Years of healthy life lost due to illegal drug use in Iran: A national registry-based study

Running Head: Drug-related deaths in Iran

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ABSTRACT

Illegal drug use mortality remains a leading cause of death among individuals aged 15-64 years worldwide. This study aimed to quantify years of healthy life lost (YLL) and relative risks (RR) due to illegal drug use mortality in Iran. This cross-sectional study analyzed data from the Iranian Forensic Medicine Organization's national registry between March 2022 and March 2024. Among 11,944 drug-related deaths (mean age 37.3 years), total YLL reached 387,681.5 years (247.4 per 100,000 population), with significant sex disparities (385.3 [males] vs. 91.8 [females] YLL per 100,000). Eight provinces showed significantly lower relative risks of drug-related deaths compared to the national average, while eight others demonstrated higher risks. Compared with the national average risk, the relative risk of drug-related death was also higher in the 15-29 and 30-44 age groups and lower in the 75+ age group. Geographic and demographic variations in drug use-related mortality across Iran highlight the need for age-specific interventions, targeted resource allocation to high-risk provinces, and expanded community-based overdose prevention programs.

Keywords: Drug overdose, Iran, Spatial analysis, Substance-related disorders

INTRODUCTION

Illegal drug use remains a significant global public health concern, affecting individual health, societal well-being, and economic productivity (Mokdad et al., 2016). The 2023 World Drug Report notes that one in 17 people used drugs in 2021, a 23% increase from a decade earlier (UNODC, 2023). Opioids continue to be the primary driver of drug-related harms, including fatal overdoses, with around 60 million people engaging in non-medical opioid use worldwide in 2021 (UNODC, 2023). The Eastern Mediterranean Region (EMR) faces unique challenges that exacerbate the drug use crisis, including political instability and socioeconomic disparities (Al-Mandhari, 2019). These factors contribute to the widespread production, trafficking, and consumption of illegal drugs, with opioids accounting for 80% of all drug-use disorder-related disability-adjusted life years (DALYs) in the region (Amirkafi et al., 2023). Drug use disorders in the EMR have risen sharply, with a 137% increase in the number of cases between 1990 and 2019, and the region is experiencing a higher rate of DALY increases compared to the global average (Amirkafi et al., 2023). Among EMR countries, Iran's geographical location between Afghanistan (i.e., the world's largest opium producer) and major consumer markets makes it particularly vulnerable to drug-related harms (Rostami et al., 2017; Amirkafi et al., 2023). Iran's geographical location in a region characterized by high rates of drug production and trafficking makes it especially vulnerable to drug use-related harms (Rostami et al., 2018; Rostami et al., 2017). Between 2017 and 2021, Iran accounted for 90% of globally seized opium (UNODC, 2023), and population estimates indicate that 4,791 per 100,000 people in Iran use illegal drugs, mainly opioids, on at least a weekly basis (Rastegari et al., 2023).

Despite Iran's harm reduction strategies, both the prevalence of drug use disorders and drug-related mortality continue to rise (Alipour et al., 2022; Moazen et al., 2015; Shahbazi et al., 2020). These strategies were first developed in the mid-to-late 1990s to address prison-based HIV transmission through needle and syringe programs, and they later expanded to include opioid agonist therapy (Ekhtiari et al., 2020; Rastegari et al., 2023). In parallel, national drug policies continue to rely primarily on strict law enforcement, border control, and the criminalization of illegal drug use. However, they also emphasize preventive measures, public-participation initiatives, and the scaling up of treatment, rehabilitation, and harm reduction services, reflecting a more comprehensive approach in principle (Ekhtiari et al., 2020; Drug Control Headquarters,

2019). However, because existing harm reduction programs in Iran remain focused primarily on HIV prevention in large urban centers, many high-risk border regions remain underserved (Mehrabi et al., 2024; Ekhtiari et al., 2020). Cultural stigma and gender-specific barriers, especially in conservative parts of the country, also reduce the effectiveness of these programs.

Earlier studies document substantial inequities in fatal drug overdoses, with important differences by sex and age group (Rostami et al., 2023; Rostami et al., 2018; Rostami et al., 2017). Drug use mortality is a major concern among young adults and ranks among the leading causes of death nationally (Alipour et al., 2022; Shahbazi et al., 2020). Previous studies also indicate significant geographic disparities in fatal and non-fatal overdoses (Rostami et al., 2018; Rostami et al., 2017; Tavakoli et al., 2024). By contrast, central provinces face added pressures from population density, rapid urbanization, internal migration, and informal settlements, which contribute to drug-related harms (Rostami et al., 2023; Rostami et al., 2017).

