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# The trend of burn mortality in Iran — A study of fire, heat and hot substance-related fatal injuries from 1990 to 2015

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## ABSTRACT

**Introduction:** Burn injuries are a major cause of preventable mortality worldwide. To implement preventive strategies, a detailed understanding of the rate and trend of fatal burn injuries is needed. The aim of this study was to determine the rate and trend of burn mortality at national and province level in Iran from 1990 to 2015.

**Materials and Methods:** The data were retrieved from various sources: the Death Registration System, cemetery databases, the Demographic and Health Survey and three national

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population and housing censuses. ICD-10 codes were converted to Global Burden of Disease (GBD) codes for comparability. After addressing the incompleteness of death data, statistical methods such as spatio-temporal modelling and Gaussian Process Regression (GPR) were applied to estimate the levels and trend of death and cause specific mortality.

**Results:** The number of deaths due to burning across Iran was 80,625, with a male to female ratio of 0.88, 0.94 and 1.14 in 1990, 1995 and 2015, respectively. The annual percentage change of age-standardized death rate from 1990 to 2015 was  $-5.42\%$  and  $-4.22\%$  in women and men, respectively. The burn-related age-standardized mortality rate decreased considerably from 5.97 in 1990 to 1.74 per 100,000 in 2015. The mortality rate due to burns was highest among those aged more than 85 years, especially in Ilam province.

**Conclusion:** This study showed a decline in burn mortality in Iran from 1990 to 2015. Continued efforts to reduce the burden of burns are needed to accelerate this progress and prevent injuries.

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## 1. Introduction

Burn injuries are a universal health problem and an important cause of death with nearly 180,000 deaths each year. The greatest burden is in low- and middle-income countries [1] where more than 95% of all burn deaths occur [2].

Smolle et al. recently conducted a systematic review on journal publications from 2001 to 2016 for trends in burn epidemiology globally. In 13 countries, including Australia, Austria, Canada, Israel, Mexico, the Netherlands, the Oman, China, South Korea, Sweden, Germany, the United Kingdom and the United States, burn mortality has decreased. In four studies conducted in the Netherlands, Singapore, China and Finland no trend in burn mortality was observed [3] while in one study from Bulgaria, burn-related mortality has increased [4]. A population-based study by Navarrete and Rodriguez from 2000 to 2009 in Colombia, South America, indicated the crude and adjusted burn mortality rate in 5448 burn-related mortalities was 1.27 and 1.30 per 100,000, respectively [5]. In 2006, the death rate due to burns was 1.2 per 100,000 population in the United States, compared to 3.8 per 100,000 in Iran [6].

In low- and middle-income countries burns continue have a high incidence and are a main problem to the healthcare provider and society [7]. Burn injury is ranked eighth amongst the leading causes of death in Iran [8]. In a study in the north west of Iran, the six-year burn mortality rate from 2010 to 2016 was 2.9%, and was greatest in the period from 2011 to 2013 [9]. Another study indicated a mortality rate among patients with burn injury in Iran ranging from 1.4 to 9.7 per 100,000 [10]. Iran is an upper middle income country, where the mortality rate due to burn is high and causes of burn are changing over time [9]. According to the WHO, deaths from burns are preventable [11] and it supports the development and use of an international burn registry to increase the number of effective programs for burn prevention [1]. Thus, conducting accurate epidemiological studies nationwide is essential to provide accurate statistics. Trend and prevalence studies can guide national policy programmers to design plans for reducing the incidence of burn and its outcomes. The aim of this study was to determine the trend of burn mortality at national and provincial levels in Iran from 1990 to 2015.

## 2. Materials and methods

### 2.1. Study design

The National and Sub-National Burden of Disease (NASBOD) study was designed to determine the burden of 290 diseases and their 67 contributing risk factors from 1990 to 2015 in both national and provincial levels in Iran. The study classified cases into 19 age groups; these were organized in 5-year intervals, except for neonatal and children, which were 0 to 1-year and 1 to 4-years, and for individuals over 85 years old, whose age group was defined as 85+. The cause of death codes were initially based on the 10th International Classification of Disease (ICD-10) and later transformed to Global Burden of Disease (GBD) 2013 study codes by a group of expert physicians [12-19].

### 2.2. Data source

The authors used the Death Registration System (DRS) in Iran from the 1995 to 2010. Death data from 'Behesht-e-Zahra' cemetery (Tehran) from 1995 to 2010 and 'Bagh-e-Rezvan' cemetery (Esfahan) from 2007 to 2010 were not available in the DRS. These data were gathered separately from each cemetery and added to the dataset. The national population and housing censuses, conducted by the Statistical Center of Iran in 1996, 2006, and 2011 were used to obtain population numbers based on age and sex groups. The populations for each of the groups from 1990 to 2015 were then estimated using a growth model.

### 2.3. Data issue

DRS in Iran is incomplete, and the available information can be sparse. The administrative boundaries in Iran have been modified from 24 provinces in 1990 to 31 in 2015. The data was therefore adjusted based on 31 provinces. There were misclassifications of age-sex groups, geographical locations, and causes of death. This data was also prone to missing values in other fields. The incompleteness of the DRS due to an inability to detect or register all the deaths were treated as missing. After cleaning and preparing the data, we used different statistical methods to estimate levels and trends of death and cause-specific mortality rates for each age-sex-province group. The methods for estimating attributed mortality rates for children and adult were different.

## 2.4. Statistical modeling

In a parallel study administered by Mohammadi et al. [15,16] a spatio-temporal model and Gaussian Process Regression (GPR) were applied to predict levels and trends of child and adult mortality rates in Iran from 1990 to 2015; we used both of these methods in our current study.

### 2.4.1. Child mortality rate (CMR)

To estimate CMR, we used two different approaches: Summary Birth History (SBH) and Complete Birth History (CBH). In the former, Maternal Age Cohort (MAC) and Maternal Age Period (MAP) methods were used to estimate the death rates and then with LOESS approach, these two methods were combined. The final estimate was then calculated by combining the results using GPR.

### 2.4.2. Adult mortality rate (AMR)

To calculate AMR, the first step is to assess the completeness of the DRS using mortality distributions. This method consists of the Generalized Growth Balance Method (GGB), Synthetic Extinct Generation (SEG), and Generalized Growth Balance – Synthetic Extinct Generation (GGB-SEG) models. After calculating the completeness, LOESS was used to incorporate these 3 estimates. The third step is to adjust the DRS data in order to correct for the death counts of the DRS. After that, by exploiting life tables, the adult mortality rate was computed. The final estimate of the adult mortality rate was calculated by applying the GPR model to the results.

### 2.4.3. Mixed effect and spatio-temporal model to estimate cause specific mortality

Having calculated the CMR and AMR, the key variables such as age, sex, the cause of death, and area of residence were extracted from the data, and all data sets were merged into one data set. Encountering missing values for any of the variables was inevitable. Multiple imputation approaches were used to impute missing values of age and sex, and multinomial imputation was used to calculate missing values of the cause of death. A mixed effect model was implemented to obtain cause fractions to capture the effect of covariates on the dependent variable. A spatio-temporal model was used to extend these results from the period of 1995–2010 to 1990–2015. The mortality rates for each set of combinations were derived by applying the cause fractions to the total mortality rates from the Mohammadi et al. study [15]. To present the uncertainty intervals (UI), a spatio-temporal model was performed on a set of 1000 simulated random values drawn from a mixed effect model distribution, and the 2.5th and 97.5th percentiles were used, respectively, as the lower and upper bands. The burn mortality rates have been calculated for age-sex-province groups. Tables and figures were used to visualize the data; all calculations of data demonstration were done using Stata version 11 and R version 3.0.2 software. Therefore, much of the data is extrapolated rather than collected primarily.

## 3. Results

Between 1990 and 2015, 80625 deaths related to burns in Iran (31 provinces) were recorded with a male: female ratio of 1.03.

