Objective To estimate fall-related mortality by type of fall in India.

Methods The authors analysed unintentional injury data from the ongoing Million Death Study from 2001–2003 using verbal autopsy and coding of all deaths in accordance with the International statistical classification of diseases and related health problems, tenth revision, in a nationally representative sample of 1.1 million homes throughout the country.

Findings Falls accounted for 25% (2003/8023) of all deaths from unintentional injury and were the second leading cause of such deaths. An estimated 160 000 fall-related deaths occurred in India in 2005; of these, nearly 20 000 were in children aged 0–14 years. The unintentional-fall-related mortality rate (MR) per 100 000 population was 14.5 (99% confidence interval, CI: 13.7–15.4). Rates were similar for males and females at 14.9 (99% CI: 13.7–16.0) and 14.2 (99% CI: 13.1–15.4) per 100 000 population, respectively. People aged 70 years or older had the highest mortality rate from unintentional falls (MR: 271.2; 99% CI: 249.0–293.5), and the rate was higher among women (MR: 281; 99% CI: 249.7–311.3). Falls on the same level were the most common among older adults, whereas falls from heights were more common in younger age groups.

Conclusion In India, unintentional falls are a major public health problem that disproportionately affects older women and children. The contexts in which these falls occur and the resulting morbidity and disability need to be better understood. In India there is an urgent need to develop, test and implement interventions aimed at preventing falls.

Introduction

Falls are the second leading cause of unintentional injury mortality and they account for 11% of all unintentional injury deaths worldwide. According to the World Health Organization (WHO), about 424 000 fall-related deaths occurred globally in 2004 and about one fifth of them (95 000 deaths) took place in India. The National Crime and Records Bureau (NCRB), which is the only agency that collects national injury data in India, reported that in 2005 falls contributed 3.2% of all unintentional injury deaths in the country; this figure reflects the large under-reporting well known to exist in police-based reports. Two surveys are additional national sources of cause-specific mortality in India: the Medically Certified Causes of Death (MCCD) survey and the Survey of Cause of Death (SCD), last conducted in 1998. The MCCD survey reports on causes of death based on mortality data from urban hospitals. According to this survey, falls were the cause of 2% of all unintentional injury deaths registered in 2004. In the SCD, the sample units are primary health-care centres in selected rural health facilities and an algorithm is used to determine the causes of death in the population. According to the SCD, fall-related deaths comprised 8% of all unintentional injury deaths in rural areas in India in 1998. The MCCD and SCD are not representative of India’s urban and rural populations. Furthermore, these surveys and the NCRB have shortcomings, namely low population coverage, the use of different data sources and a high proportion of deaths that are either misclassified or attributed to ill-defined causes.

Small regional studies in India have reported higher rates of deaths from falls than have been reported earlier, even among older age groups. However, these studies were relatively small and were conducted in specific geographical areas. Hence, their results are not generalizable at the national level.

To help redress the lack of reliable population-based data on deaths from unintentional falls in India, we have aimed to establish rates of death from unintentional falls in India, by type of fall, using a nationally representative sample.

Methods

Study settings

We reviewed all deaths from unintentional falls in India over a period of 3 years (2001–2003) as recorded by the Million Death Study, a comprehensive study based on verbal autopsy that assigned causes to all deaths in areas of India covered by the Sample Registration System. Verbal autopsy is a method of ascertaining the cause of death by interviewing a family member or caretaker of the deceased to obtain information on the clinical signs, symptoms and general circumstances that preceded the death.

The Sample Registration System monitors a representative sample population of 6.3 million people in over 1 million homes in India. It records deaths, births and other vital events in the country’s 28 states and 7 union territories. Based on the 1991 census, the Registrar General of India randomly selected 6671 areas from approximately 1 million having about 1000 inhabitants in each. (India’s total population was about 1 billion in 2001.) In 1993, the characteristics of households in the sampled areas...
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were documented, and from 1993 to 2004 births and deaths were reliably enumerated twice a year through a dual recording system.10,12 The first surveyor was a part-time enumerator familiar to the population of each area or village (a local school teacher) who visited households every month. The second one was a full-time (non-medical) Registrar General surveyor who visited the households in the sample unit every 6 months. The enumerator and the Registrar General surveyor independently recorded the births and deaths in the household for the period. A third staff member reconciled the two reports and arrived at a final list of births and deaths for each household, thereby completing each half-yearly survey.10,11

