Original Article

# A Burden Assessment of Occupational Exposures in Iran, 1990–2010: Findings from the Global Burden of Disease Study 2010

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## Abstract

**Background:** The present study describes the burden of occupational diseases in Iran based on the results of the Global Burden of Disease study conducted in 2010 (GBD 2010). This study aimed to determine the burden of occupational diseases in Iran based on the results of GBD 2010. It is a cross-sectional study. **Methods:** Disability-adjusted life years (DALYs) of occupational diseases were calculated based on the prevalence rates obtained through model estimation, as well as GBD 2010 disability weights and mortality rates obtained from different data registry systems of Iran. Causal association criteria application to select risk outcome pairs, estimation of exposure to each risk factor in the population, estimation of etiological effect size, selection of a counterfactual exposure distribution, risk assessment, and identification of burden attributable to each risk factor were the main conducted statistical steps. **Results:** There was an increasing trend of DALYs (710.08/100,000 people in 1990 and 833.00/100,000 people in 2005) followed by a slight decrease (833.00/100,000 in 2005–784.55/100,000 people in 2010). A total of 50.4% and 36% of total DALYs per 100,000 people were due to the adverse effects of musculoskeletal disorders and work-related injuries, respectively. **Conclusions:** Musculoskeletal disorders and work-related injuries are the most important adverse consequences of work-related risks that require urgent interventions to be controlled. Male workers (15–25 years and over 60) with the highest DALYs and mortality rates need more training programs, safety regulations, and higher level of protection support. In spite the decreasing trend of occupational disease related DALYs and death rates in Iran in recent years, a long-term effort is required to maintain the currently decreasing trend.

**Keywords:** *Global burden of diseases, Iran, occupational diseases*

## Introduction

To measure the burden of diseases and injuries in different populations, it is necessary to utilize scales and metrics to capture premature mortality, ill-health prevalence, and severity of diseases.[1] Such scales provide unique perspectives on the level of health and causes of diseases through combining information on mortality and nonfatal health outcomes. One of the main uses of population-based health metrics and scales is to provide an overall picture of diseases, injuries, and risk factors that largely contribute to health problems in a given population.[1]

A limited number of previous studies have measured the burden of diseases in Iran.[2,3] However, the Global Burden of Disease study 2010 (the GBD 2010) was conducted at an international level by the Institute for Health Metrics and Evaluation and reported data on health problems associated with cause-specific diseases and injuries worldwide, including Iran. It aimed to estimate DALYs and mortality rates due to different diseases and injuries to improve evidence-based policy-making and adopt appropriate risk management measures based on available evidence.[4] Accordingly, DALYs, death rates, YLLs, and YLDs were calculated.

The GBD 2010 comprehensively and comparatively assessed 291 diseases and injuries and their associated sequelae, in 1990, 1995, 2000, 2005, and 2010, through synthesizing available epidemiological data on all major diseases and injuries. Moreover, the study estimated DALYs attributable to the independent effects of 67 risk factors and clusters of risk factors in 21 regions in 1990 and 2010.[5,6] In this study, occupational exposures were defined as major risk factors categorized into seven main clusters, including: occupational carcinogens, occupational asthmagens,



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occupational particulate matters, gases and fumes, occupational noise, occupational risk factors for injuries, and occupational low back pain.[6]

This paper presents the results of the GBD 2010 on occupation-related diseases and death rates by age group, gender, type of exposure, and related outcomes in Iran between 1990 and 2010.

## Methods

### Study design and data sources

Several previous studies have assessed the burden of diseases and injuries caused by work-related hazards and occupational exposures; however, the estimated burdens reported by these studies vary considerably.[7-9] This raises concerns regarding the reliability and suitability of these studies; moreover, the observed variations have been mainly attributed to defects in available data.[8] To overcome this limitation, the World Health Organization (WHO) conducted one of the most appropriate and reliable studies called comparative risk assessment (CRA) and collected the most comprehensive data on mortality and morbidity from exposures to selected occupational hazards and their sequelae. The CRA results were then used in the GBD 2010.

### Variables assessment

Details regarding data collection method, data quality improvement and statistical modeling are described in related publications.[1-6,10-13] As an important advantage of the GBD 2010, it carried out a CRA to compute the proportion of deaths or diseases burden attributed to every risk factor. This important study included and investigated 20 age groups, both genders, and 187 countries during the years 1990, 1995, 2000, 2005, and 2010.[1,5] For the first time, this study provided a brief presentation of occupational exposures and diseases in Iran.

