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Original Article

Analysis of Potentials to Increase Iranian life Expectancy by Removing the Leading Causes of Mortality in 2010

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Abstract

Introduction: Recent studies on Iranian mortality clearly underscore the role of cardiovascular diseases, unintentional injuries, and cancers as three leading causes of reduced life expectancy during the last three decades. The purpose of current study is to measure the effect of these causes on the 2010 life table for Iran.

Materials & Methods: The number of registered deaths by age, sex, and death distribution by cause for Iran in 2010 was obtained from death registration system operated by the Ministry of Health. In order to know more about the population at risk population forecast information of the Statistical Centre of Iran (SCI) was used. The obtained data were analyzed using Multiple Decrement Life Table and Kitagava analysis method.

Results: The results showed that there are three leading causes of death for a potential 13-yearlost life of Iranian men and women. More detailed results indicated that cardiovascular diseases, cancers, and unintentional injuries play larger roles in this regard while men were more likely to die by unintentional injuries than women. Life expectancy of middle aged men was more affected by unintentional injuries while old aged women were more affected by cardiovascular diseases.

Conclusion: Particular consideration of cardiovascular diseases' risk factors of both sexs and males' death by unintentional injuries was of utmost importance in reducing mortality rate and increasing life expectancy as a result.

Keywords: Life expectancy at birth, Aged-based analysis, Cardiovascular diseases, Unintentional injuries, Neoplasms.

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Introduction

Life expectancy at birth along with education level and per capita income are the three indicators used as a basis for measuring Human Development Index (HDI). This index is one of the measures of monitoring and evaluating the achievements of Millennium Development Goals (MDGs) that the world's state heads have committed to achieve by the year 2015 [1-3].

Developments concerning mortality rate have eventually led to increased life expectancy of Iran so that it has mounted from -40 in 1956 to +70 in recent years [2, 4]. Reduced mortality rate of 5-year-old children has been the major cause of improved life expectancy during the transition process of mortality (1956- 1986) in this country. Increasing trend of life expectancy has been slowed down since the late 1980s, though increasing life expectancy would be basically possible through multilateral developments made particularly by reducing healthcare inequalities and increasing life expectancy at older ages of infancy and childhood. In recent years, a major factor that effect life expectancy at birth, has been the significant increase of mortality by non-communicable diseases; notably, cardiovascular diseases, unintentional injuries, and cancers. Based on recent studies, more than two third of mortalities in Iran are due to three main causes: cardiovascular diseases, unintentional injuries, and cancers [5, 6]. Increased risk factors of cardiovascular diseases, such as more calorie intake per day, inactivity, and increased prevalence of smoking, have turned it to the most common cause of death in recent years. Consequently, if this situation continues, it may extend its boundaries in near future [7]. During the last two decades, unintentional injuries have been the second cause of mortality in the country. However, due to their lowering effect on the life of younger age group, unintentional injuries have changed to a significant socio-demographic challenge.

Awareness of demographic rates, consequences of mortality caused by leading factors of death, and their impact on life expectancy at birth provides useful information to facilitate optimal allocation of resources for future research activities and public health programs. It also helps researchers as well as planners to gain a better understanding of mortality causes and patterns which in turn makes the bases of developing new priorities for health programs and socio-economic plans, in general.

Materials and Methods

This study was conducted based on secondary analysis. The gathered data indicated causes of death by age and sex in 2010 and were obtained from death registration system operated by the Ministry of Health and medical education. It should be noted that the research data did not include deaths registered in Tehran, Alborz, and Isfahan since death data records and registrations of these provinces were not

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available. Thus, the current study examined data of 28 provinces of Iran assuming that distribution of population and mortality of the selected provinces do not differ across the country. In addition, for the purpose of estimating annual mortality of the predicted population, required data were obtained from the statistics center divided by age and sex.

To correct the most problem of misclassification of cause of death in the country means ill-defined and garbage codes, an algorithm was used, the conceptual framework of which is based on the assumption that death attributed to the ill-defined and garbage codes in all age groups and sex, follow distribution of causes of death of its same age, sex and regional group. Therefore, according to the used algorithm, these ill-defined and garbage codes were redistributed in mortality of the country [8].

