Disparities in and characteristics of drowning deaths in India: findings from a population-based mortality study

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ABSTRACT

Background We report on sociodemographic inequalities in drowning mortality rate and characteristics of drowning deaths in India.

Methods Verbal autopsy interviews were undertaken for a nationally representative sample of deaths of all ages between 2019 and 2022 in 1 million population across nine Indian states. Details about drowning were documented from the adult most knowledgeable about the event.

Results Data were available for 26 964 deaths (92.1% participation). Drowning deaths accounted for 0.48% all deaths with the highest proportion in the lowest wealth index. It accounted for 8.8% of unintentional injury deaths at an annualised drowning mortality rate of 3.2 (95% CI 2.1 to 4.3) per 100 000 population. This rate was 3.3 times significantly higher in males than in females. The age-specific mortality rate was the highest for 50–76 years (4.1 per 100 000) followed by 10–14 years (3.9 per 100 000). The mean age at death was 59.1 years irrespective of the cause of death and was 30.9 years for drowning deaths. Bathing, followed by playing near a waterbody and crossing a waterbody, was the most common activities at the time of drowning with variations documented by type of waterbody, age, sex and state. 23 deceased (17.7%) were found alive post-drowning, but 11 (55.0%) had died before reaching a healthcare provider. 53 (40.8%) of drowning deaths were likely not reported to the police, with significant state and urban–rural variations.

Conclusions These findings can facilitate targeted drowning prevention strategies under the National Strategic Framework for Drowning Prevention of India.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The majority of drowning deaths globally are in developing countries. The last national drowning mortality rate estimate for all ages at the population level for India is available for 2000–2003 with no details on the context for drowning deaths available that could facilitate planning of interventions.

WHAT THIS STUDY ADDS

⇒ The drowning mortality rate in a nationally representative sample of deaths in India was estimated at 3.2 per 100 000 population in 2019–2022, a reduction of 43% from 2001 to 2003.

⇒ The burden of drowning deaths remains high in males, in young children and adolescents, among the poor and in rural areas.

⇒ Routine daily activities accounted for most drowning deaths, highlighting the areas that need attention for targeted interventions for drowning prevention.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These data contribute to the National Strategic Framework for Drowning Prevention to develop targeted strategies for reducing drowning deaths in India while also providing globally relevant insights into drowning deaths across age groups in developing countries.

INTRODUCTION

The adoption of the first ever resolution on drowning prevention by the United Nations General Assembly in 2021 recognised the devastating effect of drowning deaths worldwide.[1 2] An estimated 274 200 drowning deaths occurred worldwide, accounting for 15.1% of all unintentional injury deaths.[3] The majority of the drowning deaths are in developing countries, and in particular impact children and young adults.[3 4] Furthermore, floods are the most common type of natural disaster and the leading cause of mortality in disasters,[2 5] and drowning is the leading cause of death during floods.[6]

An estimated 50 800 drowning deaths were reported for India in 2021 by the Global Burden of Disease (GBD) study.[3] In response to addressing the drowning deaths, India has recently released a National Strategic Framework for Drowning Prevention (NSFDP) that encompasses several vital components.[7] There remains a pressing need for a deeper and more nuanced understanding of drowning patterns and risk factors, which is crucial for defining, refining and enhancing prevention strategies.[2 7 8] The last national drowning mortality rate estimate for all ages at the population level for India is available for 2000–2003 (6.4 deaths per 100 000 population), with no details on the context for drowning deaths available that could facilitate planning of interventions.[9] Two decades later, the NSFDP provides an important opportunity to

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improve data and understanding of the context of drowning for prevention. In this background, we report on drowning mortality from a nationally representative sample of deaths of all ages in India between January 2019 and December 2022.[10] We provide detailed epidemiology that can facilitate actionable insights to inform the development of more targeted and effective drowning prevention strategies and to prevent drowning deaths in India.

METHODS

Study population

Detailed sampling methods for the survey are reported previously, and methods relevant to this paper are described.[10] Nine states—Assam, Gujarat, Haryana, Jharkhand, Kerala, Maharashtra, Odisha, Tamil Nadu and Uttar Pradesh—were selected as per the sampling criteria described elsewhere.[10] The sample size for deaths was estimated at 25 800 deaths for a 1 000 000 population sample based on the crude death rate for each of the sampled state and the assumed excess deaths in these sampled states during January 2020 to December 2021. Following the state selection, a multistage sampling procedure was used to select 1000 clusters from 50 districts in the nine sampled states with the aim of having a sample representative of the population of India. The number of districts was distributed across the nine sampled states based on the total population in these states. Four districts each were sampled in the states of Odisha, Kerala, Jharkhand, Assam and Haryana; 6 districts each in Gujarat and Tamil Nadu; 8 districts in Maharashtra; and 10 districts in Uttar Pradesh. The districts in each state were sampled randomly until a reasonable geographical spread was achieved within the state.[10]

Based on the Census 2011 data,[11] 20 study clusters of about 1000 population each were sampled in each district using stratified systematic sampling technique, with the proportion of rural–urban clusters similar to the proportion of rural–urban population in each district. The rural–urban population proportion in each district during the study period was estimated by applying the percentage increase in urban population in each sampled state between Census 2001 and Census 2011[11 12] to the period after 2011. In the selected districts, we divided large villages into segments of 1000 population each and combined villages with smaller populations with others to make a cluster size of 1000 population each. We then systematically selected the rural clusters from the villages with the first cluster sampled randomly, and similarly the urban clusters from the wards. All households in the sampled cluster were mapped and listed in a serpentine pattern starting from the north-east corner and ending in the opposite corner. A household was defined as people eating from the same kitchen.

