Trends in the drowning mortality rate in Iran

Article *in* Injury Prevention · August 2020

DOI: 10.1136/injuryprev-2019-043225

20 authors, including:

Pegah Derakhshan
Iran University of Medical Sciences
12 PUBLICATIONS **102** CITATIONS
SEE PROFILE

Sahar Saeedi Moghaddam
Shahid Beheshti University of Medical Sciences
55 PUBLICATIONS **513** CITATIONS
SEE PROFILE

Soheil Saadat
Tehran University of Medical Sciences
173 PUBLICATIONS **6,829** CITATIONS
SEE PROFILE

Nazila Rezaei
Tehran University of Medical Sciences
46 PUBLICATIONS **265** CITATIONS
SEE PROFILE

Trends in the drowning mortality rate in Iran

Pegah Derakhshan,[1,2] Sahar Saeedi Moghaddam,[3] Soheil Saadat,[1] Ali Ghanbari,[3] Nazila Rezaei,[3] Sepehr Khosravi,[4,5] Parinaz Mehdipour,[3] Mina Amirmohammadi,[6] Shima Jahani,[7] Mahdi Sharif-Alhoseini,[1] Seyed Behzad Jazayeri,[1] Maryam Chegini,[3] Zahra Ghodsi,[1] Farideh Sadeghian,[8,9] Khatereh Naghdi,[1] Peyman Salamati,[1] Ali H Mokdad,[10] Gerard O'Reilly,[11] Maziar Moradi-Lakeh,[12] Vafa Rahimi-Movaghar[1]

► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136injuryprev-2019-043225).

For numbered affiliations see end of article.

Correspondence to
Professor Vafa Rahimi-Movaghar, Sina Trauma and Surgery Research Center (STSRC), Tehran University of Medical Sciences (TUMS), Tehran 11365-3876, Islamic Republic of Iran; v_rahimi@tums.ac.ir

Received 8 April 2019
Revised 20 July 2019
Accepted 24 July 2019

To cite: Derakhshan P, Saeedi Moghaddam S, Saadat S, *et al*. *Inj Prev* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/injuryprev-2019-043225

ABSTRACT

Objective The WHO estimates the global incidence of death by drowning to be about 300 000 cases per year. The objective of this study was to estimate the trend in mortality due to drowning in all provinces of Iran in all age groups and both genders from 1990 to 2015.

Study design The National and Subnational Burden of Diseases (NASBOD) project is a comprehensive project in Iran. It is based on the Global Burden of Disease study and includes novel methods to estimate the burden of diseases in Iran.

Methods This study used the results of the mortality rate due to drowning as part of NASBOD and investigated the causes behind the mortality rates. The data set recorded mortality rates by 19 age groups and two genders with the corresponding subnational pattern during the time period from 1990 to 2015.

Results The drowning mortality rate decreased in Iran from 1990 to 2015. From 1990 to 2015, the annual percentage change for males and females was −5.28% and −10.73%, respectively. There were 56 184 male and 21 589 female fatalities during the study period. The highest number of deaths was seen in 1993 with 4459, and the lowest number of fatalities was observed in 2015 with 903 deaths.

Conclusion Our data showed a decline in drowning mortality in Iran from 1990 to 2015, but the rates and declines varied by province. Our findings are of great importance to health officials and authorities in order to further reduce the burden of drowning.

INTRODUCTION

Drowning is a preventable cause of morbidity and mortality. The WHO has estimated in 2017 that about 300 000 people lose their lives due to drowning.[1] Hereafter, deaths caused by drowning are stated as drowning mortality or drowning deaths. Nearly half of the deaths due to drowning occurred among those who were aged less than 25 years.[2]

According to the Global Burden of Disease (GBD) report, in 2010 drowning was the 12th cause of death in Central and Eastern Asia.[3] Efforts to prevent deaths due to drowning in low-income and middle-income countries (LMICs) have been ineffective, and models for drowning prevention in high-income countries did not have a significant impact in LMICs.[4] According to the 2017 GBD report, the number of drowning death in Iran in 2017 is 1043.73 (1006.51–1110.13). Deaths due to drowning ranked 10th in males and 25th in females in terms of the number of deaths due to any cause.[5] Drowning is the third cause of death due to non-intentional injury and accounts for 7% of all injury-related deaths in Iran.[6] Despite prevention campaigns at the non-governmental level which mainly focus on cultural improvements, drowning continues to result in substantial morbidity and mortality.[7]

Despite the high rates of death, relatively few epidemiological studies have examined drowning in Iran.[8–10] Iran requires studies of drowning because it has many types of water settings aside from swimming pools, such as the Caspian Sea, Persian Gulf, Sea of Oman, and numerous rivers and dams. At the subnational level, there are similarities geographically and culturally between Iran and other countries in the Middle East to the end that basically they share common seas and rivers for swimming, and actions regarding prevention of drowning in Iran provinces could be applicable to Iraq, Turkey, Azerbaijan and other countries in the region. Also, Iran as an upper-middle-income country has different ecological pattern among its provinces, and by analysing the drowning pattern in its provinces one can estimate the risk of drowning in countries with similar ecological, religion or economical patterns to Iran. There are many challenges with regard to gathering data on drowning in Iran. For instance, because of the social stigma of suicide in the rural areas of Iran, it is not easy to differentiate intentional and unintentional drowning. Another challenge that previous studies have faced is the differentiation in reporting of near drowning since the near drowning incidence could present valuable lessons for reduction of drowning deaths.[11] Also, there are no detailed data regarding the place of drowning, such as drowning in bathtubs for children less than 5 years of age and specifically under 1 year of age. The objective of this study was to estimate the trends of mortality due to drowning in all provinces of Iran in all age groups and in both genders from 1990 to 2015.

METHODS

The National and Subnational Burden of Diseases (NASBOD) is a comprehensive project in Iran modified from the GBD[12] study which includes novel methods to estimate the burden of diseases in Iran.[6 13] A significant part of this project measures incompleteness and misclassification in the Death Registration System (DRS).[14] In this study, we used

the results on death due to drowning as part of NASBOD to investigate the rates of death. The data set recorded mortality rates by 19 age groups and two genders for 31 provinces (subnational) during the time period from 1990 to 2015.[15]

Completeness in DRS for child mortality ranged from 42.7% in 1990 to 85.9% in 2015, and for the adults ranged from 80.9% in 1990 to 100% in 2015. To deal with the incompleteness and misclassification of DRS, we used various methods to estimate the levels and trends of mortality rate. These methods are described in detail elsewhere.[15 16] In the first step, the crude mortality rates from data sources, including Demographic and Health Survey in 2000, census in 1996, 2006 and 2011, and DRS data between 1995 and 2010, were used. Using the demographic methods on the above-mentioned data and unifying with a Gaussian process regression model, the level and trend of mortality rates were measured.[17] In this Bayesian model, a spatiotemporal model is employed as its mean function and its uncertainty defined with sampling and non-sampling hyperparameters over time.[17] There are some differences between the calculation of child and adult mortality rates, the details of which are described in Mohammadi *et al*.[16] By measuring the completeness of DRS for child and adult mortality, we extrapolated all-age mortality by each age–gender–year–province combination.

