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High Fasting Plasma Glucose Mortality Effect: A Comparative Risk Assessment in 25–64 Years Old Iranian Population

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ABSTRACT

Background: High fasting plasma glucose (FPG) is one of the main leading risk factors of ischemic heart disease (IHD), stroke, and chronic kidney diseases (CKDs). We estimated population attributable fraction (PAF) and attributed death of these fatal outcomes of high FPG at national and subnational levels in 25–64 years old Iranian adult.

Methods: We used national and subnational data of the Non-Communicable Disease Surveillance Survey for exposure to risk factors in 2005 and 2011 among Iranian adults of 25–64 years old. For estimating the attributed death, using the death registration system data of Iran, we multiply the cause-specific PAFs by the number of outcome-specific deaths.

Results: In Iran, high FPG was responsible for about 31% of attributed total deaths of IHD, stroke, and CKD in 2011. The related attributed deaths had increased from 2005 to 2011. In females, the PAFs for the effect of high FPG on IHD, stroke, and CKD were higher in 2011 than 2005 in all age groups. In males, this increase has occurred in over 45 years old. The highest PAFs of high FPG outcomes mostly related to central provinces of Iran. The central region of Iran had the highest and the southeast of the country had the lowest levels of attributed deaths.

Conclusions: Considering the global 25 × 25 targets for noncommunicable disease mortality reduction, high FPG as a leading risk factor of fatal outcomes should be more targeted through the dietary, behavioral, and pharmacological interventions in Iran.

Keywords: Comparative risk assessment, high fasting plasma glucose, Iran, mortality

INTRODUCTION

Cardiovascular and circulatory diseases are the leading causes of death in the world, particularly in the Middle

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East and North Africa regions.[1,2] In Iran, based on Global Burden of Disease Study (GBD) 2010 results, 31.34% of total deaths are attributed to ischemic heart disease (IHD), ischemic stroke, and chronic kidney diseases (CKDs). In 1990, these outcomes were responsible to 12.79% of total death.[1-3]

In this regard, high fasting plasma glucose (FPG) as an important modifiable risk factor had an adverse change in national list of death related risk factors between 1990 and 2010.[3]

There is a progressive need to applicable and comparable information for priority setting and policy making for appropriate interventions on modifying risk factor.[4,5] Despite the priority of the problem and the urgent needs for evidence-based planning, there are considerable gaps in required information. Although the information on total attributed deaths of metabolic risk factors is available for Iran, no information is available at provincial level. In addition, a little information existed about population at risk and attributed death changes in provinces.[6]

The comparative risk assessment (CRA), as a responsive approach in health planning, evaluates the scenario of population health changes that would be happen following the modification of population distribution and risk factor/s exposure.[7] Through which, comparing different situations of interest lead to more accurate selection of target groups and cost-effective interventions.[7]

Thus, we estimated population attributable fraction (PAF) and attributed death (and uncertainty intervals) of the main fatal outcomes of high FPG including, IHD, stroke, and CKD, at national and subnational levels in 25–64 years old Iranian adult.

METHODS

Using CRA, we compared the population exposure to high FPG at national and subnational level by sex, age group, in 2005 and 2011. Our data source was the Non-Communicable Disease Surveillance Surveys following a STEPwise approach based on the WHO guidelines. The population representative data for FPG are available for 2005, and 2011.[8] In the present study, we estimated PAFs of main outcomes of high FPG including IHD, stroke, and CKD in 16 age groups (25–64 years) for both sexes, and 31 provinces for 2005 and 2011. In the next step, attributed death for each outcome has been estimated by sex, province, and age groups.

To CRA analysis, we followed these steps: (a) Estimation of high FPG exposure distribution, (b) selection high FPG pairs' outcome, (c) specification of the etiological effect size of risk factor for each outcome, (d) determination the theoretical minimum risk exposure distributions for counterfactual comparison, (e) estimation number of cause-specific deaths.

Estimation high fasting plasma glucose exposure distribution

Based on STEPS surveys' data, considering sampling weight of each year, we estimated mean and standard deviations (SDs) of FPG distributions of both sexes by age groups in 2005 and 2011, at national and subnational levels. The total number of study participants in 2005 and 2011 were 83,937 and 12,236, respectively. The values of FPG measures were available in 49,768 participants in 2005 and 5412 persons in 2011. Considering geographical variations of provincial divisions, using the districts' information, data were rearranged for 31 provinces.

Selection high fasting plasma glucose pairs' outcome

According to their considerable burden,[9] sufficient evidence for causal effects,[3] and availability of etiological effect size,[10] IHD, stroke, and CKD were selected as the main paired outcomes of high FPG.

Specification of the etiological effect size of risk factor for each outcome

The effect size of high FPG for outcomes' specific mortality was included by relative risk (RR). As, in Iran, we have not comprehensive evidence for etiological effects, we used recent relevant meta-analyses of international cohorts evidence.[10]

Determination theoretical minimum risk exposure distributions for counterfactual comparison

In CRA, PAFs of outcomes attributable to risk factors estimated by comparison exposure distribution with counterfactual distribution as expected condition. To assess the full effects of FPG distribution as an "exposure" following the CRA processes, the counterfactual was considered as an FPG distribution with a mean of 88.2 mg/dl and an SD of 5.4.[10]

Estimation of the number of cause-specific deaths

The Ministry of Health and Medical Education collected death events by cause through death registration systems. Deputy of Research and Technology collected data from 1996 to 2001 and Deputy of Public Health was responsible for collection of death data from 2001 to 2010.[11] We used estimates of deaths number by underlying cause, age, sex, and province.

Mortality and disease burden attributable to high fasting plasma glucose

The contribution of high FPG in disease burden or mortality verified by PAF and attributed mortality.[7] PAFs estimate the proportional reduction in disease or death for the situation in which exposure to the risk factor was reduced to the counterfactual distribution.[7] We compared PAF of each outcome of high FPG for both sexes by age groups and province in 2005 and 2011.