Data collection

Data collection was undertaken from January to August 2023. Trained interviewers documented the number of current usual residents, in-migration and out-migration, and deaths between January 2019 and December 2022 in all households during enumeration. All households with at least one death between January 2019 and December 2022 were considered eligible for detailed survey. At least three attempts were made to reach all eligible deaths. Confidential interviews were undertaken in local language with the adult who was most knowledgeable about the deceased to ascertain the cause of death using the Population Health Metrics Research Consortium (PHMRC) verbal autopsy (VA) questionnaire.[13 14] The PHMRC VA questionnaire, which is in English, was translated into the local languages of the sampled states, and then back-translated into English to ensure accurate and relevant meaning and intent of the questions. Pilot testing of the questionnaire was carried out in each state and modifications made as necessary. Specifically, for the analysis presented, the intent of drowning, type of waterbody where drowning occurred, whether the deceased was alone at the time of drowning and the activity that he/she was involved with, whether healthcare was sought post-drowning, survival duration post-drowning and whether a police case was registered for the drowning death was documented. In the open narrative section, the respondent was asked to narrate the context of drowning in his/her own words which was documented in verbatim by the interviewer in the local language.

The interview data were captured using Open Development Kit software in hand-held tablets.[15] Data entered were scrutinised using the internal consistency checks built in to detect and correct errors using the procedures standardised in the study for data quality. In addition, spot-check and back-check techniques were adopted to assess and maintain the quality of interview data collected. Spot-check of interviews was planned in 20% of all deaths and was completed for 5935 (98·9%) deaths. Back-check for completed interviews was planned in 30% of the sampled clusters (n=300) and in 15% of the interviewed deaths (n=1750), and was completed for 1399 (79.9%) deaths.

Data analysis

All open narratives from local languages were translated into English for review. The cause of death was assigned as per the PHMRC protocol using the validated SmartVA automated algorithm.[13] Furthermore, three team members (MA, SSPD and MM) reviewed the open narratives of the reported drowning deaths to confirm the intent of drowning deaths and to identify any additional themes that may not have been captured in the close-ended section. This review led to the identification of two additional themes—whether the deceased was found alive or dead post the drowning event and whether the body of the deceased was found post-drowning. In addition, a detailed review of other unintentional injury cases identified 14 additional cases of drowning deaths that were reported as 'fall' by the respondents. These people had fallen in a waterbody.

For the analysis presented, we considered drowning cases that were reported of unintentional intent by the respondents. Two cases of drowning deaths in floods are included. Distribution of drowning deaths by select demographic characteristics is presented among all deaths irrespective of the cause of death, and among all unintentional injury deaths for both sexes combined. The mean age at death, considering all deaths, only drowning deaths and unintentional injury deaths is reported. We report the overall annualised drowning mortality rate for India between 2019 and 2022, by sex, by urbanicity, by regions of India, by age categories and by month of death. The rate estimates are reported for 100 000 population per year with 95% CI and are adjusted for age and sex and urban–rural distribution of population as relevant.

In addition, the distribution of drowning deaths by the type of waterbody and type of activity at the time of drowning is reported. We categorised the waterbody into artificial (canal, dam, swimming pool, water bucket, water pit, water tank, well), natural (river, sea) and combination (pond).[16 17] The distribution of activities resulting in drowning death is reported by the type of waterbody and also if the deceased was alone or with someone at the time of drowning. Furthermore, care seeking postinjury and range of survival time in hours post-drowning is reported

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for deceased who were found alive post the drowning event. Distribution of drowning deaths not reported to the police is presented by select demographic characteristics of the deceased. Finally, we present some examples of narratives to highlight the context of drowning by age at death.

Wealth index quartiles were calculated using the standard methods used in the National Family Health Survey to calculate wealth index.[18 19] We report χ^2 and z test of significance as relevant, and 95% CI is reported for all estimates. All analyses were performed using Stata V.13.1 software (StataCorp, USA).

RESULTS

A total of 29 273 deaths between January 2019 and December 2022 were enumerated in 240 975 (87.1% participation rate) households with an average population of 1 002 098 in the survey. A detailed interview was available for 26 964 (92.1% participation rate) deaths, including 11 093 (41.1%) female deaths and 19 303 (71.6%) deaths in rural areas.