To measure the three main causes of mortality in the country, under the assumption that deaths attributed to these three causes were eliminated from mortality rate, the possible number of years that can be added to the life expectancy were calculated. The impact of these causes is measured using Multiple Decrement Life Table and Single Decrement Life Table methods. Given the independence of deaths' causes from each other, these methods emphasize on evaluation of the net impact of competing risk factors of different causes of death [9, 10]. According to preliminary assumption, different causes of mortality cannot be mutually related (i.e., two events cannot occur simultaneously) and the total is exhaustive (i.e., the all-cause of mortality, include all possible events) [10, 11].

In analyzing the causes of mortality, the effective force of mortality rises from accumulation of various causes. Because specifying the exact causes of death, particularly when there is no precise scale, is difficult. Therefore, accumulation of various causes of mortality equals to all causes combined:

$$\mu(x) = \sum_{i=1}^{I} \mu_i(x)$$

Where $\mu(x)$ is force of mortality from all causes combined, and parameters $\mu_i(x)$ refer to death rate for the *i*th causes of death. The following relation indicates that mortality rates are also cumulative:

$${}_n m_x = \sum_{i=1}^{I} {}_n m_{x_i}$$

Where, ${}_n m_x$ and ${}_n m_{x_i}$ represent reduction in all-cause mortality and cause-specific mortality.

Given that in real world, single decrement processes (in which there is only one reason for all deaths) are not directly observable; certain functions of ordinary life table have to be generalized to the corresponding single decrement life table. Generally, reduction rate of death cause depends on being the sole cause of reduction or one of the affecting causes. Here, the aim is that to make a life table that called associated single decrement life table which attributes population reduction to only one cause. Here the considered reduction is all causes of reduction except “i.” Thus, the aim of

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this study was to devise a life table based on $\mu^{-i}(x)$ in which i can be optionally removed from a set of multiple decrements. Calculation of the life table columns, such as ${}_n a_x$, ${}_n q_n$, ${}_n d_x$, ${}_n L_n$, and etc., in the analysis of multiple decrement life table, follows an approach to ordinary life table analysis. Changing mortality rate to the probability of ordinary death is calculated according to the following equation:

$$ {}_n q_x = \frac{{}_n m_x}{1+(n-{}_n a_x)_n m_x} $$

Probability of death from a specific cause ${}_n q_x^i$ is calculated based on fraction of deaths from that certain cause to total deaths probability in a period between x and x+n years of age:

$$ {}_n q_x^i = {}_n q_x \frac{{}_n D_x^{\,i}}{{}_n D_x} $$

In devising the corresponding single decrement life table, R^{-i} represents the fraction of all-cause mortality except one certain cause (e.g., unintentional injuries). In devising a periodic life table, between x and x+n years of age, it is necessary to remove the single causes of death and calculate it using the following equation:

$$ R^{-i} = \frac{{}_n D_x - {}_n D_x^{\,i}}{{}_n D_x} $$

Having removed the specific causes of death, survival probability between x to x+n years of age, is calculated using Chiang Formula [12]:

$$ {}_n p_x^{\,-i} = \left[{}_n p_x \right]^{R^{-i}} $$

To find the age groups that leave greater impacts on differences in life expectancy at birth as a result of removing specific causes, changes in life expectancy of certain age groups were analyzed using the method proposed by Arriaga [13]:

$$ {}_n\Delta_x = \frac{l_x^{all}}{l_0^{all}} \cdot \left(\frac{{}_n L_x^{-i}}{l_x^{-i}} - \frac{{}_n L_x^{all}}{l_x^{all}} \right) + \frac{T_{x+n}^{-i}}{l_0^{all}} \cdot \left(\frac{l_x^{all}}{l_x^{-i}} - \frac{l_{x+n}^{all}}{l_{x+n}^{-i}} \right) $$

The first part of this equation indicates direct estimation of changes in mortality rates between x and x+n years of age, while the second part indicates a set of indirect and interactive effects of a person's survival age x+n endangered by new causes of death. This equation for the last age group becomes:

$$ {}_\infty\Delta_x = \frac{l_x^{all}}{l_0^{all}} \cdot \left(\frac{T_x^{-i}}{l_x^{-i}} - \frac{T_x^{all}}{l_x^{all}} \right) $$

Results

The obtained results indicate that three leading causes of mortality including cardiovascular diseases, unintentional injuries, and cancers account for more than two thirds (almost 70%) of mortality of both sexs in Iran (table 1). Findings of this study show that, in 2010, more than 40%, i.e., the largest share, of mortality rate of both sexs is caused by cardiovascular diseases. Sex differences in total deaths caused by cardiovascular diseases in this study clearly showed higher prevalence of this kind of diseases among women. Generally, in the same year, cancers were the second main cause of mortality in Iran; however, the causes' pattern of Iranian men and women mortality does not make

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any tangible difference on this leading cause. Men are more likely to die by unintentional injuries (i.e., 16%), so it is clearly the second main death cause of men while it accounts for only 7% of women's mortality in 2010.

