Original Article

The Economic Burden of Smoking-Attribution and Years of Life Lost due to Chronic Diseases in Mashhad, 2015–2016

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Abstract

Background: Tobacco smoking is one of the most preventable causes of mortality related to noncommunicable diseases (NCDs). This study aimed to estimate the direct economic burden and years of life lost (YLL) attributable to smoking in NCDs in Mashhad, 2015–2016. **Methods:** Hospital-based data were utilized to calculate the economic burden of four selected diseases related to smoking. An epidemiological population-attributable risk method was used to determine the smoking-attributable fraction (SAF). Moreover, the study was conducted by data related to disease-specific expenditures and patients' information on cost and the number of mortality for estimating the YLL for each disease, population and life expectancy data, the prevalence of smoking, and the relative risk of smoking. Data analysis was performed with STATA software, version 12. **Results:** The total costs attributable to smoking for stroke, myocardial infarction, chronic obstructive pulmonary disease (COPD), and lung cancer were 94148, 151272, 1191396, and 574784 US Dollars, respectively (per 100000). In 2015, the YLL per deaths due to COPD were 4217 and 3522 among males and females, respectively. Furthermore, in 2016, the YLL per deaths due to the stroke in males and females were 8317 and 7563, respectively. In the same year, the highest proportion of years of potential life lost per 100000 smoking-attributable deaths belonged to COPD. **Conclusions:** The results of this study can be used to inform policy-makers about smoking-attributable diseases in Iran. To decrease the smoking-attributable costs, which have resulted in the spread of NCDs, policy-makers should adopt and implement effective policies regarding smoking prevention and control.

Keywords: *Global burden of disease, health care costs, lung neoplasms, myocardial infarction, smoking, stroke*

Introduction

Tobacco smoking is one of the most preventable causes of deaths due to noncommunicable diseases (NCDs) throughout the world.[1] Smoking is responsible for the increase in the prevalence of numerous types of diseases such as lung cancer, chronic obstructive pulmonary disease (COPD), stroke, and myocardial infarction (MI).[2,3] Every 24 h, about 3000 people die due to tobacco-related complications. It is estimated that the annual number of deaths due to tobacco smoking will reach 8.3 million by 2030.[4] Furthermore, smoking was the second risk factor for premature disability and mortality in the world in 2015.[5] Disability-adjusted life years attributable to smoking are 4% and 13% in developed and developing countries, respectively.[6,7]

It is estimated that NCDs, especially cancer, cardiovascular diseases, and chronic respiratory diseases, kill 38 million people annually.[8] Among NCDs, about 80% of mortality and morbidity are attributed to three diseases: Cardiovascular disease, which is estimated to account for about 40% of the deaths due to smoking; Lung cancer, which is estimated to be responsible for about 20% of smoking-related mortality; and COPD, that is estimated to be responsible for around 20% of smoking-related mortality.[9] The total number of mortality due to COPD in Iran increased from 3665 in 2001 to 8832 in 2015.[10] Moreover, the mortality related to lung cancer increased from 5.7 to 8.49 deaths (per 100000). Furthermore, the number of deaths due to the stroke reached 29.19 and 27.67 in 100000 deaths in 2001 and 2015, respectively.[11]

According to the results of the recent study in Iran, the prevalence of past smoking in Mashhad was 10.3%.[12] Quantifying the burden of smoking is an

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effective way for showing the burden of smoking-related NCDs.[13] There are several measures for estimating the burden of NCDs such as mortality rate, years of potential life lost, and cost of productivity lost.[13,14] In this study, we used the first two measures for estimating the burden of NCDs.

This study aimed to estimate the economic burden and the years of life lost (YLL) attributable to smoking among cases of lung cancer, COPD, stroke, and MI in Mashhad from the provider perspective in Iran in 2015–2016. Moreover, years of potential life lost due to smoking-induced diseases was calculated. Undoubtedly, the results of this study can help policymakers and experts in health sectors to identify the costs of smoking in the community and to determine the planning priorities to control tobacco consumption.