Distribution of drowning deaths

A total of 130 (0.48%; 95% CI 0.41% to 0.57%) drowning deaths were identified, including two cases of drowning in floods. Considering all deaths irrespective of the cause of death (online supplemental table S1), the proportion of drowning deaths was significantly higher in the age group of 9–14 years (p<0.001), males (p<0.001), never married people (p<0.001) and in wealth index quartile 1 (p=0.005). Furthermore, drowning deaths accounted for 8.8% of unintentional injury deaths and these deaths were significantly higher in the younger age groups (p<0.001), in never married (p<0.001), in lower wealth index quartile (p=0.007) and in the states of Odisha and Kerala (p=0.006) as compared with all unintentional injury deaths (online supplemental table S2). The mean age at death was 59.1 years (95% CI 58.8 to 59.4), 44 years (95% CI 42.8 to 45.2) and 30.9 years (95% CI 26.9 to 35.0) for deaths irrespective of the cause of death, deaths due to unintentional injuries and drowning deaths for both sexes combined.

Drowning mortality rate

The annualised drowning mortality rate for India was estimated at 3.21 (95% CI 2.10 to 4.32), 1.47 (95% CI 0.40 to 2.55) and 4.88 (95% CI 2.96 to 6.80) per 100 000 population for both sexes combined, female and males, respectively. The annualised drowning mortality rate was higher but not statistically significant in the rural areas (3.38; 95% CI 2.03 to 4.73) than in the urban areas (2.86; 95% CI 0.92 to 4.81). The annualised drowning mortality rate was relatively higher in the east, west and north-east regions of India compared with the other two regions (online supplemental table S3).

Age-specific annualised drowning mortality rate is shown in table 1. Overall, this rate was the highest in 50–79 years (4.1 per 100 000 population) followed by 10–14 years (3.9 per 100 000 population) for both sexes combined. Across all the age groups, the drowning mortality rate was generally higher among males, except in the age groups of 15–19 years and 80 years and above, where females had a higher drowning mortality rate, but not statistically significant (figure 1). Drowning mortality rate was consistently higher in the rural areas compared with the urban areas across most age groups (figure 1). Overall, the mean age at death due to drowning for females was 27.2 years as compared with males for whom this was 32.1 years (online supplemental figure S1). The mean age for drowning deaths was similar for males and females across all age groups other than 50–79 years where the mean age at death was higher for females than males.

Table 1 Annualised age-specific drowning mortality rate by age group for India, 2019–2022

Age group (years)	Drowning mortality rate (95% CI)
0–14	3.1 (0.3 to 7.4)
0–4	2.8 (0 to 6.0)
5–9	2.7 (0 to 5.9)
10–14	3.9 (0.3 to 7.6)
15–49	2.1 (1.0 to 3.1)
15–19	2.0 (0 to 4.5)
20–29	1.7 (0.1 to 3.4)
30–39	2.1 (0.1 to 4.1)
40–49	2.4 (0 to 4.8)
50 and over	4.4 (1.8 to 6.9)
50–79	4.1 (1.5 to 6.6)
80+	3.8 (0 to 14.2)

Considering seasonality, 21 (16.2%) of the drowning deaths were between December and February (winter), 32 (24.6%) between March and May (summer), 57 (43.9%) between June and September (monsoon) and 20 (15.4%) between October and November (autumn). Distribution of drowning deaths and annualised drowning mortality rate by month between 2019 and 2022 is shown in online supplemental figure S2.

Activity at the time of drowning

Most drowning deaths (72.3%) occurred when the deceased was alone (online supplemental figure S3). Activity at the time of drowning was reported as do not know for 12 (9.4%) of all cases. Most common activities at the time of drowning included bathing (40; 31.2%), playing near the waterbody (20; 15.6%), crossing or working near the waterbody (13; 10.6%) and sitting near waterbody (10; 7.8%) as shown in online supplemental figure S4. Though bathing was the predominant activity across all the wealth index quartiles, it accounted for 35% deaths in wealth index quartiles 1 and 2.

A distinct pattern by sex was seen in the activities (online supplemental figure S4). While both males and females had a higher proportion of drowning during bathing (32.6% for males and 26.7% for females) and playing (15.3% for males and 16.7% for females), drowning while crossing or walking near a waterbody (20%) and collecting water (16.7%; p=0.058) was predominately in females. Both urban (35.3%) and rural (29.8%) areas showed a higher proportion of drownings while bathing, rural areas had a higher drowning rate during activities like playing (19.1%) and crossing or walking near a waterbody (12.8%, p=0.007), whereas sitting near a waterbody was reported more in urban areas (11.8%). Significant variations were observed across the states in the type of activity, as shown in online supplemental figure S5. Bathing accounted for 68.8% drowning cases in Odisha and 41.2% cases in Jharkhand, whereas playing accounted for 54.5% cases in Assam and 40% of cases in Haryana that were related to open defecation near a waterbody.