Previous estimates from 2017, suggest that incidence rate of drug-related deaths varied from 3.8 per 100,000 people (Baberi et al., 2023) to 4.1 per 100,000 people (Alipour et al., 2022). However, these studies do not fully capture the broader burden of premature mortality or report on geographic variations across provinces. To address this gap, the present study advances previous research by quantifying years of healthy life lost (YLL)—a key metric for measuring premature mortality (Ferrari et al., 2024; Shahbazi et al., 2020)—across all 31 provinces of Iran using the most recent national illegal drug-related mortality data from the Iranian Forensic Medicine Organization (FMO). By focusing on years of full health lost, our YLL approach shifts the narrative from the quantity of life lost to the quality of life lost, aligning with holistic public health goals that emphasize preserving health span rather than simply extending lifespan (Ferrari et al., 2024). By examining the age, sex, and geographic distribution of YLL, this work provides more comprehensive and up-to-date insights into population-level drug use–related deaths across the country. Such detailed analyses are essential for guiding targeted public health strategies aimed at reducing the burden of illegal drug–related harms in Iran.

METHODS

Data sources

Under Iranian law, all deaths classified as *suspicious* or *undetermined* are referred to the FMO for further investigation. FMO forensic physicians examine these cases to determine precise cause of death and issue official death certificates (Rostami et al., 2017). While these certificates are typically prepared in response to law enforcement investigations, deaths are recorded as '*death due to illegal drug use*' without the corresponding International Classification of Diseases (ICD) codes (Rostami et al., 2017). Legal drug overdoses, including accidental cases, are categorized and reported separately from illegal drug overdose deaths under the designation of '*drug poisoning*'. We analyzed FMO data on all direct illegal drug-related deaths during a two-year period (March 21, 2022 to March 20, 2024; corresponding to the Iranian calendar years 1401-1402). Deaths were attributed to various illegal drugs, including opiates (e.g., opium, heroin, and other unregulated opioids), amphetamines, unregulated stimulants, hallucinogens, psychoactive substances, and other unspecified drugs. While the dataset contained demographic information (i.e., nationality, age, sex, and primary province of residence), a notable limitation was the absence of toxicology data specifying the primary substance(s) implicated in each death. We obtained population data for each province, age group, and sex from the Statistical Center of Iran's estimates (Statistical Centre of Iran, 2022), to estimate for the population at risk. The Statistical Center of Iran is the official source of demographic data in Iran, conducting a population and housing census every 10 years and providing interim population estimates based on growth rates. While no rigorous studies have assessed the completeness and accuracy of this organization's estimates, they are considered the most reliable source of population data in Iran (Statistical Centre of Iran, 2022).

Data analysis

In line with the Global Burden of Disease reference methodology and WHO guidelines, we calculated Years of Life Lost (YLL) using a simplified approach, which excluded factors like age-weighting and discounting (Global Burden of Diseases, 2017). To maintain consistency with previous research (Alipour et al., 2022; Shahbazi et al., 2020), we broke down the data into 15-year age ranges: 0-14, 15-29, 30-44, 45-59, 60-74, 75 and above. Age data was missing for a small portion of individuals (n=66; 0.55%). The YLL was calculated separately for each province, age group, and sex, based on the number of deaths in each category, and adjusted according to the

expected lifespan at the time of death, derived from the Global Burden of Disease studies conducted by the Institute for Health Metrics and Evaluation (IHME, 2024). These values were rounded to the nearest whole number.

To understand how factors like province, age group, and sex affected the relative risk (RR) of losing years of healthy life, we used a statistical model designed to predict the likelihood of such loss (Lawson, 2018). This model accounted for differences in population size across provinces and groups, as well as the RR of premature death. The risk itself was influenced by a combination of factors, including a baseline risk level, differences between provinces, age group effects, and sex differences (Lawson, 2018). **Figure 1** illustrates how we calculated years of healthy life lost using mortality data, healthy life expectancy, and population data. We then applied a negative binomial model, well-suited for count-based outcomes, to estimate the relative risk of drug use mortality by province, age group, and sex. We estimated these factors and their effects using a Bayesian approach via the Integrated Nested Laplace Approximation package in R (version 24.05.10) (Gómez-Rubio, 2020). This approach incorporates both observed data and prior uncertainties, making it particularly useful for disease mapping. We summarized the posterior distribution with the posterior mean, representing the expected value or weighted average of all plausible parameter values, and used 95% credible intervals to capture the variability in these estimates. Please see the supplementary file for more details on the statistical analysis.

Ethical consideration

The study protocol was reviewed and approved by the Ethics Committee of the Iranian Legal Medicine Organization (Reference Number: IR.LMO.REC.1403.004). Informed consent was not required due to the anonymized and de-identified nature of the drug-related mortality data.

