Health system performance in Iran: a systematic analysis for the Global Burden of Disease Study 2019

GBD 2019 Iran Collaborators*

Summary
Background Better evaluation of existing health programmes, appropriate policy making against emerging health threats, and reducing inequalities in Iran rely on a comprehensive national and subnational breakdown of the burden of diseases, injuries, and risk factors.

Methods In this systematic analysis, we present the national and subnational estimates of the burden of disease in Iran using the Global Burden of Disease Study 2019. We report trends in demographics, all-cause and cause-specific mortality, as well as years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life-years (DALYs) caused by major diseases and risk factors. A multi-intervention segmented-regression model was used to explore the overall impact of health sector changes and sanctions. For this analysis, we used a variety of sources and reports, including vital registration, census, and survey data to provide estimates of mortality and morbidity at the national and subnational level in Iran.

Findings Iran, which had 84·3 million inhabitants in 2019, had a life expectancy of 79·6 years (95% uncertainty interval 79·2–79·9) in female individuals and 76·1 (75·6–76·5) in male individuals, an increase compared with 1990. The number of DALYs remained stable and reached 19·8 million (17·3–22·6) in 2019, of which 78·1% were caused by non-communicable diseases (NCDs) compared with 43·0% in 1990. During the study period, age-standardised DALY rates and YLL rates decreased considerably; however, YLDs remained nearly constant. The share of age-standardised YLDs contributing to the DALY rate steadily increased to 44·5% by 2019. With regard to the DALY rates of different provinces, inequalities were decreasing. From 1990 to 2019, although the number of DALYs attributed to all risk factors decreased by 16·8%, deaths attributable to all risk factors substantially grew by 43·8%. The regression results revealed a significant negative association between sanctions and health status.

Interpretation The Iranian health-care system is encountering NCDs as its new challenge, which necessitates a coordinated multisectoral approach. Although the Iranian health-care system has been successful to some extent in controlling mortality, it has overlooked the burden of morbidity and need for rehabilitation. We did not capture alleviation of the burden of diseases in Iran following the 2004 and 2014 health sector reforms; however, the sanctions were associated with deaths of Iranians caused by NCDs.

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Introduction During the past four decades, Iran has experienced substantial turmoil in its economy and international policy. After the 1979 revolution, Iran was afflicted with the longest war in the 20th century with its neighbour Iraq. After the end of the war in 1988, Iran entered an era of massive construction and investment in its health and non-health infrastructures, with an increase in gross domestic product (GDP) per person. The economic and social development included, but was not limited to, improvement in literacy, urbanisation, and investments in the transport and food industries. In the health sector, policies were designed and implemented in the four main domains of primary care, secondary and tertiary care, training health-care professionals, and research to reach universal health coverage (UHC). Nevertheless, international sanctions against Iran in 2011 imposed some restrictions on these efforts. On the path towards UHC, Iran has undergone several major transformations, including expanding the primary health-care (PHC) system and integrating the Ministry of Health with Medical Education in the 1980s, the 2004 Universal Rural Health Insurance, and the 2014 Health Transformation Plan; however, existing evidence indicates unequal improvements in the distribution of specific health indicators across 31 provinces (appendix p 2).

Assessment of the performance of the health-care system is necessary for evaluating the success or failure of previous policies, assessing needs, setting priorities, and directing future evidence-based policies; nonetheless, this initiative requires a comprehensive national and subnational breakdown of the burden of diseases, injuries, and risk factors. In this study, we aimed to provide this breakdown in Iran, using the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019. This report is the first on the burden...
Research in context

Evidence before this study
We searched online databases including PubMed and Google Scholar for Farsi and English language articles using keywords including “Iran”, “burden of disease”, “subnational level”, “epidemiological trends”, “mortality”, “morbidity”, “health system performance”, and “sanction”. In 2019, a review paper was published in The Lancet entitled Iran in Transition, which reported a comprehensive history of Iran and its health-care system and presented the main turning points in the health-care system and infrastructure in Iran. The paper discussed the current health status and future directions on the basis of results and information from various sources. Additionally, several national and subnational studies on the burden of certain diseases and risk factors have been done and reported in Iran at certain points during the past three decades.

Added value of this study
To the best of our knowledge, the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 is the most comprehensive, systematic, and concerted effort so far that reports life expectancy, mortality, and disability from 369 causes, and the burden attributable to 87 risk factors at the national and subnational level in Iran from 1990 to 2019. This study includes special consideration of the Iranian health-care system’s performance and action plans.

Implications of all the available evidence
This study shows a demographic transition leading to population growth and ageing, and an increase in life expectancy, along with an epidemiological transition. Evidence shows that the expanded health-care system has been quite successful in halting communicable, maternal, and neonatal diseases. Economic and social development in Iran is linked to the decreased burden of certain conditions, such as injuries and certain environmental risk factors; however, policies to control non-communicable diseases, such as substance-use disorders and mental disorders, and certain risk factors, including metabolic risk factors, have not been successful. Given the future burden of COVID-19 in the coming years, and the probable continuation of sanctions and their impact on Iran’s economy and the function of the health-care system, policies should focus on maintaining the infrastructure and the financing of the health-care system, human resources, and equality and quality of health-care services, and setting priorities favouring fatal causes in vulnerable populations with restricted access to health care.

Methods
Overview
GBD 2019 provided estimates of the burden of 369 diseases and injuries and 87 risk factors for 204 countries and territories from 1990 to 2019, with subnational estimates for 21 countries, including Iran. The detailed estimation framework of GBD 2019 has been discussed previously. All measures are reported in age-standardised rates derived from the GBD standard population structure that were developed as part of the GBD framework. Our article complies with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER). Our full GATHER checklist is available in the appendix (p 25). All data sources used in this analysis and related code can be found on the Global Health Data Exchange. Additional results from GBD 2019 can be viewed with our data visualisation tools.

Subnational estimation
We investigated subnational inequalities through comparing age-standardised rates. GBD 2019 used several databases from Iran, which have been summarised (appendix section 2). The data for national and subnational estimates of health in Iran were retrieved from various sources, including censuses and vital registration. A decomposition analysis was used to identify the cause-specific contributions to changes in life expectancy. Detailed steps to achieve the decomposition analysis are included in the appendix (p 21). There were sharp declines in life expectancy because of earthquakes in 1990 (Gilan, Iran, and Zanjan, Iran) and 2003 (Kerman, Iran). Therefore, 1991 was chosen as the reference year for life expectancy and all-cause estimates. We reported 95% uncertainty intervals (UIs) for each measure that were generated using the 25th and 975th ordered 1000 draws of the posterior distribution. To investigate the impact of different health sector reforms (details on the history of major health policies in Iran are provided in the appendix, section 1) and the economic crisis caused by sanctions on the Iranian health-care system, we utilised two methods, the annual percentage change in age-standardised deaths and a multi-intervention segmented regression model to explore the changes in non-communicable diseases (NCDs) and under-5 mortality rate (USMR). The USMR incorporated death rates as the dependent variable and the two major changes (health sector changes and the economic crisis caused by sanctions) as independent variables adjusted to 2021 health expenditure per person (extracted from The World Bank). The segmented regression model is a method for statistically modelling interrupted time-series data, and to draw more formal inferences regarding the effect of an intervention or event on the response variable. Therefore, by using a multi-intervention segmented regression model, we can specify more than one change point. In the multi-intervention segmented regression model, level (which is the value of the series at the beginning of a given time interval) and
trend (which is the rate of change of a measure) in the preintervention segment and changes in level and trend after the interventions were estimated. Additional details on the methods are presented (appendix section 2).