In 2001 the Registrar General Surveyor introduced an enhanced form of verbal autopsy for assessing the cause of death. This was known as the routine, reliable, representative, re-sampled household investigation of mortality with medical evaluation (RHIME). Nearly 800 Registrar General surveyors who knew the local languages were trained to conduct the RHIME. These trained field workers visited the families to record the events that preceded each death using age-specific questionnaires for neonates (aged 0–28 days), children (aged 29 days to 14 years) and adults (aged ≥ 15 years). For every death a narrative of the events leading to the death was recorded in the local language. In addition, the neonatal and child death questionnaires also included the following direct question: “Did he/she die from an injury or accident? If yes, what was the kind of injury or accident?” Response options included: road traffic accident; fall; falling object; burn; drowning; poisoning; bite/sting; natural disaster; homicide/assault; unknown. The cause of death was determined from the narrative of the respondent, not the direct question. Concurrence between the two physicians on the codes for injuries from falls was 88%. For child deaths, 142 of the 203 (70%) injury deaths finally coded had a “yes” response to the direct question of whether the child had died from an injury or accident. The place of death was recorded based on the following response options: home; health facility (such as a government hospital, private hospital and or registered practitioner’s office), and other (including roadside, public area or transport vehicle). In addition, for deceased persons aged 15 years or older, information was also collected on any history of physician-diagnosed co-morbidity

Table 1. Deaths from unintentional falls by age, sex and place of residence, in the present study and in national estimates, India, 2005

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Deaths in study, 2001–2003</th>
<th>National estimates</th>
<th>Deaths (per 100 000) in all India, 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males/Females</td>
<td>Rural/Urban</td>
<td>Total</td>
</tr>
<tr>
<td>0–14</td>
<td>109/94</td>
<td>168/35</td>
<td>203</td>
</tr>
<tr>
<td>15–29</td>
<td>89/30</td>
<td>105/14</td>
<td>119</td>
</tr>
<tr>
<td>30–44</td>
<td>124/32</td>
<td>130/26</td>
<td>156</td>
</tr>
<tr>
<td>45–59</td>
<td>154/73</td>
<td>190/37</td>
<td>227</td>
</tr>
<tr>
<td>60–69</td>
<td>157/69</td>
<td>252/99</td>
<td>409</td>
</tr>
<tr>
<td>70+</td>
<td>437/550</td>
<td>760/227</td>
<td>987</td>
</tr>
<tr>
<td>All</td>
<td>1070/933</td>
<td>1605/398</td>
<td>2003</td>
</tr>
</tbody>
</table>

Note: No deaths were recorded as W15 and W16.

CI, confidence interval.
such as hypertension, depression, stroke, diabetes or heart disease.

A random sample of about 5% of the areas was resurveyed independently by Registrar General employees. Results were consistent for broad families in the International statistical classification of diseases and related health problems, tenth revision (ICD-10), but lesser agreement was noted on specific codes. Details of the methods, validation and preliminary results for various conditions have been reported elsewhere.10–13

Cause of death assignment

Based on information extracted from the household interview, verbal autopsy reports were sent randomly (based on language) to at least two of a total of 130 physicians trained in ICD-10 coding. The physicians independently assessed the underlying cause of death and assigned a three-digit code to each death.10,11 Unintentional fall injury deaths were allocated ICD-10 codes from W00 to W19 in chapter XX, for external causes of morbidity and mortality.

In case of disagreement on the ICD-10 codes at the chapter level, reconciliation between reports was conducted, followed by a third senior physician’s adjudication. In case of disagreements on the codes at the subchapter level or within chapters (between W00–W19), a member of the research team adjudicated the final code during data analyses.

Included in the analysis were all deaths enumerated between January 2001 and December 2003, a period during which 136 000 interviews were conducted. RHIME reports could not be conducted for 12% of the deaths for reasons such as family migration or change of residence. In addition, 9% of the reports could not be coded because they had incomplete information, the image of the scanned verbal autopsy report was poor, or there were other field problems. Hence, physicians coded a total of 122,848 records, and 2003 deaths among them were coded as being from unintentional falls.

