

## Productivity costs and years of potential life lost associated with five leading causes of death: Evidence from Iran (2006-2010)

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### Abstract

**Background:** Economic burden due to premature mortalities is significant both on health system and on the society as a whole. This study aimed to determine the productivity costs and years of potential life lost associated with five leading causes of death in Iran from 2006 to 2010.

**Methods:** Data on mortality by sex and age-groups due to five main leading causes of death (myocardial infarction (MI), cerebral vascular diseases (CVD), transport accidents (TA), hypertensive heart disease (HHD) and gastric cancer (GC)) were obtained from the Ministry of Health and Medical Education from 2006 to 2010 for 29 providences of Iran (data on Tehran province was not available). Three measures including years of potential life lost (YPLL), years of potential productive life lost (YPPLL) and the cost of productivity loss (CPL) due to premature mortality were used. To estimate the CPL and YPLL, the human capital approach and life expectancy method were used, respectively.

**Results:** There were 518,815 deaths due to the five main leading causes of death; of which, 58% occurred in males. The estimated YPPLL resulted in 209,552,135 YPPLL from 2006 to 2011; of which, 141,966,592 (67%) were in males and 67,585,543 (33%) in females. The total cost of productivity loss caused by premature deaths due to the five leading causes of death was 7.86 billion dollars (US\$) from 2006 to 2010, ranging from 1.63 billion dollars in 2006 to 1.31 billion dollars in 2010.

**Conclusion:** This study revealed that the economic burden of premature mortalities due to the five main causes of death is substantial, and that these five leading causes should be considered in policy/decision making and prevention programmes. The allocation of financial resources to control these causes may decrease their economic burden, resulting in higher level of health and well-being.

**Keywords:** Economic Burden, Premature Mortality, Lost Productivity, Iran.

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### Introduction

According to the World Health Organization (WHO) report, about 395,000 deaths have occurred from all causes in Iran in 2012, of which 76% account for non-communicable diseases (1). Premature mortality imposes significant economic burden on the society in different aspects (2). There are many approaches to estimate

the economic burden of diseases and its consequences. One of the most important approaches is the cost of illness (COI) studies (3,4). In COI studies, total cost is divided by direct costs and indirect costs. Direct cost consists of healthcare costs (hospitalization, medicine, visits, etc) and non-healthcare costs (transport, food, etc). Indirect costs include morbidity cost (absentee-

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ism from work, early retirement) and mortality cost (lost productivity due to premature deaths) (2,5-9). Based on this perspective, the inclusion or exclusion of these costs is different. The comprehensive perspective is the societal perspective, in which both direct and indirect costs are considered (7,10). Several studies have found that mortality costs account for the largest proportion of the total cost. Therefore, it is necessary to quantify disease-related mortality in financial terms to make a better estimation for resource allocation and policy/decision making (11,12).

Thus, it is important to quantify the value of labor productivity loss due to premature mortality in measuring the economic burden of diseases (2,3). Quantification of the lost productivity due to premature mortality is useful for interpreting economic burden of diseases and predicting costs to the society (13). In addition, this helps the policy-makers to set the disease control priorities and design effective preventive interventions to reduce burden of diseases and mortalities (14-16). That is why cost analysis is one of the top first five areas of research priorities (17). Although a few related studies had been conducted in Iran, they only focused on DALYs (18, 19) and cancer productivity losses (20). Moreover, economic burden of premature mortality on productivity loss attributed to most important causes of death have not been yet estimated in Iran at the national level, and no overall picture of lost productivity due to leading causes of death is available.

Therefore, this study aimed to estimate the years of potential life lost (YPLL), years of potential productive life lost (YPPLL) and the cost of productivity lost (CPL) due to premature mortality caused by five leading causes of death in Iran over a five-year period from 2006 to 2010.

## Methods

### General Approach

Based on previous studies (3,7,20,21), the Human Capital Approach was used to estimate the cost of lost productivity due to

five leading causes of premature mortality in Iran from 2006 to 2010. To estimate the burden of these diseases, three measures of years of potential life lost (YPLL), years of potential productive life lost (YPPLL) and the cost of lost productivity (CLP) due to premature mortality were used. These measures focus on the social and economic impact of premature mortality (20,22,23). To estimate the YPLL and CPL, we used life expectancy method and working age (from 15 to 65 years), respectively.