Drowning death by type of waterbody

Most of the drowning deaths were reported to be in an artificial waterbody (59; 47.2%) followed by a natural waterbody (38; 30.4%) and combination (28; 22.4%) as shown in table 2. An artificial waterbody was reported significantly

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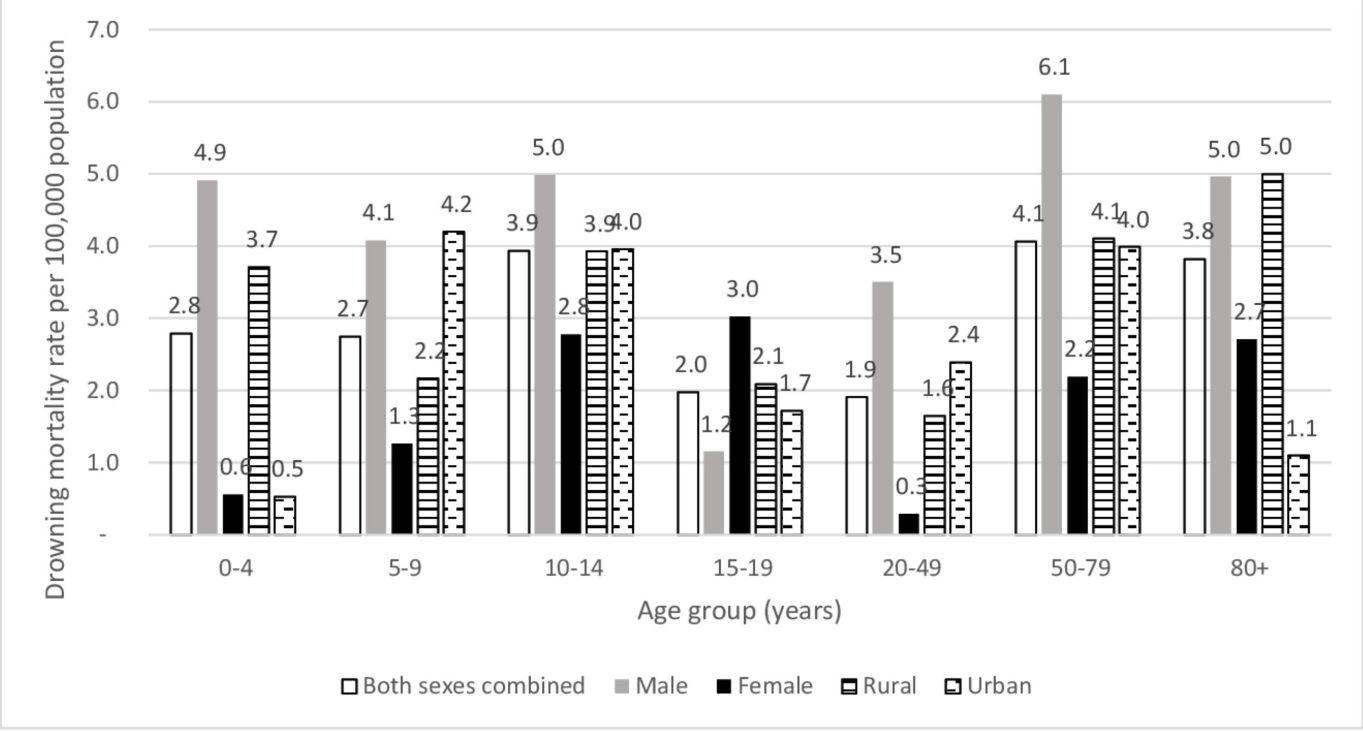


Figure 1 Annualised drowning mortality rate by age group for India, by sex and place of residence, 2019–2022.

Table 2 Distribution of drowning deaths by the type of waterbody and age at death. Two cases of drowning in floods are excluded

Age group of the deceased (in years)	Sex of the deceased	Number of drowning deaths N=125*	Type of waterbody (% of variable category)			X^2 test of significance p value for sex
			Artificial	Natural	Combination	
All ages	Both sexes combined	125	59 (47.2)	38 (30.4)	28 (22.4)	
	Male	95	39 (41.1)	30 (31.6)	26 (27.4)	0.021
	Female	30	20 (66.7)	8 (26.7)	2 (6.7)	
0–4	Both sexes combined	13	10 (76.9)	0	3 (23.1)	
	Male	10	7 (70.0)	0	3 (30.0)	0.279
	Female	3	3 (100)	0	0	
5–9	Both sexes combined	11	10 (90.9)	1 (9.1)	0	
	Male	7	6 (85.7)	1 (14.3)	0	0.428
	Female	4	4 (100)			
10–14	Both sexes combined	15	4 (26.7)	6 (40.0)	5 (33.3)	
	Male	10	2 (20.0)	4 (40.0)	4 (40.0)	0.638
	Female	5	2 (40.0)	2 (40.0)	1 (20.0)	
15–19	Both sexes combined	10	4 (40.0)	5 (50.0)	1 (10.0)	
	Male	4	1 (25.0)	2 (50.0)	1 (25.0)	0.392
	Female	6	3 (50.0)	3 (50.0)	0	
20–49	Both sexes combined	48	19 (39.6)	15 (31.3)	14 (29.2)	
	Male	42	15 (35.7)	13 (31.0)	14 (33.3)	0.194
	Female	6	4 (66.7)	2 (33.3)	0	
50–79	Both sexes combined	25	10 (40.0)	11 (44.0)	4 (16.0)	
	Male	20	7 (35.0)	10 (50.0)	3 (15.0)	0.471
	Female	5	3 (60.0)	1 (20.0)	1 (20.0)	
80 or more	Both sexes	3	2 (66.7)	0	1 (33.3)	
	Male	2	1 (50.0)	0	1 (50.0)	0.386
	Female	1	1 (100)	0	0	

*Data not available for three cases on type of waterbody.