In 1990, 1995 and 2015, the burn-related mortality was 3053 (M/F ratio=0.88), 4089 (M/F ratio=0.94), and 1398 (M/F ratio=1.14), respectively.

### 3.1. Age-standardized mortality rate with annual percentage change (APC) of death rate by sex

At the national level, the burn mortality age-standardized rate was 6.58 (95% UI: 5.14–8.43) per 100,000 for females and 5.44 (4.20–7.05) per 100,000 for males in 1990. This was reduced to 1.63 (1.29–2.07) and 1.85 (1.45–2.36) per 100,000 in 2015 for females and males, respectively. Among males and females, the highest age-standardized mortality rate was observed in 1995: 7.50 (5.87–9.59) per 100,000 in males and 8.33 (6.57–10.53) per 100,000 in females (Table 1). The burn-related age-standardized mortality rates for both sexes in 1990, 1995, and 2015 were 5.97 (4.63–7.68), 7.88 (6.19–10.01), and 1.74 (1.37–2.22) per 100,000, respectively.

Our provincial data revealed that in 1990 the highest female age-standardized mortality rates per 100,000 belonged to Razavi Khorasan (14.61 (11.54–18.42)), North Khorasan (10.58 (8.23–13.55)), and South Khorasan (9.94 (7.76–12.70)). These rates were reduced to 1.56 (1.22–1.98), 2.32 (1.82–2.96), and 2.86 (2.22–3.67), respectively in 2015. The same estimations were submitted sequentially for males from South Khorasan (10.54 (8.14–13.62)), North Khorasan (10.17 (7.82–13.20)), and Razavi Khorasan (7.85 (6.11–10.09)) in 1990, which in 2015 were reduced to values of 3.64 (2.80–4.70), 3.06 (2.38–3.93), and 1.86 (1.45–2.39), respectively.

Similar to the national level data for both sexes, the highest burn-related age-standardized mortality rates during 1990–2015 were observed in 1995 in Razavi Khorasan (18.65 (14.80–23.33)), North Khorasan (13.80 (10.81–17.52)), and Kermanshah (12.41 (10.21–15.08)) per 100,000 respectively in females. These were reduced to 1.56 (1.22–1.98), 2.32 (1.82–2.96), and 3.52 (2.87–4.31) in 2015. Amongst males these figures belonged to North Khorasan (13.63 (10.61–17.53)), South Khorasan (13.16 (10.23–16.81)) and Razavi Khorasan (10.97 (8.63–13.95)) per 100,000. These were reduced to 3.06 (2.38–3.93), 3.64 (2.80–4.70), and 1.86 (1.45–2.39), respectively in 2015 (Table 1).

Alborz province had the lowest burn-related age-standardized mortality rate in the country in 1990 at 1.87 (1.41–2.48) for females and 2.31 (1.72–3.07) for males. This was reduced to 0.79 (0.60–1.03) for females and 0.70 (0.54–0.92) for males in 2015. Tehran had the lowest age-standardized burn-related mortality rate among provinces of Iran in females in 2015 (0.68 (0.48–0.95) per 100,000). The APC of mortality between 1990 and 2015 declined by 5.42% in females and 4.22% in males; however, the mortality rate distribution varied by province. Considering gender, the highest reduction in females was observed in Razavi Khorasan (8.57%) and in males was observed in Tehran (6.79%) (Table 1). Surveying the records, the least changes were registered in Hormozgan province in females and males, 3.34% and 2.47%, respectively. Fars province also was reported to have a decrease by 3.34% among females (Table 1).

### 3.2. Gender-specific mortality rate

In 1990, Alborz province was the only province with an age-standardized mortality rate from burns less than 2.92 per