### Statistical analysis

Five steps have been defined to estimate the GBD attributable to risk factors such as occupational exposures and diseases, as follows:

1. Using causal association criteria to select risk outcome pairs to be included in the analysis: Concerning occupational exposure it was defined as the average hours per day when workers are exposed to work-related risks (measured/h/day). Musculoskeletal disorders, such as low back pain and neck pain, occupation-related transport injuries, other unintentional injuries (fall, drowning, fire, heat and hot substances, poisoning, and exposure to mechanical forces), chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD) and asthma, sense organ diseases, neoplasms such as trachea and bronchus, lung cancers, larynx cancer, and leukemia are the most frequent outcomes of occupational risk
2. Estimation of exposure to each risk factor in the population: In this systematic search of major risk factors, the published and unpublished data sources (when possible) were collected and categorized to estimate the distribution of occupational exposure risk factors in 1990 and 2010. The main strategy used to collect data on occupational risks was to utilize the results of the noncommunicable disease risk factors survey through adopting a methodology developed by the WHO to help countries establishing on-communicable disease surveillance systems
3. Estimation of etiological effect size: It is often used to calculate the relative risk per unit of exposure for each risk–outcome. To estimate occupational exposure, we used mixed effect regression method and Dis-Mod version 3
4. Selection of a counterfactual exposure distribution: In this step, the existing exposure distributions were compared with each other. Thus, an optimum exposure distribution and a theoretical-minimum-risk exposure distribution were selected by the global team
5. Estimation of uncertainly for all sources to assess the risks and identify corresponding burden attributable to each risk factor.

R-Studio Desktop for windows on Ubuntu 12.10 which is an open-source integrated development environment for R as a programming language for statistical computing and graphics was applied to draw graphs and figures.

## Results

### Frequency of occupational exposures and related sequelae

The GBD 2010 results in Iran showed that 70.42% and 15.03% of total DALYs were due to noncommunicable diseases and injuries, respectively.[14] Occupational exposures are the cause of a number of diseases and injuries and contribute to 30% of the attributable risk factors of DALYs.[15] Occupational exposures are the ninth major cause of DALYs in Iran, leading to around 580,277

DALYs in all age groups and both genders in 2010. Other risks including dietary risk, high blood pressure, high body mass index, physical inactivity, smoking, high fasting plasma glucose, ambient particulate matter pollution, and high total cholesterol are more in priority than occupational risk.[15]

In 2010, occupational exposure accounted for 37% of back pain (317,602 DALYs), 16% of hearing loss (21,657 DALYs), 13% of COPD, 11% of asthma (47,130 DALYs), 8% of injuries (182,610 DALYs), 9% of lung cancers, and 2% of leukemia (11,277 DALYs). Risks at work caused 850,000 deaths worldwide and resulted in the loss of around 24 million years of healthy life in 2010. Needle-stick injuries accounted for approximately 40% of hepatitis B and hepatitis C infections and 4.4% of HIV infections in health-care workers.[15]

Several sequelae of occupational exposures have been addressed, including musculoskeletal disorders, occupational injuries, chronic respiratory disorders, sense organ disease, and neoplastic disorders. As shown in Table 1, the disease categories and corresponding attributable risks induced by occupational exposures in 1990 and 2010 were separately compared and ranked. Only occupational low back pain contributed to 1.64% of total DALYs (429.41 DALYs per 100,000 people). Total DALYs increased from 1990 to 2010 for all work-related disorders listed in Table 1. There was a notable increase in DALYs over 20 years (a total of 190,999 DALYs) that was mainly due to a dramatic rise in low back pain and neck pain, exposure to mechanical forces, and COPD. Five main work-related disorders increased too; in 2010, musculoskeletal disorders with 9,317,602 DALYs and neoplasms with 11,277 DALYs had the highest and lowest mean DALYs, respectively.

### Total DALYs and death rates of occupational exposures (per 100,000) by both sexes and all age groups

Over the 20 years of the study (1990–2010), the total DALYs increased from 710.08 in 1990 to 719.15, 774.0, and 833.3 (per 100,000 people) in 1995, 2000, and 2005, respectively; then, it decreased for the next 5 years, reaching 784.55/100,000 people in 2010 in both genders and all age groups [Table 2]. As shown in Figure 1, death rate had a similar trend. The figure shows an increasing number of deaths from 1990 to 2005, which later decreased from 6.52 to 6.24 per 100,000 people in both genders and all age groups. YLLs and YLDs also had a similar trend as it increased over the first 15 years, and then, it had a significant decrease from 2005 to 2010.