Methods

A hospital-based data record is utilized to calculate the economic burden attributable to smoking in four selected diseases, including lung cancer, COPD, MI, and stroke. It seems that there is a significant relationship between smoking and the risk of death due to aforementioned diseases. In fact, the mentioned diseases have the highest correlations with smoking among all types of NCDs.[15] Table 1 shows the details of selected diseases and their codes according to ICD-10. An epidemiological population-attributable risk method is utilized to determine the smoking-attributable fraction (SAF), which has been used to calculate the proportion of smoking-attributable cost and mortality. The target population was people of 18 years and up.

Table 1: Relative risk and smoking-attributable fraction for selected diseases (%)

Diseases	RR for Smoking-related diseases				SAF	
	Male		Female		Male	Female
	RR_C	RR_F	RR_C	RR_F		
Stroke	1.67	1.08	1.83	1.17	11.3	1.63
MI	1.43	1.20	2.24	1.2	7.44	2.41
COPD	11.86	3.34	11.86	3.34	67	17.84
Lung cancer	4.40	1.82	3.20	1.90	75.79	62.34

RR_C: The relative risk of current smoking compared to never smoking, RR_F: The relative risk of past smoking compared to never smoking, SAF : Smoking-attributable fraction

Data sources

The data divided into two parts. The first part was used for estimating the smoking-attributable cost of diseases and the second part was utilized for calculating the YLL due to smoking in Mashhad.[16] Moreover, the population-based data obtained from a project titled "STEPs" were used in this study. The STEPs project is conducted every two years in Iran to determine the prevalence of smoking in terms of current smoking, past smoking, and never smoking.[12] The data related to the disease-specific expenditures and patients' costs were obtained from the hospital-based record data of the health information systems in Mashhad. Furthermore, the population and life expectancy data in 2015–2016 were derived from a report titled "The Health Profile of Iran."[17] Moreover, the data needed for estimating the YLL for each disease in 2015–2016 were obtained from a recent report by the Research Center for Noncommunicable Diseases. The details of using data are discussed elsewhere.[16]

Smoking-attributable fraction (SAF)

A standardized measure titled "SAF" was used for estimating the tobacco-attributable mortality and costs in terms of the disease type, age groups (18–24, 25–34, 35–44, 45–54, 55–64, 65–69, and 70+), and sex. For measuring the SAF, two components including the prevalence of smoking and the relative risk (RR) were need. In terms of smoking, the respondents classified into three groups: never smoking, current smoking, and past smoking. The following epidemiological formula was used to measure the smoking-attributable dysfunction in lung cancer[18]:

$$SAF(\%) = \frac{\left[P_n + P_c * RR_c + P_f \times RR_f\right] - 1}{\left[P_n + P_c * RR_c + P_f \times RR_f\right]} \times 10$$

Where P_c is the prevalence of current smoking, P_f is the prevalence of past smoking, and P_n is the prevalence of never smoking. RR_c is the proportion of current smoking to never smoking and RR_f is the proportion of past smoking to never smoking.

Furthermore, the following formula is used to calculate the smoking-attributable dysfunction in COPD, stroke, and MI. We modified the sentence as follows: The risk of smoking-induced diseases (3 Selected Diseases told) was

calculated based on the comparison of the exposed group with the group without any exposure to the age group.[19]

$$SAF = \frac{\sum_{r=1}^{n} P_{r(RR_c-1)}}{\sum_{r=1}^{n} P_{r(RR_c-1)} + 1}$$

Where RR_c is the proportion of current smoking to never smoking and P_r is the outbreak of the agent exposed to "*r*." Moreover, "*n*," "*l*," and "*s*" are the representatives of the number of categories at risk, the type of disease, and sex, respectively.

We used the data gathered from the STEPs study in 2016 to estimate the prevalence of never smoking, current smoking, and past smoking among population aged 18 years and up. The data relating to the RR of smoking for selected diseases not found in the literature review conducted by the authors. Therefore, the data related to the RR of smoking proportion were obtained from various studies conducted in other countries.[20-24]

Direct costs

In this study, direct costs defined as costs paid by patients for outpatient visits and hospitalization and were extracted from the health information systems in hospitals. Inpatient expenditures were included the visits by physicians and nurses, prescribed medications, hoteling the patient, and imaging and laboratory tests during hospitalization. Outpatient visits included the visit by physicians and imaging and laboratory tests. The smoking-attributable costs for inpatient and outpatient services were measured by multiplying the SAF by the total costs of each group in terms of age group, sex, and the type of disease.