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

| Province                    | Female               |                        |                       |                      |                     |                     |                         | Male                |                       |                      |                     |                     |                     |                         |
|-----------------------------|----------------------|------------------------|-----------------------|----------------------|---------------------|---------------------|-------------------------|---------------------|-----------------------|----------------------|---------------------|---------------------|---------------------|-------------------------|
|                             | Year                 |                        |                       |                      |                     |                     | APC<br>1990-2015<br>(%) | Year                |                       |                      |                     |                     |                     | APC<br>1990-2015<br>(%) |
|                             | 1990                 | 1995                   | 2000                  | 2005                 | 2010                | 2015                |                         | 1990                | 1995                  | 2000                 | 2005                | 2010                | 2015                |                         |
| Alborz                      | 1.87<br>(1.41-2.48)  | 2.44<br>(1.85-3.21)    | 2.36<br>(1.80-3.06)   | 1.80<br>(1.39-2.33)  | 1.27<br>(0.98-1.65) | 0.79<br>(0.60-1.03) | -3.41                   | 2.31<br>(1.72-3.07) | 3.18<br>(2.40-4.20)   | 2.81<br>(2.15-3.67)  | 1.94<br>(1.49-2.52) | 1.22<br>(0.94-1.58) | 0.70<br>(0.54-0.92) | -4.64                   |
| Ardebil                     | 5.72<br>(4.54-7.16)  | 7.61<br>(6.13-9.41)    | 6.47<br>(5.28-7.93)   | 5.24<br>(4.29-6.37)  | 3.76<br>(3.06-4.60) | 2.00<br>(1.61-2.47) | -4.12                   | 5.75<br>(4.54-7.26) | 8.71<br>(6.96-10.87)  | 7.51<br>(6.12-9.24)  | 5.87<br>(4.78-7.20) | 3.98<br>(3.23-4.89) | 2.16<br>(1.73-2.68) | -3.83                   |
| Bushehr                     | 6.47<br>(5.11-8.21)  | 8.44<br>(6.75-10.55)   | 6.33<br>(5.12-7.79)   | 5.04<br>(4.08-6.21)  | 3.64<br>(2.92-4.54) | 2.04<br>(1.61-2.59) | -4.50                   | 5.14<br>(4.02-6.55) | 7.16<br>(5.68-9.00)   | 6.77<br>(5.44-8.40)  | 5.56<br>(4.49-6.90) | 3.95<br>(3.15-4.95) | 1.79<br>(1.40-2.29) | -4.12                   |
| Chahar Mahall and Bakhtiari | 6.05<br>(4.83-7.55)  | 7.30<br>(5.86-9.07)    | 5.85<br>(4.73-7.22)   | 4.45<br>(3.60-5.48)  | 3.22<br>(2.60-3.99) | 1.86<br>(1.49-2.32) | -4.60                   | 6.44<br>(5.10-8.10) | 8.78<br>(7.02-10.95)  | 7.42<br>(5.95-9.21)  | 5.77<br>(4.62-7.17) | 4.64<br>(3.70-5.79) | 2.58<br>(2.04-3.26) | -3.59                   |
| East Azarbaijan             | 7.71<br>(6.16-9.62)  | 10.27<br>(8.29-12.68)  | 8.75<br>(7.12-10.71)  | 5.49<br>(4.48-6.73)  | 3.24<br>(2.63-3.99) | 1.81<br>(1.46-2.25) | -5.63                   | 5.61<br>(4.43-7.05) | 8.82<br>(7.06-11.02)  | 8.50<br>(6.89-10.49) | 6.00<br>(4.86-7.37) | 3.87<br>(3.12-4.80) | 2.16<br>(1.73-2.70) | -3.73                   |
| Esfahan                     | 4.59<br>(3.52-5.99)  | 5.42<br>(4.18-7.01)    | 4.31<br>(3.34-5.54)   | 3.01<br>(2.33-3.87)  | 1.93<br>(1.49-2.49) | 1.07<br>(0.82-1.39) | -5.67                   | 3.83<br>(2.90-5.04) | 5.56<br>(4.24-7.24)   | 5.28<br>(4.07-6.84)  | 3.82<br>(2.94-4.95) | 2.84<br>(2.18-3.68) | 1.63<br>(1.25-2.13) | -3.37                   |
| Fars                        | 5.84<br>(4.62-7.35)  | 7.96<br>(6.37-9.92)    | 6.91<br>(5.59-8.52)   | 5.92<br>(4.79-7.30)  | 4.18<br>(3.36-5.19) | 2.50<br>(1.98-3.14) | -3.34                   | 4.88<br>(3.84-6.19) | 7.18<br>(5.71-9.02)   | 7.27<br>(5.84-9.03)  | 6.10<br>(4.91-7.58) | 4.41<br>(3.53-5.51) | 2.44<br>(1.94-3.09) | -2.73                   |
| Gilan                       | 5.17<br>(4.11-6.52)  | 5.85<br>(4.68-7.27)    | 4.55<br>(3.67-5.64)   | 3.34<br>(2.68-4.16)  | 2.32<br>(1.86-2.90) | 1.27<br>(1.01-1.60) | -5.46                   | 4.66<br>(3.69-5.86) | 5.85<br>(4.70-7.29)   | 5.41<br>(4.39-6.69)  | 4.03<br>(3.26-4.97) | 2.81<br>(2.26-3.48) | 1.61<br>(1.28-2.00) | -4.17                   |
| Golestan                    | 6.67<br>(5.31-8.35)  | 8.80<br>(7.08-10.90)   | 6.31<br>(5.11-7.78)   | 4.73<br>(3.83-5.83)  | 3.40<br>(2.73-4.23) | 1.96<br>(1.56-2.46) | -4.79                   | 6.22<br>(4.90-7.85) | 9.73<br>(7.75-12.17)  | 7.70<br>(6.19-9.56)  | 6.07<br>(4.89-7.54) | 3.96<br>(3.16-4.97) | 1.99<br>(1.57-2.52) | -4.45                   |
| Hamadan                     | 5.97<br>(4.85-7.34)  | 7.90<br>(6.46-9.62)    | 6.64<br>(5.48-8.02)   | 5.07<br>(4.19-6.12)  | 3.53<br>(2.89-4.30) | 2.02<br>(1.64-2.48) | -4.25                   | 5.58<br>(4.48-6.92) | 8.35<br>(6.78-10.24)  | 7.72<br>(6.33-9.39)  | 5.95<br>(4.88-7.22) | 4.23<br>(3.45-5.18) | 2.48<br>(2.00-3.07) | -3.20                   |
| Hormozgan                   | 5.29<br>(4.11-6.82)  | 7.54<br>(5.93-9.56)    | 6.00<br>(4.79-7.53)   | 5.32<br>(4.23-6.66)  | 3.89<br>(3.06-4.94) | 2.26<br>(1.75-2.92) | -3.34                   | 4.94<br>(3.85-6.31) | 7.92<br>(6.25-9.99)   | 8.09<br>(6.47-10.13) | 7.55<br>(6.01-9.45) | 4.18<br>(3.27-5.33) | 2.64<br>(2.03-3.43) | -2.47                   |
| Ilam                        | 8.69<br>(6.89-10.93) | 11.14<br>(8.83-14.01)  | 9.94<br>(7.97-12.41)  | 7.10<br>(5.66-8.83)  | 5.01<br>(3.98-6.30) | 2.77<br>(2.18-3.52) | -4.47                   | 6.57<br>(5.12-8.38) | 9.01<br>(7.07-11.40)  | 9.16<br>(7.25-11.54) | 6.84<br>(5.40-8.63) | 5.12<br>(4.03-6.48) | 2.89<br>(2.26-3.70) | -3.23                   |
| Kerman                      | 6.81<br>(5.53-8.36)  | 8.97<br>(7.37-10.91)   | 7.61<br>(6.30-9.19)   | 5.17<br>(4.25-6.28)  | 3.14<br>(2.54-3.86) | 1.80<br>(1.44-2.25) | -5.18                   | 7.67<br>(6.21-9.46) | 10.62<br>(8.66-13.00) | 9.93<br>(8.16-12.04) | 7.08<br>(5.80-8.60) | 4.53<br>(3.67-5.59) | 2.57<br>(2.05-3.22) | -4.28                   |
| Kermanshah                  | 8.69<br>(7.08-10.65) | 12.41<br>(10.21-15.08) | 11.52<br>(9.52-13.87) | 8.78<br>(7.26-10.59) | 5.91<br>(4.85-7.17) | 3.52<br>(2.87-4.31) | -3.55                   | 6.38<br>(5.16-7.86) | 8.82<br>(7.18-10.82)  | 8.97<br>(7.36-10.9)  | 6.63<br>(5.44-8.07) | 5.16<br>(4.20-6.30) | 2.98<br>(2.41-3.69) | -3.00                   |
| Khuzestan                   | 4.79<br>(3.81-6.02)  | 6.70<br>(5.35-8.36)    | 6.04<br>(4.86-7.49)   | 4.46<br>(3.60-5.52)  | 3.34<br>(2.68-4.14) | 1.99<br>(1.59-2.49) | -3.45                   | 3.44<br>(2.69-4.38) | 5.50<br>(4.36-6.93)   | 5.26<br>(4.18-6.59)  | 4.15<br>(3.30-5.18) | 3.26<br>(2.60-4.08) | 1.82<br>(1.44-2.3)  | -2.52                   |
| Kohgiluyeh and Buyer Ahmad  | 7.25<br>(5.48-9.53)  | 8.76<br>(6.68-11.46)   | 7.88<br>(6.08-10.17)  | 6.37<br>(4.97-8.14)  | 4.20<br>(3.27-5.38) | 2.23<br>(1.74-2.85) | -4.61                   | 6.54<br>(4.87-8.77) | 8.71<br>(6.58-11.55)  | 8.29<br>(6.31-10.80) | 7.13<br>(5.50-9.23) | 5.03<br>(3.88-6.50) | 2.72<br>(2.09-3.54) | -3.45                   |
| Kordestan                   |                      |                        |                       |                      |                     |                     | -4.38                   |                     |                       |                      |                     |                     |                     | -3.70                   |

(continued on next page)

Table 1 (continued)

