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Innocenti Working Paper

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

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and Rodney Hatfield**

Special Series on Child Injury No. 1

IWP-2007-04

October 2007

Innocenti Working Papers

UNICEF Innocenti Working Papers are intended to disseminate initial research contributions within the Centre's programme of work, addressing social, economic and institutional aspects of the realization of the human rights of children.

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The Special Series on Child Injury is a joint initiative of UNICEF Programme Division, The Alliance for Safe Children, the UNICEF Regional Office for East Asia and the Pacific and the UNICEF Innocenti Research Centre.

The present version of this paper (February 2008) reflects minor editorial adjustments to the original version.

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ISSN: 1014-7837

Readers citing this document are requested to use the following form:
Linnan, Michael, et al., 'Child Mortality and Injury in Asia: An overview', *Innocenti Working Paper 2007-04, Special Series on Child Injury No. 1*. Florence, UNICEF Innocenti Research Centre, 2007.

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Child Mortality and Injury in Asia: An Overview

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Summary: This paper presents an overview of the IRC Child Injury Series, a working paper series on child injury that has its first focus on injury in developing countries. The series summarizes the findings of six national and subnational surveys in Asia: Bangladesh, China (two regions), Philippines, Thailand and Viet Nam.

The surveys, undertaken using a new methodology resembling a census, found that injury is the leading cause of death after infancy in children through 17 years of age in all countries surveyed. The methodology involved creating a very large, representative sample of households in each national/subnational survey and directly counting all mortality events in the previous three years and all morbidity events that required missing work, school, or being hospitalized from injury in the previous one year.

The results show that prior estimates of child mortality have omitted most injury deaths in early childhood as they did not include children aged five years and over. As a result, injury, which is a leading cause of death in children under five, and the leading cause of death in children aged five years and over, has been largely invisible to policymakers and is not included in child health programmes. The surveys show a consistent pattern of types of injury in the different stages of childhood in the countries surveyed. Drowning, greatly underestimated by traditional methods of surveillance, is the leading injury cause, responsible for over half of all injury deaths in children. Evidence from the surveys shows that the social, health and economic burden of non-fatal injury is significantly high. While falls, road traffic, cuts and burns were found to be leading causes of morbidity, injury caused by animals also emerged as a leading cause of mortality and morbidity. Addressing injury is necessary to continue current progress in child mortality and morbidity reductions in the region.

Keywords: children, demographic change, epidemiological transition, cause of death, Asia, Bangladesh, China, Philippines, Thailand, Viet Nam, low- and middle-income countries (LMICs), injury, community survey, mortality estimates, infant mortality, under-five mortality, child mortality, drowning, disability.

Acknowledgements: The authors gratefully acknowledge the partnership of the Innocenti Research Centre, and have a special debt of gratitude to those in UNICEF IRC and New York Headquarters who endeavoured to make this series a reality, in particular, Marta Santos Pais, David Parker, Alan Court, Peter Salama and Kayode Oyegbite.

The paper results from the work of a large number of technical contributors who are listed in detail in the annex. The authors acknowledge the enormous contributions made by those listed to this series of papers.

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'.

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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 this data and that 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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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 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

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.

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.

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.

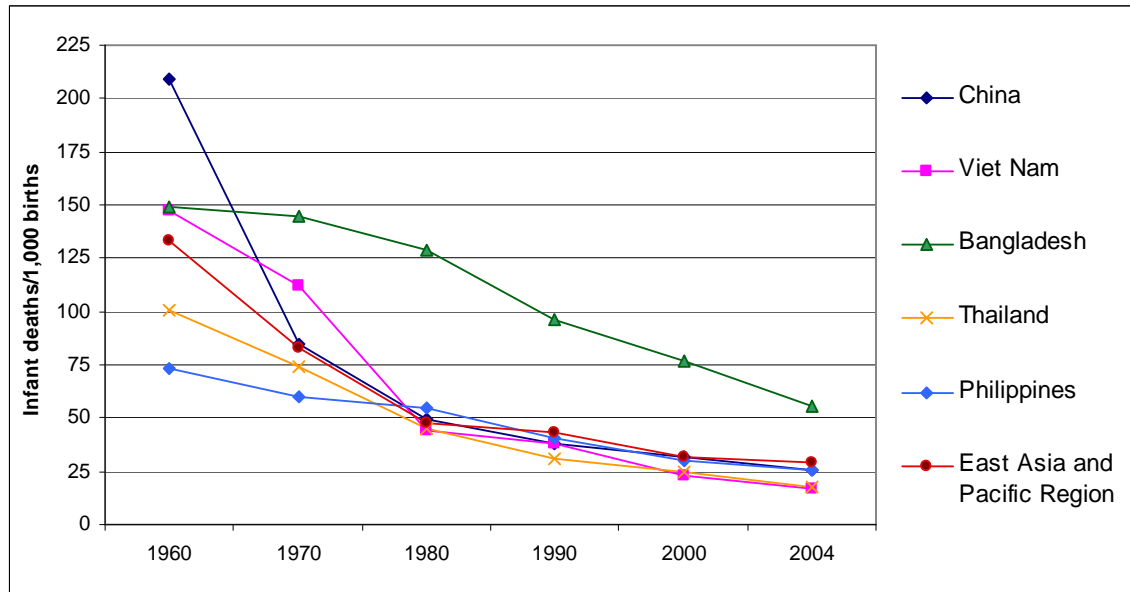
Figure 1 shows the period of the late 1970s through to the 1990s, when most of the causality work was done. It was characterized by rapidly declining child mortality. The trend has since continued and a new pattern of childhood mortality is emerging. Between 1990 and 2004 the infant mortality rate (per 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