National death estimates and mortality rates

The analysis is based on cause-specific mortality proportions from the Million Death Study. The cause-specific proportion of deaths in each five-year age category from 0 to 79 years and for people aged 80 years and over was weighted by the inverse probability of a household being selected within rural and urban subdivisions of each state to account for the sampling design. National estimates for deaths and mortality rates are based on United Nations 2005 estimates for India,15 by age, sex and area. The year 2005 was selected for estimation due to the availability of the most accurate, stable demographic estimates, which were comparable to Indian census projections for 2006.16 Age-specific proportions of deaths from the Million Death Study are compared with the proportions from other available sources.5,13

Results

Unintentional falls accounted for 25% (2003/8023) of all unintentional injury deaths. Marginally, more males (1070) than females (933) died from falls, and male deaths exceeded female deaths in all age groups except that of people aged 70 years or older. In the sample population, close to one third of all recorded deaths and one fifth of all unintentional injury deaths were observed in the age group 70 years or older. Nearly half of all fall-related deaths occurred in this group. When age-specific percentages were applied to United Nations age-specific death totals for 2005, the national fall-related mortality rate (i.e. the number of deaths per 100 000 people) that year was 14.5 for both sexes, 14.9 for males and 14.2 for females. A total of 160 000 people died from falls in India in 2005. This included more than 100 000 people aged over 60 years and nearly 20 000 people aged 0–14 years. Mortality rates increased progressively after the age of 14 years and were highest among people aged 70 years or older (Table 1 and Fig. 1).

Same-level falls due to slipping, tripping and stumbling accounted for the largest number (32 000) and proportion (20%) of fall-related deaths. Falls from a higher level, such as from furniture or into wells or holes, were the second most common types of fall, followed by same-level falls not caused by slipping, tripping or stumbling, such as bumping into objects and colliding with other people. About 30% of fall-related deaths were coded as attributed to unspecified falls and nearly two thirds of these occurred among people aged 70 years or over. Deaths from falls of all types occurred at higher rates among males than among females except for same-level falls (Table 2). Males fell from trees 6 times more often than females and they fell from building structures twice as often.

Fig. 1 shows the age distribution for the top four types of fall-related deaths. Falls from buildings or structures were a leading cause of death among children aged 0–14 years. Deaths due to falling from trees were highest in people aged 15–44 years. Same-level fall deaths increased with age and rose sharply in people aged 50 years and over.

The rate of death from unintentional falls was 13.9 per 100 000 for rural areas and 15.6 per 100 000 for urban areas. The death rates caused by falls of various types showed little differences by place of residence (rural versus urban) except for significantly higher rates of death from falling from trees in rural areas and from stairs and ladders in urban areas ($P < 0.01,$
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Deaths due to falls from trees accounted for 9% of all fall-related deaths in rural areas but for only 3% in urban areas. Conversely, deaths due to falling from stairs and ladders accounted for 8% of all fall-related deaths in urban areas but for only 4% in rural areas. About 68% (1047/1531) of people aged 45 or over who died from falls had one or more co-morbidities such as hypertension (12%), stroke (4%), diabetes (6%), asthma (8%) and heart disease (4%). Most deaths due to falls (72%) occurred at home, 14% occurred in health facilities and 14% occurred in other places.

Discussion

Data from this nationally representative sample of deaths indicates that the number of deaths related to unintentional falls that occurred in India in 2005 is substantially higher than the previous estimate (160 000 versus 95 000, respectively).1 This is equivalent to a national rate of 14.3 deaths per 100 000 people, which is higher than the worldwide average of 6.6 per 100 000.1

Our estimates are higher than those reported by non-representative national sources. For the year 1998, the SCD reported that in rural areas 8% of all injury deaths were attributable to falls,4 a rate much lower than the 24% found in the present study. Similarly, MCCD reported that in 2003 2% of injury-related deaths in urban areas were related to falls, compared with 28% in the present study.5 We compared the percentage of fall-related deaths in broad age groups from previous data sources with the results observed in the present study (Table 3). No systematic difference was noted between older and younger age groups in the percentage of deaths from unintentional falls.