| Province               | Female              |                     |                     |                   |                  |                  |       | APC<br>1990-2015<br>(%) | Male                |                    |                   |                  |                  |       |  | APC<br>1990-2015<br>(%) |
|------------------------|---------------------|---------------------|---------------------|-------------------|------------------|------------------|-------|-------------------------|---------------------|--------------------|-------------------|------------------|------------------|-------|--|-------------------------|
|                        | Year                |                     |                     |                   |                  |                  | Year  |                         |                     |                    |                   |                  |                  |       |  |                         |
|                        | 1990                | 1995                | 2000                | 2005              | 2010             | 2015             | 1990  |                         | 1995                | 2000               | 2005              | 2010             | 2015             |       |  |                         |
| Lorestan               | 6.75 (5.29-8.59)    | 9.30 (7.45-11.61)   | 8.32 (6.80-10.17)   | 6.36 (5.25-7.71)  | 3.88 (3.19-4.70) | 2.20 (1.80-2.69) | -5.85 | 5.47 (4.24-7.02)        | 7.90 (6.25-9.97)    | 7.65 (6.18-9.43)   | 5.84 (4.80-7.13)  | 3.89 (3.18-4.75) | 2.13 (1.72-2.62) | -5.10 |  |                         |
|                        | 7.81 (6.24-9.76)    | 10.14 (8.20-12.52)  | 7.90 (6.49-9.58)    | 5.41 (4.45-6.55)  | 3.40 (2.78-4.15) | 1.73 (1.40-2.13) |       | 7.54 (5.99-9.50)        | 10.29 (8.28-12.73)  | 8.90 (7.26-10.92)  | 5.90 (4.82-7.22)  | 3.79 (3.08-4.66) | 2.04 (1.64-2.53) |       |  |                         |
| Markazi                | 5.66 (4.51-7.09)    | 7.32 (5.88-9.09)    | 6.02 (4.90-7.36)    | 4.52 (3.68-5.54)  | 2.98 (2.40-3.69) | 1.55 (1.24-1.95) | -5.04 | 5.37 (4.26-6.75)        | 7.43 (5.98-9.24)    | 7.05 (5.73-8.67)   | 5.66 (4.58-6.95)  | 4.07 (3.27-5.04) | 2.22 (1.77-2.78) | -3.47 |  |                         |
|                        | 5.62 (4.43-7.13)    | 6.51 (5.15-8.21)    | 5.13 (4.06-6.47)    | 3.56 (2.80-4.52)  | 2.37 (1.85-3.04) | 1.23 (0.95-1.60) |       | 4.81 (3.78-6.10)        | 6.41 (5.07-8.08)    | 5.29 (4.19-6.66)   | 4.16 (3.27-5.27)  | 2.83 (2.21-3.61) | 1.62 (1.25-2.10) |       |  |                         |
| Mazandaran             | 5.62 (4.43-7.13)    | 6.51 (5.15-8.21)    | 5.13 (4.06-6.47)    | 3.56 (2.80-4.52)  | 2.37 (1.85-3.04) | 1.23 (0.95-1.60) | -5.89 | 4.81 (3.78-6.10)        | 6.41 (5.07-8.08)    | 5.29 (4.19-6.66)   | 4.16 (3.27-5.27)  | 2.83 (2.21-3.61) | 1.62 (1.25-2.10) | -4.25 |  |                         |
|                        | 10.58 (8.23-13.55)  | 13.80 (10.81-17.52) | 10.71 (8.47-13.49)  | 7.27 (5.75-9.12)  | 4.15 (3.28-5.26) | 2.32 (1.82-2.96) |       | 10.17 (7.82-13.2)       | 13.63 (10.61-17.53) | 12.12 (9.51-15.43) | 8.30 (6.54-10.54) | 5.92 (4.64-7.54) | 3.06 (2.38-3.93) |       |  |                         |
| North Khorasan         | 7.35 (5.95-9.06)    | 8.04 (6.53-9.82)    | 6.33 (5.18-7.74)    | 4.44 (3.62-5.42)  | 2.86 (2.32-3.52) | 1.54 (1.23-1.91) | -6.07 | 7.04 (5.66-8.77)        | 8.76 (7.08-10.79)   | 7.57 (6.18-9.28)   | 5.36 (4.37-6.55)  | 3.53 (2.86-4.34) | 1.84 (1.48-2.28) | -5.23 |  |                         |
|                        | 3.20 (2.36-4.32)    | 3.99 (2.95-5.37)    | 3.80 (2.85-5.06)    | 3.03 (2.28-4.02)  | 1.80 (1.36-2.39) | 1.07 (0.80-1.42) |       | 5.05 (3.71-6.89)        | 6.55 (4.85-8.80)    | 5.95 (4.46-7.91)   | 4.43 (3.34-5.87)  | 3.52 (2.67-4.64) | 1.75 (1.32-2.31) |       |  |                         |
| Qom                    | 14.61 (11.54-18.42) | 18.65 (14.8-23.33)  | 15.04 (12.06-18.74) | 8.58 (6.85-10.72) | 3.21 (2.53-4.04) | 1.56 (1.22-1.98) | -8.57 | 7.85 (6.11-10.09)       | 10.97 (8.63-13.95)  | 11.84 (9.39-14.93) | 7.40 (5.83-9.36)  | 3.59 (2.82-4.58) | 1.86 (1.45-2.39) | -5.60 |  |                         |
|                        | 8.22 (6.33-10.61)   | 8.94 (6.92-11.50)   | 6.87 (5.37-8.76)    | 4.67 (3.65-5.94)  | 2.98 (2.33-3.81) | 1.66 (1.29-2.14) |       | 6.90 (5.28-9.03)        | 9.22 (7.08-11.89)   | 8.29 (6.46-10.62)  | 6.11 (4.75-7.82)  | 4.33 (3.37-5.59) | 2.43 (1.87-3.14) |       |  |                         |
| Semnan                 | 8.44 (6.42-11.07)   | 10.57 (8.11-13.71)  | 9.20 (7.15-11.79)   | 6.39 (4.97-8.19)  | 4.45 (3.46-5.73) | 2.45 (1.89-3.16) | -4.83 | 7.15 (5.39-9.48)        | 8.86 (6.74-11.61)   | 7.80 (5.99-10.14)  | 5.96 (4.61-7.68)  | 4.42 (3.42-5.70) | 2.83 (2.18-3.68) | -3.64 |  |                         |
|                        | 9.94 (7.76-12.7)    | 11.64 (9.15-14.75)  | 10.40 (8.21-13.08)  | 7.46 (5.89-9.40)  | 4.97 (3.89-6.32) | 2.86 (2.22-3.67) |       | 10.54 (8.14-13.62)      | 13.16 (10.23-16.81) | 12.16 (9.53-15.45) | 9.11 (7.15-11.62) | 6.63 (5.17-8.50) | 3.64 (2.80-4.70) |       |  |                         |
| Sistan and Baluchestan | 4.39 (3.02-6.40)    | 4.91 (3.40-7.01)    | 3.50 (2.47-4.91)    | 2.26 (1.61-3.17)  | 1.25 (0.89-1.75) | 0.68 (0.48-0.95) | -7.19 | 4.14 (2.81-6.09)        | 4.93 (3.41-7.11)    | 3.70 (2.60-5.25)   | 2.39 (1.69-3.37)  | 1.36 (0.97-1.91) | 0.71 (0.50-1.00) | -6.79 |  |                         |
|                        | 6.10 (4.84-7.65)    | 7.96 (6.42-9.85)    | 7.71 (6.31-9.40)    | 6.15 (5.07-7.46)  | 4.03 (3.31-4.90) | 2.32 (1.89-2.85) |       | 4.50 (3.54-5.71)        | 6.58 (5.25-8.22)    | 6.58 (5.34-8.08)   | 5.62 (4.59-6.87)  | 3.71 (3.01-4.55) | 2.14 (1.73-2.65) |       |  |                         |
| West Azarbaijan        | 6.04 (4.78-7.61)    | 7.19 (5.72-9.01)    | 6.04 (4.83-7.54)    | 4.39 (3.50-5.49)  | 2.75 (2.18-3.47) | 1.51 (1.19-1.92) | -5.40 | 7.56 (5.95-9.53)        | 10.26 (8.11-12.92)  | 8.02 (6.37-10.07)  | 5.79 (4.60-7.27)  | 4.01 (3.18-5.06) | 2.24 (1.76-2.86) | -4.74 |  |                         |
|                        | 6.97 (5.41-8.96)    | 9.78 (7.83-12.15)   | 7.96 (6.49-9.73)    | 5.29 (4.27-6.52)  | 3.21 (2.52-4.09) | 1.63 (1.24-2.15) |       | 6.19 (4.76-8.07)        | 9.52 (7.55-12.00)   | 9.14 (7.39-11.26)  | 6.48 (5.20-8.07)  | 4.40 (3.42-5.63) | 2.31 (1.74-3.07) |       |  |                         |
| Zanjan                 | 6.58 (5.14-8.43)    | 8.33 (6.57-10.53)   | 6.89 (5.49-8.62)    | 4.80 (3.83-6.01)  | 2.94 (2.33-3.70) | 1.63 (1.29-2.07) | -5.42 | 5.44 (4.20-7.05)        | 7.50 (5.87-9.59)    | 6.95 (5.50-8.78)   | 5.07 (4.02-6.40)  | 3.35 (2.64-4.24) | 1.85 (1.45-2.36) | -4.22 |  |                         |
|                        | 6.04 (4.78-7.61)    | 7.19 (5.72-9.01)    | 6.04 (4.83-7.54)    | 4.39 (3.50-5.49)  | 2.75 (2.18-3.47) | 1.51 (1.19-1.92) |       | 7.56 (5.95-9.53)        | 10.26 (8.11-12.92)  | 8.02 (6.37-10.07)  | 5.79 (4.60-7.27)  | 4.01 (3.18-5.06) | 2.24 (1.76-2.86) |       |  |                         |

Data in parentheses are 95% uncertainty intervals.

