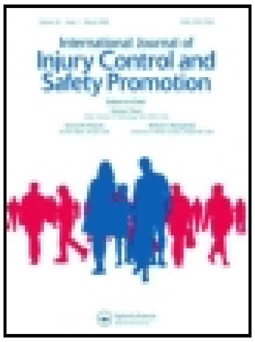

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The trend of fall-related mortality at national and provincial levels in Iran from 1990 to 2015

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ABSTRACT

Falls are one of the major causes of unintentional injuries. Understanding the epidemiology of fall-related mortality helps to identify the root causes of this event and planning preventive strategies to inhibit falls. The aim of this study was to assess the trend of fall-related mortality rate and its epidemiological patterns based on sex and age-groups at national and subnational levels in Iran during the years 1990 to 2015. All data were gathered from Death Registration Systems, cemetery databases of Tehran and Isfahan, the Demographic and Health Survey of 2000 and three rounds of national population and housing censuses. The age-standardized death rate (ASDR) due to falls per 100,000 people decreased from 2.61 (95% Uncertainty Interval (UI): 1.94–3.51) in 1990 to 2.13 (1.62–2.80) in 2015 at national level. Males were at higher risk of death due to falls than females. Our data showed that the elderly population was at higher risk of death due to falls and individuals less than 4-year old had the highest fall-related mortality rate among children and adolescents. Our data should be used to accelerate interventions to reduce fall-related mortality.

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Introduction

The epidemiological profile of most countries has been shifting from communicable diseases to non-communicable diseases and injuries (Beaglehole et al., 2011). Unintentional injuries are a growing concern in several nations including Iran. According to the Iranian Legal Medicine Organization, one out of ten deaths among Iranian population is due to unintentional injuries (Naghavi et al., 2009). Falls are one of the causes of unintentional injuries and are commonly defined as 'inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest on furniture, wall or other objects' (World Health Organization, 2007).

According to the World Health Organization, over 646,000 fatal falls occur each year and are the second leading cause of deaths due to unintentional injuries (World Health Organization, 2018). Falls are more frequent in middle- and low-income countries (World Health Organization, 2018). Studies have shown that the global burden and mortality rate of most unintentional injuries have decreased over time but an increase has been observed in the global fall-related burden and mortality (Abubakar et al., 2015). It is estimated that the direct and indirect cost of falls will reach to USD$55 billion in 2020 (Hu & Baker, 2012).

Understanding the epidemiology of fall-related mortality helps to identify the root causes of this event and informs the planning of preventive strategies to inhibit falls. The national and subnational burden of diseases (NASBOD) project in Iran is a systematic effort for estimating the magnitude of health loss due to diseases, injuries and related

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risk factors (Farzadfar et al., 2014). The aim of this study was to assess the trend of fall-related mortality rate and its epidemiological patterns based on genders and age-groups at national and subnational levels in Iran during the years 1990 to 2015.

Material and methods

Study design

NASBOD is a pioneering study to provide the burden of 291 diseases and their 67 related risk factors in 19 age groups for both sexes from 1990 to 2015 at national and subnational levels in the country. Five year intervals were used for categorizing for age. For neonates and children, the 0–4 year group was further divided into the less than 1 year and 1–4 year groups, respectively; and for persons over 85-year old, the category was defined as greater than or equal to 85 years (Farzadfar et al., 2014).

Data source and data issue

The death data source in the present study included the Death Registration System (DRS) data from 1995 to 2010. In Iran, occurring deaths are legally registered by death certificates. In DRS mortality data are collected from hospitals, health houses and health centres, forensic medicine bureau, authorized cemeteries, civil registration bureau and other probable sources in district and checked with civil registration in district health center. These death data sends to provincial health center each 3 to 6 months and then annually to Ministry of Health and Medical Education (MOHME) (Jafari et al., 2009). The deputy for research and technology from 1995 to 2001 and the deputy for public health from 2001 onwards have been responsible for collecting cause of death registration data in MOHME. In DRS death records across all provinces of Iran were registered except Tehran (Behesht-e-Zahra) and Isfahan (Bagh-e-Rezvan) because they administered their deaths data independently. In the DRS neither the data from 1995 to 2010 of 'Behesht-e-Zahra' cemetery nor from 2007 to 2010 of 'Bagh-e-Rezvan' cemetery were included; therefore, the data were directly obtained from each of these cemeteries and added to the dataset. Since data of DRS and cemeteries had some varieties, all essential variables in cause of death study were chosen to make an aggregate dataset and were recorded based on the same codebook to form main dataset (Sheidaei et al., 2017). The codes of cause of death in the DRS were initially defined according to the International Classification of Disease-version of 10 (ICD10), and then, were mapped to 165 codes according to Global Burden of Diseases (GBD) study (Lozano et al., 2012).

The DRS has following issues which have to be addressed. This database includes several kinds of duplicates and misclassification in cause of death and provinces as well as garbage and ill-defined codes. In addition, the number of provinces has been changed from 24 provinces in 1990 to 31 in 2015 based on 2011 divisions, requiring an adjustment to the data. This database was also prone to incompleteness because of the inability to record all deaths. Also existence of lost space-time data points were as the main issues in the DRS.

To estimate the levels and trends of mortality rates for child and adult during the 26 year period, as in a parallel research conducted by Mohammadi et al. (2017), a spatio-temporal model and Gaussian Process Regression (GPR) were used (Mehdipour et al., 2014; Parsaeian et al., 2014). In order to determine populations, according to age, sex, year and province, the national population and housing censuses, adopted by the Statistical Center of Iran in 1996, 2006 and 2011 were used and the populations from 1990 to 2015 were estimated using a growth model.