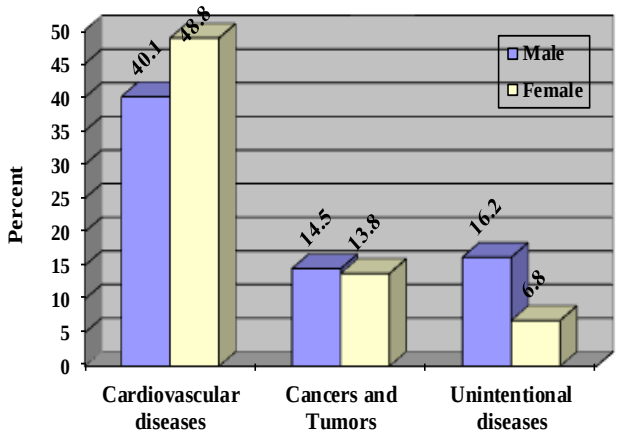

Figure1: Distribution of death main causes by sex in Iran in 2010 (%)

According to average age of death (Table 1), distribution of deaths caused by unintentional injuries by age demonstrates a totally different trend from all-cause mortality distribution by age. In comparison with the other two main causes of death, age distribution of deaths caused by unintentional injuries has dropped to more than 20 years on the younger age groups. Therefore, the average age of deaths caused by unintentional injuries is less than 40. Mortality caused by cardiovascular diseases, as the main cause of death in the country, has more likely affected old age group. The average age of deaths from such diseases is about 70. Age distribution of mortality caused by cancers is also high at old ages; however, the average age is less than deaths caused by cardiovascular diseases.

Table 1. Mean age of specific-cause and all-cause mortality by sex in 2010

	Female	Male	Total
Cardiovascular diseases	73.9	71.1	72.4
Cancers and Tumors	61.8	65.2	63.9
Unintentional diseases	39.5	37.9	38.2
Total	63.7	58.4	60.5

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Results obtained from multiple decrement life table of Iran in 2010 indicate that life expectancy at birth for men and women are 73.9 and 78.2 years, respectively. Based on the results obtained from table 2, in the case of removing three main causes of death (i.e., cardiovascular disease, cancer, and unintentional accident) from the causes of women mortality, life expectancy at birth increases to 89.1, 79.9, and 79 years, respectively. It means that cardiovascular diseases account for reduction of 10.9 years of women's life expectancy at birth as well as1.7 and 0.84 years for cancers and unintentional injuries of women, respectively.

Table 2. Results of multiple and single decrement life table after removing the three main causes of women mortality in Iran in 2010.

Age	${}_nq_x$	l_x	${}_nL_x$	e_x	R^{-i}	e^{-i}	R^{-ii}	e^{-ii}	R^{-iii}	e^{-iii}
0	0.0098	100000	99096	78.2	0.9785	89.1	0.9893	79.9	0.9653	79.0
1-4	0.0027	99017	395389	78.0	0.9669	88.9	0.9199	79.7	0.6358	78.8
5-9	0.0017	98745	493300	74.2	0.9470	85.2	0.8876	75.9	0.5320	74.9
10-14	0.0014	98575	492529	69.3	0.9373	80.3	0.8394	71.0	0.6788	70.0
15-19	0.0020	98437	491700	64.4	0.8827	75.4	0.8671	66.0	0.6734	65.0
20-24	0.0027	98243	490564	59.5	0.8635	70.5	0.8587	61.2	0.6642	60.1
25-29	0.0026	97982	489262	54.7	0.8444	65.7	0.8426	56.3	0.6897	55.2
30-34	0.0033	97723	487818	49.8	0.8278	60.8	0.7595	51.4	0.7347	50.3
35-39	0.0041	97404	486026	44.9	0.7976	56.0	0.7018	46.5	0.7667	45.4
40-44	0.0054	97006	483713	40.1	0.7155	51.2	0.7035	41.7	0.8114	40.6
45-49	0.0090	96480	480221	35.3	0.6482	46.4	0.6940	36.8	0.8694	35.7
50-54	0.0150	95609	474463	30.6	0.5786	41.6	0.7227	32.0	0.9021	31.0
55-59	0.0245	94176	465105	26.1	0.5230	37.0	0.7529	27.3	0.9292	26.4
60-64	0.0427	91866	449524	21.6	0.4764	32.4	0.7862	22.8	0.9493	21.9
65-69	0.0690	87944	424559	17.5	0.4351	28.0	0.8206	18.5	0.9579	17.7
70-74	0.1320	81880	382387	13.6	0.4099	23.8	0.8519	14.5	0.9713	13.8
75-79	0.2115	71075	317792	10.3	0.3773	20.1	0.8792	11.0	0.9775	10.4
80-84	0.4089	56042	222920	7.4	0.3719	16.7	0.9096	7.9	0.9826	7.5
85+	1	33126	191068	5.8	0.3922	14.7	0.9378	6.2	0.9868	5.8