To estimate the rate of death due to drowning in the Iranian population from 1990 to 2015 at national and subnational levels, by 19 categories of age and gender, causes of death codes based on the International Classification of Diseases 10th version (ICD-10) were mapped to GBD 2013 codes in order to compare with the GBD results. In this regard, ICD-10 codes V90, V90.0, V90.01–V90.9, V92–V92.9, W65–W70.9 and W73–W74.9 were considered as drowning.[18]

Information on 3 645 608 individuals from DRS data and Esfahan and Tehran cemeteries was used. All cemeteries around the country were registered in national DRS except Tehran and Esfahan cemeteries (Behesht-e-Zahra and Bagh-e-Rezvan, respectively). A number of problems such as administration inconsistency, duplicate information, misclassification, missing values and incompleteness existed in the data, each of which was handled appropriately. Missing data were dealt with using multiple imputations. We mapped our results to GBD codes using a proportional redistribution method by applying a Poisson regression model to all-cause mortality rates. The incompleteness of DRS gathered from using predicted levels and trends of mortality between 1990 and 2015 for children and adults[16] was used to rescale the various-cause mortality rates. A two-stage model consisting of a generalised linear mixed model and a spatiotemporal model was applied to the data. The spatiotemporal model considered variations of time and space, in addition to covariates such as wealth index, years of schooling and urbanisation. Components of year and province led to considering the correlation between consecutive years and neighbouring provinces to influence death rates. Finally, cause fractions were applied to all combinations of the level and trend of mortality rates, and the 95% uncertainty intervals (95% UI) of cause-specific mortality rates were calculated using simulation, the details of which are provided elsewhere.[17]

We calculated age-specific and gender-specific mortality rates for each age group and gender in 31 provinces. It is noteworthy to mention that provincial estimates were calculated based on the place of residence and not the place of drowning. The national population of Iran in 2015 was used to compute the age-standardised mortality rate by direct method at national and subnational levels from 1990 to 2015.

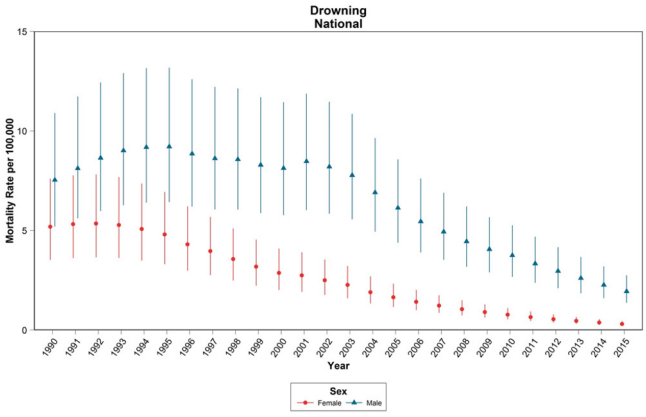

Figure 1 Time trend of age-standardised mortality rate due to drowning by sex at the national level. The highest mortality rate in females was in 1990 and in males was in 1995. The lowest rate was recorded in 2015 in both sexes.

RESULTS

There were 56 184 male and 21 589 female fatalities during the study period. The highest number of deaths was in 1993 with 4459, and the lowest number of fatalities was in 2015 with 903 deaths. The national age-standardised highest mortality rates due to drowning per 100 000 in females and males were 5.2 (95% UI: 3.5–7.6) and 7.5 (5.2–10.9), respectively, in 1990. Conversely, the lowest levels were 0.3 (0.2–0.4) and 1.9 (1.4–2.7) in females and males, respectively, in 2015. The mortality rate was always higher among males. From 1990 to 1995, the mortality rate seemed to have an uptrend in males, but after that it faced a downtrend in both genders until 2015 (figure 1).

The highest subnational age-standardised drowning mortality rate for females was in Qazvin Province in 1990 and the lowest was in Mazandaran Province in 2015. The highest subnational age-standardised drowning mortality rate for males was in North Khorasan Province in 1995 and the lowest was in Qom Province in 2015 (online supplementary appendix). In general, mortality rate decreased in males and females at the national level during this period, with an annual percentage change (APC) of death of −5.3 and −10.7, respectively (table 1). There were 56 184 male and 21 589 female fatalities during the study period. The highest number of deaths was in 1993 with 4459, and the lowest number of fatalities was in 2015 with 903 deaths.

The highest number of deaths occurred in males between 15 and 49 years old during the period of 1990–2015. In females, the greatest number of deaths was in children less than 5 years old (figure 2). The annual mortality rate of drowning was higher in males compared with females up to the age of 60 in 1990, and again became higher in males after the age of 80. Between the ages of 60 and 79 years, the drowning rate was higher in females until 2015 (figure 3).

At the subnational level, the largest decline in male mortality was in Zanjan with an APC of −16.8% and the largest decline for females was in Qom with −9.2%. The smallest decline was observed in Hormozgan in both males and females with an APC of −1.4% and −6.7%, respectively. In 2015, in the centre of Iran, the provinces of Semnan, Isfahan and Yazd had a low age-standardised death rate per 100 000 for both genders. In 2015, the western part of Iran had a greater than 1.97 per 100 000 age-standardised death rate (figure 4).

Table 1 National and subnational age-standardised mortality rate due to drowning per 100 000 in 1990, 1995, 2000, 2005, 2010 and 2015 with APC of death between 1990 and 2015 by sex