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

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

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

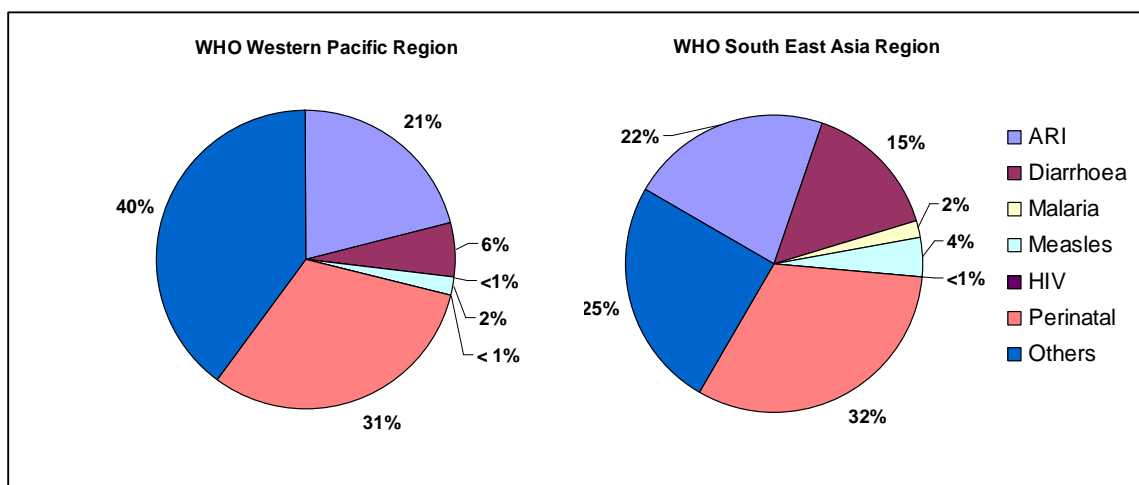


Source: World Bank; UNICEF, The State of the World's Children, various years.

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

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

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

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.

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

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 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).

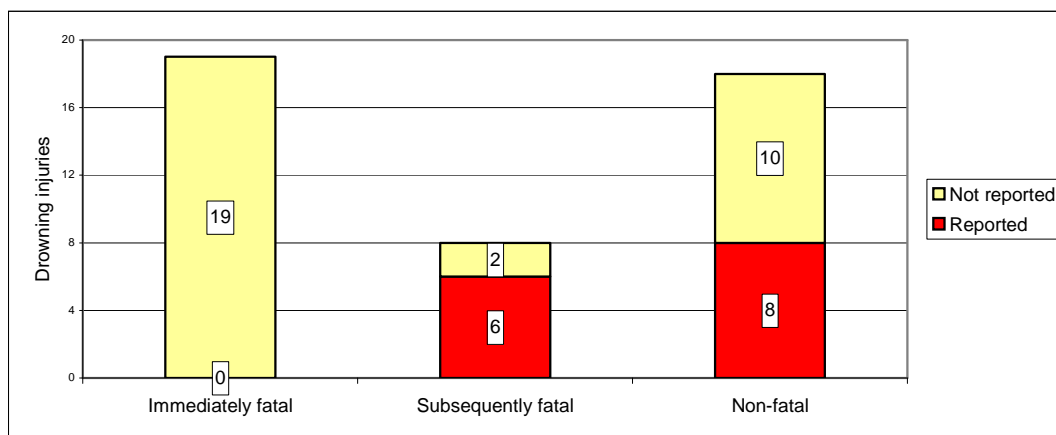
Most deaths occur in the community and not in hospitals. Deaths occurring in or known to hospitals and health facilities are fundamentally different.

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.

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

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

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.