100,000 in females, and Alborz and Khuzestan were the only provinces with an age-standardized mortality rate less than 3.49 per 100,000 in males. However, in 2015, Kermanshah was the only province with an age-standardized mortality rate more than 2.92 per 100,000 in females and South Khorasan was the only province with an age-standardized mortality rate more than 3.49 per 100,000 in males (Fig. 1).

### 3.3. Age-gender mortality rate of burn per 100,000

While the burn mortality rate increased between 1990 and 1995, it then declined between 1995 and 2015.

Overall, burn mortality rates in all ages and both sexes in 1990, 1995 and 2015 were 5.65 (4.38-7.27), 6.96 (5.47-8.83), and 1.74 (1.37-2.22) per 100,000, respectively. In Fig. 2, the gender-specific mortality rate has been demonstrated among different age groups at national level. Men and women older than 85 years had the highest rates of burn-related mortality. The trend of burn mortality among all age groups except those older than 85 years in most provinces of Iran was similar to the national level. In a few provinces, a different pattern was observed, such as Ilam and Ardebil (Appendix A). In 2015, among those older than 85 years in 18 of the 31 provinces of Iran, the mortality from burns in females was higher than males.

### 3.4. Time trends of burn-related mortality rate based on gender

At the national level, from 1990 to 1998, the female age-standardized mortality rate has been higher than for males. By 1998, the mortality rates in both sexes was the same. However,

from 1998 to 2015, recorded data were inverted and the mortality rate for males was higher than for females (Fig. 3).

In province-specific data, rates changed between the sexes during the time period with no clear patterns.

In several provinces such as Esfahan, Fars, and Tehran in the earlier years of the study, the age-standardized mortality rate amongst females was higher than males, but in the later years approaching 2015, the female mortality rate became lower than that of males. In some provinces, such as Chahar Mahall and Bakhtiari and South Khorasan, the male age-standardized mortality rate was always higher than in females, but the reverse pattern was observed in Kermanshah. In Alborz province, in earlier years, the male age-standardized mortality rate was higher than in females (in 1990 it was 1.87 (1.41-2.48) for females and 2.31 (1.72-3.07) for males) but in later years, the female age-standardized mortality rate was higher (in 2015, 0.79 (0.60-1.03) for females and 0.70 (0.54-0.92) for males). In Bushehr, the female age-standardized mortality rate was higher than for males in the earlier period, then lower, and more recently it became higher than the male mortality rate once again (Table 1).

## 4. Discussion

We described the trend of burn-related mortality rate in Iran according to age and sex at different provincial levels from 1990 to 2015. The results indicate that the mortality rate increased from 1990 to 1995 in both genders at the national level, and then the mortality rate decreased considerably until 2015. This pattern is detectable among most of the provinces of

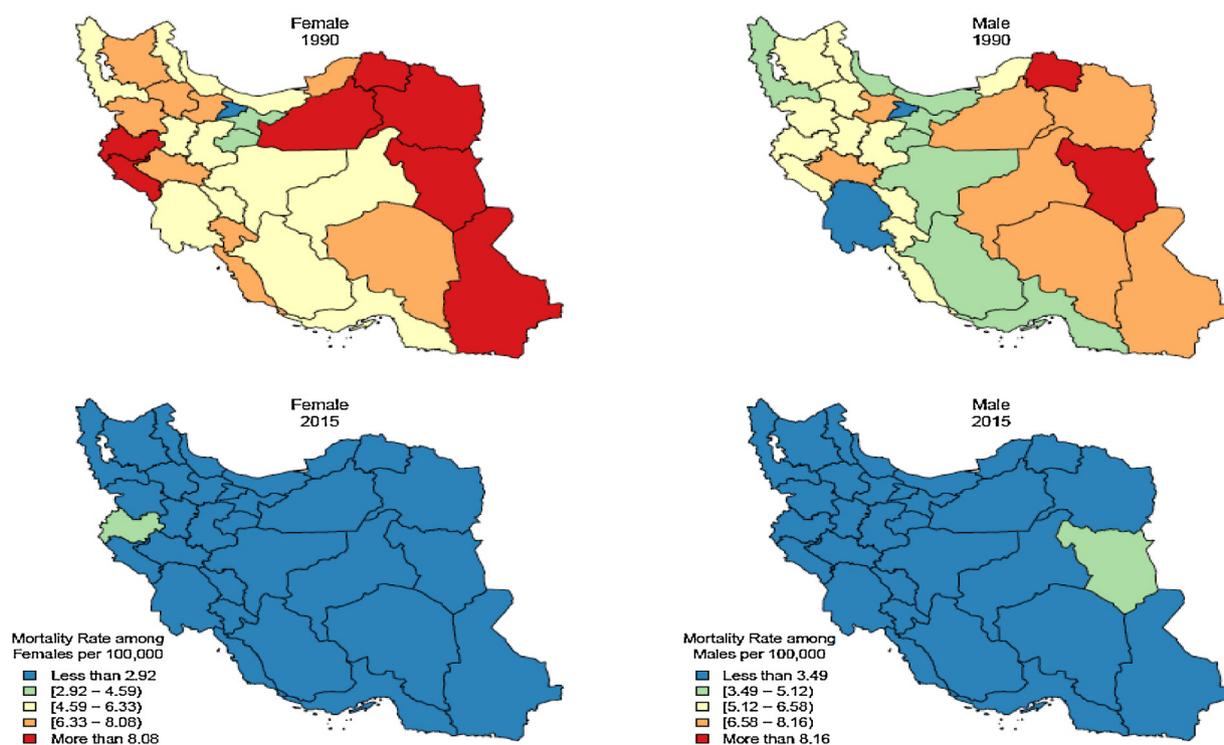
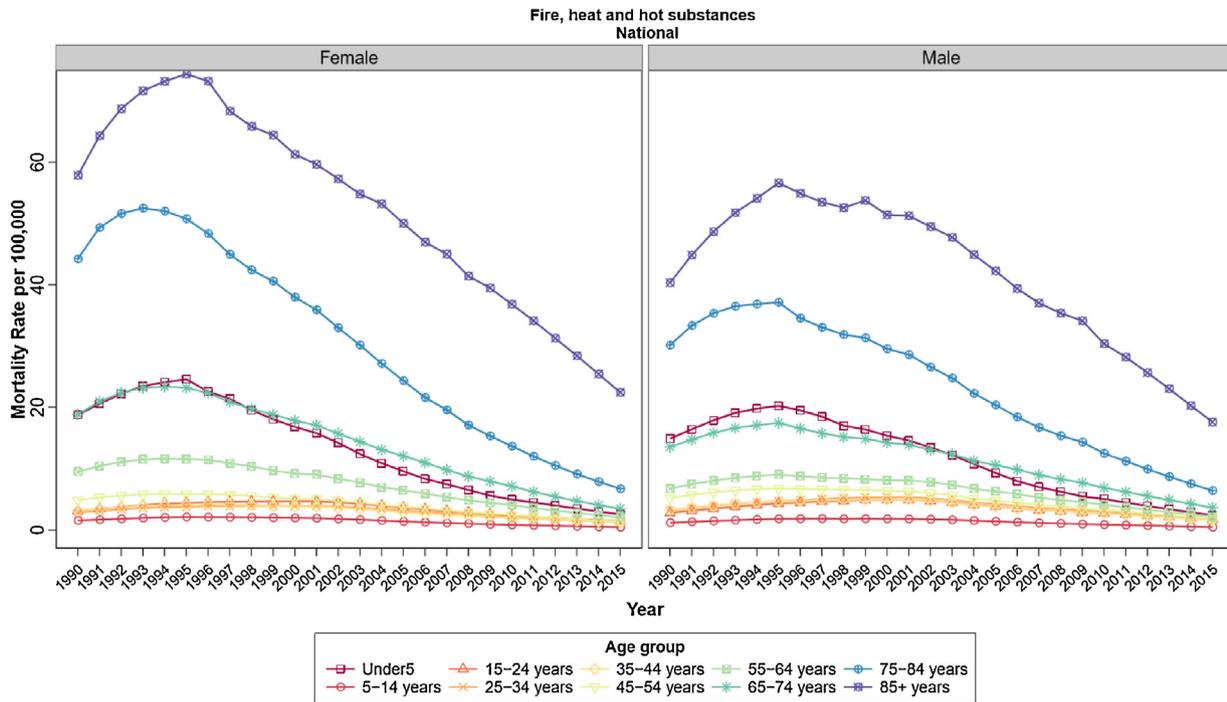