Years of potential life lost

For calculating the indirect mortality costs in terms of each subgroup (the type of disease, sex, and age group), the total YLL related to each subgroup and the amount of smoking-attributable mortality for each subgroup were estimated by the following formula:

Smoking-attributable YLL = SAF × total YLL in terms of the type of disease, sex, and subgroup

For calculating the YLL in each subgroup, the amount of mortality in each group is multiplied by the life expectancy in terms of age group, sex, and disease subgroup.

Statistical analysis

In order to obtain the results comparable to years and age groups, the age-standardized YLL and direct economic burden of smoking-attributable diseases were calculated based on Mashhad population in 2016.

Results

Table 1 shows the RRs and smoking-attributable fraction in terms of selected diseases. In addition, Figures 1 and 2 demonstrate the total direct costs attributable to smoking in terms of age groups of residents of Mashhad in 2015–2016. The total costs attributable to smoking for stroke, MI, COPD, and lung cancer (per 100000) were 94148, 151272, 1191396, and 574784 US Dollars, respectively (in terms of direct cost including hospitalization and outpatient visits). The results show that the highest cost of stroke, COPD, MI, and lung cancer is in age group 70+.

In this study, all YLL related to four selected diseases were calculated using the data gathered from NASBOD project cited in a report by the Noncommunicable Diseases Research Center. Based on the findings of NASBOD project in Iran, the YLL due to COPD in 2015

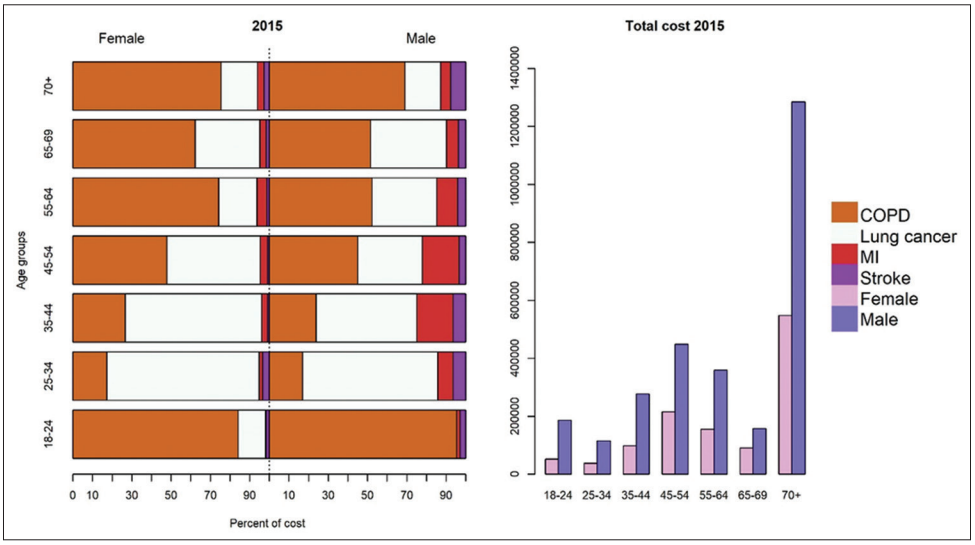

Figure 1: Total cost of smoking in terms of the type of disease, age group, sex, and year (per 100000 deaths) in 2015