RESULTS

Over the study period, a total of 11,944 individuals with a mean age of 37.3 years who experienced drug-related deaths were recorded. Of these, 10,167 (85.1%) were male, and 1,777 (14.9%) were female. The majority were Iranian nationals (11,269; 94.3%), followed by Afghan nationals (480; 4.0%). Nationality was not recorded for 166 individuals (1.4%), and 29 deceased individuals (0.3%) had other nationalities. The total YLL due to premature drug-related deaths amounted to

387,681.5 years for both sexes (247.4 YLL per 100,000 people). The sex-specific YLL due to premature drug-related deaths was 320,049.5 years for males (385.3 YLL per 100,000 people) and 67,632 years for females (91.8 YLL per 100,000 people). The distribution of fatal drug overdose by age and sex, along with the attributed YLLs, is summarized in **Table 1**. Among females, the highest YLL was associated with the age group of 15-29 years, while among males, the highest YLL was associated with the age group of 30-44 years. The sum of YLL values for each province and sex is summarized in **Table 2**. Males had significantly higher YLL values than females, and YLL values varied across provinces.

Unlike crude YLL values, RRs of losing years of healthy life were adjusted for population differences between provinces, age groups, and sexes, which provided a clearer understanding of the extent of illegal drug-related deaths across the country. **Figure 2 and Table S1** show the posterior mean and 95% credible interval of the RRs of losing years of healthy life for all provinces, with age group and sex effects held at their average levels. Provinces with significantly lower RRs compared to the national average included Kurdistan (RR: 0.48), Khuzestan (RR: 0.48), Mazandaran (RR: 0.51), West Azarbayejan (RR: 0.52), Golestan (RR: 0.54), Hormozgan (RR: 0.55), East Azarbayejan (RR: 0.66), and Gilan (RR: 0.74). On the other hand, provinces with significantly higher RRs compared to the national average included Kermanshah (RR: 1.90), Kerman (RR: 1.77), Hamadan (RR: 1.58), Kohgiluyeh and Boyer-Ahmad (RR: 1.46), Sistan-and-Baluchistan (RR: 1.45), Lorestan (RR: 1.43), Markazi (RR: 1.38), and Fars (RR: 1.36). The posterior means of RRs for each province are also presented in a heat map in **Figure 3**.

Figure 4 and Table S2 show the posterior mean and 95% credible interval of the RR of losing years of healthy life for different age groups and sexes, while controlling for other factors. The RR of death related to illegal drug use was significantly higher for the 15-29 and 30-44 age groups than for all other age groups, and significantly lower for the 75+ age group. After adjusting for population, age group, and province effects, no significant difference was observed between men and women in terms of the RR of death due to illegal drug use.

DISCUSSION

We quantified the burden of premature mortality due to illegal drug use across Iran by analyzing data from the FMO's national drug-related mortality registry. Our findings revealed several key

patterns. The total YLL due to premature drug-related deaths over the 2-year period was substantial. We observed significant geographic variations in YLL across provinces and demographic groups. To further understand these disparities, RR analysis, which adjusts for population differences, identified distinct regional patterns of risk compared to the national average.

Our findings identified significant geographical heterogeneity in drug use-related deaths across Iran, particularly among young and middle-aged adults. Our findings are in line with previous analyses of drug overdose deaths from 2014 to 2017, suggesting that mean YLL could vary from 67,616.6 years (2014) to 72,895.8 years (2017) for males, and from 7,548.8 years (2014) to 37,284.5 years (2017) for females, with YLLs showing an upward trend for both sexes (Alipour et al., 2022). Our findings are also comparable to previous evidence highlighting age- and geographical-disparities in illegal drug-related mortality rates across Iranian provinces (Alipour et al., 2022; Rastegari et al., 2023; Rostami et al., 2017; Shahbazi t al., 2018). We observed the highest mortality rates to be concentrated among individuals aged 20-39 years, primarily in western and southeastern provinces. These spatial variations may be influenced by historical factors, such as long-standing prevalence of opioid use in certain regions (Rastegari et al., 2023), as well as geographical factors, such as proximity to major drug trafficking routes from Afghanistan to Europe (Rostami et al., 2017; Zolala et al., 2016). Nonetheless, socioeconomic disparities also appear to amplify this trend. Studies have shown that lower literacy rates, high unemployment, and limited substance use treatment services can exacerbate drug-related harms (Mehrabi et al., 2024; Moradinazar et al., 2020; Rostami et al., 2017), which aligns with our observation that provinces with historically high opioid use often face significant socioeconomic challenges. Thus, western and southeastern provinces may experience compounding effects from both historical patterns of drug use and societal factors, contributing to the marked heterogeneity in mortality rates across Iran.