### Data Sources

Data on mortality by sex and age groups for 29 provinces (data on Tehran province was not available) were obtained from the Ministry of Health and Medical Education (MoHME) (24). The database contains number of deaths due to all causes by sex and 5-year age- groups (including under one, 1-4, 5-9, 10-14, 15-19, 20-24, 24-29, 30-34, 35-39, 40- 44, 45-49, 50-59, 60-64, 65-69, 70- 74, 75-79, 80-84 and 85+). To achieve the purpose of the study, we extracted data on five leading causes of premature mortality. Number of deaths during 2005-2009 in all age groups was used to calculate YPLL. To estimate the cost of productivity loss, number of deaths between the ages of 15 and 64 was extracted from the database, using the International Classification of Diseases (ICD) codes (A00- Y98). To estimate the average life expectancy for each age group, Iran life table from the World Health Organization was used (25). Data on age- and sex-specific wages came from the Iranian Ministry of Cooperation Labor and Social Welfare. In addition, the data on age and sex-specific employment and housekeeping rate for the study period were obtained from the Iranian Statistical Center (ISC) (26). Based on the mean economic growth in the past 30 years in Iran, 3.7% was considered in the study (26).

### Estimation Methods

**YPLL Estimation Due to Premature Mortality:** To estimate YPLL for premature

mortality due to five leading causes of deaths, we assumed that all the deaths in each age group occurred in the mid-point of that age group. To calculate YPLL, the number of deaths in each age group was multiplied by the average of the remaining life expectancy for that age group. The number of YPLL was calculated as follows (27):

$$YPLL = \sum_{i=0}^{\infty} d_i \times L_i$$

Where  $d_i$  is the number of deaths at the mid-point of each age group;  $i$ , and  $L_i$  is the average of remaining life expectancy for that age group  $i$ .

Cost of Productivity Lost due to Premature Mortality: First, we estimated years of potential productive life lost (YP-PLL). YPPLL estimation is similar to YPLL estimation, but to calculate YPPLL, all deaths below 15 and above 65 years (the retirement age in Iran) were disregarded. Second, YPPLL was calculated by multiplying the number of cause-specific deaths for a given age group by the expected remaining productive life years (until retirement age) at the mid-point for each age group. The number of YPPLL was calculated as follows (27):

$$YPPLL = \sum_{i=0}^N d_i \times (W_U - W_L)$$

Where  $d_i$  is the number of deaths at the

mid-point of each age group;  $i$ ,  $W_U$  is the upper limit of working age (65 years), and  $W_L$  is the lower working age (from 15 to 65).

Third, the calculated YPPLL was multiplied by age and sex-specific annual wages from age of deaths until the retirement age. The estimated costs of lost productivity were adjusted based on the employment and housekeeping rate. Moreover, to obtain the present value, the future costs were discounted at 3% per year. Cost of productivity loss for each death was summed across age groups by sex and cause of death.

### Results

Based on our data, 1,283,372 deaths occurred due to all causes in Iran from 2006 to 2011 (excluding Tehran province); of which, 40% (518,815) were attributable to five main leading causes of death. Moreover, 58% of the total deaths due to five main leading causes were in males; 260,767 deaths were due to myocardial infarction (MI), 127,301 to cerebral vascular diseases (CVD), 59,231 to transport accidents (TA), 43,474 to hypertensive heart disease (HHD) and 28,042 were due to gastric cancer (GC) (Table 1).

There were 350,055 working-age (15-64) deaths related to these five main causes between 2006 and 2010. Of these deaths, 172,216 were due to MI, 76,340 to CVD, 55,088 to TA, 24,423 to HHD and 21,988 due to GC.

Table 1. The Number of Deaths due to Five Leading Causes by Sex in Iran during 2006-2010

ICD COD	Cause	2006	2007	2008	2009	2010
Male						
C16	Gastric cancer	3,680	3,790	3,777	3,740	3,735
I11	Hypertensive heart disease	3,671	4,375	4,393	4,098	4,295
I20-I25	Myocardial infarction	30,336	29,501	28,691	29,941	30,938
I60-I69	Cerebral vascular diseases	13,564	13,403	12,983	12,934	13,021
V01-V99	Transport accidents	12,064	9,581	8,655	8,948	7,990
Total		63,315	60,650	58,499	59,661	59,979
Female						
C16	Gastric cancer	1,849	1,905	1,824	1,853	1,889
I11	Hypertensive heart disease	4,131	4,761	4,661	4,392	4,697
I20-I25	Myocardial infarction	22,372	21,828	22,100	22,049	23,011
I60-I69	Cerebral vascular diseases	12,433	12,749	12,495	11,649	12,070
V01-V99	Transport accidents	2,974	2,440	2,240	2,363	1,976
Total		43,795	43,683	43,320	42,306	43,643