	Female							Male						
	Year							Year						
Province	1990	1995	2000	2005	2010	2015	APC 1990–2015	1990	1995	2000	2005	2010	2015	APC 1990–2015
Alborz	2.65 (1.72–4.01)	2.74 (1.81–4.11)	1.75 (1.17–2.60)	1.09 (0.74–1.59)	0.58 (0.39–0.85)	0.25 (0.17–0.37)	−8.97	3.64 (2.45–5.35)	5.04 (3.42–7.31)	4.89 (3.39–7.05)	4.19 (2.93–5.91)	2.75 (1.92–3.93)	1.43 (0.98–2.07)	−3.66
Ardebil	6.17 (4.34–8.69)	5.48 (3.92–7.62)	2.84 (2.09–3.85)	1.45 (1.07–1.95)	0.63 (0.46–0.85)	0.22 (0.16–0.30)	−12.52	6.32 (4.56–8.68)	7.69 (5.60–10.50)	6.40 (4.73–8.61)	3.87 (2.88–5.19)	2.00 (1.49–2.70)	0.97 (0.71–1.33)	−7.22
Bushehr	3.53 (2.51–4.95)	3.71 (2.68–5.11)	2.66 (1.96–3.60)	1.55 (1.14–2.10)	0.72 (0.52–1.00)	0.31 (0.22–0.44)	−9.26	6.19 (4.44–8.54)	8.10 (5.86–11.05)	8.20 (6.05–11.06)	6.71 (4.96–8.98)	4.38 (3.19–5.94)	1.83 (1.31– 2.55)	−4.76
Chahar Mahall and Bakhtiari	6.48 (4.64–9.06)	5.85 (4.17–8.14)	2.34 (1.69–3.21)	1.21 (0.88–1.65)	0.70 (0.50–0.97)	0.29 (0.21–0.41)	−11.65	7.73 (5.61–10.55)	9.01 (6.57–12.28)	7.22 (5.30–9.74)	5.52 (4.04–7.46)	3.63 (2.63–4.95)	1.92 (1.37–2.68)	−5.42
East Azarbaijan	5.12 (3.63–7.13)	5.07 (3.64–7.01)	2.87 (2.08–3.93)	1.39 (1.02–1.89)	0.59 (0.43–0.81)	0.23 (0.17–0.32)	−11.65	6.10 (4.37–8.46)	7.94 (5.73–10.90)	7.29 (5.36–9.86)	4.92 (3.61–6.69)	3.09 (2.26– 4.21)	1.61 (1.17– 2.22)	−5.19
Esfahan	2.62 (1.73–3.96)	2.43 (1.61–3.62)	1.64 (1.11–2.42)	1.02 (0.70–1.49)	0.54 (0.37–0.79)	0.21 (0.14–0.31)	−9.55	4.28 (2.90–6.27)	5.97 (4.07–8.70)	5.92 (4.12–8.50)	4.74 (3.30–6.80)	3.00 (2.09– 4.28)	1.61 (1.12– 2.31)	−3.83
Fars	3.76 (2.61–5.38)	3.95 (2.78–5.56)	3.03 (2.18–4.19)	2.33 (1.69–3.21)	1.33 (0.95–1.83)	0.58 (0.41–0.81)	−7.23	6.40 (4.53–8.98)	8.91 (6.40–12.31)	9.04 (6.57–12.38)	8.64 (6.30–11.76)	6.10 (4.44– 8.39)	3.16 (2.28–4.37)	−2.78
Gilan	5.62 (4.00–7.83)	4.54 (3.28–6.25)	2.45 (1.79–3.33)	1.26 (0.92–1.72)	0.56 (0.41–0.76)	0.25 (0.18–0.35)	−11.65	8.60 (6.29–11.75)	9.43 (6.95–12.75)	9.00 (6.71–12.01)	7.20 (5.37–9.62)	4.46 (3.30–6.00)	2.41 (1.77–3.28)	−4.97
Golestan	5.00 (3.57–6.91)	4.83 (3.45–6.66)	2.55 (1.83–3.5)	1.25 (0.91–1.72)	0.58 (0.41–0.81)	0.24 (0.17–0.35)	−11.37	6.61 (4.76–9.10)	9.37 (6.83–12.79)	9.58 (7.03–12.94)	7.55 (5.52–10.20)	4.42 (3.21– 6.03)	1.98 (1.41– 2.76)	−4.71
Hamadan	4.12 (2.97–5.66)	4.15 (3.03–5.68)	2.49 (1.85–3.35)	1.47 (1.10–1.97)	0.60 (0.44–0.81)	0.25 (0.18–0.34)	−10.61	6.09 (4.46–8.32)	8.22 (6.07–11.07)	7.46 (5.59–9.91)	6.57 (4.91–8.76)	4.43 (3.29–5.94)	2.57 (1.88– 3.50)	−3.39
Hormozgan	2.79 (1.91–4.05)	3.00 (2.10–4.26)	2.33 (1.66–3.25)	1.96 (1.40–2.71)	1.11 (0.78–1.59)	0.50 (0.34–0.73)	−6.67	4.53 (3.21–6.35)	7.02 (5.05–9.72)	8.18 (5.96–11.13)	8.50 (6.21–11.59)	4.78 (3.41– 6.60)	3.19 (2.23– 4.54)	−1.39
Ilam	6.69 (4.72–9.32)	6.06 (4.28–8.52)	3.54 (2.52–4.93)	1.74 (1.23–2.44)	0.78 (0.55–1.12)	0.31 (0.21–0.45)	−11.54	6.79 (4.85–9.44)	8.33 (5.97–11.52)	7.42 (5.37–10.22)	4.79 (3.45–6.67)	2.73 (1.93–3.86)	1.47 (1.02– 2.11)	−5.94
Kerman	4.67 (3.36–6.46)	4.68 (3.42–6.40)	3.10 (2.30–4.17)	2.10 (1.56–2.83)	0.97 (0.70–1.33)	0.35 (0.25–0.49)	−9.82	7.35 (5.40–10.03)	8.90 (6.56–11.98)	8.38 (6.24–11.22)	7.61 (5.66–10.19)	4.70 (3.46– 6.36)	2.41 (1.74–3.31)	−4.37
Kermanshah	5.02 (3.62–6.88)	5.00 (3.64–6.81)	3.11 (2.29–4.19)	1.82 (1.35–2.44)	0.89 (0.65–1.20)	0.38 (0.28–0.52)	−9.79	8.48 (6.23–11.45)	10.18 (7.53–13.70)	8.17 (6.10–10.88)	6.75 (5.05–8.98)	4.55 (3.39–6.11	2.57 (1.88– 3.49)	−4.66
Khuzestan	3.17 (2.20–4.52)	3.23 (2.26–4.58)	2.22 (1.58–3.12)	1.55 (1.11–2.16)	0.92 (0.65–1.28)	0.40 (0.28–0.56)	−7.97	5.52 (3.92–7.68)	7.99 (5.71–11.09)	8.50 (6.12–11.74)	6.45 (4.65–8.88)	4.30 (3.10– 5.92)	2.32 (1.66– 3.21)	−3.42
Kohgiluyeh and Buyer Ahmad	8.19 (5.39–12.28)	6.84 (4.51–10.24)	4.15 (2.83–6.01)	2.32 (1.60–3.29)	1.17 (0.81–1.67)	0.43 (0.30–0.62)	−11.12	9.06 (6.08–13.38	10.31 (6.96–15.12	8.41 (5.84–11.99)	6.09 (4.29–8.59	3.73 (2.61–5.28)	1.83 (1.26–2.61)	−6.21
Kordestan	5.77 (3.99–8.30)	5.35 (3.76–7.52)	3.05 (2.22–4.15)	1.86 (1.38–2.49)	0.82 (0.61–1.11)	0.30 (0.22–0.42)	−11.13	8.11 (5.73–11.37)	9.32 (6.71–12.87)	8.62 (6.36–11.58)	6.87 (5.15–9.13)	4.23 (3.15–5.64)	2.00 (1.48–2.70)	−5.44
Lorestan	6.46 (4.53–9.19)	5.51 (3.95–7.67)	3.12 (2.28–4.26)	1.42 (1.05–1.91)	0.57 (0.42–0.78)	0.20 (0.14–0.27)	−13.06	11.13 (8.07–15.29)	12.18 (8.93–16.55)	10.27 (7.60–13.79)	6.29 (4.69–8.40)	3.61 (2.68–4.85)	1.76 (1.29– 2.41)	−7.11
Markazi	4.33 (3.07–6.06)	4.40 (3.16–6.11)	2.85 (2.08–3.88)	1.93 (1.42–2.63)	1.04 (0.76–1.43)	0.43 (0.31–0.61)	−8.83	7.59 (5.51–10.38)	9.77 (7.17–13.28)	8.69 (6.46–11.71)	7.56 (5.64–10.13)	4.96 (3.65– 6.72)	2.63 (1.91– 3.61)	−4.14