### Trend of DALYs and death rates per 100,000 people, according to the age groups and gender

Although there was a small decrease in total DALYs and death rates over the first 15 years of the study (1990–2005), this pattern varied among different age groups. We investigated DALYs and death rates for the three main

**Table 1: Ranked disease categories due to occupational risk exposure based on their related disability-adjusted life year rates (per 100, 000) in 1990 and 2010 for total population (all age groups and both sexes) of Iran, findings of Global Burden of Disease study, 2010**

| 1990 | | | 2010 | | |
|---|---|---|---|---|---|
| **Rank** | **Disease categories** | **Mean DALYs number** | **Rank** | **Disease categories** | **Mean DALYs number** |
| 1 | Musculoskeletal disorders | 198,331 | 1 | Musculoskeletal disorders | 317,602 |
| 1.1 | Low back and neck pain | 198,331 | 1.1 | Low back and neck pain | 317,602 |
| 2 | Occupational injuries | 132,751 | 2 | Occupational injuries | 182,610 |
| 2.1 | Transport injuries | 65,159 | 2.1 | Transport injuries | 125,472 |
| 2.2 | Unintentional injuries other than transport injuries | 67,592 | 2.2 | Unintentional injuries other than transport injuries | 57,138 |
| 2.2.1 | Fall | 2290 | 2.2.1 | Fall | 5085 |
| 2.2.2 | Drawing | 10,363 | 2.2.2 | Drawing | 8739 |
| 2.2.3 | Fire heat and hot substances | 10,723 | 2.2.3 | Fire heat and hot substances | 10,630 |
| 2.2.4 | Poisoning | 9662 | 2.2.4 | Poisoning | 8348 |
| 2.2.5 | Exposure to mechanical forces | 182 | 2.2.5 | Exposure to mechanical forces | 8800 |
| 3 | Chronic respiratory disease | 36,127 | 3 | Chronic respiratory disease | 47,130 |
| 3.1 | COPD | 21,705 | 3.1 | COPD | 31,763 |
| 3.2 | Asthma | 14,421 | 3.2 | Asthma | 15,367 |
| 4 | Sense organ disease | 13,487 | 4 | Sense organs disease | 21,657 |
| 5 | Neoplasma | 8579 | 5 | Neoplasma | 11,277 |
| 5.1 | Trachea/bronchus/lung cancer | 6867 | 5.1 | Trachea/bronchus/lung cancer | 9009 |
| 5.2 | Larynx cancer | 604 | 5.2 | Larynx cancer | 716 |
| 5.3 | Leukemia | 1093 | 5.3 | Leukemia | 1511 |
| Total | | 389,278 | | Total | 580,277 |

COPD=Chronic obstructive pulmonary disease, DALYs=Disability-adjusted life year rates