PAF estimated by this formula:

$$\mathrm{PAF} = \frac{\int_{x=0}^{m} \mathrm{RR}(x)P(x)dx - \int_{x=0}^{m} \mathrm{RR}(x)P'(x)dx}{\int_{x=0}^{m} \mathrm{RR}(x)P(x)dx}$$

RR (x) is the RR at exposure level x,
P (x) is the population distribution of exposure,
$P'(x)$ is the counterfactual distribution of exposure,
m is the maximum exposure level.

As a result of within-person variation of metabolic risk factors, the SD of the usual population exposure distribution in health surveys overestimated. Thus, in estimation of PAF, we quantified the usual population SD of FPG by multiplying the FPG mean's SD in the STEPS survey sample by the dilution ratio from studies that had multiple exposure measurements.[12]

In addition, through the following formula, we estimated attributed mortality for each outcome by sex and province in mentioned years:

$$\mathrm{AM}_{ij} = \mathrm{PAF}_{\text{M-ij}} \times \mathrm{M}_j$$

AM_{ij} is attributed mortality for risk factor i and outcome j,
PAF_{M-ij} is PAF of risk factor i and outcome j,
M_j is mortality number of outcome j.

In estimation of attributed mortality to high FPG, we quantified uncertainty interval of the deaths number attributable to high FPG, accounting for uncertainty due to sampling variability. In these processes, we used a simulation approach to combine the uncertainties of exposure distributions, RRs, and outcome-specific mortality in each sex, age group. The uncertainty of death registration incompleteness considered variance of the estimated level of completeness by assuming an SD of 20% of the estimated completeness.[13] We used 1000 draws for each of mentioned parameters in repeated calculations and reported 95% uncertainty intervals based on the distributions of 1000 estimated attributable deaths. This analysis did not consider the uncertainty of the basic assumptions on the extrapolation of age patterns and RRs across populations.[3]

These analyses were conducted using STATA software (Version 11; StataCorp, College Station, TX) and R software (Version 3.0.2, The R Foundation) (version 3.0.2). All graphs have been drawn by R software.

RESULTS

In 2011, 21,807 deaths occurred due to the IHD, stroke, and CKD. From them, 6811 (31.23%). cases were attributed to high FPG However, in 2005, 4953 (26.20%) of total 18,899 deaths of these outcomes were attributed to high FPG. In 2011, IHD, stroke, and CKD, respectively with 68.6%, 23%, and 8.4% of high FPG attributed mortality, followed the decreasing orders. Figure 1, for both sexes, shows an increasing death of all pair's outcomes from 2005 to 2011. The national attributed deaths of high FPG on IHD and stroke have increased 34% and 31% in females and 31% and 37% in males. Further, CKD attributed deaths were increased 3.1-fold in females and 3.6-fold in males.

Figure 2 demonstrates the attributed deaths of high FPG on IHD, stroke, and CKD by sex and age groups in 2005 and 2011. For both sexes, the highest attributed deaths of IHD were aligned to 55–59 age groups. For stroke and CKD, the counterpart age groups were 60–64 years.

The geographical patterns of attributed deaths of high FPG on IHD, stroke, and CKD, for both sexes, at provincial level, have been compared between 2005 and 2011 [Figure 3]. High FPG is responsible for higher attributed deaths caused by IHD, stroke, and CKD in the center of the country. Constantly, southeast of the country had less attributed deaths of mentioned outcomes.

In 2011, the attributed deaths of high FPG on IHD had the highest and lowest measures in Isfahan and

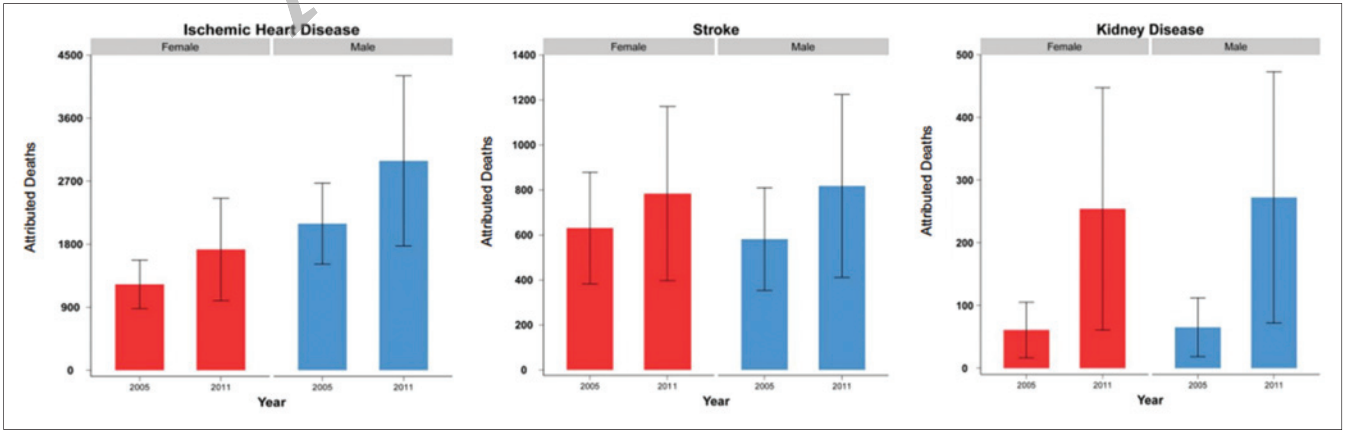

Figure 1: The national attributed deaths of high fasting plasma glucose on ischemic heart disease, stroke, and chronic kidney disease by sex in 2005 and 2011 for population 25–64 years