Table 2. Estimated YPLL for Five Main Causes by Sex in Iran during 2006-2010

ICD COD	Cause	2006	2007	2008	2009	2010
Male						
C16	Gastric cancer	3,452,435	3,556,324	3,497,347	3,474,500	3,460,583
I11	Hypertensive heart disease	3,001,086	3,566,476	3,502,377	3,243,086	3,375,947
I20-I25	Myocardial infarction	27,368,890	26,404,177	25,324,677	26,397,891	26,824,894
I60-I69	Cerebral vascular diseases	10,943,567	10,620,892	10,060,298	10,184,364	10,036,975
V01-V99	Transport accidents	14,395,032	11,372,877	10,298,047	10,630,598	9,566,669
Total		59,161,010	55,520,746	52,682,746	53,930,439	53,265,068
Female						
C16	Gastric cancer	1,878,243	1,942,208	1,844,060	1,825,545	1,910,794
I11	Hypertensive heart disease	3,445,412	3,882,685	3,767,671	3,548,044	3,726,028
I20-I25	Myocardial infarction	19,465,490	18,719,733	18,752,869	18,651,951	19,183,013
I60-I69	Cerebral vascular diseases	10,362,611	10,575,275	10,191,173	9,475,783	9,589,670
V01-V99	Transport accidents	3447995	2797873	2537043	2722637	2273052
Total		38,599,751	37,917,774	37,092,816	36,223,960	36,682,557

Table 3. Estimated YPPLL for the Five Main Causes of Death by Sex in Iran during 2006-2010

ICD COD	Cause	2006	2007	2008	2009	2010
Male						
C16	Gastric cancer	1,536,114	1,637,184	1,549,353	1,614,315	1,644,043
I11	Hypertensive heart disease	1,016,289	1,205,569	1,157,608	1,090,266	1,131,258
I20-I25	Myocardial infarction	12,592,092	12,262,663	11,786,048	12,369,898	12,571,810
I60-I69	Cerebral vascular diseases	3,547,362	3,394,198	3,107,399	3,496,572	3,312,210
V01-V99	Transport accidents	12784,833	1,0036,911	9,159,396	9,444,637	8,518,566
Total		31,476,690	28,536,525	26,795,804	28,015,688	27,177,887
Female						
C16	Gastric cancer	912,613	977,750	908,019	870,993	991,512
I11	Hypertensive heart disease	939,237	1,041,103	1,020,587	1,017,053	990,363
I20-I25	Myocardial infarction	6,618,507	6,194,778	6,302,392	6,460,854	6,481,836
I60-I69	Cerebral vascular diseases	3,050,543	3,177,438	2,937,198	2,796,614	2,698,931
V01-V99	Transport accidents	2,816,288	2,248,559	2,046,933	2,232,546	1,852,895
Total		14,337,188	13,639,628	13,215,129	13,378,060	13,015,537

For both sexes, the highest number of the YPLL was related to MI, followed by CVD, TA, HHD, GC, respectively (Table 2). These five leading causes of death resulted in 461,076,890 YPLL in total, 274,560,022 (59.5%) in males and 186,516,868 (40.5%) in females. From 2006 to 2010, the overall number of YPLL decreased by 8%.

Table 3 demonstrates the number of YPPLL by cause and sex. The estimated YPPLL resulted in 209,552,135 YPPLL from 2006 to 2011; of them, 141,966,592 (67%) were in males and 67,585,543 (33%) were in females. From 2006 to 2010, the total number of YPPLL decreased by 13%.

The total cost of lost productivity caused by premature deaths due to five leading causes was 7.86 billion dollars (US\$) from 2006 to 2010, ranging from 1.63 billion dollars in 2006 to 1.31 billion dollars in 2010, and it decreased by 0.8% in this period. The main contributors of the total cost of productivity lost were transport acci-

dents, myocardial infarction, cerebral vascular diseases, gastric cancer and hypertensive heart disease, respectively. The percentage of the total costs due to productivity losses for the five leading causes of death was 91.2% in males and 8.8% in females (Table 4).