To estimate Child Mortality Rate (CMR), we calculate incompleteness of the DRS for child by Summary Birth History (SBH). In this approach, Maternal Age Cohort (MAC) and Maternal Age Period (MAP) methods were used and combined them with LOESS approach; and by combining results based on spatio-temporal model and GPR the CMR was estimated. The completeness of DRS for child were estimated as 42.7% in 1990 and 85.9% in 2015.

Three steps were used for calculating Adult Mortality Rate (AMR). The first one consisted of using the Generalized Growth Balance (GGB), Synthetic Extinct Generation (SEG) and Generalized Growth Balance-Synthetic Extinct Generation (GGB-SEG) models, was the incompleteness of the DRS for adult addressed. Then in the second step LOESS was used to incorporate the above three estimates and by applying the spatio-temporal and GPR models the adult mortality rate was estimated. The completeness of DRS for adult were estimated as 80.9% in 1990 and 100% in 2015. This process yield total mortality for child and adult (Mohammadi et al., 2014).

In process of estimating cause-specific mortality, different statistical methods were used. In order to impute missing values for age and sex variables Amelia package in R (R Foundation for Statistical Computing; Vienna, Austria) were used (Honaker et al., 2011). To impute missing values for causes of death multinomial imputation was used in STATA version 11 (STATA Corp., College, Station, TX, USA) (White et al., 2011). To predict number of deaths the Poisson regression model with logarithm link function and years of schooling, wealth index and urbanization ratio as covariates and logarithm of population as offset were considered. Mixed effect model including demographic variables and covariates were used for modelling cause fraction of death by age groups, sex, province and year. Residuals of the mixed effect model, which contain additional variations in three dimensions of age groups, time and space were adjusted by a weight matrix including effects of these variables in age-spatio-temporal model. In this study, age-spatio-temporal model was applied to utilize additional prediction analysis to consider how the dependent variable further varies across time (year), space (province) and age groups. Cause-specific mortality was estimated by applying cause fraction to total mortality rates. We performed a spatio-temporal model on 1000 simulated random values drawn from a mixed effect model distribution; and the 2.5th and 97.5th percentile, respectively, to present the 95% Uncertainty Intervals (UI), as the lower and upper bounds (Sheidaei et al., 2017).

ICD10 codes of W00-W19 were mapped to define fall moratlity (Lozano et al., 2012). Annual Percent Change (APC) at national and subnational levels was calculated as exponential regression coefficient from the regression of the natural logarithm (ln) of death rate on year (Muggeo, 2008). Age-Standardized Death Rates (ASDR) were caluculated by direct method and considering Iranian population in 2015 as standard population by 'epitools' package in R (Tomas, 2012). More details about the NASBOD study's methodology, data presentation and analyses can be found elsewhere (Farzadfar et al., 2014; Mehdipour et al., 2014; Mohammadi et al., 2014; Parsaeian et al., 2014; Sheidaei et al., 2017). Results of the NASBOD study can be accessed online using Iranin population health and diseases information data visualization tools at www.vizit.report.

Ethical approval

The Ethics Committee of Tehran University of Medical Sciences approved the study (Reference number: IR.TUMS.EMRI.REC.1396.00175).

Results

Age-standardized death rate and annual percentage change

National level

Falls caused 1,139 individuals (468 females and 671 males) to die in 1990 and 1,705 deaths (527 females and 1178 males) in 2015. The highest number of all age mortality due to falls was recorded in the 2001 to 2004 period with over 2,400 deaths. The ASDR due to falls per 100,000 population decreased from 2.61 (95% UI: 1.94–3.51) in 1990 to 2.13 (1.62–2.80) in 2015 at national level. The ASDR due to falls was 2.32 (1.70–3.17) among females and 2.89 (2.18–3.83) among males in 1990. This rate decreased to 1.32 (0.98–1.77) among females and increased to 2.93 (2.25–3.82) among males in 2015. The annual percentage change (APC) of fall-related mortality was −2.23% among females and +0.06% among males (Table 1).

Provincial level

In 1990, Tehran province, with 123 fatal falls (47 females and 76 males) had the highest number of all age deaths compared to other provinces of Iran. Razavi Khorasan with 155 fall-related deaths (37 females and 118 males) had the highest number of all age falls deaths in 2015. The highest fall-related ASDR per 100,000 individuals was recorded in North Khorasan province, but this was reduced from 5.63 (4.15–7.62) in 1990 to 3.80 (2.90–4.98) in 2015. The lowest ASDR was observed in Alborz province (1.09 (0.79–1.52)) in 1990 and Tehran province (0.90 (0.61–1.32)) in 2015 (Figure 1).

During the study period, Zanjan province had the highest decrease in fall-related mortality in both genders (females APC: −6.25%; males APC: −3.05%). This was followed by Tehran province among females (APC: −3.94%) and Lorestan province among males (APC: −1.94%). Hormozgan (APC: +1.66%), Bushehr (+0.86%) and Fars (+0.05%) were the only provinces of Iran with an increase in mortality rates due to falls among females. The highest level of increase in the fall-related death rate in males was observed in Hormozgan province (APC: +3.54%); followed by Isfahan province (APC: +2.25%) from 1990 to 2015 (Table 1).

Age mortality rate due to falls

Our data showed that the elderly population were at a higher risk of death due to falls. People of both genders aged above 85 years had the highest fall-related mortality rate; followed by individuals aged 80 to 84 years (Figure 2). It was observed that in 2015 the rate of mortality due to falls in people aged 85+ years was more than double the rate in 80 to 84 year-old-individuals. During this study, the fall-related death rate decreased in all age groups except for 85+-year-old-people. Individuals less than 1-year old and from 1- to 4-year old had the highest fall-related mortality rates among children and adolescents. The trend of fall mortality among all age groups in most provinces of Iran was similar to the national level (Supplementary material Appendix 1).