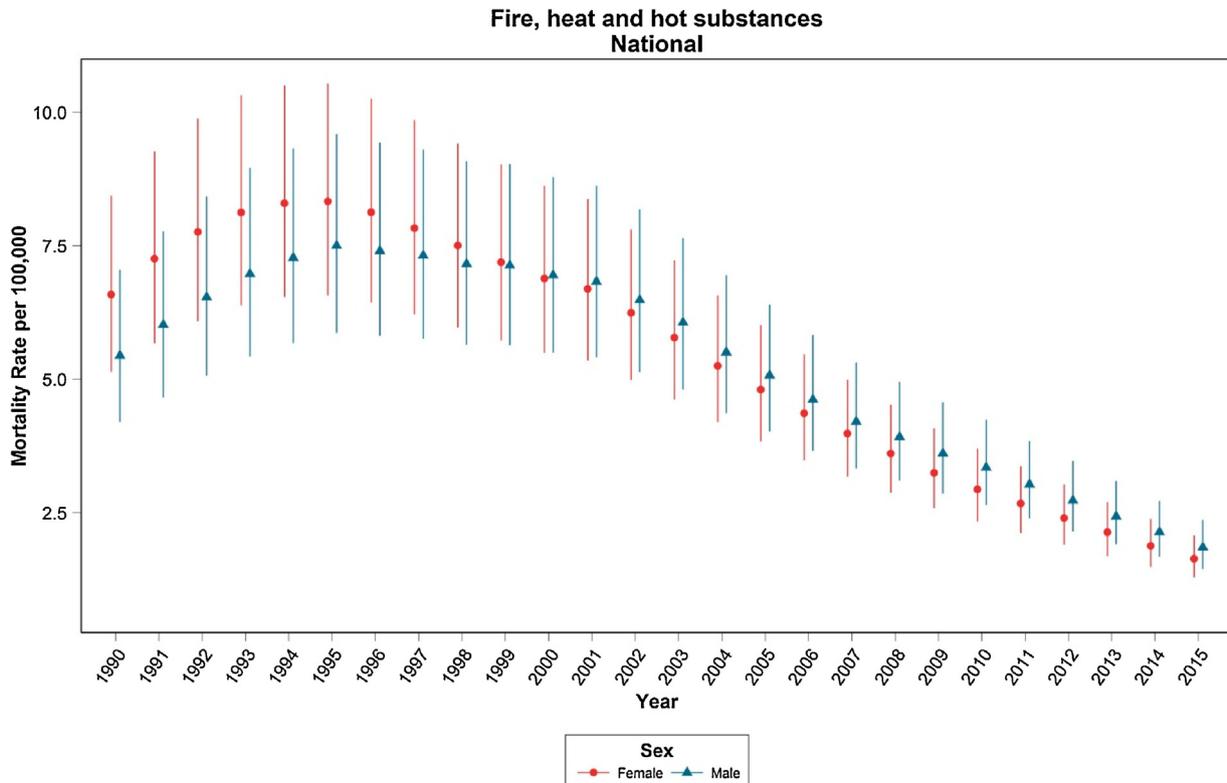
Fig. 1 – Age-standardized burn-related mortality rate among males and females in different provinces of Iran in 1990 and 2015.



**Fig. 2 – Burn-related mortality rate among females and males in different age groups in Iran from 1990 to 2015.**

Iran. Only among the older than 85 years age group is the trend not the same in some provinces of Iran. More efforts to reduce burns and their mortality through safety programs in Iran is needed.

Similar reductions of burn deaths have been reported during these years in other countries [3,20]. However, the health situation has not improved in recent years in several EMR countries [21,22].



**Fig. 3 – Time trend of burn-related age-standardized mortality rate among females and males in Iran from 1990 to 2015.**

A study about the mortality trends of burns in Chile from 1954 to 1999 indicated a reduction in the burn mortality rate from 7.03 to 0.53 per 100,000 [23]. In Colombia, the mortality rate of burn between 2000 and 2009 declined from 1.400 to 0.978 per 100,000 [5]. Many preventive factors might have a role in the reduction of burn mortality: wound dressing containing topical antimicrobials, early burn excision, multidisciplinary teams, and progress in critical care [20].

In our study the burn-related mortality rates per 100,000 in 1990, 1995 and 2015 were 5.6, 7.0 and 1.7 respectively and the age-standardized mortality rates per 100,000 in these years were 6.1, 7.9 and 1.7 respectively. Previous studies covering 2000 to 2004 in Iran reported rates of burn mortality ranging from 1.4 to 9.7 per 100,000 [10]. The mortality rate due to burns between 1998 and 2001 in a Tabriz referral burn center was reported to be 5.6 per 100,000 [24]. Also, in a study in Fars province in the south west of Iran during 1994-1998, this figure was 4.6 per 100,000 [25]. In Colombia during the 2000 to 2009 period, the crude and standardized burn mortality rate was 1.27 and 1.3 per 100,000, respectively [5]. In a study in Korea the burn mortality rate was 1.3 per 100,000 in 2001 [26] and for USA this figure was 1.09 per 100,000 in 2007 [27]. The global mortality rate of burns is 2.9 per 100,000 [28].

The elderly population ( $\geq 85$ ) had the highest mortality rate in our study. In line with our study, several researchers demonstrated that there is a correlation between age and mortality following burns with elderly patients usually bearing a higher mortality [29,30]. A study in the UK indicated that patients older than 75 are the main victims of burn [31]. In Colombia patients less than 5 and over 65 years had higher mortality rates [5]. Conversely to our study, Kumar et al. indicated almost 89% of the fatalities were in the age group of 10-49 years [32], which is comparable to the study of Singh et al. [33]. In a study in Chile during the years 1954-1999 mortality rate due to burn in all age groups was decreased but the mortality rate in the elder group revealed a considerable increase from 4.28 to 11.03 [23].

In the present study at national level the burn mortality rate among females was generally higher than males from 1990 to 1998. In 1999 the mortality rates among both sexes was the same. However, in 2000 recorded data showed that the mortality rate was higher among males. The patterns are not similar; both are decreasing, but the male: female ratio has changed from less than 1 in 1990 to more than 1 in 2015.

There is a disagreement about gender differences in the burn mortality in other studies. Some studies have shown that female gender is a risk factor for burn mortality [34,35]. Others have indicated that there is not a significant association between burn mortality and gender [36]. Several studies have indicated that females experience a better survival following severe trauma than males, mainly due to the female sex hormones. By contrast the survival rate for thermal injury is higher in males than females [37,38].

In a study in Australia between 2005 to 2011 among 1,715 intensive care unit patients with acute thermal burns, the mortality rate for females ranged from 13% to 54% and for males ranged from 3% to 11% [39]. Definitive reasons for this discrimination are not clear, but some studies suggest that this discrepancy is related to skin graft failure, which is due to the extra abdominal fat in females [39].

