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Cost Effectiveness and Resource Allocation

RESEARCH

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Estimation of economic burden of high salt intake in cardiovascular disease attributed to hypertension in Iran

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Abstract

Background Excessive salt consumption is a significant risk factor for the development of cardiovascular disease (CVD) attributed to hypertension, major contributors to mortality in Iran. This study aims to estimate the economic burden of high salt consumption on CVD attributed to hypertension in Iran in 2022.

Methods The cross-sectional research was conducted in public and private hospitals in the southeast of Iran. The costs of CVD patients attributed to hypertension (ICD I10-I15) were estimated using a prevalence-based and bottom-up approach from society's perspective classifying costs into direct and social Costs of disease management. The indirect costs of productivity losses were quantified using the human capital approach. Sensitivity analysis was employed to investigate the effect of uncertain parameters.

Results The mean cost per CVD patient was US$1392.48, with an estimated total economic burden of US$980.61 million in Iran. Direct costs constituted 44.47% of the total disease burden, while social costs accounted for 55.53%. The results were robust, with a 20% variation in the average unit price of all direct medical and non-medical costs.

Conclusion The study highlights the substantial economic burden of high salt consumption on CVD attributable to hypertension in Iran, amounting to 3.25 times current health expenditures per capita and 0.27 times GDP per capita in 2022. Indirect costs, including productivity losses, surpass direct costs, underscoring the broader societal impact. Sensitivity analysis confirms the robustness of results, emphasizing the urgent need for preventive measures and resource allocation. Policymakers are encouraged to prioritize salt reduction programs to mitigate costs, enhance patient care, and promote long-term economic and health benefits.

Keywords Excess salt intake, Cardiovascular disease, Economic burden, Cost-of-illness

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Introduction

Today, chronic or non-communicable diseases are the leading causes of death in many countries worldwide [1]. Cardiovascular diseases (CVD) are recognized as the primary cause of mortality among chronic diseases, accounting for 17.9 million deaths globally [2]. It is projected that the number of deaths caused by CVD will reach 23.6 million by 2030 [3]. Statistical data indicates that approximately three-quarters of all CVD related deaths in low- and middle-income countries occur before the age of 70 [4].

A number of risk factors contribute to the development of CVD [5]. Hypertension is one of the most significant contributors to CVD in many countries, with 25% of adults suffering from it [6]. In Iran, hypertension accounts for 49% of CVD mortality [7]. Excessive salt intake is strongly associated with hypertension and an increased risk of CVD [8]. Various studies have reported the relationship between dietary salt consumption and CVD attributed to hypertension [9, 10]. It is evident that the ramifications of CVD extend beyond mortality and incapacitation, endangering significant health and economic repercussions. The prevalence of disability, premature retirement, and absenteeism, leads to a decline in productivity and economic efficiency [11]. Concurrently, individuals with low and moderate incomes are less likely to have access to adequate healthcare and health services compared to those in higher income brackets. This discrepancy in access to care and health services has been linked to an increased risk of CVD mortality among lower income groups [12]. Evidence further indicates that CVD can impoverish families due to catastrophic health costs, ultimately reducing GDP [13].

In the meantime, the development of CVD can be prevented by addressing risk factors such as a high-salt diet [14]. It is important to note that salt consumption in Iran is significantly higher than the amount recommended by WHO [15–19]. One of the most straightforward, impactful, and cost-efficient methods for reducing the economic burden of CVD is decreasing in salt consumption [12]. Therefore, this study focuses on the economic burden associated with high salt consumption in CVD.

In studies that estimate the economic burden of disease, the burden per patient is quantified, and the potential savings from modifying specific risk factors are assessed [20–22]. This study considers the potential impact of high salt consumption. It estimates the economic repercussions of excessive salt consumption and aims to help policymakers and health system planners make informed decisions about resource allocation by understanding its economic implications for CVD.

Although several studies have investigated the economic impact of CVD related to high salt consumption in various global regions [23–25], a similar study has not been conducted in Iran. Thus, the objective of this study is to estimate the economic burden of high salt consumption on cardiovascular disease (CVD) cases attributed to hypertension in Iran.