The observed discrepancies between data sources in fall-related mortality are due in part to differences in the population sample. The MCCD’s sample, unlike our nationally representative sample of deaths, only collects data on people who seek care in an urban hospital after an injury; similarly, the SCD samples injured people seen in primary-healthcare centres in villages, where available.7 Neither sample is representative of either the urban or the rural population, and both have other limitations, one of them being a large proportion (~20%) of ill-defined causes of death, partial coverage and incomplete data.56
To conduct the household survey in this study we used validated verbal autopsy methods, which are less vulnerable to biases affecting the estimated cause-specific mortality rates in earlier studies. WHO’s global burden of disease (GBD) estimates rely on the MCCD and the SCD. Hence; GBD figures are probably underestimates of the actual number of deaths from unintentional falls in the population. NCRB reports rely on police registration and may therefore reflect the underreporting by victims and families of falls and other injuries with legal implications.

Women aged 70 years or over had higher rates of death from falls than men. Falls on the same level, such as slipping and tripping, caused most of these deaths. Analytical studies from low- and middle-income countries have shown that the risk factors for fall-related injuries among women are the same as in high-income countries, namely, low bone density; co-morbid conditions such as hypertension and diabetes; low levels of physical activity; poor cognitive function; poor perceived health status; poor vision; and alcohol consumption. In our study more than two thirds of the deceased aged 45 years and above had co-morbidities, which constitute significant risk factors for fall-related injury among older adults in India and other settings.

Studies have also suggested that environmental factors such as building structure and socioeconomic factors such as the availability of electric lighting may contribute to falls to a greater extent in low- and middle-income countries.

Some of these contextual factors could be at play in the socially and geographically diverse Indian population, but further exploration of the context of falls is required.

India’s population of older adults is rising. In 2001 India had 72 million people aged 60 years and above. The projected number for 2021 is 137 million. The female to male ratio in this age group is projected to be 1031 females to 1000 males in 2016, primarily because men have lower life expectancy and smoke more than women. The demographic transition will surely lead to a rise in the number of falls among older adults, especially women, and this will pose a challenge for the health system in the future.

Several high-income countries have succeeded in reducing fall rates through community-based public health programmes. To date India has not established any widespread programme for the prevention of falls. Multifaceted programmes focused on strength and balance training, improving vision among the elderly, vitamin D supplementation and home environment modification have been effective in preventing falls in many trials in high-income countries. Research has also shown improvements in body balance using yoga-based exercises, which are culturally well accepted in India. Most programmes based on exercises for improved balance, medication management and home modification have proven cost-effective in high-income settings. However, no research has been conducted to date on the effectiveness or cost-effectiveness of such interventions in low-income settings such as India.

Although our results show high rates of death from falls among older adults, fall-related mortality in other age groups is also substantial. In studies in Asia, falls have been among the 10 leading causes of death in people aged 0–17 years. In the present study, fall-related injury was one of the five leading causes of death among children aged 0–14 years and accounted for about 20000 deaths in this group in 2005. Appropriate prevention programmes therefore need to be tailored to different age groups as well as different risk factors. Programmes known to effectively reduce falls from high-rise buildings among children in high-income countries, such as “Children can’t fly”, may also prove effective in low- and middle-income countries if adapted to the local context.

Mortality from falls was higher among males than females in the group aged 15–49 years. In urban areas, most falls leading to death among males were either from a building or another structure, while in rural areas they were mainly from trees. We did not collect data on the places where the falls had occurred (i.e. whether at home, in the workplace, in school, etc.). Falls from trees in rural areas tend to be context-specific; they most commonly occur among orchard farmers or wood pickers, since wood is used as cooking fuel in over 70% of rural households in India. Detailed data on the environmental risk factors surrounding these falls would be useful in designing preventive interventions.