The RR of illegal drug use-related death was significantly higher in the 15-29 and 30-44 age groups compared to other age groups, with notably lower rates among those aged 75 and above. While previous studies reported the highest mortality and attributed YLL in the 30-39 age group (Baberi et al., 2023; Ghoreishi et al., 2017; Shahbazi et al., 2018), these variances likely reflect differences in age group categorization. These findings collectively underscore the need for age-

specific overdose prevention interventions in Iran. For young adults (ages 15-30), effective strategies could include education (Calihan et al., 2024), and peer support networks (Mercer et al., 2021). For adults aged 30-44, interventions could focus on workplace mental health programs (de Oliveira et al., 2020), family involvement in responding to problematic drug use (Bagley et al., 2015), and increased access to comprehensive treatment approaches (Cernasev et al., 2021). For all age groups, a critical priority is expanding nationwide access to the life-saving medication of naloxone (Miller et al., 2022), which is currently restricted to hospitals and emergency care settings in Iran (Mehrpour, 2019). Implementing these interventions at scale, through expanded harm reduction programs, broader naloxone distribution, and enhanced education and treatment services, could alter the current trajectories of illegal drug use mortality by reducing overdose risks, improving access to care, and mitigating the socioeconomic factors that contribute to regional disparities.

In our study, the total YLL due to premature drug-related deaths was 247.4 YLL per 100,000 individuals (385.3 for males and 91.8 for females). These findings align with previous burden of drug use studies in Iran, which reported significantly higher YLL due to drug use disorders among men (351.8) compared to women (24.8) (Moazen et al., 2015). Although we observed the highest crude YLL in males aged 30–44 years, our analysis found no statistically significant difference in the RR of illegal drug–related death between the sexes, given overlapping credible intervals. This result may be influenced by subgroup imbalance (females made up less than 15% of the total dataset) which can reduce statistical power to detect genuine sex-based differences. Therefore, the absence of statistical significance should not be interpreted as evidence of a negligible substance use burden among women. Nonetheless, the lower RR of drug-related death among females should not be interpreted as indicating a minimal substance use burden in this population. These findings require careful interpretation within Iran's conservative socio-cultural context, where women's drug use is highly stigmatized and underreported (Karamouzian et al., 2017; Khoei et al., 2018; Rostami et al., 2017). Such underreporting can lead to gaps in surveillance data and insufficient resource allocation for women-specific services (Apsley et al., 2023). Overlooking the true extent of women's substance use may perpetuate inadequate funding for gender-sensitive programs. This pattern, coupled with documented disparities in women's access to substance use harm reduction and treatment

services in Iran, emphasizes the urgent need to address gender-specific barriers to care (Alam-Mehrjerdi et al., 2016). Indeed, A fundamental shift is required from viewing drug use through a moral lens (Zolala et al., 2016) to adopting a comprehensive public health approach (Crepault et al., 2023) that acknowledges and addresses the unique challenges faced by women who use drugs in Iran. This shift might involve expanding women-only treatment services, creating community-based support programs, and integrating substance use and mental health interventions (Alam-Mehrjerdi et al., 2016). Such efforts could ensure equitable resource allocation and deliver more targeted interventions for this often-underserved population.

These province-level disparities in Iran reflect a broader regional pattern observed across the EMR. Recent analyses indicate that countries such as the UAE, Libya, Iran, and Lebanon report some of the highest rates of drug use disorders, predominantly linked to opioids (Amirkafi et al., 2023). EMR nations face a range of intersecting challenges, including socio-demographic shifts, conflict, and their geographic positions along regional and international drug trafficking routes, which exacerbate the burden of drug use in the region (Van Hout et al., 2021). Notably, nearly every EMR country experienced an increase in drug-related DALYs between 1990 and 2019, with the exceptions of Qatar and Pakistan (Amirkafi et al., 2023). The UAE, in particular, saw a striking rise in drug use-related YLL, with increases of 267% among the 15-49 age group and 185% among those aged 50-69. Across the region, drug use disorders remain most prevalent in the 15-49 age group, where rates have steadily increased over the past three decades. Although other age groups have experienced more modest increases, the largest proportional rise in DALYs (i.e., over 30%) occurred among adults aged 70 and older, pointing to a potentially underrecognized risk in older populations. These trends emphasize the urgent need for regional, targeted, and age-specific preventive and rehabilitative interventions. Such efforts must account for the diverse sociopolitical realities of EMR countries to effectively address the complex and evolving challenges posed by drug use disorders.