Methods

Economic burden approach

In this cross-sectional study, the economic burden was assessed using both the cost-of-illness (COI) and the human capital methods. The COI method included calculating individuals' lifetime income based on age- and sex-specific income data, combined with projected production trends [26]. Direct medical costs were calculated using the bottom-up approach, which estimates costs incurred by individual patients. In contrast, social costs—incorporating direct non-medical costs and productivity losses—were estimated using separate analytical techniques [27]. A societal perspective was adopted, accounting for all direct medical costs, direct non-medical costs, and social costs, while considering the broader impact of the disease on patients, families, employers, governments, and society at large [28]. To achieve a comprehensive analysis, all direct and indirect medical costs for entire population were calculated from a societal perspective.

Data sources

Population data and employment rates were extracted from the Iranian Statistics Centre, while disease prevalence and mortality data were obtained from the Iranian Ministry of Health and Medical Education [29, 30]. Data on local currency unit (LCU) and GDP per capita in US dollars were sourced from the World Bank. LCU was then converted to the relative value of each US dollar using the exchange rates for Iranian rials [31, 32].

Study population and sampling

Cost estimation involved data collection for both inpatients and outpatients:

Direct Medical Costs: For inpatients, a census of all hospitalized patients diagnosed under International Classification of Diseases (ICD) codes I10–I15 was conducted across two public and two private hospitals in southeast Iran [33, 34]. For outpatients, data were collected using proportional random sampling techniques.

Direct Non-Medical Costs and Social Costs:

These were assessed for all study participants, irrespective of inpatient or outpatient status. Data collection involved structured questionnaires completed by patients and their companions. All participants provided informed written consent after being briefed on the study objectives.

Cost estimation

The key elements for estimating the economic burden of direct costs (both medical and non-medical) and Social Costs (including complications, mortality costs, and productivity losses) are as follows:

Direct medical costs were calculated separately for inpatients (including visits, medicines, surgery, hoteling, etc.) and outpatients (including visits, diagnostic tests, medicines, medical supplies, rehabilitation, etc.) [34, 35]. Average costs were calculated based on patient distribution across private and public sectors and the relevant tariffs, with a patient distribution 80% in public and 20% in private hospitals [36]. It should be noted that the shared RESOURCES of patients were VALUED using a top-down approach.

Direct non-medical costs include expenses related to transportation, complementary or alternative therapies, dietary modifications, special equipment, telephone calls, accommodation, and other related items [33, 34]. Estimates were derived from the questionnaires completed by patients and companions.

Social Costs were estimated using a human capital approach. These costs are defined as the sum of the value of lost productivity due to the inability to work and the present value of future lost productivity due to premature mortality [26, 37]. To estimate productivity losses, the number of days absent from work was multiplied by the average daily wage. Additionally, the time costs incurred by companions during hospitalizations were considered. The estimation of mortality costs involved three parameters: the number of deaths, potential life years lost, and the value of productivity losses [26]. To calculate the monetary value lost due to premature mortality, the average age at death was subtracted from the life expectancy, and the total expected income for the remaining years was calculated. Productivity losses were estimated based on employment rates and the average annual wage with a discount rate of 3% applied to convert the lifetime income stream to present value.

Sensitivity analysis

A sensitivity analysis was performed to assess the impact of uncertain and variable parameters, including disease prevalence, exchange rates, and costs, on the model's outcomes. One-way sensitivity analysis was used to evaluate how variations within a specific range of these non-deterministic parameters affect the study's results. The analysis examined the impact of a 20% change in prevalence rates, case prevention rates, and other key data on direct costs, social costs, and productivity losses associated with the economic burden of CVD.

Results

Descriptive findings

A total of 1,797 inpatient medical records for CVD patients with ICD codes I10-15 from the studied hospitals were analyzed. Additionally, 307 outpatients were included in the study through proportional stratified random sampling to complete the standard developed questionnaire. In the present study, 49.48% of patients were male and 50.22% were female. 93.97% of patients had basic insurance. The majority of those covered (42.31%) were related to health insurance, while 39.45% were related to social security insurance. Additionally, the mean age of the subjects in this study was 60.93 ± 16 years, with the mean age of men being 60.53 ± 16.33 years and the mean age of women being 61.23 ± 15.73 years. Additionally, 48.82% of the subjects were residents of Kerman, while the remaining participants were from other nearby cities.

