Non Comunicable Diseases

Burden attributable to Iodine deficiency in Iran from 1990 to 2019: findings from Global Burden of Disease study

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Keywords

Epidemiology • Iodine • Iodine deficiency • Micronutrient deficiency • Age-standardized disability-adjusted life years • Iran

Summary

Introduction. *Iodine is necessary for the synthesis of thyroid hormones which rely on sufficient levels of iodine. Iodine deficiency (ID) gives rise to various diseases. This is the first study presenting the epidemiology of ID in the Iranian population from 1992 to 2019.*
Methods. *This study was performed based on the analysis of global burden of disease (GBD) study data. Epidemiological indices including prevalence, incidence, and age-standardized disability-adjusted life years (DALYs) were compared in all provinces located in Iran between 1992 and 2019.*
Results. *The studies' collective conclusions showed that Iran's age-standardized DALYs rate (ASDR) for iodine deficiency dropped from 14.76 to 5.92. Additionally, the ASDR for Iodine Deficiency is clearly trending lower for all provinces. The ASDR for iodine deficiency peaked in 1990 in middle-aged people of both sexes. But later in the year, the pattern changed, with males and older age groups in particular reporting a larger ASDR of iodine deficiency.*
Conclusions.*The findings of this study show that the burden of iodine deficiency disorder has decreased in different provinces, all age and, males, but some provinces and groups still need more regulations to reduce the burden of iodine deficiency.*

Introduction

The manufacturing of thyroid hormones depends on iodine, a non-metallic trace element that is vital to human health [1]. The thyroid gland, a vital organ in the body, contains the largest iodine stores and relies on sufficient iodine levels to produce thyroid hormones, such as thyroxine (T4) and triiodothyronine (T3), which are essential for the proper functioning of the liver, kidneys, muscles, and central nervous system [2, 3]. Evidence shows that adults require a daily intake of 150 micrograms of iodine to maintain thyroid hormone synthesis and overall homeostasis. Iodine deficiency stands as one of the most common nutrient deficiencies, resulting in reduced intrathyroidal synthesis of T4 and subsequently elevating thyroid-stimulating hormone (TSH) concentrations in the blood [4, 5]. This deficiency gives rise to various diseases: in adults, severe deficiency manifests as hypothyroidism, goiter, mental disability, and decreased fertility, while in children, it can cause goiter, intellectual/physical developmental impairments, deafness, and cretinism [4]. Many people worldwide suffer from iodine insufficiency, particularly in areas where iodine-deficient soil and food are prevalent [6]. The primary dietary sources of iodine are foods high in the mineral, such as fish, meat, milk, and eggs [7]. Despite global efforts to address iodine deficiency, including in Iran, where universal salt iodization (USI) has been implemented, understanding the burden of iodine deficiency in specific populations remains critical. This study aims to assess the burden of iodine deficiency in Iran from 1990 to 2019, utilizing data from the Global Burden of Disease (GBD) study. Iran also set up committees to monitor on the project's efficacy [5].
An international initiative run by the University of Washington's Institute for Health Metrics and Evaluation (IHME) is the global burden of diseases, injuries, and risk factors research (GBD). This endeavor affords several nations the chance to assess and contrast their respective state of health on an international level [8]. While there have been limited studies on iodine deficiency in Asia based on the GBD database, these studies do not specifically focus on the Iranian population. Hence, we utilized the GBD database to ascertain the burden

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attributed to iodine deficiency in Iran from 1992 to 2019. This study seeks to fill the research gap by examining the burden of iodine deficiency in Iran over the past three decades using GBD data, with a focus on understanding trends and identifying at-risk populations [9].

Method and material

In this study, GBD data were used. The GBD study was managed by the Institute for Health Metrics and Evaluation (IHME) to estimate the burden and epidemiology of 369 diseases and injuries, 87 risk factors, and the burden of disease during a 30-year period, from 1990 to 2019. The study was conducted in 204 countries and territories [10]. The methodological and statistical reports for the GBD study are provided here [10, 11]. In summary, the GBD data was gathered from epidemiological characteristics of different illnesses and injuries through a range of data sources, such as disease-specific registries, health surveys, and vital registration systems [11]. The data is clear, standard, and consistent amongst several sources. The GBD global data on iodine deficiency in Iran were used in this investigation. In order to increase the accuracy of estimation from partial reports, GBD used a complex statistical model to estimate the burden of disease and injury for various populations. This model comprises DisMOD-MR 2.1, a valid and dependable Bayesian meta-regression tool [11-13].