Role of the funding source
The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results
Outlines of population structure and health status
Iran is having a late demographic transition.1 Iran’s total population increased from 58·5 million (95% UI 53·1–63·5) in 1990 to 84·3 million (77·3–91·9) in 2019 because of high fertility rates in the early 1990s (appendix pp 33, 56). From the late 1990s to 2019, the total fertility rate decreased steadily from 4·2 (95% UI 3·7–4·6) to 1·8 (1·4–2·4), which resulted in an apparent ageing of the population in this period (appendix pp 34, 62). In 2019, life expectancy for female individuals in Iran was 79·6 years (95% UI 79·2–79·9) and 76·1 years (75·6–76·5) for male individuals. From 1991 to 2019, life expectancy at birth increased from 68·9 (95% UI 68·2–69·6) to 77·8 (77·5–78·0), with diverse provincial patterns by sex (figure 1; appendix pp 36, 58). The absolute difference between the highest and the lowest life expectancy across provinces was 12·0 years in 1991, which declined to 8·2 years in 2019, indicating a convergence (appendix p 37). The ratio of the highest-to-lowest age-standardised death rates in provinces remained almost constant from 1991 to 2019 (2·0 vs 1·9; appendix p 41). More information about the results can be found in the appendix (sections 3, 4).

All provinces observed increases in life expectancy (appendix p 37). The decline in age-standardised death rates of almost all causes improved life expectancy during the study period. The causes whose reductions made the largest contributions to improvement in life expectancy were cardiovascular diseases (2·9 years), unintentional injuries (2·6 years), maternal and neonatal diseases (1·8 years), and transport injuries (0·9 years). The alleviation of most infectious diseases substantially contributed to the improvement in life expectancy. Conversely, very few conditions quite minimally counteracted the progress in life expectancy, including diabetes and kidney diseases, HIV/AIDS and sexually transmitted infections, substance-use disorders, musculoskeletal disorders, and mental disorders. Improvement in substance-use disorders led to increased life expectancy in six provinces, and neoplasms were associated with life expectancy decrease in five provinces (figure 2; appendix p 63).

In addition to the demographic transition, an epidemiological transition is ongoing, with a shift in burden from injuries and communicable, maternal, neonatal, and nutritional diseases (CMNNDs) towards NCDs. In 2019, the total number of DALYs reached 19·8 million (95% UI 17·3–22·6; appendix p 125). In 2019, 78·1% of disability-adjusted life years (DALYs) were caused by non-communicable diseases compared with 43·0% in 1990. The epidemiological transition level, defined as the ratio of the all-age DALY rate caused by CMNNDs to the DALY rate caused by NCDs, increased from 0·8% in 1990 to 103·2% in 2019, and from 5·1% to 23·6% in 2019 among provinces (appendix p 38). Over the period studied, the number of DALYs attributed to all risk factors showed a decline of 16·8%, although deaths attributable to risk factors increased substantially by 43·8%. From 1991 to 2019, all-age numbers and age-standardised rates of DALYs and years of life lost (YLLs) due to all causes considerably decreased by more than 35%; however, estimates of years lived with disability (YLDs) were constant, underscoring the crucial role of infrastructure for managing morbidity (appendix p 40). In 2019, the share of age-standardised YLDs contributing to DALYs steadily increased to 44·5%.
Public health, infectious diseases, and the issue of emerging diseases

During the study period, reductions in major infectious diseases including malaria, measles, and diphtheria were among the major drivers of the nearly 95% of the decrease in the burden of communicable diseases based on the percentage change in the number of all-age DALYs. Within almost every subcategory of communicable diseases, a remarkable decrease in the DALY rate (range 93·4–59·0%) was detected, except for HIV/AIDS and sexually transmitted diseases, which had a substantial 197·6% increase. Among CMNNDS, the HIV/AIDS DALY rate increased by almost 13 times and climbed to the 6th rank (appendix pp 51, 52). Although
the burden of tuberculosis had a decreasing pattern (–64·0% in the number of DALYs), this halted in the mid-2000s with the large surge of HIV/AIDS in Iran. The burden of tuberculosis almost reached a steady state in the past two decades, highlighting the importance of the re-emerging condition of tuberculosis as the major comorbidity of HIV/AIDS.

Considering the emergence of HIV/AIDS in Iran, the age-standardised DALY rate of this disease increased in most provinces from 1990 to 2019; however, this rise was more pronounced in Sistan and Baluchistan (23-fold increase), Lorestan (20-fold increase), and Hormozgan (18-fold increase). The highest DALY rates were noted in Kermanshah (299·4 per 100 000 people,
95% UI 229.9–388.8) and the lowest DALY rates were recorded in Semnan (3.5 per 100 000, 2.5–4.8) in 2019. The increasing difference between HIV/AIDS rates of DALYs among provinces in the past three decades was remarkable, with the highest-to-lowest ratio being 17.3 in 1990 compared with 85.8 in 2019 (appendix p 152).

Given the high social stigma of HIV/AIDS in Iran,21 its burden has been substantially underestimated and control measures have been neglected, and there is also a pattern of behaviours associated with a higher risk of HIV acquisition coupled with a lower perception of individual risk in the Iranian population.22 Injection-drug use and substantially increasing sexual transmission of
HIV since the early 1990s are the main drivers of the increasing burden of HIV/AIDS.21–24 Iran started triangular clinic services in the late 1990s to address the growing epidemic of HIV/AIDS. These clinics provided services for people at high risk of HIV infection and those who were infected in three domains of HIV units, addiction units, and sexually-transmitted-disease units. In the early 2000s, the health-care system integrated these clinics with the PHC system to effectively address the epidemic.25 However, shortages in several aspects of this policy resulted in the country’s surge in HIV/AIDS cases.27

Improved sanitation and nutrition preceded profound improvements in the reduction of communicable diseases in Iran.28 Vaccination programmes have been largely successful in reducing the burden of bacterial and viral infections. Hepatitis B vaccination was launched in 1993 in Iran, requiring that all children born after this time receive vaccination for hepatitis B. Increasing vaccination coverage was followed by a sharp decline in cirrhosis caused by chronic hepatitis B since 2001.29 Another example is the success of the mumps-measles-rubella mass vaccination that reached more than 96.4% in 2008.30 Certain diseases have been systematically controlled with concerted efforts; for example, malaria (P vivax) has been largely controlled, with Iran in the WHO pre-elimination phase, with a directly observed therapy method in the PHC network.1

Primary health-care network and improvements in maternal and child health

One of the main drivers of the remarkable reduction in the burden of CMNNDs was improvements in the care of neonatal disorders, the leading cause of DALYs in 1990. By 2019, neonatal disorders had descended to the fourth rank among all causes of DALYs in Iran, decreasing by 81-5%. Furthermore, DALYs caused by maternal disorders substantially decreased by 68-0%. The top cause of DALYs among neonatal disorders was neonatal preterm birth in both 1990 and 2019. Among maternal disorders, the leading causes of DALYs were maternal hypertensive disorders in 1990 and indirect maternal deaths in 2019 (appendix p 130).