The majority of patients with a 32.9% prevalence were identified as housewives, while 32.57% were employed. The highest frequency, at 32.25%, was observed among patients with a bachelor's degree, while the lowest, at 4.56%, had a bachelor's degree or higher.

89.52% of the patients required the care and medical services of a person or another person after contracting the disease, with the wife and children requiring the most care (67.21%). 39.41% of patients were accompanied during hospitalization in the previous year and 60.59% were not accompanied. The average income of working people is $\$261 \pm 89$ per month, which was most common in 43.59% of patients whose total household income was between \$250 and \$350 per month. 57.98% of caregivers had an income of $\$211 \pm 9.4$ per month, and the highest percentage, 57.98%, was related to those caregivers of patients whose income was reported in the range of \$150 per month (Tables 1 and 2).

Direct medical costs for inpatient and outpatient care

To quantify direct costs, total disease-related costs were calculated separately for inpatients and outpatients. These costs included hospitalization/hoteling, physician outpatient services, emergency department outpatient services, ambulance services, home care, rehabilitation services, specialist and other health professional services, diagnostic tests, medicines and medical supplies [34]. A large proportion of direct treatment costs for outpatients are related to the cost of medicines 34.7%, followed by the cost of diagnostics 21.23%. For inpatients, surgery accounts for the largest share of costs at 34.56%, followed by hotel costs at 29.15% (see Table 3).

Table 1 Demographic characteristics of the participants($n = 2104$)

Variable name		Variables		Total (%)
		Outpatient	Inpatient	
Gender	Man	149	892	1041 (49.48)
	Female	158	905	1063 (50.22)
Type of insurance	Health insurance	105	785	890 (42.31)
	Social Security	104	726	830 (39.45)
	Armed Forces	44	81	125 (5.94)
	Private insurance	42	90	132 (6.27)
	No basic insurance	12	115	127 (6.03)
Age	41 – 1	37	125	162 (7.69)
	42–61	111	648	759 (36.07)
	62–81	126	796	922 (43.83)
	82–101	33	228	261 (12.41)

Direct medical costs of patients hospitalized in public and private hospitals

Direct medical costs in the public sector were estimated at US$238.10 per patient. The majority of this in the public sector is related to the cost of surgery, which ranks first at 34.16%, followed by accommodation costs at 30.78%. In the private sector, the direct medical cost per hospitalized patient is US$1,107.90. For each hospitalized patient in the private sector, surgical costs are the main component of departmental costs, accounting for 37.52% (see Table 4).

Direct non-medical costs for patients

The average direct non-medical cost was estimated at US$95.96 per patient per year, with US$17.23 for outpatients and US$78.72 for inpatients. Among the direct non-medical costs for outpatients, accommodation constituted the highest cost at 43.42%. For inpatients, travel expenses were the highest direct non-medical cost, accounting for 58.59% (see Table 5).

Estimation of social costs

In 2022, the average indirect cost of CVD attributable to hypertension was US$972.72 per patient. The average cost of lost production due to premature death was estimated at US$436.1, using a discount rate of 3%. Each patient affected by disease and disability incurs a societal cost of US$181.29 in lost productivity due to absences from work and travel, along with an average of $217.10 in unpaid caregiving expenses. The average duration of disability for all CVD patients was more than 61.17 days (see Table 6).

Estimation of the economic burden of high salt consumption on disease

The prevalence of CVD in Iran is estimated to be 9,000 per 100,000 individuals [38]. Given the Iran's population of 84,055,000, the estimated total prevalence of CVD is approximately 7,560,000 individuals. Research indicates that 17% of CVD the risk of CVD cases are attributable to high salt consumption [39]. According to WHO guidelines, adults should consume no more than 5 g of salt per day [40]. Reducing salt intake to this recommended level could potentially prevent 1,285,200 cases of CVD individuals annual. This prevention translates to an estimated cost of $1392.48 per patient, based on financial data from inpatient and outpatient records (see Table 7). Additionally, employment data from the Iranian Statistics Center suggests that high salt consumption results in productivity losses equivalent to 510,738 individuals.

