at the global level led to a reassessment of the likely causes of child

²⁸ Le Vu Anh, Le Cu Linh, et al., 'Assessment of the Burden of Disease in Chi Linh District, Hai Duong Province after Analyzing Mortality in 1997–1998', Hanoi School of Public Health, Hanoi, 1999.

²⁹ Truong Dinh Kiet, et al., 'Research Assessment of the Diseases in Western Plateau, Center of the South, Southeastern, Cuu Long Delta and Ho Chi Minh City regions of Vietnam', 1999.

³⁰ Le, P., M. Linnan, and Le Vu Anh, 'The Five Cities Injury Survey: Using private sector marketing research methods for injury surveillance', unpublished data, Hanoi School of Public Health, 1999.

³¹ Personal communication, Dr P. Len, National Health Officer, UNICEF Viet Nam and Morten Giersing, former UNICEF Country Representative, Vietnam.

³² UNICEF, 'Report on the Viet Nam Multi-center Injury Survey', UNICEF Hanoi, 2001.

³³ Dao, L. H., et al., 'Burden of Premature Mortality in Rural Vietnam from 1999 to 2003: Analyses from a Demographic Surveillance Site', *Population Health Metrics*, vol. 4, no. 9, 2006; Hoang Minh Hang et al., 'Community-Based Assessment of Unintentional Injuries: A pilot study in rural Vietnam', *Scandinavian Journal of Public Health*, vol. 31, suppl. 62, 2003, pp. 38–44.

mortality elsewhere in Asia. In a region of the world with the longest and most rapid sustained decreases in under-five mortality, it seemed likely that in most of the countries in the region the leading causes of child death after infancy were no longer the classic infectious and nutritionally related causes.

The UNICEF East Asia and Pacific Regional Office recognized that an epidemiological shift would make achieving Millennium Development Goal 4 (MDG 4) more difficult. MDG 4 requires a reduction in the under-five mortality rate (U5MR) by two thirds from the 1990 rate. It was recognized that if injury was a leading cause of mortality in the under-five age group, it would be difficult to meet the Goal without interventions specifically targeting this cause.³⁴

In order to answer the question of whether injury was a significant cause of early child mortality in other countries in Asia as well as Viet Nam, additional surveys were undertaken in Bangladesh, China, the Philippines and Thailand. The lessons learned in doing the survey in Viet Nam were used to extend the methodology to these countries. Each round of surveys provided new experience and lessons learned and these were incorporated in the next round. The goal of the changes was to extend the usefulness of the surveys for programme planners, for intervention design, and for developing a methodology for cost-effectiveness that would be used later in evaluation. The changes included nesting case-control studies into the larger survey to provide risk factor information, defining prevalence of risk factors at the household and individual level, and adding modules on economic costs and social burden.

While the methodology has evolved in response to lessons learned, the core components and definitions have remained consistent. One lesson identified early on during the literature review for the Viet Nam survey was that standard definitions of populations surveyed, their age groups, socio-economic descriptors, and deaths and morbidities measured was critical to any comparative use. Therefore, all the surveys use the same definitions of populations, ages, and classifications of fatal and non-fatal events. Virtually all of the evolution process has been the addition of modules rather than changes from the standard methodology developed for VMIS.

3 SURVEY GOVERNANCE

The work of the surveys was guided by a Technical Advisory Group (TAG). At the time of the surveys in this series of papers, the TAG had representatives from UNICEF, the World Health Organization, the US Centers for Disease Control and Prevention and universities in Australia, China, India, Thailand, USA, and Viet Nam. A list of the current TAG members is available on The Alliance for Safe Children (TASC) website at www.tasc-gcipf.org.

Within each country, surveys are governed by separately constituted Technical Advisory Groups. Primarily, these are comprised of academics from local research institutes, with support provided by TASC and the UNICEF country office. The country TAG will typically have representation from the Department or Ministry of Health, the national statistics office, and the agency responsible for the national census. The country TAG is asked to undertake a

³⁴ Personal communication, Mehr Khan Williams, former UNICEF Regional Director, East Asia and Pacific.

literature review aimed at identifying current estimates for injury and provides an indication of the quality, completeness and inherent biases in the national injury information. The TAG then helps localize and refine the instruments for the particular country context. All protocols and instruments are then submitted to an ethical review board for approval prior to the commencement of fieldwork.

4 SAMPLE DESIGN AND METHOD

Sample size

The sample size for the first survey (VMIS) used the following formula and assumptions:

$$n = \frac{z_{1-\alpha/2}^2 p(1-p)}{(\epsilon p)^2}$$

Assumptions: Precision = 20%
Alpha = 0.05 (two-sided)
Response rate = 95%
Design effect = 1.1

The survey had a large sample. In 2001, the sample size of about 27,000 households made it the largest household injury survey ever carried out in a developing country. However, despite this, an early lesson was that it lacked the power to discriminate deaths by the narrow age groups required when they were stratified by sex and urban or rural residence.

In subsequent surveys the sample size was determined by the size of the least frequent age- and sex-specific injury type for which an estimate was required. As a result, the sample sizes increased to four or five times the size of the Viet Nam study. This is illustrated in table 1, which shows the average number of visited households required to find a death from any cause in each of the age categories shown. The numbers required are much larger than those listed in the table when differentiations are made by gender, location (urban or rural), injury causes, etc.

Table 1: Average number of households visited to find one child death, by age and survey

	Age	Viet Nam	Bangladesh	Thailand	Philippines	Jiangxi	Beijing
Households visited to find once child death from any cause	0–17	386	118	254	188	1,177	4,012
	0–1	2,077	179	344	395	7,693	14,042
	1–4	2,250	619	3,298	766	3,031	28,084
	5–9	1,227	1,462	3,853	1,773	4,546	–
	10–14	1,688	3,090	4,770	2,153	11,112	28,084
	15–17	3,857	4,132	3,853	2,206	12,501	9,361

Source: Authors' calculations based on the individual survey reports.

Sample design

In general, the surveys use stratified, multi-stage, cluster-sample designs. The specific design features vary and are summarized in table 2. Typically, the strata are administrative regions and/or rural and urban areas for which prevalence estimates are required. Efficiency gains were expected from stratification due to anticipated regional variability in injury prevalence. Within strata, typically two- or three-stage cluster sampling was performed. UN Mega-cities (Bangkok, Beijing, Dhaka) were always included (selection probabilities of 1). Simple random sampling (SRS) or probability proportional to size (PPS) sampling was used to distribute sampling units. The primary, secondary, and tertiary sampling units (PSU, SSU,

TSU respectively) for each survey are shown in the table. Cluster sampling was used to minimize field costs associated with face-to-face interviewing and overcome limitations of available sampling frames. The sampling unit for all surveys was households, and all household members were included. The definition of household was typically that used in doing the national census. This allowed use of existing enumeration areas, facilitating survey logistics. It also provided a common basis for demographic and socio-economic status (SES) data comparisons with the previous census, and permitted direct comparisons of life tables from the census with the surveys.

Table 2: Sample size, design and method of the surveys

	Viet Nam	Bangladesh	Thailand	Philippines	Beijing, China	Jiangxi, China	Total
Year of fieldwork	2000	2003	2003	2003	2004	2005	
Household	26,733	171,366	100,179	90,446	28,084	100,010	516,818
Members	128,662	819,429	389,531	418,522	81,604	319,543	2,157,291
Children	46,858	351,651	98,904	178,938	13,508	98,335	788,194
Strata	8 regions Urban /rural	Urban/rural	5 regions Urban/rural	National	18 districts	Urban/rural	
Allocation method	Proportional to sq. root allocation	Proportional to per cent in last census	Proportional to size	Proportional to size	Proportional to size	Proportional to size	
PSU	Provinces	Districts	Provinces	Regions	District committee	Street committee and townships	
Method	SRS	SRS	PPS	SRS	PPS	PPS	
SSU	Districts	Upazilla-rural Mohalla-urban	Census blocks (urban) Villages (rural)	Census blocks	Street committee	Neighbourhood committee, village	
Method	SRS	SRS	PPS	PPS	PPS	PPS	
TSU	Blocks of 90 households	Union (rural) Households (urban)	Households (urban)	Barangay	Neighbourhood committees	200-household block	
Method	SRS	SRS (rural) Systematic (urban)	Systematic	Systematic	PPS	PPS	
Sampling unit	Household	Household	Household	Household	Household	Household	
Observation unit	All members	All members	All members	All members	All members	All members	

SRS = simple random sampling.

PPS = probability proportional to size with measure of size being the number of households.

Source: Author summaries of national injury surveys.

In countries where the surveys included a UN defined mega-city, a separate sample was taken to allow ascertainment of injury in these cities in comparison with other urban areas in the same country. In these cases the sample was stratified by slum versus non-slum. Dhaka, Bangladesh, Bangkok, Thailand and Manila, Philippines are in this category. Beijing, China was surveyed separately even though it has no slums, and was stratified into urban districts and rural counties.

5 SURVEY INSTRUMENTS

The survey questionnaires consist of modules that were first developed and piloted in 1999/2000 as part of the Viet Nam Multi-Center Injury Survey. A brief description of each module is provided in table 3. The modules are designed to collect demographic information on household members, causes of mortality and morbidity, and causes, circumstances and consequences of injury events, and to provide a description of household injury hazards. The first four modules – screening forms, injury mechanism, and verbal diagnosis and autopsy – were initially developed for the Viet Nam survey. Modules Five and Six – control forms for nested case-control studies of drowning for both children and adults – were first developed in 2002 for use in Bangladesh and in subsequent surveys.

Table 3: Summary description of survey modules

Module	Description
Screening form	<p>All surveys: Basic demographic information (age, sex, marital status, household roles), mortality and morbidity (illnesses and injury) of household members. Additional items are collected for women of reproductive age to enable calculation of indirect measures of infant and child mortality such as preceding birth estimates and sibling survivorship.</p> <p>In Beijing and Jiangxi Province, China, the Philippines and Thailand: Injury hazards at the household level were included (risk factors for fire, poisoning, falls, and sharp object exposure; sleeping position and place of infants and children under five; children's swimming ability).</p> <p>The most recent surveys have incorporated detailed SES questions on the screening form as well as additional risk factors.</p>
Verbal autopsy form	<p>All surveys: Age-specific forms to allow determination of cause of death (separate verbal autopsy forms for infant deaths in the first month of life, in the post-neonatal period to end of infancy (29 days through 11 months), deaths in years 1–4, deaths in years 5–17, and deaths in adults (18 years and above).</p> <p>The forms were adapted from the WHO standard for verbal autopsies for infants and children under five. For infants and children 1–4 years of age the forms are unmodified except for the addition of a detailed typology of injury deaths. Forms were developed for 5–17 year olds, based closely on the forms for 1–4 year olds. A truncated version was developed for adults, for whom the purpose was to resolve specific injury causes, and other causes only as non-communicable, communicable and other.</p> <p>In Bangladesh the same forms were used after comparison with verbal autopsy forms from Matlab and additions made to ensure comparability. These were field tested and validated with urban and rural populations where the cause of death was known and show high levels of agreement, particularly for children. The forms have remained largely unchanged since then for surveys in China, Indonesia, the Philippines, and Thailand.</p>
Verbal diagnosis form	<p>Surveys in Bangladesh, Beijing (China), the Philippines, Thailand, and Viet Nam include proportional morbidity, and these age-specific forms to allow determination of the cause of morbidity. The forms were adapted from the verbal autopsy forms, and use a similar structure, elicit information about the same symptoms, and record the diagnosis from any available health records rather than the cause of death. In subsequent surveys (Cambodia and Jiangxi, China) morbidity has been measured from injury and the form is not included in these surveys.</p>
Injury mechanism form	<p>All surveys: For each injury recorded, a separate form was administered to examine the circumstances leading to the injury as well as the actual injury event and its outcome. Temporary and permanent disability are included in outcome issues, as well as social and economic cost data that pertain to the injury and subsequent treatment and rehabilitation.</p>
Control form	<p>Control group questionnaire for case-control drowning study. Used in Bangladesh, China and Thailand. Subsequent surveys have added nested case-control studies for suffocation, animal bites, burns, poisoning and cuts as well as drowning and these are now incorporated into the screening form and a separate control form is no longer used.</p>

SES form	Added as a specific form in late surveys, with congregation of various SES data elements from the other forms. In the most recent surveys (Cambodia and Jiangxi, China) the SES data has been moved to the screening form to allow SES factors to be included in risk ratios for households without injury as well as those with injury. This allows ascertainment of SES associations with mortality from all causes, and specific types of fatal and non-fatal injury.
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Source: Compiled from original survey forms, administered 2000-2005.

The survey instruments for Viet Nam Multi-Center Injury Survey (VMIS) were initially developed in English. They were translated into Vietnamese in 2000 following pre-testing with English-speaking members of the Viet Nam Public Health Research Network. The questionnaire was further developed and tested through repeated small-scale studies in rural, peri-urban, and urban areas in Viet Nam in the year leading up to the national survey.

In subsequent surveys, the instrument was adapted for each country: the English language version was pre-tested with English-speakers from local research institutes, modified and translated into the local language, and then pre-tested again with approximately 50 households. The language was modified as necessary, and the revised instrument was given a full pilot test under field conditions with a minimum of 250 households each in urban, peri-urban and rural areas, plus slums if a city defined as a UN mega-city was included in the survey. The full pilot test was used to test the data collection process in the field and finalize the Standard Operating Procedures Manual and the Interviewer and Supervisor Guidebooks, and work out efficient logistic procedures.

In general, the instruments were translated into the main national language spoken by all the interviewers. The training programme for interviewers included local dialect terms to facilitate on-the-spot translation; where large population groups did not speak the main language, interviewers from that area were chosen. This allowed on-the-spot translation for local or minority languages as necessary. This was considered preferable to specifically excluding certain language groups or treating it as a sampling error.

Although the survey instrument was localized for each country, the adaptations are for language only and incorporate locally appropriate idiomatic responses to each question. The definitions of injury type were held constant in all surveys. Injury severity definitions were also held constant, except for the least severe level.

The common data elements obtained in the surveys are as follows:

Demographic: name, age, sex, marital status, relationship within family for consanguineous members, ethnic group, religion. These were obtained for all surveys.

Socio-economic: occupation, education (years completed), role in household for non-consanguineous members, household income and/or expenditures, size (square metres) and construction of house (floor and roof materials), type of toilet, presence of running water and electricity. Ownership questions included the house and common household assets (such as refrigerator, air conditioner, car, motorbike, bicycle, television, cell phone, etc.). These were obtained for all surveys with the exception of Viet Nam. In Viet Nam, the major economic variables were home ownership and household income.

Epidemiologic: household-level risks for drowning (large water vessels inside, presence of bodies of water outside, wells, troughs, etc.), for road traffic accidents (RTA)³⁵ (proximity to road, whether door kept closed, etc.), for asphyxiation (type of heater used), for suffocation (infant sleeping position, bed-sharing practices), for poisons (type of poison, storage container and place of storage), for falls (balconies or porches, stair rails in multistorey dwellings), for burns (type of cooking appliance, types of hot water boiler and hot water storage vessel), for cuts (types of sharp objects and storage practices), and for dog bites (presence of dog at household, whether dog is vaccinated against rabies, and its sleeping location).

Personal risks: drowning (ability to swim for parents, for children four years and older, for primary caretaker of children under five) and suffocation (bed-sharing practices and sleeping positions for infants).

6 CLASSIFICATION OF MORTALITY AND MORBIDITY CAUSES

All reported episodes of mortality and morbidity are classified as a single, mutually exclusive type – maternal causes; non-communicable diseases (NCD); infectious or communicable diseases (CD); injury; or undetermined (UTD) – and are assigned a specific cause, e.g., pneumonia, meningitis, malnutrition, drowning, and so forth.

The classification of injury is made in the field by the interviewer so that immediate follow-up questions can be asked according to injury type. The classification for injury requires a detailed history of antecedent events and a detailed description of the injury incident itself to prevent misclassification.

Classification of non-injury causes is made by medical staff after fieldwork is complete. The information used to make the classification is contained in the verbal autopsy and verbal diagnosis, and is extracted from medical records, where available. A single classification is required for the type of cause (maternal, NCD, infectious, injury, undetermined) to avoid causes summing to more than 100 per cent of deaths.

The classification forms are based on standard WHO verbal autopsy forms for deaths of children under five. The forms are modified to include specific causes of injury, and to cover children older than four years (5–17 years). A separate classification form is used for adult deaths and is based on a short description of the circumstances involved prior to and at the time of death.

³⁵ ‘Road traffic accidents’ (RTA) is the term used in the countries surveyed to refer to injuries due to road transport, sometimes referred to as ‘road transport injuries’. For the purposes of this definition, ‘accident’ indicates a lack of intent.

Case definition for injury and illness

The case definition of injury and illness for Viet Nam was: any injury/illness serious enough to cause death or permanent disability, require trained medical care to be sought, or result in missing one day of work or school. An injury or illness not meeting this minimal criterion (seeking care or missing one day of work or school) was deemed insignificant in terms of health care and economic or social costs and was not counted.

This same definition was also used in Beijing. The lowest level of severity was modified for Bangladesh, the Philippines, and Thailand to reflect three days' rather than one day's absence from school or work. The modification was suggested in pre-testing, and adopted after extensive discussions with social scientists and epidemiologists familiar with cultural norms in each country.

Classification of injury severity

All surveys classify injury severity in five categories: fatal, severe, serious, major, moderate.

Fatal injury (death): injury resulting in death, whether immediately or later, but as a direct result of the injury. This is the same for all surveys.

Severe injury (permanent disability): injury resulting in permanent disability from blindness, deafness, loss of an extremity (arm or leg) or loss of the ability to use the hands or walk, or the loss of mental abilities. Emotional and psychiatric causes were not included because of the difficulty of diagnosis and classification. This is the same for all surveys.

Serious injury (10+ hospital days): injury requiring hospitalization for 10 days or more. This is designed to capture injuries requiring a major surgical procedure. It is the same for all surveys.

Major injury (1–9 hospital days): injury requiring hospitalization for nine days or less. This definition is designed to capture injuries requiring significant medical care and hospitalization, but not major surgical intervention. This is the same for all surveys.

Moderate injury (missing school or work, seeking care from health practitioner but not being hospitalized): injury requiring medical care, or missing either one or three days of school or work, or being unable to carry out activities of daily living for the same time period, but without hospitalization. The definition used one day for Viet Nam, Beijing, and Jiangxi Province, and three days for Bangladesh, Thailand and Philippines.

Classification of injury type

All injuries are classified according to their physical cause and are maintained in that form in a database. For reporting purposes, they are then classified according to what policymakers and intervention programme designers feel is the most useful categorization scheme. For example, all deaths from submersion in water are coded as drowning, together with the circumstances surrounding the event. This approach allows the estimation of a crude

drowning rate that incorporates all deaths from submersion and also facilitates the customary distinctions, for instance, classifying some drownings in the transport injury category, as when they relate to ship or ferry sinkings, etc. The separation of physical cause from categorization in the database allows the generation of International Classification of Disease (ICD) format reports, if desired (within the limitations of the classification methods used in the survey).

The classification of injury used in the Viet Nam Multi-Center Injury Survey was a functional classification that included 11 types of injury:

1. Transport accidents
2. Injury caused by sharp objects
3. Drowning
4. Poisoning (including food poisoning from toxic plants)
5. Falls
6. Animal injury (injury caused by an animal)
7. Electric shock
8. Burn/Fire
9. Suffocation
10. Injury caused by falling objects
11. Injury caused by machines

Subsequent modifications of this classification in later surveys include the addition of assault, suicide and 'other' injuries.

Recall periods

A one-year recall period for all mortality and morbidity events was used in the Viet Nam Multi-Center Injury Survey. For subsequent surveys, respondents were asked to recall morbidity and mortality events over successive month and quarter time periods, as shown in table 4.

Table 4: Recall periods for morbidity and mortality events

	Viet Nam	Bangladesh	Thailand/Philippines	Beijing/Jiangxi, China
Morbidity	1 year	1, 3, 6, 12 months	1, 3, 6, 12 months	1, 3, 6, 9, 12 months
Mortality	1 year	1, 3, 6, 12 months, 2, 3 years Dhaka mega-city 1, 3, 6, 12 months, 2 years for other districts	1, 3, 6, 12 months 2, 3 years	1, 3, 6, 12 months 2, 3 years

Source: Individual injury surveys.

7 FIELDWORK PROCEDURES

Recruitment and training of field staff

For each survey, interviewers and supervisors were recruited by the local research institutes implementing the survey. The ratio of supervisors to interviewers varied, ranging between 1:5 and 1:7.

Field staff training was conducted by the local research institutes, incorporating standardized role-playing scenarios and covering standardized interview techniques and record keeping. As a general rule, the surveys are done as quickly as possible, in order to minimize problems from changing seasonal patterns of injury, as well as trying to minimize inherent risks to field staff given their continuous exposure to hazards associated with fieldwork (transport injury, dog bites and snake bites, falls, etc.). The time needed to complete the fieldwork varied according to the sample size and the number of interviewer/supervisor teams. The fastest survey was done in Beijing, where only three weeks were needed to interview all 28,000 households. The longest was in Thailand, where fieldwork was interrupted by the SARS epidemic midway through. As a result, it lasted over eight months and recall calendars were changed to allow for the passage of time.

Fieldwork

Informed consent was obtained from all respondents before data were collected. The respondent was chosen as the most knowledgeable adult member of the household among those present at the time of the interview. Where possible, the head of household plus as many household members as possible were present to corroborate answers or add detail. For a child death or serious morbidity, the respondent was the child's caretaker, usually the mother.

Local governments engaged in intensive awareness-raising campaigns several weeks prior to the survey. Interview times were scheduled to maximize the number of household members available. The household revisit policy required at least two revisits before a substitution was allowed.

The reinterview rate was 5 per cent of randomly selected households; and when a child death was found, an attempt was made by the supervisor to revisit the house to validate the information obtained.

Data entry

Data entry was carried out locally with double entry, except in Thailand, where single entry method was used.

8 ANALYTICAL FRAMEWORK

A standard framework was used for all analyses. The rates, ratios, and proportions of various events were determined by sex and location (urban/rural, slum/non-slum), together with specific groupings (e.g., role in family, occupation, level of education, household income, and other SES measures). Additional standardized analyses included:

Injury orphanhood: injury orphans are defined using the WHO standard for HIV orphans but adapted to injury; that is, children who have lost a primary caregiver (mother) from injury, lost a primary economic provider (father) from injury, or lost both.

Economic burden: a number of SES-related parameters were collected in the survey to define economic groups within each population (e.g., standardization by quintile using the wealth asset index calculated from household responses to questions about ownership of assets, type of construction materials for walls, floor and roof of dwelling, type of toilet facilities, etc.). Various analyses were done for direct and indirect economic costs from injury.

Social burden: a number of elements related to the social impact of injury were collected in the survey (e.g., the number of days of schooling or employment lost, the effect on household income, effect on family roles, extended care requirements for serious and disabling injury, etc.). Since one level of severity for non-fatal injury is permanent disability, a series of burden/impact analyses were done on this subgroup.

9 WEIGHTING AND ADJUSTMENTS

In Viet Nam, a self-weighting PPS sample was obtained, with probability of selection proportional to the square root of the population size. Viet Nam has a very large range in population density among its eight geographic regions. The square root proportionality scheme was designed by the census bureau to ensure that enough sampling units were present in the very sparsely populated regions to allow meaningful comparisons at the regional level. Capture-recapture methods were used for the adjustment of regional numbers of deaths.

In Bangladesh, sampling was done in 12 randomly selected districts, with sample weights distributed according to the urban/rural proportions of the populations as denoted in the previous census. A separate sample scheme was used for Dhaka, because its status as a UN mega-city required a separate sample large enough to ensure sufficient power for comparisons between slum and non-slum areas.

In China, a self-weighting, stratified PPS sampling scheme was used in both Beijing (city) and Jiangxi Province. Beijing is a UN mega-city, but there are no slums and therefore no need for a more complex sampling scheme.

In Thailand, a stratified PPS scheme was provided by the national census bureau for the initial sample design, weighted to reflect the provincial and regional urban/rural distribution of households. Following this, five additional provinces were added to allow direct comparisons between the community-based sample and hospitals participating in the national sentinel injury surveillance system. Additionally, Bangkok is a UN mega-city and a quota sample of slum households was obtained to give sufficient power for slum/non-slum comparisons. In Thailand, mortality rates for infants and children under five were adjusted using census-derived age-specific mortality rates.

The Philippines sample used a non-standard cluster survey frame because of UNICEF country office's need for data on iodized salt use in each province. As a result, one cluster was sited in each province, and all data refer to the national sample of 90,446 households (418,522 household members), which is not weighted.

The software used for data analysis varied by country. Local analysts used STATA SE 8.0 and SPSS 12, for the most part. Both account for complex survey design and use the Taylor series linearization method for variance estimation where complex samples were obtained.

10 SURVEY COSTS

Although the surveys were very large, the costs have been relatively modest. Table 5 shows the approximate field cost of each survey, including training, printing of instruments, transport, and data entry. The average cost per household was approximately two US dollars, and the average survey cost was about US\$200,000. The costs in any country were mainly related to transport and labour, meaning that geography and macroeconomic factors were the most important determinants. All figures are in unadjusted dollars, spent in the years indicated. The costs of the surveys were shared between TASC and the UNICEF country office for the survey in question.

Table 5 Field costs of each survey

Country/Province	Year of fieldwork	Households in sample	US dollars	Cost per household
Viet Nam	2000	26,733	85,000	3.18
Bangladesh	2003	171,366	125,000	0.73
Thailand	2003	100,179	175,000	1.75
Philippines	2003	90,466	150,000	1.66
Beijing, China	2004	28,084	225,000	8.01
Jiangxi, China	2005	100,010	400,000	4.00

Source: Authors' calculations based on individual survey reports.

Validity and accuracy

The issue arises in the use of large survey datasets as to how valid the conclusions from the survey are for the population group covered and whether the findings are accurate. The survey methodology described here has built-in mechanisms to provide quantitative information on this. The surveys are large enough to contain sufficient numbers to construct a life table with the same radix (reference population) as is generated from the most recent census or intercensus of the country or province surveyed.

The sample populations in the surveys are quite large and are drawn using equal probability of selection methods (e.g. probability proportional to size, PPS) or are based on census sampling schemes. In most cases, the survey populations approximate the statistical samples taken from the national census (usually 2 or 3 per cent of the households in the census). These statistical samples are what are used to create life tables and other demographic summary measures from the census.

The life table derived from the survey population can be used for a detailed comparison with each of the major social, economic and demographic indices as derived from the most recent census, to measure whether the survey population is representative of the national population. These measures of representativeness provide evidence for whether the measures are valid for their stated use. Additionally, it allows direct comparison of the crude mortality functions over all age intervals between the life table derived from the survey population and the most recent census life table. The goodness-of-fit for the mortality function expressed in the

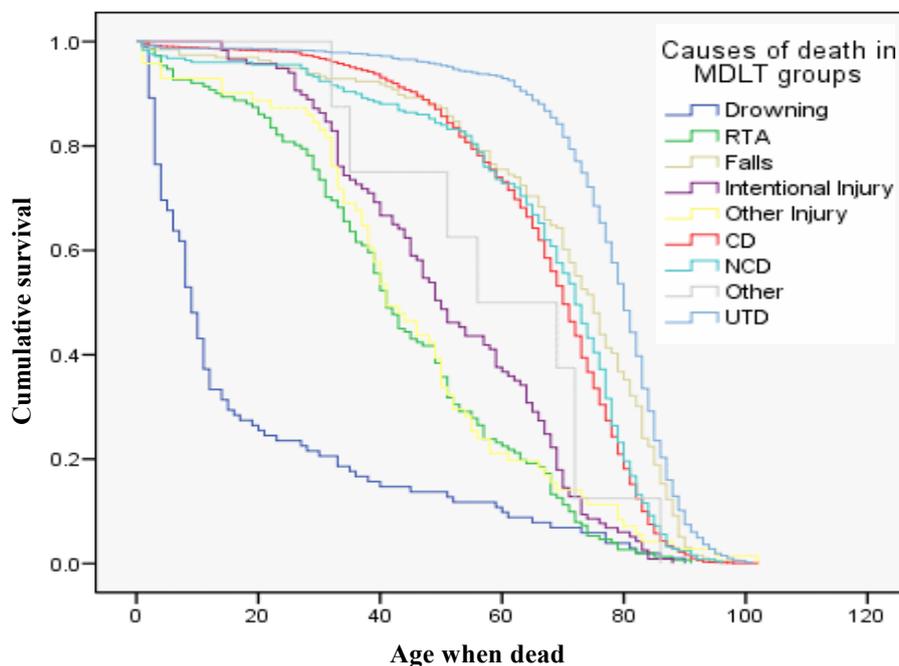
population life table with that of the latest census life table provides a measure of overall quality.