In our study, even in 2015 after the reduction of burn mortality, among the 85+ years age group in 18 out of 31 provinces of Iran,

the burn mortality in females was higher than males. Provinces where this was the case included Ilam, Ardebil, and Kohkiluyeh and Buyer Ahmad which had the highest rate of burn mortality. Naghavi et al. studied the 20 highest-mortality rates of all diseases in Iran; death rates due to burns in men were ranked eleventh and in women ranked tenth [40]. In our study, not all risk factors for burns were investigated and we only studied age, sex, and provincial populations. Studies indicated death from burns is more common in areas with lower socioeconomic status [6,41,42]. One explanation is cultural barriers in Iran. A qualitative study showed that females receive less help after a fire catastrophe than males [43]. Furthermore, studies indicated that women are more likely to commit self-immolation than men [44,45]. In a study in the south west of Iran, the mortality rate was significantly higher for self-inflicted burns versus accidental burns (78.0% vs. 26.7%) [25]. A study in USA in 2008 indicated that self-inflicted burn patients were not at greater risk of mortality compared to accidental burn patients [46].

Self-immolation is common in low and middle income countries especially in Asia and Africa and is rare in high income countries [47]. The highest incidence of self-immolation has been reported in India and often among young women. In Europe, self-immolation occurs more often in men who are in their fourth and fifth decades of life [48]. Rates in some regions of Iran are high, with up to 71% of committed suicides being the result of self-immolation [47]. Although, suicide is forbidden in Islamic beliefs [49] self-immolation is the third most common method of suicide among all people [50] in Iran, and the third leading cause of years of life lost (YLL) among females in Iran [51].

The residents of Ilam have the highest rate of suicide in Iran. Self-immolation contributes 69% of all suicides by physical methods and young females are at high risk. Because the people of Ilam experienced bombing during the war Iran-Iraq in 1980-1988, this may be one of the reasons for psychological problems compared to people of other provinces of Iran [52]. Another reason is that in most Iranian families, women do the cooking and there is a high rate of burns at home [25,53].

Prevention measurements are needed for the high-risk groups, including those aged  $>85$  years, of Ilam, Ardebil, Kohkiluyeh and Buyer Ahmad, and Chahar Mahal and Bakhtiari as their improvement in burn mortality was less than in other provinces, especially for females older than 85 years in Ilam province. In this regard, demographic, cultural, economic, and health-related aspects of burn mortality that may vary across these provinces of Iran should be recognized. Then an appropriate interventional program is required to be implemented. A macro social-based program during long-term interventions was suggested by Ahmadi et al. in this regard [47].

A study by Hosseini et al. in the northwest of Iran from 2000 to 2016 indicated that the causes of burns changed during these years and chemical and gas explosion burns increased. Economic and pharmaceutical sanctions on Iran were reported by authors as related factors [9]. A study in Kohkiluyeh and Buyer Ahmad indicated mortality rates for accidental and self-inflicted burns were 0.24 and 3.81 per 100,000 person-year, respectively. There was a significant difference in the male: female ratio between accidental and self-inflicted burns [53].

Our study had several limitations. Increases in the reported mortality rate from 1990 to 1995 may be related to better

registration. Considering the retrospective design of the study, we were unable to further survey critical variables like economic and social status, causes of burn, TBSA (total body surface area), ABSI (abbreviated burn severity index), inhalation injury (INH), the number of surgical procedures, time from burn to operating theatre, suicide by burn, immediate or delayed death, all of which can lead us to better understand the situation. Changes in reporting and acceptance over time may increase reporting and hence the declining trends we have maybe higher as the under reporting may be higher in early years.

## 5. Conclusion

Our study reported a decline in burn rates in Iran in recent years. This is welcome news but efforts to reduce burns and injuries are needed to accelerate this progress and reduce the burden of burns in Iran. The disparities in rates by province and the changing patterns by sex throughout the time period are an indication of the possibilities that could be achieved. Indeed, the whole country could have the same rates of the lowest province

if adequate programs are in place to reduce the burden and continue the decline in burns and their related burden.