Time trends of fall death rate based on gender

At the national level, the time trends of mortality rates per 100,000 showed fluctuations in both genders. An increased mortality rate was recorded from 1990 to 1995 among females and peaked at 3.43 (2.55–4.60) per 100,000. The mortality rate among males had growth until 2000 and reached to 5.73 (4.43–7.42) per 100,000. The mortality rate, then, decreased in both genders until 2015 (Figure 3). The fall-related ASDR in males tended to be higher than in females with a ratio of 1.2 in 1990 and 2.2 in 2015. The provincial data on time trends of IPV-related mortality rates are presented in Appendix 2 (Supplementary material).

Discussion

To our knowledge, this is the first study to have assessed the trend of mortality due to falls at national and provincial levels in Iran. The fall-related mortality was evaluated in both genders and in all age groups during 26 years to show a better perspective of the event among Iranian population. These findings are of great importance to health officials and should be used to develop and implement measures to reduce the burden of falls. Efforts should include both an educational campaign as well as the enforcement of rules and regulations of Iran.

According to the GBD study (Abubakar et al., 2015), the global number of all age deaths due to falls had more than 65% increase from 1990 to 2013. The global age-standardized mortality rate was 9 per 100,000 in 1990 and had about 3%

Table 1. National and sub-national age standardized mortality rate due to Falls per 100,000 in 1990, 1995, 2000, 2005, 2010 and 2015 with annual percentage change (APC) of death between 1990 and 2015 by sex.