Sensitivity analysis

A sensitivity analysis was conducted by varying the rates (prevalence, cases averted, costs, etc.) by ±20% in both directions. The analysis revealed that the most significant changes in the number of CVD cases prevented are associated with reducing salt intake to 5 g per day. If salt reduction prevents 13.6% of CVD cases, the economic burden of CVD attributable to hypertension would be reduced by approximately $651 million. Conversely, if 20.4% of cases are prevented, the reduction in economic burden could be around $976 million (see Table 8).

Discussion

The results of this study showed that the economic burden of high salt consumption in CVD attributed to hypertension imposes $980.61 million to the economic system of Iran.

Estimates of the economic burden of CVD due to high salt consumption vary across studies due to differences in methodology, cost types, treatment patterns, and healthcare systems. However, comparing CVD costs across countries with different healthcare systems can enhance understanding of the economic implications of various health policies and programs [41, 42].

Our study reveals a higher prevalence of CVD among women compared to men align with existing research [41, 43, 44]. For instance, studies have shown that while

Table 2 Demographic and hospital characteristics based on the questionnaire ($n = 307$)

Variables		Frequency (%)
Income of working patients	Up to $150	17 (14.35)
	$151 to $250	36 (30.77)
	$251 to $350	51 (43.59)
	Over $351	13 (11.11)
Place of residence	Kerman	149 (48.54)
	Other nearby cities	158 (51.46)
Supplementary insurance	Yes	73 (24.33)
	NO	234 (75.76)
Employment status	Employed	100 (32.57)
	Retired (employed)	22 (7.17)
	Retired (unemployed)	64 (20.85)
	Unemployed	20 (6.51)
	Housewife	101 (32.9)
Education	Illiterate	68 (22.15)
	High school	99 (32.25)
	Diploma	83 (27.04)
	Associate Degree	43 (41.01)
	Bachelor's degree and higher	14 (4.56)
Supporting institution	Aid Committee	52 (16.88)
	Rehabilitation	8 (2.06)
	Martyrs Foundation and Martyrs' Affairs	21 (6.82)
	Charity associations	1 (0.32)
	None	226 (73.36)
Family relationship between caregiver and patient	Spouse	87 (28.25)
	Child	124 (40.26)
	Relatives	18 (5.84)
	Parents	15 (4.87)
	Government support institutions	2 (0.64)
	Privately	1 (0.32)
	without a caretaker	60 (19.48)
Caregiver employment status	Employed	156 (50.18)
	Retired	25 (8.14)
	Unemployed	20 (6.97)
	Housewife	106 (42.08)
Caregiver income	Up to $150	178 (57.98)
	$151 to $250	45 (14.65)
	$251 to $350	48 (15.63)
	Over $351	36 (11.72)
Hospitalization	Yes	136 (44.58)
	No	171 (45.42)
Visit	Yes	273 (88.93)
	No	34 (11.07)
Diagnostic	Yes	67 (21.82)
	No	240 (28.18)
Laboratory	Yes	171 (55.7)
	No	136 (44.3)
Drug	Yes	270 (87.95)
	No	37 (12.05)
Equipment	Yes	178 (57.98)
	No	129 (40.02)

men may exhibit higher rates of certain risk factors like smoking and hypertension, women often face unique biological and hormonal influences that contribute to their CVD risk. Additionally, the lifetime risk of CVD is nearly equal between men and women, but the manifestation of the disease can differ significantly [45]. Women are more likely to experience conditions like heart failure with preserved ejection fraction and microvascular angina, which are often underdiagnosed.

Additionally, we observed an increase in the prevalence of CVD with age, rising from 34% in individuals aged 40–60 to 43% in those aged 60–80, as shown by the data in Table X. This trend is consistent with numerous studies highlighting the strong correlation between aging and the prevalence of CVD [41, 46–48]. The economic burden of CVD among working-age adults is substantial, further underscoring the urgency of implementing preventive measures. Public education focused on the adoption of a low-salt diet, alongside other lifestyle modifications, could play a crucial role in reducing both the prevalence and the associated healthcare costs of CVD.