Data

We obtained age-standardized disability-adjusted life years (DALYs) for iodine deficiency in Iran from the GBD database, stratified by sex and year (1990-2019). DALYs were calculated by multiplying the prevalence of iodine deficiency by specific disability weights, derived from a variety of data sources, including disease registries, health surveys, and vital registration systems [8].

Index

In the GBD study, DALYs are calculated by multiplying the prevalence of Iodine deficiency by specific disability weight. The disability-adjusted life years were extracted from a number of Iodine deficiencies in Iran. We have rated DALYs for males, female, and both sexes in age-standardized rates per 100,000 from 1990 to 2019. Also, choropleth maps were created to visualize the geographical distribution of age-standardized DALY rates for iodine deficiency across Iranian provinces in 1990 and 2019, highlighting regional variations and changes over time. We included 95% uncertainty intervals for all estimates, calculated using a Bayesian approach to account for variability and uncertainty in the data, providing a more robust understanding of the burden of iodine deficiency.

Statistical Analysis

We employed an ordinary least squares simple linear regression model to evaluate trends in DALYs over time, as this model is suitable for analyzing temporal trends in continuous data from 1990 to 2019. We used mathematical methods and models for these analyses. All other analyses were performed via Python (version 3.10; Python Software Foundation). We evaluated the association between the DALYs rate for iodine deficiency across years and Iran provinces. The libraries used for these analyses were Pandas, Matplotlib, Numpy, Seaborn, and Geopandas. Python was chosen due to its robust data analysis and visualization libraries, such as Pandas for data manipulation, Numpy for working with arrays, Matplotlib, and Seaborn for visualization, and Geopandas for geographical analysis. Significance was assessed using a threshold of 0.05.

Results

National Level

Between 1990 and 2019, the Age-standardized DALYs rate (ASDR) of Iodine Deficiency decreased globally, with the MENA area and Iran experiencing the same trend. Iran's ASDR of Iodine Deficiency decreased from 14.76 (9.53-21.73) in 1990 to 5.92 (3.44-9.61) in 2019, as was noted. Also, ASDR of Iodine Deficiency in 1990 for the Global Scale and MENA region were 46.84(28.64-76.01) and 38.34 (23.72-57.53), Decreased to 30.69 (17.32-53.12) and 21.61 (13.25-33.41) in 2019, respectively as shown in Table I and Figure 1.

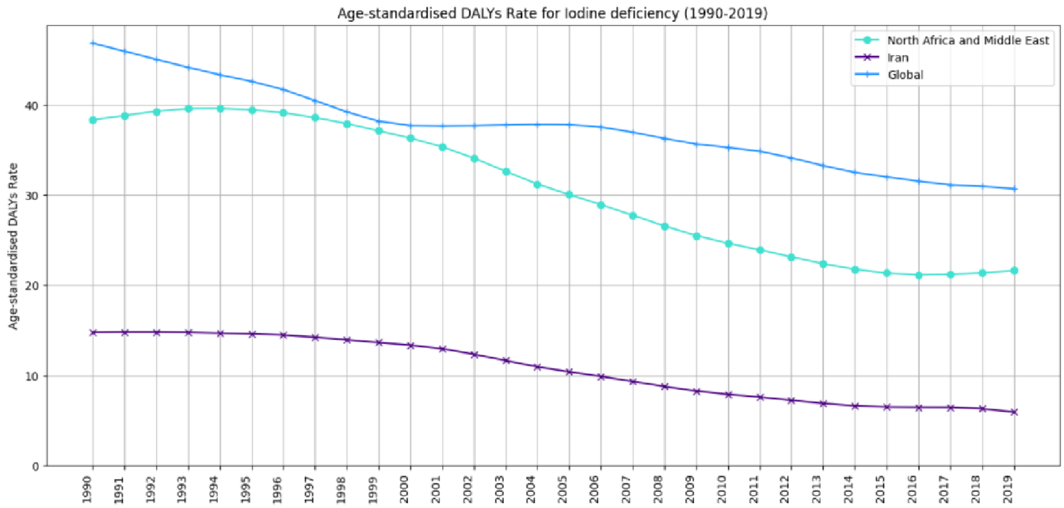
Sub-national Level

At the sub-national level, for all the provinces, there is a clear downward trend in the ASDR of Iodine Deficiency from 1990 to 2019. In 1990, the provinces of South Khorasan [19.7 (12.59-28.39)], Kurdistan [18.76 (12.05-27.43)], and Khorasan-e-Razavi [18.46 (11.95-26.93)], which are all border provinces, had highest ASDR related to iodine deficiency. After three decades in 2019,

Tab. I. Burden of Iodine deficiency in the world, Iran, and Middle East North Africa in 1990 and 2019.