	Female							Male						
	Year						APC 1990–2015 (%)	Year						APC 1990–2015 (%)
Location	1990	1995	2000	2005	2010	2015		1990	1995	2000	2005	2010	2015	
Alborz	0.95 (0.67–1.35)*	1.38 (0.99–1.92)	1.42 (1.03–1.96)	1.06 (0.77–1.44)	0.92 (0.68–1.27)	0.67 (0.49–0.93)	−1.38%	1.23 (0.90–1.69)	2.08 (1.54–2.82)	2.55 (1.90–3.41)	2.21 (1.67–2.92)	2.00 (1.52–2.65)	1.46 (1.10–1.95)	0.69%
Ardebil	3.77 (2.81–5.04)	5.71 (4.36–7.45)	5.32 (4.14–6.81)	4.02 (3.16–5.10)	2.88 (2.26–3.66)	1.80 (1.40–2.31)	−2.92%	3.31 (2.56–4.27)	5.52 (4.32–7.02)	6.64 (5.27–8.32)	5.62 (4.50–7.01)	5.01 (4.00–6.26)	3.24 (2.57–4.08)	−0.09%
Bushehr	2.48 (1.82–3.36)	4.19 (3.16–5.53)	4.81 (3.72–6.21)	4.67 (3.62–5.98)	4.15 (3.18–5.39)	3.07 (2.30–4.06)	0.86%	2.90 (2.22–3.79)	5.55 (4.29–7.15)	6.63 (5.22–8.39)	6.48 (5.13–8.21)	5.52 (4.33–7.04)	3.68 (2.83–4.76)	0.95%
Chahar Mahall and Bakhtiari	3.64 (2.73–4.82)	5.46 (4.15–7.17)	5.23 (4.05–6.73)	4.33 (3.36–5.56)	3.16 (2.43–4.08)	2.23 (1.70–2.89)	−1.94%	4.09 (3.17–5.26)	6.81 (5.32–8.71)	7.18 (5.66–9.09)	7.00 (5.56–8.84)	6.33 (4.97–8.01)	4.53 (3.53–5.78)	0.41%
East Azarbaijan	2.37 (1.80–3.09)	3.55 (2.73–4.61)	3.50 (2.71–4.51)	2.47 (1.92–3.17)	1.88 (1.45–2.43)	1.14 (0.87–1.49)	−2.89%	2.78 (2.16–3.58)	5.14 (4.02–6.56)	6.86 (5.40–8.70)	5.35 (4.22–6.75)	4.84 (3.81–6.13)	3.16 (2.47–4.04)	0.52%
Esfahan	1.42 (1.02–1.99)	2.18 (1.58–3.02)	2.22 (1.62–3.03)	2.21 (1.62–3.00)	1.81 (1.32–2.46)	1.31 (0.95–1.80)	−0.33%	1.88 (1.38–2.55)	3.47 (2.59–4.67)	4.39 (3.31–5.82)	4.66 (3.51–6.14)	4.38 (3.32–5.80)	3.28 (2.46–4.37)	2.25%
Fars	1.37 (1.02–1.83)	2.22 (1.69–2.92)	2.52 (1.93–3.27)	2.35 (1.81–3.03)	1.90 (1.45–2.47)	1.39 (1.05–1.83)	0.05%	2.35 (1.80–3.06)	4.27 (3.32–5.49)	5.99 (4.70–7.61)	5.96 (4.69–7.57)	5.37 (4.20–6.87)	3.81 (2.96–4.91)	1.95%
Gilan	2.30 (1.74–3.04)	3.12 (2.38–4.06)	2.83 (2.19–3.66)	2.20 (1.70–2.84)	1.77 (1.36–2.29)	1.18 (0.89–1.54)	−2.65%	2.67 (2.06–3.45)	4.06 (3.19–5.18)	5.20 (4.12–6.56)	4.80 (3.79–6.03)	4.12 (3.25–5.20)	2.89 (2.28–3.67)	0.32%
Golestan	2.67 (2.02–3.52)	4.39 (3.37–5.72)	4.12 (3.22–5.28)	3.76 (2.92–4.80)	3.32 (2.56–4.27)	2.35 (1.79–3.08)	−0.50%	3.20 (2.48–4.11)	6.34 (4.97–8.06)	7.04 (5.59–8.88)	6.84 (5.43–8.60)	5.71 (4.49–7.24)	3.91 (3.04–5.03)	0.81%
Hamadan	2.58 (1.99–3.33)	4.28 (3.36–5.46)	4.14 (3.28–5.21)	3.84 (3.06–4.82)	3.10 (2.45–3.92)	2.11 (1.64–2.70)	−0.80%	3.71 (2.92–4.68)	6.55 (5.21–8.18)	8.17 (6.58–10.12)	8.08 (6.52–9.99)	6.94 (5.58–8.64)	5.13 (4.08–6.45)	1.31%
Hormozgan	1.72 (1.23–2.37)	3.03 (2.24–4.09)	3.54 (2.66–4.67)	4.06 (3.07–5.35)	3.26 (2.42–4.38)	2.59 (1.88–3.55)	1.66%	1.90 (1.44–2.52)	3.98 (3.06–5.19)	5.75 (4.46–7.39)	6.61 (5.14–8.46)	5.46 (4.19–7.14)	4.54 (3.42–6.05)	3.54%
Ilam	3.67 (2.71–4.93)	5.90 (4.43–7.85)	5.47 (4.15–7.20)	4.62 (3.52–6.04)	3.78 (2.88–4.96)	2.56 (1.94–3.39)	−1.42%	4.03 (3.07–5.29)	6.81 (5.23–8.84)	7.84 (6.08–10.09)	6.46 (5.02–8.32)	5.09 (3.93–6.56)	3.61 (2.78–4.71)	−0.43%
Kerman	2.20 (1.69–2.87)	3.50 (2.73–4.49)	3.35 (2.64–4.25)	2.75 (2.16–3.48)	1.90 (1.47–2.46)	1.19 (0.91–1.56)	−2.42%	3.17 (2.49–4.03)	5.31 (4.22–6.67)	5.69 (4.55–7.09)	4.74 (3.79–5.91)	3.65 (2.90–4.60)	2.46 (1.93–3.13)	−1.01%
Kermanshah	2.46 (1.88–3.21)	4.30 (3.32–5.54)	3.96 (3.09–5.08)	3.46 (2.72–4.40)	2.96 (2.31–3.77)	1.98 (1.53–2.56)	−0.86%	3.05 (2.40–3.87)	5.28 (4.20–6.63)	5.98 (4.78–7.46)	6.33 (5.10–7.89)	5.80 (4.64–7.23)	4.12 (3.27–5.19)	1.20%
Khuzestan	1.21 (0.91–1.61)	2.03 (1.54–2.67)	2.03 (1.56–2.65)	1.82 (1.40–2.35)	1.46 (1.12–1.90)	1.08 (0.82–1.42)	−0.44%	1.71 (1.30–2.22)	3.44 (2.66–4.45)	4.02 (3.13–5.16)	3.52 (2.75–4.50)	2.74 (2.14–3.50)	2.07 (1.61–2.66)	0.77%
Kohgiluyeh and Buyer Ahmad	4.83 (3.37–6.88)	7.14 (5.09–10.01)	6.82 (4.94–9.35)	5.66 (4.17–7.68)	4.18 (3.10–5.62)	2.49 (1.83–3.37)	−2.61%	5.22 (3.76–7.23)	8.81 (6.44–11.97)	8.87 (6.62–11.87)	8.14 (6.14–10.74)	6.00 (4.54–7.89)	3.81 (2.87–5.03)	−1.25%