Continued

Table 1 Continued

Province	Female							Male						
	Year							Year						
	1990	1995	2000	2005	2010	2015	APC 1990–2015	1990	1995	2000	2005	2010	2015	APC 1990–2015
Mazandaran	5.51 (3.84–7.80)	4.36 (3.07–6.15)	2.15 (1.53–3.01)	1.03 (0.74–1.45)	0.43 (0.30–0.61)	0.18 (0.12–0.26)	–12.87	8.04 (5.77–11.10)	9.03 (6.54–12.44)	9.08 (6.66–12.38)	7.09 (5.14–9.73)	4.65 (3.34– 6.44)	2.57 (1.81– 3.61)	–4.46
North Khorasan	7.56 (5.26–10.70)	7.27 (5.08–10.28)	4.04 (2.85–5.68)	1.98 (1.40–2.78)	0.86 (0.60–1.22)	0.32 (0.22–0.46)	–11.93	12.07 (8.51–16.86)	14.43 (10.26–20.04)	11.19 (8.03–15.43)	7.37 (5.31–10.16)	4.26 (3.05– 5.95)	2.20 (1.54– 3.11)	–6.59
Qazvin	11.65 (8.44–15.90)	10.73 (7.85–14.65)	3.50 (2.57–4.73)	1.52 (1.12–2.06)	0.57 (0.42–0.78)	0.23 (0.17–0.32)	–14.53	10.91 (7.93–14.95)	13.73 (10.03–18.67)	7.35 (5.47–9.87)	5.77 (4.29–7.69)	2.99 (2.22– 4.03)	1.51 (1.10– 2.05)	–7.61
Qom	3.60 (2.29–5.57)	3.14 (2.01–4.84)	1.98 (1.29–3.02)	1.16 (0.77–1.75)	0.49 (0.32–0.74)	0.22 (0.14–0.33)	–10.64	8.12 (5.33–12.18)	8.72 (5.80–13.04)	6.35 (4.32–9.33)	3.75 (2.56–5.47)	1.49 (1.02– 2.18)	0.73 (0.49– 1.07)	–9.19
Razavi Khorasan	7.02 (4.80–10.14)	6.97 (4.83–9.98)	5.27 (3.72–7.45)	2.49 (1.75–3.52)	0.84 (0.59–1.20)	0.28 (0.19–0.41)	–12.09	7.71 (5.34–11.06)	10.31 (7.28–14.57)	10.38 (7.38–14.50)	7.37 (5.23–10.31)	3.88 (2.75– 5.48)	1.77 (1.24– 2.50	–5.72
Semnan	8.24 (5.73–11.61)	6.83 (4.76–9.68)	3.60 (2.51–5.06)	1.75 (1.21–2.48)	0.81 (0.56–1.17)	0.35 (0.24–0.51)	–11.88	8.10 (5.65–11.47)	10.17 (7.13–14.32)	7.70 (5.46–10.75)	5.55 (3.97–7.72)	3.60 (2.56–5.05)	1.96 (1.38– 2.78)	–5.51
Sistan and Baluchestan	6.88 (4.56–10.34)	6.48 (4.33–9.62)	3.29 (2.23–4.83)	1.97 (1.35–2.89)	1.01 (0.68–1.48)	0.35 (0.23–0.52)	–11.22	7.00 (4.79–10.10)	7.27 (5.00–10.48)	5.32 (3.68–7.59)	4.42 (3.11–6.30)	3.20 (2.24–4.55)		–5.06
South Khorasan	5.82 (4.00–8.37)	6.13 (4.26–8.65)	4.32 (3.04–6.06)	2.54 (1.79–3.58)	1.26 (0.87–1.80)	0.52 (0.35–0.75)	–9.23	11.04 (7.75–15.34)	12.12 (8.58–16.93)	10.18 (7.28–14.11)	6.79 (4.85–9.46)	4.30 (3.02– 6.08)	2.13 (1.48–3.08)	–6.36
Tehran	5.55 (3.12–9.55)	4.61 (2.67–7.72)	2.35 (1.40–3.93)	1.34 (0.82–2.19)	0.62 (0.38–1.01)	0.25 (0.15–0.41)	–11.65	9.90 (5.90–16.46)	11.04 (6.61–18.09)	7.83 (4.81–12.63)	4.87 (3.05–7.74)	2.65 (1.66– 4.20)	1.28 (0.80–2.02)	–7.86
West Azarbaijan	5.60 (3.93–7.93)	5.06 (3.63–7.04)	2.87 (2.09–3.90)	1.64 (1.21–2.22)	0.74 (0.54–1.00)	0.26 (0.19–0.36)	–11.56	7.74 (5.56–10.72)	9.16 (6.67–12.54)	8.44 (6.22–11.34)	6.28 (4.65–8.40)	3.74 (2.77– 5.06)	1.86 (1.35– 2.55)	–5.54
Yazd	3.78 (2.66–5.31)	3.58 (2.53–5.03)	2.59 (1.83–3.65)	1.63 (1.15–2.29)	0.85 (0.60–1.21)	0.33 (0.23–0.48)	–9.27	6.82 (4.90–9.41)	8.20 (5.88–11.35)	6.66 (4.79–9.21)	5.15 (3.74–7.08)	3.22 (2.31–4.47)	1.75 (1.24– 2.46)	–5.29
Zanjan	10.94 (7.52–15.69)	8.57 (6.08–11.96)	3.66 (2.68–4.96)	1.26 (0.91–1.74)	0.39 (0.27–0.57)	0.11 (0.07–0.17)	–16.81	10.72 (7.51–15.11)	11.66 (8.44–16.09)	8.95 (6.63–12.04)	5.20 (3.83–7.07)	2.69 (1.90– 3.80)	1.27 (0.85– 1.87)	–8.19
National	5.19 (3.52–7.61)	4.80 (3.31–6.93)	2.87 (2.01–4.09)	1.64 (1.16–2.33)	0.77 (0.54–1.10)	0.30 (0.21–0.44)	–10.73	7.54 (5.20–10.90)	9.22 (6.43–13.18)	8.13 (5.77–11.44)	6.14 (4.39–8.57)	3.75 (2.67– 5.26)	1.94 (1.37– 2.74)	–5.28

Data in parentheses are 95% uncertainty intervals.
APC, annual percentage change.