	Iran			Mena			World		
	1990	2019	Percentage change	1990	2019	Percentage change	1990	2019	Percentage change
Prevalence	434.97	285.12	-34.43	1,602.52	942.86	-41.16	2,833.70	2,215.54	-21.81
DALY rate per 100000	13.15	6.12	-53.46	35.56	21.88	-38.47	46.73	31.52	-32.54
Age-standardized DALY rate per 100000	14.76	5.93	-59.82	38.35	21.62	-43.62	46.85	30.70	-34.47

Fig. 1. Trends in the age-standardized DALY rate of Iodine deficiency in Iran, Middle East and North Africa, and world from 1990 to 2019.



Sistan Baluchistan [7.87 (4.51-12.69)], Kerman [7.23 (4.24-11.71)] and South Khorasan [7.15 (4.08-11.62)] provinces had the highest ASDR respectively. In addition, Alborz [12.7 (7.83-19.57) in 1990 and 5.99 (3.44-9.73) in 2019], Mazandaran [12.7 (7.83-19.57) in 1990 and 6.1 (3.56-9.66) in 2019], and Tehran [8.04 (4.44-13.32) in 1990 and 2.58 (1.17-4.92) in 2019] provinces had the lowest ASDR related to iodine deficiency in both 1990 and 2019, as detailed in Table II and illustrated in Figures 2 and 3.

Age and Gender Disparities

In 1990, the ASDR of iodine deficiency reached its peak among middle-aged individuals of both genders. However, during the same year, there was a shift in the pattern, with older age groups, particularly males, experiencing a higher ASDR of iodine Deficiency. In 1990, the age group of 45-49 years exhibited the highest ASDR for iodine deficiency in males and females. In 2019, the age group of 45-49 years remained the highest ASDR among females, while among males, the age group of 75-79 years had the highest. In 1990, ASDR of iodine deficiency in females was 18.19 (11.7-26.93) and in males was 11.49 (7.40-16.83). In 2019, these values reached the 7.49 (4.34-12.33) and 4.41 (2.54-7.16) in females and males, respectively. Then, The Ratio of ASDR of iodine deficiency of females to males was 1.58 in 1990. This ratio has slightly increased and reached 1.7 in 2019, as shown in Table III and Figure 4.

Discussion

Based on the current results, iodine deficiency ASDR in Iran follows the global decremental trends in the past three decades. We observed this reduction in at-risk provinces revealing proper counter-actions against iodine deficiency. However, some parts of Iran still require more attention to mitigate iodine deficiency including; Sistan Baluchistan, Kerman, and South Khorasan. Age and gender-wise, the highest iodine deficiency ASDR remained unchanged in females from 1990 to 2019 with the highest value in age 45-49. In contrast, we observed a 30-year shift in age for the highest ASDR in males, reaching from 45-49 to 75-79. Concurrently, the ratio of iodine deficiency ASDR of females to males had an incremental trend from 1990 to 2019.

Proper policy-making has led to a significant reduction of iodine deficiency disorders (IDD) in past decades using a sustainable way of supplementing iodine by salt iodization programs leading to various health and economic outcomes especially in low- and middle-income countries [14, 15]. Salt iodizing was begun 19 1990 in Iran, however, there was no mandatory law for that until 1994; Since 1996, Iran has become a part of the global program of IDD prevention and followed all criteria to eliminate iodine deficiency [16]. Two decades after these health policies, nationwide investigations in 2001 and 2007 demonstrated the possible eradication of iodine deficiency [17].