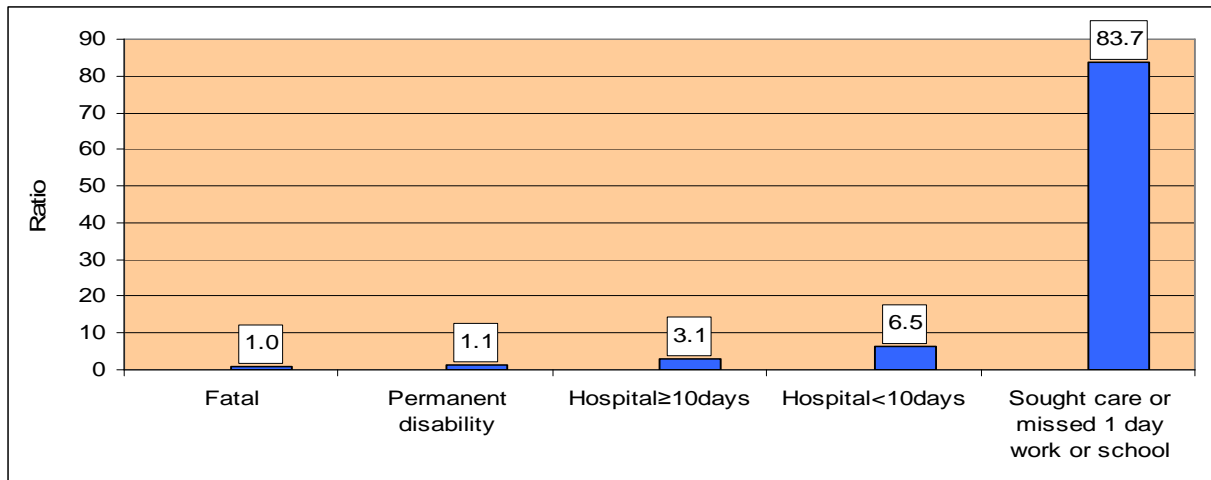
A separate report (Innocenti Working Paper, forthcoming in 2008) details the economic costs of the injuries in Jiangxi Province, China, as well as the association of injury and poverty. However, the issues involved do not require precise data here to be appreciated. It is clear that injury has enormous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

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.

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.

hospitalization 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).

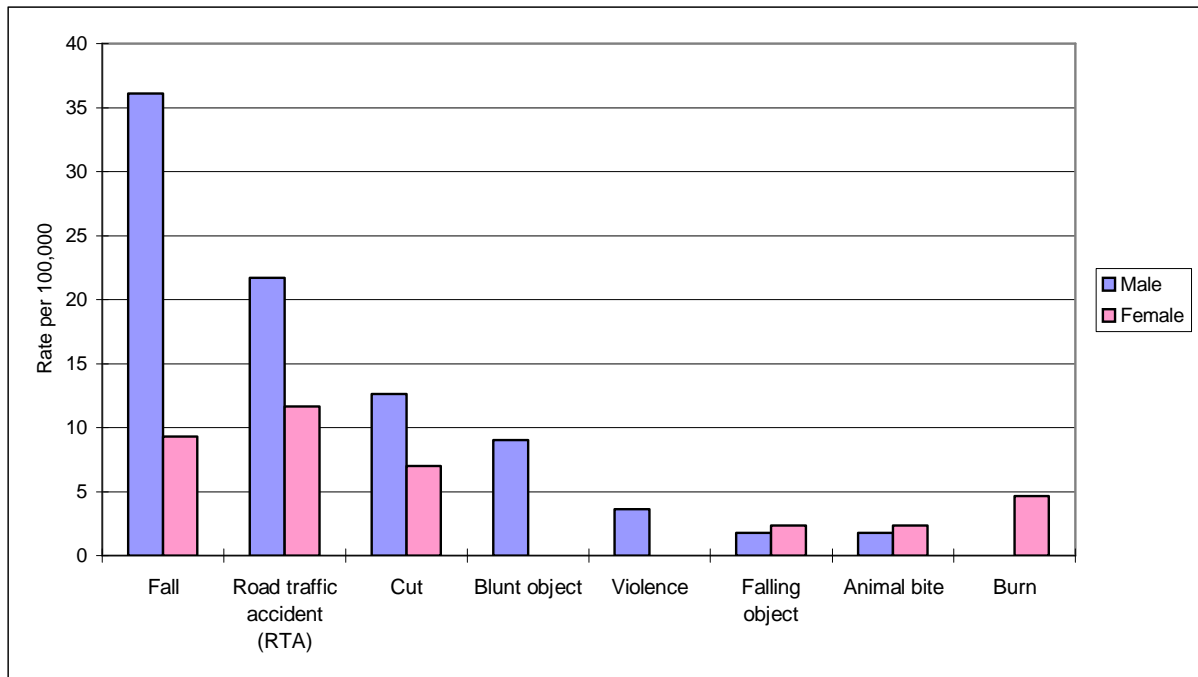
Data from the Jiangxi survey demonstrate the burden of permanent disability attributable to injury, by type. The gender-specific rates highlight the distinct pattern according to injury type (see figure 5).¹³ Three things become immediately apparent:

- 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
- 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.