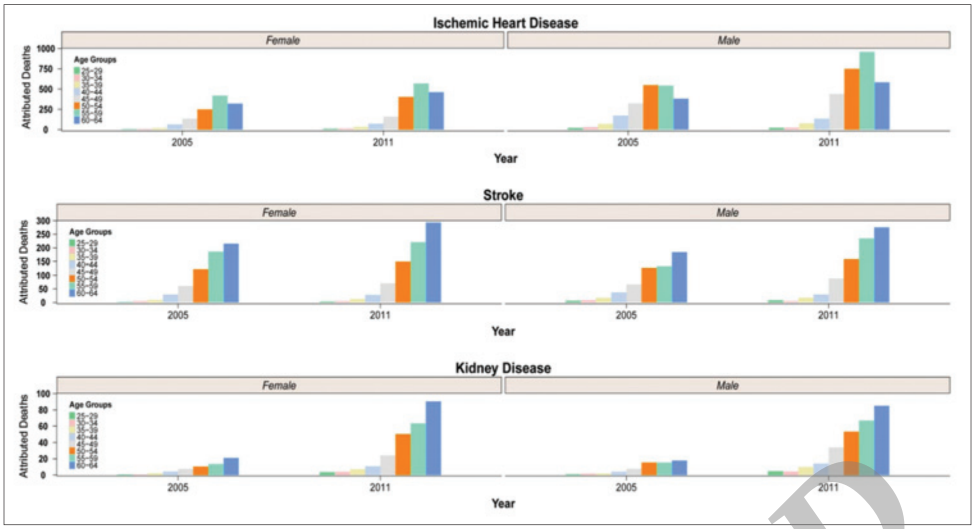

Figure 2: The national attributed deaths of high fasting plasma glucose on Ischemic hearth disease, stroke, and Chronic kidney disease by sex and age group, in 2005 and 2011

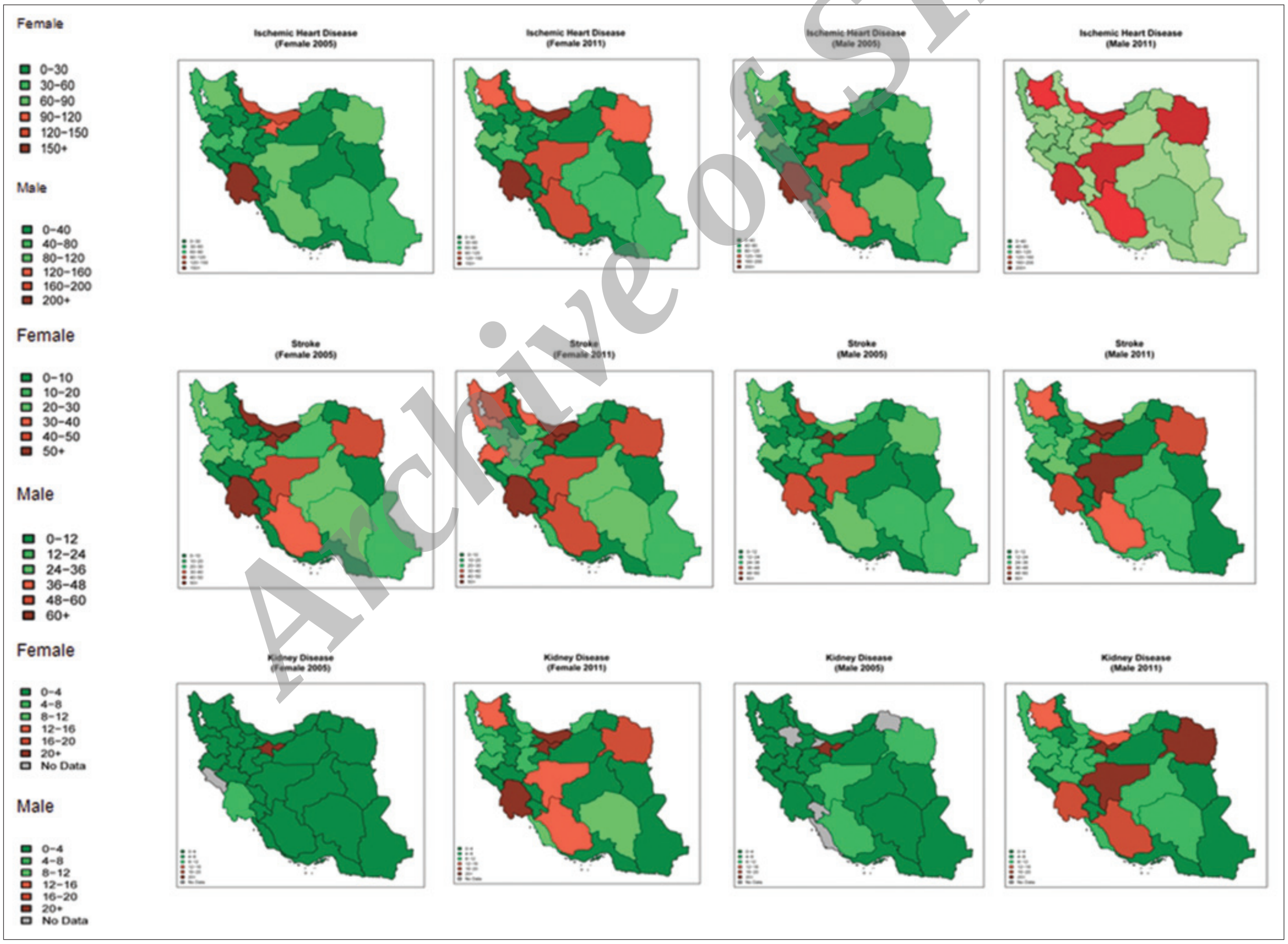
Female
0-30
30-60
60-90
90-120
120-150
150+
Male
0-40
40-80
80-120
120-160
160-200
200+
Female
0-10
10-20
20-30
30-40
40-50
50+
Male
0-12
12-24
24-36
36-48
48-60
60+
Female
0-4
4-8
8-12
12-16
16-20
20+
No Data
Male
0-4
4-8
8-12
12-16
16-20
20+
No Data
Ischemic Heart Disease (Female 2005)
Ischemic Heart Disease (Female 2011)
Ischemic Heart Disease (Male 2005)
Ischemic Heart Disease (Male 2011)
Stroke (Female 2005)
Stroke (Female 2011)
Stroke (Male 2005)
Stroke (Male 2011)
Kidney Disease (Female 2005)
Kidney Disease (Female 2011)
Kidney Disease (Male 2005)
Kidney Disease (Male 2011)

Figure 3: The provincial attributed deaths of high fasting plasma glucose on ischemic heart disease, stroke, and chronic kidney disease by sex in 2005 and 2011 for population 25–64 years

Kohgiluyeh and Boyer-Ahmad, respectively. In all provinces except for Sistan and Baluchestan, Zanjan, and Ardabil, the attributed deaths of IHD were more in males than in females. At the same year, the highest and lowest attributed deaths of stroke were related to Tehran and Kohgiluyeh and Boyer-Ahmad, respectively. In the most provinces, attributed deaths of stroke were higher in females than in males.