We acknowledge the limitations of this study, which mainly reflect the limitations of Iran's available drug-related death data sources. First, reliance on FMO's administrative database may have led to underestimation of illegal drug-related deaths, particularly in rural and remote areas where deaths may go unreported due to limited forensic referrals and higher levels of drug use-related stigma. Such gaps in data could skew public health strategies, as policymakers may not

allocate sufficient resources to regions with underreported mortality. Second, potential lag between the actual time of death and official cause-of-death registration may introduce reporting delays that could affect the accuracy of our estimates. Third, the limited availability of individual-level socio-demographic data (e.g., marital status, occupation, and education), restricted our ability to conduct comprehensive risk factors analyses. Without clearer insight into the socioeconomic context of drug-related deaths, it becomes more challenging for public health decision makers to tailor interventions to the needs of high-risk subpopulations. Lastly, the absence of data on the manner of death (e.g., accidental or intentional), specific type of drugs involved (e.g., opioids or stimulants or alcohol), drug use-related communicable diseases (e.g., HIV or blood-borne hepatitis), and indirect drug-related deaths (e.g., traffic accidents) restricted our understanding of the full spectrum of drug-related mortality. In particular, the absence of toxicology results specifying the primary substance(s) implicated in each death, limited our ability to determine precise classification of substance-specific mortality rates. Future studies incorporating more comprehensive toxicology data would help clarify how different substances drive overdose deaths across Iran, inform targeted interventions, and guide more effective resource allocation toward the regions and populations most in need.

CONCLUSIONS

Our findings reveal geographic heterogeneity and demographic disparities in drug use-related deaths across Iran, particularly among young and middle-aged adults. These results highlight the urgent need for age-specific prevention programs and strategic resource allocation to high-risk provinces. Moreover, community-based overdose management programs, including take-home naloxone programs, remain crucial for preventing premature opioid-related deaths in Iran. Future studies could benefit from exploring the socioeconomic and environmental determinants of geographical disparities, investigating gender-specific differences, and developing methods to reduce underreporting, particularly among marginalized groups. Linking multiple data sources, such as forensic databases, hospital records, and community surveys, would offer a comprehensive understanding of drug-related mortality patterns and inform more targeted, evidence-based interventions in Iran.

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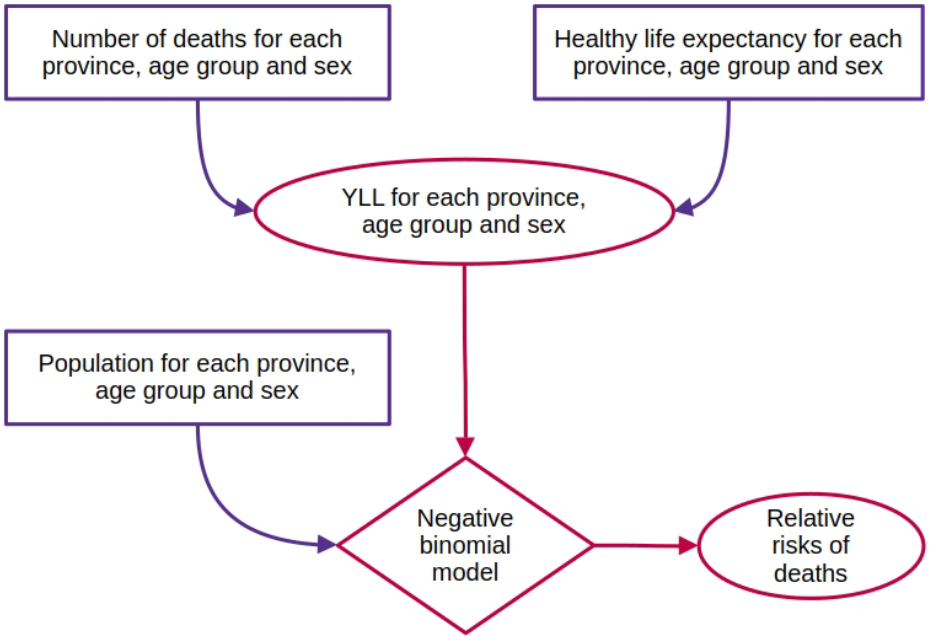

Figure 1. Flowchart of YLL calculation, followed by a negative binomial model for relative risk estimation.