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Table 3 Distribution of type of activity at the time of drowning by major types of waterbodies. Two cases of drowning in floods are excluded

Type of waterbody*	Activity at the time of drowning	Both sexes combined	Male	Female	Z test of significance p value for sex
Artificial		**N=59 (% of N)**	**n=39 (% of n)**	**n=20 (% of n)**	
	Playing	15 (25.4)	10 (25.6)	5 (25.0)	0.958
	Bathing	9 (15.3)	5 (12.8)	4 (20.0)	0.472
	Sitting near waterbody	5 (8.5)	5 (12.8)	0	0.102
	Swimming	2 (3.4)	2 (5.1)	0	0.309
	Defecation	3 (5.1)	3 (7.7)	0	0.211
	Crossing/walking	3 (5.1)	2 (5.1)	1 (5.0)	0.983
	Collecting water	6 (10.2)	2 (5.1)	4 (20.0)	0.082
	Working	4 (6.8)	3 (7.7)	1 (5.0)	0.699
	Other than above*	4 (6.8)	2 (5.1)	2 (10)	0.486
	Activity not known	8 (13.6)	5 (12.8)	3 (15.0)	0.818
Natural		**N=38 (% of N)**	**n=30 (% of n)**	**n=8 (% of n)**	
	Bathing	16 (42.1)	13 (43.3)	3 (37.5)	0.769
	Sitting near waterbody	3 (7.9)	3 (10.0)	0	0.359
	Fishing	5 (13.2)	5 (16.7)	0	0.225
	Crossing/walking	7 (18.4)	3 (10.0)	4 (50.0)	0.015
	Collecting water	1 (2.6)	0	1 (12.5)	0.059
	Other than above*	4 (10.5)	4 (13.3)	0	0.284
	Activity not known	21 (5.3)	2 (6.7)	0	0.459
Combination		**N=28 (% of N)**	**n=26 (% of n)**	**n=2 (% of n)**	
	Bathing	15 (53.6)	14 (53.9)	1 (50.0)	0.817
	Playing	4 (14.3)	4 (15.4)	0	0.555
	Defecation	1 (3.6)	1 (3.9)	0	0.780
	Sitting near waterbody	2 (7.1)	2 (7.7)	0	0.687
	Crossing/walking	3 (10.7)	2 (7.7)	1 (50.0)	0.074
	Collecting water	1 (3.6)	1 (3.9)	0	0.780
	Activity not known	2 (7.1)	2 (7.7)	0	0.687

*Data not available for three cases on type of waterbody.

higher for females (66.7%) than males (41.1%), whereas drowning in the other types was reported more for males than females (p=0.021). A distinct age pattern was seen by type of waterbody where the artificial waterbody was reported more in the younger age group and the natural waterbody in the older age groups (table 2). The proportion of drowning deaths was higher in artificial waterbodies in the states of Assam (60.0%), Gujarat (68.7%), Haryana (80.0%), Tamil Nadu (50.0%), Jharkhand (56.2%) and Uttar Pradesh (47.6%), whereas the proportion of drowning deaths was higher in natural waterbodies in Kerala (62.5%) as shown in online supplemental figure S6. No significant difference was seen in the type of waterbody by the wealth index quartile (p=0.241) or place of residence (p=0.211) for both sexes combined.

Table 3 shows the distribution of type of activity at the time of drowning for types of waterbodies for both sexes combined, females and males. Considering both sexes combined, playing near the waterbody (25.4%) was the major activity for artificial waterbody drowning, whereas bathing (42.1%) was the major activity for natural waterbody drowning. Some variation was seen in the type of activity by sex (table 3).

Qualitative context review of verbal autopsy narratives

We present case reports by age at death to highlight the context that led to drowning, which could possibly provide guidance for potential interventions to prevent these deaths. The case reports from the VA narratives exemplify a variety of scenarios (translated verbatim as is). The absence of a caretaker, unsafe environment and lack of swimming skills are highlighted for deceased aged 0–15 years (box 1). On the other hand, unsafe environment, lack of toilet, use of alcohol and body not found are highlighted for deceased >15 years of age (box 1).