Kordestan	3.83 (2.81–5.25)	5.73 (4.32–7.62)	5.04 (3.9–6.51)	4.06 (3.21–5.12)	3.06 (2.41–3.87)	1.75(1.36–2.24)	−3.10%	5.07 (3.87–6.64)	8.23 (6.39–10.56)	8.80 (7.00–11.07)	7.13 (5.74–8.87)	5.41 (4.35–6.72)	3.33 (2.64–4.17)	−1.67%
Lorestan	3.47 (2.58–4.66)	5.12 (3.89–6.72)	4.62 (3.59–5.92)	3.72 (2.94–4.70)	2.43 (1.91–3.08)	1.38 (1.07–1.77)	−3.64%	4.38 (3.38–5.64)	6.95 (5.45–8.84)	7.04 (5.61–8.85)	5.76 (4.61–7.19)	4.27 (3.41–5.33)	2.68 (2.12–3.39)	−1.94%
Markazi	2.37 (1.77–3.15)	3.77 (2.86–4.95)	4.12 (3.19–5.30)	3.90 (3.04–4.99)	3.23 (2.50–4.16)	2.16 (1.65–2.83)	−0.37%	2.86 (2.21–3.69)	5.02 (3.93–6.40)	6.27 (4.98–7.88)	6.43 (5.11–8.04)	5.6 (4.44–7.05)	3.93 (3.08–4.98)	1.28%
Mazandaran	2.53 (1.88–3.42)	3.36 (2.52–4.48)	3.08 (2.32–4.10)	2.33 (1.74–3.11)	1.64 (1.21–2.22)	0.97 (0.70–1.33)	−3.78%	3.05 (2.35–3.96)	4.57 (3.55–5.89)	5.55 (4.32–7.13)	5.02 (3.90–6.47)	4.05 (3.11–5.26)	2.88 (2.20–3.80)	−0.22%
North Khorasan	5.62 (4.08–7.71)	8.31 (6.16–11.16)	8.12 (6.11–10.78)	6.08 (4.63–7.97)	4.07 (3.08–5.36)	2.48 (1.85–3.30)	−3.23%	5.73 (4.28–7.66)	9.09 (6.89–11.98)	11.04 (8.45–14.35)	9.86 (7.63–12.71)	8.10 (6.27–10.45)	5.13 (3.94–6.66)	−0.45%
Qazvin	3.72 (2.85–4.86)	5.36 (4.16–6.88)	5.15 (4.06–6.52)	4.27 (3.37–5.40)	3.32 (2.61–4.22)	2.12 (1.65–2.74)	−2.22%	4.47 (3.49–5.71)	7.19 (5.69–9.11)	7.75 (6.19–9.69)	6.95 (5.58–8.66)	5.89 (4.71–7.36)	3.87 (3.07–4.86)	−0.57%
Qom	2.05 (1.40–2.99)	3.06 (2.12–4.41)	3.34 (2.35–4.75)	3.23 (2.3–4.54)	2.13 (1.51–2.99)	1.55 (1.11–2.18)	−1.10%	2.75 (1.96–3.86)	4.47 (3.23–6.19)	5.21 (3.81–7.10)	5.29 (3.91–7.16)	4.02 (2.98–5.41)	2.69 (1.98–3.62)	−0.10%
Razavi Khorasan	2.85 (2.13–3.80)	4.21 (3.18–5.56)	4.33 (3.30–5.68)	3.29 (2.50–4.30)	2.13 (1.61–2.81)	1.17 (0.87–1.57)	−3.49%	2.97 (2.27–3.90)	5.01 (3.85–6.50)	7.74 (6.01–9.97)	8.19 (6.35–10.56)	5.83 (4.49–7.56)	3.83 (2.93–4.99)	1.01%
Semnan	3.38 (2.43–4.72)	4.84 (3.52–6.61)	4.86 (3.61–6.51)	4.51 (3.38–5.99)	3.5 (2.63–4.65)	2.39 (1.78–3.20)	−1.39%	2.86 (2.12–3.84)	4.93 (3.71–6.52)	6.25 (4.75–8.20)	6.60 (5.08–8.60)	5.56 (4.28–7.23)	4.14 (3.16–5.41)	1.49%
Sistan and Baluchestan	3.76 (2.60–5.40)	5.31 (3.71–7.54)	5.13 (3.66–7.19)	3.88 (2.78–5.38)	2.78 (2.00–3.85)	1.72 (1.24–2.38)	−3.09%	3.51 (2.57–4.79)	5.39 (3.98–7.31)	5.04 (3.77–6.73)	3.86 (2.91–5.11)	3.70 (2.79–4.90)	2.60 (1.96–3.46)	−1.19%
South Khorasan	3.64 (2.62–5.03)	5.61 (4.12–7.60)	6.03 (4.48–8.08)	5.20 (3.88–6.95)	4.44 (3.31–5.94)	2.96 (2.19–4.00)	−0.82%	4.39 (3.26–5.89)	6.85 (5.16–9.05)	8.04 (6.12–10.49)	7.38 (5.65–9.61)	6.21 (4.73–8.13)	4.17 (3.14–5.50)	−0.21%
Tehran	1.36 (0.85–2.17)	1.74 (1.11–2.72)	1.59 (1.03–2.44)	1.13 (0.74–1.70)	0.76 (0.5–1.13)	0.50 (0.33–0.75)	−3.94%	2.02 (1.32–3.07)	2.96 (1.98–4.44)	3.20 (2.18–4.71)	2.75 (1.89–4.00)	1.97 (1.36–2.85)	1.31 (0.91–1.90)	−1.71%
West Azarbaijan	2.88 (2.17–3.82)	3.98 (3.05–5.17)	3.49 (2.74–4.44)	2.72 (2.14–3.45)	1.98 (1.55–2.52)	1.15 (0.88–1.49)	−3.62%	3.52 (2.71–4.55)	5.61 (4.39–7.16)	6.13 (4.87–7.72)	4.95 (3.96–6.19)	4.23 (3.37–5.31)	2.62 (2.07–3.32)	−1.17%
Yazd	2.44 (1.82–3.26)	3.56 (2.68–4.73)	3.70 (2.80–4.87)	3.61 (2.76–4.70)	3.01 (2.29–3.94)	1.91 (1.44–2.53)	−0.97%	3.62 (2.78–4.71)	6.07 (4.68–7.89)	6.10 (4.73–7.84)	5.58 (4.36–7.12)	4.90 (3.81–6.30)	3.45 (2.67–4.45)	−0.19%
Zanjan	5.46 (3.92–7.57)	7.46 (5.67–9.84)	5.92 (4.63–7.56)	3.90 (3.00–5.03)	2.23 (1.64–3.03)	1.09 (0.75–1.56)	−6.25%	5.86 (4.38–7.78)	8.79 (6.81–11.32)	9.31 (7.40–11.70)	7.09 (5.60–8.96)	4.92 (3.76–6.42)	2.70 (1.99–3.66)	−3.05%
National	2.32 (1.70–3.17)	3.43 (2.55–4.60)	3.32 (2.51–4.40)	2.74 (2.08–3.60)	2.04 (1.54–2.70)	1.32 (0.98–1.77)	−2.23%	2.89 (2.18–3.83)	4.79 (3.66–6.28)	5.73 (4.43–7.42)	5.25 (4.07–6.78)	4.29 (3.31–5.54)	2.93 (2.25–3.82)	0.06%