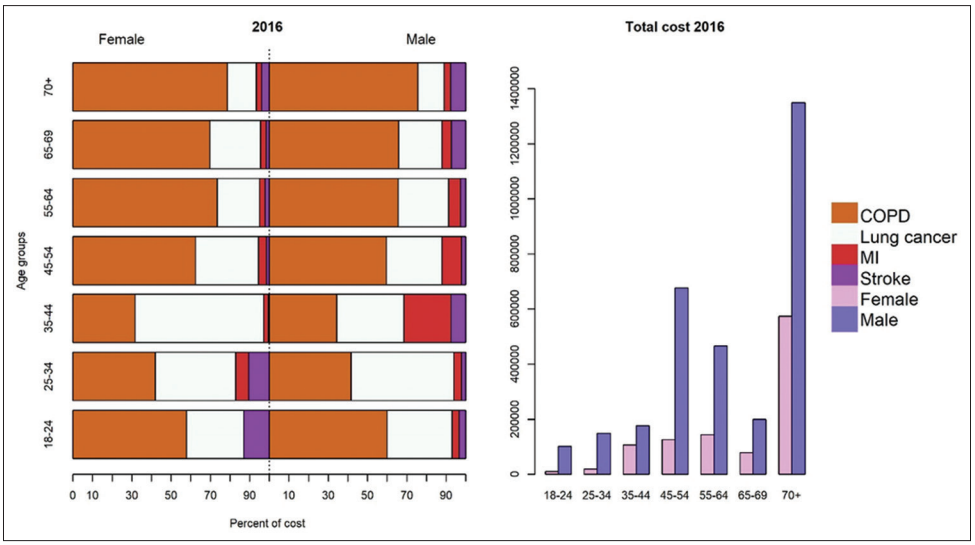

Figure 2: Total cost of smoking in terms of the type of disease, age group, sex, and year (per 100000 deaths) in 2016

Table 2: Years of life lost per death in Mashhad in terms of the type of disease, sex, and year (per 100000)

Year	Sex	YLL						
		18-24	25-34	35-44	45-54	55-64	65-69	70+
Stroke								
2015	Male	26 (19-35)	17 (13-24)	36 (26-48)	147 (108-199)	434 (320-580)	1832 (1369-2432)	6773 (5102-8938)
	Female	20 (14-28)	13 (9-19)	25 (18-36)	124 (87-176)	394 (281-551)	1913 (1386-2622)	6966 (5111-9353)
2016	Male	24 (18-32)	16 (12-22)	31 (23-43)	115 (85-158)	335 (246-453)	1667 (1246-2219)	6129 (4556-8082)
	Female	17 (12-24)	12 (8-17)	22 (16-32)	130 (92-183)	426 (301-594)	1762 (1271-2423)	5194 (3767-6984)
MI								
2015	Male	354 (256-489)	279 (201-381)	641 (486-834)	2075 (1596-2618)	3567 (2813-4417)	10534 (8258-13000)	18085 (14165-22348)
	Female	197 (144-266)	95 (70-130)	176 (133-231)	703 (538-902)	1647 (1276-2076)	7065 (5579-8698)	17189 (13725-20920)
2016	Male	312 (226-433)	257 (187-354)	595 (447-775)	1681 (1301-2120)	3064 (2399-3778)	9923 (7902-12226)	13522 (10582-16686)
	Female	171 (126-230)	84 (61-113)	160 (120-211)	753 (579-965)	1817 (1406-2282)	6643 (5205-8146)	16378 (13098-19804)
COPD								
2015	Male	87 (68-111)	57 (45-73)	88 (69-111)	216 (172-274)	370 (291-466)	1257 (1006-1584)	2142 (1685-2711)
	Female	29 (22-37)	15 (11-19)	24 (18-31)	81 (62-106)	165 (127-214)	727 (568-938)	2481 (1920-3224)
2016	Male	85 (67-107)	55 (43-71)	88 (69-112)	191 (150-242)	316 (247-403)	1283 (1026-1607)	2225 (1751-2838)
	Female	30 (23-39)	15 (11-20)	23 (18-30)	86 (65-113)	185 (140-238)	749 (578-974)	2583 (1981-3353)
Lung cancer								
2015	Male	69 (56-86)	35 (28-43)	64 (52-79)	176 (143-217)	376 (303-460)	1050 (863-1269)	996 (808-1223)
	Female	36 (28-47)	14 (11-18)	25 (20-31)	65 (52-82)	140 (112-174)	378 (306-466)	407 (327-507)
2016	Male	66 (53-82)	31 (25-39)	57 (46-70)	162 (130-199)	318 (258-391)	978 (806-1192)	1156 (935-1430)
	Female	29 (23-38)	13 (10-17)	22 (18-28)	62 (49-77)	138 (111-171)	345 (279-427)	595 (477-743)

YLL=Years of life lost, MI=Myocardial infarction, COPD=Chronic Obstructive Pulmonary Disease

were calculated as 4217 and 3522 deaths per 100000 in males and females, respectively. Furthermore, the YLL due to the stroke in 2016 in males and females were 8317 and 7563, respectively [Table 2].