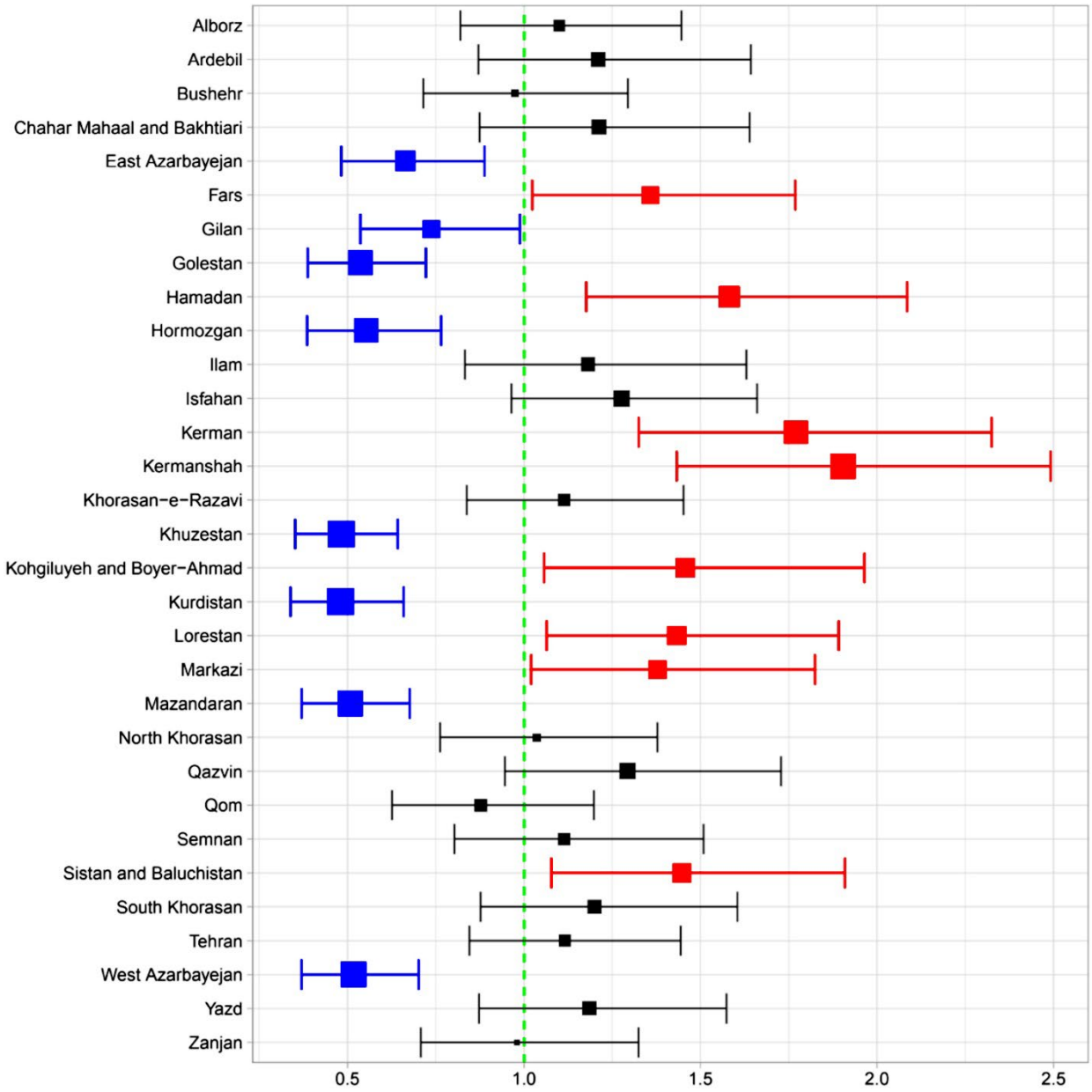

Figure 2. The posterior mean (represented by squares) and 95% credible interval (shown by bars) of the relative risk (RR) of losing years of healthy life due to deaths related to illegal drug use in all 31 provinces of Iran, with age group and sex effects held at their average levels.

Notes: The dashed green line (RR = 1) represents the national average risk. Provinces with significantly higher RRs are shown in red, while those with significantly lower risks are shown in blue. The size of the squares is based on precision, which is inversely proportional to the length of the corresponding credible intervals. More precise values (i.e., narrower credible intervals) have larger square sizes, while less precise values (i.e., wider credible intervals) have smaller square sizes.