Almost, in half of the provinces, attributed deaths to CKD were higher in females than in males. In 2011, the highest and lowest attributable deaths for CKD were related to Tehran and Kohgiluyeh and Boyer‑Ahmad, respectively. From 2005 to 2011, the highest increase of attributed deaths to IHD and CKD related to Isfahan and the highest rise of attributed deaths to stroke related to Tehran.

Figure 4 shows the attributed deaths of high FPG on IHD, stroke, and CKD in different age groups in 2005 and 2011.

In Iran, in 2011 compared with 2005, the PAFs for the effect of high FPG on IHD, stroke, and CKD had increased in all of females' age groups. In men, for all three outcomes, these increases have been occurred only in over 45 years old. The same pattern also observed in stroke and CKD's PAFs. The PAFs of high FPG attributed outcome have been compared in different age groups, by sex and by year in national level [Figure 5]. The highest PAFs of IHD and stroke in both sexes allied to 55–59 ages and the highest PAFs of CKD related to 60–64 years in males and females.

PAFs of high FPG on IHD, stroke, and CKD in 2011 have been presented by sex, age, and provinces [Tables 1 and 2]. For each province, the lowest and highest levels have been showed in green and red, respectively.

DISCUSSION

According to our findings, about one‑third of deaths caused by IHD, stroke, and CKD attributed to high FPG. In 2011, IHD had the highest mortality attributed to high FPG, which was followed by stroke and CKD. This pattern was seen in global level and attributable deaths to high FPG increased across the time.[3] Noteworthy, 72.7% of these deaths occurred in developing countries.[3]

Among 67 studied risk factors in 2010 GBD, high FPG was in the 7th position. In the Middle East and North Africa region, with the 4th rank of attributable burden of disease, it was responsible for more than 170,000 deaths.[3]

We found Yazd and Qazvin with the highest PAFs of high FPG on IHD, stroke, CKD in both sexes, consequently, attributed death of mentioned diseases is largest in the

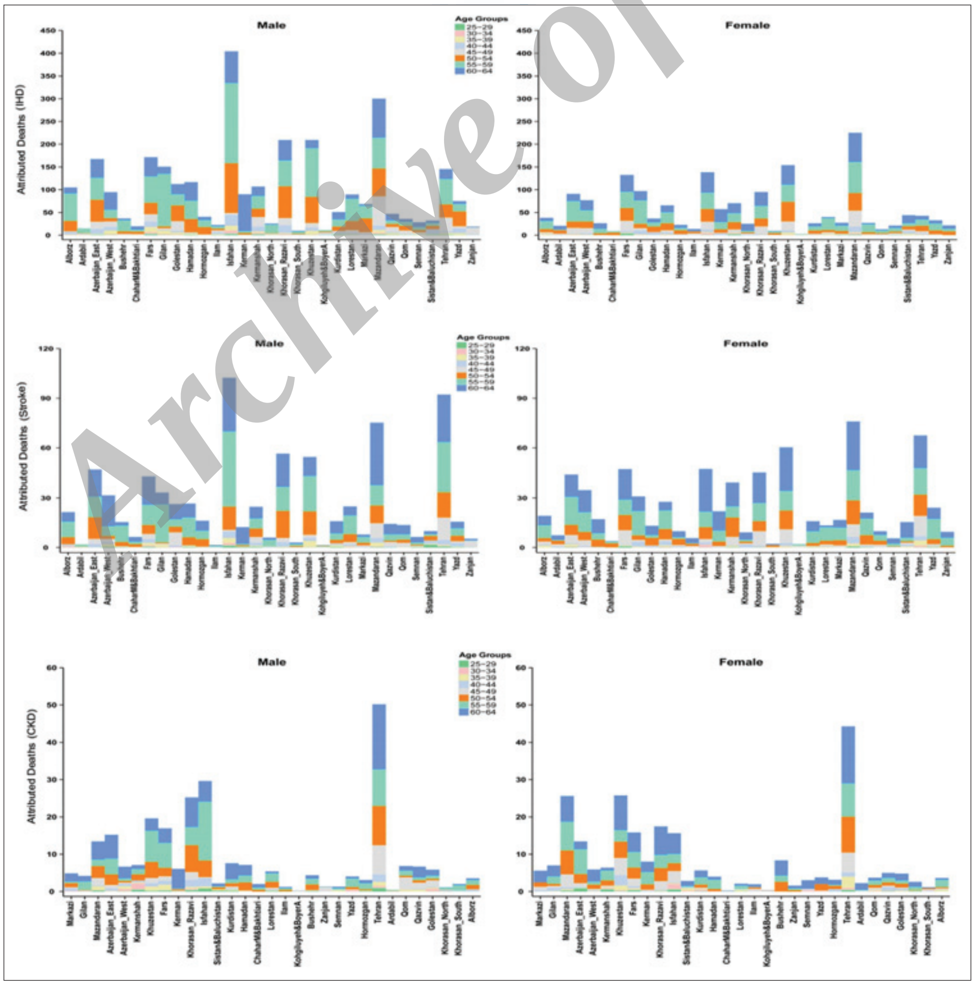

Figure 4: The provincial attributed deaths of high fasting plasma glucose on ischemic heart disease, stroke, and chronic kidney disease by sex, age in 2005 and 2011 for population 25–64 years