The average premature mortality cost per cause for both sexes combined was \$172,906 in the study period, which was \$273,838 for males and \$71,975 for females. In this period, the most costly cause per death in both sexes combined was transport accidents (\$72,571 per death), followed by myocardial infarction (\$27,212). However, the least costly cause in both sexes was hypertensive heart disease (\$33 701 for male vs. \$9 337 for female). Table 5 demonstrates the average premature mortality cost per YPPLL by sex from 2007 to 2010. The cost per YPPLL for both sexes combined was \$25.4 in the study period, and it was \$40.8 for males and \$10.1 for females from 2006 to 2010. In term of

Table 4. Estimated Premature Mortality Costs due to the Five Leading Causes of Death by Sex in Iran during 2006-2010, (US \$)

ICD COD	Cause	2006	2007	2008	2009	2010
Male						
C16	Gastric cancer	39,005,208	46,647,752	45,482,655	50,260,028	43,152,544
I11	Hypertensive heart disease	22,729,431	27,582,467	30,833,206	31,279,646	28,074,504
I20-I25	Myocardial infarction	345,022,647	345,022,650	410,219,144	451,221,205	370,786,268
I60-I69	Cerebral vascular diseases	96,805,400	97,026,445	106,037,549	132,087,684	100,528,127
V01-V99	Transport accidents	99,8547,905	829,297,422	912,928,738	937,923,785	682,108,151
Total		1,502,110,591	1,345,576,736	1,505,501,292	1,602,772,348	1,224,649,594
Female						
C16	Gastric cancer	893,155	9,142,011	9,378,496	9,473,632	7,482,980
I11	Hypertensive heart disease	5,675,311	6,514,238	7,955,501	7,724,154	5,715,652
I20-I25	Myocardial infarction	46,435,456	47,654,162	57,944,378	65,476,405	49,604,550
I60-I69	Cerebral vascular diseases	20,459,375	25,067,205	27,213,372	27,440,535	19,115,364
V01-V99	Transport accidents	57,203,705	51,740,998	54,180,119	60,075,293	4,922,391
Total		130,667,002	140,118,614	156,671,866	170,190,019	86,840,937

Table 5. Premature Mortality Costs Per Death/YPPLL for the Five Leading Causes of Death in Iran, 2006-2010, (US \$)

Cause		2006	2007	2008	2009	2010
Male						
Gastric Cancer	CPL/DEATH	34,366	38,776	39550	41,988	35,575
	CPL/YPPLL	25.4	28.5	29.3	31.1	26.3
Hypertensive Heart Disease	CPL/DEATH	30,065	30,887	35,769	38,521	33,263
	CPL/YPPLL	22.4	22.9	26.6	28.7	24.8
Myocardial infarction	CPL/DEATH	37,539	38,442	47,539	49,836	40,176
	CPL/YPPLL	27.4	28.1	34.8	36.5	29.5
Cerebral vascular diseases	CPL/DEATH	36,808	38,502	45,883	50,842	40,749
	CPL/YPPLL	27.3	28.6	34.1	37.8	30.4
Transport accidents	CPL/DEATH	103,358	109,521	131,907	132,120	107,199
	CPL/YPPLL	78.1	82.6	99.7	99.3	80
Female						
Gastric Cancer	CPL/DEATH	1,397	13,463	14,769	15,404	10,720
	CPL/YPPLL	0.1	9.4	10.3	10.9	7.5
Hypertensive heart disease	CPL/DEATH	8,508	8,685	10,927	10,581	7,982
	CPL/YPPLL	6	6.3	7.8	7.6	5.8
Myocardial infarction	CPL/DEATH	9,879	10,803	12,902	14,240	10,762
	CPL/YPPLL	7	7.7	9.2	10.1	7.6
Cerebral vascular diseases	CPL/DEATH	9,450	11,106	12,971	13,761	9,950
	CPL/YPPLL	6.7	7.9	9.3	9.8	7
Transport accidents	CPL/DEATH	28,803	32,789	37,756	38,435	3,821
	CPL/YPPLL	20.3	23	26.5	26.9	2.6

cost per YPPLL, like cost per death, transport accidents and myocardial infarction were the most and least costly causes, respectively.

### Discussion

The purpose of this study was to quantify the economic burden of five main causes of premature mortality in Iran between 2006 and 2011. It was measured by mortality, YPLL, YPPLL and cost of lost productivity. To estimate the cost of lost productivity, we used the human capital approach, the most commonly used method in the literature (3,6,7,20,28,29).