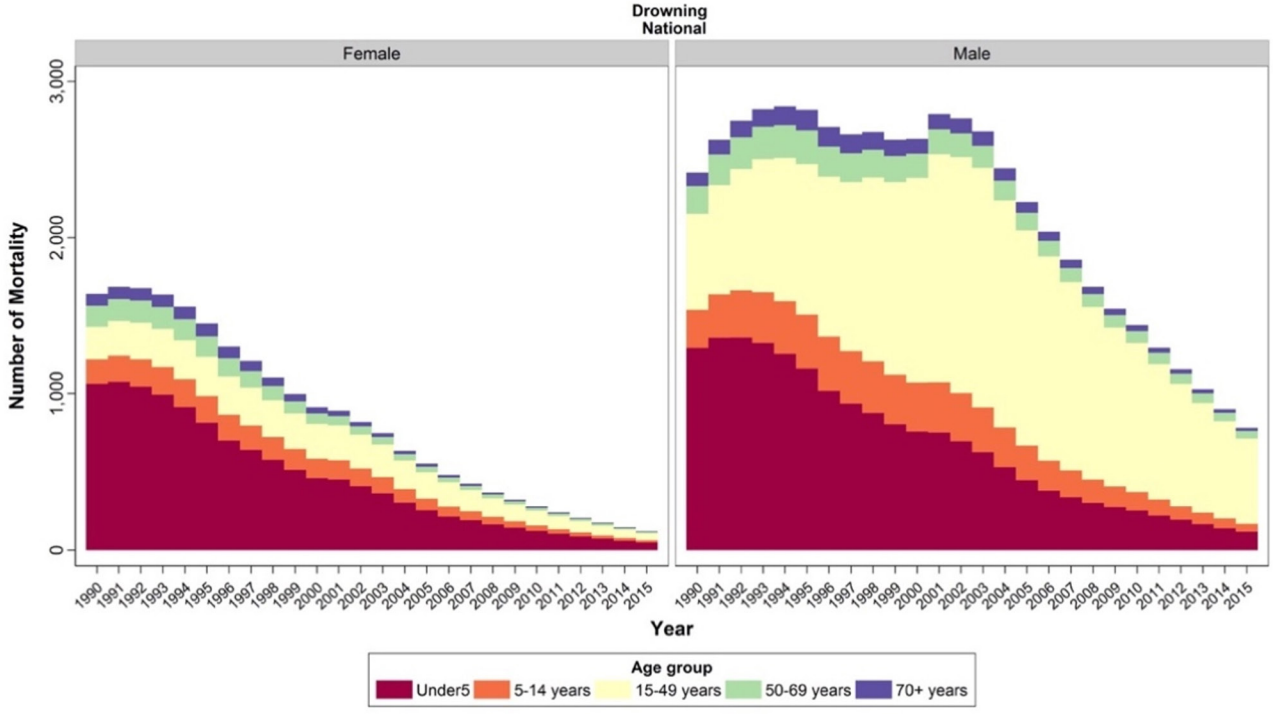

Figure 2 Number of mortality due to drowning at the national level from 1990 to 2015 by age. The maximum height of each age group presents the highest mortality rate per 100 000 among the provincial rates on that year, and the lowest height in each age group presents the lowest mortality rate per 100 000 among the provincial rates.

DISCUSSION

This study demonstrates a decline in drowning deaths over a 26-year period up to 2015 at the national level. Our results were consistent with the GBD study (figure 5) on drowning mortality rates from 1990 to 2016.[12] Some events that resulted in drowning of Iranians have caused wide media coverage, and as a result the Iranian Parliament had discussions regarding those incidents, but apart from legislating that swimming pools should earn a standard quality control certificate from Iran National Standards Organization there is no other documented law that could be found.[19]

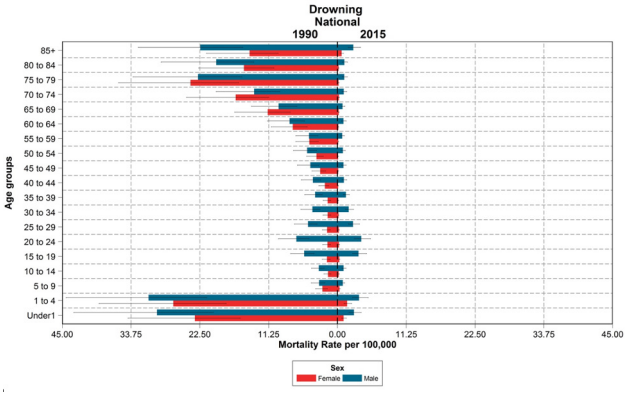

Figure 3 Comparison of mortality rate from drowning between 1990 and 2015 in different age groups of both sexes. The red bars present the mortality rate per 100 000 in females, and the blue bars present the mortality rate per 100 000 in males. The left end of bars presents the mortality rate in 1990 and the right end presents the mortality rate in 2015. The vertical axis shows the age groups, which start with less than 1 year and end over 85 years of age.

Regarding changes in bodies of water during this study, Zayandehrood River, the largest river in central Iran, dried out specifically at the lower reaches of the river, and this has an effect on the number of drowning deaths mainly in Esfahan. A definite point in time cannot be associated with drought of this river.[20] Urmia Lake (located in West Azerbaijan), the largest lake in the north-west of Iran, also dried out during the study period, which also has an effect on drowning deaths in this province.[21]

According to Iran Legal Medicine (the organisation for forensic medicine), from 2013 to 2017, 3716 deaths occurred due to drowning.[22] About one-third (1010 deaths) of this number occurred in rivers, the site with the greatest incidence of drowning deaths in Iran. In Iran, most rivers do not have warning signs surrounding them that warn people to avoid swimming in these waters. Furthermore, due to increasing financial problems, many children do not have the benefit of swimming in private pools. This has led to swimming in rivers as an activity during leisure time. Ardebil, a province with one of the largest reductions in APC, has implemented warning signs with the help of the Water Organization of Ardebil on the banks of rivers, dams and water channels of the province from 2005. They also conduct lifeguard courses for Red Crescent Movement forces at the subnational level. (All lifeguard courses in Iran are conducted by Iran Swimming Federation, so Red Crescent forces are not official lifeguards and they gain skills for emergency situations.) With warning signs like this and lifeguard training courses, a 12.52 and 7.22 reduction in the APC of drowning deaths from 1990 to 2015 was achieved in females and males, respectively. After rivers, seas, with 690 deaths, have the second most number of deaths due to drowning.[22 23]

Mazandaran, Gilan and Khuzestan are the provinces with the most access to seawaters. The Swimming Federation will now