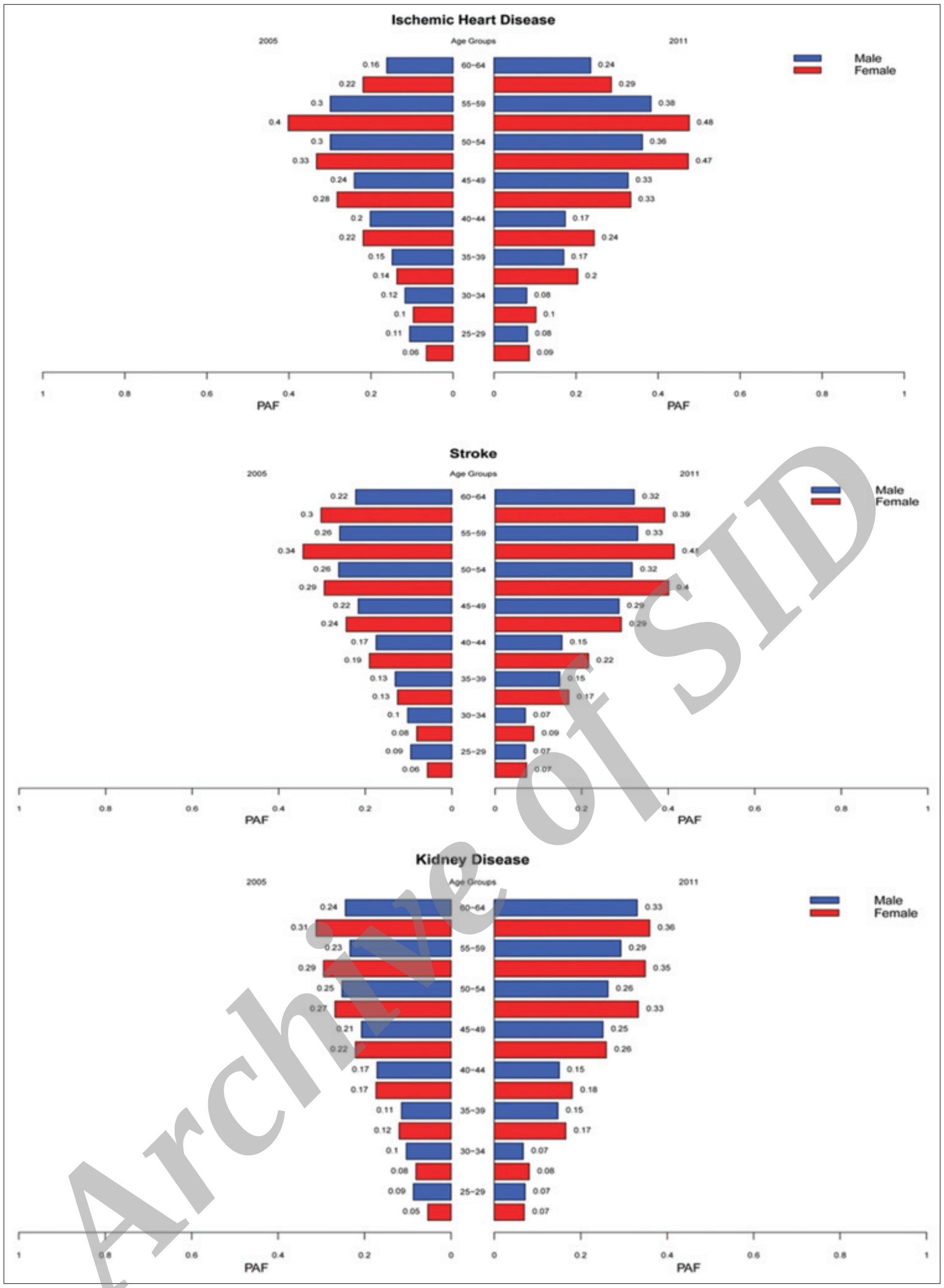

Figure 5: The national population attributable fractions of the effect of high fasting plasma glucose on ischemic heart disease, stroke chronic kidney disease in 2005 and 2011 by sex and age for population 25–64 years

central region of the country. It might be due to higher exposure to risk factor. A related study showed the highest prevalence of high FPG in the central region of Iran.[4,5]

It is noteworthy that the highest attributed deaths of high FPG outcomes were related to Isfahan and Tehran which are of the wealthiest provinces of Iran. A study reported that the diabetes prevalence was highest in city corporations.[14] Unhealthy diet, high body mass index, and large population could be contributed to high attributed deaths of high FPG in these provinces. In contrast, some studies insist on relation between diabetes and low socioeconomic status.[15] Hence, there is need to comprehensive study in this regards.

At subnational level, the pattern of CRA measures is different among provinces. This heterogeneity resulted from variation in exposure to risk factors and health effects.[3,16-18] Reduce the current prevalence of this risk factor near to the theoretical minimum could lead to reduce avoidable deaths. Identifying peoples who needed intervention even based on the presence of a single risk factor could promote the results of years of life lost index.[19-21] Evidence shows that in diabetic patients, reduction of the FPG levels to

Table 1: The population attributable fractions of high fasting plasma glucose on ischemic heart disease, stroke, and chronic kidney diseases in males by age in 2011 for population 25–64 years