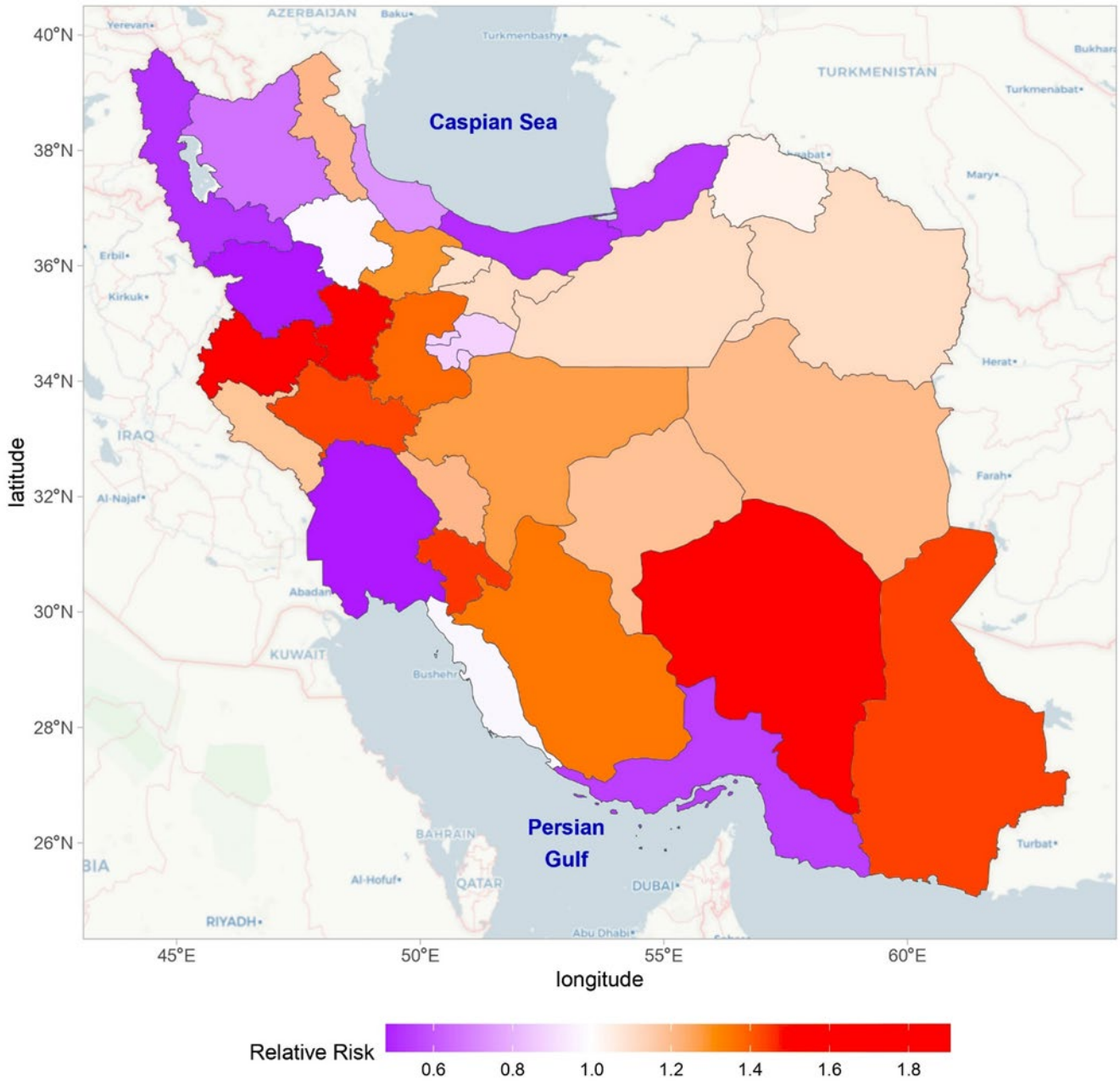

Figure 3. The posterior mean of the relative risk (RR) of losing years of healthy life due to deaths related to illegal drug use in the provinces of Iran, with age group and sex effects held at their average levels.

Note: RR = 1 represents the national average risk.