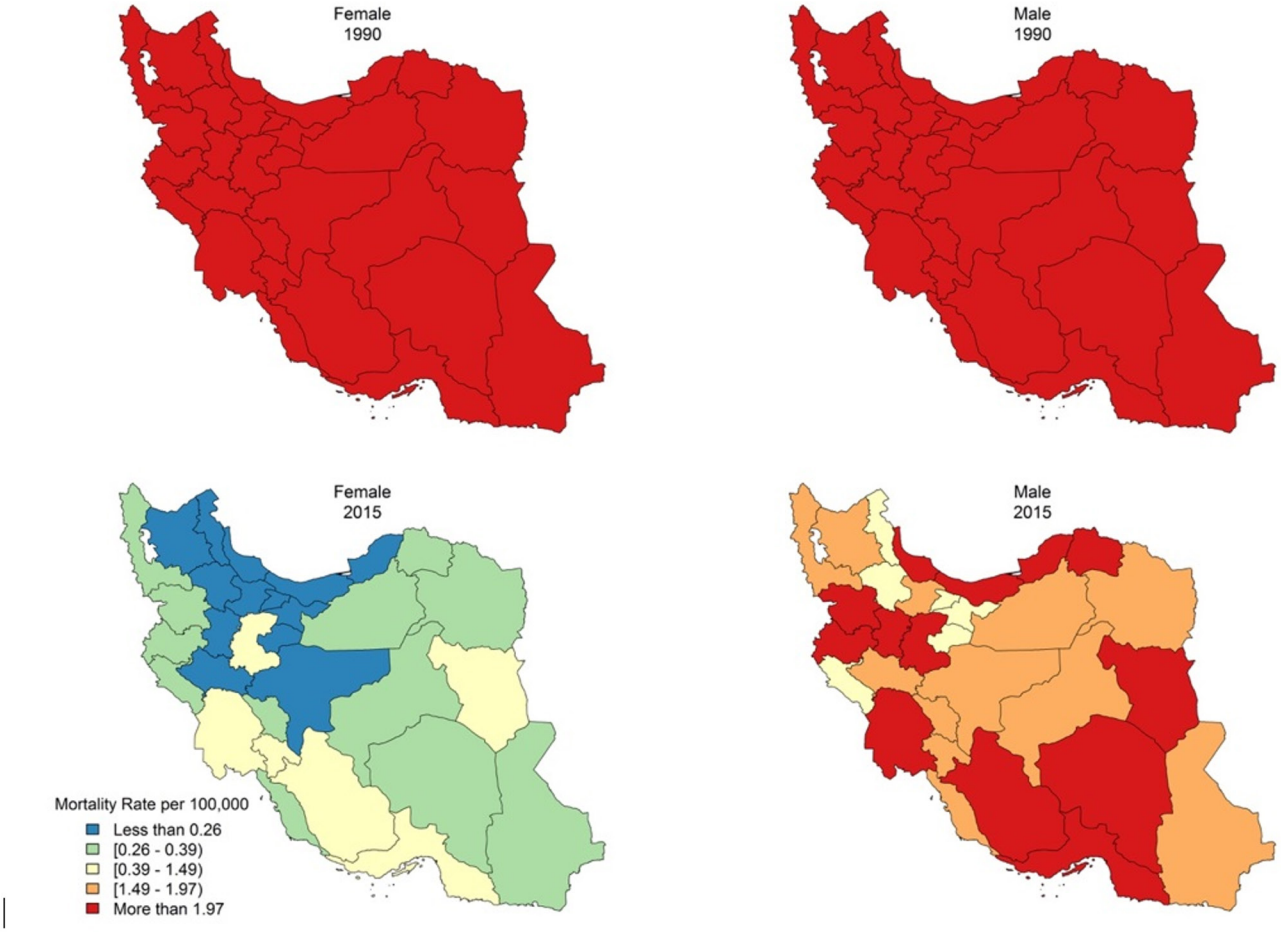

Figure 4 Geographical distribution of age-standardised mortality rate due to drowning by sex in 1990 and 2015.

certify lifeguards in Iran after passing an exam. This exam was upgraded so that a lifeguard will have more skills.

Pools, with 582 deaths due to drowning, had the third most number of deaths from 2013 to 2017. Swimming in the water behind dams was the fourth leading cause of death due to drowning in Iran from 2013 to 2017.[22]

Swimming in the water behind dams is common in Iran, and the government has started to raise awareness on public television regarding the risk associated with doing so. Zanjan has the highest number of dams in Iran and has the second highest APC reduction in drowning deaths among males from 1990 to 2015. This is likely due to protecting the dams with fences so that swimming in dams could not happen as much as they did before. Fences have been reviewed in previous studies as a passive and yet effective method for drowning reduction.[24]

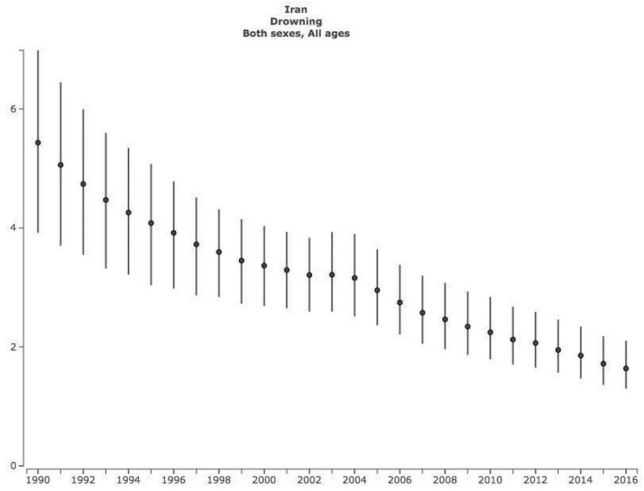

Figure 5 Global Burden of Disease report on drowning mortality rate in both sexes from 1990 to 2016.

From 2013 to 2017, 123 deaths occurred due to drowning in water wells, with farmers at particular risk. The number of wells has fallen because of the period of drought Iran has been experiencing. In Qom, a province with a nearly equal APC in drowning deaths in both females and males, there is little access to water except for the public swimming pool, and the main reason for the reduction in the number of deaths was employing certified lifeguards.[9] As mentioned before, in spite of campaigns for drowning prevention, success was limited. The reason for failure is that these campaigns are mainly at the non-governmental level so they cannot have as much resource and impact as governmental actions. These campaigns are mainly focused on cultural changes and raising awareness and often they are not well funded. Before the conduct of this study, even a clear report in Iran was not accessible, and the statistics on drowning were either provided by WHO or some reports by Iran Forensic Organization. The main challenge for data collection in this study was the missing data on the place of death in hospital and forensic medical reports. Data regarding place of death were referenced sometimes from other studies, and it is important to mention that a few studies, and to be more exact only 12 studies, examined drowning in Iran and they are mainly conducted in north

of Iran. All in all, documentation in Iran is not a standard and common procedure, and the methods mentioned in the Methods section of this paper were used to cover these missing data. With more detailed data set, this study could have better conclusions, and as a result of the data set that we currently have this study only made assumptions.