Our study estimates the average economic burden per CVD patient to be $1,277.57. This figure aligns with findings from other studies, where reported costs range between $500 and $1,500 [15, 49]. However, the economic burden of high salt consumption in CVD attributable to hypertension is more than three times the current health expenditure per capita of Iranians, which was $392.54 in 2022 [41] and 0.27 times the current GDP per capita in 2022 in Iran. This significant disparity underscores the substantial economic impact of CVD, influenced by unhealthy dietary habits. This staggering economic impact underscores the urgent need for targeted public health interventions and resource allocation strategies to mitigate the financial and health consequences of high salt consumption, a major risk factor for hypertension and subsequent CVD. Given the high prevalence of excessive salt intake in Iran, exceeding the World Health Organization's recommended levels, it is imperative for policymakers to prioritize salt reduction initiatives. Implementing cost-effective and impactful measures to lower salt consumption could significantly alleviate the financial strain on the healthcare system and improve overall public health outcomes [50]. Our study highlights the critical importance of addressing modifiable risk factors, such as dietary habits, to prevent the development and progression of CVD. By understanding the substantial economic burden posed by high salt consumption, health system planners and policymakers can make informed decisions to allocate resources more effectively, focusing on prevention and early intervention.

Direct costs in our study amount to $539 million, representing 55.51% of the total economic burden. This proportion is comparable to findings from a study in

Table 3 Estimation of direct medical costs in outpatient and inpatient care

Variables	Outpatient (per person)				Inpatient (for each person), $N=1797$			Total ($)	Percent
	Number	Mean ($)	Standard deviation	Percent (percent of total)	Mean ($)	Standard deviation	Percent (percent of total)		
Visit	273	11.25	2.8	18.72	15.6	2.12	6	26.9 (8.29)	8.29
Empowerment	67	4.56	1.25	7.08	------	-----	------	4.56 (1.40)	1.40
Laboratory or diagnostic	171	13.86	1.85	21.23	9.57	4.2	3.68	23.26 (4.18)	4.18
Drug	116	22.37	1.99	34.7	10.32	1.9	3.97	32.69 (10.09)	10.09
Equipment	178	11.76	1.59	18.25	58.86	12.65	22.62	70.62 (21.18)	21.18
Surgery	------	-------	--	----	89.92	18.95	34.56	89.92 (27.77)	27.77
Hoteling	------	-------	--	----	75.84	12.15	29.15	75.84 (23.42)	23.42
Total		63.64	4.35	100	260.14	47.67	100	323.79 (100)	100

Table 4 Direct cost items of hospitalized patients by private and public sectors

Variable	Public sector($N=1705$)			Private sector($N=92$)			Mean of costs ($)	Percent
	Mean ($)	Standard deviation	Percent	Mean ($)	Standard deviation	Percent		
Visit	14.27	2.68	5.99	66.47	4.13	6.02	15.6	6
Drug	9.53	1.81	4.09	40.63	2.58	3.66	10.32	3.98
Laboratory	8.6	1.23	3.61	21.20	11.43	1.19	8.93	3.44
Equipment	51.08	10.11	21.37	220.39	13.76	19.89	55.41	21.3
Surgery	81.16	18.89	34.16	415.72	28.33	37.52	93.98	36.12
Hoteling	73.32	11.04	30.78	343.34	20.06	31	75.87	29.16
Total	238.01	45.76	100	1107.9	80.29	100	260.1	100

Table 5 Direct non-medical costs by outpatient and inpatient

Variables	Outpatient ($N=307$)			Inpatient ($N=307$)			Total ($)	Percent
	Mean ($)	Standard deviation	Percent	Mean ($)	Standard deviation	Percent		
Travel	5.59	0.82	32.47	46.14	0.54	58.59	51.72	53.9
Accommodation	7.48	1.53	43.42	17.14	3.36	21.78	24.64	25.66
Nutrition, etc.	4.15	0.93	24.11	15.44	2.36	19.62	19.6	20.43
Total	17.23	3.28	100	78.72	6.62	100	95.96	100

Table 6 Cost of lost time of patients and companions per employed and unemployed person's salary