The majority of the previous studies have estimated the productivity costs that

focused on one cause or disease (2,3,5,13, 20,21,28-32) that may not have necessarily been conducted on the leading cause of death. However, in this study, we considered five main causes of deaths in Iran from 2006 to 2010. Several studies were conducted in Iran; of which, two estimated the burden of diseases by DALYs (18,19), and others estimated cancer related lost productivity (20,32). Based on our results, average deaths per year was 256, 674 during 2006-2010. The study of Forouzanfar et al. showed that almost 350,000 deaths occurred in Iran in all age groups and both sexes in 2010 (18). One reason for this difference may be due to the unavailability of the data on Tehran

province, which constitutes a large proportion of Iran's population. About 518,815 (40%) of deaths occurred due to the five main causes in Iran from 2006 to 2010; of which, 58% were in males. MI, CVD and TA were the three leading causes of deaths in both sexes. This finding is similar to the findings of previous studies in Iran that reported road injuries and ischemic heart disease as the two main causes of death in both sexes (18,19).

This study indicated that main contributors to YPLL in both sexes were MI, CVD, TA, HHD, GC, respectively. This finding is in line with the report of above mentioned studies that reported ischemic heart disease and road injuries were two of the main contributors to DALYs (18,19). Furthermore, a systematic analysis for the Global Burden of Disease (GBD) study by Lozano et al. showed that ischaemic heart disease, cerebrovascular disease and road injury were three of the 10 leading causes of both death and years of life lost due to premature mortality (YLLs) at the global level and for any region in the world in 2010 (15). In addition, a previously mentioned report showed that stomach cancer and hypertensive heart disease are two of the 25 leading causes of YPLL at the global and regional level (15). The findings of this study revealed that the total number of YLLs from transport accidents decreased by 34%, but increased by 10% for ischemic heart disease for both sexes combined during 2006-2010. The 34% reduction in YPLL in TA may imply the following two points: First, the health system of Iran has provided better curative and rehabilitative interventions for injured individuals. Second, this may be due to the fact that the reduction injuries policies of the government has had good outcomes. Rezaei et al. found a significant negative relationship between number of physicians per 10,000 population and deaths from road traffic crashes in Iran (30). Second, a share of prevented cost of premature mortality (YPLL) probably shifted to cost of morbidity (years lived with disability

(YLD)). For example, a saved injured individual from death (YPLL) may experience absenteeism from work or early retirement (2,5,7,8) or both.

Our findings revealed that the total productivity costs from premature mortality were about US\$ 7.86 billion between 2006 and 2010, and average productivity cost per year was US\$1.57 billion for both sexes combined. This study revealed a higher total cost of premature mortality in males (\$7.1 billion vs. \$684 million) during 2006-2010, and this difference was due to higher mortality, employment and wage rate for males. The findings of a previous study in Iran showed that the total cost of premature cancer-related mortality for males was 67% higher than females (20). Furthermore, in Ireland and the United States, it was 90% and 80% times higher in the males, respectively (3,30).

This study showed that TA was the most costly cause in males, females and both sexes, implying that the majority of deaths that have occurred due to TA were near lower limits of the working-age range, which resulted in higher YPLL. Therefore, its productivity cost losses is higher than the other causes. The ranking of causes by type of measures was different; for instance, TA ranked 3rd in terms of YPLL and 1st in terms of CPL and CPL per YPLL. These changes depend on age of death for each cause and survival rate. When a cause or disease with low survival rate results in death in a young age, it generally receives higher rank of YPLL per death and cost per death (3,20,30).

This study had some limitations; therefore, interpreting the results should be made with caution. First, our analysis was based on data on 29 provinces of Iran, with no data on Tehran province, meaning that a large percentage of deaths were not included in the study. The second limitation was the lack of data on deaths and diseases at the national level in Iran. Moreover, there was a remarkable underestimation of mortality data in Iran (18). The third limitation was that this study estimated

productivity losses due to premature mortality; and therefore, other productivity losses such as absenteeism from work, early retirement and reduction in employment were not considered.

### Conclusion

Estimating productivity losses in monetary term provides an overall picture of economic burden of diseases, which may be useful for health system policy makers to design effective interventions and priority-based resource allocation, specially during times of constrained resources. This study revealed that the economic burden of premature mortalities due to the five main causes of death is substantial, which was about \$7.86 billion during 2006-2010 in Iran. In this period, the overall cost of productivity losses for the males was 10.5 times higher than the females. Our results also showed that transport accidents and myocardial infraction were the most costly cases in term of the total cost. In summary, these five leading causes of death, specially transport accidents and myocardial infraction, should be considered in prevention programmes.

The allocation of financial resources to control these causes can decrease their economic burden and may result in higher level of health and well-being.

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