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.

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

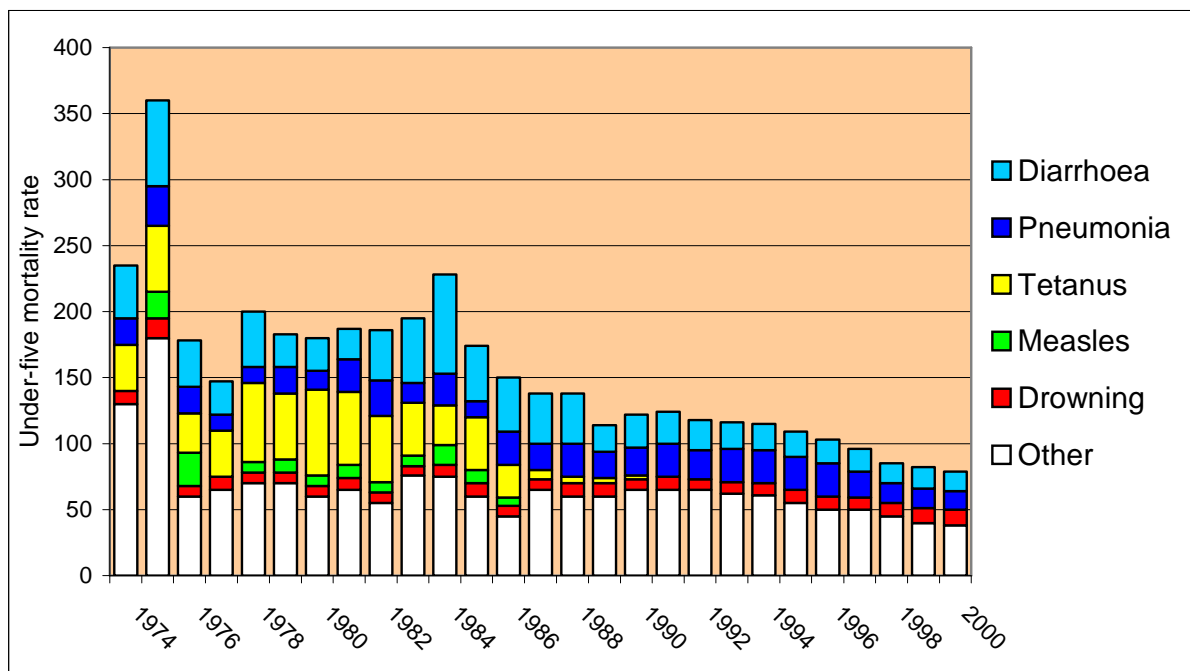
of child death may be unique to the Asian region and not be expected to be present in other regions with similar indices of child mortality.

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.

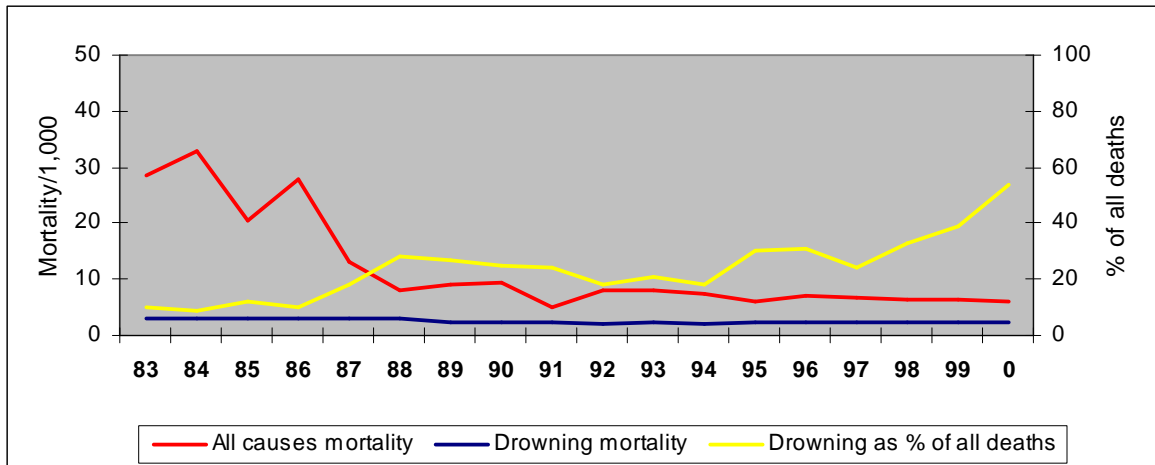
Figure 6: Decrease in under-five mortality rate over time, Matlab, Bangladesh, 1974-2000



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.