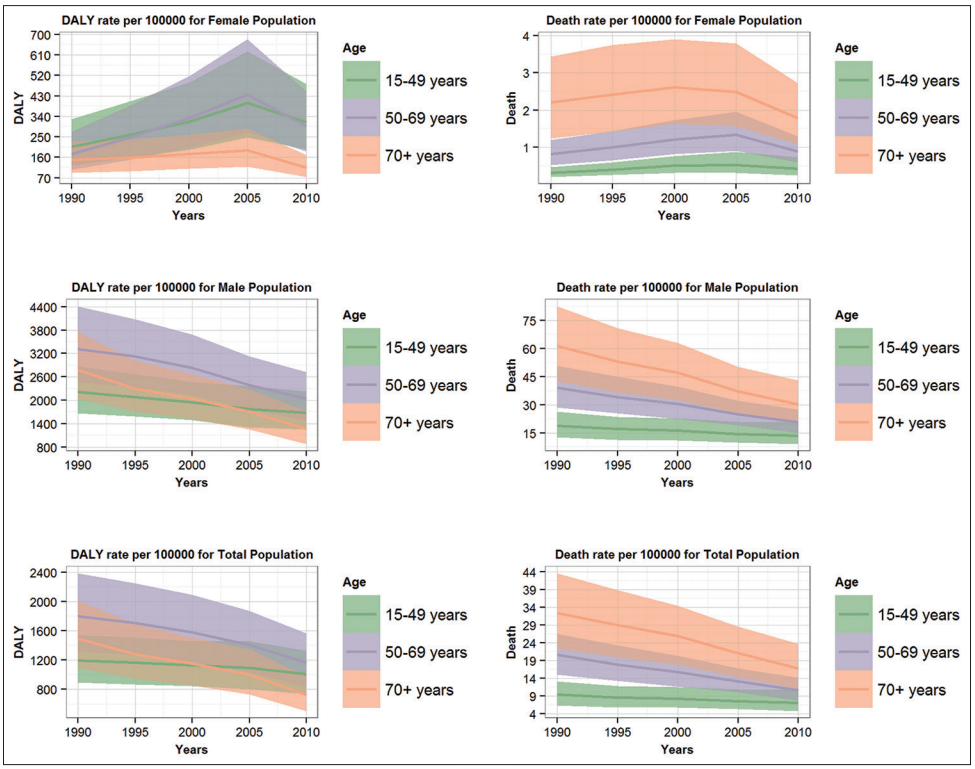


**Figure 1: Disability-adjusted life year rates (DALYs)(left) and Death rate (right) (per 100, 000) due to occupational risk exposure in Iran for both sexes and total population based on study years (1990, 1995, 2000, 2005, and 2010) and three age groups (15–49, 50–69, and 70+ years)**

**Table 2: Disability-adjusted life year rates, death rate, years of life lost, and years lived with disability per 100, 000 population due to occupational risk exposure in Iran according the five study year from 1990 to 2010**

| | 1990 | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|---|
| DALYs rate | 710.08 | 719.15 | 774.00 | 833.00 | 784.55 |
| Death rate | 6.53 | 6.22 | 6.54.16 | 6.52.23 | 6.24.22 |
| YLL | 286.00 | 274.34 | 294.36 | 294.43 | 280.61 |
| YLD | 423.14 | 444.65 | 479.16 | 538.26 | 503.16 |

DALYs=Disability-adjusted life year rates, YLL=Years of life lost, YLD=Years lived with disability

age groups including15–49 years, 50–69 years, and 70+ years. For those aged 15–49 years, there was a small decrease in total DALYs, and it was around 1200 years per 100,000 people during the study. We observed a dramatic decrease in the other two age groups, as it was 400 years in those aged 50–69 years and around 700 years in 70+ year age group [Figure 1].

Death rate per 100,000 people also decreased in all the three age groups; however, the highest DALYs were observed among those aged 50–69 years, and the highest death rate was observed among those aged 70+ years. Thus, occupational exposure apparently results in death in the latter age group more than in the other two age groups [Figure 1]. YLL for this group (280.61) was also higher than that among the other age groups. The death rate for those aged 50–69 years decreased by 9/100,000 people and was ranked the second, as compared with the two other groups. The rising YLD rate indicates the effect of occupational exposure in the incidence of disabilities among this age group [Figure 1]. Hence, the rate of death from occupational exposure is higher at 70+ age group while the risk of disability is higher in 50–69 age group. There was a small decrease in DALYs in 15–49 years age group, with no change in death rate (9/100,000 people). Taking into account DALYs and death rates in both females and males and in various age groups, clearly the trends vary by gender [Figure 1]. In general, both DALYs and death rates due to occupational exposures were more common in males than females in Iran in 2010. The highest prevalence of DALYs was just under 2000 years in males in 50–69 age groups, while it was around 300 years in females in the same age group and the same population. DALYs were higher in males than females in both 1990 (males: 3,200 vs. females: 200/100,000 people) and 2010 (males: 2,000 vs. females: 320/100,000 people) [Figure 1]. Moreover, death rate was higher in males than females in both 1990 (males: 60 vs. females: 2.2/100,000 people) and 2010 (males: 30 vs. females: 2/100,000 people) [Figure 1]. The trend of DALYs and death rates decreased in males in all the three age groups over the 20 years of the study. The highest level of DALYs was reported in people aged 50–69 years (3200 years in 1990–2000 years in 2010). The decreasing trend of death rates was also observed in those aged 70+ years from 60 in 1990 to around 32/100,000 people in 2010. There was a different DALYs and death rate per

100,000 people in female workers, with an increasing trend changing from 1990 to 2005 in all the three age groups. The DALYs peaked at around 430 years in 2005 in females aged 15–49 years and those aged 50–69 years old. The death rate showed a decreasing trend (2005–2010) from 2.2 to 1.7/100,000 in the female population.