Healthcare seeking and survival time post-drowning

Of the 130 drowning deaths, bodies of 4 (3.1%) cases were not found and 23 (17.7%) cases were found alive post immediate drowning (online supplemental figure S7). A higher proportion of females (23.3%) than males (16.0%), though these differences were not statistically significant (p=0.356), and urban (29.4%) cases significantly higher than rural cases (13.5%) were found alive post the drowning event (p=0.037). Those who drowned in an artificial waterbody (25.4%) were more likely to be found alive as compared with those who drowned in a natural (13.2%) or combination waterbody (10.7%), but this difference was not statistically significant (p=0.154). 20 (87%) of the 23 cases found alive post-drowning were taken to a healthcare provider,

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Box 1 Verbatims of drowning death cases

Deceased aged 0–15 years
Case study 1
Deceased age: 7 months; sex: male; respondent relationship: mother
My son did not have any health issues. I put my baby on the cot and went to the toilet. When I came back from the toilet, I saw that my baby had fallen into the water bucket which was kept below the cot. The baby was already dead.
Case study 2
Deceased age: 8 years; sex: male; respondent relationship: mother
My son was playing near a water pit and fell into it. His body was not recovered even after searching for almost 1–2 months by the police and by a rescue team from Chandigarh. Later, the police decided to write this as a missing case because the body was not found.
Case study 3
Deceased age: 7 years; sex: female; respondent relationship: mother
While playing, my daughter fell into the well. When she was taken out of the well, she was already dead. We still took her to the doctor who also declared her dead. A police case was registered.
Case study 4
Deceased age: 11 years; sex: male; respondent relationship: mother
No one was at home. My son was alone at home. There is a small fish pond in our house. Later in the evening, when we returned we saw that my child was lying in the fish pond. He was taken to the hospital. The doctor informed that my son had died due to water entering in his lungs and did his post-mortem. No one knows how he fell into that pond.
Case study 5
Deceased age: 13 years; sex: male; respondent relationship: brother
My youngest brother went to swimming in the dam with his friends for the first time. He drowned while swimming. No one found him for three days; the family was searching for him. We complained to the police. My brother's body was found on the third day. If he had not gone swimming, he would have been alive.
Deceased aged >15 years
Case study 1
Deceased age: 18 years; sex: female; respondent relationship: sister
My sister went to cut grass with her husband. She felt thirsty and started drinking water from the river and slipped and fell into the river. Her dead body was found after 3 days.
Case study 2
Deceased age: 21 years; sex: male; respondent relationship: father
My son went to a canal with a friend to take bath. As he did not return home till the evening, a family member went in search and then registered a police complaint. A poster was also displayed as he was not found. We came to know this after 12 days that his body was found and the police did the final rights for my son without informing us.
Case study 3
Deceased age: 45 years; sex: male; respondent relationship: wife
It was a hot summer day and my husband went for bathing. He slipped into the pond as he was drunk. He could not swim. He was taken to the hospital where he was declared dead by the doctor.
Case study 4
Deceased age: 62 years; sex: male; respondent relationship: mother-in-law
My son-in-law went for defecation near the canal as there is no toilet in the house. He drowned in the flood water running through the canal. His body was found after 3 days.
Case study 5
Deceased age: 18 years; sex: female; respondent relationship: father-in-law
My daughter-in-law was drawing water from the house well when her foot slipped, and she fell into the well, resulting in her tragic and immediate death.

but 11 (55%) of them had died before reaching a healthcare provider. Among these 23 cases found alive post the drowning event, 12 (52.2%) had died within <1 hour, 4 (17.4%) within 1–5 hours, 3 (13.0%) within 6–10 hours and 4 (17.4%) died between 10 and 72 hours post the event.

Under-reporting of drowning deaths to the police

Overall, 53 (40.8%) of drowning deaths were not likely to be in the police system (figure 2). Though a higher proportion of female (46.7%) as compared with male drowning deaths (39.0%) were not likely to be reported to the police, this difference was not statistically significant (p=0.454). Drowning deaths in urban areas (14.7%; p<0.001) were significantly less likely to be under-reported to the police than in rural areas (50%). The states of Jharkhand (94.1%), Odisha (68.8%) and Gujarat (47.1%) had a higher under-reporting of drowning deaths to the police in contrast to Kerala (0%) and Tamil Nadu (8.3%, p<0·001).

DISCUSSION

The drowning mortality rate has reduced in India over the last two decades and was estimated at 3.2 per 100 000 population in 2019–2022. The burden of drowning deaths remains in males, in young children and adolescents, among the poor and in rural areas. Routine daily activities accounted for most drowning deaths, highlighting the areas that need attention for targeted interventions for drowning prevention.