The distribution of the burden of maternal and neonatal disorders varied at the subnational level. The decreasing trend of age-standardised deaths caused by maternal disorders had a converging pattern among provinces in the past three decades, indicating reduced differences between provinces, with the highest age-standardised deaths in Sistan and Baluchistan (19·3, 95% UI 15·6–23·7) and the lowest in Gilan (5·5, 4·1–7·2) in 2019. The decreasing trend in age-standardised death rates caused by maternal disorders had a converging pattern, with the highest rates in female individuals in Sistan and Baluchistan (1·9, 1·4–2·4) and the lowest in Tehran (0·2, 0·1–0·3) in 2019 (appendix pp 818, 871).

Nutritional deficiencies, another major contributor to CMNNDs, showed a 59-4% decrease in the all-age number of DALYs in the study period reaching 123·514 (95% UI 81·350–174·299) in 2019. Dietary iron deficiency and protein-energy malnutrition were the top two causes of nutritional deficiencies in both 1990 and 2019; nevertheless, the DALYs associated with both these nutritional deficiencies declined in their trend by 46·7% for dietary iron deficiency and 77·9% for protein-energy malnutrition. Comparing the age-standardised DALY rates at the subnational level showed that provinces had a converging declining pattern, because the highest-to-lowest ratio of age-standardised DALY rates was 3·6 in 1990 against 1·8 in 2019. The Sistan and Baluchistan province had the highest rates of nutritional deficiencies in both 1990 and 2019 (appendix p 152).

The remarkable improvement in maternal, child, and nutritional health status occurred mainly because of improved health literacy, especially among women, urbanisation, and advances in the economic status of the country during specific periods.1 Iran implemented many strategies to advance maternal and child health. One of the earliest was the PHC system implemented in the 1980s, which provided health-care services, child nutritional support, better access to clean water and sanitation, and national vaccination programmes in deprived areas of the country.1,10–14 Furthermore, the Ministry of Health took responsibility for educating health-care personnel in 1986, which resulted in a considerable increase in the number of medical students and universities, and the number and density of hospitals, outpatient clinics, and health-care personnel.1,15

Environmental and ecological changes as arising major risks in Iran

Ambient particulate matter pollution, unsafe water, and unsafe sanitation were among the major environmental risk factors with strong impacts on health status. In 2019, ambient particulate matter pollution was the fifth leading contributor to DALYs (137·832, 95% UI 113·167–163·498) and deaths (4913, 3967–5931) in Tehran province, which has a large population. Ambient particulate matter showed a 46·7% increase in attributable DALYs and a 109·6% increase in deaths in this province (appendix p 971). In Tehran province, air pollution is estimated to have contributed to deaths from cardiovascular diseases (6·2%), diabetes and kidney diseases (2·1%), and chronic respiratory diseases (0·6%). The substantial adverse effect of air pollution on health and economics16,17 necessitates more rigorous legislative measures, as well as applying novel approaches, such as spatiotemporal screening tools, for the collection and analysis of environmental data.18

The number of all-age all-cause DALYs attributable to unsafe water sources declined to 99·237 (95% UI 51·328–151·535) in 2019; the corresponding number for unsafe sanitation was 27‘018 (15·392–43·370). With a converging pattern at the subnational level, the highest age-standardised DALY rates attributable to unsafe water sources occurred in Sistan and Baluchistan (208·6,
|                              | 1990          | 2019          |       |       |       |       |       |       |       |       |       |       |
|------------------------------|---------------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                              | DALYs Number  | DALYs Rate    | Deaths Number | Deaths Rate |       |       |       |       |       |       |       |       |       |
| Both sexes                   | 9,243,948     | 19,189.8      | 19,011   | 610.3 | 16,856,044 | 768.304 | 10,286.0 | 243,052 | 378.8 |
| Female                       | 3,840,371     | 16,154.7      | 69,264   | 529.9 | 3,139,891  | 1,037.3  |          | 104,477 | 344.1 |
| Male                         | 5,402,577     | 21,986.2      | 99,474   | 684.2 | 5,468,183  | 11,839.9 |          | 138,575 | 414.9 |
| Environment and occupational risks |       |       |       |       |       |       |       |       |       |       |       |       |
| Overall                      | 24,567,746    | 58,032.2      | 5,117.1  | 9.4  | 22,806,400 | 1,278.54 | 169.1   | 7,548.2 | 116.6 |
| Female                       | 9,410,398     | 4,484.1       | 10,272   | 168.2 | 8,123,577  | 1,187.55 |          | 317.9 | 102.2 |
| Male                         | 15,157,347    | 70,247.4      | 31,399   | 229.8 | 1,418,282  | 360.96 |          | 44,304 | 134.4 |
| Unsafe water, sanitation, and handwashing |       |       |       |       |       |       |       |       |       |       |       |       |
| Both sexes                   | 471,547       | 618.5         | 516.4    | 9.4  | 1,278,544  | 169.1   |          | 304.0 | 1.7 |
| Female                       | 22,204.1      | 59.1          | 2,733.1  | 9.3  | 6,051.6    | 163.4   |          | 470   | 0.04 |
| Male                         | 2,495,606     | 639.6         | 73.0     | 9.4  | 6,528.5    | 174.7   |          | 569   | 1.7 |
| Air pollution                | 1,325,247     | 319.8         | 39,463   | 116.4 | 1,190,330  | 160.3   |          | 43,203 | 65.5 |
| Female                       | 540,695       | 2,868.9       | 12,404   | 100.4 | 489,256    | 136.4   |          | 18,483 | 54.7 |
| Male                         | 79,582        | 3,664.0       | 18,159   | 70,080.5 | 1,841.6 | 24,720.0 |          |       |       |
| Non-optimal temperature      | 3,019,596     | 313.8         | 961.4    | 48.3  | 3,484,066  | 510.2   | 19,997  | 32.5 |
| Female                       | 1,474,011     | 877.7         | 4,481    | 45.4  | 1,593,246  | 479.7 | 9,445   | 31.9 |
| Male                         | 1,546,595     | 975.4         | 5,579    | 95.7  | 1,891,561  | 545.0 | 10,553  | 33.2 |
| Other environmental risks    | 266,794       | 903.5         | 831.9    | 9.9  | 3,111,633  | 468.5 | 15,328  | 24.6 |
| Female                       | 85,838        | 628.8         | 2,744    | 29.4  | 114,358    | 333.8 | 569.7   | 19.4 |
| Male                         | 180,956       | 115.0         | 557.5    | 316.8 | 180,805    | 599.9 | 962.0   | 29.8 |

(Table 1 continues on next page)
### Occupational Risks

|                      | Male                                      | Female                                   | Both sexes                                  |
|----------------------|-------------------------------------------|------------------------------------------|---------------------------------------------|
| Number               | 11309121                                  | 337807                                  | 4478078                                    |
| DALYs                | 7262 to 1426                              | 188 to 144                              | 9855 to 65770                              |
| Deaths               | 93 to 137                                 | 7 to 112                                | 352 to 1397                                |
| Number               | 29%                                         | 8%                                      | 10%                                        |
| DALYs                | 145 to 212                                | 176                                    | 700                                        |
| Deaths               | 621 to 918                                | 770                                    | 4147                                       |
| Rate (95% CI)        | 2.7 to 6.4                                | 0.7                                    | 0.7                                        |