Variable	Average lost days	Standard Deviation	Average income of working people based on dollars (daily)	$Total cost	Per-cent
Lost times due to patients' disability and travel	20.66	13.71	8.77	181.21	18.62
Time lost due to the travel of the patient's companions	15.74	10.54		138.31	14.21
The average number of days of unpaid care and nursing	24.77	13.8		217.1	22.31
The monetary value of production lost as a result of the death of the individual in question	-	-	-	436.1	44.84
Total	61.17	12.68	8.52	972.72	100

Table 7 Estimated economic burden of high salt consumption in CVD in 2022

Variable	Estimated number of patients	Per Capita Cost ($)	Percentage	Total cost (million dollars)	Percentage
Direct medical cost	1,285,200	323.79	25.65	421.160	42.95
Direct non-medical cost	1,285,200	95.96	7.51	123.327	12.58
Indirect cost	510,738	972.72	66.83	436.124	44.47
Total	1392.47		100	980.61	100

Table 8 Sensitivity analysis of deterministic parameters affecting the economic burden

Variable	Various scenarios	Values of each scenario		Total cost (million dollars)	The amount of deviation from the base (million dollars)	Deviation percentage
		Day	percentage /Day			
Prevalence of heart disease in Iran	Minimum	-----	7.2	784.49	196.12	-20
	Base	-----	9	980.61	------	----
	Maximum	-----	10.08	1065.86	85.26	+0.08
Prevented rate of occurrence of the patient	Minimum	-----	13.6	784.49	196.12	-20
	Base	-----	17	980.61	---	---
	Maximum	-----	30	1176.41	195.8	+19.98
The cost of lost time for patients	Minimum	48.28	48.28	916.45	64.16	-0.07
	Base	61.17	------	980.61	0	0
	Maximum	73.62	-----	916.45	64.16	+0.07
Direct medical costs	Minimum	-----	80	853.22	127.39	-13
	Base	-----	100	980.61	0	0
	Maximum	-----	120	1108.08	127.39	+13

southwest Iran, where direct costs accounted for 60% of the economic burden of CVD [50]. Globally, direct costs are similarly substantial, with heart failure patients' direct costs approximating 60% of the total burden [50], and the European Union reporting 62% of the economic burden attributed to direct costs [50]. Thus, direct costs represent a major component of the economic burden of CVD.

Our findings indicate that direct medical costs for hypertension-related CVD average over $327.7 per patient, accounting for 42.94% of the total burden. This is consistent with studies from South Korea [51] and the European Union, where direct medical costs represent 53% and 51% of total costs [52], respectively. In contrast, a study in India reported that direct medical costs comprised 90% of the total economic burden [53]. This consistency across studies highlights the significant role of direct medical expenses in the overall economic burden of CVD.

Our findings indicate that more than 80% of direct medical costs associated with hospitalization are related to visits and diagnostic procedures, surgery, and hoteling, while drug treatment accounts for approximately 20% of these costs. This observation aligns with the majority of studies examining the economic burden of CVD, where hospital costs often constitute over 50% of the total direct costs [13, 52, 54]. This emphasizes the substantial financial impact of CVD on healthcare systems globally.

A significant finding from our study is that surgical costs represent over 27% of direct medical expenses, making it the largest single category of expenditure. Hoteling costs rank as the second largest category. These results are consistent with studies conducted in Iran, which also identified surgical costs as the most substantial expenditure category [55, 56]. Notably, a study on coronary heart disease in Iran found that the highest direct medical cost was related to angioplasty, followed by surgery [50]. However, due to limited availability of angioplasty in some Iranian medical centers, the proportion of patients receiving this procedure may be lower, which contrasts with our findings.