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

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.

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.

range of sources, with classic harbingers such as childhood obesity and non-insulin dependent diabetes mellitus diagnosed in late childhood with increasing frequency.¹⁷

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.

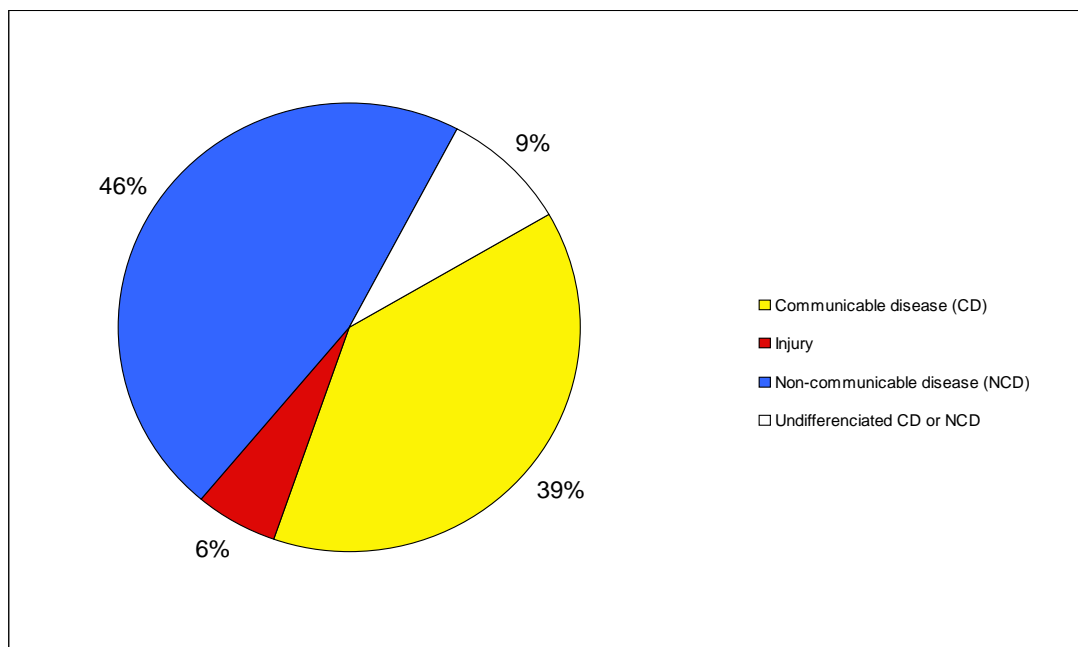
Rapidly changing causes of death over the first five years of life make it misleading to treat the five-year period as a single stage

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.

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.

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

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

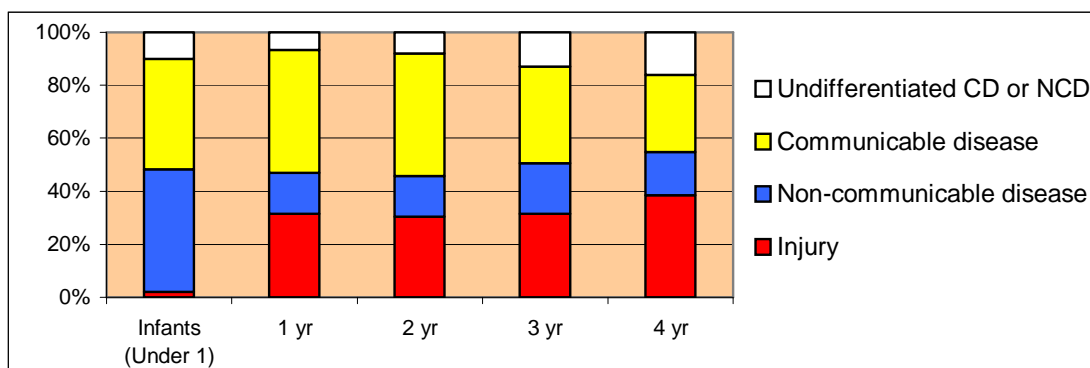


Source: Authors' calculations based on all surveys; composite is population-weighted.

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.