### Behavioural Risks

#### Overall

|                      | Male                                      | Female                                   | Both sexes                                  |
|----------------------|-------------------------------------------|------------------------------------------|---------------------------------------------|
| Number               | 53937322                                  | 171310                                  | 7104832                                    |
| DALYs                | 2652 to 3972                              | 2652 to 3972                            | 290663 to 434273                          |
| Deaths               | 145 to 212                                | 176                                    | 700                                        |
| Number               | 29%                                         | 8%                                      | 10%                                        |
| DALYs                | 145 to 212                                | 176                                    | 700                                        |
| Deaths               | 621 to 918                                | 770                                    | 4147                                       |
| Rate (95% CI)        | 2.7 to 6.4                                | 0.7                                    | 0.7                                        |

#### Child and maternal malnutrition

|                      | Male                                      | Female                                   | Both sexes                                  |
|----------------------|-------------------------------------------|------------------------------------------|---------------------------------------------|
| Number               | 50249                                    | 13145                                   | 63394                                      |
| DALYs                | 149010                                  | 39875                                   | 54778                                      |
| Deaths               | 140 to 210                                | 39875                                   | 1075                                        |
| Number               | 29%                                         | 8%                                      | 10%                                        |
| DALYs                | 149010                                  | 39875                                   | 1075                                        |
| Deaths               | 140 to 210                                | 39875                                   | 1075                                        |
| Rate (95% CI)        | 2.7 to 6.4                                | 0.7                                    | 0.7                                        |

#### Tobacco use

|                      | Male                                      | Female                                   | Both sexes                                  |
|----------------------|-------------------------------------------|------------------------------------------|---------------------------------------------|
| Number               | 56029                                    | 14601                                  | 70630                                      |
| DALYs                | 17186 to 2634                            | 22108 to 2634                           | 20757 to 3239                               |
| Deaths               | 176 to 2050                              | 176                                    | 700                                        |
| Number               | 29%                                         | 8%                                      | 10%                                        |
| DALYs                | 17186 to 2634                            | 22108 to 2634                           | 20757 to 3239                               |
| Deaths               | 176 to 2050                              | 176                                    | 700                                        |
| Rate (95% CI)        | 2.7 to 6.4                                | 0.7                                    | 0.7                                        |

#### Alcohol use

|                      | Male                                      | Female                                   | Both sexes                                  |
|----------------------|-------------------------------------------|------------------------------------------|---------------------------------------------|
| Number               | 51607                                    | 21843                                   | 73450                                      |
| DALYs                | 1210 to 1183                             | 1210 to 1183                            | 1210 to 1183                               |
| Deaths               | 21 to 113                                | 21 to 113                               | 21 to 113                                  |
| Number               | 29%                                         | 8%                                      | 10%                                        |
| DALYs                | 1210 to 1183                             | 1210 to 1183                            | 1210 to 1183                               |
| Deaths               | 21 to 113                                | 21 to 113                               | 21 to 113                                  |
| Rate (95% CI)        | 2.7 to 6.4                                | 0.7                                    | 0.7                                        |

#### Drug use

|                      | Male                                      | Female                                   | Both sexes                                  |
|----------------------|-------------------------------------------|------------------------------------------|---------------------------------------------|
| Number               | 121828                                   | 13707                                   | 25890                                      |
| DALYs                | 13070 to 1768                            | 13070 to 1768                          | 297777 to 39650                          |
| Deaths               | 7 to 112                                 | 7 to 112                                | 7 to 112                                   |
| Number               | 29%                                         | 8%                                      | 10%                                        |
| DALYs                | 13070 to 1768                            | 13070 to 1768                          | 297777 to 39650                          |
| Deaths               | 7 to 112                                 | 7 to 112                                | 7 to 112                                   |
| Rate (95% CI)        | 2.7 to 6.4                                | 0.7                                    | 0.7                                        |
| Articles | Number | Rate | Number | Rate | Number | Rate | Number | Rate |
|----------|--------|------|--------|------|--------|------|--------|------|
| **1990** |        |      | 1990   |      | 1990   |      | 1990   |      |
| **Dietary risks** | | | | | | | | |
| Both sexes | 1004233 | (840580 to 1166327) | 37880 | (3155 to 43903) | 37273 | (39028 to 43483) | 1828 | (151 to 212) | 1475202 | (1208521 to 1739207) | 19868 | (16276 to 2364) | 64424 | (52234 to 76488) | 1000 |
| Female | 361178 | (302580 to 451972) | 29873 | (25076 to 34334) | 14531 | (11947 to 16553) | 155 | (128 to 180) | 573055 | (473687 to 663363) | 16241 | (22210 to 32704) | 27392 | (73310 to 1061) | 905 |
| Male | 643055 | (533177 to 760324) | 45139 | (37496 to 53531) | 22322 | (18838 to 27346) | 206 | (172 to 247) | 900631 | (728882 to 1092221) | 23923 | (29787 to 44723) | 30322 | (1100 to 1330) | 1100 |
| **Intimate partner violence** | | | | | | | | |
| Female | 59495 | (12668 to 110038) | 2618 | (573 to 49337) | 152 | (99 to 207) | 0 | (0 to 0) | 126718 | (102399 to 237808) | 276 | (66 to 5357) | 342 | (241 to 487) | 0 |
| Male | 884 | (28073 to 125638) | 104 | (427 to 1979) | 37 | (2 to 39) | 0 | (0 to 0) | 103460 | (401470 to 207055) | 124 | (49 to 238) | 127 | (4 to 63) | 0 |
| Both sexes | 66060 | (26073 to 125638) | 114 | (427 to 1979) | 74 | (2 to 39) | 0 | (0 to 0) | 103460 | (401470 to 207055) | 124 | (49 to 238) | 127 | (4 to 63) | 0 |
| **Childhood sexual abuse and bullying** | | | | | | | | |
| Both sexes | 19940 | (149861 to 247047) | 574 | (433 to 687) | 435 | (317 to 524) | 17 | (12 to 21) | 50884 | (40983 to 65816) | 56 | (45 to 69) | 1354 | (914 to 1422) | 15 |
| Female | 17693 | (12007 to 21037) | 108 | (80 to 129) | 425 | (304 to 512) | 3 | (2 to 4) | 38352 | (21239 to 46660) | 87 | (71 to 134) | 953 | (755 to 1127) | 25 |
| Male | 2247 | (1506 to 3270) | 9 | (6 to 13) | 10 | (5 to 15) | 0 | (0 to 0) | 13732 | (83098 to 18379) | 25 | (17 to 36) | 195 | (111 to 304) | 0 |
| **Unsafe sex** | | | | | | | | |
| Both sexes | 128650 | (59165 to 242900) | 5855 | (2863 to 10317) | 5490 | (2548 to 10053) | 34 | (17 to 58) | 298831 | (164409 to 506886) | 433 | (243 to 722) | 14444 | (780 to 23762) | 24 |
| Female | 55765 | (28689 to 97035) | 5426 | (2831 to 9099) | 2543 | (1288 to 4214) | 33 | (17 to 54) | 147116 | (85254 to 233837) | 436 | (258 to 6888) | 752 | (4150 to 11381) | 25 |
| Male | 72884 | (29488 to 149871) | 6217 | (2753 to 11779) | 2947 | (1214 to 5808) | 35 | (16 to 62) | 151215 | (75241 to 271785) | 431 | (221 to 748) | 794 | (3601 to 12516) | 23 |
| **Low physical activity** | | | | | | | | |
| Both sexes | 13276 | (119850 to 146536) | 9281 | (84739 to 10381) | 4055 | (4075 to 4997) | 423 | (377 to 469) | 2472067 | (2025742 to 2712522) | 66347 | (60493 to 72748) | 95300 | (87591 to 103591) | 289 |
| Female | 932718 | (82987 to 1031052) | 76273 | (6916 to 83935) | 399150 | (37400 to 41970) | 375 | (338 to 414) | 2013201 | (1806646 to 2205679) | 57271 | (5023 to 6204) | 84222 | (76496 to 91071) | 270 |
| Male | 1326814 | (119850 to 146536) | 93781 | (84739 to 10381) | 4055 | (4075 to 4997) | 423 | (377 to 469) | 2472067 | (2025742 to 2712522) | 66347 | (60493 to 72748) | 95300 | (87591 to 103591) | 289 |
| **Metabolic risks** | | | | | | | | |
| Overall | 2264132 | (2065676 to 2470091) | 85708 | (779570 to 93584) | 79124 | (72173 to 86453) | 409 | (364 to 442) | 4490268 | (4092380 to 4912190) | 61754 | (56463 to 67337) | 17522 | (165891 to 19335) | 283 |
| Female | 932718 | (82987 to 1031052) | 76273 | (6916 to 83935) | 399150 | (37400 to 41970) | 375 | (338 to 414) | 2013201 | (1806646 to 2205679) | 57271 | (5023 to 6204) | 84222 | (76496 to 91071) | 270 |
| Male | 1326814 | (119850 to 146536) | 93781 | (84739 to 10381) | 4055 | (4075 to 4997) | 423 | (377 to 469) | 2472067 | (2025742 to 2712522) | 66347 | (60493 to 72748) | 95300 | (87591 to 103591) | 289 |