*Data in parentheses are 95% uncertainty intervals.

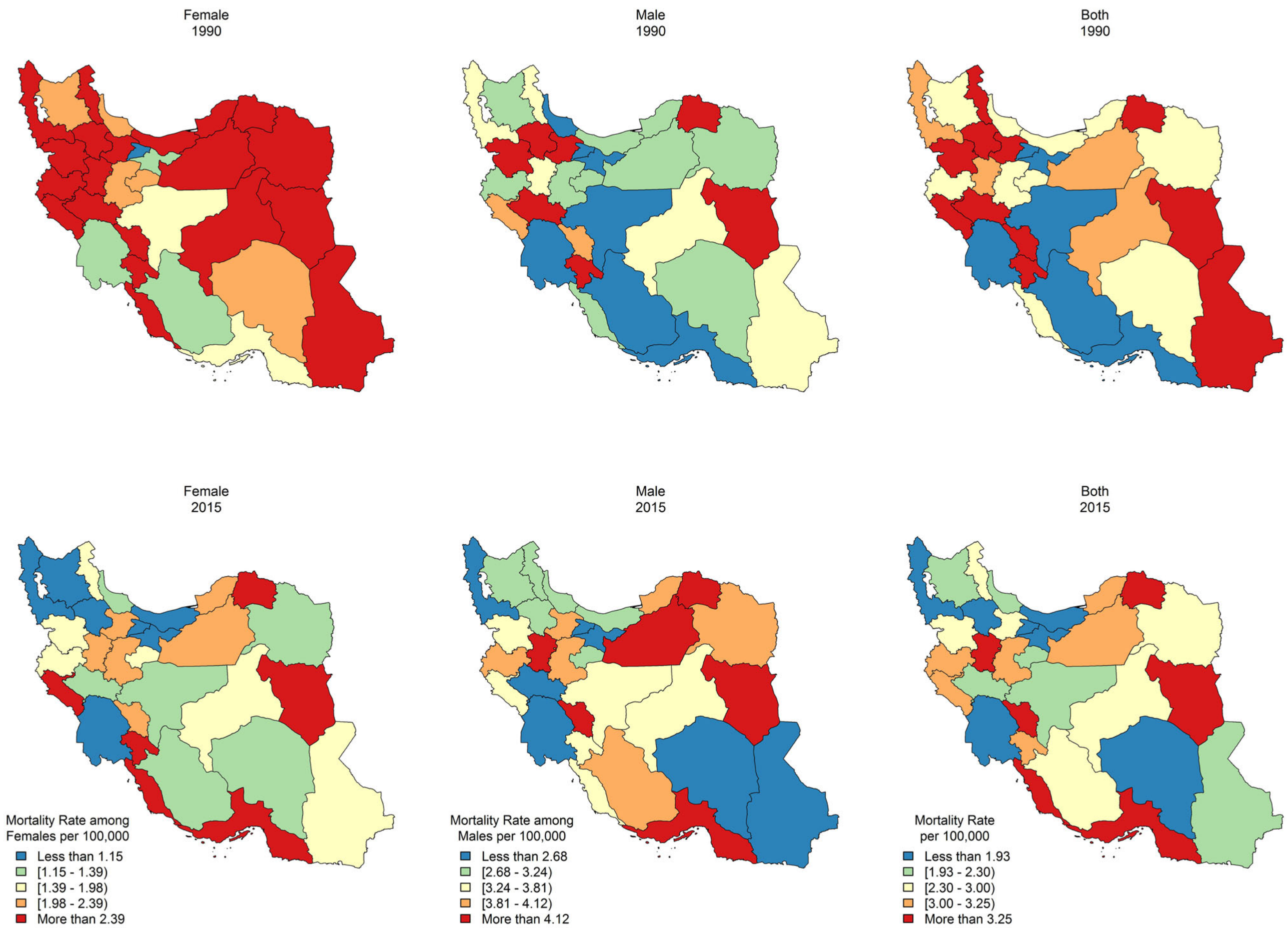

Figure 1. Mortality rate due to falls per 100,000 at provincial levels of Iran.

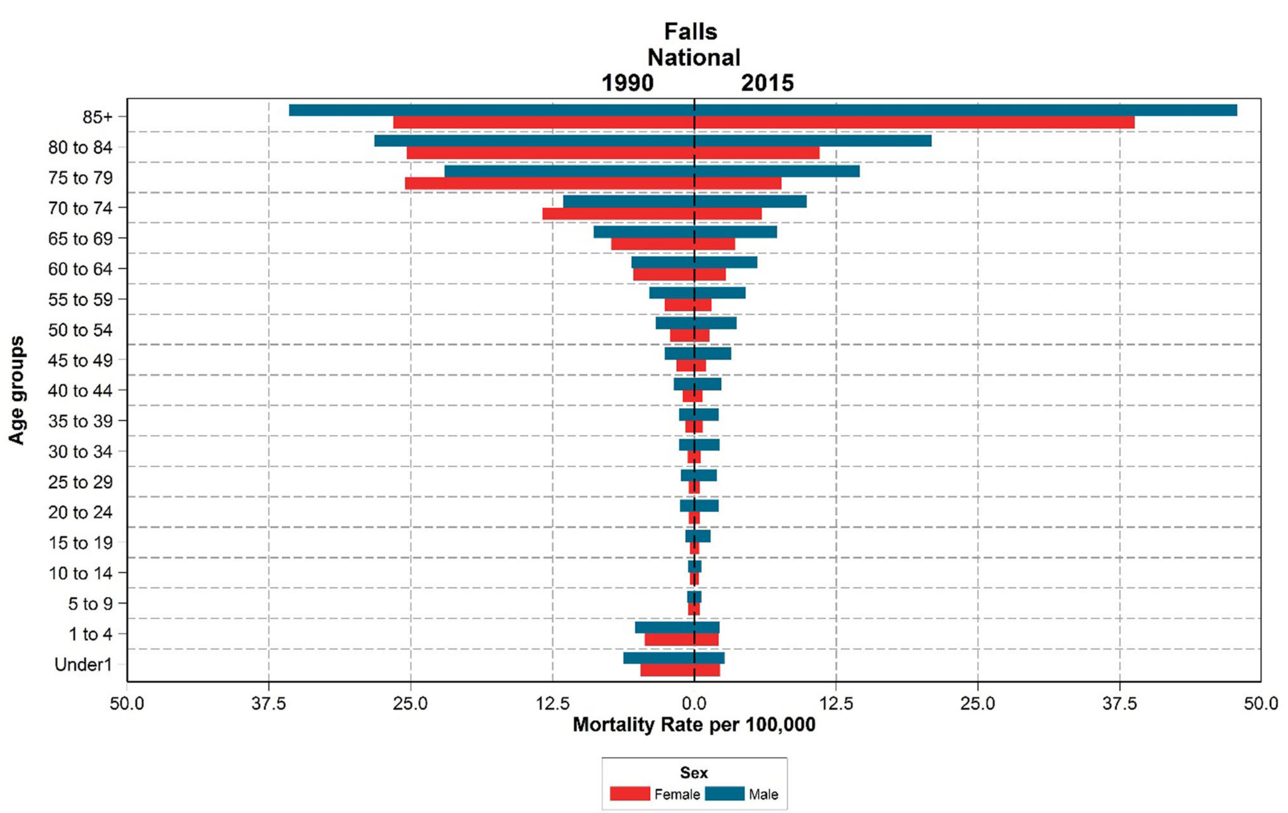

Figure 2. Mortality rate due to falls per 100,000 based on age-groups.