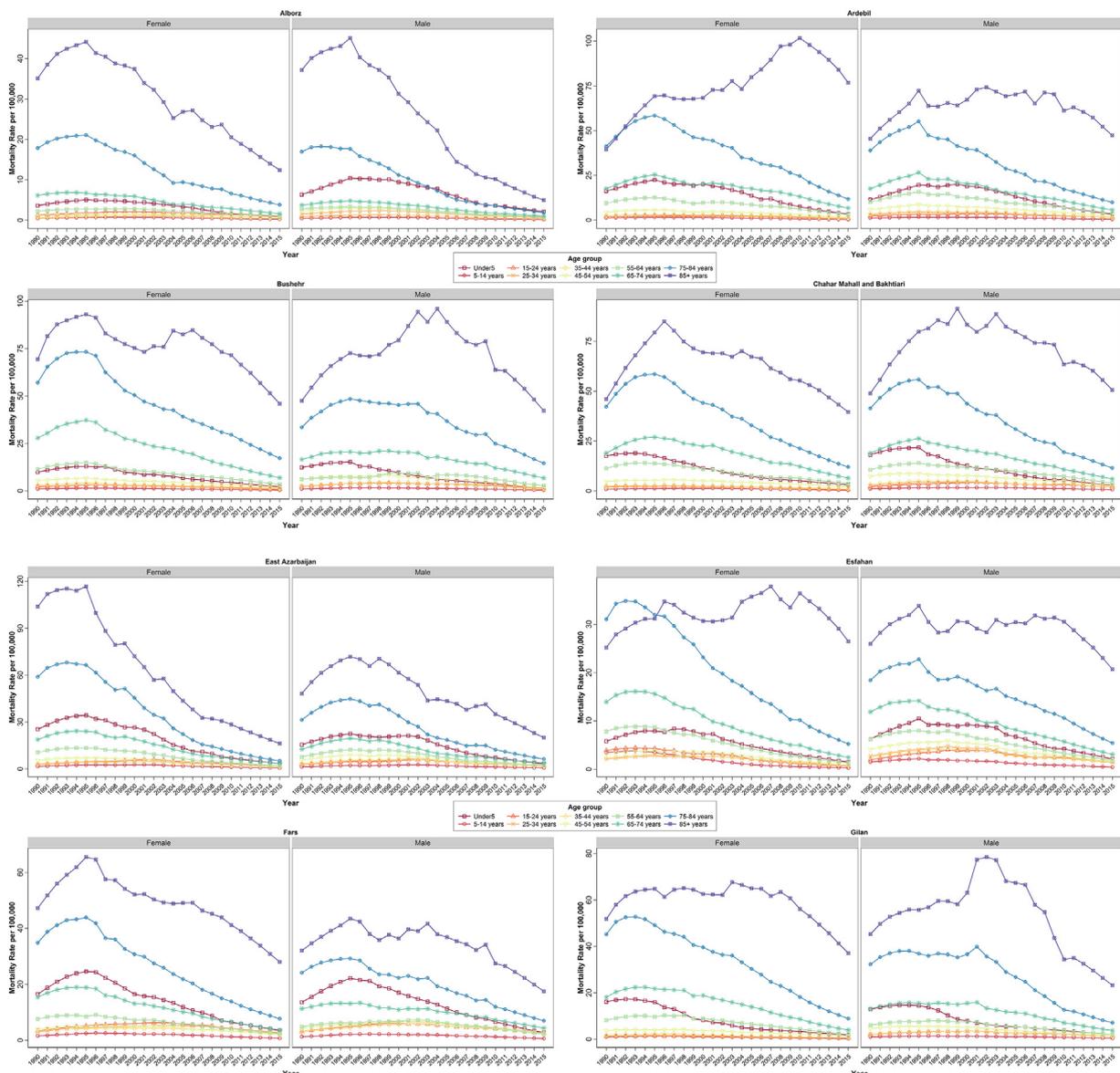
## Conflict of interest

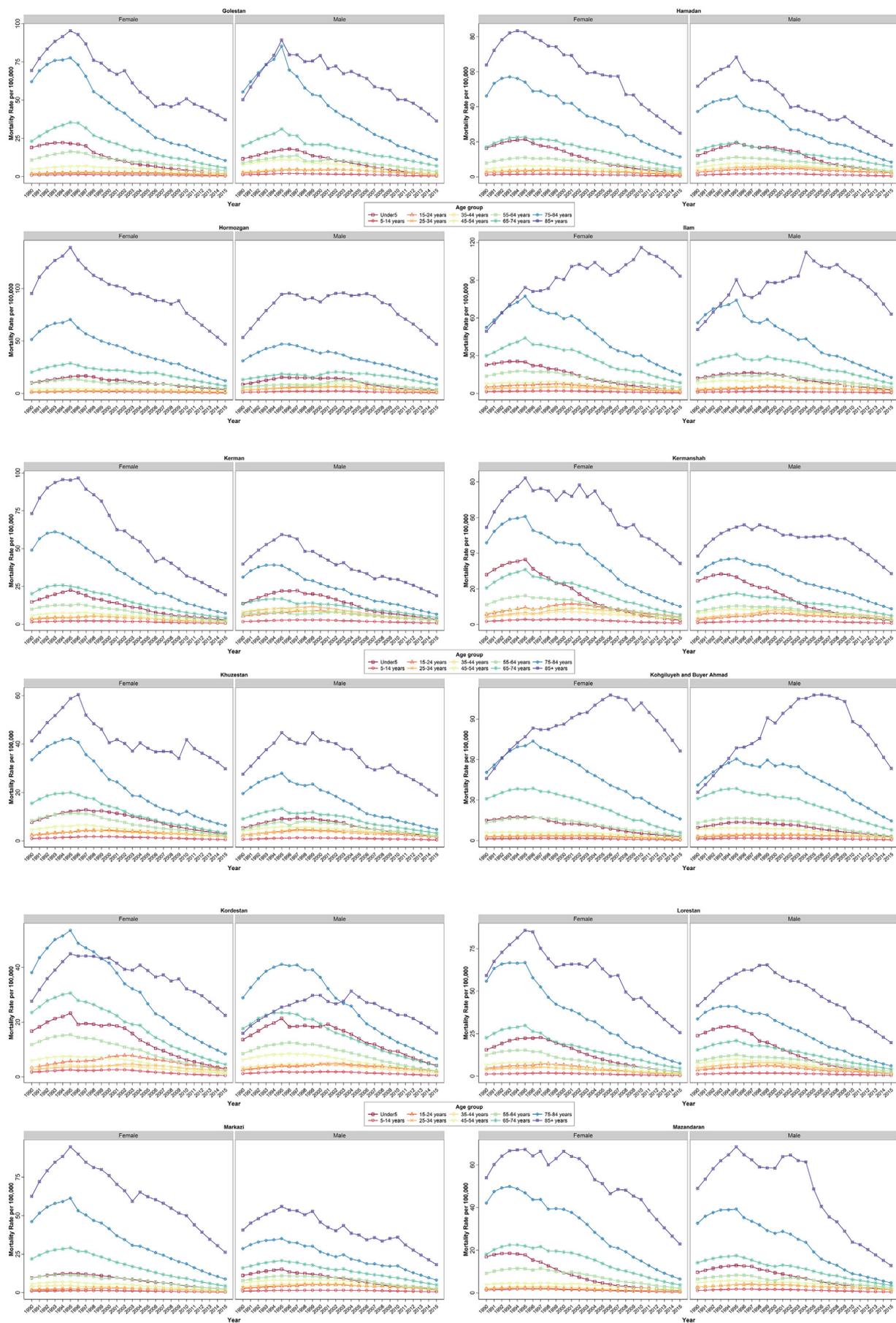
The authors declare that they have no conflict of interest.

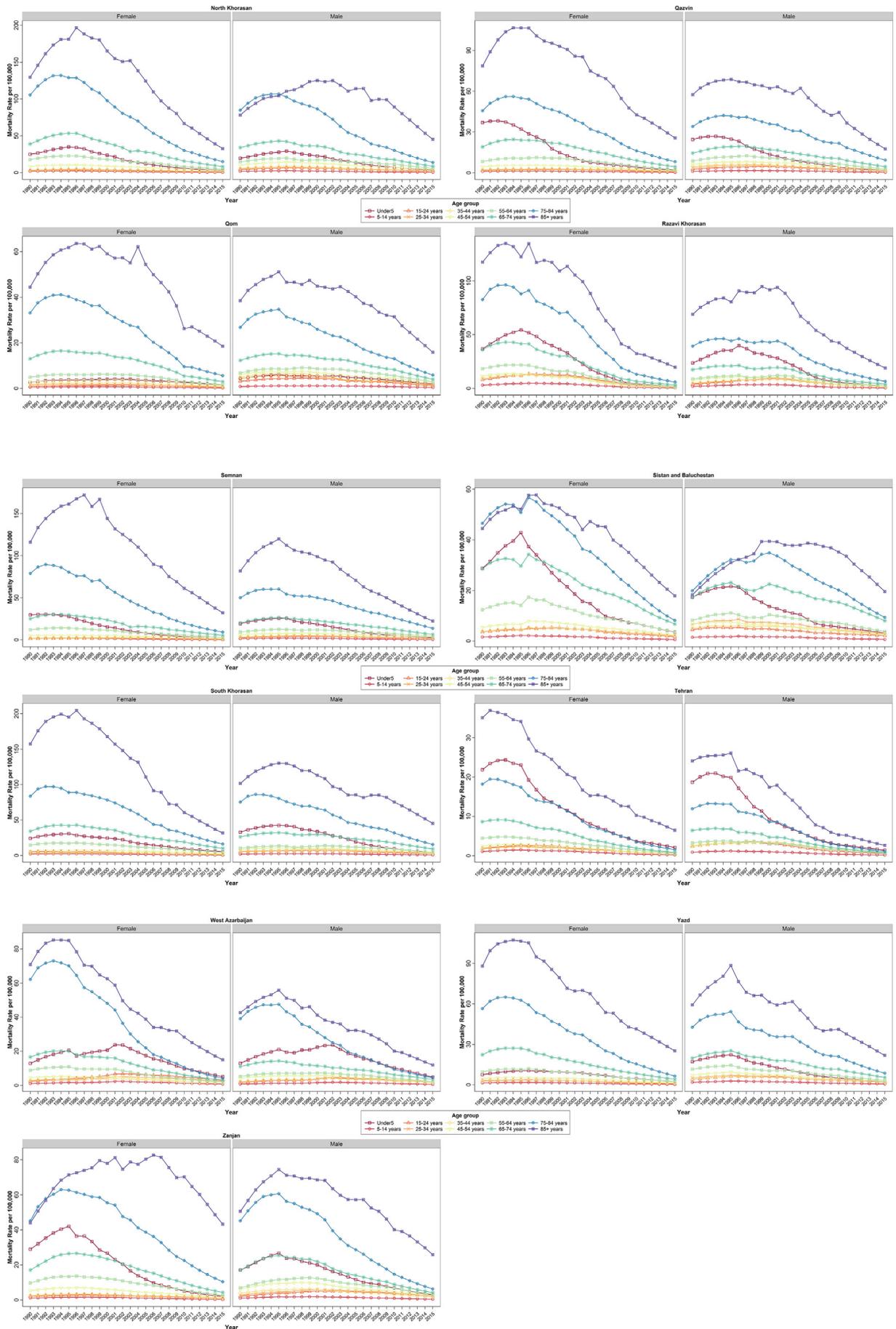
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## Appendix A.







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