11 CAPACITY FOR EXTENSION

Once the sample is shown to be nationally representative, the ability to derive a representative life table from it provides a number of potential opportunities for it to be used for further public health purposes by itself or in combination with a national census or intercensus:

- The surveys demonstrate the potential for extending a census or intercensus into five-year serial surveys that provide much more detailed information on the trends of various causes of death in specific age groups. This is somewhat similar to what is done in typical national household health surveys, but with larger populations and thus better estimates in each stage of childhood and directly linked to other social, epidemiologic and demographic analyses from the census.
- Once the crude mortality function from the survey is shown to closely approximate the crude mortality function in the latest census, the cause-specific mortality functions from the survey can be applied to a statistical sample of the national census population. This provides cause-specific mortality estimates from the census and, with it, all the epidemiologic information on ages and causes of death. This may provide a more useful technique of proportional mortality estimation that covers all of the population, as well as all ages, overcoming major limitations of the current proportional mortality estimation process.
- Using multiple decrement methods provides an opportunity for other analyses of particular interest for child health, such as deriving the childhood risk of a particular cause of death and comparing it with other age- and cause-specific risks. An example of this would be deriving the risk of drowning over the length of childhood as well as the rest of life and comparing it to other causes. This is illustrated in figure 2.

Figure 2 Cause-specific survival functions by multiple decrement life table (MDLT) group



Source: Jiangxi Injury Survey (2005).

The figure is a multiple decrement life table derivation (MDLT) of the life table constructed using the survey dataset from the Jiangxi Injury Survey. This statistical technique uses proportional hazards models to construct a survival function for each cause of death. The survival functions depict the proportion surviving at each year of life by cause of death.

It is seen that drowning is uniquely concentrated in early, middle and late childhood and young adulthood. In this perspective, prevention of a single drowning death would provide a larger number of years of life gained than from targeting interventions on other causes of injury.

Analyses using a combination of demographic and epidemiologic techniques have great potential in providing policymakers with information on the most efficient approaches to child health programming.

12 METHODOLOGICAL LESSONS FROM THE SURVEYS

Six large surveys in five countries with a combined sample size of over half a million households and nearly 2.5 million respondents provide an extraordinary opportunity for learning. Much of the experience has resulted in refinements to the surveys themselves, but lessons were also learned that are pertinent to other community-based injury research. Some indicate the potential reasons why the current body of evidence regarding child injury has not been as informative as had been expected. In particular, a number of key issues stand out as having particular relevance to existing research on child injury in LMICs. These can be summed up in five assertions:

1. Count all children, not just a particular group.
2. Count all causes, not just particular ones.
3. Count all outcomes, not just fatal ones.
4. Count the events where they occur, in the community, not where some seek care, in facilities.

And – when counting is done in this fashion, it becomes clear that

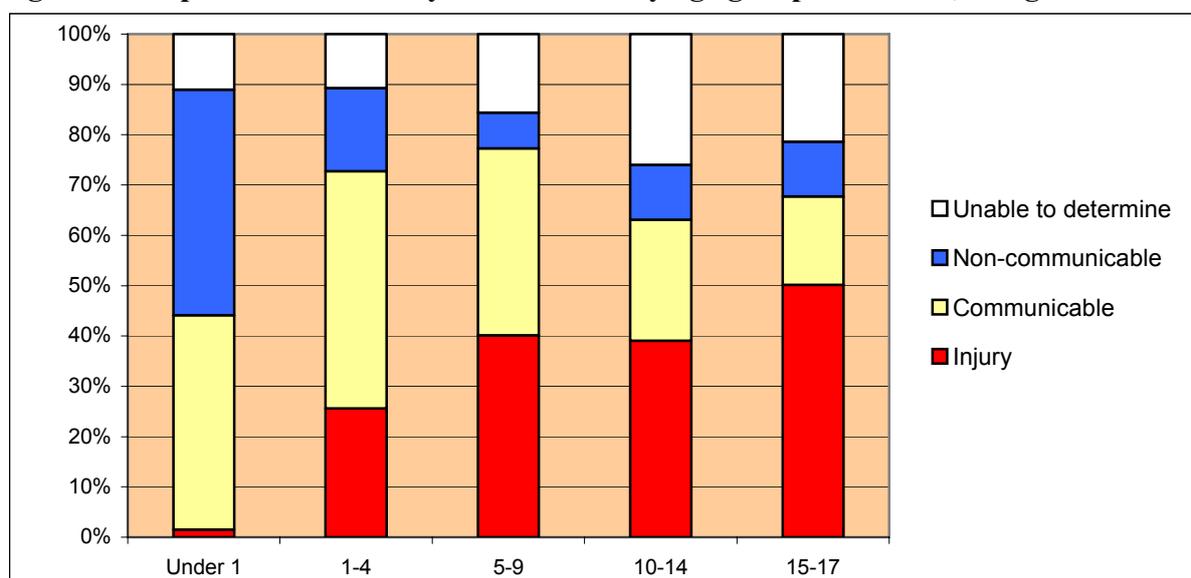
5. The pattern of childhood injury in LMICs has fundamental differences in comparison to its pattern in rich countries.

These are illustrated below with figures from the surveys and discussion of relevant technical points.

COUNT ALL CHILDREN, NOT JUST A PARTICULAR GROUP

Measures of child deaths and serious morbidity need to include all children in the measure. The net effect of limiting mortality estimates to only the first five years of childhood is to exclude a large number of child deaths and these deaths are predominantly injury. The deaths in the older child age groups – those from age five through 17 – account for about half of all childhood injury deaths, as seen in figure 3.

Figure 3 Proportional mortality in childhood by age group and cause, Bangladesh



Source: Authors' calculations from Bangladesh Health and Injury Survey (2003).

A corollary is that when measuring all ages, it is necessary to use a standard grouping of the age groups to enable comparison. All UN Member States have agreed to a standard definition of childhood in the Convention on the Rights of the Child. It defines it as 0–17 years. Using different ages for childhood (0–14 or 0–19), as in most global-level estimates, makes

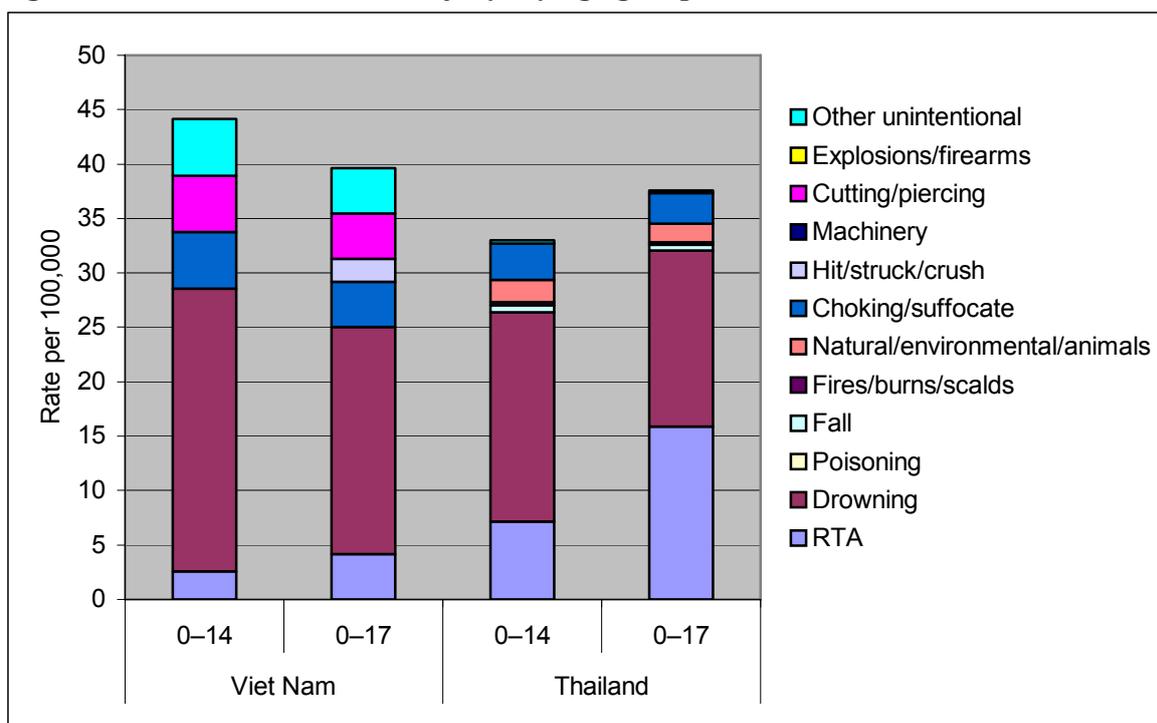
comparisons difficult, as well as raising serious technical issues about correct denominators. The total number of children defined by ages 0–14 or 0–19 is different from that grouped by 0–17 because the denominators are not the same. Additionally, since the proportions of causes of death differ in the two groups, using different age groups introduces different epidemiologic patterns, as seen below.

Changing the ages changes the epidemiology

Using 0–14 underestimates intentional injury and RTA, and 0–19 overestimates both, in comparison to 0–17. Both of these injury types have rapidly changing age distributions between 14 and 19 years. Interpolation from present datasets with 14 or 19 as the endpoint is not a solution. As seen in figures 4 and 5 below, depending on the relative distribution of types of injury, the rates can increase or decrease. This renders interpolation unworkable.

Figure 4 shows the age-specific rates of fatal injury in Viet Nam and Thailand calculated for two different age groups: 0–14 years and 0–17 years. The rates differ, and in differing directions depending on the relative proportion of drowning and RTA.

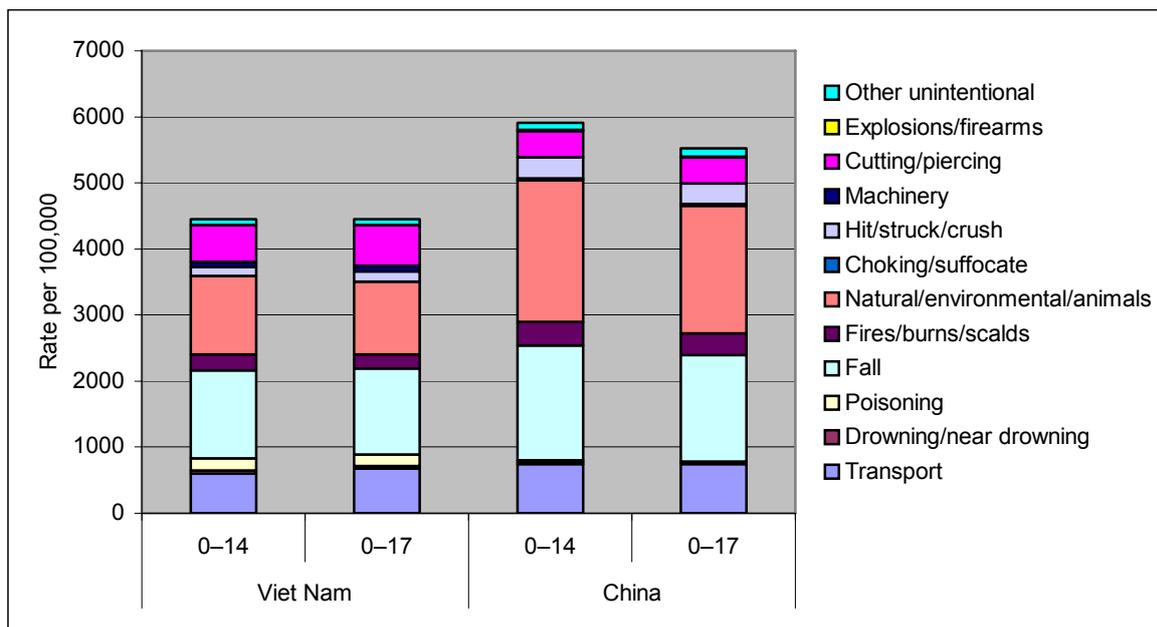
Figure 4: Causes of fatal child injury, by age group, Thailand and Viet Nam



Source: Authors' calculation from Thailand (2003) and Viet Nam (2000) datasets.

The same effect is seen in figure 5 comparing morbidity in the age groups in Viet Nam and China. The relative proportions of falls and animal bites, the two leading causes of injury morbidity determine the direction of change when three additional years are added to the 0–14 age group.

Figure 5: Causes of non-fatal child morbidity, by age group, Viet Nam and Jianxi, China



Source: Authors' calculations from Viet Nam (2000) and Jiangxi, China (2005) datasets.

COUNT ALL CAUSES, NOT JUST SELECTED ONES

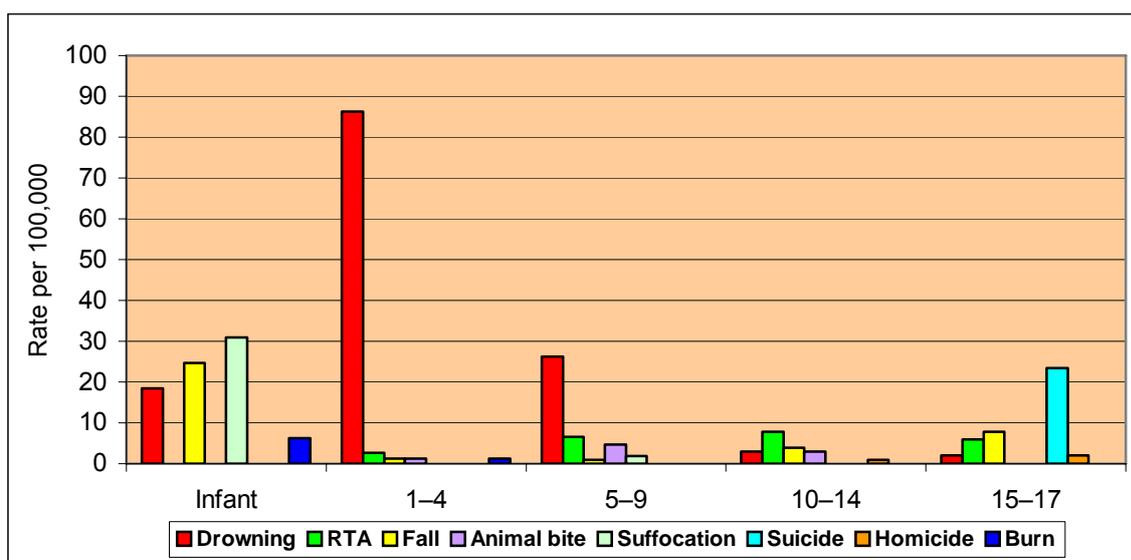
When proportional childhood mortality is analyzed by age group and the three broad categories of injury, communicable diseases (CD) and non-communicable diseases (NCD), it becomes clear that injury claims an increasing proportion as age increases.

There is no intervention called 'other'

Measurements of child deaths and serious morbidity need to include all causes of death. Excluding injury or lumping it within 'other' results in an incomplete picture of causality, often seriously distorted from the true picture. Unless linked to an identified cause, an intervention cannot be delivered.

Measurements of child deaths and serious morbidity need to be based on sufficiently large samples to provide adequate numbers of events within each of the age groups of childhood. The patterns of mortality and serious morbidity change for each age group, and without this fine-grained information, it is not possible to design effective interventions since these depend on changing the risk environment characteristic of each stage of childhood.

As seen in figure 6, suffocation, drowning, falls and burns characterize infancy. The toddler years (1–4 years) are almost entirely characterized by drowning. As school-aged children roam the community, RTA becomes a leading cause of fatal injury, and as children progress through adolescence, intentional injury (suicide and homicide) becomes a leading cause of injury deaths.

Figure 6: Causes of fatal child injury, by age group, Bangladesh

Source: Authors' calculations based on Bangladesh Health and Injury Survey (2003).

To be effective, interventions for these different causes would need to focus on different changes to behaviours and environments. For example, drowning and suffocation interventions in infants and very young children are most effective when mediated through caregivers; but for older, school-aged children, interventions must be targeted at the children themselves. However, unless the survey is able to clearly discriminate the different rates of drowning and suffocation in the different age groups, the key information is lost.

A corollary to the maxim of counting all causes is that sample sizes need to have sufficient power to find injury deaths at the different stages of childhood

If sample size is not sufficient, estimates are incomplete and potentially misleading. Lacking sufficient power leads to two different and important potentials for distortion. The first relates to the fact that the end-users of the data are policymakers who are generalists and do not have a technical background in epidemiology or statistics. The absence of deaths from a particular cause in the survey data leads the users of the data to wrongly conclude that a particular cause of death is not present. This results in both a failure to take action and the erroneous impression that the cause is not an issue of concern.

The second potential for distortion occurs if the power calculation for the minimal sample size uses the overall child age group. This eliminates the ability to find key differences within the individual age groups that constitute childhood. The result is to obscure causes that are significant to a particular developmental stage, such as suffocation in infancy and suicide in adolescence. This is clearly shown in figure 6 above. It has large consequences since the causes of child injury are very different across the major stages of childhood.

COUNT ALL OUTCOMES, NOT ONLY FATALITIES

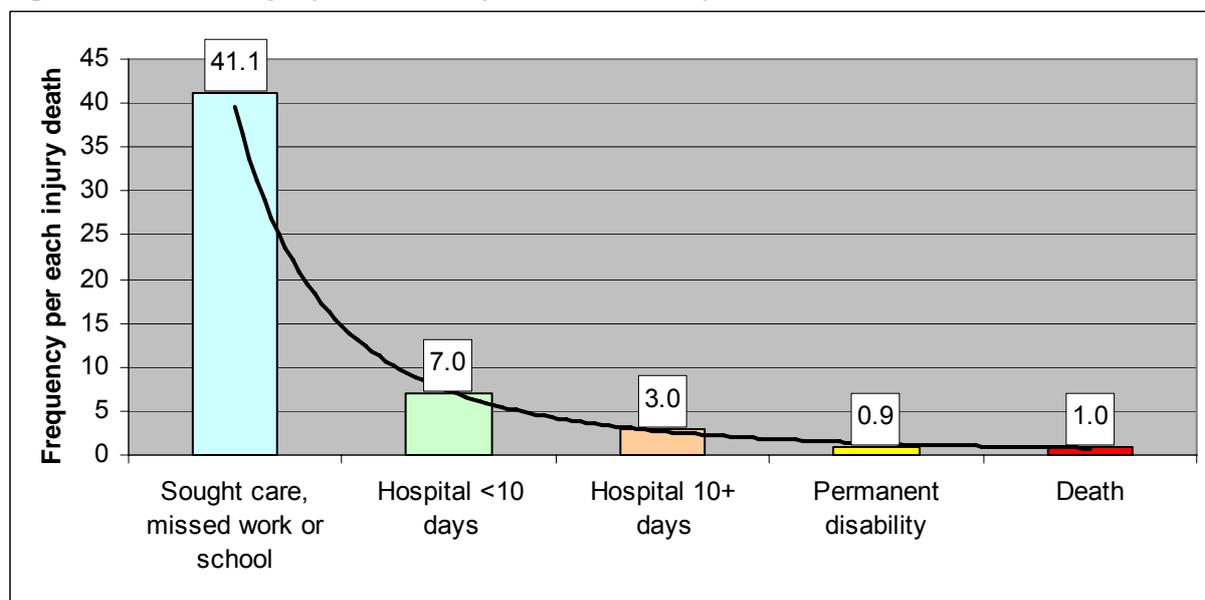
Measuring child deaths is necessary but not sufficient. Mortality tells only part of the story, often the part with the lowest social and economic costs. The picture is incomplete without measuring morbidity, especially that causing permanent disability and lengthy hospitalization.

As one concrete example, the cost and social burden module of the Jiangxi survey showed that the majority of economic costs and the lifelong social burden accompany the more severe, non-fatal injuries. The cost of injury in Jiangxi was 4.3 per cent of provincial GDP.

While infectious and non-communicable diseases also generate disability and large costs (as with HIV/AIDS and diabetes), injury has a unique impact for children because it is at far higher rates among all child age groups.

Figure 7 shows the ratios of non-fatal injury of all types by severity level compared to one death. It is clear that the total burden of injury is much more than that incurred by fatal injury alone.

Figure 7 Ratio of injury to death, by level of severity



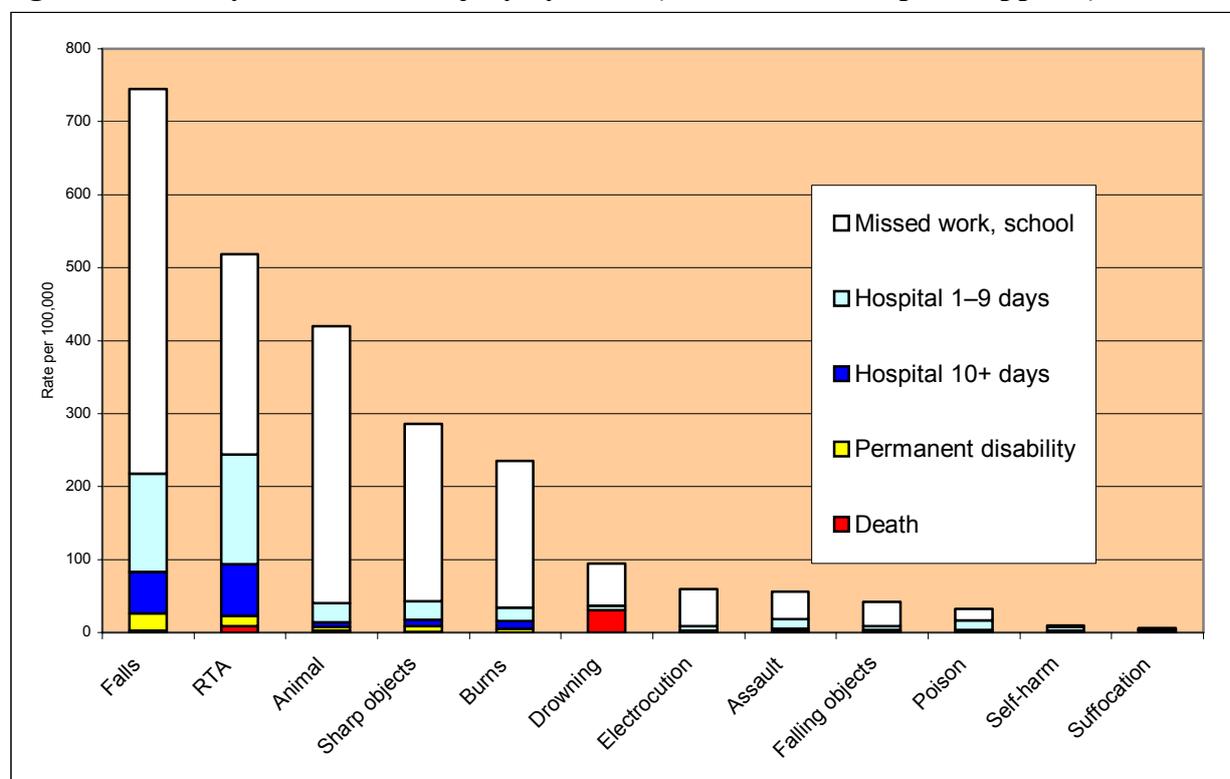
Source: Authors' calculations based on all surveys (2000–2005); composite is population-weighted.

Injury outcome is a continuous variable. Fatal injury is only the most severe outcome among the various other levels which begin at the least severe measured in the surveys (missing school), through hospitalization, to permanent disability and, finally, to death. When different levels of severity are categorized, as in figure 8, it becomes evident that non-fatal injury causes greater social and economic burden than fatal injury.

When presented as different categories of severity from least severe to fatal, the predominance of non-fatal outcomes is visually striking. When seen in this light,

policymakers can understand that just making mortality estimates looks at only a part of the overall picture. It also limits examination of other linked factors such as economic costs, social burden and the overall priority for interventions.

Figure 8: Severity of childhood injury by cause (all countries except Philippines)



Source: Authors' calculations based on all surveys except Philippines (2000–2005); composite is population weighted.

COUNT THE EVENTS WHERE THEY OCCUR, IN THE COMMUNITY, NOT JUST WHERE SOME SEEK CARE, IN FACILITIES

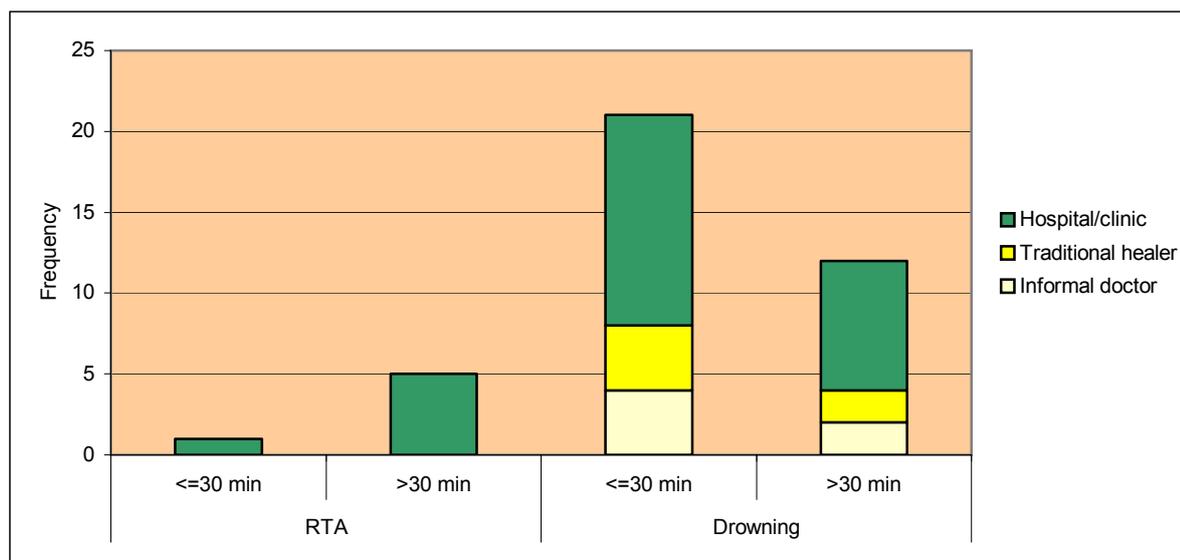
Measuring child deaths and serious morbidity in developing countries is most complete when measurements are made where the deaths and morbidity events occur – in the home and community.

Developing countries are characterized by unequal social stratifications that place large portions of the population below the poverty line. This results in major barriers for access to health facilities. Most commonly three-quarters or more of the populations are rural, with poor access to health facilities because of the lack of infrastructure in rural areas. Finally, very often, if not most often, health-seeking behaviours in these countries involve non-formal health care providers, such as traditional healers, who fall outside the standard health statistics and reporting systems. Because the users of hospitals and health facilities are not representative of the entire population, relying on data from these facilities yields a distorted picture of morbidity and mortality, compared to that emerging from measurements made at the community level.

What people believe regarding injury determines where they seek care

The formative research in each country clearly showed that people usually defined injury as having occurred when there was blood or an open wound (trauma). Atraumatic injury (drowning, poisoning, etc) was usually not considered ‘injury’. This different belief or categorization system has a great impact on where care is sought. Figure 9 clearly illustrates this from Bangladesh.

Figure 9: Place of treatment by type and frequency of fatal injury and length of survival, children 0–17, Bangladesh



Source: Authors' calculations based on Bangladesh Health and Injury Survey data (2003).