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

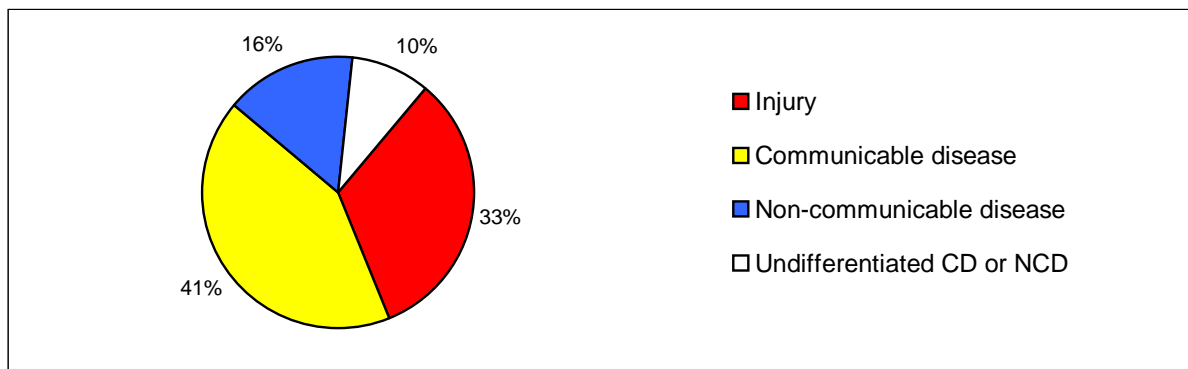
deaths, are mostly related to the pregnancy, birth and the immediate aftermath. Neonatal deaths only occur in infancy, and do not repeat in later years. Infancy is also unique in childhood in that the child, not being able to walk, is kept particularly close to the caregiver, who is a protective influence. 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.

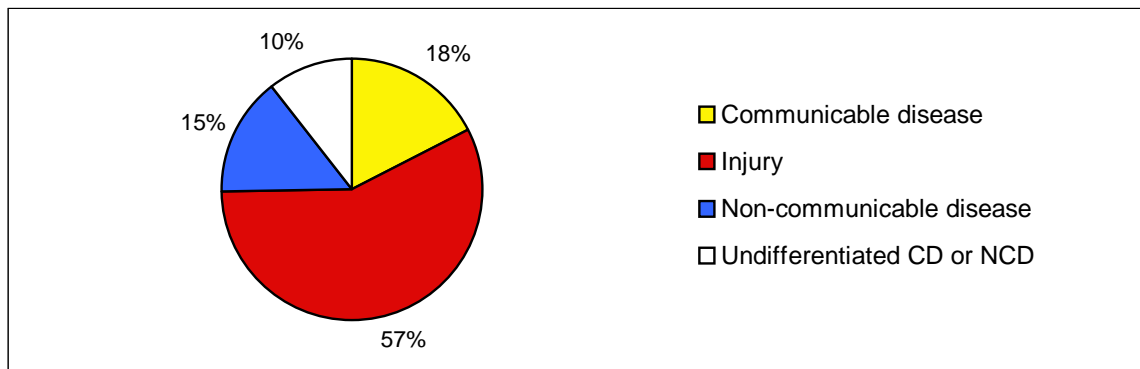
Of equal significance to the unique epidemiology of infancy is the finding that almost all (>90 per cent) of the injury deaths were attributed to a single cause: drowning. The identification of this problem permits public health intervention to begin. This is also true for infants (under age one), since 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.

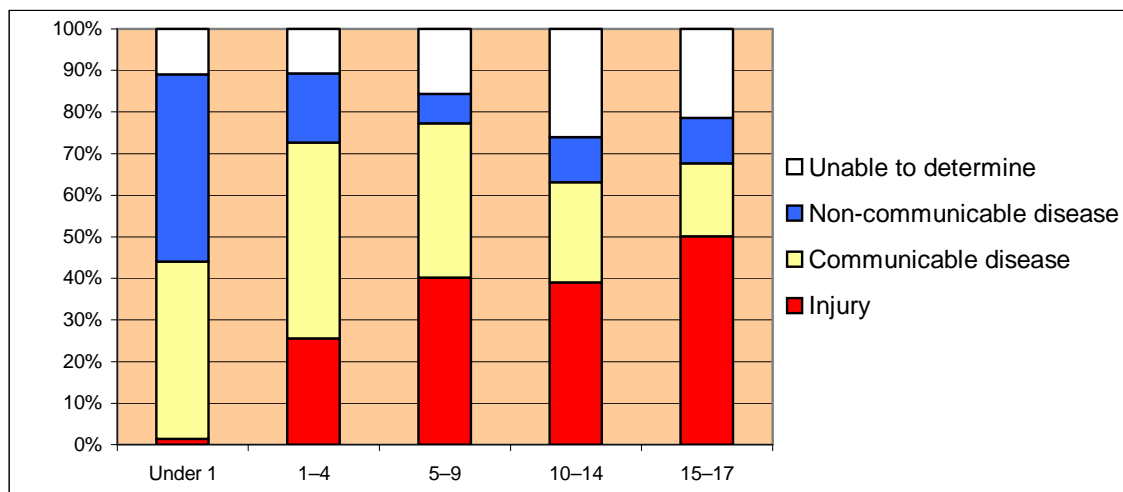
The U5MR measures the probability of surviving the period from birth to the fifth birthday, which ties the death of the child from any cause to the moment of its birth. The denominator for U5MR is per 1,000 live births. It is possible to extend the period to the 18th birthday, creating a U18MR to cover 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