With removing cardiovascular diseases from the main causes of mortality, life expectancy of men at birth increased from 73.9 to 83.1 years that means cardiovascular diseases account for 9.2 years of reduced life expectancy of men at birth while this figure drops to 1.2 and 2.2 for cancers and unintentional injuries, respectively. Accordingly, by removing cancers and unintentional injuries from causes of mortality,

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life expectancy of men at birth increases from 73.9 to 76.1 and 76.2, respectively (Table 3).

Table 3. Results of corresponding multiple and single decrement life table after removing the three main causes of men mortality in Iran in 2010

Age	$_nq_x$	l_x	$_nL_x$	e^x	R^{-i}	e^{-i}	R^{-ii}	e^{-ii}	R^{-iii}	e^{-iii}
0	0.0131	100000	98796	73.9	0.976	83.1	0.9872	76.1	0.9727	76.2
1-4	0.0034	98691	393968	73.9	0.957	83.2	0.9165	76.1	0.5853	76.2
5-9	0.0023	98358	491216	70.1	0.971	79.5	0.8753	72.3	0.4725	72.3
10-14	0.0022	98128	490096	65.3	0.960	74.6	0.8845	67.5	0.4640	67.4
15-19	0.0054	97910	488220	60.4	0.940	69.8	0.9129	62.6	0.3987	62.5
20-24	0.0080	97378	484935	55.7	0.931	65.1	0.9425	57.9	0.4234	57.6
25-29	0.0087	96596	480872	51.2	0.910	60.6	0.9327	53.3	0.4797	52.8
30-34	0.0093	95752	476532	46.6	0.897	56.1	0.9214	48.8	0.5107	48.0
35-39	0.0109	94861	471715	42.0	0.830	51.5	0.9055	44.2	0.5786	43.2
40-44	0.0129	93826	466107	37.4	0.731	47.0	0.8646	39.6	0.6683	38.5
45-49	0.0183	92617	458847	32.9	0.629	42.4	0.8347	35.0	0.7490	33.8
50-54	0.0282	90922	448192	28.5	0.575	37.9	0.8079	30.5	0.8207	29.2
55-59	0.0429	88355	432300	24.2	0.523	33.4	0.8000	26.1	0.8743	24.9
60-64	0.0651	84565	409057	20.2	0.509	29.2	0.7876	22.0	0.8982	20.7
65-69	0.0932	79058	376875	16.4	0.491	25.1	0.7792	18.0	0.9247	16.8
70-74	0.1611	71692	329589	12.8	0.470	21.2	0.7950	14.2	0.9408	13.2
75-79	0.2362	60144	265196	9.8	0.450	17.8	0.8127	11.0	0.9557	10.1
80-84	0.4449	45935	178579	7.1	0.429	14.7	0.8497	8.0	0.9720	7.3
85+	1	25497	147473	5.8	0.441	13.1	0.8843	6.5	0.9759	5.9

Given the assumption of removing the three main causes of mortality, analysis results of increased life expectancy at birth by age and sex (Table 4) demonstrate that by removing cardiovascular diseases, the old age groups (esp. +70) of both sexs play the greatest role in increasing life expectancy at birth. The effect of cancers is also much like cardiovascular diseases since in case of removing it from the main causes of mortality the old age groups play a significant role in increasing life expectancy at birth, as well. However, unintentional injuries are somewhat different from the other two causes of mortality. The results of analysis of life expectancy at birth indicated that removing unintentional injuries affects middle aged men to a large extent. What is more, life expectancy at birth for those aged between 20-29 increases about 2.3 years (more than 20%) in case of removing unintentional injuries from causes of mortality. However, this is less influential for

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those who have less than 16, 65, and more than 65 years of age.