Most traumatic injury (e.g. road traffic accident) was seen at a clinic or hospital if the person survived to reach the facility. In contrast, almost half of atraumatic injuries (e.g. drowning) was not seen at a facility, even when surviving to arrival is factored in. Traditional and informal doctors see a large proportion of injury, mostly atraumatic, and are not part of the health information systems. These injuries are lost to the information system.

You can't count it unless people understand what 'it' is

The questions asked in order to count deaths and non-fatal events has an important effect on what the answer is, since injury means different things to different people. There are different cultural viewpoints that determine what constitutes injury, as well as health-seeking behaviours when it occurs.

The pilot studies carried out in each country for questionnaire development showed very large differences in the responses to questions about injury depending on how they were asked. Asking whether an accident or injury had occurred, even using different local names and terms, resulted in relatively low response rates. Giving the respondent a complete definition of what constituted injury, with a concrete example of each type of injury (suffocation, drowning, fall, poison, etc.), resulted in higher recall rates, often two or more times higher. Using a flash card with an artist's drawing of an event happening (child drowning, falling down stairs, hit crossing a road, etc.) further increased recall rates.

There were wide cultural differences apparent in the different countries as to what constitutes injury in the average respondent's mind. The standard classification system of intentional and unintentional, with various types defined as resulting from energy transfer, lack of oxygen, etc., was found to be extremely confusing in most of the formative pilot research. The most reliable manner of asking was to start by defining what was being asked using the native languages and including local idioms or slang, while covering every category of injury, and showing a pictorial example of each while it was being explained. Finally, at every subsequent question regarding whether a particular injury had occurred, the question was asked using the flash card with repetition. The experience of piloting the questionnaires in the six different surveys was a very clear validation of the old saying, “what answer you get depends on how you ask the question.”

Recognize that laypeople – not health care providers – principally determine health-seeking behaviour following occurrence of an injury

It is the sum of people's knowledge, customs and beliefs that result in where they seek care for an injury and this is the predominant factor influencing the types of injury that are seen at various institutions – some of which report the event to the health system, and some of which do not. The Bangladesh survey serves as a clear example: The quantitative module in the survey examined knowledge, attitudes and beliefs of caregivers. The survey showed that what mainly determined whether a child was taken to a hospital after injury was the presence of bleeding or other open wound. The care-seeking behaviour of medically unsophisticated caretakers preferentially channels traumatic injury to facilities that report as part of the health information system (clinics and hospitals). Non-traumatic injury is channelled to providers that do not (traditional healers, etc.). These tend to be associated with rural residence (usually 75–80 per cent of national populations) and, combined with the other issues seen with rural locations (access issues, higher rates of injury, etc.), this operates to increase the bias for hospitals to see traumatic injury more than atraumatic injury. This is seen in figure 9 above, where almost half of fatal drownings were seen by traditional healers and informal doctors – with the result that these fatal drownings were unreported in the health system. The traditional healers and informal doctors mainly saw atraumatic injury, with none of those affected by trauma from RTA seeking their care.

Recognize that to be counted at a facility requires surviving to reach the facility

Survival bias is clearly an issue with facility-based systems. Injury that kills quickly is often not seen at facilities, and if not seen, cannot be reported.

Drowning is fatal within minutes of submersion. There is no time for seeking care while the victim is still alive, and there are economic and cultural disincentives to taking a dead child to a hospital. Thus drowned children are rarely brought to a clinic or hospital. Accordingly, drownings are greatly under-represented by facility-based surveillance. Similarly, when traumatic injury such as RTA is immediately fatal, the same disincentives are present, but the survivable trauma then becomes preferentially represented in information systems that have case-finding based on facility data.

The surveys are designed to allow a comparison of the community events with presentation of cases to hospitals and clinics to precisely define many of the biases. In the case of the Thai survey, the sampling plan deliberately directly overlaid community samples with catchment areas from hospitals participating in the national injury sentinel surveillance system. This was done to allow measurements of incidence rates when measured in the community as compared to incidence as measured in the sentinel hospital where the injury was treated or reported. The data shown in figures 10 and 11 illustrate a variety of facility biases (severity, trauma, survival, access, etc.) using the Thai survey dataset.

Figure 10: Child drowning, severity and report, Thailand



Source: Authors' calculations based on Thailand dataset (2003).

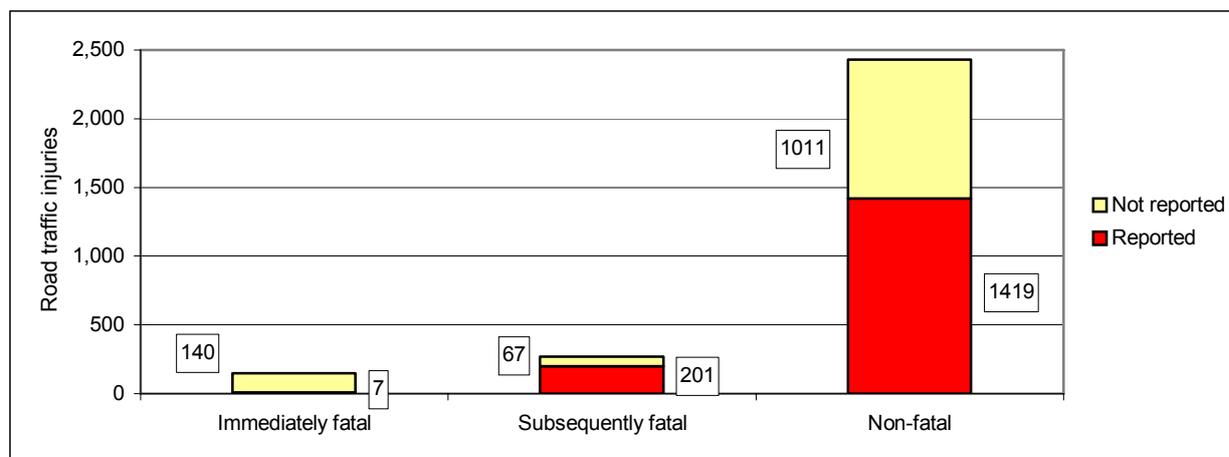
Within the Thai survey (100,179 households, 389,531 respondents, 98,904 children), there were a total of 45 child drownings (27 fatal and 18 non-fatal) recalled over the previous three years. Less than one quarter of the fatal drownings (6 subsequently fatal, 22.2 per cent) were reported to a hospital. Of the immediately fatal drownings, none were reported to a hospital. These represented over two thirds of the total sample (19 of 27; 70.3 per cent). One quarter (2 of 8; 25 per cent) of drownings that were fatal but not immediately so were never reported to a hospital. In addition, less than half (8 of 18; 44.4 per cent) of non-fatal drownings were reported to a hospital.

The lesson repeated here is that when measured at the community level, child drownings occur at much higher rates (in some cases by entire orders of magnitude) than are reported through information systems centred on health facilities. This is not unexpected given the known limitations of facility-based data. However, the magnitude of the bias is sufficient to make drowning, the leading cause of child death after infancy, almost invisible within the formal health information reporting systems.

Furthermore, one aspect of a sentinel hospital reporting system is the goal of looking beyond the hospital itself in order to gain a better understanding of the epidemiology of specific causes within the community. The system does not appear to overcome this surveillance

disconnection and raises some fundamental issues regarding whether injury surveillance can be done through systems such as these, at least in the countries where the surveys were done.

Figure 11: Child RTA, severity and report, children 0–17, Thailand



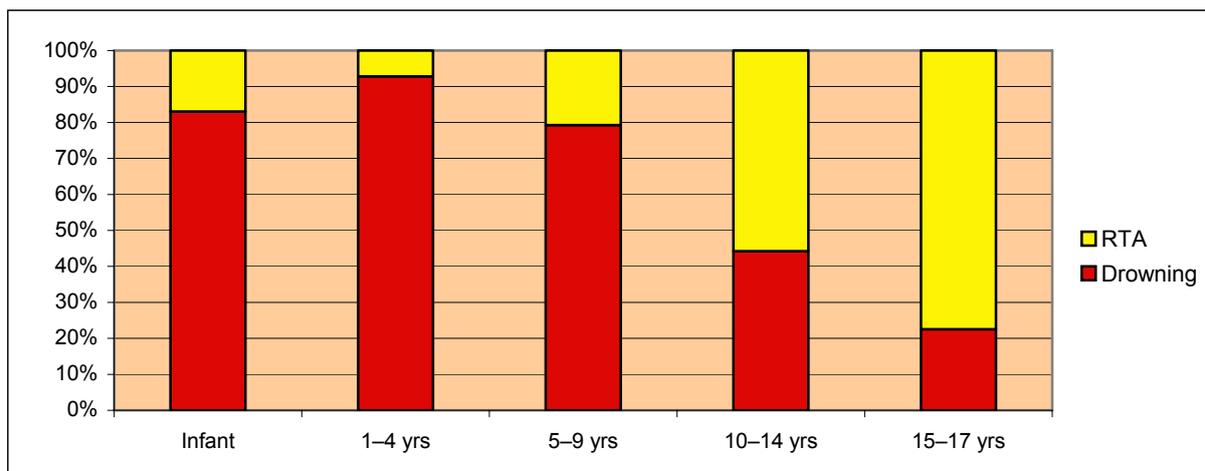
Source: Authors' calculation from Thailand dataset (2003).

The RTA data reflect the same survival bias evident in drowning. To be seen at the hospital requires survival of the initial crash and survival long enough to be admitted to the hospital. Victims of immediately fatal crashes were rarely seen at hospital, and neither were those injured so severely that they expired prior to admission ('dead on arrival', or DOA). The most serious (immediately fatal) injuries were reported to hospitals less than 5 per cent of the time (7 of 147, 4.8 per cent). Very serious injuries that were subsequently fatal were reported to a hospital at the highest rate, about three quarters of the time (201 of 268, 75 per cent). Less serious injuries that did not produce a fatality were reported to a hospital just less than three fifths of the time (1,419 of 2,430, 58.4 per cent). The data demonstrate that injury surveillance for road traffic injury which relies on hospital reporting underestimates fatal RTA, and the data that are reported are biased towards serious injuries that are not immediately fatal.

However, immediate deaths from RTA are not lost because they are routinely reported by the traffic police and the Ministry of Transport. This is not the case with drowning deaths, since they are not captured by other systems reporting centrally and are completely lost. This results in the loss of visibility of drowning in the Ministry of Health information systems and a distortion of the pattern of child injury causality.

Virtually all relevant global, regional and national level databases appear to show fatal RTA predominating as the leading cause of fatal child injury. This may be a result of the issues demonstrated in the survey data. The proportional mortality for drowning versus RTA in every survey showed drowning predominating. The aggregate of the surveys is shown in Figure 12. The age pattern noted was seen in each individual survey.

Figure 12: Proportion of child deaths attributable to road traffic accidents and drowning



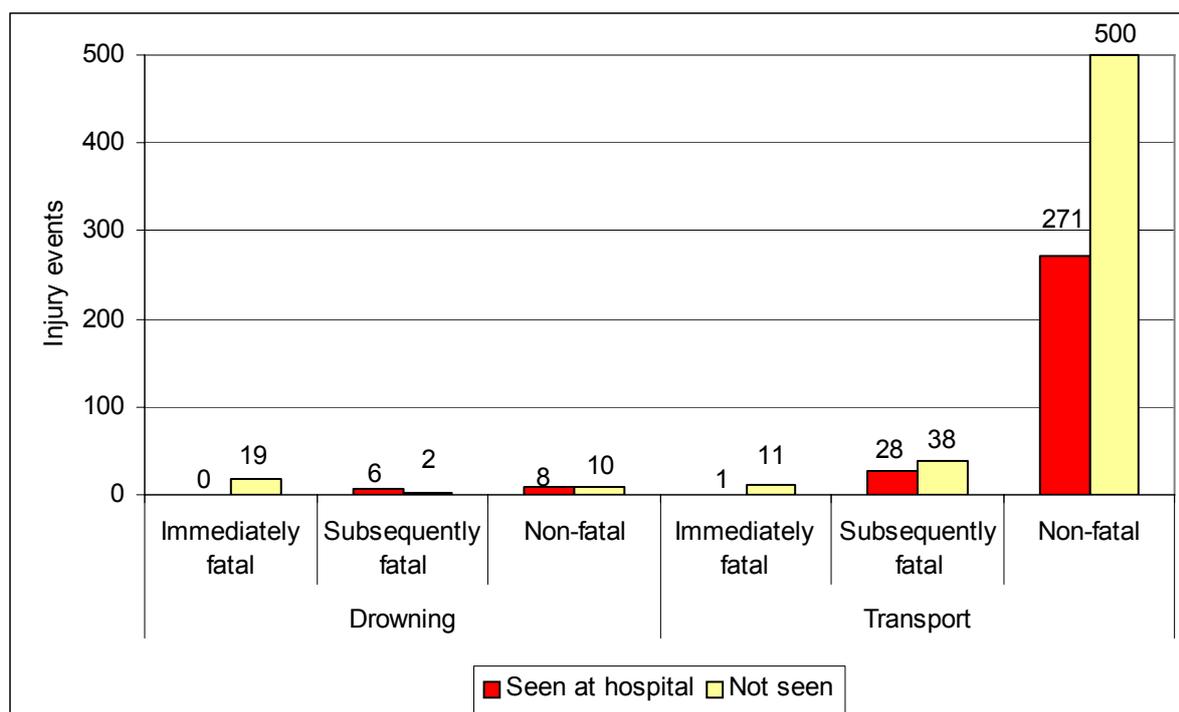
Source: Authors' calculations based on all surveys (2000–2005); composite is population weighted.

This pattern was independent of level of development or motorization. It was also independent of location, whether urban or rural. Whether measured separately in the mega-city survey components of the surveys or in the standard urban/rural national or provincial strata of the surveys, drowning was the leading cause of child death after infancy.

In addition to a survival bias, facility-based injury data have a trauma bias. Trauma requires surgery, and people know that such care is usually only available at hospitals. Atraumatic injury such as drowning, suffocation and poisoning is often left untreated, since without blood or other signs of trauma, people do not recognize the need to take the victim to a hospital. This was previously shown in the Bangladesh data (figure 9 above) and can be seen as well in the Thailand data set. Combining the Thai RTA and drowning data (one-year recall) shows this clearly in figure 13.

For atraumatic fatal injury (the 27 fatal drownings), less than one quarter (6, 22.2 per cent) were seen at a hospital. For traumatic fatal injury (the 78 fatal RTA events), the proportion seen at hospital was over a third (29, 37.2 per cent).

Figure 13: Child drowning and RTA events in first year of recall, children 0–17, Thailand



Source: Authors' calculations based on Thailand National Injury Survey (2003).

The cumulative effect of each of the biases (survival and trauma) is that facility reporting significantly misrepresents two leading causes of fatal child injury, drowning and RTA. Since drowning is atraumatic, more frequently immediately fatal, and is less often survived per potentially fatal exposure, it is seen less frequently than RTA in hospitals and other health facilities. Many of the global-level reporting systems such as the WHO Global Burden of Disease database mirror at a macro level what appears to be an artefact of the biases inherent in reporting mechanisms. The primary source of data for these databases is from the compiled national reports³⁶ of members of the WHO World Health Assembly, and these primarily reflect facility reports. Additional evidence can be seen in the recent WHO publication on child injury in LMICs, which uses the Global Burden of Disease Database, and reports that RTA deaths are the leading cause of fatal child injury, attributing 182,833 deaths in children under 15 to RTA and 144,926 deaths to drowning.³⁷

To avoid misinterpretation, measurements need to use standard recall periods, standard definitions of cause and standard age groupings

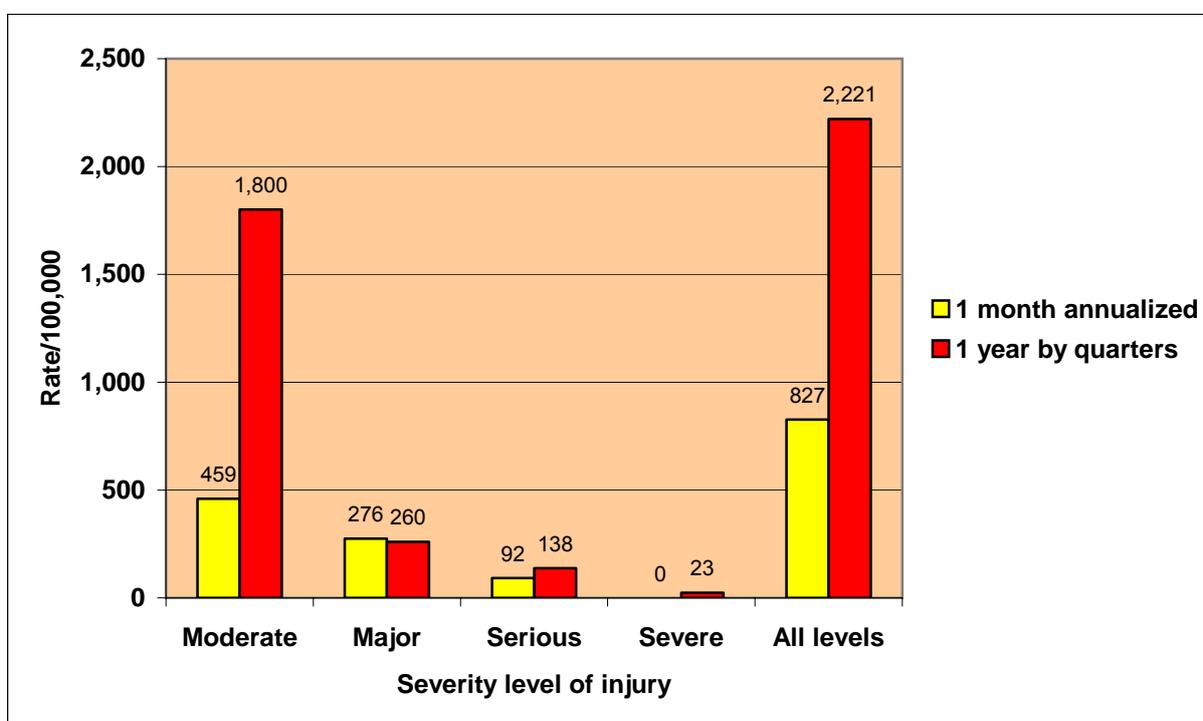
The recall period chosen in a community-based survey greatly affects the injury rates found. It is almost impossible to achieve valid comparison of injury rates from different surveys unless identical recall periods have been used.

³⁶ www.who.int/healthinfo/statistics/mortdata/en/index.html

³⁷ WHO and UNICEF, *Child and Adolescent Injury Prevention: A global call to action*, WHO, Geneva, 2005, using 2002 WHO Global Burden of Disease Project database, Version 5.

A technical goal of the surveys was to examine the relationship between severity and recollection of events, in order to better understand biases introduced by varying periods of recall for fatal versus non-fatal injury, and in particular, for the least serious levels of non-fatal injury. The method for recalling injury morbidities in the surveys uses a special recall calendar that has identifying events for the household in the year prior to the survey (holidays, natural disasters, cultural events, household members' birthdays, etc.). These are used as time period prompts by the interviewers and the respondents are asked about the occurrence of injuries that qualify over the course of the year. The questions start with the previous month, and then ask about the two months prior to that, then the three months prior to that, etc. In this manner, the one-year recall period is asked about in months and quarters. This allows an examination of the effect of the severity of injuries recalled on the length of recall. The method was validated in the Beijing survey where it was possible to check official records of injury events by level of severity and compare them to those recalled at the household level.

Figure 14: Non-fatal injury in children 1–17, by two methods of recall, Beijing China



Source: Authors' calculation from Beijing survey data (2004).

Figure 14 shows rates of non-fatal injury recalled in children (1–17 years) by level of severity, from the Beijing survey. The figure shows the severity-specific non-fatal injury rates graphed by two different methods of recall. The first, monthly method ('1 month annualized') refers to the number of injuries at each level of severity that occurred in the month prior to the survey; it is annualized by multiplying by 12, and expressed as an annual rate. The second, quarterly ('1 year by quarters') refers to the total number of injuries at each level of severity that occurred within each three months in the previous one year. They sum to provide the total number by severity level in one year. The figure shows that a one-month recall period resulted in non-fatal injury rates about one-half as large as those yielded by

longer recall periods; the underestimate was greatest at the level of permanent disability (severe).

A one-month recall period, common in surveys, underestimates injury at most levels of severity. This happens for two main reasons. First, a one-month recall period doesn't allow for the occurrence of multiple episodes of moderate severity over the course of a year, common with active children. (This is analogous to infectious disease surveys where children have several respiratory and diarrhoeal disease episodes per year.) Since the most frequent injuries are those of low severity, these make up the majority of all injury, and when under-reported on a one-month basis, this results in a substantial underestimate of non-fatal injury as a whole.

The second reason of the degree of underestimation is related to the increasing severity level. The more severe injuries occur much less frequently, and even in this large population of children in the Beijing survey (13,508 children) severe injuries (defined as causing permanent disability) occur rarely. If a severe injury did not occur once in the first month, the annualized severe injury rate measured using the short recall period is zero. However, when measured using a 12-month recall period the rate is 23/100,000. This recall brevity bias has significant implications for rates available through most of the community-acquired datasets which include non-fatal injury. It appears to be operative regardless of whether the non-fatal injuries are classified by some level of severity, or simply counted as all non-fatal injury. The recall brevity bias shown here mainly applies to community surveys, with retrospective case finding done from a single point in time.

Many injury morbidity surveys use one-month recall or at most, three months. The largest standardized surveys in the region, the Demographic and Health Surveys (DHS) have used a one-month morbidity recall. Additionally, DHS survey instruments do not use pictographic methods for injury recall. It is very likely that DHS surveys that include injury morbidity underestimate injury and particularly, the more severe classifications.

WHEN CHILDHOOD INJURY IS COUNTED IN THIS MANNER IT BECOMES CLEAR THAT ITS PATTERN IS FUNDAMENTALLY DISTINCT IN THE COUNTRIES SURVEYED, AS COMPARED TO RICH COUNTRIES

How injury is categorized has implications in these countries

Another categorization issue that makes it difficult for comparison between the surveys and other datasets relates to the functional categorization of injury in the surveys as compared to other methods used (e.g., International Classification of Disease (ICD) 9 or 10 in WHO datasets). A good example of this is animal injury (injury caused by an animal), which is rarely identified as a major cause of morbidity or mortality in most datasets describing child injury in LMICs. However, in each survey, animal injury was one of the leading causes of morbidity, and a significant cause of mortality.

The surveys used a functional classification scheme, which is most suitable for intervention development. Child injury related to animals was classified in this fashion (e.g. animal injury: bite: cat, dog, snake, etc.; and animal injury: envenomations: snake, bee/wasp, scorpion, etc.). Most fatal animal injury was due to rabies (an infectious sequel of a bite, usually from a dog) and snake bites (a toxic envenomation). While these can be classified using ICD 9 or 10, the coding skills necessary are usually not found in these countries outside specific research institutions, and these are few in number. Most hospitals and clinics lack the ability to code these diagnoses other than as 'rabies' or 'snake bite', a functional classification in itself. However, when they are reported to higher levels, these often drop out, as they are not translated into the ICD codes of the national reports. It is unusual for large, national-scale datasets on injury to be reported using functional classifications. As a result, animal injury, as a single category, does not appear. This has the effect of obscuring one of the leading causes of child injury in the countries surveyed. When classified functionally and reported in the same way as we do in the surveys, they can be seen to be the third leading cause of morbidity and fifth leading cause of mortality in children in the countries surveyed.

The ICD scheme works well for wealthy countries, where the intervention infrastructure is already in place and a detailed ICD scheme allows for precise monitoring. It is less useful for LMICs where the interventions haven't yet been implemented. Exposure to animals is very different for children in LMICs compared to rich countries. Pets and insects are overwhelmingly the leading animal exposure in most rich countries. However, most LMICs are predominantly rural, and children are tasked with grooming, feeding and caring for most farm and work animals in these countries. Dogs are frequently a part of this, either as working animals (herding, guarding, etc.) or as strays. In either case, they are usually not immunized for rabies. Exposure to snakes is similarly great due to the rural nature of most of the countries. Exposure increases with frequent flooding, an annual cyclical issue in large areas of most of these countries.

Child injury patterns show real differences between LMICs and rich countries

A global map of the distribution of rabies provides a visual demonstration of the boundaries between the rich countries and the rest of the world. Were the uncounted drownings or poisonings to be included, it would only reinforce this picture. That picture exists because rich countries have almost completely removed many of the injury risks from children's environments. Whether through vaccination of dogs, child-resistant packaging of toxic drugs and substances, or limiting water exposure to recreational settings, they have fundamentally changed their risk environments for children – of all social strata, not only the rich or urban. Primary prevention of injury is a luxury afforded by the wealth and regulatory and enforcement infrastructure of these countries operating on educated populations who have safety awareness as part of their cultural norms. This has taken the better part of a century of social and economic development to achieve.

Child injury in countries such as the ones in these surveys occurs at high rates because hazard and risk of injury are ubiquitous in all child environments in these countries. Simply adopting some of the proven interventions of rich countries and trying to localize them may not work without a fundamental understanding of the differences in risk environments between the

two. Many primary prevention strategies may not be feasible in these cultural settings at current levels of development and much will depend on secondary prevention. Surveys such as these clearly delineate the risk environments and point out which injuries have the highest population attributable risk (PAR), who can be most effectively targeted by interventions, and which interventions would tackle the injuries with the largest social and economic burdens.

13 DISCUSSION

This set of surveys is unique among mortality and morbidity surveys in LMICs. It uses very large, representative samples, a common set of definitions, has a common methodology for interviewing and analysis, and looks at mortality and morbidity as it occurs at the household level. The power of the surveys enables fine discrimination of patterns of mortality of all causes at the different stages of childhood and adulthood. They provide information previously unavailable on morbidity from injury, and with standard categories of severity to make comparisons possible between surveys. They also provide comparative information on risk factors for injury, on the association of injury with socio-economic status, and on the economic costs and social burden of injury.

Directly counting all deaths in the community where they occurred and assigning cause to them was previously considered too difficult and/or expensive to do. However, these surveys show that within countries in Asia there now exists sufficient local capacity to carry out direct measurement surveys. This makes it possible to count each child death in all age groups from 0 to 17 years and to classify the cause of each death.

These health and injury surveys have been conducted in five East and South Asian countries: Bangladesh, China, the Philippines, Thailand, and Viet Nam. There is ongoing work in Cambodia and Indonesia which will be communicated in future working papers in this series. Together, these countries provide a cross-section of the Asian region, including various economic and social development stages, differing geographies, and different cultures, political systems, and religions. Applying the standardized survey methodology with a common set of definitions across these countries permits comparison of injury rates. It allows the exploration of commonality of cause and proportional mortality across multiple child and parent age groups.

A number of the findings are of potentially great public health importance:

- Injury is the leading killer of children after infancy in all the locations surveyed. Accordingly, it may be inferred to be a leading cause of child death throughout the entire Asian region and in other regions with similar or better IMR/U5MR indices, including as Latin America, North Africa, the Middle East, Eastern Europe and the former Soviet Union.
- Drowning, previously greatly undercounted, accounts for about half of all child injury deaths in the surveys.
- Injury due to animals has not been widely recognized as a leading cause of child mortality and morbidity, although it was found to be the first or the second leading cause of child morbidity in the surveys, and a significant cause of mortality as well.

- Finally, the surveys show that, at least in the countries surveyed, which are representative of Asia, the pattern of child mortality and morbidity now closely resembles that in developed countries. The epidemiologic transition is far advanced in this region, but the design of child health programmes has not caught up with it.

Other important lessons from the surveys are that the methodological problems they were designed to avoid, such as small sample sizes, lack of power, short recall periods and facility-based case finding, remain very serious issues which fundamentally distort the picture of child and adult health. A review of the available literature on child injury mortality and morbidity in LMICs shows that a large proportion of studies are affected by the issues just mentioned. In addition, studies dealing with morbidity apply inconsistent definitions of severity. These factors may explain, in part, why the available literature has not provided sufficient evidence to allow injury deaths to be included in most current child death estimates.