To verify the accuracy of this study, a comparison with previous studies in Iran was conducted. A population-based study in Mazandaran analysed data from 2002 to 2006. During the course of the Mazandaran study, the mean drowning rate was 7.6 per 100 000 population-years, while in our study in the same province in 2000 the drowning rate was 9.2 per 100 000 population-years and in 2005 the rate was 5.6 per 100 000 population-years.[10] There were 47 victims of drowning in a study regarding children drowning in Iran. Their results presented the rate reported for mortality due to drowning in children according to the Ministry of Health and Medical Education in Iran in 2001, which ranged from 4.1 per 100 000 in a coastal province to 0.9 per 100 000 in a province with no or little access to the sea or lake.[8 25] Consistent with the current study, studies reporting mortalities in males and females from drowning reported more male deaths than female deaths.[26 27] This could be due to several factors; in Iranian culture, men are more likely to swim, and tend to have more risky behaviours such as swimming alone, boating or drinking prior to swimming. The higher rate of mortality in children aged less than 5 years old may be due to a lapse in supervision. It is mentioned in other studies in LMICs that the most number of deaths in this age group happened in bathtubs.[28]

A major difference between our study and the previous studies is the use of the place of residence in this study compared with the place of drowning in the previous ones. This may explain some of the difference in patterns we report here. Moreover, in our study, the higher rates in certain areas may be because the dead person did not live in an area with access to water for swimming and hence is at a higher risk when attempting swimming in other areas. To clarify, in Iran, swimming lessons are not mandatory for every school student so the main way that people learn to swim is based on where they live. For instance if they live near the sea, such as in Mazandaran and Gilan, the culture urges them to learn swimming at an early age, while if they live in Qom with no access to water the chance that they learn swimming is slimmer. As a result, when individuals travel to Mazandaran to swim in the Caspian Sea, they are considered amateur swimmers, and if they drowned in the Caspian Sea it is not necessarily due to safety but rather lack of swimming education in their own province. This was mentioned as a challenge in previous studies in Iran.[9]

Although the period of the current study is slightly different from that of the Mazandaran study, data are otherwise comparable. This study used registry data that are checked for errors and accuracy, while the Mazandaran study used autopsy reports and paper death certificates.[25] From 1990 to 2015 paper records had been used as the source of data collection, while in this study the registry has gathered data from multiple sources and has undergone a thorough standardisation process and transformed into electronic format. The large variation in mortality between the provinces in Iran is informative. Indeed, examining the drivers of higher mortality rates and the best performing province in terms of declining mortality will enable health officials and others to develop and implement measures to reduce drowning in countries with similar ecological patterns.

Studies regarding drowning mortality in upper-middle-income countries focused on children rather than middle-aged and senior adults. This is mainly because of the cost-effectiveness of reducing mortality in children. Based on figure 3 of this study, although Turkey has many cultural and income similarities to Iran, the drowning mortality among under 5 years of age in Iran is considerably higher than in Turkey.[29] A different study suggests that this significantly lower mortality rate in Turkey may be due to systems of death data capture in Turkey; that is, data are captured only in selected administrative units, so completeness of death registration is high but the coverage is poor.[3 29]

Bangladesh as a lower-middle-income country has published a considerable number of detailed and precise reports on its drowning mortality. Drowning rates in Bangladesh are significantly higher than Iran especially in children under 5 years of age. The mortality rate in children under 1 year of age is 9.0 (1.6–36.4) per 100 000 per year, while in children between 1 and 4 years the drowning mortality rate is 121.5 (100.3–147.0) per 100 000 per year.[30] But we should consider that the amount of rainfall in Bangladesh is more than other middle-income countries; for example, the literature reports the mean rainfall amount in Bangladesh ranges from 1527 mm in the west to 4197 mm in the north-east,[31] while the mean amount of rainfall in Iran varies from 64.1 mm in Yazd to 344 mm in Shiraz.[32] Another potentially relevant difference is the long coastline of Bangladesh, which is about 720 km long along the continental shelf, and also the high percentage (80%) of the rural population.[31]

Precise recording of deaths due to mortality and published reports based on age, gender and jobs, and more importantly recording the

What is already known on the subject

- Few studies in Iran and neighbouring countries regarding drowning have been conducted and most of these studies have focused on mortality rate in locations near the sea.
- Methods used for gathering data on mortality rate in Iran are not precise enough and inconsistencies in other middle-income countries in reporting symptoms have been found.
- Mortality due to drowning is still a prominent cause of death in middle-income countries.
- Children are at most risk and therefore the burden on the society is significant.

What this study adds

- Even middle-income countries have not conducted many studies to find pitfalls in order to improve mortality rate due to drowning.
- Data provided in this study and how these are presented could prompt other studies of this kind.
- Iran has similar geographical and cultural features compared with many of its neighbouring countries such as Iraq, Afghanistan, Azerbaijan and Turkey.
- The data this paper provided could be of help to these countries and to other countries with similar geographical features to Iran; the countries mentioned in the study have access to similar rivers and seas.
- The method for gathering data is designed to cover the pitfalls of previous methods.
- Missing or misleading data have been reported in studies that report on mortality rates in other middle-income countries.

changes between mortality rates in different years in Bangladesh, provide the opportunity for multiple programmes to access the efficacy of their programmes on deaths due to drowning specifically in children. The result of those studies supported new methods for reducing drowning, and this study could also be used in a similar way to studies in Bangladesh.[30 33–35]

Limitations

This study has some limitations. First, we used the place of residence rather than the place of the drowning incident in our study. Second, our data were collected by different operators at national and provincial levels, which may lead to some variation in coding. Data collected in paper form was transformed into electronic form. While doing so, the operator check the data entered for the purpose of quality and completeness. The data collected does not include underlying medical conditions such as ischemic heart disease, cardiac arrhythmias, and seizures. These conditions are known as risk factors for drowning. Finally, the data imputed during analysis phase.

CONCLUSION

This study revealed a decrease in drowning mortality in Iran but at different levels by province. Our findings are of great importance to health officials and authorities in order to reduce the burden of drowning in middle-income countries. Indeed, learning the drivers of the differences by province would inform programmes, and sharing of successful programmes or initiatives to middle-income countries might reduce this burden especially among young children and males.

Author affiliations
[1]Sina Trauma and Surgery Research Center (STSRC), Tehran University of Medical Sciences (TUMS), Tehran, The Islamic Republic of Iran
[2]Student Research Committee, Iran University of Medical Sciences, Tehran, The Islamic Republic of Iran
[3]Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, The Islamic Republic of Iran
[4]Medicine, Iran University of Medical Sciences, Tehran, The Islamic Republic of Iran
[5]Hazrat-e Rasool General Hospital, Tehran, The Islamic Republic of Iran
[6]Tehran University of Medical Sciences, Tehran, The Islamic Republic of Iran
[7]Students' Scientific Research Center, Tehran University of Medical Sciences, Tehran, The Islamic Republic of Iran
[8]Center for Health Related Social and Behavioral Sciences Research, Shahroud University of Medical Sciences, Shahroud, The Islamic Republic of Iran
[9]Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, Tehran, The Islamic Republic of Iran
[10]Institute for Health Metrics and Evaluation, University of Washington, Seattle, Washington, USA
[11]Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Clayton, Victoria, Australia
[12]Preventive Medicine and Public Health Research Center, Iran University of Medical Sciences, Tehran, The Islamic Republic of Iran

Acknowledgements The authors would like to thank Dr. Farshad Farzadfar, Chair of Non-Communicable Diseases Research Centre (NCDRC) of Endocrinology and Metabolism Research Institute of Tehran University of Medical Sciences, who is the principal investigator of the NASBOD study. The authors would like to thank Dr. Mohammadreza Zafarghandi, Chair of Sina Trauma and Surgery Research Centre, Tehran University of Medical Science. Also, the authors would like to thank Dr. Mehrdad Azmin and the staff at NCDRC for their wholehearted cooperation. This study was funded by the Iran's Ministry of Health and Medical Education.