Provinces	The PAFs of high FPG																							
	Ischemic heart disease								Stroke								Kidney disease							
	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Iran	0.08	0.08	0.17	0.17	0.33	0.36	0.38	0.24	0.07	0.07	0.15	0.15	0.29	0.32	0.33	0.32	0.07	0.07	0.15	0.15	0.25	0.26	0.29	0.33
Alborz	0.11	0.20	0.08	0.30	0.03	0.34	0.56	0.16	0.10	0.17	0.07	0.27	0.03	0.30	0.48	0.22	0.10	0.16	0.07	0.24	0.03	0.26	0.39	0.23
Ardabil	0.03	0.11	0.09	0.05	0.10	0.04	0.25	0.00	0.03	0.10	0.07	0.05	0.08	0.03	0.22	0.00	0.03	0.10	0.07	0.04	0.08	0.04	0.20	0.00
Azerbaijan_East	0.06	0.02	0.06	0.20	0.18	0.45	0.37	0.30	0.06	0.02	0.05	0.17	0.15	0.41	0.32	0.40	0.05	0.02	0.05	0.17	0.15	0.33	0.30	0.38
Azerbaijan_West	0.08	0.13	0.46	0.22	0.20	0.10	0.20	0.42	0.07	0.11	0.40	0.19	0.18	0.08	0.17	0.54	0.07	0.10	0.35	0.19	0.16	0.08	0.17	0.43
Bushehr	0.13	0.00	0.01	0.00	0.33	0.28	0.71	0.15	0.12	0.00	0.00	0.00	0.29	0.25	0.61	0.20	0.12	0.00	0.01	0.00	0.22	0.23	0.47	0.22
ChaharMahal and Bakhtiari	0.01	0.02	0.10	0.00	0.18	0.27	0.13	0.22	0.01	0.02	0.09	0.00	0.16	0.23	0.12	0.30	0.01	0.02	0.08	0.00	0.15	0.21	0.12	0.30
Fars	0.09	0.18	0.40	0.24	0.19	0.19	0.36	0.23	0.07	0.16	0.38	0.21	0.17	0.16	0.32	0.31	0.08	0.16	0.32	0.19	0.16	0.16	0.29	0.30
Gilan	0.04	0.13	0.31	0.02	0.06	0.03	0.78	0.10	0.04	0.12	0.26	0.02	0.05	0.03	0.68	0.14	0.04	0.11	0.23	0.02	0.05	0.03	0.50	0.17
Golestan	0.05	0.18	0.31	0.16	0.64	0.56	0.31	0.34	0.04	0.15	0.28	0.14	0.57	0.48	0.26	0.45	0.04	0.14	0.26	0.13	0.43	0.39	0.24	0.38
Hamadan	0.04	0.00	0.20	0.06		0.31	0.35	0.45	0.04	0.00	0.17	0.05		0.27	0.30	0.39	0.04	0.00	0.17	0.06		0.25	0.27	0.34
Hormozgan	0.15	0.08	0.05	0.02	0.02	0.39	0.35	0.20	0.13	0.07	0.04	0.02	0.01	0.34	0.31	0.28	0.13	0.07	0.04	0.02	0.02	0.29	0.27	0.28
Ilam	0.09	0.11	0.23	0.27	0.33	0.14	0.20	0.10	0.08	0.10	0.21	0.24	0.29	0.12	0.17	0.13	0.08	0.11	0.19	0.22	0.26	0.12	0.16	0.15
Isfahan	0.08	0.23	0.34	0.38	0.04	0.46	0.83	0.26	0.07	0.20	0.31	0.33	0.03	0.40	0.71	0.36	0.07	0.18	0.27	0.30	0.03	0.35	0.54	0.35
Kerman	0.05	0.04	0.00	0.00		0.04	0.02	0.78	0.04	0.04	0.00	0.00		0.03	0.02	0.68	0.04	0.04	0.00	0.00		0.03	0.02	0.51
Kermanshah	0.17	0.32	0.14	0.32	0.41	0.22	0.26	0.17	0.15	0.28	0.13	0.28	0.35	0.20	0.22	0.23	0.14	0.26	0.12	0.26	0.31	0.19	0.21	0.26
Khorasan_North	0.05	0.15	0.17	0.12	0.12	0.03	0.46	0.08	0.04	0.13	0.15	0.11	0.11	0.02	0.41	0.12	0.05	0.12	0.14	0.10	0.10	0.02	0.33	0.14
Khorasan_Razavi	0.04	0.09	0.08	0.33	0.19	0.49	0.40	0.34	0.03	0.07	0.07	0.28	0.17	0.43	0.33	0.45	0.03	0.08	0.07	0.24	0.16	0.37	0.30	0.42
Khorasan_South	0.06	0.07	0.15	0.24	0.11	0.10	0.31	0.10	0.05	0.06	0.12	0.20	0.09	0.08	0.28	0.14	0.05	0.06	0.12	0.19	0.10	0.08	0.24	0.14
Khuzestan	0.02	0.06	0.23	0.13	0.11	0.41	0.59	0.13	0.02	0.05	0.21	0.11	0.09	0.36	0.51	0.18	0.02	0.05	0.19	0.11	0.09	0.31	0.41	0.19
Kohgiluyeh and Boyerahmad	0.11	0.01	0.01	0.11	0.29	0.14	0.16	0.02	0.10	0.01	0.01	0.10	0.26	0.12	0.13	0.03	0.09	0.01	0.01	0.09	0.21	0.12	0.13	0.04
Kurdistan	0.20	0.00	0.20	0.25	0.15	0.25	0.29	0.25	0.18	0.00	0.16	0.22	0.13	0.22	0.25	0.34	0.18	0.00	0.17	0.20	0.13	0.20	0.23	0.34
Lorestan	0.04	0.07	0.09	0.17	0.15	0.31	0.61	0.18	0.04	0.06	0.08	0.14	0.14	0.27	0.53	0.25	0.04	0.06	0.07	0.15	0.12	0.23	0.42	0.25
Markazi	0.01	0.08	0.06	0.12	0.13	0.87	0.40	0.10	0.01	0.07	0.05	0.11	0.11	0.78	0.34	0.14	0.01	0.07	0.05	0.11	0.11	0.54	0.30	0.17
Mazandaran	0.07	0.20	0.27	0.18	0.75	0.52	0.41	0.56	0.06	0.18	0.24	0.16	0.65	0.46	0.36	0.69	0.06	0.16	0.22	0.16	0.50	0.37	0.31	0.53
Qazvin	0.19	0.13	0.33	0.19	0.84	0.23	0.25	0.57	0.16	0.11	0.29	0.17	0.74	0.20	0.22	0.72	0.15	0.11	0.27	0.16	0.53	0.19	0.21	0.58
Qom	0.20	0.05	0.17	0.04	0.61	0.56	0.31	0.33	0.17	0.05	0.15	0.03	0.53	0.47	0.27	0.45	0.17	0.05	0.15	0.03	0.44	0.39	0.23	0.41
Semnan	0.16	0.24	0.42	0.16	0.16	0.24	0.20	0.33	0.14	0.21	0.37	0.14	0.14	0.21	0.17	0.43	0.14	0.19	0.32	0.13	0.14	0.20	0.16	0.40
Sistan and Baluchistan	0.12	0.01	0.11	0.37	0.00	0.18	0.11	0.09	0.10	0.01	0.09	0.32	0.00	0.16	0.10	0.13	0.10	0.01	0.09	0.27	0.00	0.16	0.10	0.15
Tehran	0.20	0.06	0.13	0.11	0.36	0.33	0.44	0.24	0.17	0.05	0.11	0.10	0.32	0.29	0.37	0.32	0.16	0.05	0.11	0.09	0.27	0.26	0.33	0.32
Yazd	0.14	0.20	0.40	0.65	0.31	0.90	0.57	0.19	0.12	0.17	0.35	0.55	0.27	0.82	0.49	0.26	0.11	0.17	0.31	0.44	0.23	0.58	0.42	0.28
Zanjan	0.03	0.01	0.00	0.08	0.88	0.01	0.01	0.05	0.03	0.01	0.00	0.07	0.78	0.01	0.01	0.07	0.03	0.01	0.00	0.07	0.56	0.01	0.01	0.08