Table 4. Analysis of years added to life expectancy by age and sex after removing three main causes of death in Iran in 2010.

Age	Years added to life expectancy						Percentage of age groups					
	Cardiovascular diseases		Unintentional injuries		Cancers		Cardiovascular diseases		Unintentional injuries		Cancers	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
0	0.019	0.026	0.027	0.027	0.008	0.013	0.17	0.28	3.23	1.19	0.50	0.58
1-4	0.008	0.012	0.076	0.103	0.017	0.021	0.07	0.13	9.13	4.46	1.00	0.93
5-9	0.007	0.005	0.058	0.085	0.014	0.020	0.07	0.06	6.88	3.66	0.83	0.89
10-14	0.007	0.007	0.030	0.076	0.015	0.017	0.06	0.07	3.59	3.30	0.90	0.76
15-19	0.017	0.023	0.040	0.193	0.017	0.029	0.15	0.25	4.74	8.33	0.98	1.30
20-24	0.024	0.035	0.051	0.249	0.022	0.026	0.22	0.38	6.04	10.78	1.28	1.15
25-29	0.026	0.044	0.043	0.222	0.022	0.029	0.24	0.48	5.09	9.58	1.30	1.30
30-34	0.032	0.050	0.041	0.199	0.038	0.033	0.30	0.54	4.85	8.63	2.22	1.47
35-39	0.043	0.087	0.040	0.179	0.053	0.041	0.40	0.94	4.82	7.74	3.11	1.85
40-44	0.074	0.146	0.039	0.146	0.062	0.062	0.67	1.58	4.63	6.33	3.65	2.77
45-49	0.136	0.253	0.040	0.137	0.093	0.094	1.24	2.74	4.74	5.92	5.49	4.20
50-54	0.239	0.391	0.043	0.129	0.120	0.143	2.19	4.23	5.15	5.57	7.10	6.40
55-59	0.384	0.569	0.045	0.114	0.147	0.187	3.53	6.16	5.32	4.95	8.70	8.38
60-64	0.624	0.737	0.047	0.113	0.180	0.240	5.72	7.98	5.62	4.88	10.62	10.74
65-69	0.894	0.874	0.054	0.096	0.192	0.273	8.20	9.46	6.50	4.15	11.34	12.22
70-74	1.407	1.198	0.056	0.094	0.221	0.311	12.91	12.98	6.71	4.06	13.03	13.92
75-79	1.733	1.279	0.056	0.074	0.196	0.271	15.90	13.85	6.63	3.18	11.57	12.13
80-84	2.266	1.629	0.028	0.039	0.151	0.231	20.79	17.64	3.31	1.71	8.90	10.34
85+	2.961	1.872	0.026	0.036	0.127	0.193	27.17	20.27	3.05	1.58	7.47	8.64
Total	10.899	9.234	0.838	2.311	1.695	2.234	100	100	100	100	100	100

Table 5 indicates the share of three main age groups (0-14, 15-49, and +65) in increasing life expectancy at birth in case of removing each of the three leading causes of mortality. Those with +65 years of age, in comparison with the other two groups have greater impact in increasing life expectancy with removing cardiovascular diseases which is attributed to both men and women (74% and 85%, respectively). The old age group with cancers plays a great role in increasing life expectancy while those who aged between 15- 65 are also of significance.

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However, unintentional injuries are totally different from the other two causes of mortality. Those who aged 15-64 are of greater importance in increasing life expectancy at birth with removing unintentional injuries so that it reaches to 73% and 51% of significance in men and women, respectively.