Funding This work was funded by the Iranian Ministry of Health and Medical Education [grant number: 1391-01-101-150] and Sina Trauma and Surgery Research Center [number: 0891/12-08-2018].

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The study was approved by Ethics Committee of Tehran University of Medical Sciences, the reference number is IR.TUMS.EMRI.REC.1396.00175.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

REFERENCES

1. Global Burden of Disease Study 2017 (GBD 2017) Results [Internet], 2017. Available: https://vizhub.healthdata.org/gbd-compare/#
2. Brundtland GH. From the world Health organization. reducing risks to health, promoting healthy life. *Jama*(): 1974;2002. 16.
3. Lozano R, Naghavi M, Foreman K, *et al*. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the global burden of disease study 2010. *The Lancet* 2012;380:2095–128.
4. Rahman A, Mashreky SR, Chowdhury SM, *et al*. Analysis of the childhood fatal drowning situation in Bangladesh: exploring prevention measures for low-income countries. *Injury Prevention* 2009;15:75–9.
5. Forouzanfar MH, Sepanlou SG, Shahraz S, *et al*. Evaluating causes of death and morbidity in Iran, global burden of diseases, injuries, and risk factors study 2010. *Archives of Iranian medicine* 2014;17:304–20.
6. Jamshidbeygi E, Rastad H, Qorbani M, *et al*. National and sub-national trend and burden of injuries in Iran, 1990 - 2013: a study protocol. *Archives of Iranian medicine* 2014;17:138–45.
7. Sachdeva RC. Near drowning. *Crit Care Clin* 1999;15:281–96.
8. Mosayebi Z, Movahedian AH, Mousavi GA. Drowning in children in Iran: outcomes and prognostic factors. *The Medical journal of Malaysia* 2011;66:187–90.
9. Kiakalayeh AD, Mohammadi R, Ekman DS, *et al*. Unintentional drowning in northern Iran: a population-based study. *Accident Analysis & Prevention* 2008;40:1977–81.
10. Saberi Anary SH, Sheikhazadi A, Ghadyani MH. Epidemiology of drowning in Mazandaran Province, North of Iran. *Am J Forensic Med Pathol* 2010;31:236–42.
11. Reijnen G, van de Westeringh M, Buster MC, *et al*. Epidemiological aspects of drowning and non-fatal drowning in the waters of Amsterdam. *J Forensic Leg Med* 2018;58:78–81.
12. Global Burden of Disease Study 2016 (GBD 2016) Results [Internet], 2016. Available: https://vizhub.healthdata.org/gbd-compare/#
13. Murray CJL, Ezzati M, Flaxman AD, *et al*. GBD 2010: design, definitions, and metrics. *The Lancet* 2012;380:2063–6.
14. Farzadfar F, Delavari A, Malekzadeh R, *et al*. NASBOD 2013: design, definitions, and metrics. *Archives of Iranian medicine* 2014;17:7–15.
15. Sheidaei A, Gohari K, Kasaeian A, *et al*. National and Subnational patterns of cause of death in Iran 1990-2015: applied methods. *Archives of Iranian medicine* 2017;20:2–11.
16. Mohammadi Y, Parsaeian M, Farzadfar F, *et al*. Levels and trends of child and adult mortality rates in the Islamic Republic of Iran, 1990-2013; protocol of the NASBOD study. *Archives of Iranian medicine* 2014;17:176–81.
17. Parsaeian M, Farzadfar F, Zeraati H, *et al*. Application of spatio-temporal model to estimate burden of diseases, injuries and risk factors in Iran 1990-2013. *Archives of Iranian Medicine* 2014;17.
18. Global MG. Regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the global burden of disease study 2013. *Lancet* 2015;385:117–71.
19. Mirzamani M, Reza Mohammadi M, Ali Besharat M. Post-Traumatic stress disorder symptoms of children following the occurrence of Tehran City Park disaster. *J Psychol* 2006;140:181–6.
20. KOLAHDOOZAN A, DINPAJOOH Y, MIRABBASI NR. *Effect of Zayandehrood river dry becoming on Najafabad aquifer oscillations during past two decades*, 2015.
21. Pesyan B V, Porakrami M, Fotouhi Mehrabani B, *et al*. *The investigation of lake Urmia drying trend and its important consequence on the surrounding settlements*, 2017: 438–53.
22. Report of drowning mortality in Iran by Iran legal medicine organization.
23. Morovatdar N, Moradi-Lakeh M, Malakouti SK, *et al*. Most common methods of suicide in eastern Mediterranean region of who: a systematic review and meta-analysis. *Archives of Suicide Research* 2013;17:335–44.
24. Thompson DC, Rivara FP. Pool fencing for preventing drowning in children. *The Cochrane database of systematic reviews* 2000;2.
25. Sheikhazadi A, Ghadyani MH. Epidemiology of drowning in Isfahan Province, center of Iran. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences* 2009;14.
26. Tan RM. The epidemiology and prevention of drowning in Singapore. *Singapore medical journal* 2004;45:324–9.
27. Suresh Kumar Shetty B, Shetty M. epidemiology of drowning in Mangalore, a coastal Taluk of South India. *Journal of forensic and legal medicine* 2007;14:410–5.
28. Alpert B. Bathtub drowning: unintentional, neglect, or abuse. *Medicine and health, Rhode Island* 2003;86:385–6.
29. Lin C-Y, Wang Y-F, Lu T-H, *et al*. Unintentional drowning mortality, by age and body of water: an analysis of 60 countries. *Inj Prev* 2015;21:e43–50.

30. Rahman A, Alonge O, Bhuiyan A-A, *et al*. Epidemiology of drowning in Bangladesh: an update. *Int J Environ Res Public Health* 2017;14:488.
31. Lindeboom W, Alam N, Begum D, *et al*. The association of meteorological factors and mortality in rural Bangladesh, 1983–2009. *Glob Health Action* 2012;5:19063–73.
32. Modarres R. De Paulo Rodrigues dA Silva V. rainfall trends in arid and semi-arid regions of Iran. *Journal of Arid Environments* 2007;70:344–55.
33. Rahman F, Bose S, Linnan M, *et al*. Cost-Effectiveness of an injury and drowning prevention program in Bangladesh. *Pediatrics* 2012;130:e1621–8.
34. Hossain MJ, Biswas A, Mashreky SR, *et al*. Epidemiology of adulthood drowning deaths in Bangladesh: findings from a nationwide health and injury survey. *F1000Research* 2017;6.
35. Agrawal P, Hyder A. Burden of injuries in Bangladesh: a population-based assessment. *Int J Environ Res Public Health* 2018;15:409.