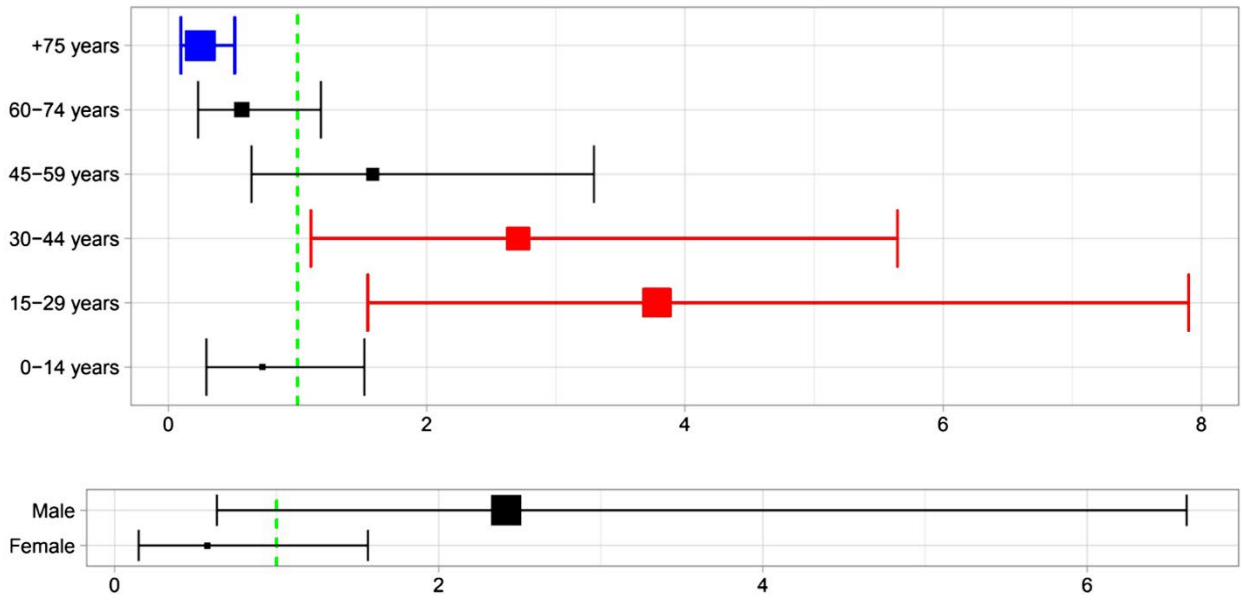

Figure 4. The posterior mean (represented by squares) and 95% credible interval (shown by bars) of the relative risk (RR) of losing years of healthy life due to deaths related to illegal drug use for different age-groups and sexes, while controlling for other factors.

Notes: The dashed green line (RR = 1) represents the national average risk. Age groups with significantly higher RRs are shown in red, while those with significantly lower risks are shown in blue. The size of the squares is based on precision, which is inversely proportional to the length of the corresponding credible intervals. More precise values (i.e., narrower credible intervals) have larger square sizes, while less precise values (i.e., wider credible intervals) have smaller square sizes

Table 1. Age and sex distribution of 11,944 deaths related to illegal drug use recorded by the Forensic Medicine Organization of Iran between March 21, 2022, and March 20, 2024.

Age group	Sex	Number of death records (%)	YLL
0-14 years	F	117 (0.98%)	6,997.9
	M	162 (1.36%)	9,566.7
15-29 years	F	656 (5.49%)	30,570.7
	M	2,519 (21.09%)	111,393.8
30-44 years	F	699 (5.58%)	23,847.4
	M	4,390 (36.75%)	141,110.5
45-59 years	F	228 (1.91%)	5,334.3
	M	2,390 (20.01%)	50,777.2
60-74 years	F	64 (0.54%)	852.4
	M	569 (4.76%)	6,819.6
75+ years	F	7 (0.06%)	29.3
	M	77 (0.64%)	381.6
Unknown	F	6 (0.05%)	---
	M	60 (0.50%)	---

Table 2. The number of years of healthy life lost (crude YLL) due to deaths related to illegal drug use for all 31 provinces in Iran, stratified by sex

Province	Male	Female	Total
Alborz	15,143.66	3,428.77	18,572.43
Ardebil	4,365.85	313.88	4,679.73
Bushehr	2,938.21	871.5	3,809.72
Chahar Mahaal and Bakhtiari	3,903.27	311.5	4,214.77
East Azarbayejan	9,818.63	1,348.91	11,167.55
Fars	27,571.55	5,904.65	33,476.20
Gilan	5,900.61	858.64	6,759.25
Golestan	2,822.41	841.71	3,664.12
Hamadan	12,503.82	1,555.28	14,059.10
Hormozgan	2,466.49	716.28	3,182.77
Ilam	2,792.47	327.67	3,120.14
Isfahan	22,775.83	4,984.56	27,760.38
Kerman	19,203.93	6,415.02	25,618.95
Kermanshah	16,085.84	3,675.94	19,761.78
Khorasan-e-Razavi	24,546.10	8,002.94	32,549.04
Khuzestan	7,578.39	1,342.80	8,921.18
Kohgiluyeh and Boyer-Ahmad	3,847.56	818.11	4,665.66
Kurdistan	2,759.85	222.74	2,982.59
Lorestan	9,705.80	1,442.88	11,148.69
Markazi	8,096.79	691.49	8,788.28
Mazandaran	4,353.30	1,362.12	5,715.42
North Khorasan	1,772.61	860.23	2,632.84
Qazvin	7,485.12	804.5	8,289.62
Qom	4,158.59	544.31	4,702.90
Semnan	2,111.66	394.78	2,506.44
Sistan and Baluchistan	9,355.98	2,165.97	11,521.95
South Khorasan	2,709.22	468.61	3,177.83
Tehran	70,303.28	14,608.54	84,911.82

West Azarbayejan	3,933.29	769.92	4,703.21
Yazd	4,461.83	1,081.77	5,543.60
Zanjan	4,577.54	496.02	5,073.56