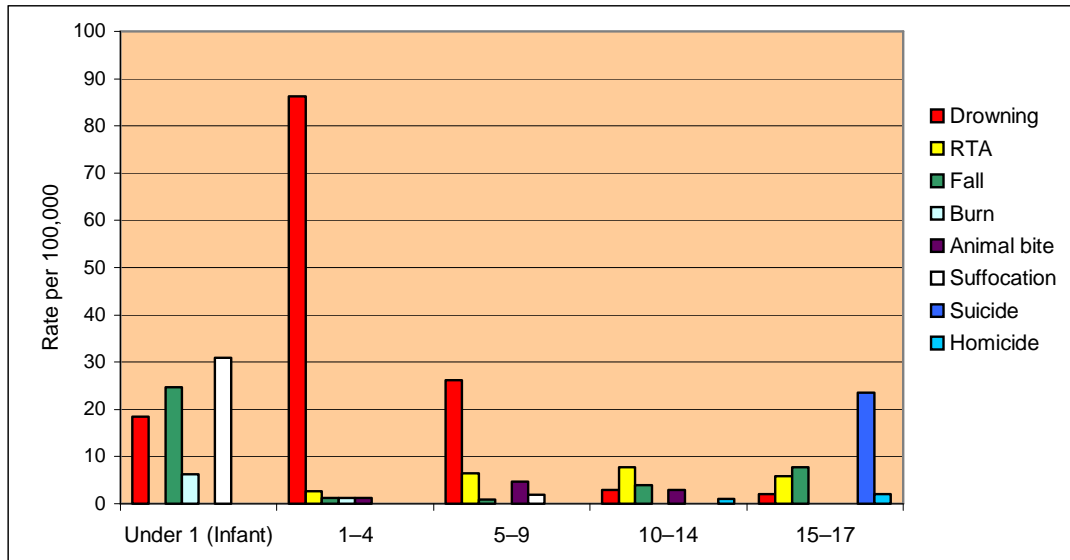
The leading causes of injury death and serious morbidity differ by age group. To fully characterize the different patterns, childhood should be divided into five groups:

- 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.

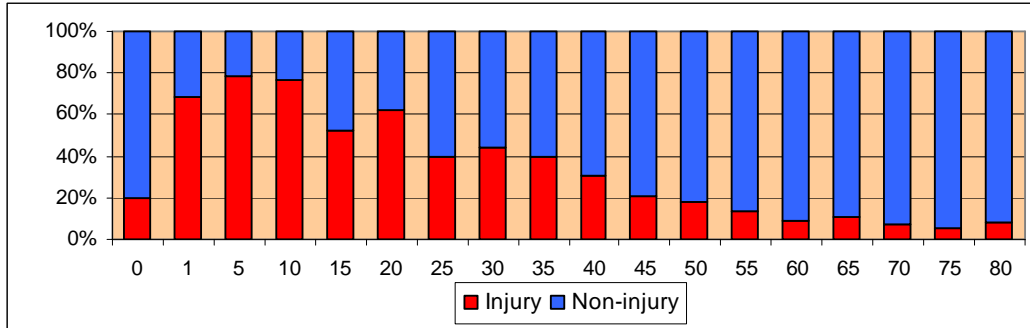
The impact of injury to parents on children

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

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

Province data to show the general case for injury being a leading cause of death in parental age groups.