The surveys go well beyond epidemiology and include economic and social costs, risk factors and dimensions of behaviour, knowledge and attitudes. The fundamental reason for conducting the surveys was to provide timely, accurate information to stimulate public health interventions against the leading causes of child injury. The surveys also establish a baseline by which these interventions can be assessed. In each country where a survey has been carried out the results have stimulated needed action on child injury interventions. They may thus be identified as effective interventions in and of themselves.

Innocenti Working Paper

**CHILD MORTALITY AND INJURY
IN ASIA:
SURVEY RESULTS AND EVIDENCE**

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**Special Series on Child Injury No. 3
IWP-2007-06**

October 2007

1 INTRODUCTION

Background

With health histories from nearly 2.5 million residents of over a half million households in five different countries in East and South Asia, the surveys recently carried out (from 2000 to 2005) form a unique evidence base regarding injury in the most populous region of the world. Because the surveys are so large, and cover representative populations in their scope, the measurements are unprecedented in precision and help paint a clearer picture of mortality at all stages of childhood, and morbidity from injury. That picture is more complete than – and markedly different from – that found in previous estimates. The overview paper (IWP-2007-04) went into some detail on the reasons for this, and they are briefly reviewed here for the benefit of readers who have not yet accessed that paper. The differences primarily relate to four factors, three of which are the technical factors of different measurement methodologies, changing epidemiologic patterns, and a more inclusive definition of childhood. The fourth is the result of 30 successful years of the child survival revolution: an alternative method is now possible because of the infrastructure developed in each country over those 30 years.

An innovative methodology

In relation to the first factor, the methodology that has been used for child mortality estimates in the past has principally started from an estimate of the overall number of children under five years of age who die annually in the South and East Asian regions of the world where the surveys summarized here have been done. Then, an estimate of the proportional causes of under-five deaths is applied to that total number. This results in the total numbers of children under five who die from each of those principal causes. Injury is not among the proportional causes estimated currently and it is generally included in an overall category called ‘other’. In contrast, the method used in the studies summarized here is to define a large, representative sample of the country, city or province being surveyed, and then to count the deaths one by one as they have been captured within that sample, assigning a cause of death to each one. The classification used in the surveys counts injury deaths as a specific category, and further breaks overall injury down into its constituent subtypes (drowning, road traffic, falls, etc., etc.) When counted in this fashion, injury is seen to comprise a much larger proportion of under-five deaths than was previously recognized.

Changed epidemiologic patterns

As far as the second factor is concerned, changing epidemiologic patterns, the surveys presented here have all been done since 2000. However, the research on causality of under-five deaths used in the previous child mortality estimations (even those done as recently as 2005) drew on work done in the mid and late 1980s for the bulk of the information. Since that time, overall child mortality rates have fallen over 50 per cent in the countries surveyed, as measured by the under-five mortality rate (U5MR). The experience of the rich countries of Europe today has been that similar rapid decreases in child mortality were accompanied by a change in the pattern of deaths from a predominance of infectious or communicable diseases (CD) to one of non-communicable diseases (NCD) and injury – precisely the pattern that appeared in the surveys summarized here.

All children, not just those under five

Thirdly, previous child mortality estimates have focused almost exclusively on children under five for better resolution of cause when using the proportional mortality methods. The surveys recounted here measure mortality over the full course of childhood, from infancy through 17 years of age, as defined by the Convention on the Rights of the Child. While the single year of infancy is the highest mortality period of all of childhood and the ages one through four years follow next in mortality, about half of all child deaths after infancy occur after age five. These child deaths, excluded from the previous estimates, have been included in the surveys reported here and most of them are caused by injury.

A collaboration with local institutions

The surveys summarized here have all been conducted by collaborations between UNICEF country offices, The Alliance for Safe Children (TASC) and counterparts within each country. After three decades of health development, the technical capacity now resident within countries in Asia (and elsewhere as well) is significant and allows for large-scale surveys to be carried out with similar quality outputs as in developed countries. Using a standard methodology, the strong multisectoral relationships between UNICEF country offices and the local capacity available in each country, the surveys have shown that it is now possible to move beyond child death estimates that are limited to the first five years of childhood and do not include all causes of death. The decentralized process that produced these surveys, with the planning, fieldwork, data entry and analysis carried out within each country, has shown it is cheaper and provides more information than other population-based surveys presently being used as supplements to the current child mortality estimates. The surveys have also added a great deal to the evidence base on child injury in Asia that has not been known before – both in terms of numbers and types of events, but as importantly, the surveys provide information on the distortions that current estimation techniques introduce and the need to recognize these in future measurement activities for child injury.

Deaths tell only a small part of the overall story

A fundamental lesson emerging from the surveys is that estimates of child mortality from injury (or any other cause) may tell only a small part of the relevant story: morbidity must also be considered. Deaths of children, whether by age five or up through age 17, are critical but they represent just the tip of the iceberg of impacts to individuals, families and society due to injury. Serious and severe non-fatal injuries can result in permanent disability affecting the child and the family as a whole, and can impose enormous resource burdens. They represent major impediments to child health and development, and so they should be measured alongside fatal events. The surveys have shown some of the technical and methodological problems involved in doing this; however, they show that these measurements are possible, and that the information so gained offers an important contribution to health policymaking and planning.

Classification of fatal and non-fatal injury

Injury is often classified as either fatal or non-fatal, but this implies a dichotomous relationship that is not true in reality. Injury actually occurs as a continuous set of outcomes of mounting severity which increase as the physical extent of the injury event increases. The most severe outcome on the spectrum of injury is death. Classifying the intermediate

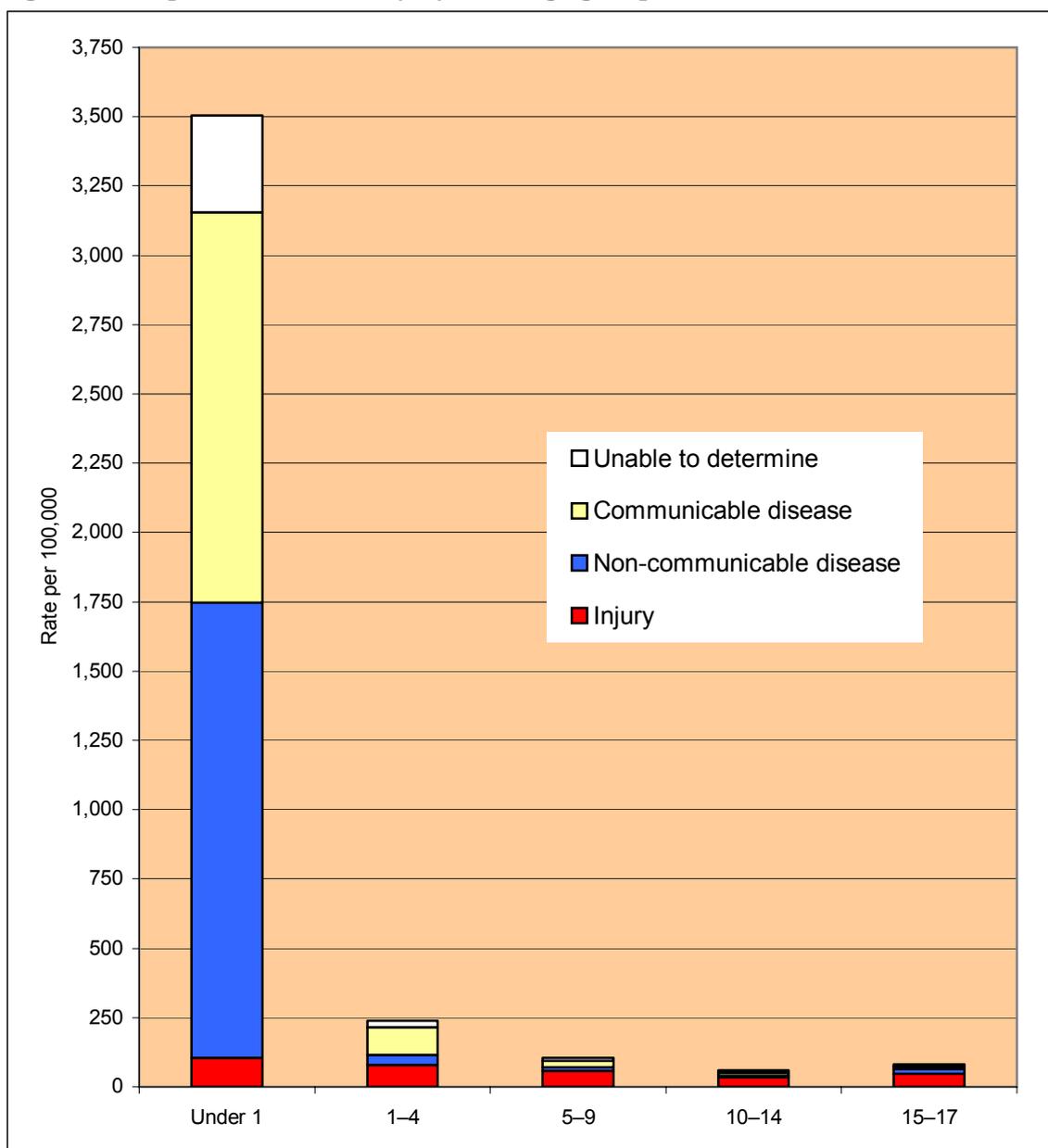
outcomes where there are varying effects on health that fall short of death is a very difficult undertaking, as discussed in the paper on the survey methods. The methodology developed to allow comparisons in a standard fashion is based on severity being proportional to the economic and social cost of the injury. Thus an injury so minor that no costs were incurred by the individual or family was ignored in the survey, and only injury that resulted in costs were counted. While it is easy to conceptualize continuously increasing levels of severity ending with death, it is often confusing for them to be presented in this manner. Thus this paper begins in the traditional fashion by presenting the most severe level of injury – fatal injury – first and later presents non-fatal injury with severity classifications. In an attempt to help the reader tie the two together, the composite results of all the surveys are presented with each type of injury showing the entire spectrum of severity from moderate to death.

Striking a balance between technical precision and clear communication

There is potential for information overload in the presentation of epidemiological and statistical detail to policy audiences, who form a key component of the intended readership of this Working Paper series. The presentation is accordingly aimed to provide a comprehensive picture so that the reader can ascertain a clear pattern in the findings, with that pattern visible both in the composite of all the surveys taken as a whole and in each of the individual surveys. It should be noted that since the earliest survey, in Viet Nam, had the smallest sample size, the confidence intervals around those estimates are larger than those in subsequent surveys. The survey in Beijing also faced an issue with statistical power due to the very low mortality in the capital city of China. However, as in the case of the WHO child mortality estimates, for the sake of clarity the working group has opted not to encumber the present charts with error estimates or confidence intervals. Readers interested to delve more deeply into the individual and comparative rates and to understand the uncertainties reflected therein are directed to the individual survey reports which contain this level of detail, available from the particular UNICEF Country Office or at <www.tasc-gcipf.org>.

2 PROPORTIONAL CAUSES OF CHILD MORTALITY BY AGE GROUP

The general pattern that can be seen in figure 1 is that injury is present as a cause of infant mortality, but is overshadowed by communicable and non-communicable causes. It is clear that the first year of life has the highest mortality of any period of childhood, and that well over half of all child deaths in the age group 0–17 occur in this first year. Most of the deaths in infancy (as many as two thirds) occur in the first month of life, the neonatal period. It is precisely this epidemiologic fact that has made infancy the keystone of child survival. The deaths in the first month are targeted by giving them a label of their own, neonatal deaths. While there are some causes of death unique to this period (mainly related to pregnancy and the process of birth), most of the other causes are the same infectious pneumonias and diarrhoeas that are the main killers in later infancy.

Figure 1: Proportional mortality by child age group

Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

It is visually striking how dramatically mortality falls immediately after the infant period, and how different the pattern of causality is after that. While injury causes only about 3 per cent (2.9 per cent) of infant deaths, it causes over a third (36.6 per cent) of deaths of children aged 1–4 years.

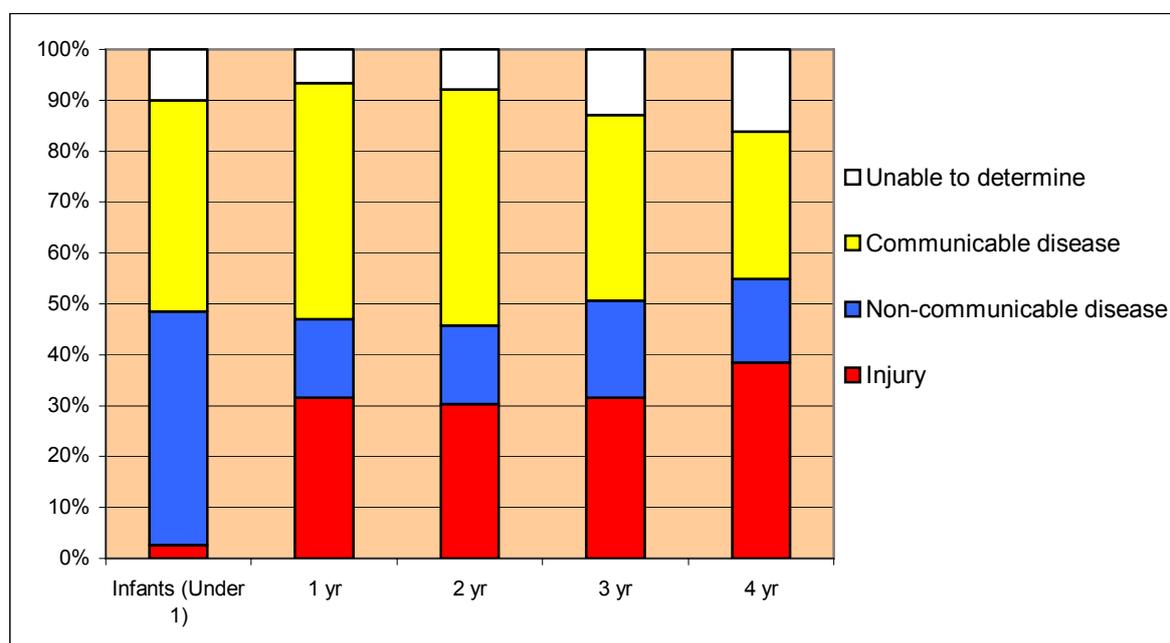
The very high mortality rates in infancy can be seen in comparison to the rest of childhood. After infancy, mortality rates from causes other than injury decline exponentially, while injury mortality declines in an approximately linear manner. It can also be seen that childhood injury is near its peak in infancy.

This epidemiologic shift occurs for two reasons. First, about two thirds of all infant deaths occur in the first month of life, the neonatal period. This is the highest mortality period in life.

Most of these early deaths are due to pregnancy, the birth process or post-partum causes. Once beyond the pregnancy and birth related period, mortality falls dramatically.

Secondly, it occurs as a result of the changing environment of the child. Born totally dependent on its mother for everything, the infant is carried everywhere and protected from hazard by the mother or other caretaker. There is little exposure to hazard, other than falling from surfaces the mother places the infant on, or being accidentally smothered while sleeping next to the mother. However, when the child begins to walk, around age one, the situation changes dramatically. It explores the world around on very unstable legs, often escaping the supervision of the busy mother and ignorant of the hazards entailed. Injury is a leading cause of death in the 1–4 age group, as can be seen in figure 2.

Figure 2: Proportional mortality of children under five



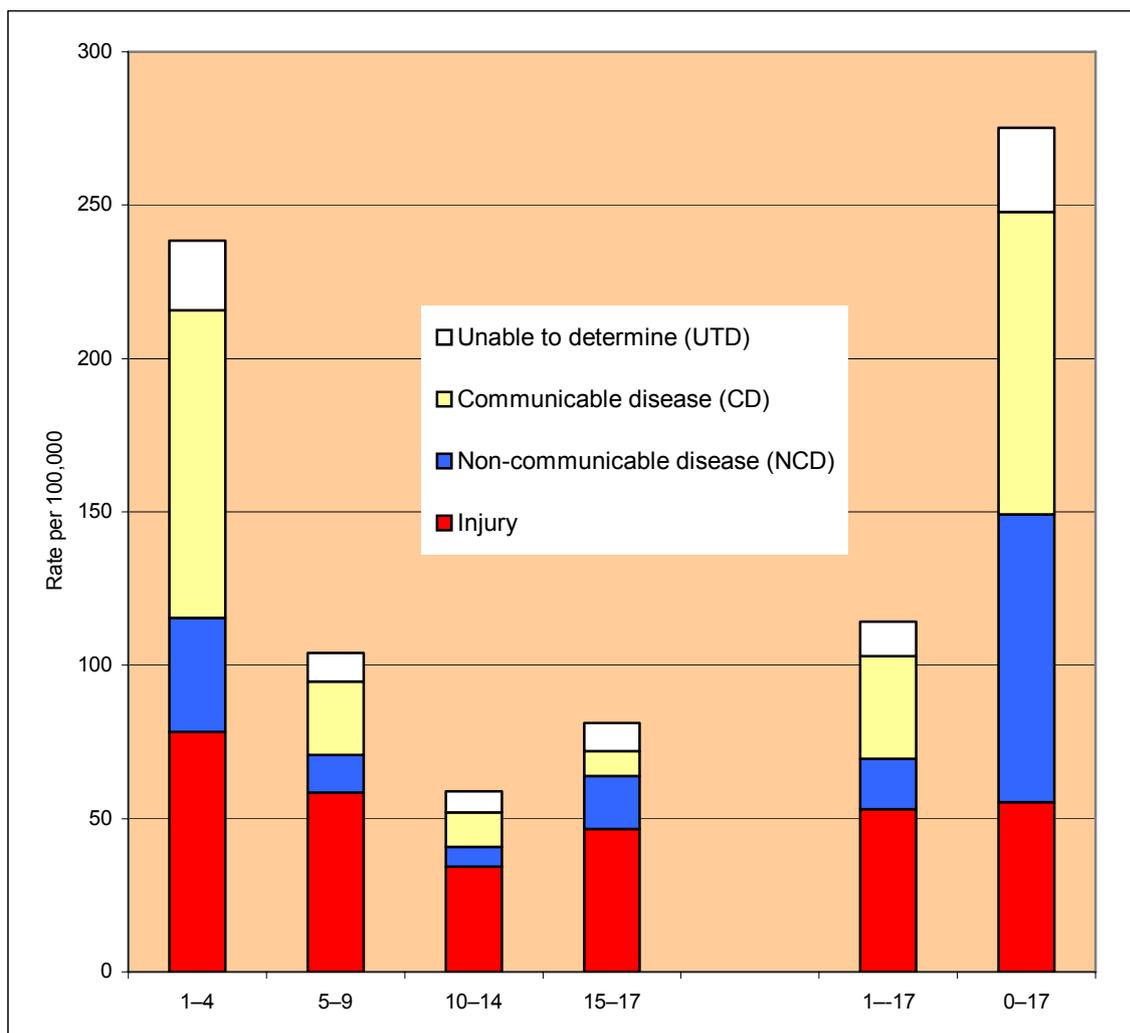
Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

The survey sample sizes are sufficiently large for there to be a sufficient number of deaths in each child age group to answer the question of how proportional mortality changes over the first five years of life. It is clear that infancy is a special and separate period of early childhood, with a distinct pattern of mortality which changes entirely after the first birthday.

This has fundamental implications for measurement of mortality in early childhood. Lumping infancy and the 1-4 period together creates a highly distorted picture of early childhood mortality. The mortality rates of infancy are the highest in life, 10 to 15 times more than for those in the next year of life. The largest proportion of those deaths relate to pregnancy, birth or its immediate aftermath, and these do not occur in the later years. Almost 8 out of 10 deaths in the five-year period after birth occur during the first, infant year. Combining these with the dramatically lower rates of the next four years, which have an entirely different pattern, overwhelmingly distorts the epidemiologic picture of the next four years.

Lumping the two different periods together, infancy and early childhood, as 'children under five' is convenient. However, it makes it impossible to distinguish which are the leading killers after infancy, and thus develop the most effective interventions for early childhood.

Figure 3: Mortality rates by child age group (per 100,000 population)



Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

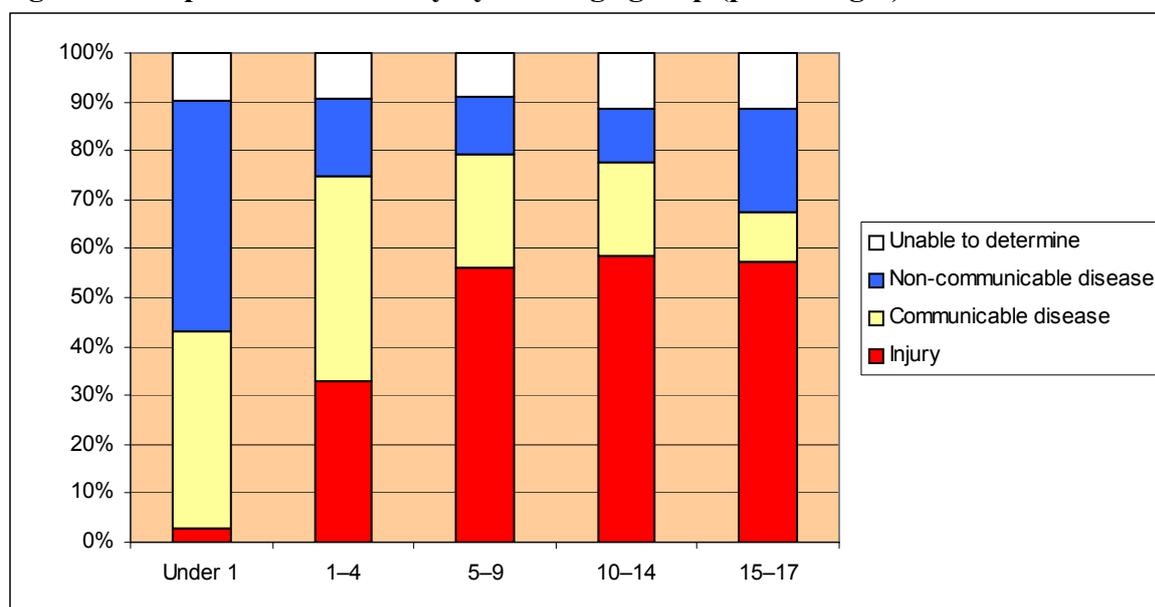
Infancy, defined as the first full year of life, has been excluded in the second bar from the right-hand side of figure 3 in order to clearly show the pattern of proportional mortality in the rest of childhood after infancy. Seen on this scale, injury is a leading killer for the rest of childhood. Injury accounts for about half of all child deaths after infancy (1–17) and for about a fifth of all mortality even when infants are included (0–17).

Injury kills an increasing proportion of children as childhood progresses, even as overall mortality falls, until the late adolescent age group (15–17) when the overall death rate begins to rise again. One reason for this is the increasing rates of intentional injury (suicide and homicide) that become leading causes of child death in the adolescent age group, along with the increase in road traffic accidents (RTA).

The next series of figures show proportional mortality as a percentage rather than a rate in each individual stage of childhood. This emphasizes the relative contributions to all mortality in the age group. It is important to note that injury, while one single cause of death, is made

up of a variety of subtypes (drowning, RTA, falls, suffocations, suicides, homicides, etc.). The different patterns of subtypes of injury will be seen in later figures.

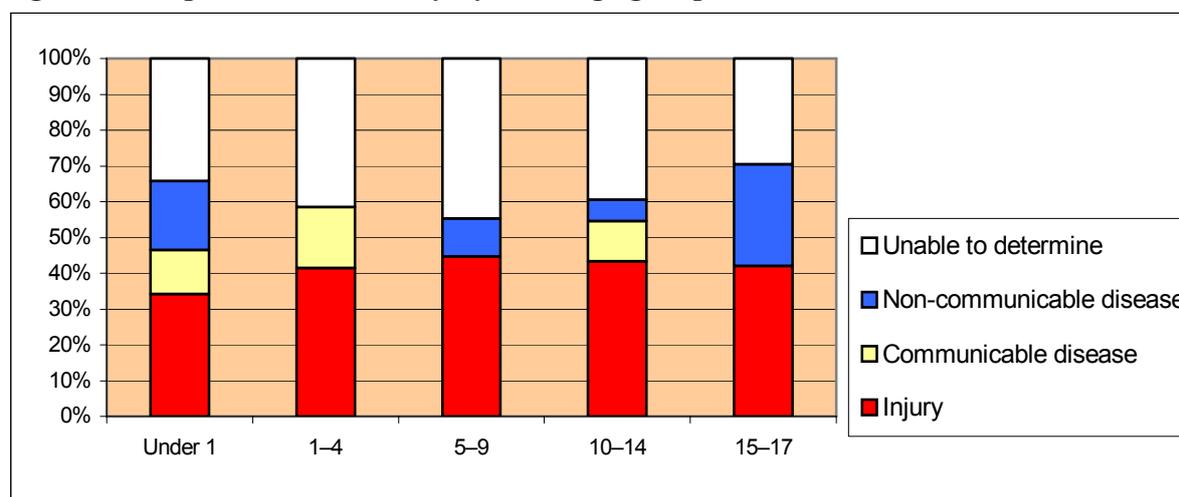
Figure 4: Proportional mortality by child age group (percentages)



Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

Figure 4 presents the overall pattern as seen in the composite of the surveys. It is based on 516,818 households from the surveys, with 788,194 children. Figures 5–10 show the respective proportional mortality patterns from each survey.

Figure 5: Proportional mortality by child age group, Viet Nam

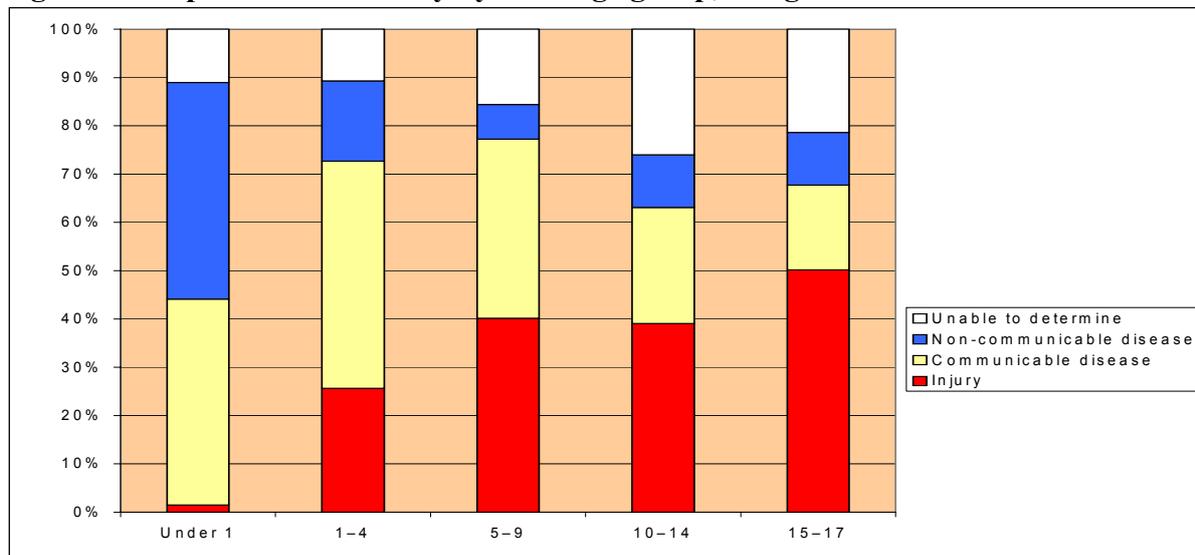


Source: Vietnam Multi-center Injury Survey (2000).