In line with these proper implementations of iodine supplementation, the burden attributable to Iodine deficiency in Iran has also decreased as we found the same trends in ASDR. As previously reported, iodine deficiency-related death and DALYs consist of a wide spectrum of disorders in age and gender groups including fetus miscarriage, stillbirth, and increased risk of perinatal mortalities, neonatal goiter and neurocognitive impairment following hypothyroidism, child and adolescent goiter retarded physical and mental development and also adults goiter, hypothyroidism, mental dysfunctions, *etc.* [18]. based on our findings these iodine deficiency-related deaths and DALYs were significantly reduced after three decades. However, some providences showed relatively higher ASDR including Sistan Baluchistan, Kerman, and South Khorasan. The higher confidence intervals observed in these provinces are likely due to smaller population sizes or variability

Tab. II. Burden of Iodine deficiency across province of Iran in 1990 and 2019.

Provinces	1990		2019		Percentage change in age-standardized rates between 1990 and 2019
	ASDR	Interval	ASDR	Interval	
Alborz	12.70	7.83-19.57	5.99	3.44-9.73	-0.53
Ardebil	15.45	10.04-22.30	6.60	3.83-10.64	-0.57
Bushehr	14.99	9.43-22.04	6.27	3.55-10.07	-0.58
Chahar Mahaal and Bakhtiari	17.80	11.49-26.21	6.43	3.64-10.25	-0.64
East Azarbayejan	15.48	9.83-22.90	6.46	3.69-10.29	-0.58
Fars	15.80	10.12-23.02	6.28	3.58-10.37	-0.60
Gilan	16.14	10.49-23.81	6.49	3.75-10.23	-0.60
Golestan	16.48	10.51-24.15	6.85	3.88-11.11	-0.58
Hamadan	17.64	11.40-25.62	6.73	3.87-10.84	-0.62
Hormozgan	16.02	10.23-23.39	6.67	3.91-10.59	-0.58
Ilam	16.73	10.57-24.56	6.82	3.95-10.96	-0.59
Isfahan	14.25	8.92-21.51	6.43	3.62-10.28	-0.55
Kerman	15.62	9.97-23.00	7.23	4.24-11.71	-0.54
Kermanshah	17.45	11.34-25.67	6.72	3.86-10.85	-0.62
Khorasan-e-Razavi	18.46	11.95-26.93	7.14	4.19-11.44	-0.61
Khuzestan	13.93	8.67-20.52	6.17	3.62-9.93	-0.56
Kohgiluyeh and Boyer-Ahmad	17.44	11.05-25.28	6.66	3.82-10.76	-0.62
Kurdistan	18.76	12.05-27.43	6.89	4.02-11.36	-0.63
Lorestan	18.15	11.53-26.70	6.88	3.92-11.05	-0.62
Markazi	17.45	11.00-25.32	6.71	3.89-10.62	-0.62
Mazandaran	12.33	7.47-19.11	6.10	3.56-9.66	-0.51
North Khorasan	18.26	11.78-26.69	6.95	4.08-11.02	-0.62
Qazvin	16.35	10.47-24.15	6.31	3.58-10.13	-0.61
Qom	15.05	9.54-22.13	6.16	3.56-9.90	-0.59
Semnan	15.85	10.14-23.33	6.64	3.78-10.71	-0.58
Sistan and Baluchistan	18.31	11.76-26.76	7.87	4.51-12.69	-0.57
South Khorasan	19.70	12.59-28.39	7.15	4.08-11.62	-0.64
Tehran	8.04	4.44-13.32	2.58	1.17-4.92	-0.68
West Azarbayejan	15.81	9.96-23.32	6.76	3.81-10.95	-0.57
Yazd	14.58	9.21-21.92	6.28	3.64-10.04	-0.57
Zanjan	16.80	10.74-24.29	6.76	3.93-10.93	-0.60

in data collection practices. In line with our results, Mirahmad et al. found a significant proportion of adults in south Khorasan demonstrated evidence of thyroid dysfunctions [19]. Two studies were conducted between 2010 and 2015 in Khorasan and Lorestan provinces to evaluate iodine concentrations in commercially iodized salts and found lower than standard concentrations of iodine in a significant number of these packages [20, 21]. Despite that Iran is among the successful countries in eliminating iodine deficiency compared to MENA region countries [22], public health measures and regular assessment of global programs of IDD prevention especially in provinces with the highest ASDR are mandatory.

In terms of age and gender disparities of highest iodine deficiency ASDR from 1990 to 2019, while no change was shown among females, the male group with the highest ASDR shifted from ages 45-49 in 1990 to 75-79 in 2019. This shift in peak ASDR among males may be attributed to age-related dietary changes, including lower appetite, food costs, and food access, as well as increased insulin resistance. Studies have shown that insulin resistance is a risk factor for higher thyroid volume in iodine-deficient areas, which may explain the increased risk of iodine deficiency-related thyroid disorders in older males [23, 24]. It is crucial for public health policies to focus on monitoring iodine deficiency in the elderly, especially males.