Table 3 shows the years of potential life lost due to smoking in terms of the type of disease, sex, age group, and year in Mashhad. According to the results, the highest proportion of years of potential life lost per 100000 smoking-attributable deaths in 2016 were observed in COPD. The number of years of potential life lost due to MI in 2016 was higher in males (2183 years in men and 627 years in women). The lowest YLL attributable to smoking were seen in stroke (941 years in men and

Table 3: Years of life lost per death due to smoking in Mashhad in terms of the type of disease, sex, age-group, and year (per 100,000)

Year	Sex	YLL						
		18-24	25-34	35-44	45-54	55-64	65-69	70+
Stroke								
2015	Male	3 (2-4)	2 (1-3)	4 (3-5)	17 (12-23)	49 (36-65)	207 (155-275)	765 (576-1010)
	Female	0 (0-0)	0 (0-0)	0 (0-1)	2 (1-3)	6 (5-9)	31 (23-43)	114 (83-152)
2016	Male	3 (2-4)	2 (1-2)	4 (3-5)	13 (10-18)	38 (28-51)	188 (141-251)	693 (515-913)
	Female	0 (0-0)	0 (0-0)	0 (0-1)	2 (1-3)	7 (5-10)	29 (21-40)	85 (61-114)
MI								
2015	Male	26 (19-36)	21 (15-28)	48 (36-62)	154 (119-195)	265 (209-329)	784 (614-967)	1346 (1054-1663)
	Female	5 (3-6)	2 (2-3)	4 (3-6)	17 (13-22)	40 (31-50)	170 (134-210)	414 (331-504)
2016	Male	23 (17-32)	19 (14-26)	44 (33-58)	125 (97-158)	228 (178-281)	738 (588-910)	1006 (787-1241)
	Female	4 (3-6)	2 (1-3)	4 (3-5)	18 (14-23)	44 (34-55)	160 (125-196)	395 (316-477)
COPD								
2015	Male	58 (46-74)	38 (30-49)	59 (46-75)	145 (115-184)	248 (195-312)	842 (674-1061)	1435 (1129-1817)
	Female	5 (4-7)	3 (2-3)	4 (3-6)	15 (11-19)	29 (23-38)	130 (101-167)	443 (342-575)
2016	Male	57 (45-72)	37 (29-48)	59 (47-75)	128 (101-162)	211 (166-270)	860 (687-1076)	1491 (1173-1901)
	Female	5 (4-7)	3 (2-4)	4 (3-5)	15 (12-20)	33 (25-43)	134 (103-174)	461 (353-598)
Lung cancer								
2015	Male	52 (42-65)	26 (21-33)	49 (40-60)	133 (108-164)	285 (230-349)	796 (654-962)	755 (613-927)
	Female	23 (18-29)	9 (7-11)	16 (12-20)	41 (33-51)	87 (70-109)	235 (191-290)	254 (204-316)
2016	Male	50 (40-62)	24 (19-29)	43 (35-53)	123 (99-151)	241 (195-296)	742 (611-903)	876 (709-1084)
	Female	18 (14-24)	8 (6-10)	14 (11-17)	39 (31-48)	86 (69-107)	215 (174-266)	371 (297-463)

YLL=Years of life lost, MI=Myocardial infarction, COPD=Chronic Obstructive Pulmonary Disease

123 years in women). In addition, smoking led to 10711 and 10222 premature deaths among 92079 and 82394 Years of Potential Life Lost (YPLLs), respectively, for these 4 main diseases related to smoking in Mashhad in 2015 and 2016.