The survey in Viet Nam, the first survey carried out, had a sample size of 26,700 households. This was sufficient to look at mortality over the 0–17 years of childhood. However, it was too small to capture large numbers of deaths in the individual age groups of childhood. This is the reason why figure 5 does not display non-communicable disease deaths in the 1–4 age range or deaths due to communicable disease in the 5–9 age range. These types of deaths

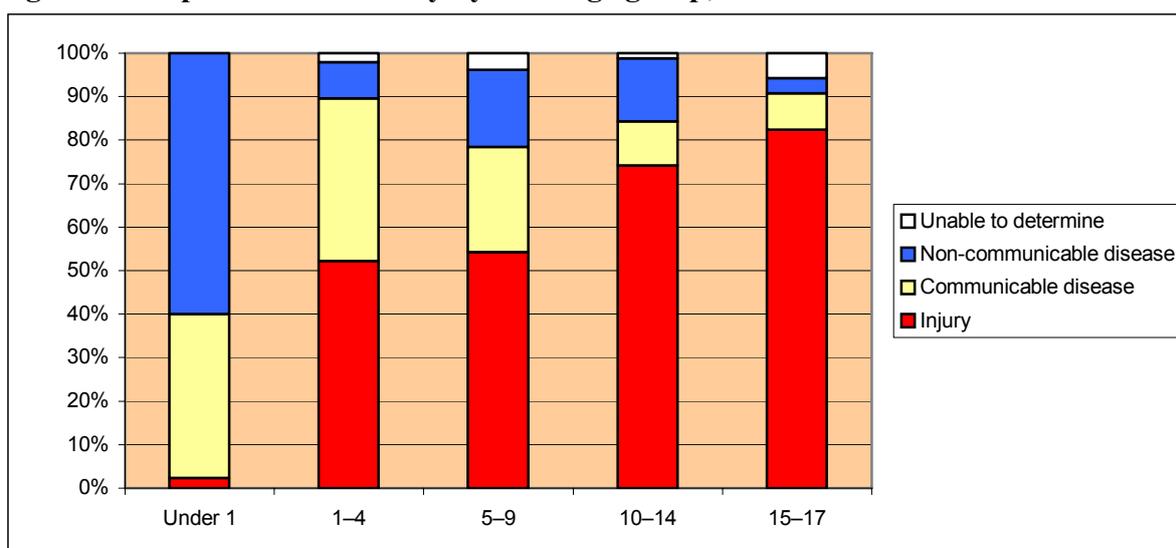
certainly occur, but they fall below the resolution power of the survey. Similarly, the high levels of injury seen in infancy are caused by the variability due to a relatively small sample.

Figure 6: Proportional mortality by child age group, Bangladesh



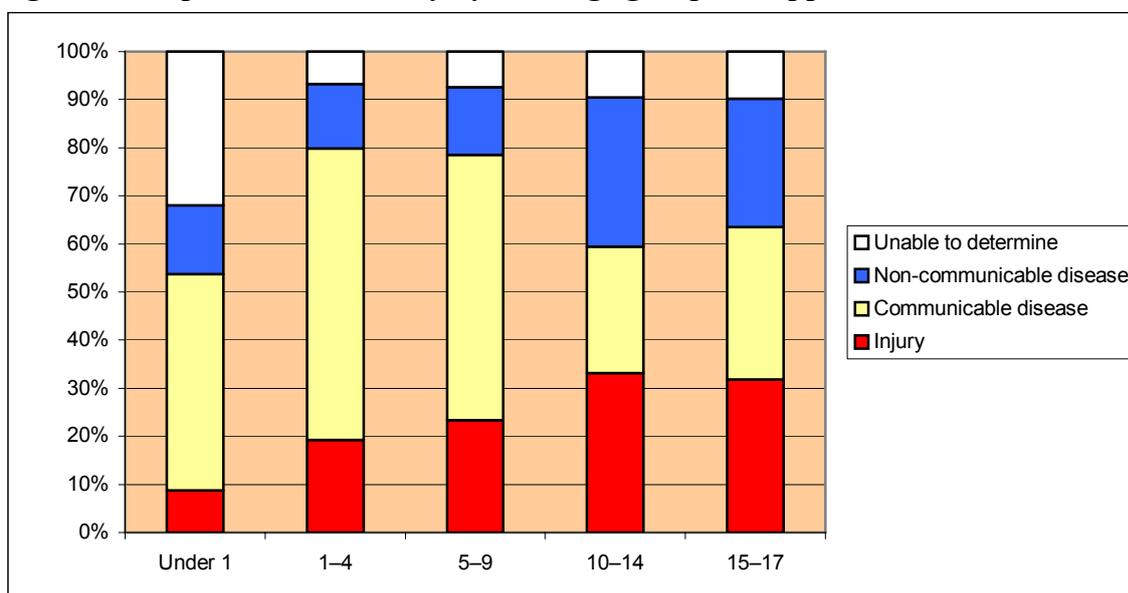
Source: Bangladesh Health and Injury Survey (2003).

The Bangladesh survey had the largest sample size (171,000 households), the largest number of children (351,651), and thus the highest power of the surveys. Bangladesh also had the highest under-five mortality rate among the countries surveyed (71.6/ per ,000 live births), showing that even at this high level of under-five mortality, injury is a leading killer in children aged one to four, and the predominant killer in children aged five and over.

Figure 7: Proportional mortality by child age group, Thailand

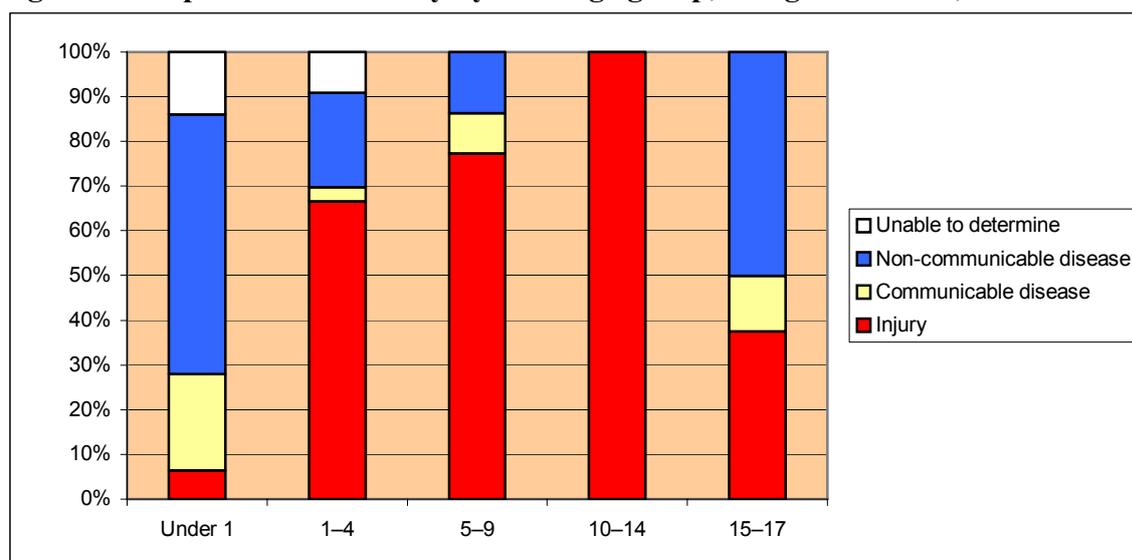
Source: Thailand Injury Survey (2003).

The sample size in Thailand was 100,179 households, with 98,904 children. It had sufficient power to show the common pattern of a small proportion of fatal injury in infancy, dramatically rising in the 1-4 age group, and continuing to increase in proportion as childhood progresses.

Figure 8: Proportional mortality by child age group, Philippines

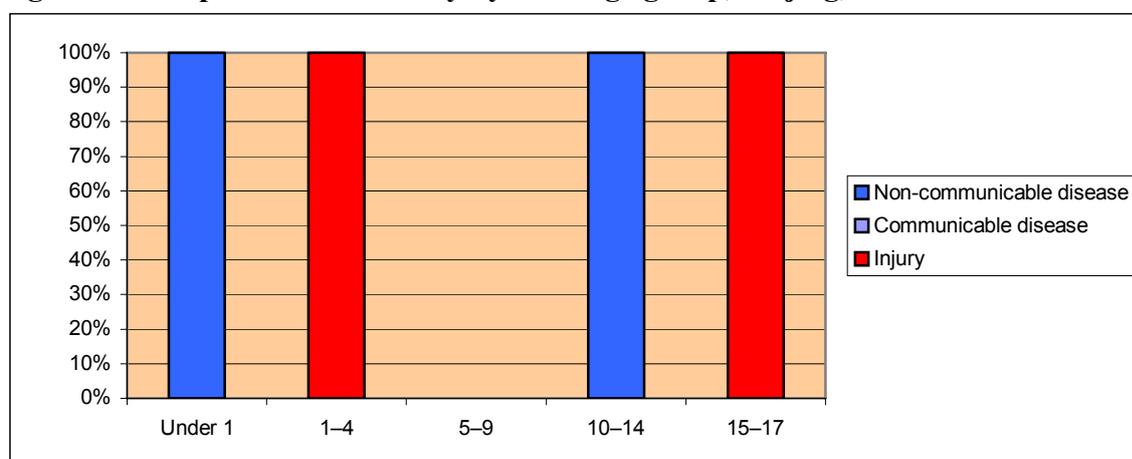
Source: Philippines National Injury Survey (2003).

The sample size in the Philippines was 90,446 households, with 178,938 children. It shows the same common pattern at somewhat lower levels for injury.

Figure 9: Proportional mortality by child age group, Jiangxi Province, China

Source: Jiangxi Injury Survey (2005).

Jiangxi Province had a sample size of 100,010 households. Consistent with the one-child policy, it covered only 98,335 children. This smaller number of children decreased the relative power of the survey in those age groups so that deaths from non-communicable diseases were below the level of resolution in the 10–14 age range. NCD and infection deaths happen in this group, but at levels too low to be detected by the survey.

Figure 10: Proportional mortality by child age group, Beijing, China

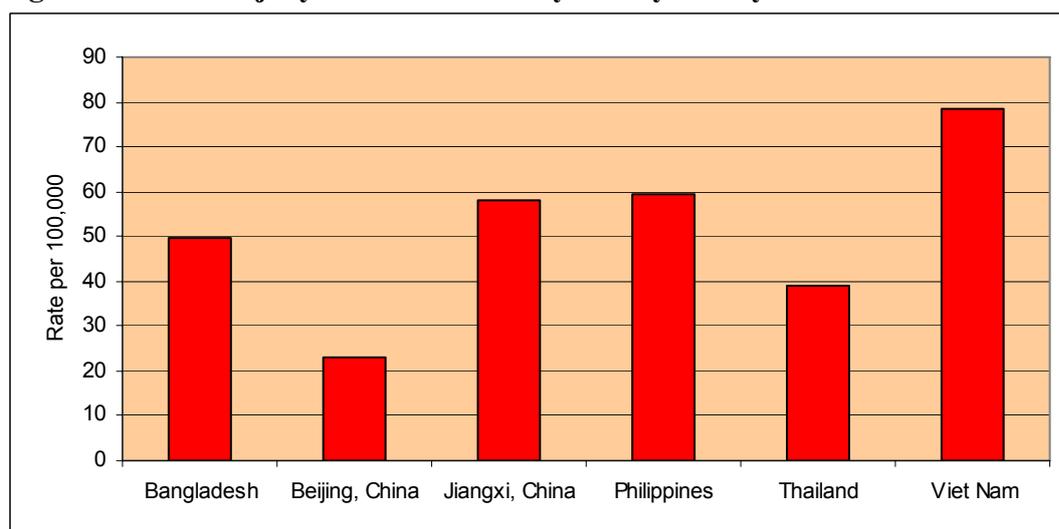
Source: Beijing Injury Survey (2004).

Child mortality from any cause was very low in Beijing; the graph is included for consistency. Despite the large sample size for this one city (28,084 households), as a result of the one-child policy and other demographic factors only 13,508 children were included. The survey lacked sufficient power to find any deaths from communicable disease. There were 7 total child deaths (0-17 years). Three of the seven were injury deaths, the other four were NCD deaths. No deaths of any cause were found in children 5-9 years old.

3 PATTERNS OF FATAL CHILD INJURY

Substantial differences in fatal injury rates in childhood can be seen in the individual surveys, with the lowest rates in Beijing (BIS) substantially lower than the highest rates surveyed, found in Viet Nam (VMIS) (see figure 11). However, these rates are not age-standardized, and China is unique in its one-child policy. Age standardization would markedly decrease the differences. It suggests that fatal injury rates in children in the countries surveyed show considerable similarity as a group and are considerably higher than in developed countries.

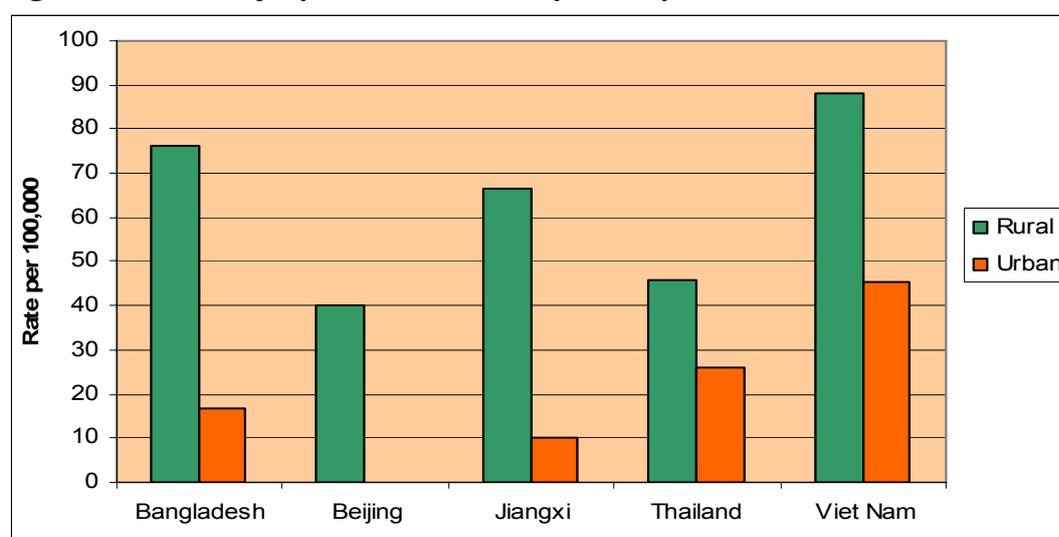
Figure 11: Fatal injury in children 0–17 years by survey location



Source: Authors' calculations from individual surveys (2000-2005).

Fatal child injury occurred at higher rates in rural areas as compared to urban areas in all the surveys (see figure 12). In the case of China, while Beijing is a capital city, it has large rural areas within the administrative boundaries which had higher rates of fatal injury than the urban portions as well. The rate for urban Beijing is so low that it does not register on the graph.

Figure 12: Fatal injury in children 0–17 years, by urban/rural area

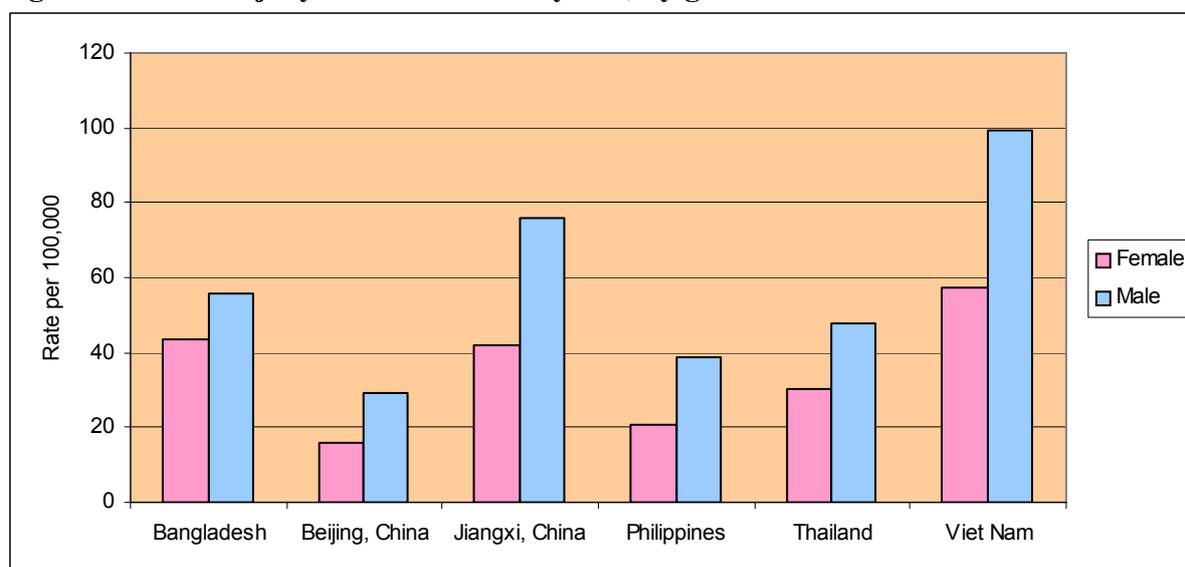


*Source:
Authors'*

calculations from individual surveys (2000-2005)

There were gender differences, with males having higher rates of fatal injury in childhood compared to females in all the surveys (see figure 13).

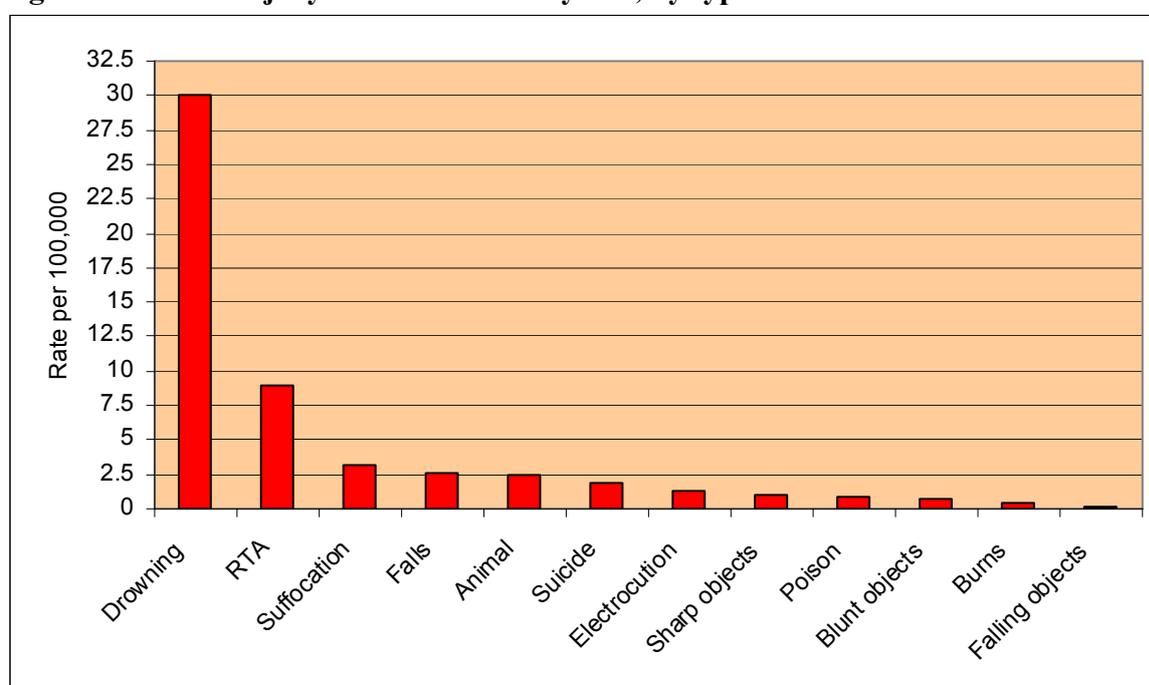
Figure 13: Fatal injury in children 0–17 years, by gender



Source: Authors' calculations from individual surveys (2000-2005).

Drowning was the overwhelming leading injury cause of death in childhood, accounting for over three times as many deaths as RTA,³⁸ which was the second leading cause (see figure 14). Overall, drowning caused about half of all injury deaths in childhood.

Figure 14: Fatal injury in children 0–17 years, by type

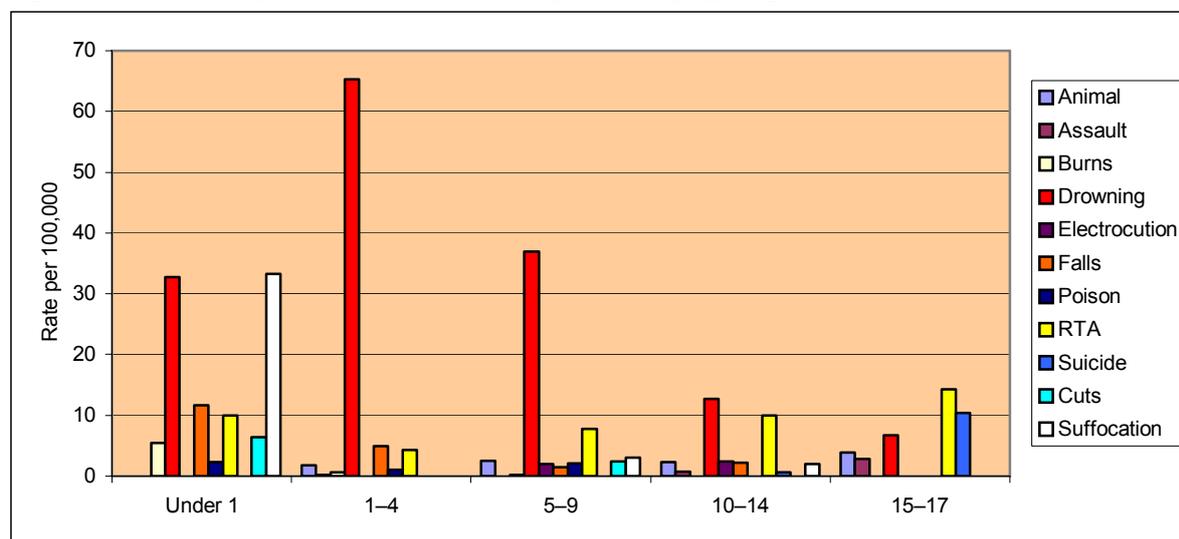


Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

³⁸ RTA is the preferred term to refer to road transport injuries in the countries. (The alternative abbreviation 'RTI' is used for respiratory tract infections and reproductive tract infections.) For the purposes of this definition 'accident' means lack of intent.

Figure 15 shows how these causes appear in the different age groups. Drowning was highest in early and middle childhood, and RTA was highest in adolescence. Suffocation mainly occurred in infants, and falls in all age groups. Fatal injury caused by animals was due to rabid dogs and poisonous snakes in younger children. Suicides occurred during adolescence.

Figure 15: Fatal injury in children by type and age group



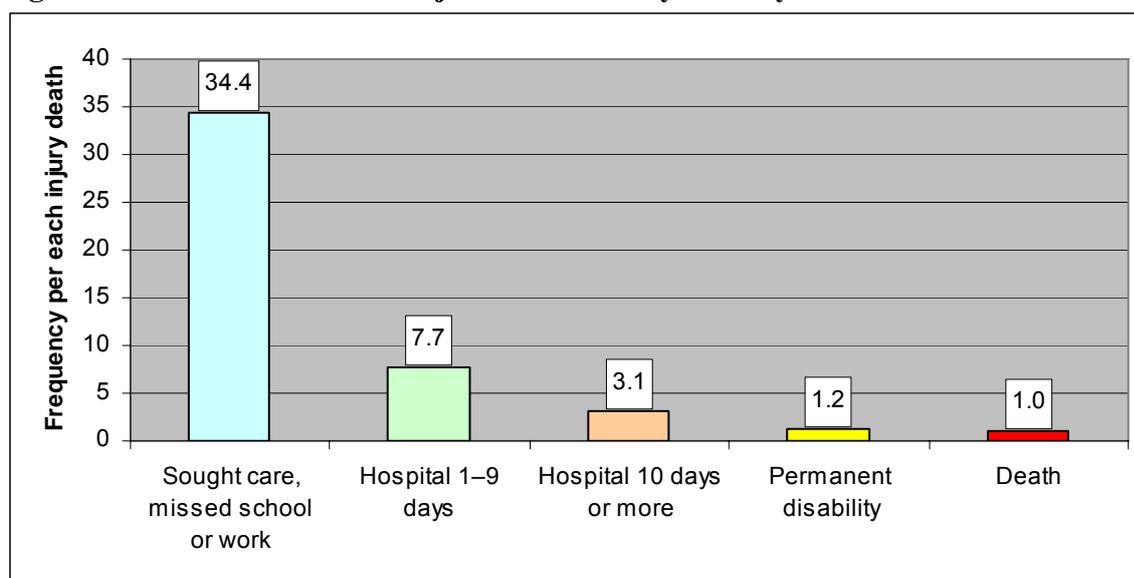
Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

4 ASSESSING FATAL AND NON-FATAL INJURY TOGETHER

Injury (like other causes of adverse health outcomes in children) is usually presented according to two separate outcomes: fatal and non-fatal. This implies that there is such a stark division between the two that they should be treated separately. In reality, three reasons may be identified for why they are presented this way. One is that many surveillance systems only count fatal injury. The second is that there is no standard way of categorizing severity levels for non-fatal injury. The third is as a convenience of graphing them – the rates of non-fatal injury are so much higher than those of fatal injury that it is awkward to place them together on the same chart.

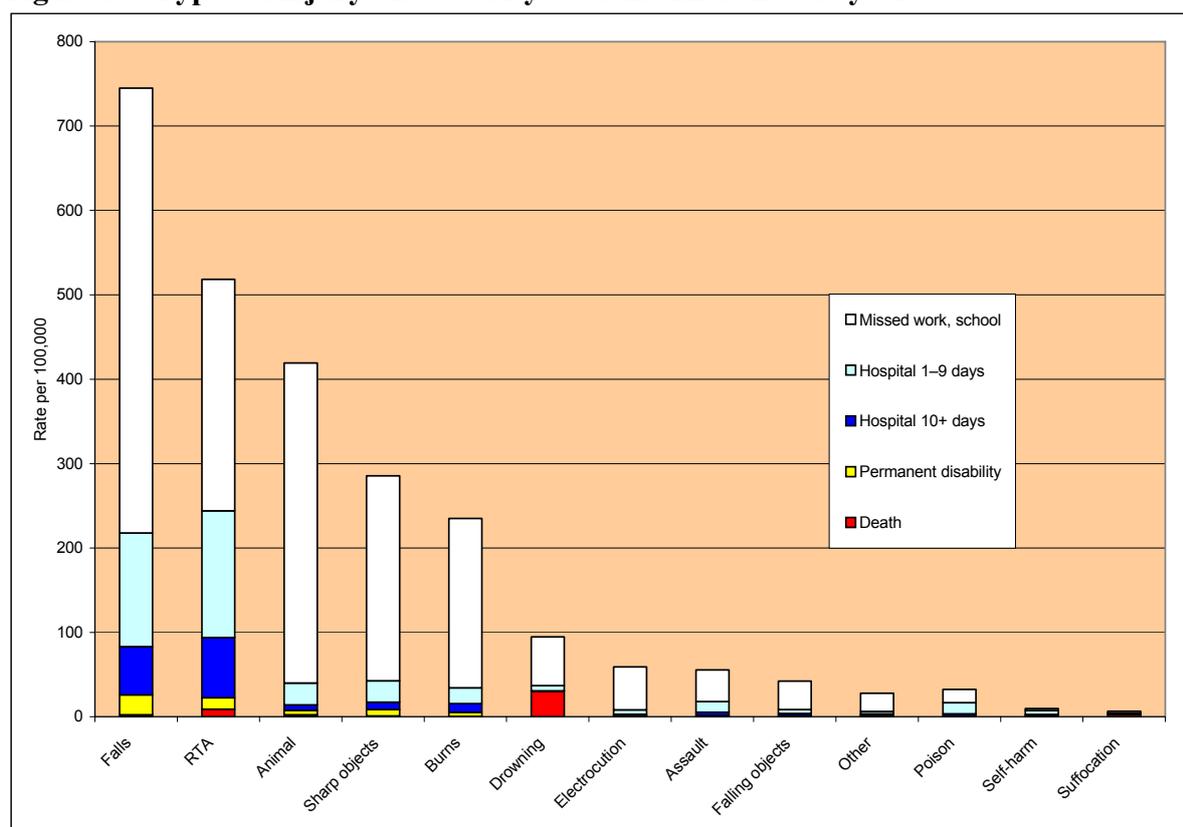
Outcomes following injury proceed in a continuous path, from no or some minimal level of severity through increasingly severe levels that require increasing levels of medical and rehabilitative care, to the most severe outcome, which is death. The present surveys apply a standard set of definitions enabling the levels of severity of injury events to be classified in a consistent manner.