In addition, we separately studied the trend of DALYs and death rate by age (15–80) in 1990 and 2010 [Figure 2]. As shown, there was an increase in DALYs per 100,000 people from 400 to 800 in 2010 and 800–1200 in 1990 in those aged 15–24 years old. Subsequently, the rise of DALYs continued smoothly in 1990. However, this was slightly different from the DALYs by age in 2010, which was nonchanged in people aged 24 through to those aged 75 years. In people aged 75 + years, the DALYs rate diminished from 2000 to 200 for 1990.

The trend of death rate by age group steadily increased from 2 (2010) to 4 (1990) per 100,000 people for those aged 15–19 years to 20 (2010) and 40 (2010) per 100,000 people for those aged 75–79 years. Considering the steadily increasing trend of DALYs and death rate (per 100,000 people), there was a significant reduction in those aged 75 + years in both 1990 and 2010 [Figure 2].

## Discussion

In this paper, we described the GBD 2010 results, focusing on the work-related risks and adverse consequences of occupational exposures. Numbers and rates of DALYs and death from occupational exposures increased from 1990 to 2005 in all age groups and both genders. There was subsequently a reducing trend from 2005, which reached its minimum level in 2010. Overall, because of the increase of DALYs by 200,000 years over the 20 years of the study, occupational exposure was ranked as the ninth leading cause of diseases and injuries. The contribution made by work-related risks to total DALYs has been proved by the CRA project, which was carried out by the WHO as one of the world's most important studies conducted to estimate DALYs from occupational risks.[4,9] Evaluating the CRA project, Fingerhut *et al*. reported the loss of around 24 million years of healthy life due to selected occupational risks, as well as 850,000 deaths, worldwide.[4] Although the CRA is the best estimate of global work-related DALYs, probably it has considerably underestimated the true number of deaths because of shortcomings in the available data.[8]

This high DALYs were mainly due to musculoskeletal disorders and work-related injuries. Indeed, 86.22% of total occupational disorders are due to a combination of these factors. It is also highlighted in the research related to burden of musculoskeletal disorders in the Eastern Mediterranean Region where Iran also included.[16] According to this study conducted based on the findings of GBD Study 2013, occupational ergonomic factor is one of the most crucial risk factors for musculoskeletal disorders. Around 1,545,221 (95% uncertainty interval 1,023,600–2,148,137) DALYs of low back or neck pain were attributable to occupational ergonomic factors.[17] On the other hand, musculoskeletal disorders mainly encompass neck and low back pain account for 54.7% of the total number of work-related DALYs.