(Continued from previous page)
|                  | DALYs |                  | Deaths |                  | DALYs |                  | Deaths |
|------------------|-------|------------------|--------|------------------|-------|------------------|--------|
|                  | Number | Rate             | Number | Rate             | Number | Rate             | Number |
| **High fasting plasma glucose** |       |                  |        |                  |        |                  |        |
| Both sexes       | 492,201 | 1988.1 (1,601.4 to 2,516.0) | 16,744 | 91.4 (68.4 to 127.3) | 1,777,838 | 2511.2 (1,449.5 to 2,170.0) | 68,121 | 109.5 (80.8 to 150.7) |
| Female           | 299,636 | 1808.2 (1,460.4 to 2,314.3) | 7,555 | 86.4 (63.0 to 120.9) | 861,064 | 2472.5 (659,980 to 1,057,758) | 33,687 | 112.2 (81.5 to 156.1) |
| Male             | 192,565 | 2,144.1 (1,708.0 to 2,720.0) | 9,190 | 96.2 (71.4 to 133.2) | 916,793 | 2555.6 (738,525 to 1,128,300) | 34,443 | 107.6 (25,987 to 47,345) |
| **High LDL cholesterol** |       |                  |        |                  |        |                  |        |
| Both sexes       | 848,799 | 3,106.8 (2,528.4 to 3,789.1) | 30,291 | 145.5 (109.3 to 188.8) | 1,203,791 | 3574.5 (998,464 to 1,473,959) | 52,530 | 79.9 (40,050 to 66,947) |
| Female           | 514,726 | 2,528.9 (2,017.3 to 3,120.2) | 12,126 | 129.2 (94.5 to 172.3) | 460,884 | 1287.6 (369,788 to 568,383) | 22,882 | 75.1 (16,693 to 30,058) |
| Male             | 334,073 | 3,620.9 (2,960.9 to 4,398.9) | 18,165 | 159.2 (100.9 to 202.5) | 742,907 | 1862.3 (624,494 to 874,498) | 29,648 | 85.2 (25,010 to 36,975) |
| **High systolic blood pressure** |       |                  |        |                  |        |                  |        |
| Both sexes       | 1,725,800 | 4,808.2 (4,200.5 to 5,423.5) | 14,768 | 244.8 (209.5 to 279.6) | 2,122,256 | 2,973.4 (1,913,281 to 2,347,736) | 99,933 | 157.8 (86,758 to 112,548) |
| Female           | 478,121 | 4,266.4 (3,714.6 to 4,858.0) | 20,663 | 231.5 (197.1 to 265.8) | 908,959 | 2,657.4 (806,424 to 1,012,532) | 46,448 | 154.5 (39,687 to 52,480) |
| Male             | 1,247,679 | 5,247.5 (4,540.8 to 6,009.4) | 25,896 | 253.4 (214.8 to 291.8) | 1,218,371 | 3,329.7 (1,091,596 to 1,384,440) | 53,491 | 162.1 (46,734 to 60,346) |
| **High body-mass index** |       |                  |        |                  |        |                  |        |
| Both sexes       | 710,771 | 2,419.4 (1,497.6 to 3,414.7) | 21,127 | 189.2 (52.9 to 131.7) | 1,989,457 | 2,580.9 (1,441,100 to 2,562,166) | 61,415 | 91.7 (43,472 to 1,315) |
| Female           | 357,493 | 2,895.8 (1,695.4 to 3,516.8) | 10,693 | 96.7 (60.6 to 137.2) | 952,599 | 2,745.9 (710,774 to 1,205,407) | 30,653 | 96.1 (22,263 to 39,710) |
| Male             | 353,277 | 2,487.7 (1,265.1 to 3,376.4) | 10,433 | 80.7 (43.3 to 125.8) | 1,037,098 | 261.7 (712,749 to 1,364,782) | 30,812 | 88.1 (20,622 to 42,064) |
| **Low bone mineral density** |       |                  |        |                  |        |                  |        |
| Both sexes       | 716,688 | 261.0 (210.0 to 300.6) | 1,828 | 7.8 (6.3 to 8.9) | 1,177,250 | 154.0 (967,500 to 1,773,753) | 3048 | 4.4 (25,86 to 33,96) |
| Female           | 211,177 | 173.4 (142.0 to 202.0) | 506 | 5.1 | 412,944 | 114.7 (333,933 to 498,855) | 1018 | 3.2 (848 to 1,144) |
| Male             | 505,511 | 341.3 (265.0 to 391.0) | 1322 | 10.3 | 76,431 | 193.0 (63,050 to 88,118) | 2030 | 5.6 (1715 to 2,333) |
| **Kidney dysfunction** |       |                  |        |                  |        |                  |        |
| Both sexes       | 445,170 | 1,596.7 (1,227.8 to 1,837.6) | 15,111 | 78.4 (65.6 to 93.1) | 790,836 | 1172.7 (692,733 to 837,947) | 35,897 | 58.3 (30,953 to 4,818,890) |
| Female           | 200,663 | 1,592.4 (1,279.7 to 1,833.1) | 6,868 | 75.1 (61.5 to 89.7) | 368,995 | 1075.7 (232,849 to 1,145,886) | 17,356 | 58.2 (14,522 to 2,024) |
| Male             | 244,507 | 1,673.4 (1,419.8 to 1,941.4) | 8,242 | 80.8 | 421,841 | 1179.4 (367,827 to 487,023) | 18,631 | 58.8 (15,793 to 21,799) |

Data in parentheses are 95% CIs. DALYs = disability-adjusted life-years.

Table 1: All-age DALYs and deaths attributable to risk factors for all causes, and age-standardised rates (per 100,000 people) in 1990 and 2019, by sex
113·8–305·3) and the lowest in Tehran (94·4, 43·8–152·5) in 2019. The highest DALY rates attributable to unsafe sanitation were seen in Sistan and Baluchistan (89·5, 48·7–140·1) and the lowest in Tehran (15·0, 6·4–29·6) in 2019, with a converging decreasing pattern among all provinces, showing the lessening of inequalities between provinces (tables 1, 2; appendix p 971).