Table 5. Analysis of life expectancy at birth with removing unintentional injuries from the causes of women's mortality in Iran in 2010

	Perceage of age groups					
Age groups	Cancers		Unintentional injuries		Cardiovascular diseases	
	Women	Men	Women	Men	Women	Men
0-14 years	3.23	3.16	22.82	12.6	0.38	0.53
15-64 years	44.45	39.57	51.01	72.72	14.66	25.27
+65 years	52.32	57.26	26.19	14.67	84.96	74.2
total	100	100	100	100	100	100

Discussion

With removing three leading causes of mortality, the present study targeted at estimating the years added to life expectancy of Iranians at birth and measuring the role of different age groups in this regard. Based on research findings, the estimated life expectancy of Iranian men and women is about 74 and 78 years of age, respectively, which is slightly higher than the calculated life expectancy of Iranian in recent years. It indicates that, in the studied year, there were some shortcomings in death registration system of the country. There are different demographic methods to assess death registration, such as Brass growth balance method, generalized growth method, and method of extinct generation which assumes a stable population and suggests only one correction factor for all ages. Further, it is obvious for all demographics that error and accuracy of death registration system in Iran depends on both age and sex adding to the fact that Iranian population is not in a stable state any more. Moreover, these methods end in a correction factor for total mortality rate. In the estimation of mortality, it was found that error left no detrimental impact on the results. To put it in other words, all causes of mortality had contributions in all deaths' occurrence included in estimated mortality rate and are independent of estimated number of deaths [14].

Considering the life table, cardiovascular diseases, unintentional injuries, and cancers technically account for more than 14 years of reduced life expectancy of Iranian men and women. Koosheshi et al., indicated that three major causes of mortality reduced about 11

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years of life expectancy of men and women living in Fars (a province in Iran) [14]. This difference is somehow due to intervening time of the researches. The obtained results suggest that cardiovascular diseases and cancers reduce life expectancy of men and women equally while unintentional injuries have variable effect on different generations' chance of living years.

Although mean age of death in Iran has reached to more than 60 years, this average has dropped to 40 years for deaths caused by unintentional injuries. Multiple decrement table analysis indicates that about 50% of deaths caused by unintentional injuries have occurred among men aged between 20 to 60 years, i.e., the age of business activity and being the head of household. This ratio decreases to 35% for women. In general, unintentional injuries reduce about 2.3 and 0.8 years of life expectancy of Iranian men and women, respectively. In a similar study carried out in Iran in 2006, this figure was about 2.7 and 1.1 years for men and women, respectively [5]; a difference which is attributed to deaths caused by unintentional injuries in recent years due to traffic events, in particular. On the other hand, the results suggested that the middle aged group (esp. men) can make a greater contribution in this regard. Therefore, although unintentional injuries are at the third place considering mortality rates in Iran, since deaths of this cause, with the same level of significance as the injuries not accounted for in the registered deaths, affect young and middle aged people more than other age groups, it is of higher socio-economic significance, at least in comparison with causes such as chronic diseases (e.g., cancers).

Unintentional injuries leave variable effects on the living chance of different generations. Our study on cause of mortality indicated that unintentional injuries reduced life expectancy of men 1.5 years more than women. A proportion of deceased men were family heads, married, or father of children. Thus, every year a significant number of the affected families lose their heads of household; an event which exposes them to socio-economic and psychological trauma and brings about many social and economic damages. Since most of the deaths caused by unintentional injuries, especially among young people, can be prevented, controlled, or intervened, and because social improvement depends on promoted health condition of the most productive group of people (i.e., young people), it is essential to increase their productivity and promote their health.

In addition, this is one of the few studies that has investigated total mortality of the country divided by its causes using advanced methods of death data analysis. Furthermore, results of this research are of a great importance because developed countries pay special attention to mathematical demography and life tables by causes of mortality, in particular. Among clear-cut researches on this ground are the studies carried out by the Vital Statistics of the United States. Therefore, it is recommended to pay particular attention, especially in academic

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researches, to more advanced methods of all-cause and cause-specified mortality data analysis to understand the level of contribution of each causes of mortality and their consequences better.

Conclusion

Changing trend of mortality causes from contagious diseases to lifestyle affected diseases has brought about striking rate of mortality caused by unintentional diseases, cancers, and cardiovascular diseases. The results show that should pay special attention to cardiovascular disease because most of the decline in life expectancy is allocated to it. In this context the unintentional injuries is second in the ranking, that due to the involvement of young population and also due to preventable of unintentional injuries, emphasizing on proceedings and preventive solutions is makes sense.

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