The release of NSFDP is a major step to address drowning deaths in India.[7] The strategy underscores the need to improve the availability of robust mortality estimates for fatal drowning that could assist with planning and monitoring of interventions to prevent drowning deaths. Our study suggests a decrease of 43% in the drowning mortality rate in India between 2000–2003 and 2019–2022,[9] which is similar to the sharp reduction in drowning deaths between 2000 and 2021 at 37.5% globally.[3] While significant challenges remain for drowning prevention in India,[7] it is important to acknowledge this significant decline in drowning mortality. Our study was not designed to explore this aspect, and understanding the facilitators for this reduction could guide addressing the current challenges. The average number of drowning deaths reported during 2019–2022 in the National

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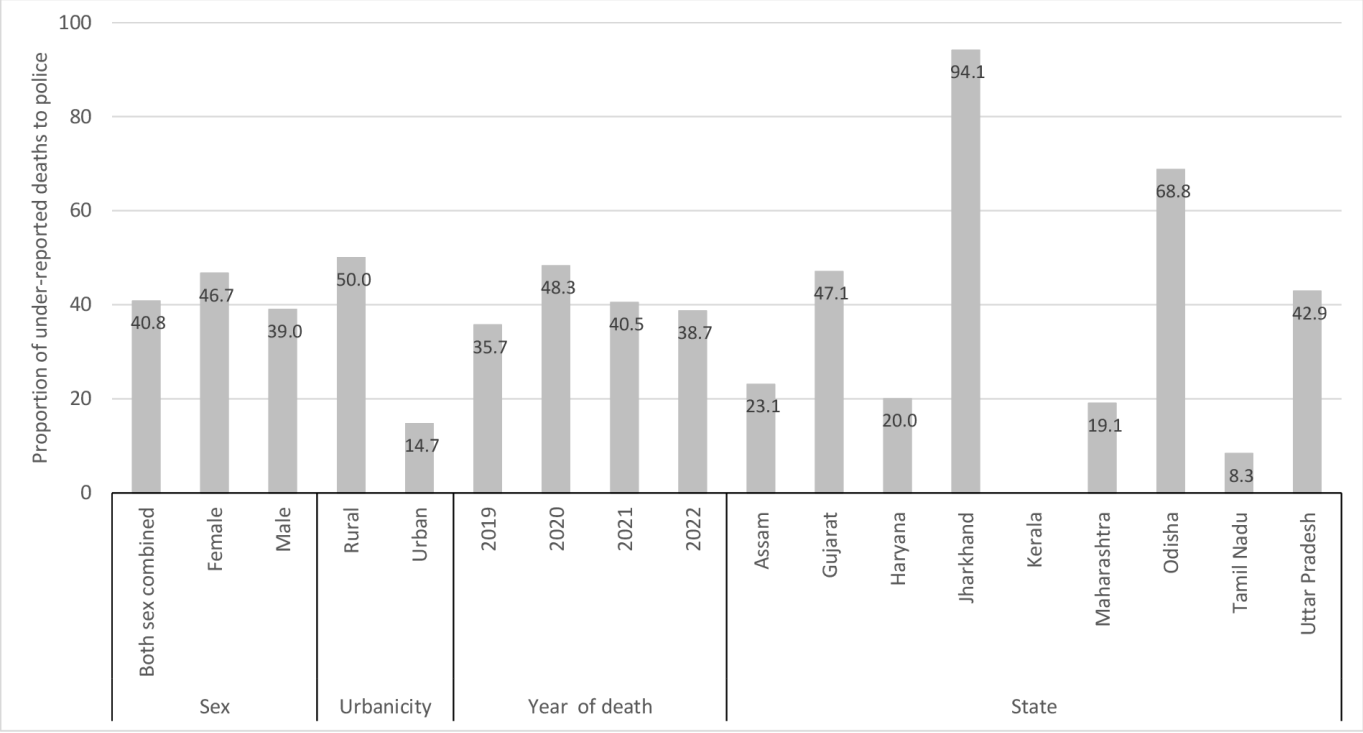


Figure 2 Distribution of under-reporting of drowning deaths in the police data by select demographic characteristics.

Crime Record Bureau (NCRB) reports, the official statistics for India based on police reports of drowning deaths, is 36 194.[20–23] Extrapolating mortality rate from our study, an estimated 44 642 (95% CI 25 728 to 63 555) drowning deaths occurred in India annually during 2019 and 2022. It is important to note that these numbers are not directly comparable for two major reasons. First, drowning mortality statistics are underestimated due to the way drowning deaths are categorised.[2] We considered drowning deaths in floods and drowning deaths for which the deceased's body was not found as unintentional drowning deaths, which is not the case with the NCRB reports. Second, varied reporting of injury death cases to police is well-known in India.[24–26] We found 4 in 11 drowning deaths to be less likely to be reported to the police, the primary source for the NCRB reports. Despite these methodology issues in comparison, our study indicated the need for a more nuanced understanding of the extent of under-reporting of drowning deaths at the state and local levels and over time in the police data, and of the reasons for under-reporting to the police at the community level is needed to fully comprehend actions to address under-reporting for more robust estimates of drowning deaths on a routine basis in India.[7 27]