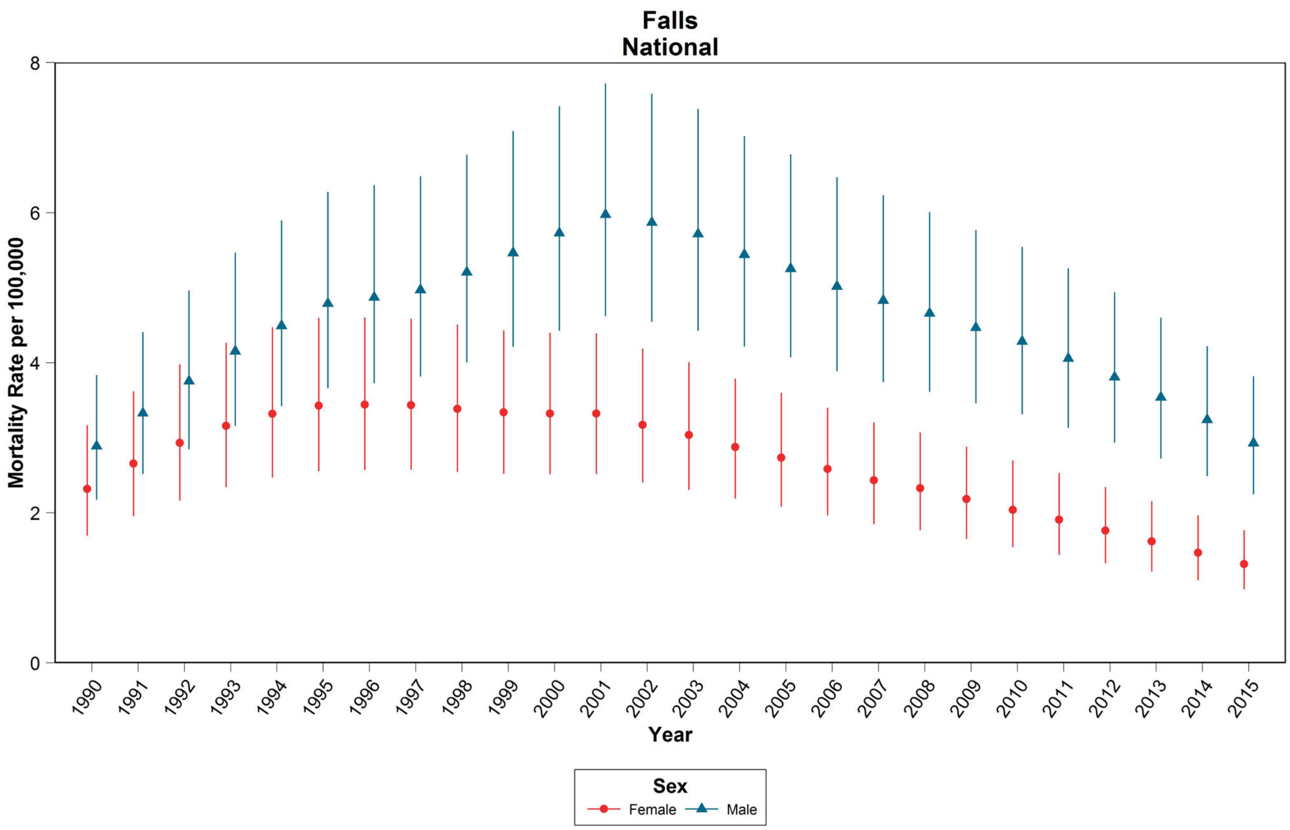

Figure 3. Time trend of mortality rate due to falls per 100,000.

total growth until 2013. The global fall-related number of all age deaths had more than 25% increase from 2007 to 2017 but about 3% total decrease was observed in fall-related ASDR (Roth et al., 2018). Our study showed that age-standardized mortality rate due to falls decreased between 1990 and 2015 in Iran. Discrepancies between our results and the GBD study may be due to the geographical diversity and methodological differences. It should be noted that one of the fundamental limitation of GDB study is its data source. GBD does not have access to data registry of fall in Iran. It used three scientific literatures and two household surveys to estimate burden of fall in Iran while in this study we had access to all fall-related mortality by age, sex and year at national and provincial levels.

Multiple population-based studies have assessed the epidemiological aspects of falls. Most previous studies were conducted in specific population groups including the elderly, youths or workers (Ranaweera et al., 2013; Tuma et al., 2013; Veras et al., 2019) and did not show the death rate due to the event. In the U.S, falls result in 1,800,000 admissions to emergency departments and 16,000 deaths each year (Alexander et al., 1992). A population-based study in China showed that the annual fall mortality rate was up to 0.49 per 100,000 (Li et al., 2019). A recent survey indicated that there was an increasing trend of deaths due to falls in southern Sweden from 1998 to 2014 (Kiadaliri et al., 2019). A study in Iran revealed that about 60 per 1000 people each year had fall-related injuries and 28 of these injuries needed medical attention (Saadat et al., 2016). A one-year survey in 10 provinces of Iran reported that falls were the third most frequent cause of death among unintentional injuries and were more common among males and individuals of rural areas (Akbari et al., 2006).