Regarding the age-sex standardized rate of mortality due to smoking in stroke, the largest number of years of potential life lost was observed in the age group 70+ years (693 years in men and 85 years in women) in 2016. Moreover, the number of years of potential life lost due to smoking in COPD was similar to the stroke and the highest number of years of potential life lost was found in age group 70+ years.

Discussion

This study aimed at the calculation of the economic burden of smoking using the hospital-based data record in Mashhad, one of the most populated cities in Iran. Diseases included in this study were lung cancer, COPD, MI, and stroke. The results of the study demonstrated that smoking led to 10711 and 10222 premature deaths among YPLLs, respectively, for the four main diseases related to smoking in Mashhad in 2015 and 2016. In addition, the results showed that COPD had the highest level of expenditure and years of potential life lost per 100000 smoking-attributable deaths in Mashhad in 2015–2016. This finding was similar to another study, which showed that COPD was the fourth leading cause of mortality in the world in 2015.[25] Furthermore, COPD is one of the ten important causes of deaths globally.[26] Rezaei *et al*. estimated that the total economic burden of smoking based on COPD and lung cancer were 132,332,906 US$ and 59,642,402 US$, respectively.[27] Economic costs of smoking in Korea per 100000 was 3154.75 for all of causes.[28] According to a recent study, the mortality rate due to COPD in Iran has increased during recent years.[10] The increase in COPD cases has a direct relationship with the high levels of air pollution in almost all provinces in Iran, especially border provinces.[24] Indeed, it has been affirmed that air pollution has a vital role in the increase of mortality rate due to COPD and respiratory diseases.[27,28]

This study revealed that the total costs and total YLL due to smoking in all selected diseases were higher in men compared to women. These results are consistent with various foreign studies.[28,29] Another study in Iran also showed that there is a significant difference between males and females in terms of COPD-induced mortality rate in total population and all provinces.[10] It seems that the significant differences among selected diseases in terms of smoking-attributable costs and mortality rate are due to the higher rate of employment in men and working in polluted environments. In addition, it can be due to the high prevalence of smoking among men.

This study calculated that the total mortality costs related with the four chronic diseases due to smoking in Mashhad were about 12%. Our results are compared with other studies conducted in China in which the total economic costs of smoking were calculated 21.5% ($6.2 billion) in direct costs and 76.1% ($22.0 billion) in indirect costs.[30]

Neubauer *et al*. reported that the mortality attributable to smoking was 13.4% in 2003.[31] The findings of this study are compatible with a number of studies regarding the YLL due to the stroke, MI, lung cancer, and COPD in Iran.[10,32] According to a report by the Institute for Health Metrics and Evaluation (IHME) in 2016, the YLL due to lung cancer in Iran was higher than the figure in the present study. While the YLL due to COPD in this study was lower than compared with IHME reported about Iran. In addition, Our results showed that the YLL due to the stroke was lower than IHME's results.[33]

This study faced several limitations. First, the rates of RR for four selected diseases were not available in the previous studies. Therefore, the authors estimated them based on the foreign studies. Hence, these figures may not be well-matched with the conditions of the Iranian community. Second, we could not obtain the data for the mortality rate and the YLL due to the four selected diseases in Mashhad. Therefore, we had to use the data reported in the previous studies. Third, this study was from paper perspective and it does not capture appropriate patients and healthcare direct and indirect cost. Hence, a broad analysis from societal perspective could be worthwhile. Forth, we do not have access to data of costs and mortality attributable to smoking in more years and we could not estimate a variation of economic burden of smoking over the years.

Conclusions

To our knowledge, the present study is the first one regarding the smoking-attributable economic burden and the YLL due to lung cancer, COPD, stroke, and MI in Mashhad, Iran. The results of this study can inform policy-makers and experts about the effects of tobacco on diseases in Iran. This can be useful in the decrease of smoking-induced costs and the prevalence of NCDs. One of the most effective solutions to this problem is raising the taxes on tobacco products. Furthermore, informing the community about the harmful effects of tobacco and its role in the development of NCDs can be effective in this regard.

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Conflicts of interest

There are no conflicts of interest.

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