The age group of 80 years and above, accounting for 2.3% of all drowning deaths in this study, was estimated to have the highest age-specific drowning mortality rate. One-third of all drowning deaths were accounted for by the 0–14 years age group, with the estimated age-specific drowning mortality rate of 3.1 per 100 000 population. Similar trends for age-specific drowning mortality rate are reported for India in the modelled estimates from the GBD study.[3] As documented globally, males accounted for the majority of drowning deaths in our population as well.[2 3 28] We also found a higher drowning mortality in rural areas than urban areas, though not statistically significant. Rurality has been indicated to be associated with higher mortality from unintentional drowning in high-income countries, which has been linked to the proximity of natural bodies of water, poorer access to emergency services and poverty.[29–32] We were not able to estimate mortality rate by wealth index as this data was not captured for households where no death was reported in enumeration, but drowning deaths were nearly 80% more in the lowest wealth index as compared with the highest wealth index among all deaths in this population. While confirming the previously known sociodemographic inequalities in the drowning deaths, the value-add of this study is data on the mean age at death for these deaths. The substantial extent of potential social and economic loss due to drowning deaths in India is highlighted by the finding of mean age at death for drowning deaths to be 28.2 years lower than the mean age at death irrespective of the cause of death, and 13.1 years lower than the mean age at death due to any unintentional injuries. A lower mean age for drowning deaths may highlight disparities in access to safety education or resources, such as swim training or protective barriers, and also suggest a need for interventions addressing socioeconomic inequalities.[32] Deaths at younger ages also often have a profound psychological impact on families and communities, leading to long-term grief and mental health concerns.[33]

Drowning can happen in many different ways, and hence needs a range of prevention strategies to target the biggest risks. The majority of drowning deaths in the NCRB report are indicated as an accidental fall into a waterbody which does not lend itself to planned preventive action.[20–23] The pattern of activities that resulted in drowning deaths in our study highlights the preponderance of bathing followed by playing near a waterbody and crossing a waterbody.[34] A range of known interventions effective at preventing drowning is relevant here, including the strategic use of barriers to control access to water, provision of safe places such as day care centres for preschool children and teaching basic swimming skills.[35–37] Qualitative studies that can allow for a more nuanced understanding of these risks, such as if bathing was a routine daily activity or was a recreational

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activity, can further facilitate appropriate interventions to prevent drowning.[37] Investment in the building of bathrooms with access to tap water for bathing would prevent drowning in the former, whereas swimming skills would be needed for drowning prevention in the latter. Limited data are available on the variations in the type of activity by the type of waterbody by age, sex, place of residence and state as reported in this study for India.[7 34] The information on which type of waterbody is used for which activity and by whom can be used for targeted interventions, including relevant and specific awareness campaigns highlighting the potential drowning risk for the general population and developing age-specific interventions in particular for the elderly.[38] With most of the deceased reported to be alone during the drowning event, prevention remains paramount to address this burden.

About one in six of the deceased was found alive post-drowning in this population. Though the majority of them were taken to a healthcare provider, most of them had died before reaching the healthcare provider. Training bystanders in rescue and resuscitation, and access to emergency services are recommended in the NSFDP to prevent death post-drowning.[7 38 39] A recent scoping review found very limited evidence from observational studies to inform evidence-based clinical practice guidelines for drowning across a variety of thematic areas, including bystander cardiopulmonary resuscitation and a variety of clinical interventions.[40] This review also highlighted the gap in relevant studies from developing countries, including India, where the majority of the drowning burden is.[40] High-quality research relevant to the local context in India is needed towards implementation of these interventions, in particular addressing the barriers and facilitators of bystander involvement in saving life.

The major strength of this survey is that it is a nationally representative sample of deaths in India between 2019 and 2022, the most recent available mortality survey to the best of our knowledge, with 87% participation among the sampled households and 92% of the enumerated deaths. Our listing of in-migration and out-migration for all ages in each household for each of the 4 years contributed to the robust estimation of the population denominator for each year, and confirmation of deaths in the usual residents ensured that documenting of non-resident deaths was avoided. The extensive checking undertaken in the survey to ensure quality of data collected is also a major strength. We used the SmartVA algorithm based on the Tariff method, which has outperformed the other available methods using VA, to assign cause of death.[41] Details of antecedent events, risk factors, reporting to police and health seeking for drowning deaths are the major strengths of this study. On the other hand, it is important to note that a nationally representative survey of deaths may dilute the drowning mortality rate in high-risk communities as drowning is geographically clustered. While this survey provides a comprehensive overview of the themes captured, detailed studies in high-risk communities will be needed to contextualise specific interventions. Like any other survey, recall bias will be considered as a limitation in this survey as well. However, we believe that the information provided is useful for action under NSFDP and for further in-depth investigations.

CONCLUSION

These data add to increase the visibility of drowning deaths by addressing many of the gaps in magnitude and risk factor understanding for drowning deaths across age groups in India that are highlighted in NSFDP. These findings also contribute to global literature towards increased understanding of drowning deaths across age groups at the population level.

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Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Institutional Ethics Committee of the Public Health Foundation of India (TRC-IEC 493/22). All participants provided written informed consent, and for those who could not read or write, the participant information sheet and consent form were explained by a trained interviewer and a thumb impression was obtained.

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