FPG=Fasting plasma glucose, PAF=Population attributable fraction

Table 2: The population attributable fractions of high fasting plasma glucose on ischemic heart disease, stroke, and chronic kidney diseases in females by age in 2011 for population 25–64 years

Provinces	The PAFs of high FPG																							
	IHD								Stroke								Kidney disease							
	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
Iran	0.09	0.1	0.2	0.24	0.33	0.47	0.48	0.29	0.07	0.09	0.17	0.22	0.29	0.40	0.41	0.40	0.07	0.08	0.16	0.18	0.26	0.33	0.35	0.36
Alborz	0.10	0.18	0.67	0.05	0.28	0.40	0.52	0.17	0.09	0.15	0.62	0.05	0.25	0.33	0.44	0.23	0.09	0.14	0.47	0.04	0.23	0.29	0.34	0.26
Ardabil	0.11	0.03	0.03	0.16	0.28	0.82	0.05	0.36	0.09	0.03	0.03	0.13	0.25	0.71	0.05	0.48	0.09	0.03	0.03	0.14	0.22	0.51	0.05	0.43
Azerbaijan_East	0.14	0.13	0.16	0.06	0.49	0.36	0.60	0.19	0.12	0.12	0.14	0.05	0.43	0.32	0.51	0.26	0.11	0.12	0.13	0.05	0.35	0.28	0.41	0.29
Azerbaijan_West	0.01	0.03	0.15	0.14	0.52	0.34	0.53	0.39	0.01	0.02	0.12	0.13	0.44	0.29	0.47	0.52	0.01	0.02	0.11	0.13	0.37	0.25	0.36	0.45
Bushehr	0.13	0.01	0.00	0.47	0.02	0.62	0.52	0.66	0.11	0.01	0.00	0.40	0.02	0.54	0.46	0.78	0.11	0.01	0.00	0.32	0.02	0.40	0.36	0.57
ChaharMahal and Bakhtiari	0.02	0.01	0.01	0.18	0.03	0.70	0.29	0.04	0.02	0.01	0.01	0.16	0.02	0.61	0.25	0.06	0.02	0.01	0.01	0.15	0.03	0.45	0.23	0.07
Fars	0.12	0.14	0.17	0.12	0.60	0.50	0.48	0.29	0.10	0.13	0.15	0.11	0.52	0.43	0.42	0.40	0.11	0.12	0.15	0.11	0.39	0.34	0.35	0.38
Gilan	0.03	0.04	0.16	0.53	0.20	0.19	0.68	0.21	0.03	0.04	0.14	0.45	0.17	0.16	0.59	0.28	0.03	0.04	0.13	0.37	0.17	0.16	0.44	0.28
Golestan	0.01	0.02	0.15	0.35	0.04	0.47	0.20	0.17	0.01	0.02	0.13	0.30	0.03	0.41	0.18	0.24	0.01	0.02	0.12	0.25	0.03	0.32	0.18	0.25
Hamadan	0.04	0.13	0.22	0.24	0.23	0.35	0.54	0.23	0.05	0.11	0.20	0.21	0.20	0.31	0.46	0.20	0.06	0.12	0.17	0.19	0.20	0.26	0.38	0.20
Hormozgan	0.01	0.15	0.15	0.25	0.21	0.61	0.24	0.25	0.00	0.13	0.13	0.21	0.19	0.52	0.21	0.33	0.00	0.11	0.13	0.19	0.17	0.41	0.19	0.31
Ilam	0.04	0.01	0.15	0.04	0.49	0.47	0.08	0.25	0.04	0.01	0.13	0.04	0.42	0.41	0.06	0.34	0.04	0.01	0.12	0.04	0.35	0.34	0.06	0.35
Isfahan	0.14	0.35	0.13	0.21	0.49	0.46	0.45	0.33	0.13	0.31	0.11	0.19	0.42	0.40	0.38	0.44	0.12	0.28	0.11	0.18	0.35	0.32	0.32	0.41
Kerman	0.00	0.00	0.00	0.22	0.07	0.23	0.41	0.45	0.00	0.00	0.00	0.20	0.06	0.20	0.36	0.39	0.00	0.00	0.00	0.19	0.06	0.18	0.30	0.32
Kermanshah	0.31	0.24	0.26	0.18	0.52	0.48	0.40	0.33	0.27	0.21	0.23	0.15	0.45	0.42	0.34	0.44	0.25	0.19	0.21	0.14	0.36	0.31	0.30	0.37
Khorasan_North	0.08	0.02	0.03	0.69	0.15	0.18	0.16	0.45	0.07	0.02	0.03	0.61	0.13	0.15	0.14	0.57	0.07	0.02	0.03	0.43	0.13	0.15	0.13	0.42
Khorasan_Razavi	0.05	0.06	0.04	0.06	0.60	0.29	0.30	0.36	0.04	0.06	0.04	0.05	0.52	0.25	0.27	0.47	0.04	0.05	0.04	0.05	0.43	0.23	0.25	0.43
Khorasan_South	0.04	0.14	0.06	0.07	0.33	0.28	0.16	0.16	0.03	0.12	0.05	0.06	0.28	0.24	0.14	0.22	0.03	0.12	0.05	0.06	0.25	0.22	0.13	0.24
Khuzestan	0.03	0.06	0.38	0.22	0.59	0.53	0.34	0.31	0.03	0.05	0.34	0.19	0.52	0.45	0.30	0.41	0.03	0.05	0.30	0.18	0.39	0.37	0.25	0.38
Kohgiluyeh and Boyerahmad	0.02	0.05	0.14	0.00	0.31	0.02	0.16	0.02	0.02	0.05	0.12	0.00	0.28	0.02	0.15	0.03	0.02	0.05	0.12	0.00	0.23	0.02	0.13	0.04
Kurdistan	0.04	0.14	0.16	0.19	0.08	0.24	0.38	0.17	0.04	0.12	0.14	0.17	0.07	0.21	0.33	0.23	0.04	0.12	0.14	0.16	0.06	0.18	0.29	0.25