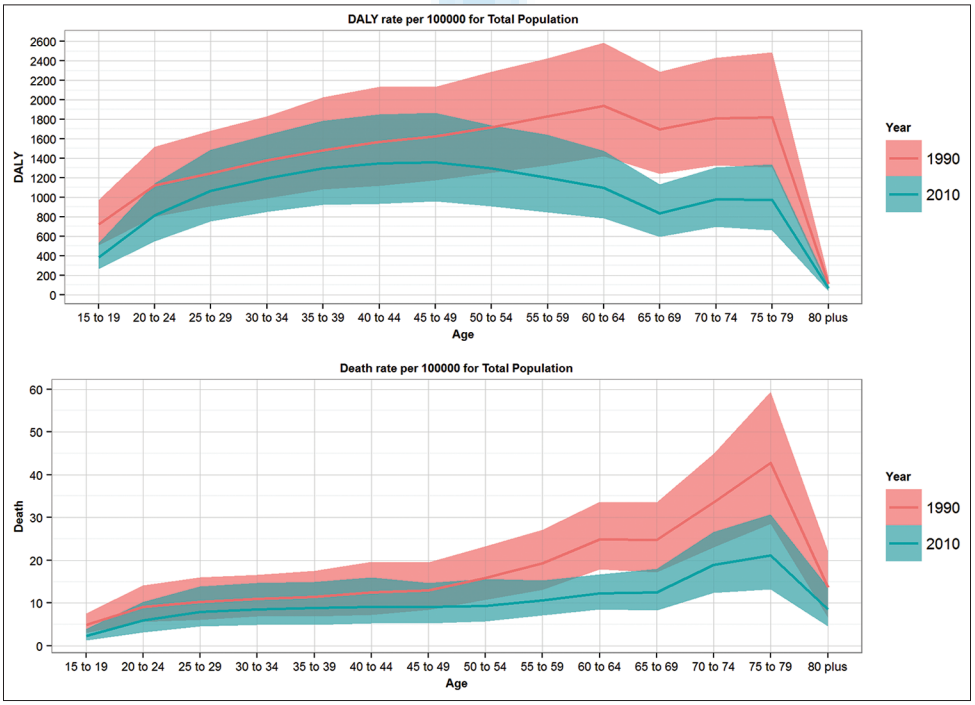


**Figure 2: Trends of disability-adjusted life year rates (DALYs) and death rates (per 100,000) due to occupational risk exposures in Iran for all age groups of total population in the year 1990 and 2010**

About 31.4% of the total DALYs are due to injuries. In other words, 68.5% and 31.5% of occupational injuries are due to transport and road injuries and unintentional injuries, respectively. Concha-Barrientos *et al*. reported that hazardous conditions in the workplace were responsible for a minimum of 312,000 unintentional fatal occupational injuries worldwide.[18] Fatal and nonfatal occupational injuries together resulted in around 10.5 million DALYs, which globally result in the loss of approximately 3.5 years of healthy life per 1000 workers every year. Occupational risk factors are responsible for 8.8% of the global burden of mortality due to unintentional injuries, and 8.1% of DALYs are attributable to this outcome.

The GBD 2010 results acknowledged that males were more at high risk of adverse occupational exposure than females during the study, and this held true for all age groups. DALYs and death rates of occupational risks are 10 and 15 times more common in males than females. These findings are proved by ILO data showing that males accounted for between 91% and 99% of all deaths from injury at work in all countries, independent of the level of economic development of the country.[4,9]

According to the GBD 2010, age groups including 15–20, 60–65, and 75–79 years had the highest DALYs and death rate attributed to occupational disease. This was also proved by Nelson *et al*.[9] showed that the most frequent pattern of occupational diseases has had a steady rise from 18 to around 64 years. The high level of DALYs and death in younger age groups can be attributed to the lack of experience in the workplace (National Institute for Occupational Safety and Health).[19] A study conducted in Turkey by Ozkan *et al*. showed that the injury rate was highest (46.7%) in 15–29 age group.[20] Other reports have also underlined the higher risk for young workers; Jackson reported that 73% of workplace-related injuries occurred among people aged 20–44 years.[21] In Iran, the high rates of work-related DALYs and death in young people may be attributed to the high numbers of young workers who are not sufficiently trained to do assigned jobs in factories and other workplaces, leading to accidents and injuries. Furthermore, considering the high DALYs and death rates for those aged 65+ years in our study, it has been reported that exposure-response relationships for hazardous work conditions are aggravating and cumulative in nature, which justifies numerous work-related problems that might suddenly appear in older people, after a long period of working and a great number of years in a specific job.[22]

Musculoskeletal disorders and injuries are among the most prevalent adverse effects of occupational exposures among Iranian workers.[17] This might be due to the lack of sufficient attention from Iranian labor law and the ministry of health's safety; these occupational and work related organizations are required to pay special notice to support young workers who employed at more risky jobs. This is the same for people at retirement age who still keep working.

Although the GBD 2010 has shed light on numerous health-related facts including occupational health and has been acknowledged as a comprehensive study with a global coverage with the largest epidemiological datasets, it faced several limitations. The main drawbacks included the scarcity of high-quality epidemiological occupation-related data from low- and middle-income countries, such as Iran. To overcome this limitation, it is allowed to use studies with both high- and low-methodological quality from these countries, for instance through imputation, rather than only use studies with high methodological quality that are used in high-income countries. In addition to the insufficiency of high-quality data in low- and middle-income countries, lack of subnational estimation was another limitation. To avoid this limitation, a grant study called the "national and subnational burden of diseases and injuries"[23] and "inpatient data collection national project"[24] were used. In addition, systematic reviews and model development are currently carried out in Iran to calculate the required data and obtain relevant information.[16,25]

## Conclusions

In brief, although DALYs and death rates have apparently decreased in Iran in recent years, a long-term effort is required by Iran health-care system as well as other work-related organizations in the country to maintain the currently decreasing trend.

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### Conflicts of interest

There are no conflicts of interest.

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