Many factors and strategies might lead to a reduction in the fall-related mortality in Iran: Progression in different aspects of health care, including the development of emergency and trauma care systems might play a significant role in decreasing deaths due to falls. Living in rural areas was found to be associated with a higher odds of falls (Saadat et al., 2016). Various physical and occupational activities performed in these areas of Iran are with limited protections. This can be due to low socio-economic status or limited facilities in rural places. Population shifts to urban areas optimizing the early care and treatment of individuals might be another factor in the reduction of fall-related mortality.

Our study revealed that people aged above 85 years were at the highest risk of death due to falls. In line with this study, ageing was showed to be a risk factor of falls and their related mortality (Baricich et al., 2018; Joshi et al., 2019; Taheri-Kharameh et al., 2019). It was identified that about one-third of adults older than 65 years had at least one fall during the last 12 months and about 70% of injuries in this population were caused by falls (Homann et al., 2013). One study in the United Kingdom indicated that over 30% of the elderly population fell each year and about half of them had recurrent falling episodes (Scuffham et al., 2003). Impaired physiological function due to age and medical conditions is an important risk factor for falls. The elderly population are at an increased risk of different pathological events including neurological disorders. Gait disturbance and postural instability due to neurological events can lead to falls. Multiple studies showed high rate of falls among people with cerebrovascular diseases, dementia and parkinson's disease (Tripathy et al., 2015; Ungar et al., 2016; Wing et al., 2017). Osteoporosis, muscle weakness and visual impairment are other medical conditions that can be seen frequently in the elderly and increase the odds of falls (Dhargave & Sendhilkumar, 2016). The use of multiple medicines is another risk factor of falls. Dizziness and fatigue are common side effects of medication. These conditions can lead to impaired balance and put older people at a higher risk of falling (Dhargave & Sendhilkumar, 2016).

Falls are the most common cause of unintentional injuries among the paediatric population in the United States and some European countries (Borse et al., 2009; de Domingo et al., 2017). Over one million children and adolescents referred to the emergency departments in the United States are due to falling (Scuffham et al., 2003). Falls are the third leading cause of death by unintentional injuries in children <9 years in Europe (MacKay & Vincenten, 2012). We showed that individuals <4 years were at the highest risk of fall-related mortality among Iranian children and adolescents. This can be due to the increasingly independent mobility and interest in exploring their surroundings (Savitsky et al., 2007).

Multiple studies showed that female gender is a risk factor of falls (Prato et al., 2017; Welmer et al., 2017). The mortality rate due to falls was, however, higher among males than females. A population-based survey showed that fall-related mortality rate was four-times greater in males than females (Li et al., 2019). Similar findings were achieved from our study. Work-related falls are more fatal than non-work-related ones (Li et al., 2019) and construction-related falls have been reported to be the most frequent causes of all the work-related falls (Al-Abdallat et al., 2015; Li et al., 2019; Rubio-Romero et al., 2013). According to the continued prevalence of a traditional culture in Iran, males are the income-earners in most families and most of adult Iranian females are home-based and this may be a reason of why falls are more fatal in men.

At provincial levels, our study showed that Hormozgan province had the highest increase in mortality rate due to falls among males and females. Zanjan province, however, had the highest reduction in fall-related deaths among both genders during the period of this study. Life style, level of urbanization and access to health facilities might cause the differences in trends of mortality. Access to emergency services is a predictor of mortality rate. An undeveloped emergency service led to a higher mortality rate in treatable cases. Studies at the provincial level in Iran indicated that Hormozgan province was among the most undesirable and undeveloped provinces based on indicators of access to health care (Roshanaei et al., 2016; Tahari et al., 2012). The reason for the high mortality rate at the borders of the country might be due to the low human development index compared with other provinces (Sabermahani et al., 2013).

Strengths and limitations

This was the first study conducted to estimate the mortality rate due to falls at national and subnational levels in Iran. The data of genders and age-groups were also provided. The present study used various methods to assess mortality rate. There were, however, some limitations. Using more covariates in the model may improve the estimations. The predictors of fall-related mortality were not evaluated in age groups and genders. Different socio-cultural factors were related to occurrence of falls (Bhattacharya & Singh, 2018). This data can be useful to provide preventive strategies and should be assessed in future studies. This study revealed the death rates due to falls as unintentional injuries but no information about falls due to suicide and homicide was reported. Further national studies are needed to have a better perspective about these injury events.

Future directions

The implementation of fall-preventive programmes is needed to decrease the prevalence, burden and mortality of this condition. To date, most of these strategies are expensive and are implemented by trained personnel at luxurious settings (Dadgari et al., 2015). The public availability of the current preventive strategies are, therefore, low. Home-based programmes are essential to increase the efficacy of preventive strategies. The U.S. Preventive Services Task Force recommended that clinicians selectively offer multifactorial interventions to prevent falls in people aged 65 years and older (Grossman et al., 2018). Few studies with small sample sizes in Shahroud city of the Semnan Province in Iran showed the efficacy of home-based exercises in reducing the incidence of falls among elderly (Dadgari et al., 2015, 2016) but no large-scale provincial or national study assessed the efficacy of different interventions to prevent falls in Iran and further efforts are required to make people more aware of these programmes.

Setting laws can decrease the mortality of work-related falls. The forth chapter of labour law in Iran mandated the occupational safety and health among workers. No other official law, however, has established to decrease the incidence of work-related unintentional injuries.

Conclusions

The fatal injuries due to falls decreased in Iran and most of its provinces from 1990 to 2015. Males, elderly people and children less than 4 years were at the highest risk of fall-related deaths and future preventive interventions should target these specific populations.

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