The least severe level counted is injury requiring medical care and missing work or school. Injuries without this result, and which do not incur economic or social costs, are not counted. The next two levels of severity count hospitalization without major surgery, and then hospitalization with major surgery. These levels have very high economic costs associated with them. The most severe non-fatal category is permanent physical disability, with major ongoing, lifelong social and economic consequences. Finally, the most severe outcome is identified as death. Figure 16 shows the relationships between these categories across the set of surveys.

Figure 16: Ratio of non-fatal injuries to death by severity level

Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

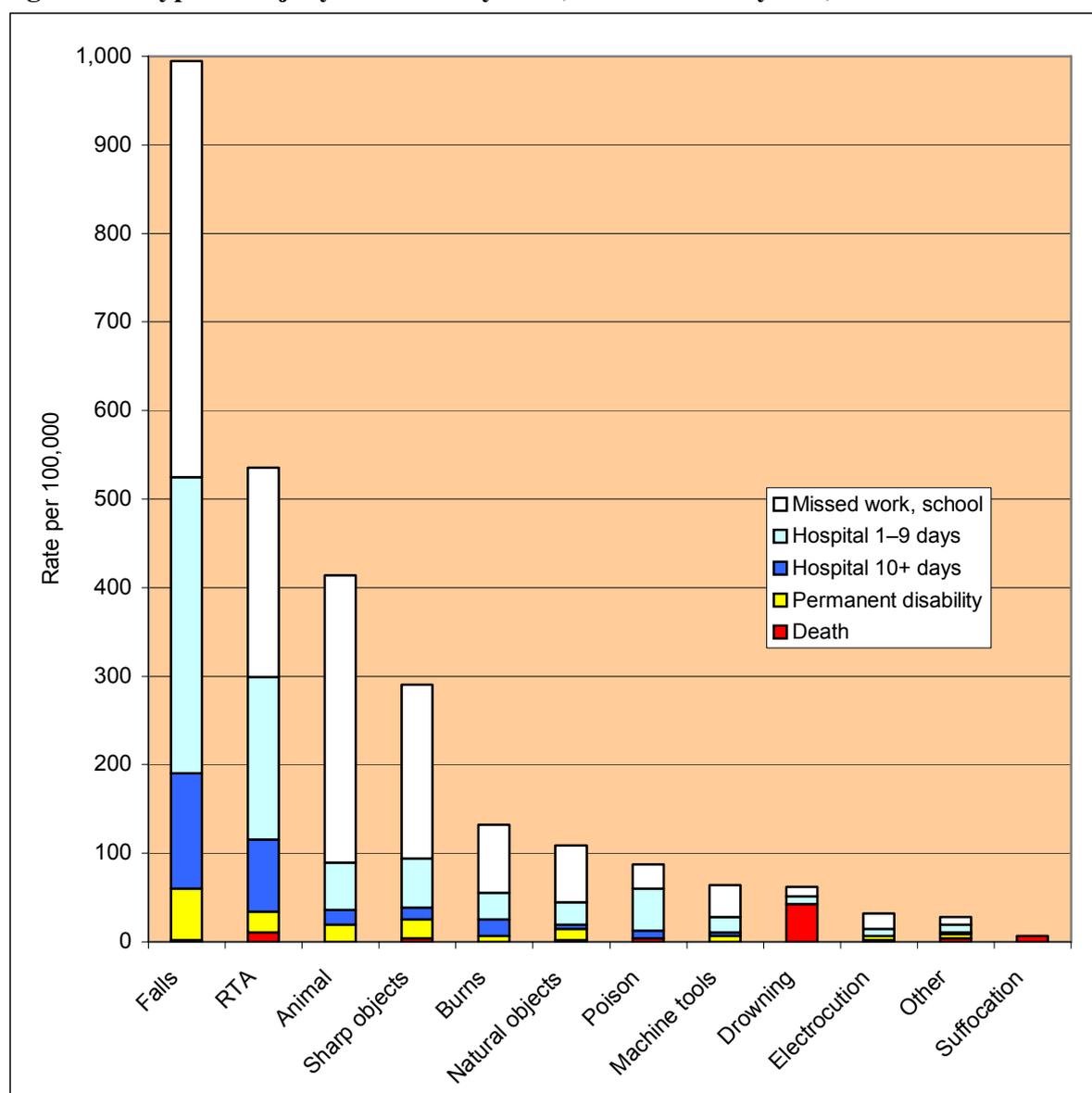
The ratios of non-fatal injury by severity level compared to one death, as seen in figure 16, demonstrate the complexity of the public health issue of the total burden of ill-health or disease, beyond that incurred by deaths alone. Large economic costs and lifetime social burden result from the high levels of severity for non-fatal injury. While infectious and non-communicable diseases also generate disability and large costs (examples are HIV/AIDS and diabetes), injury has a great impact on children because it is so frequent.

Figure 17: Types of injury and severity level in children 0–17 years

Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

The leading causes of non-fatal injury differ from those of fatal injury, as presented in the figures above. While this may suggest two distinct injury dynamics, in reality what is reflected is different degrees of injury outcome, with fatal injury the most severe. Figure 17 shows that non-fatal injury imposes the larger health burden, an understanding that is missed when only child mortality estimates are relied upon. This figure also shows the extremely high case fatality rates for drowning, illustrating why it is the leading cause of death from injury. However, when viewed against the full spectrum of child injury at all severity levels, it is the sixth leading cause of injury overall.

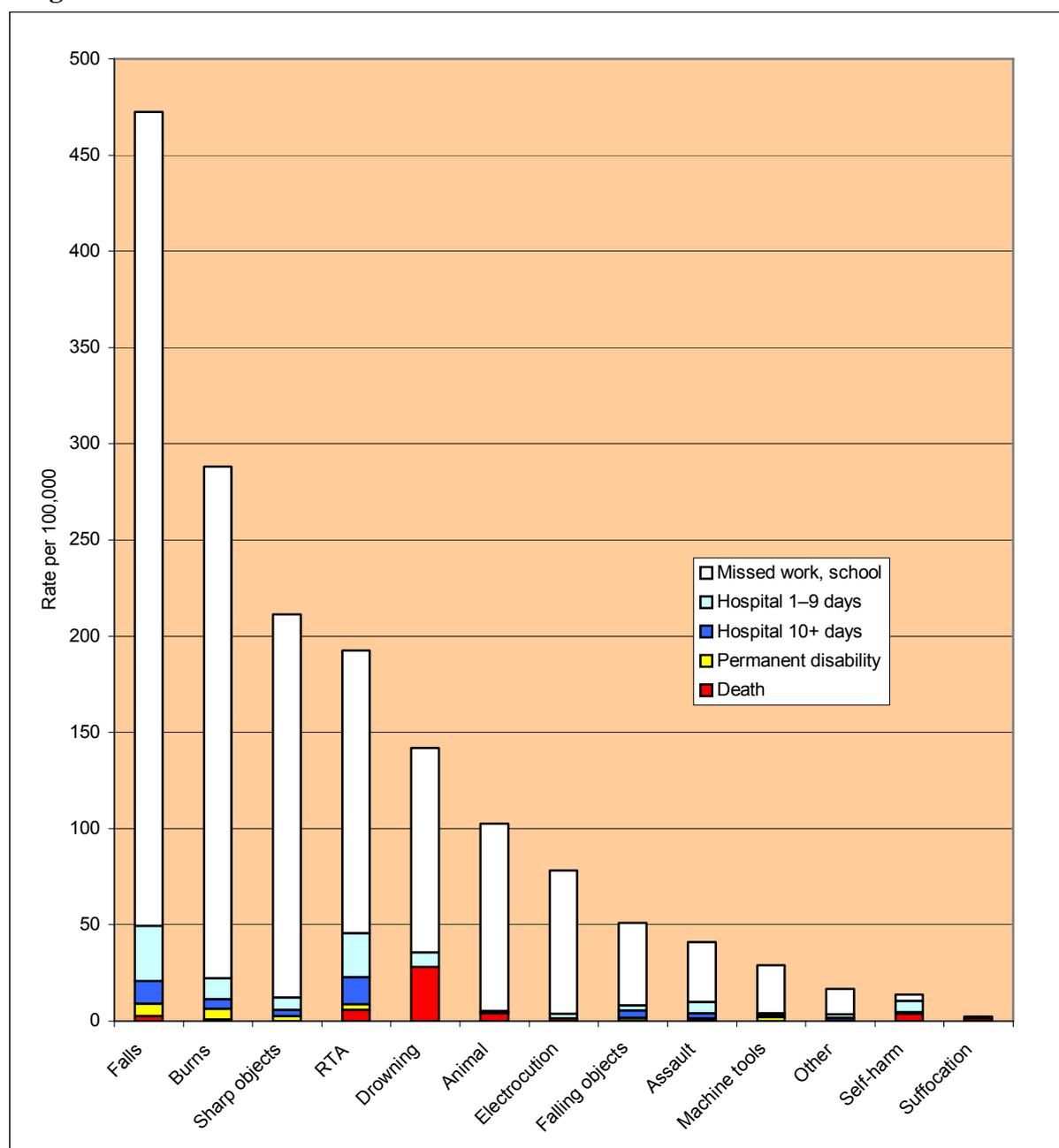
Figure 18: Types of injury and severity level, children 0–17 years, Viet Nam



Source: Vietnam Multi-center Injury Survey (2000).

Figure 18 shows the pattern of non-fatal injury in Viet Nam by severity level and type. Falls are the leading cause of permanent disability from injury in childhood, largely as a result of brain and spinal cord injury associated with falls.

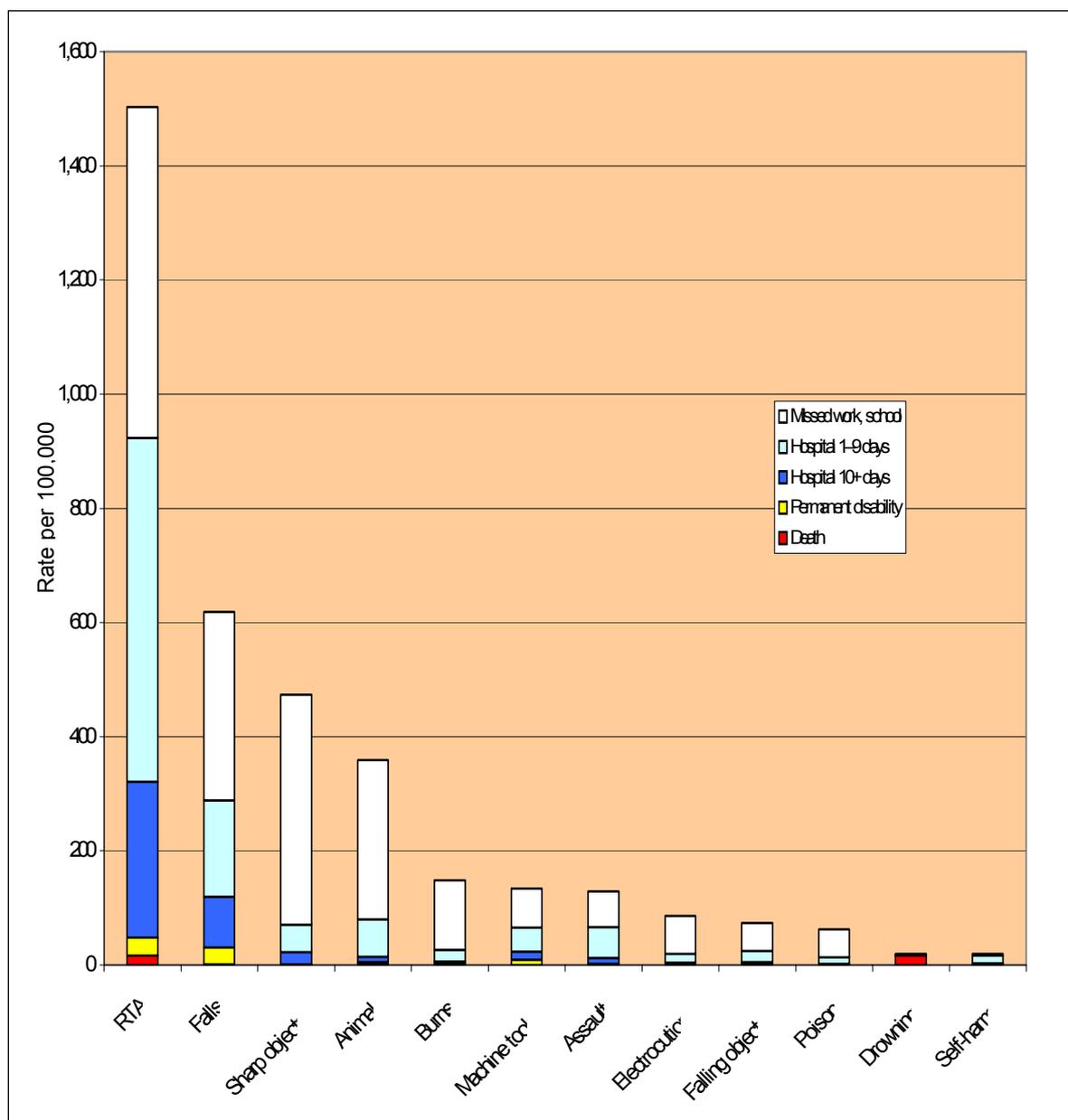
Figure 19: Types of injury and severity level, children 0–17 years, Bangladesh



Source: Bangladesh Health and Injury Survey (2003).

The same basic pattern is seen in figure 19 for Bangladesh, with falls being the leading cause of permanent disability, and traumatic injury (falls, burns, cuts, RTA) being the leading causes overall. The unique nature of drowning, with its very high case fatality rate, is clearly seen.

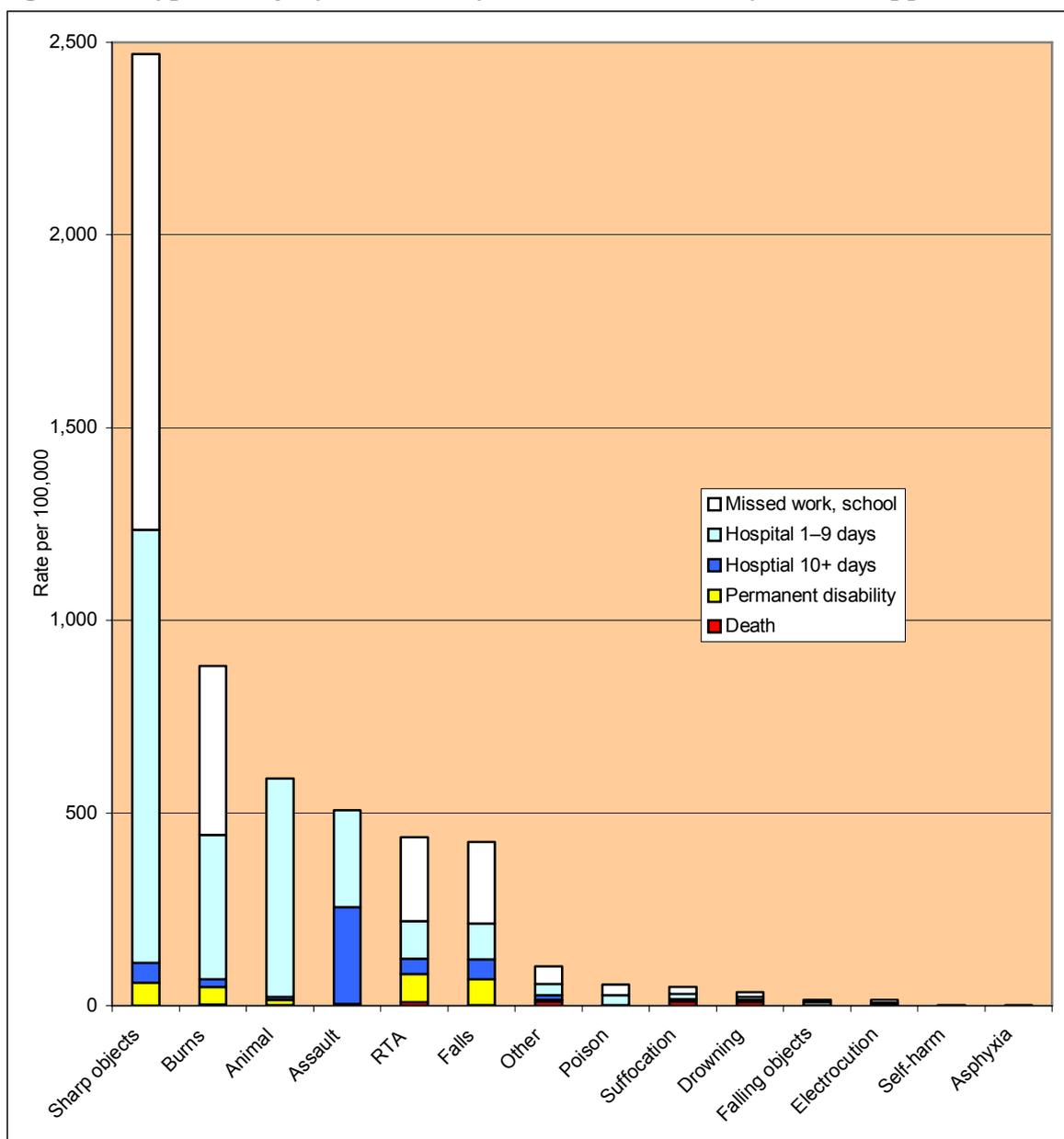
Figure 20: Types of injury and severity level, children 0–17 years, Thailand



Source: Thailand Injury Survey (2003).

Thailand follows the preceding basic pattern (figure 20), with traumatic types of injury being the leading causes of non-fatal injury in children. RTA was the leading cause of non-fatal injury, falls the leading cause of permanent disability, and the high case fatality rate of drowning is easily visible.

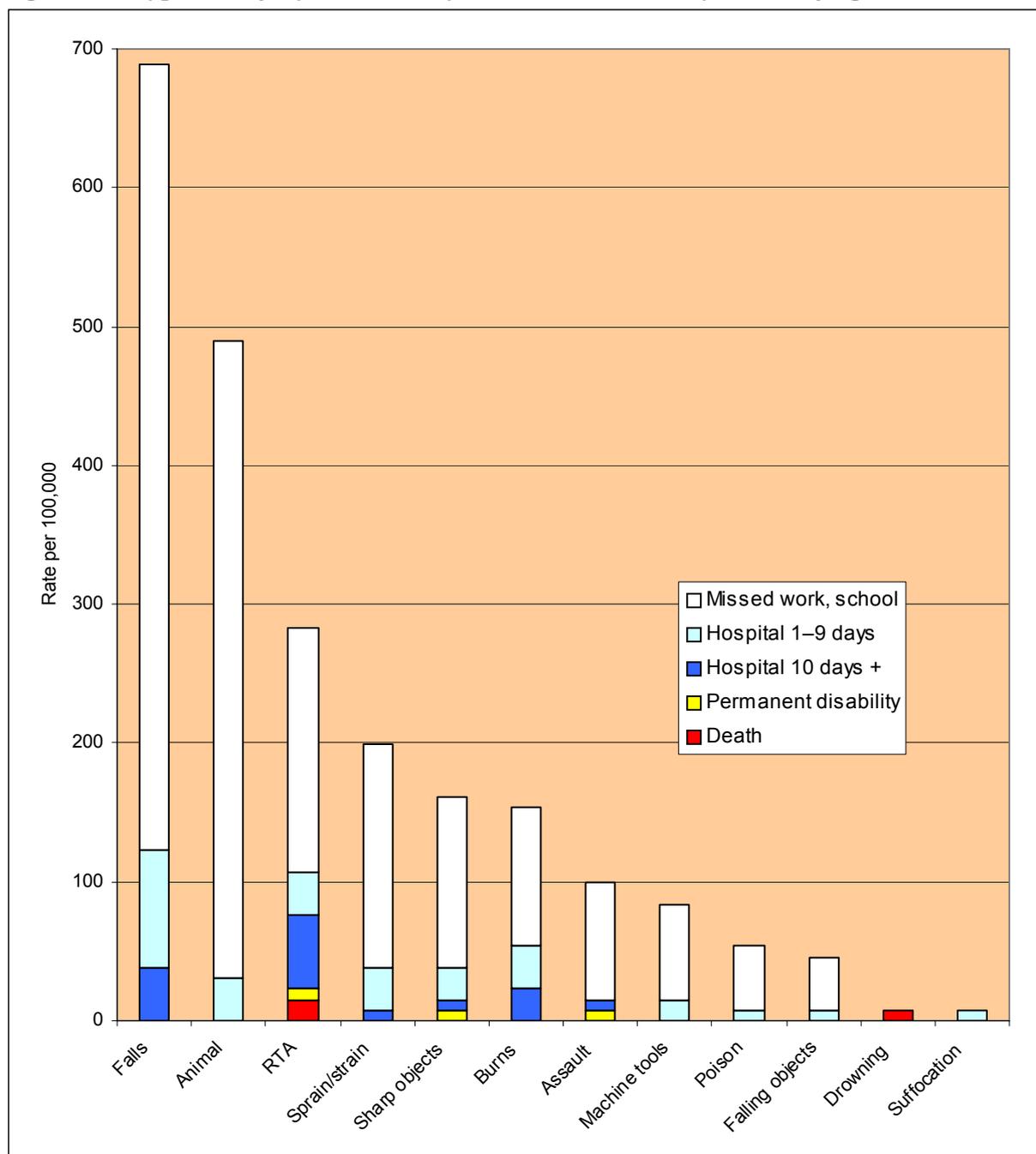
Figure 21: Types of injury and severity level, children 0–17 years, Philippines



Source: Philippines National Injury Survey (2003).

The Philippines followed the same basic pattern (figure 21), with traumatic injury (cuts, burns, animal bites) leading causes of non-fatal injury.

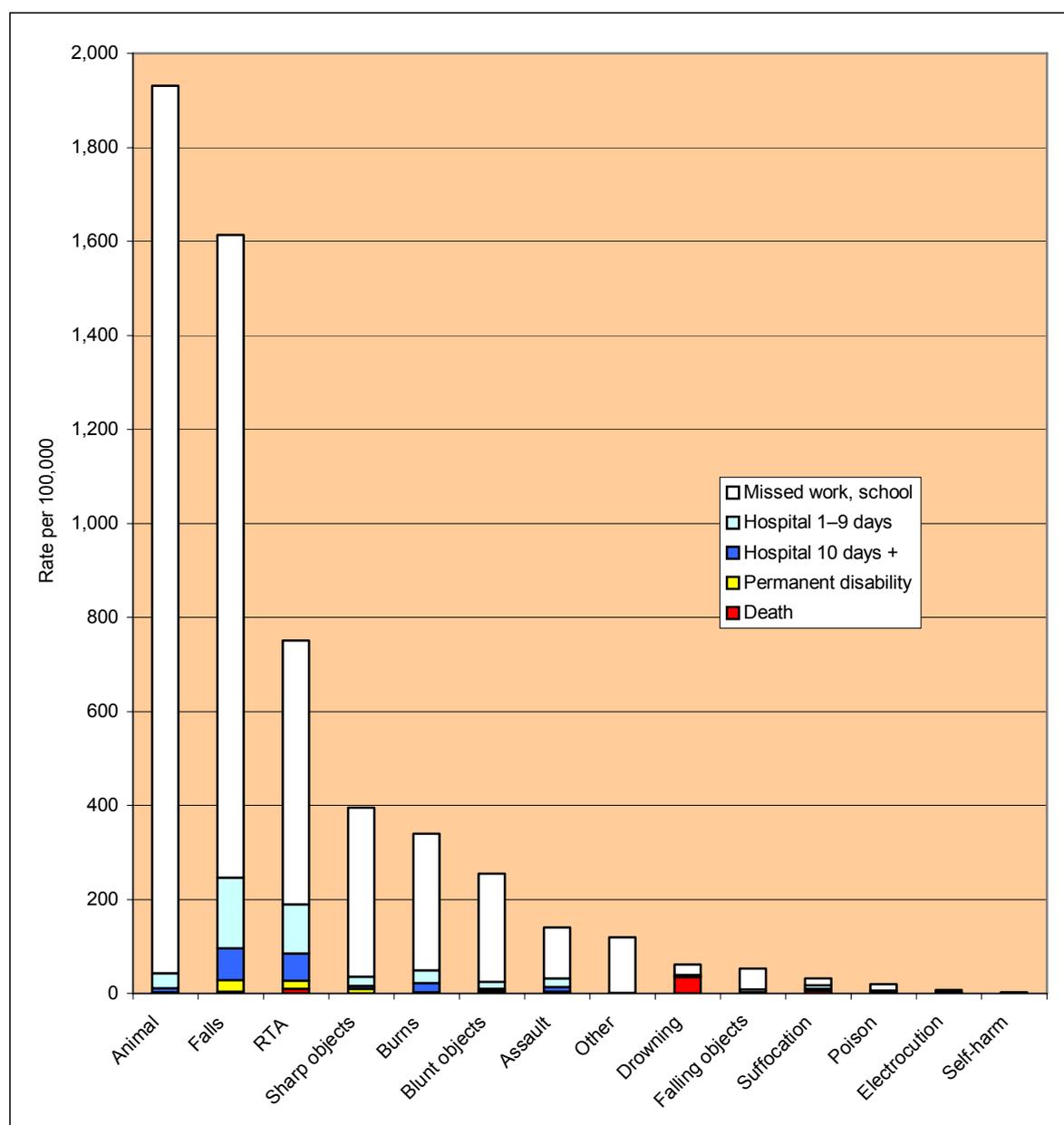
Figure 22: Types of injury and severity level, children 0–17 years, Beijing, China



Source: Authors' calculations from Beijing Injury Survey (2003).

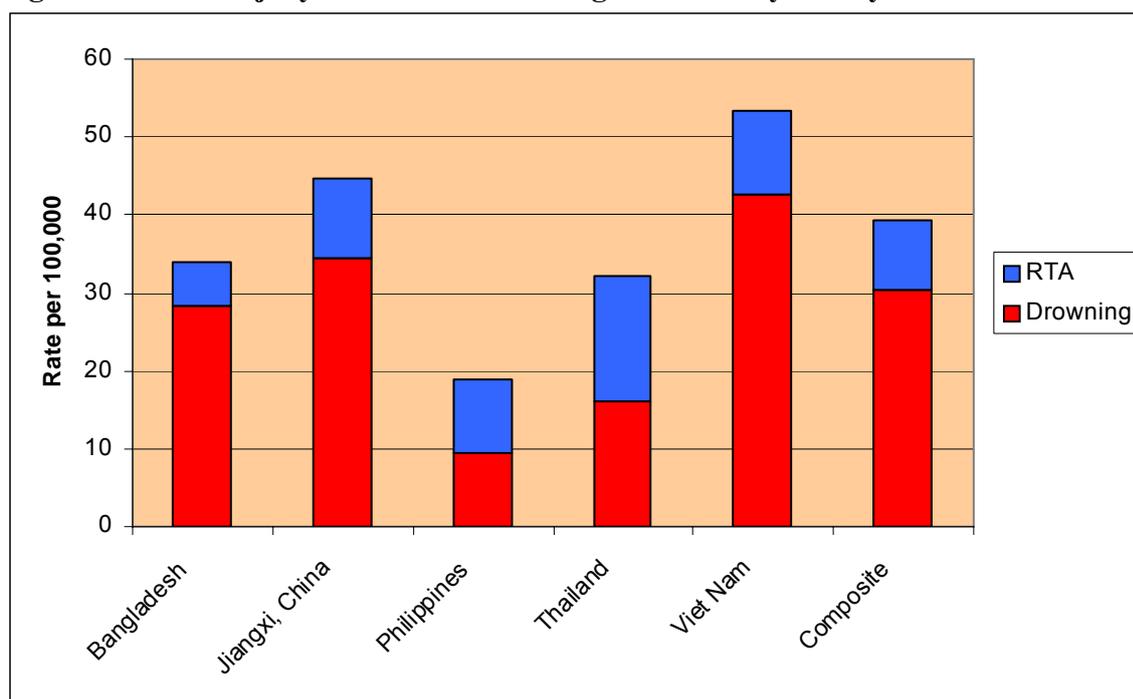
Beijing also shows the same pattern (figure 22), with traumatic injury accounting for the leading causes. Almost all the animal injury in the Beijing survey was from dog bites. Drownings were entirely fatal in the survey.