On the other hand, we observed an increased ratio of females to males for iodine deficiency-related ASDR. This emerging trend is alarming as females, especially in pregnancy and lactating require more iodine as the disorders not only affect females only, but also have irreversible effects on fetus, and breast-fed child physical and mental development [4]. pregnant and Lactating mothers have very high requirements of iodine and so have more risk of iodine deficiency ASDR as they have higher renal iodine losses, higher needs of iodine

Fig. 2. Age-standardized DALY rate of Iodine deficiency across Iran provinces in 1990 and 2019.

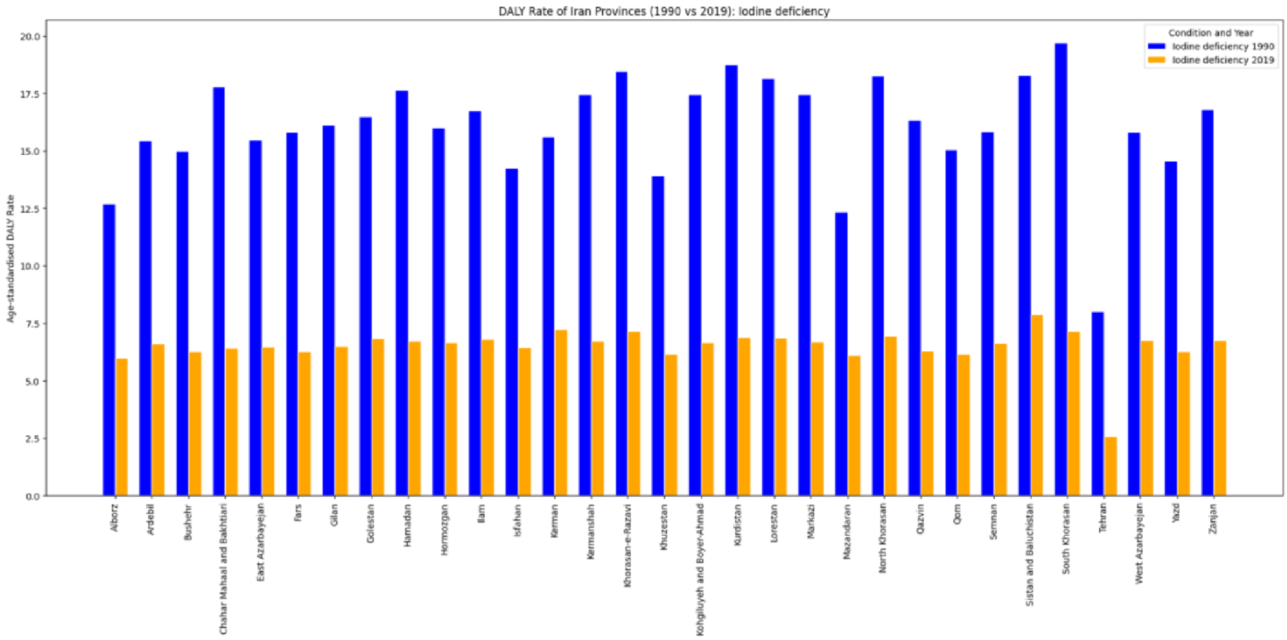
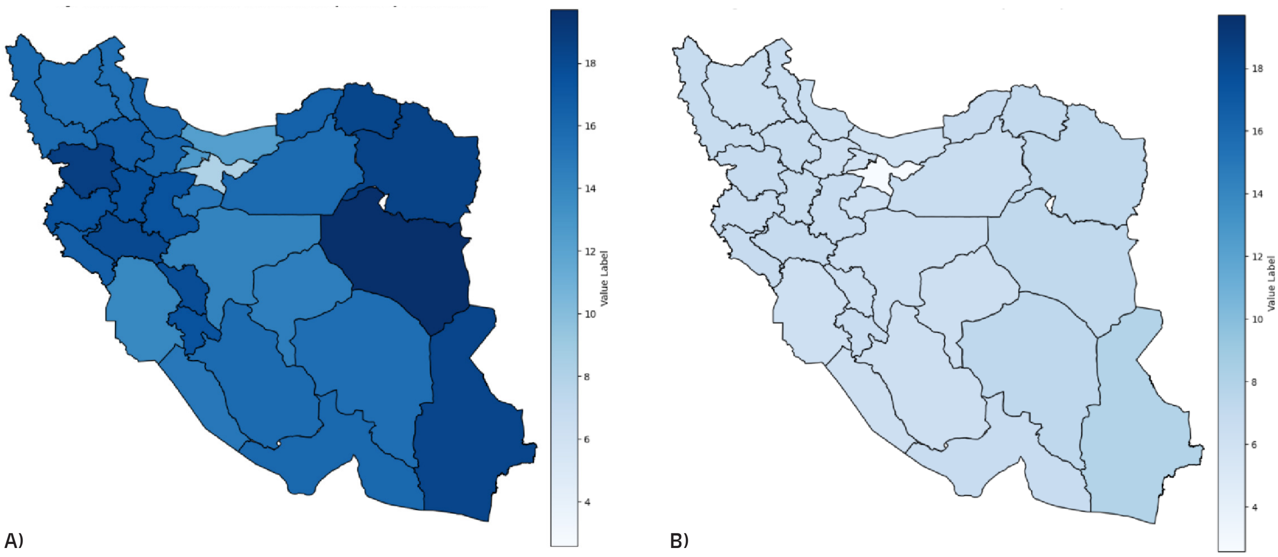