These patterns showed that environmental risk factors are primarily dependent on socioeconomic development. An example is unsafe water and sanitation, with the highest burden in a deprived province—Sistan and Baluchistan—and the lowest burden in the capital, Tehran. Results show a slight peak in the burden attributable to unsafe water and sanitation and mortality caused by enteric infections in 1990, followed by a sharp decline until 2019, which coincides with the expansion of the piped water and sewerage network.\(^1\) Another example is the Iran Gas Trunk line associated with decreased household air pollution caused by using solid fuels for cooking and heating.\(^1\) Therefore, supporting development in deprived regions could prevent exposure to harmful environmental risks.

### NCDs as a growing concern

The emergence of NCDs is a new challenge to Iranian health care.\(^1\) In 2019, 15·5 million (95% UI 13·2–18·1) DALYs were caused by NCDs, 44·2% more than in 1990, whereas the age-standardised DALY rate of NCDs substantially decreased by 25·9% (appendix p 125). Ischaemic heart disease was the leading cause of age-standardised DALY rates in 1990 and 2019 (figure 3; appendix p 45). The next leading causes were stroke, diabetes, lower back pain, and depressive disorders at the national level and in most provinces in 2019, with the largest 30-year change observed for diabetes, a nearly two-fold increase. Chronic obstructive pulmonary disease (age-standardised DALY rate 517·2 per 100 000 people, 471·0–560·8) and asthma (232·3 per 100 000, 185·0–299·3), are main WHO targets for Sustainable Development Goals (SDGs; target 3·4), with percentage changes of −7·0% and −56·1% from 1990 to 2019, respectively. The age-standardised death rate of most neoplasms showed a mixed pattern, with stomach (16·2, 95% UI 14·9–17·4), tracheal, bronchus, and lung (12·9, 11·9–13·9), colorectal (9·3, 8·5–10·1), and prostate (6·5, 4·9–7·4) cancers occupying the leading ranks in 2019 (appendix p 125).

The pattern of all-cause health burden attributable to risk factors changed in favour of metabolic risk factors from 1990 to 2019 (appendix p 53–55). We estimate that 31·7% of total DALYs caused by NCDs (6·3 million, 95% UI 5·7–6·9) were attributable to at least one risk factor in 2019, including 22·0% attributable to metabolic (4·4 million, 4·0–4·8), 17·1% to behavioural (3·4 million, 3·0–3·7), and 9·3% to environmental and occupational (1·9 million, 1·7–2·1) risks. Implementation of the PHC system, Health Transformation Plan, and ease of access to screening programmes for cancer and metabolic disorders are believed to be the lower-stream sources of the changing trend of NCDs at the health-provider level,\(^1\) which is in line with the upper-stream developments in the economy, literacy, and infrastructure, among other...
areas. Variability at the subnational level of modified diet, urbanisation, sedentary lifestyle, and age of the population can be regarded as the cause of geographical disparities in NCDs.4,46

In 2019, 326,508 Iranians (95% UI 318,268–335,734) died from NCDs, 88·0% more than in 1990 (appendix p 125). The age-standardised YLL rate of NCDs significantly declined by 41·3%, whereas the age-standardised YLD rate remained statistically stable with a 1·4% increase. This observation implies that the share of DALYs consisting of YLDs increased compared with the share of YLLs in the past three decades. The number of premature (30–70 years of age) deaths caused by four main NCDs (neoplasms, cardiovascular diseases, chronic respiratory diseases, and diabetes) was 66,818 (52·7% of all-age mortality caused by NCDs) in 1990 and reached 100,893 (37·1%) in 2019. According to SDGs target 3.4, the share of premature deaths should reach 11·6% in 2025 in Iran, which might not be attainable with the current trend. As the top-ranked NCD, cardiovascular diseases caused about 54·6% of premature deaths in 2019. The unconditional probability of death (UPoD) has been estimated to be constantly decreasing by 4·6% in 2019. The unconditional probability of death (UPoD) was estimated in the Golestan province with the lowest UPoD (21·6%) probability, compared with 9·1% in Tehran (the highest UPoD).

Primary, secondary, and tertiary prevention should be adopted to tackle the challenge of NCDs in Iran. Health policy makers should implement multisectoral approaches to address the high prevalence of modifiable cardiovascular risk factors, including obesity and overweight (60%),41 dyslipidaemia (80%),42 and hypertension (53%) in Iranian adults. Since the early 2000s, lifesaving treatments for NCDs, such as primary percutaneous coronary intervention, fibrinolytic therapy, and emergency surgeries, became more extensively available with increasing hospital bed density and adoption of modern facilities.44,45 Although the prevention of deaths is an important target, averting deaths can lead to higher rates of chronic conditions compared with previous time periods because of an ageing population, such as heart failure after an acute coronary syndrome, which cause disability and necessitate appropriate rehabilitation centres.

Although the Iranian health-care system appears to be alleviating the risks of NCDs, this does not downgrade the importance of control measures for NCDs.46 Subnational geographical dissimilarity indicates uneven distribution of health system goods and urgent need for action. The PHC network, the 2004 Universal Rural Health Insurance, and the 2014 Health Transformation Plan partially contributed to resolving these disparities by easing accessibility and affordability of health-care

### Table 2

| DALYs | Death |
|-------|-------|
|       | Number | Rate       | Number | Rate       |
| **Overall** |        |            |        |            |
| Both sexes | -41·4% | -56·7% | 2·8%  | -47·4% |
|           | (-50·2 to -31·0) | (-61·6 to -51·8) | (-9·4 to 15·6) | (-51·0 to 43·9) |
| Female   | -48·4% | -59·3% | 4·0%  | -47·8% |
|           | (-57·4 to -38·2) | (-64·9 to -53·9) | (-17·4 to 9·7) | (-52·0 to 43·3) |
| Male     | -36·6% | -54·5% | 7·1%  | -46·8% |
|           | (-46·2 to -25·7) | (-59·7 to -49·3) | (-5·8 to 19·9) | (-51·2 to 42·5) |

| Child and maternal malnutrition |        |            |        |            |
| Both sexes | -84·5% | -80·9% | 87·9%  | -84·2% |
|           | (-88·4 to -80·0) | (-85·6 to -75·3) | (-91·4 to -83·7) | (-88·7 to -78·8) |
| Female   | -84·9% | -81·2% | 87·8%  | -84·4% |
|           | (-79·0 to -80·2) | (-86·3 to -75·5) | (-91·5 to -83·5) | (-88·7 to -78·9) |
| Male     | 74·3%  | -6·7%  | 7·1%  | -84·4% |
|           |        |        |        | (-84·9 to -78·5) |

| Tobacco use |        |            |        |            |
| Both sexes | 40·7%  | 42·2% | 58·1%  | -41·4% |
|           | (27·0 to 55·5) | (-46·9 to -37·1) | (45·4 to 73·4) | (-46·1 to -36·2) |
| Female   | 29·7%  | 42·5% | 58·5%  | -40·6% |
|           | (7·0 to 57·9) | (-57·1 to -31·9) | (32·4 to 89·8) | (-50·3 to -29·0) |
| Male     | 44·1%  | 40·9% | 58·0%  | -41·7% |
|           | (20·0 to 59·9) | (-43·5 to -35·1) | (43·4 to 75·5) | (-46·9 to -35·6) |