Figure 23: Types of injury and severity level, children 0–17 years, Jiangxi Province, China



Source: Jiangxi Injury Survey (2005).

Jiangxi Province, China, also exemplifies the pattern of traumatic injury constituting the leading causes (figure 23). Animal injury was particularly high, with the majority caused by dog bites. Drowning was the leading cause of injury death for children, but only the ninth leading cause of injury when non-fatal injury is included.

Figure 24: Fatal injury rates from drowning and RTA by survey location

Source: Authors' calculations from individual surveys (2000-2005).

Figure 24 shows the relative contributions of drowning and RTA to fatal injury in the locations surveyed. These two were the leading causes among all causes of fatal injury. In each survey, drowning was the leading cause and often by a significant margin (Bangladesh, Jiangxi Province and Viet Nam). However, at the national, regional and global levels, drowning has largely been invisible because the surveillance methods depend on hospital and facilities for reporting. Drownings are very rapidly fatal, and most children who die from drowning are simply buried or cremated, depending on the country, and are never seen at a hospital. Surveillance for drownings requires data gathered at the community level.

5 DISCUSSION

It is easy to become overwhelmed by the 'figure-after-figure' presentation. Many more detailed and important figures were omitted in an attempt to foster communication of the key points. Readers desiring greater detail with more extensive statistical information are referred to the individual survey reports. The following are the key points to be conveyed in this paper.

Injury is a significant cause of child death in all age groups in each survey location.

The weight of the evidence is considerable. Epidemiologists and statisticians can (and no doubt will) have arguments about power, confidence intervals and the arcana of complex sampling. However, policymakers simply need to understand one clear finding: Injury is a major killer of children in Asia. Whether it is *the* leading killer after infancy or *a* leading killer after infancy can be argued in technical terms. However, from the policymakers' perspective it does not matter which of these is correct; it is clear that injury is responsible for a very large proportion of child deaths, and these deaths are largely preventable.

While fatal injury is high in all the countries surveyed, the economic impact and social burdens imposed by serious non-fatal injury appear to exceed those for fatal injury.

Previous analyses of the impacts of child injury have not systematically incorporated non-fatal (morbidity) estimates because of the limitations of available data. The surveys presented in this series of papers do so, and provide a strong basis to argue that non-fatal injury imposes high economic and social costs when compared to fatal injury. These factors should be incorporated into decision-making regarding child health programmes. Injury is a leading cause of permanent disability in each of the countries surveyed and a leading cause of hospitalizations. Due to the traumatic nature of most injury, the higher severity levels create major burdens for scarce clinical health resources. Injury is a leading cause of major surgery in childhood – requiring blood banks, anaesthesiologists, surgeons and ancillary trained health staff to support them, as well as recovery rooms and intensive care units. The economic costs of injury are very high, and they can be predicted to rise dramatically in the near term as development and motorization rates increase.

Injury is a leading cause of death, permanent disability and serious morbidity in children in the countries and their neighbours in Asia; however, there are no intervention programmes in place to address it.

Injury is the only leading cause of child death, disability and serious morbidity not currently being monitored and addressed through programmes and policies. An important goal of this series of Working Papers is to note this gap and to support the process of redressing it. Efforts to prevent injury and to mitigate its impacts need to be included within the set of interventions aimed at decreasing child mortality.

Drowning is unique among causes of death of children from injury, sharing many attributes with vaccine-preventable infectious diseases.

Similarly to the case for vaccine-preventable diseases, lifelong protection may be provided against drowning by teaching a child to swim. Once mastered, the protective skill is always there. Work carried out in Bangladesh shows that it is possible to safely train children aged four years and over to swim within their natural village environments in the same cost-effective manner that immunizations are delivered in those same village environments.³⁹

A second similar attribute is herd immunity, which protects the vulnerable by surrounding them with protected peers. Just as having large numbers of immunized children serves to isolate and shelter those not yet immunized against an infectious disease, children who have learned to swim can use these skills to rescue their peers and save their lives when they are at risk of drowning.

The third similar attribute is the large proportion of mortality addressed by preventing drowning. Just as vaccine-preventable diseases were responsible for more than half of all deaths of children under five, drowning caused about half of all child injury deaths in the surveys.

³⁹ See 'Midterm Review of PRECISE (Prevention of Child Injuries through Social-intervention and Education) Project', July 2007, conducted jointly by TASC, the Center for Injury Prevention and Research, Bangladesh, and UNICEF Bangladesh Country Office.

Despite solid evidence showing it to have been a leading killer over the last 25 years,⁴⁰ drowning has not registered on the global child health radar. The surveys summarized here show the centrality of drowning prevention for the 1–4 years age group, where drowning is responsible for between 75 and 90 per cent of all injury deaths.

A final lesson of the surveys is that the failure to recognize the importance of drowning results from the current system of facility-based surveillance (mainly hospitals and clinics). The surveys show that child drownings are largely invisible to this system. This issue is addressed in detail in the Survey Methods paper in this series (IWP-2007-05). The conclusion is that surveillance for child deaths and serious injuries is most effectively conducted where the deaths and injuries occur, namely at the community level. This is a key lesson of the surveys for child health in developing countries.

In summary, there is clear and convincing evidence from the surveys that injury represents a leading cause of child mortality in Asia. As importantly, it is also a leading cause of serious morbidity and permanent disability for children in Asia. There is the opportunity to act on this knowledge and to intervene with the same focus and vigour that has been so effective in diminishing the other leading killers of children.

⁴⁰ Based on annual Matlab surveillance data, 1982 through 2006.

Innocenti Working Paper

**CHILD MORTALITY AND INJURY IN ASIA:
POLICY AND PROGRAMME IMPLICATIONS**

**Michael Linnan, Morten Giersing, Huan Linnan, Ross
Cox, Mehr Khan Williams, Christian Voumard and
Rodney Hatfield**

Special Series on Child Injury No. 4

IWP-2007-07

1 INTRODUCTION

This paper examines the policy and programme implications of the surveys which have been presented in previous papers in this series.⁴¹ The six surveys of the causes of death and disability of children and their parents, conducted in Viet Nam, Bangladesh, Thailand, the Philippines, and in Jiangxi Province and Beijing, China, were undertaken as a joint collaboration between UNICEF, The Alliance for Safe Children (TASC) and government partners in each country. The surveys have been conducted with a new methodology that takes advantage of the extensive technical capacity now available at the national and local levels in most countries in Asia. This national capacity has been harnessed to perform a standardized survey that counts deaths as they happen and classifies them by cause, including causes of infectious (communicable) diseases, non-communicable diseases, injury, and 'unable to determine'. The surveys also count serious and disabling injury events. The surveys have very large sample sizes on the order of 100,000 households, and are able to examine causes of death in the different age groups of childhood and parenthood.

The surveys have been undertaken to provide information where there was little or none before. Information on causes and numbers of child deaths is readily available in rich countries. Developed countries have both the funds and technical capacity to develop and maintain vital registries and information systems that draw on data from a variety of sectors (health, education, welfare, public safety, etc.). However, these sets of data are not available in countries classified as low-and middle-income countries (LMICs), including those discussed in this series. This paucity of data so vital for health policy and programmes was one of the fundamental reasons which led to the undertaking of these surveys. A second reason was the mismatch between the official estimates of causes of death in children in each country and what had been observed in smaller community studies within the countries. The final reason was a pressing need to respond to the dramatic increase in the need for clinical care for serious injury that has overburdened the clinics and hospitals in most of the countries in Asia.

Official estimates of child deaths are available at the global and regional levels, and the most authoritative estimate is maintained by the Child Health and Epidemiology Research Group (CHERG) of the World Health Organization (WHO). The latest estimates are for 2000–2003, but only include deaths in children under five years of age, do not include serious morbidity or permanent disability, and are limited in the categories of deaths included.⁴² A comparison of the WHO estimates with the surveys in this series (Viet Nam in 2000, Bangladesh in 2003, Thailand in 2003, the Philippines in 2003, Beijing in 2004, and Jiangxi Province, China, in 2005) shows very significant differences. The surveys all found injury to be a leading cause of mortality and disability – among children under five as well as among children over five

⁴¹ UNICEF, *Innocenti Working Paper, Special Series on Child Injury*, IWP 2007-04,-05,-06, UNICEF Innocenti Research Centre, Florence, Italy.

⁴² <www.who.int/child-adolescent-health/OVERVIEW/CHILD_HEALTH/map_00_region.jpg>

years of age. The significant differences between the WHO estimates and these estimates are related to three technical factors: different measurement methodologies, changing epidemiological patterns, and a more inclusive definition of childhood.

The measurement methodologies utilized for the present analysis differ from those used most frequently in previous efforts to address child injury. In those estimates, the process begins by making an estimate of the total number of children under five years of age who die annually in the South and East Asian regions. The proportions of the total number of children dying due to each principal cause, as considered by panel of experts, are then determined, and these proportions are applied to the total estimated numbers of under-five deaths.⁴³ This produces estimates of the total numbers of children under five who die from each of the principal causes used by the expert panels. Injury is not among the principal causes currently estimated, but is generally included within an overall category called 'other'.⁴⁴

In contrast, the methodology used in the surveys reported in this series of papers defines a large, representative sample of the country, city or province being surveyed, and uses household interviews to find all deaths, counting them one by one, and assigning a cause to each one. Injury is counted as one category, and broken down into subtypes (drowning, road traffic accidents, falls, burns, poisoning, etc.). When measured in this fashion, overall causes of child mortality in poor countries is shown to include much higher numbers of injury deaths before and after the age of five than has been believed in the past. The approach also provides an important measure of the bias found in hospital- or clinic-based health information systems, which miscount injury deaths because those already dead at the scene are rarely taken to hospital. For example, drowned children are almost never taken to the hospital or the local clinic, but instead are simply buried or cremated.

The second factor, changing epidemiologic patterns, also accounts for some of the large differences between this research and earlier findings. The surveys presented here have all been done after 2000. However, the research on under-five deaths used in the typical child mortality estimations was carried out primarily in the mid and late 1980s. Since then, overall under-five mortality rates in the surveyed countries have fallen by almost 50 per cent.⁴⁵ In rich countries, a similarly rapid decrease in child mortality was accompanied by a change in the pattern of deaths, shifting from predominantly infectious diseases to non-communicable diseases and injury, often referred to as 'the epidemiologic transition'.⁴⁶ This is the pattern that has appeared in the surveys summarized here.

⁴³ Mathers, C.D., et al., 'Counting the Dead and What They Died From: An assessment of the global status of cause of death data', *Bulletin of the World Health Organization*, vol. 83, no. 3, March 2005, pp. 171–177.

⁴⁴ Bryce, J., et al. and the WHO Child Health Epidemiology Research Group, 'WHO Estimates of the Causes of Death in Children', *The Lancet*, vol. 365, no. 9465, March 2005, pp. 1147–1152.

⁴⁵ UNICEF, 'Progress since the World Summit for Children: A statistical review', UNICEF, New York, 2001, < http://www.unicef.org/publications/index_6440.html>.

⁴⁶ Gribble, J.N. and S.H. Preston (eds.), *The Epidemiologic Transition: Policy and planning implications for developing countries*, National Academy Press, Washington, D.C., 1993.

The third reason for the large difference relates to differing definitions of childhood. Previous child mortality estimates have focused on children under five; this was due both to difficulties experienced in estimating causes of death among older children, and to the fact that under-five mortality was seen as the best overall indicator of child health and of the effectiveness of measures to improve it. The surveys reported here measure mortality over childhood in its entirety, from infancy through 17 years of age, as defined by the Convention on the Rights of the Child.⁴⁷ However, the surveys show that about one-half of all child deaths after infancy occur after the child has graduated from the ‘under-five’ age group. These previously uncounted child deaths are counted in the surveys and the majority of them are caused by injury.

2 SUMMARY OF RESULTS

To frame the discussion on the policy implications, the composite results of the six surveys are presented below. The key points are first summarized and then followed by graphical figures to illustrate these key issues:

- Injury is overshadowed as a cause of mortality and serious morbidity in infants by the extremely high rates of communicable, non-communicable and birth-related causes of death and illness. However, the rates of injury in infants were shown to be among the highest compared to those experienced in the rest of childhood. Suffocation, falls and drowning are significant causes of deaths during infancy and have been shown to be easily preventable.
- Infancy is the only time in childhood when the environment is totally controlled by the caretaker, rather than the child. This fact has been an advantage for other child health interventions and needs to be a key consideration in injury prevention for children.
- After infancy, injury is a leading cause of death in all child age groups and increases in proportion as the age of the child increases.
- Drowning, unrecognized as a major cause of child death in the previous estimates, accounts for about half of all child injury deaths in each country surveyed. It is particularly significant in children aged one to four, where it makes up over eighty percent of injury deaths.
- Injury both increases in prominence and changes in type with age group: suffocation, drowning, and falls predominate in infancy; drowning predominates in early and middle childhood; and road traffic accidents and suicide predominate in adolescence.
- Fatal injury is important, but there is a larger burden of non-fatal injuries that cause lengthy hospitalization and permanent disability. Injury is a leading cause of permanent disability. The numbers of permanently disabled children are larger than those fatally

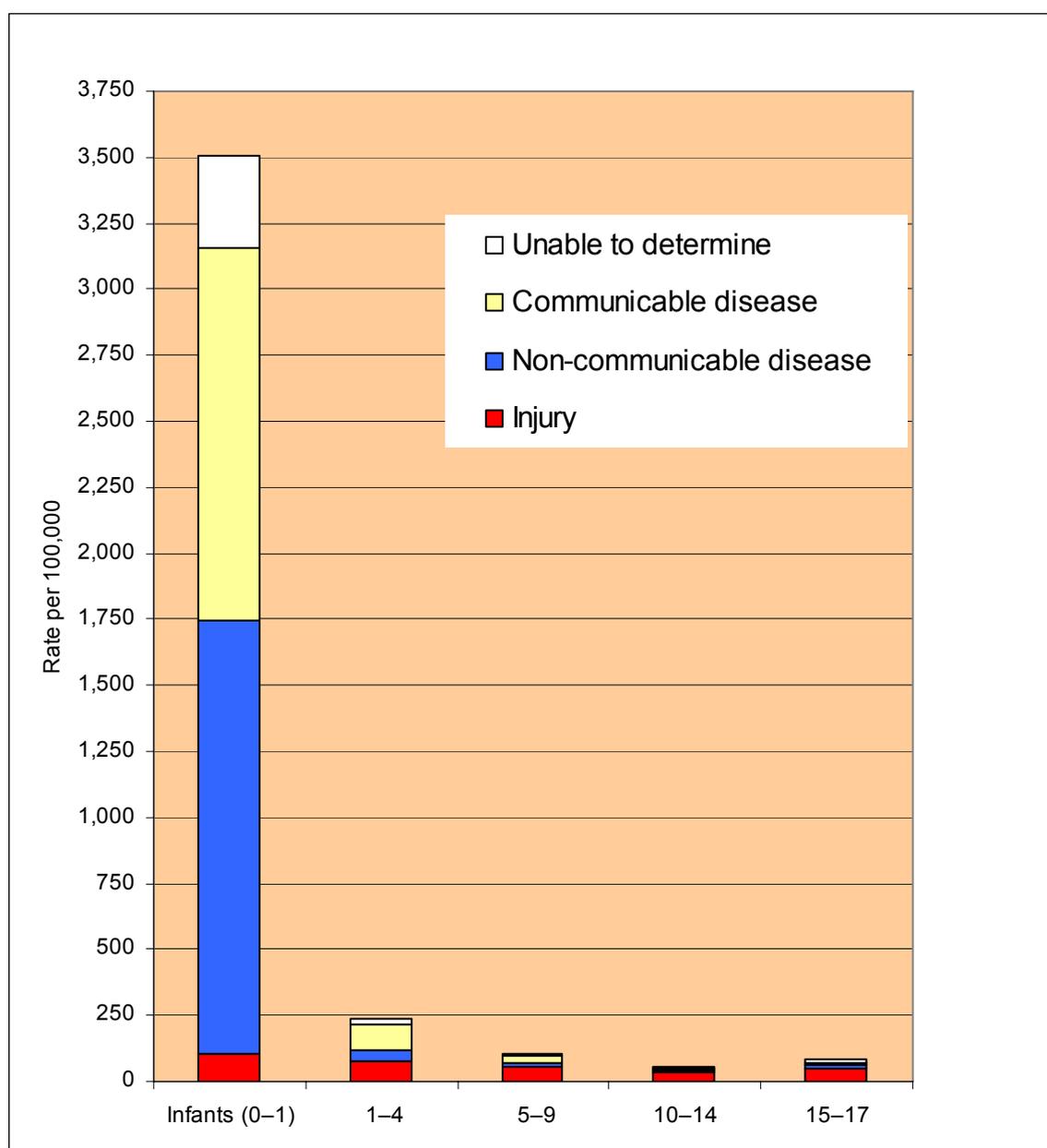
⁴⁷ The United Nations General Assembly adopted the Convention into international law on 20 November 1989; it came into force on 2 September 1990. The Convention defines a child as any person under the age of 18.

injured. Permanent disability imposes a lifelong burden on the child and the family, as well as on the society.

- Falls, traffic accidents, cuts and burns are leading causes of non-fatal injury in children in the surveys, similar to the pattern in rich countries.
- Injury caused by animals is a major unrecognized cause of death and serious morbidity in children. It was one of the three leading causes of morbidity in every country surveyed. As the fifth leading cause of child death in all the surveys, it was a significant cause of mortality in children, unrecognized in previous child mortality estimates.

Fatal injury of course occurs not only among children. The surveys also captured the significant number of parents who died from injury, leaving behind one or more children with only one or no parents to support them. The vulnerability of orphans, which has been brought to global attention in the context of HIV/AIDS, is also an important dimension of the injury pandemic. This area of findings will be addressed more fully in later analysis.

The most important findings of the surveys are summarized in the following figures.

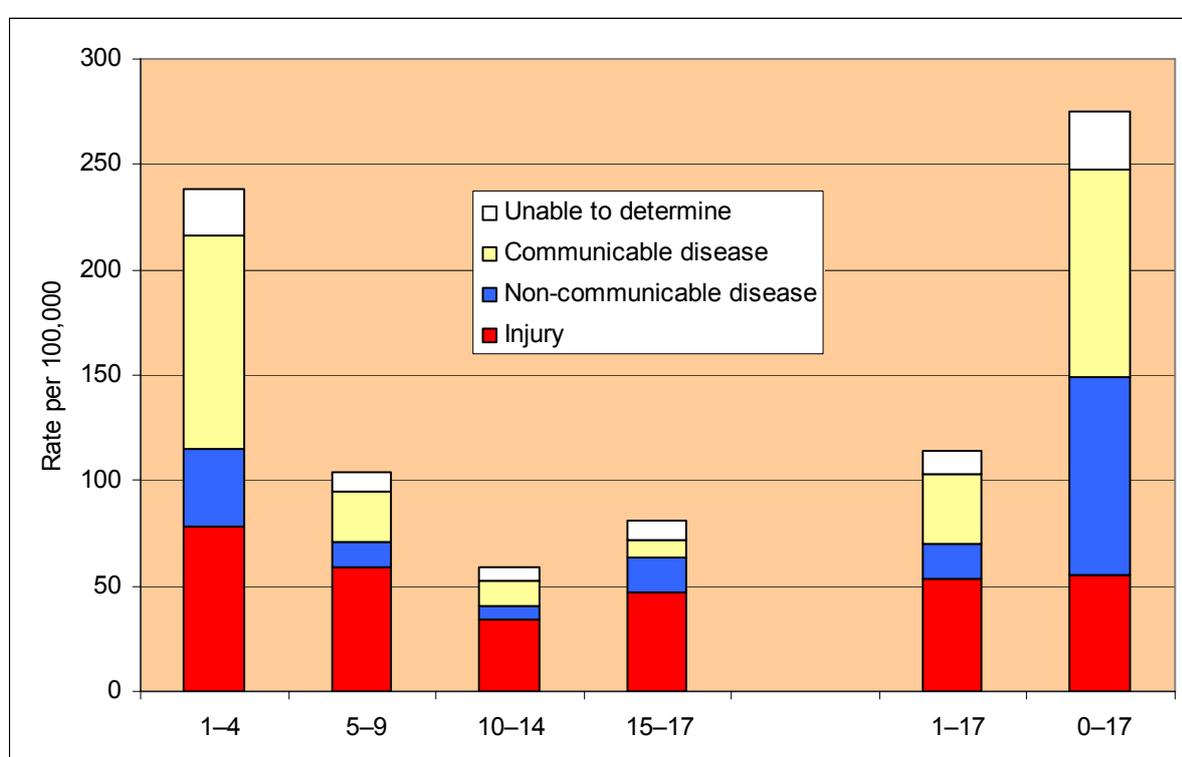
Figure 1: Proportional mortality by age

Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

The dramatic mortality rates in infancy in comparison to the rest of childhood are evident in figure 1. While overshadowed by communicable and non-communicable diseases, fatal injury in infancy is actually at or near its peak rate during the full span of childhood. After infancy, mortality rates from causes other than injury decline radically while injury remains relatively constant. Proportionally, it becomes a much larger share; for example, it accounts for about 37 per cent of all deaths in the 1-4 age group.

This epidemiologic shift occurs for two reasons. One is that about two thirds of all infant deaths occur in the first month of life, the neonatal period. This is the highest mortality period in life, with most earliest deaths due to problems of pregnancy or the birth process. Once beyond this pregnancy and birth-related period, mortality falls dramatically. The second reason is the changing environment of the child. Born helpless and unable even to lift its head, infants are totally dependent on the mother and are carried everywhere, thus protected from danger. There is little exposure to hazard, other than accidental falls, burns, or suffocation during sleep. At age one, when the child begins to walk, the situation changes dramatically. The child explores the world on very unstable legs, does not understand danger, and often escapes from the close supervision of a busy mother. This combination makes injury (particularly drowning) a leading cause of death in the 1–4 age group.

Figure 2: Proportional mortality by age

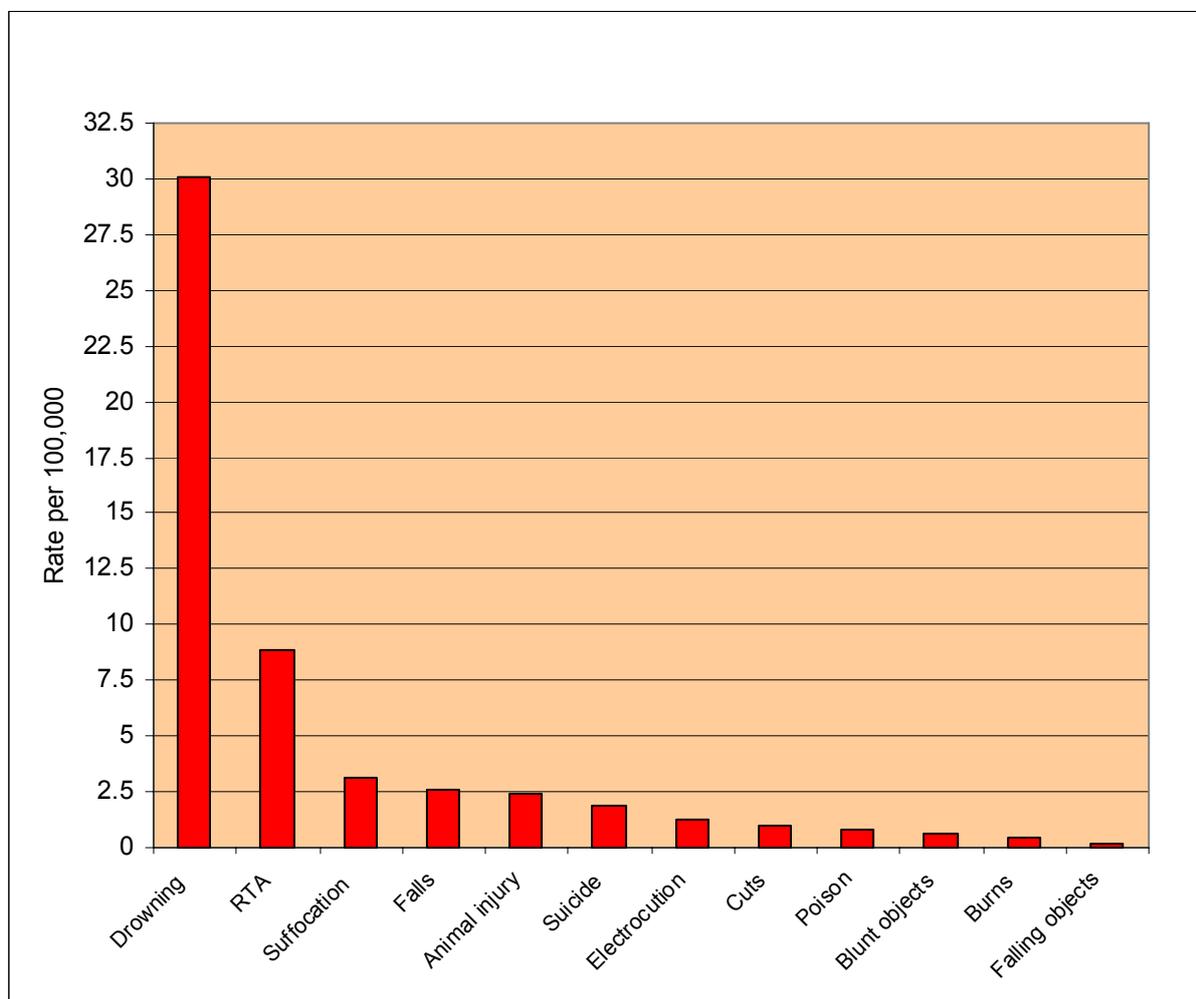


Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

Figure 2 excludes a bar dedicated to infancy to better show the pattern of proportional mortality in the rest of childhood. Seen on this scale, injury is a leading killer for all post-infancy child age groups. Injury accounts for about half of all child deaths after infancy (1–17) and for about a fifth of all mortality when infants are included (0–17). Injury kills an increasing proportion of children as they grow in age. Overall mortality declines and then

rises again in the late adolescent age group (15–17) due to large increases in intentional injury (suicide and homicide) as well as road traffic accidents.⁴⁸

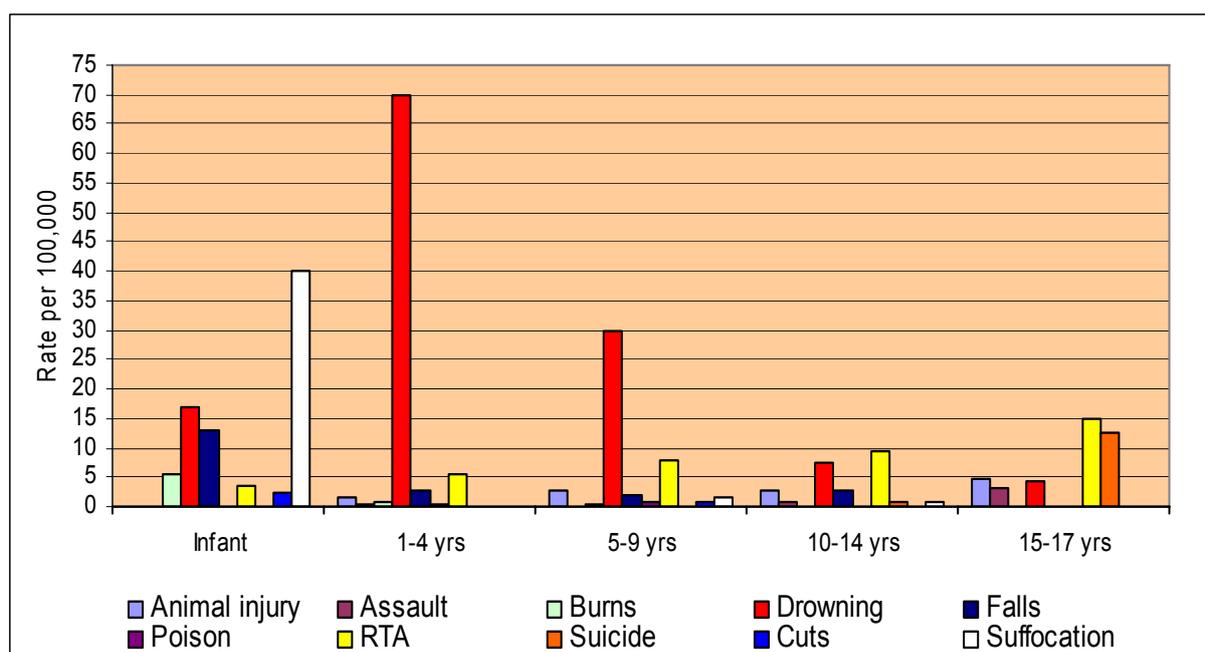
Figure 3: Fatal injury rates in children 0–17 years, by cause



Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

Drowning was by far the leading injury cause of death in childhood (see figure 3), accounting for over three times as many deaths as road traffic accidents (RTA), the second leading cause. Drowning was highest in early and middle childhood, and traffic accidents were highest in adolescence. Suffocation primarily occurred in infants, and falls were common in all age groups. Fatal animal injury was caused by the bites of rabid dogs or poisonous snakes, usually in younger children. Suicides were found mainly during adolescence.