Fig. 3. Age-standardized DALY rate of Iodine deficiency across Iran provinces in A) 1990 and B) 2019.



for developing fetuses, and even higher losses of iodine through breast milk [25].

To our knowledge, this study was the first investigation of the iodine deficiency burden from 1990 to 2019 in Iran as a successful country in the MENA region to mitigate iodine deficiency. We investigate the burden based on gender and different age groups and at national and sub-national levels.

Limitations

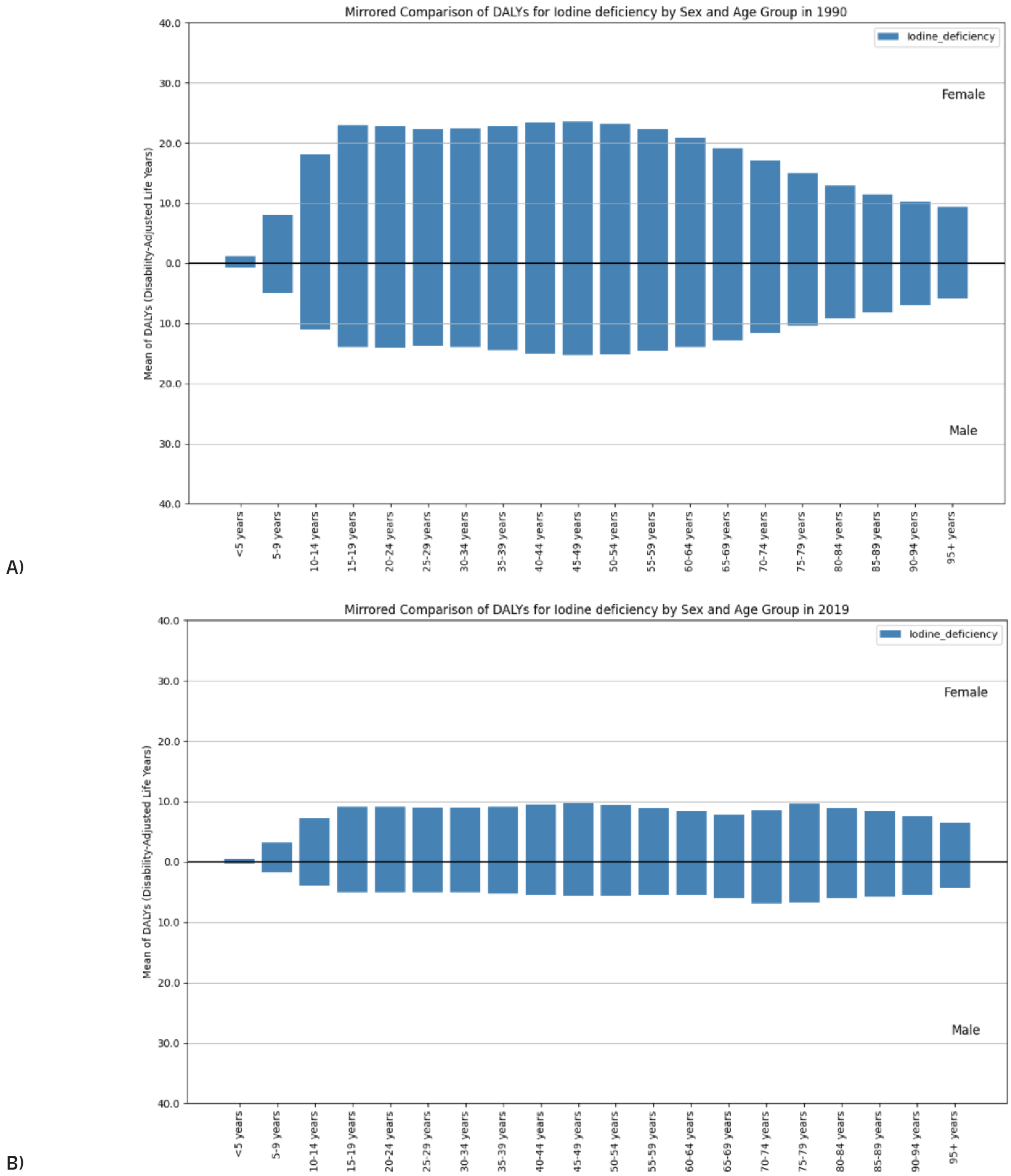
This study, while providing valuable insights into the burden of iodine deficiency in Iran, has several limitations. First, the data were derived from the Global Burden of Disease (GBD) study, which uses the DisMOD-MR 2.1 model for estimation. Although this model is robust, it assumes data uniformity across regions, which can introduce biases, particularly in provinces with smaller populations or inconsistent data collection practices, such as Sistan Baluchistan and Kerman. The wider confidence intervals in these areas reflect greater uncertainty in the data, suggesting that caution is needed when interpreting the results for these regions [26].