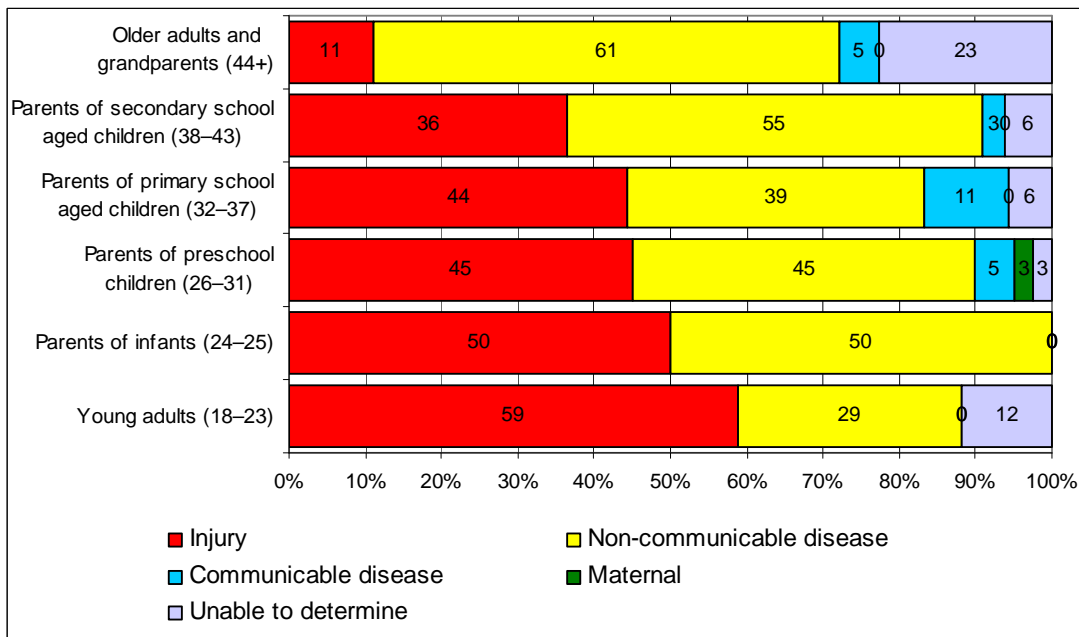
Figure 14: Mortality from injury and non-injury causes, by age, Jiangxi Province, China, 2005



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.

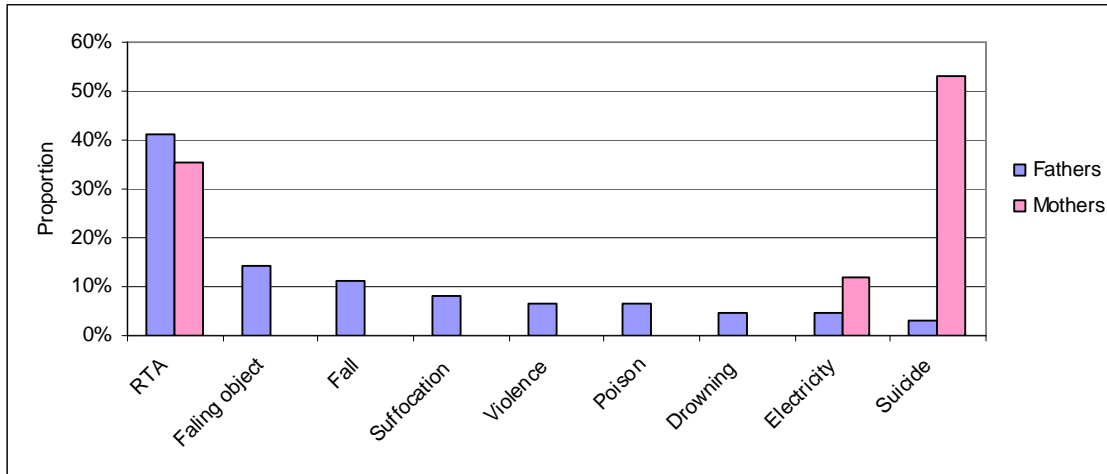
Figure 15: Causes of death among parents by relationship to child, Jiangxi Province, China, 2005



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.

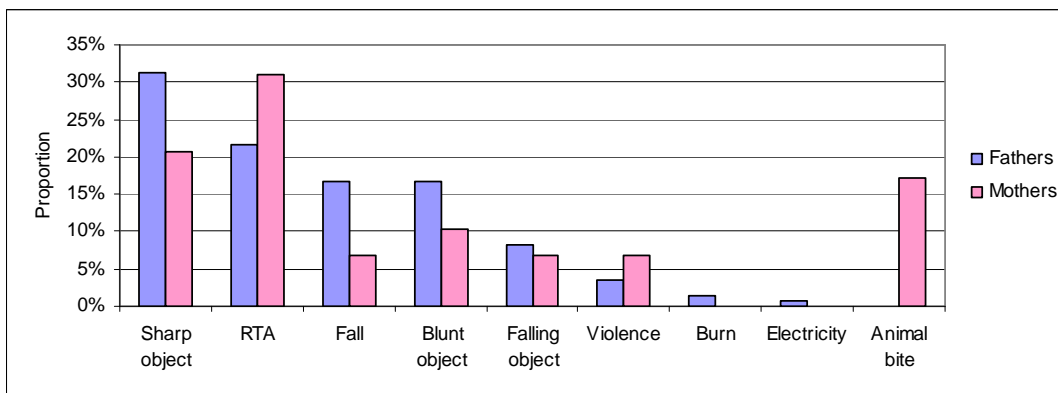
Figure 16: Causes of parental death from injury by sex of parent, Jiangxi Province, China, 2005



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).

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.

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 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

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.

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.

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 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.

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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