| Alcohol use |        |            |        |            |
| Both sexes | 178·9% | 27·0% | 255·5% | 36·7% |
|           | (122·1 to 251·6) | (3·6 to 59·5) | (167·7 to 383·9) | (2·7 to 89·6) |
| Female   | 118·0% | -0·7%  | 169·6% | -2·8%  |
|           | (86·3 to 165·4) | (-17·9 to 22·6) | (92·1 to 294·2) | (-34·7 to 49·7) |
| Male     | 194·8% | 36·4%  | 275·0% | 49·5%  |
|           | (134·7 to 281·1) | (8·1 to 76·0) | (176·0 to 427·9) | (10·9 to 106·7) |

| Drug use |        |            |        |            |
| Both sexes | 158·9% | 28·2% | 204·8% | 28·3% |
|           | (139·6 to 182·4) | (18·8 to 39·4) | (166·4 to 255·2) | (10·7 to 50·1) |
| Female   | 107·3% | 7·1%   | 149·1% | 6·5%   |
|           | (87·8 to 131·2) | (-2·2 to 17·3) | (107·3 to 204·5) | (-13·5 to 29·1) |
| Male     | 179·9% | 37·6%  | 220·7% | 36·9%  |
|           | (155·3 to 211·3) | (25·6 to 52·9) | (175·8 to 282·2) | (16·5 to 62·7) |

| Dietary risks |        |            |        |            |
| Both sexes | 46·7%  | -47·5% | 72·8%  | -45·3% |
|           | (32·3 to 59·3) | (-52·3 to -43·3) | (56·9 to 87·6) | (-49·8 to -40·7) |
| Female   | 58·7%  | -45·6% | 90·9%  | -41·8% |
|           | (41·9 to 76·6) | (-51·1 to -39·6) | (71·3 to 114·1) | (-67·7 to -33·9) |
| Male     | 40·1%  | -47·9% | 61·6%  | -47·0% |
|           | (25·1 to 55·1) | (-53·4 to -42·6) | (43·3 to 78·1) | (-52·6 to -41·8) |

| Intimate partner violence |        |            |        |            |
| Female   | 113·0% | 5·4%  | 125·4% | 19·2% |
|           | (90·3 to 135·0) | (1·6 to 15·6) | (84·9 to 186·9) | (-1·4 to 45·1) |

| Childhood sexual abuse and bullying |        |            |        |            |
| Both sexes | 56·6%  | 18·8% | 57·4%  | -40·0% |
|           | (35·1 to 80·5) | (8·8 to 27·9) | (28·4 to 127·1) | (-50·9 to -13·5) |
| Female   | 61·9%  | 21·4% | 44·4%  | -51·8% |
|           | (38·5 to 88·1) | (10·7 to 38·8) | (-11·5 to 22·2) | (-58·4 to -43·9) |
| Male     | 54·1%  | 16·3% | 62·5%  | -38·0% |
|           | (31·4 to 82·0) | (5·9 to 28·1) | (30·2 to 141·8) | (-49·9 to -8·8) |

(Continued from previous page)
Unsafe sex

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 155%     | (112 8 to 220 2) | 165%     | (111 6 to 256 5) |
| Female       | 115%     | (82 5 to 173 1) | 125%     | (81 5 to 197 2) |
| Male         | 466%     | (273 0 to 759 9) | 1849%    | (1034 1 to 3769 0) |

Low physical activity

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 121%     | (93 3 to 216 6) | 163%     | (123 5 to 223 5) |
| Female       | 163%     | (96 6 to 132 6) | 185%     | (131 4 to 252 1) |
| Male         | 107%     | (73 3 to 190 1) | 144%     | (103 3 to 232 1) |

High fasting plasma glucose

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 261%     | (225 3 to 304 3) | 306%     | (227 4 to 385 9) |
| Female       | 210%     | (176 4 to 250 7) | 289%     | (212 5 to 430 8) |
| Male         | 224%     | (186 8 to 273 0) | 266%     | (208 5 to 350 9) |

High LDL cholesterol

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 41%      | (24 0 to 56 8) | 73%      | (47 0 to 99 3) |
| Female       | 46%      | (24 8 to 66 2) | 88%      | (59 0 to 121 4) |
| Male         | 39%      | (22 0 to 55 0) | 63%      | (38 3 to 89 5) |

High systolic blood pressure

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 76%      | (58 3 to 90 0) | 109%     | (85 0 to 127 1) |
| Female       | 86%      | (61 2 to 105 8) | 124%     | (90 5 to 148 5) |
| Male         | 69%      | (52 9 to 86)  | 92%      | (77 6 to 119 5) |

High body mass index

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 179%     | (136 4 to 256 3) | 190%     | (148 0 to 270 2) |
| Female       | 166%     | (127 7 to 229 1) | 186%     | (141 0 to 261 6) |
| Male         | 193%     | (137 6 to 232 4) | 195%     | (141 1 to 315 7) |

Low bone mineral density

| Number       | Rate     | Number       | Rate     |
|--------------|----------|--------------|----------|
| Both sexes   | 64%      | (50 6 to 89 1) | 66%      | (49 7 to 102 0) |
| Female       | 95%      | (79 3 to 120 0) | 101%     | (73 0 to 162 8) |
| Male         | 51%      | (36 3 to 85 8) | 53%      | (35 0 to 101 3) |

(Continued from previous page)
Injuries, an emerging challenge for the health-care system

Road injuries climbed to the second rank by DALY rates from 1990 to 2019 (1302.1 per 100,000, 95% UI 1147.4–1488.3) and caused 21122 deaths (95% UI 18110–24648) in 2019. DALY and death age-standardised rates substantially decreased by around 60% in this period, with a slightly steeper decline between 2002 and 2015. The reduction in the DALY rate might be associated with increased GDP per person, given the reverse-U-shaped association between this index and the burden of transport injuries.51,52 Therefore, the minimal reduction in DALYs from road injuries might be related to the impact of sanctions on GDP.79 It is noteworthy that, although Iran managed road injury mortality and decreased DALYs, the age-standardised rate of YLDs reduced by 41·0%, and the share of YLDs out of DALYs increased (appendix p 47).

The highest number of new cases of road injuries, 77143 (95% UI 63 939–91 908), occurred in Tehran province in 2019. Tehran had the lowest (303.8, 95% UI 216.9–667.2) age-standardised DALY rates and Sistan and Baluchistan province, the highest (2286.8, 95% UI 1784.0–2813.4) age-standardised DALY rates in 2019. All of the subnational DALY rates converged in this period. Qom, Khorasan-e-Razavi, and Zanjan recorded the greatest declines in age-standardised DALY rates, by 70%, and Tehran had one of the lowest percentage changes in this regard (appendix p 152).

Policies to control road traffic injuries showed many shortcomings in Iran, pointing to the need for more effective measures.53 The low prevalence of seatbelt (about 75%) and helmet use (about 14%) in the Iranian population is a major contributor to road traffic injuries.54 Despite improvement in road infrastructure, low-quality domestic vehicles along with poor driving behaviours still contribute to this burden.55 Although control measures by the traffic police contributed to this,56 limitations in the widespread implementation of these measures highlight the importance of novel approaches such as telematics.57 Towards this objective, the national action plan for NCD Prevention and Control provided by the Iranian Non-Communicable Diseases Committee (INCDC) was developed in 2015, with a specific target of a 20% relative reduction in the mortality rate caused by traffic injuries by 2025, which needs a multisectoral approach.58

| DALYs | Death |
|-------|-------|
| Number | Rate   | Number | Rate   |
| Both sexes | 77.6% | -29.4% | 138.2% | -25.8% |
| Female | 83.9% | -28.3% | 152.7% | -22.4% |
| Male | 72.5% | -29.5% | 126.0% | -27.8% |

Data in parentheses are 95% CIs. DALYs=disability-adjusted life-years.