Second, this study relies on available data from registries, health surveys, and vital statistics, which may suffer from underreporting or misclassification of iodine deficiency cases, especially in rural and underdeveloped

Tab. III. Burden of Iodine deficiency across genders in Iran in 1990 and 2019.

	Prevalence			DALY rate per 100000			Age-standardized DALY rate per 100000		
	1990	2019	Percentage change	1990	2019	Percentage change	1990	2019	Percentage change
Female	545.13	368.61	-32.38	16.29	7.77	-52.30	18.19	7.49	-58.82
Male	329.70	204.03	-38.11	10.16	4.52	-55.51	11.49	4.41	-61.61

Fig. 4. DALY of Iodine deficiency among males and females in Iran in A) 1990 and B) 2019.



regions. This could lead to either overestimation or underestimation of the actual burden of iodine deficiency in some areas [27, 28].

Additionally, while disability-adjusted life years (DALYs) provide a useful measure of disease burden, they may not fully capture the broader, subclinical impacts of iodine deficiency, such as cognitive impairments or developmental issues that may not directly contribute to DALYs but still affect overall public health [28, 29].

Finally, the study does not explicitly model potential confounders such as healthcare access, socio-economic factors, or the effectiveness of public health interventions over time, which could have influenced trends in iodine deficiency. Further research should explore these factors in more detail, especially at the sub-national level, to provide a more comprehensive understanding of the burden of iodine deficiency [28, 30, 31]

Conclusions

In conclusion, we found that the iodine deficiency disorder burden decreased from 1990 to 2019. Some provinces still require more regulation to mitigate the burden of iodine deficiency. Moreover, the female population aged 45-49 despite the reduction in ASDR, still has the highest burden of disease which requires more robust health policy practices as they have the most critical part in a sustainable health system, especially in child development. Moreover, the elderly male population (aged between 75 and 79) in 2019 had the highest ASDR compared to the highest levels in 45-49 years in 1990.

Conflict of interest statement

The author declares no financial or ethical conflicts of interest for any of the studies described in this manuscript.

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Authors' contributions

PR: conceptualization, study design, data analysis, supervision, project administration and manuscript proofreading; MAK: data collection and manuscript preparation; MAA: literature review and drafting of the manuscript; SG: literature review and drafting of the manuscript; MNA: literature review and drafting of the manuscrip; ZR: data verification and manuscript editing; KD: supervision, project administration, and manuscript review; AF: data acquisition and quality assurance; ED: supervision, project administration and manuscript proofreading.

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