⁴⁸ 'Road traffic accidents' (RTA) is the term used in the countries surveyed to refer to injuries due to road transport, sometimes referred to as 'road transport injuries'. For the purposes of this definition, 'accident' indicates a lack of intent.

Figure 4: Fatal injury rates in children, by age group and cause

Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

Figure 4 shows that different patterns of injury occur in different childhood age groups:

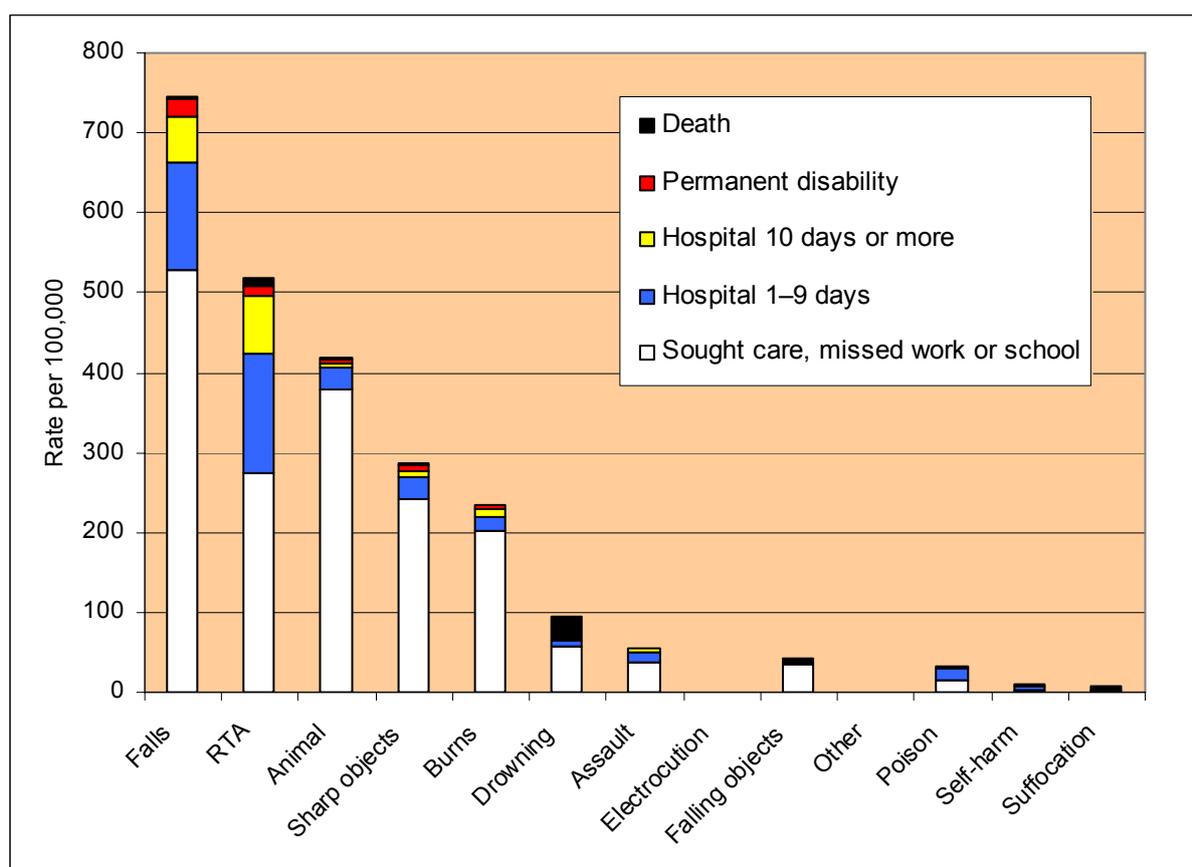
- In infancy, suffocation, drowning, falls and burns are the leading causes of injury death. For prevention, all efforts will have to focus directly on parents and caregivers, as they are the ones who determine the risks and hazards the infant faces.
- For toddlers in the 1–4 year age group, drowning is the overwhelming cause of injury death, responsible for over 90 per cent of all injury deaths. For prevention, the main strategies are supervision and decreasing exposure to hazard (e.g. fencing a pond, covering a well). Toddlers stay close to the home, and the water hazards near the home are fixed in location and can be individually identified and rendered less hazardous. Falls are the second leading cause and RTA is the third. Supervision and decreasing exposure to hazards is also the primary prevention strategy for these two causes but, with much of the exposure on a mobile and changing basis, it is much more difficult to control or lower risks from falls or RTA than from drowning.
- For children in the primary school years, drowning remains the leading cause, responsible for over half of all injury deaths. Since these children are mainly with peers rather than adults, and are far from home, swimming ability is the major factor in prevention of drownings. RTA is the second leading cause, with almost all of these deaths among pedestrians and bicyclists. This exposure is incurred at least twice a day (on the journey to and from school), and as the nature of the hazard changes with high traffic densities near schools, prevention needs to focus on these somewhat predictable factors.
- For children in the secondary school years, RTA becomes a leading cause of injury death after drowning. Drowning declines and intentional injury (suicide and homicide) begins to rise, mainly during and after the post-pubertal ages of 12–14 years. Most of this period of childhood precedes puberty, with its attendant changes in children's physical and

emotional context. Injury rates are lowest in this age group, a time when children's mental development allows them to understand the risks, but they are not yet under the influence of pubertal factors that lead to increased interpersonal violence and risk-taking.

- In late adolescence, RTA is the single leading cause of injury death, followed by suicide. Intentional injury, taking suicide and homicide together, is the leading killer of children aged 15–17. Adolescence is classically described as a time of turbulence and risk-taking and the upturn in injury rates in this age group is consistent with that. Efforts for injury prevention will have to deal with these primary factors in order to be effective.

Figure 5 shows how the causes of non-fatal injury differ from those of fatal injury. Fatal injury is the most severe outcome on a spectrum of severity. The comparison shows that non-fatal injury actually causes a larger health burden. This key public health concept is lost in relying on child mortality estimates alone. Note that minor injury (injury not resulting in seeking care, or missing work or school) was not counted in the surveys and so is not seen on the graph.

Figure 5: Fatal and non-fatal injury rates by severity for age group 0–17

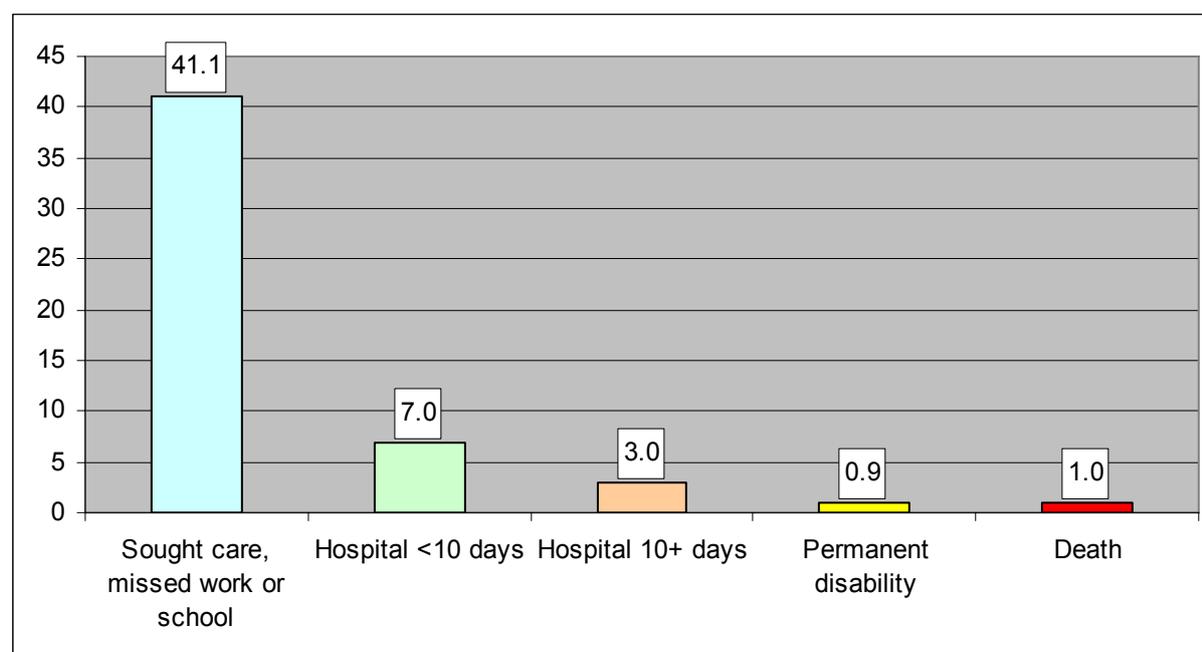


Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

Figure 5 also shows the extremely high case fatality rates associated with drowning and clearly demonstrates how it is the leading cause of death. Seen in the larger spectrum of child injury which includes all severity levels, drowning is the sixth leading cause of injury.

Figure 6 details the ratios of non-fatal injury by severity level compared to one death. It underscores the public health issue that the total burden of injury is much more than that incurred by fatal injury alone. Most of the deaths occur pre-hospital, leading to no hospitalization and few direct medical costs; hence they generate a minor share of the direct economic costs of injury. Almost all the medical costs for hospital and for rehabilitative care following hospitalization are accrued by children who are not fatally injured. The majority of economic costs and the lifelong social burden accompany the more severe, non-fatal injuries. While infectious and non-communicable diseases also generate disability and large costs (as with HIV/AIDS and diabetes), injury has a significantly higher incidence across each stage of childhood.

Figure 6: Ratio of injury frequency to death by severity level for age group 0–17



Source: Authors' calculations from individual surveys (2000-2005); composite is population-weighted.

3 POLICY AND PROGRAMME ISSUES

With health histories from a sampling of more than 500,000 households, or nearly 2.5 million people in five countries in East, South, and Southeast Asia, the surveys form a unique injury evidence base for the world's most populous region. The surveys confirm the limitations of present knowledge regarding cause-specific mortality and morbidity in this region, and highlight many programmatic considerations and issues of child health policy.

Understanding child mortality requires counting all children

About one-half of all child deaths (0–17 years) occur after infancy (0–1), and about one-half of these occur after the age of five years. Yet, the under-five mortality rate (U5MR) remains the single most important yardstick of child health in global discussions of development. As shown by the surveys, however, the under-five mortality rate masks several important issues. The high mortality in infancy, age 0 to 1, colours the rates for the full 0–5 age group but omits all detail for the 1–4 age group. And it self-evidently contains no information about 5–17 year olds. Most critically, when the priority given to the under-five mortality rate influences programme design and may lead to a cut-off for interventions affecting the older age group, then two thirds of all children are excluded. Equal priority should apply to six year olds as to four year olds.

Increased visibility of deaths and adverse health events in children older than five years is needed. This mandates mortality measurements for children over five and the creation of suitable indicators. Given the linkage between rates of death in specific age groups, as demonstrated by U5MR, and child survival programmes, it is necessary to have indicators that measure these same events in older children: Deaths of those children should be registered when they are due to diarrhoea, pneumonia, or drowning, comparably to how they are registered for children under five years of age.

Policymakers and programme implementers clearly need a new indicator that applies to all children. These surveys show that proportional estimates are no longer the only option since it is feasible to count deaths (and serious non-fatal events as well) as they occur. In doing this, a wealth of additional information, including serious non-fatal health events, becomes available to health policymakers. Of course, counting all children is beneficial for more than injury prevention and control alone; while injury causes about half of all deaths of children after the age of five, communicable and non-communicable causes are responsible for the other half. Without counting these deaths (and serious morbidities as well), it will not be possible to address child injury and its impact in the most effective manner.

Prevention requires a life-course approach

Since the leading causes of injury death and serious morbidity differ by age group, standard age groupings are needed to obtain an accurate picture of child injury and recognize the different characteristics of the different age groups. To clarify the salient patterns, childhood could be divided into five age groups, such as those developed for the TASC survey methodology: (1) infancy; (2) early childhood, 1–4 years of age; (3) childhood, 5–9 years of age; (4) early adolescence, 10–14 years of age; and (5) late adolescence, 15–17 years of age. These groupings correspond to the major periods of socialization in childhood: infancy and 1–4 years as preschool; 5–9 years as primary school; 10–14 years as secondary school; and 15–17 as late adolescence, often with entrance into the workforce. These groupings are appropriate because there are different risk and health hazard exposure patterns in each group, and, consequently, different patterns of injury and disease. Without such a breakdown, it will be difficult to design adequate interventions and, as importantly, monitor and evaluate their effectiveness.

Children progress through stages of childhood in the same way as adults progress through the stages of adult life. Preventive medicine and public health programmes have long recognized this and have for the last several decades been organized on a life-course basis. It is important for the same efficient approach to be taken to childhood.

Policymakers need proper data on child mortality and morbidity

Injury was responsible for around 10 per cent of all mortality in the countries surveyed. Most policymakers initially believed it was not a significant health policy issue, for a variety of reasons including that the other nine tenths of total mortality may have been considered more pressing. This might be a strategically valid response if injuries were evenly distributed across all ages of the whole population, but injuries are in fact mainly concentrated in childhood and early adulthood. Policymakers have clearly lacked information separating infancy from the rest of childhood, and childhood from adulthood. With the full epidemiological picture it would have been clear that injury has been the leading cause of death for young children, adolescents and young adults for at least a decade or longer.

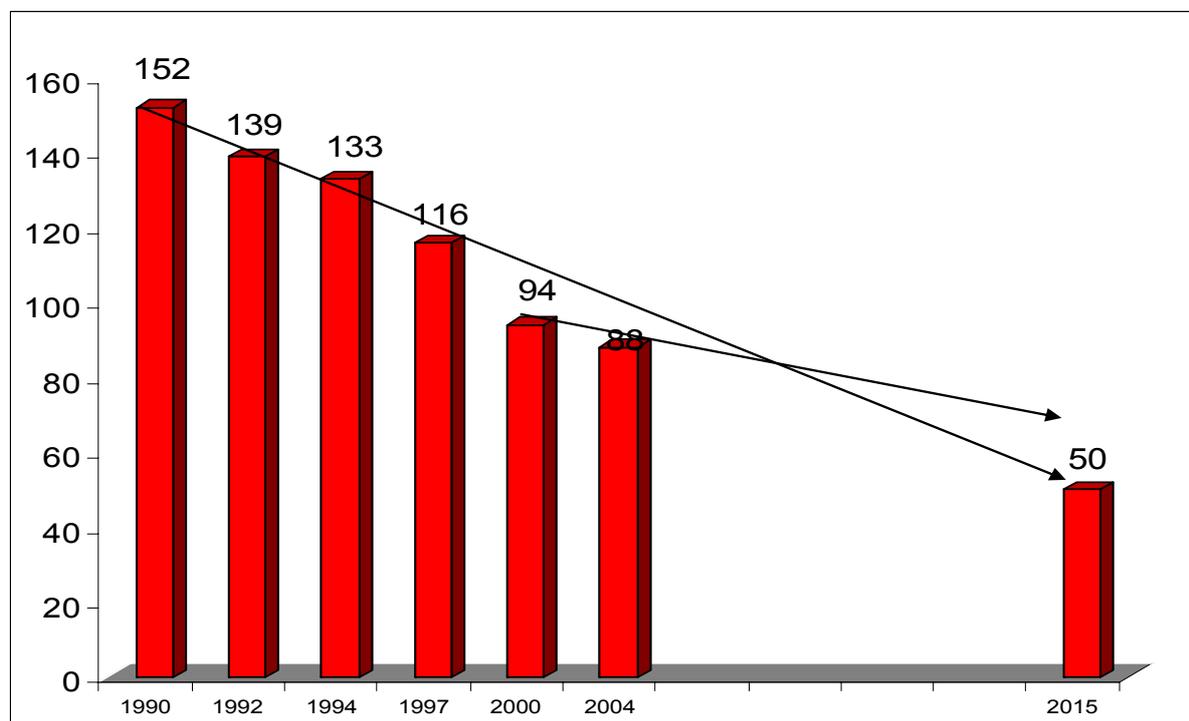
Measuring injury deaths in age groups and communicating the basic facts of epidemiology to health and development policymakers is a primary and necessary step to change this misperception. Indeed, in each country where the surveys have been conducted the government has subsequently made a significant commitment to injury reduction, especially among children. While the policy histories differ among countries, a common feature has been the use of evidence to mobilize partners within health and across other sectors, generating a momentum that has led to national policy changes.

Progress in child survival needs injury prevention

In all the countries surveyed, injury has become a significant cause of death in children under five years of age. As mortality has become increasingly compressed into the neonatal period, suffocation, falls and drownings have become proportionally larger causes of infant deaths, both because other causes are being addressed and because more children are surviving to the ages where injury is a major killer. For children aged 1–4, injury is now a leading cause of death

To drive down under-five mortality, which remains the focus in internationally agreed goals such as the Millennium Development Goals (MDG), these injury deaths must be prevented. Bangladesh serves as an example. The current under-five mortality rate (U5MR) is 72 deaths of children under five per 1,000 live births and the MDG target requires a reduction to 50 deaths. Until the mid-1990s, the rate of decline in U5MR (as measured by two rounds of the Demographic and Health Survey (DHS)) was sufficient to meet the 2015 goal. However, as the majority of infectious and other causes have been significantly addressed through the successes of child survival, this leaves injury as the predominant remaining cause of death. It is arguable that the limited focus to date on addressing injury within policy agendas may have contributed to a slowing down the rate of decline in U5MR, as seen in figure 7.

Figure 7: Rate of decline of under-five mortality rate in Bangladesh 1990–1994, and 2015 prediction



Source: Bangladesh Demographic and Health Surveys, and UNICEF Bangladesh Country Office.

Priority in preventing child injury: drowning

Given the broad mixture of injury causes in adulthood, no single strategy will significantly reduce serious and fatal injuries. However, the picture is very different for children. After infancy and through early adolescence, more than half of all injury deaths result from a single cause of injury: drowning. Targeting drowning provides an efficient injury prevention strategy, which has proved successful in the rich world. Evidence has now accumulated from Bangladesh that prevention of drowning in children is feasible as well in the low-resource setting of LMICs,

There are public health aspects of child injury prevention that apply particularly to drowning in a way that mirrors immunization, one of the bedrocks of child survival, as a basis for potential lessons to address drowning.

- Just as a vaccination provides lifelong protection against the targeted disease, a child taught to swim gains the same lifelong protection against drowning.
- Just as immunizing most children against a disease prevents other children who are not yet immunized from being exposed, so preventing infection (the concept of herd immunity), teaching most children to swim provides a herd of protective peers who can rescue unprotected children who cannot swim if they are exposed to water and at risk of drowning.
- Just as the group of vaccine-preventable diseases represented a large proportion of diseases causing early child deaths and was susceptible to an efficient and cost-effective

intervention, prevention of drowning removes the leading cause of child deaths after infancy and through the end of childhood.

As discussed also in the Survey Results and Evidence Paper in this series (IWP 2007-06), evidence from a large-scale injury intervention programme in rural villages in Bangladesh demonstrates that drowning before the age of five can be prevented by increasing supervision and decreasing exposure to water, and after five by teaching children to swim.⁴⁹

It is also clear that there are many established mechanisms within existing programmes relating to child survival, maternal health and early childhood education that could be utilized for infant and early childhood drowning prevention programmes. Similarly, many programmes in primary education already include ‘life skills’, and drowning prevention could easily be associated with these. Given that this one cause – drowning – is responsible for over half of all child deaths after the age of one, this provides an amazing opportunity to dramatically reduce child death at low cost.

Other early opportunities

Significant injury reductions are possible simply by changing existing policies, which often miss opportunities for prevention, or even inadvertently increase injury risk. As a first step, changing policies and improving practices is a significant intervention in and of itself.

Poisoning The surveys show poisoning to be a significant cause of mortality and morbidity. The leading agents are household and agricultural chemicals, but a significant source is medicine from maternal and child health programmes and infection control programmes such as for tuberculosis. Hundreds of millions of doses are dispensed every year, including iron pills, vitamins, fever medicines and tuberculosis medicines. These are distributed to households in containers that are not child resistant, and in quantities sufficient for multiple lethal child doses. Parents are often unaware of the hazard this presents to the children in the home and leave the pill containers lying about. Since virtually all of these medications are procured through global supply chains, the opportunity is there to require child-resistant packaging for all distributed medicines.

This is also an opportunity for the various health programmes to educate parents about poisons in general, and the need to store common poisons like kerosene, bleach, insecticides and rat poisons on high shelves or in cabinets out of the reach of children.

Suffocation All the surveys show that suffocation in early infancy is a significant cause of infant death. They show a high prevalence of multiple risk factors for infant suffocation, including (1) non-supine sleeping position; (2) parental smoking; (3) parental alcohol use (except Bangladesh) and (4) multiple bed sharers. In all the surveys, almost universally there was only one bed for the entire family, shared by all members, and in most families at least one parent smoked. Given the known risks of suffocation in these circumstances, antenatal

⁴⁹ See ‘Midterm Review of PRECISE (Prevention of Child Injuries through Social-intervention and Education) Project’, July 2007, conducted jointly by The Alliance for Safe Children (TASC), the Center for Injury Prevention and Research, Bangladesh (CPIRB), and UNICEF Bangladesh Country Office.

care programmes should educate expectant mothers about proper sleep positions and the suffocation hazards to the infant from parental smoking and/or drinking. Programmes should also work with mothers to plan a safe way to share the adult bed with vulnerable infants. This is the norm with antenatal care programs in wealthy countries; expectant parents in LMICs deserve the same education, given the known risks to infants of these factors and their high frequencies.

Most antenatal care programmes stress the known benefits of breastfeeding and strongly encourage expectant mothers to breastfeed exclusively for the first six months of life. There are many proven health benefits to infants and children from breastfeeding, and co-sleeping of mothers and infants has been shown to lead to higher rates of successful breastfeeding. Educating mothers about the benefits of breastfeeding and skin-to-skin contact should also include ways to reduce the risks of suffocation for their infants. The increased emphasis on the advantages of breastfeeding should also increase breastfeeding rates as well.

Falls The surveys show that falls are a significant cause of serious morbidity and mortality for infants as a group. This results in large part from the virtually universal practice of infants sharing the bed with the parents. Although infants tend to be well-protected by their mothers and other caregivers while they are awake, they become especially vulnerable when the caregivers fall asleep and do not watch over them. Their inability to raise their head or roll over until the sixth month of life leaves them vulnerable to suffocation. In turn, normal motor development means that by seven months, infants are crawling: they are quite active and crawl about the bed, sometimes falling from it, while the parents are sleeping. The resulting falls can cause serious or fatal injury to the infant. (Infants have soft, unclosed skulls with an open fontanelle and their heads are large in proportion to their body. Thus, when falling after crawling to the edge of a bed, they usually fall directly on the top of their skulls.) This important point regarding co-sleeping for infants should be emphasized for injury prevention in settings such as those covered by the surveys and in other LMICs. Antenatal care programmes have the opportunity to educate mothers about this hazard and to suggest ways to prevent the falls.

Animal bites The surveys show poisonous snake bites and rabies from dog bites as substantial causes of mortality in all the countries. Most facilities stock only the therapeutics on WHO's Essential Drugs List, which does not contain snake anti-venom, hyper-immune rabies globulin, or rabies vaccine. The problem is compounded by the fact that some of the materials need cold storage, and that often the only available storage is the EPI (Expanded Programme of Immunization) cold chain, where current policy forbids non-EPI products. This represents a missed opportunity to make the life-saving medication more widely available at the local service delivery point, where they would be most effectively used.

The problem of dog bites exists year round at high rates regardless of season. Snake bites occur at a lower rate in the dry season, and increase in the rainy season when there are frequent floods. The rising waters force families and snakes to congregate on higher ground. When bites occur, the flooding usually prevents access to health facilities. This is also a

missed opportunity for pre-positioning as part of disaster response systems since the drugs are needed but not currently included as part of the emergency response system.

Beyond Asia

The countries surveyed have all made the epidemiologic transition. A clear lesson from the rich countries has been that the changed epidemiology of child death due to the epidemiologic transition requires a change in prevention strategy in order to continue to drive down child mortality. In the region surveyed, further improvements to child health will similarly require broad injury reduction and control programmes for children up to age 18.

These needed policy and programme changes are however not limited to the countries surveyed, nor to other rapidly developing countries in East, South and Southeast Asia. Inspection of health indices (such as life expectancy at birth, infant mortality rate and under-five mortality rate) strongly suggests that similar patterns of child mortality and morbidity exist in Latin America and the Caribbean and in most of the Middle East and North Africa, Eastern Europe, and Central Asia. It is in fact likely that the pattern reported here is occurring in almost every region except Sub-Saharan Africa, and even there injury can be predicted to be a significant cause of child death and disability. Determining this will require that large, community-based surveys are conducted, such as those described here.

Child survival has been a remarkably successful endeavour. At the beginning of the 'child survival revolution', more than 75 per cent of the world's children lived in countries where child mortality was high (with U5MR over 90). Only 30 years later, less than 20 per cent do. The world before us is no longer a world best served by a focus on survival of children under five. Further progress for the region's children will require protecting children throughout childhood, and this is equally true elsewhere in the developing world.

ANNEX: Contributors to the Series

This series of papers grew out of a meeting of the Technical Advisory Group (TAG) for The Alliance for Safe Children (TASC), held in Bangkok, Thailand in August 2005. At the meeting, the group considered the results of the six national and subnational surveys that form the basis of these papers. These were done in Bangladesh, China, Philippines, Thailand and Viet Nam, with an additional sentinel survey on drowning carried out in Indonesia in 2004. This resulted in the formation of the Bangkok Working Group on Child Mortality Estimates (BWG-CME).

During 2005-2007 Dr. Michael Linnan, the Technical Director for TASC, worked with BWG-CME members, the Principal Investigators for the surveys and UNICEF regional and country staff to jointly author the first seven papers in the series. The individual contributors are listed in each paper. Others who contributed to the series as authors, editors or reviewers, including members of the TAG and the Bangkok Working Group, survey Principal Investigators and UNICEF staff, are listed below along with their institutional affiliations.

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