Table 2: All-age percentage change between 1990 and 2019, by sex

Consequences of sanctions and major health sector reforms on the health of Iranians

Exploring the impacts of the 2011 sanctions and two major health sector reforms in 2004 (the Universal Rural Health Insurance) and 2014 (the Health Transformation Plan) revealed that NCD deaths had a smaller decreasing slope during the 5 years after the beginning of sanctions in 2011 compared with the previous and following periods. Among NCDs, neoplasms showed the most substantial change in this investigation (appendix p 1176). Concerning NCD deaths, the regression model showed that deaths from NCDs had a significant decreasing effect on temporal changes after 2004 (coefficient –10.58, SE 0.97; p<0.0001) and a significant increasing effect on temporal changes after 2011 (coefficient 11.21, SE 2.25; p=0.0001; appendix p 1177). In the case of USMR, the model showed a mild increase in mortality after the 2004 health-care transformation (coefficient 0.64, SE 0.21; p=0.013), and the effects of other changes were not statistically significant (appendix p 1178). Overall, among these major changes, the 2011 sanctions had the most remarkable and detrimental impact on the health of Iranians, especially regarding deaths caused by NCDs (figure 5).

The neutral effect of the 2004 reform might be attributed to the fact that this strategy was not planned to address NCDs. Although there were some guidelines for managing NCDs and their risk factors, integrating multifactorial approaches to control NCDs was not done until the 2014 reform. Notably, the 2004 reform aimed to improve children’s health; nevertheless, with Behvarzes in health houses, improved vaccination coverage and nutrition messaging had already achieved great strides in improving children’s health. Therefore, the 2004 reform was not able to further decrease USMR. The 2011 sanctions might have affected deaths of Iranians caused by NCDs, especially neoplasms, through decreasing timely diagnosis and reducing accessibility of modern pharmacological interventions.11 The wide-ranging impacts of sanctions constrained drug supplies and non-pharmaceutical resources necessary for health-care services.24,25 The national pursuit of UHC coverage was dampened by the sanctions, leaving some health policy reforms underfunded or ineffective.44 We did not capture alleviation in the burden of disease following the 2014 reform, given that it aimed to enhance health infrastructure and improve health-care density, which needs more time to affect the health-care system. It
Figure 3: Ranking of age-standardised rates of disability-adjusted life-years caused by level 3 non-communicable diseases at national and subnational levels, 2019
| National | Subnational |
|----------|-------------|
| Iran     | Qom         |
| Alborz   | Hamadan     |
| Ardabil  | Kerman      |
| Kohgiluyeh | Razavi   |
| Khuzestan| Khuzestan   |
| Lorestan | Lorestan    |
| Khorasan | Khorasan    |
| Fars     | Fars        |
| Chahar Mahaal and Bakhtiar | Chahar Mahaal and Bakhtiar |
| East Azarbayejan | East Azarbayejan |
| Khorasan | Khorasan    |

**Figure 4:** Time trend of the unconditional probability of death at national and subnational levels, 1990-2019
Call to action
Altogether, the results of this study should be translated into practical actions and strategies. National and international agencies and policy makers should be prompted and informed that sanctions indirectly had major adverse effects on the health of Iranians by diminishing access to quality care. Delayed or inaccessible treatment exacerbated health burdens, especially in those with cancers. Although sanctions do not include health and medical issues, their effects on financial transactions, such as those required for the importation of medicines, have had unfavourable consequences, as represented in this study.

Future policies in the health sector should be prioritised to integrate health-care services to address NCDs, especially cardiovascular diseases, and modifiable risk factors, into the existing health-care infrastructure, such as the Iranian Package of Essential NCD Interventions for primary health care. Because the PHC system is unable to manage NCDs alone, this issue needs an integrated intersectoral collaboration such as the INCDC. Examples in this regard are dietary improvements that require an alliance between the health sector and the food industry, and improvements in ambient air pollution in major cities that require cooperation to shift from using fossil fuels to cleaner sources of energy. Further, strategies should focus on providing integrated care to those with mental health and substance use disorders to combat their increasing and unmet burden. The concurrent HIV/AIDS epidemic and re-emergence of tuberculosis in Iran require continued prevention efforts such as the directly-observed therapy short course.

Regarding the existing health disparities among provinces, closing the health equity gaps in Iran needs a two-part approach of health sector policies and cross-government actions to effectively use all resources to address this concern. One of the major steps in resolving health disparities is monitoring health inequalities; that includes practical and continuous measurement and reporting of disparities, which is an essential step in low-income and middle-income countries that do not have adequate data sources. These disparities should encourage multisectoral policy making, collaboration, and resource allocation on the basis of affirmative action to resolve disparities through equal distribution of education, sanitation, nutrition, road infrastructure, and PHC across the country.

Ultimately, the emergence of COVID-19 and its confluence with socioeconomic gaps, economic recession, and the heavy burden of NCDs in Iran could have direct and indirect effects on the care provided for major diseases and expand inequalities in the care provided. Therefore, careful evidence-based policies should be made to prevent the further adverse effects of COVID-19, which requires integrated collaboration and effort. Limitations of this study are presented in the appendix (section 6).

Conclusion
A remarkable improvement in life expectancy has happened in the past three decades in Iran. The Iranian health-care system has successfully managed CMNNDs; however, it is encountering NCDs and injuries as its new challenges. In the study period, the Iranian health-care system has been more effective at averting deaths than managing morbidity and mental disorders, indicating an unmet need for rehabilitation centres and integration of mental health services into PHC. Environmental changes as developing risks threaten the population. Besides addressing the current challenges and subnational disparities, the Iranian health-care system must be more prepared for emerging diseases, such as the COVID-19 pandemic.

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For more detailed information about individual author contributions to the research, divided into the following categories, please see the appendix (pp 118–88): managing the estimation or publication process; writing the first draft of the manuscript; primary responsibility for applying analytical methods to produce estimates; primary responsibility for seeking, cataloguing, extracting, or cleaning data; designing or coding figures and tables; providing data or critical feedback on data sources; developing methods or computational machinery; critical feedback on methods for publication or manuscript; revising or editing it for important intellectual content; and managing the overall research enterprise.

Declaration of interests
MAJ reports leadership or fiduciary roles in a board, society, committee, or advocacy groups, paid or unpaid, or International Affairs in the Ministry of Health, Iran as Director General, all outside the submitted work. SBor reports support for the present manuscript from medical writing. All other authors declare no competing interests.

Data sharing
This study follows the Guidelines for Accurate and Transparent Health Estimates Reporting. All data sources used in this analysis are found on the Global Health Data Exchange (http://ghdx.healthdata.org/gbd-2019/data-input-sources), and related code is available at http://ghdx.healthdata.org/gbd-2019/code. Additional results from this study and the larger GBD 2019 analysis can be explored using our data visualisation tool (https://vizhub.healthdata.org/gbd-2019/).

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