Table 3. Proportion of deaths from unintentional injuries and falls, by age group, from mortality surveys, the present study and indirect Global Burden of Disease estimates for India

<table>
<thead>
<tr>
<th>Data sources</th>
<th>Unintentional injuries (%)</th>
<th>Falls (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0–14</td>
<td>15–59</td>
</tr>
<tr>
<td></td>
<td>years</td>
<td>years</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey of Cause of Death, 1998</td>
<td>16</td>
<td>70</td>
</tr>
<tr>
<td>Present study, 2001–2003</td>
<td>21</td>
<td>49</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medically Certified Cause of Death, 2003</td>
<td>7</td>
<td>85</td>
</tr>
<tr>
<td>Present study, 2001–2003</td>
<td>10</td>
<td>56</td>
</tr>
<tr>
<td>All India</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Crime Research Bureau, 2003</td>
<td>5</td>
<td>85</td>
</tr>
<tr>
<td>Global Burden of Disease, 2004</td>
<td>16</td>
<td>62</td>
</tr>
<tr>
<td>Present study, 2001–2003</td>
<td>19</td>
<td>51</td>
</tr>
</tbody>
</table>

* For the Medically Certified Cause of Death survey the age ranges are 15–64 years and 65 years and above, since proportional mortality is reported for 15-year intervals.
A strength of the Million Death Study is its nationally-representative sample. However, the study has several limitations. Verbal autopsy helps ascertain causes of death indirectly and can result in biased cause-specific mortality estimates. According to validation studies based on hospital deaths, injuries have a sensitivity of 85% and a specificity better than 95% on verbal autopsy, but such studies have not validated different types of injury. We caution against assuming that hospital-based studies validate causes of death for people who die at home without medical attention. One study has reported a sensitivity of 78% for falls on verbal autopsy because a few falls were misclassified as having occurred from cerebrovascular conditions. In another study, 12% of the deaths caused by falls were misclassified as having been from "natural causes", which are essentially equivalent to ill-defined causes or senility. The current study, nearly 15% of the deaths among people aged 70 years or over were attributed to senility, and 4% to ill-defined causes. Some of these deaths may have actually been fall-related. Thus, misclassification of the cause of death among older people (> 60 years) resulting from the use of verbal autopsy may have caused an underestimation of the rates of death from falls.

As noted in this study, falls are an emerging and major public health challenge in India. With the anticipated progressive increase in the number and fraction of elderly people, falls are bound to increase dramatically in coming years and will impose a commensurate burden on families and health-care systems. Future research should focus on investigating the circumstances and context in which falls occur and their predisposing factors to guide the planning of preventive interventions.

Competing interests: None declared.
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**Resumen**

**Mortalidad en niños y adultos por caídas no intencionadas en la India**

**Objetivo** Estimar la mortalidad asociada a caídas por tipo de caída en la India.

**Métodos** Los autores analizaron los datos sobre lesiones no intencionadas procedentes del Million Death Study, el estudio del millón de muertes, (aún en curso) de 2001 a 2003 con autopsias verbales y codificación de todas las muertes de conformidad con la Clasificación estadística internacional de enfermedades y problemas relacionados con la salud, décima versión, en una muestra representativa a nivel nacional de 1,1 millones de hogares de todo el país.

**Resultados** Las caídas representaron el 25% de todas las muertes por lesiones no intencionadas; fueron la segunda causa más importante de este tipo de muertes. Se estima que en 2005, en la India se produjeron 160 000 fallecimientos asociados a caídas; de estos, casi 20 fueron de niños de entre 0 y 14 años. La tasa de mortalidad (TM) asociada a caídas no intencionadas por cada 100 000 habitantes fue del 14,5 (intervalo de confianza del 99%, IC: 13,7–15,4). Las tasas eran similares para hombres y mujeres, 14,9 (IC del 99%: 13,7–16,0) y 14,2 (IC del 99%: de 13,1 a 15,4) para una población de 100 000 personas respectivamente. Los individuos de 70 años o más presentaron el mayor riesgo de mortalidad a causa de caídas no intencionadas (TM: 271,2; IC del 99%: de 249,0 a 293,5), y se reportó el mayor número de muertes por caídas en el grupo de edad de 0 a 14 años (TM: 271,2; IC del 99%: de 249,0 a 293,5). Las caídas desde altura eran más comunes en los grupos de edad más jóvenes, mientras que las caídas a nivel se produjeron entre adultos mayores, pero las caídas desde altura fueron más comunes en los grupos de edad más jóvenes.

**Conclusiones** En la India, las caídas no intencionadas constituyen un problema de salud pública importante que afecta a mujeres mayores y niños. Es necesario entender mejor los contextos en los que se producen estas caídas y las morbilidad y discapacidad resultantes. En la India existe una necesidad urgente de preparar, probar e implementar medidas para evitar caídas.
References