Among direct non-medical costs, transportation expenses constitute the largest share, exceeding 53% of the total. This aligns with findings from a study in southern Iran, where transportation costs also represented the largest portion, over 40% of direct non-medical expenses [50]. Conversely, a South Korean study identified complementary treatments as the major non-medical cost, which differs from our results [51]. The high transportation costs observed in our study reflect the additional burden on patients traveling to treatment centers, particularly from regions with limited local healthcare facilities.

social Costs account for over 44.47% of the total economic burden of CVD in our study. This proportion is higher compared to South Korea, where social Costs due to disability were estimated at 33% [51], and the European Union, where social Costs constituted approximately 34% of total costs [52]. In Turkey, social Costs were reported to be over 66% of the total costs [57]. These discrepancies highlight the variability in indirect cost estimates, which can be attributed to differences in methodologies and economic contexts. Nonetheless, the substantial impact of social Costs on the overall economic burden of CVD is evident. The variation in the monetary value of lost production due to illness, disability, and mortality across different countries largely stems from differences in the methodologies used to calculate social Costs. While these costs have been reported in various studies, they are often less discussed in the literature. There is an increasing acknowledgment of the significance of social Costs, highlighting the necessity for greater focus and more detailed analysis in this area.

In general, studies in the field of social Costs and productivity losses related to CVD have demonstrated that the costs of reduced productivity are considerable, representing between 21 and 63% of the total economic burden of this disease [58, 59]. Studies have demonstrated that productivity losses due to CVD can range between 21% and 63% of the total economic burden. Our study's findings are consistent with these figures, with an average of 71 to 97 days lost due to CVD, as reported in the European Union [60], and 61 days in Iran [55]. These results underscore the significant impact of lost productivity on the economic burden of CVD.

It is essential to modify the variables in order to ascertain the range of potential cost values under an economic scenario [61]. Sensitivity analysis revealed that a 20% variation in CVD cases prevented could result in a 20% decrease or 19.98% increase in the total cost estimation. This is consistent with findings from a study in England, where a 20% change in key variables was observed [54]. This suggests that while adjustments to study assumptions can influence outcomes, the overall findings remain robust.

This study also had some limitations. It is important to note that this study does not account for intangible costs such as pain and suffering, which are challenging to quantify in monetary terms. The focus is primarily on direct financial costs, as non-monetary costs are difficult to estimate. Additionally, the use of epidemiological data on disease prevalence may have affected the accuracy of cost estimates. Future studies addressing these limitations could provide more precise estimates of the economic burden of cardiovascular diseases.

Conclusion

This study represents the first comprehensive analysis of the economic burden of CVD in Iran, incorporating both direct healthcare costs and economic losses stemming from complications and fatalities associated with high salt consumption. The findings reveal that CVD attributed to excessive salt intake imposes a substantial economic strain on society, exceeding three times the per capita health expenditures in 2022 and amounting to approximately one-fourth of the GDP per capita for the same year, based on World Bank data. These figures emphasize the urgent need for policymakers to prioritize preventive initiatives and allocate resources effectively to enhance the care and management of CVD patients.

Given the considerable financial burden posed by high salt consumption, health authorities must implement comprehensive and cost-efficient public health strategies aimed at reducing salt intake across the population. Such measures would not only mitigate the prevalence of hypertension and subsequent CVD but also alleviate the associated economic burden on the healthcare system, ultimately improving public health outcomes. Economic burden studies are indispensable for substantiating resource allocation toward preventive measures. These studies offer critical insights into the financial ramifications of dietary risk factors and underscore the potential cost savings from targeted interventions. By demonstrating the economic advantages of prevention-focused strategies, health system planners and policymakers are better equipped to make informed decisions, ensuring efficient and effective resource allocation.

Addressing these conditions and curtailing associated costs necessitates modifying risky behaviors, such as excessive salt consumption, to reduce individual vulnerability to these diseases. Accordingly, policymakers are urged to utilize data on the economic burden of CVD to invest in and allocate resources toward initiatives that aim to lower salt intake one of the most effective methods for preventing CVD and its resultant disabilities.

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Author contributions
VYF contributed to conceptualization, study design, interpretation of the results and overall supervised the study. SP contributed to data gathering, analysis and writing the findings. SP and VYF wrote the draft of manuscript. RG, MA, and NN contributed to data analysis and verified the analytical methods. All the authors read and approved the final draft of manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethical approval
This research with Reg. No. 98001171 was approved by ethical committee of Kerman University of Medical Sciences. The Ethic approval Code is IR.KMU.REC.1399.294. All methods were carried out in accordance with relevant guidelines and regulations. Participation in this study was voluntary. All participants were explained about the objectives and process of the study and their informed consent was obtained.

Competing interests
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