Lorestan	0.02	0.10	0.59	0.07	0.15	0.21	0.55	0.05	0.02	0.08	0.54	0.06	0.13	0.19	0.47	0.07	0.02	0.07	0.44	0.06	0.13	0.17	0.38	0.08
Markazi	0.18	0.03	0.11	0.16	0.39	0.51	0.66	0.29	0.16	0.02	0.10	0.14	0.34	0.43	0.58	0.39	0.15	0.02	0.10	0.13	0.31	0.36	0.45	0.37
Mazandaran	0.26	0.22	0.31	0.58	0.74	0.70	0.80	0.50	0.23	0.19	0.27	0.50	0.64	0.60	0.68	0.64	0.22	0.18	0.26	0.43	0.47	0.47	0.52	0.51
Qazvin	0.12	0.12	0.21	0.58	0.16	0.58	0.88	0.18	0.10	0.10	0.18	0.50	0.14	0.51	0.76	0.24	0.10	0.10	0.17	0.38	0.13	0.41	0.56	0.24
Qom	0.11	0.14	0.15	0.33	0.40	0.47	0.43	0.17	0.10	0.12	0.13	0.29	0.34	0.41	0.37	0.24	0.08	0.12	0.13	0.26	0.29	0.35	0.35	0.25
Semnan	0.32	0.15	0.07	0.04	0.59	0.42	0.51	0.43	0.28	0.13	0.06	0.03	0.52	0.37	0.44	0.55	0.26	0.13	0.06	0.03	0.40	0.33	0.38	0.44
Sistan and Baluchistan	0.02	0.05	0.25	0.27	0.13	0.18	0.15	0.41	0.02	0.04	0.22	0.24	0.10	0.16	0.13	0.53	0.01	0.04	0.21	0.23	0.10	0.15	0.12	0.44
Tehran	0.06	0.16	0.39	0.20	0.46	0.43	0.35	0.24	0.05	0.14	0.35	0.18	0.39	0.37	0.30	0.33	0.05	0.13	0.31	0.17	0.34	0.32	0.28	0.35
Yazd	0.38	0.46	0.43	0.31	0.27	0.84	0.86	0.37	0.34	0.42	0.38	0.28	0.23	0.73	0.76	0.49	0.30	0.33	0.33	0.25	0.21	0.53	0.56	0.43
Zanjan	0.01	0.01	0.03	0.12	0.00	0.54	0.44	0.31	0.01	0.01	0.03	0.10	0.00	0.46	0.38	0.42	0.01	0.01	0.03	0.10	0.00	0.38	0.35	0.38

FPG=Fasting plasma glucose, IHD: Ischemic heart disease, PAF=Population attributable fraction minimum risk level lead to a considerable reduction in cardiovascular disease's disability-adjusted life years (6.8% in females and 3.1% in males).[22] These changes are also reported for the other risk factors.[23-25] Effective lifestyle interventions,[26] high-quality primary health care (PHC) for preventive interventions, and early diagnosis and control diabetes could promote this situation.[27-30]

The present study has benefited from many strength. For the first time, we conducted a more detailed analysis of the PAFs and attributed deaths in Iran at national and subnational levels. In addition, considering data uncertainty, we estimated CRA measures for different age groups and both sexes. Yet, we faced with some limitations. We used registered death data and incompleteness of data was not considered in this step, but we will pay attention to this point in the next study.[8,11,31-34] Further, we did not compute modeling uncertainty in our estimations. In addition, our analysis conducted on population 25–64 years; therefore, the attributed death for older peoples was not considered.

Our study provided comparable estimation of the effects of high FPG on IHD, stroke, and CKD that could be used for strategic planning, priority setting, and action planning.[29,30]

CONCLUSIONS

Presented evidence could help in effective governance responses to the surge of NCDs such as highlighting PHC and equitable and cost-effective population health interventions[35-38] and prioritize prevention to achieve the global 25 × 25 targets for noncommunicable disease mortality.

Considering our lesson learned, following these steps, benefiting from advanced methodological methods, we are conducting the comprehensive study on the National and Sub-national Burden of Disease in Iran.[8,11,31-34,39,40]

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Conflicts of interest

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