

Modifiable Behavioral Risk Factors and the Value of Lifetime Earnings Lost among US Citizens From 2000-2016

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Abstract

There has been a steady, long-term decline in mortality rates in the US. Yet, modifiable behavioral risk factors still appear responsible for approximately one million yearly premature deaths or 40% of the annual total mortalities in the United States. This study evaluated seven modifiable behavioral risk factors (tobacco smoking, misuse of alcohol, poor diet and physical inactivity, motor vehicle crashes, suicide, illicit use of drugs, and risky sexual behaviors) with respect to using the value of lifetime earnings lost (VLTEL) attributable to premature deaths. In this study, we estimated US annual deaths caused by modifiable behavioral risk factors for the period of years inclusive of 2000-2016 and it was stratified by age groups. Annual deaths per modifiable risk factor and age group were used to estimate trends on mortality. Potential economic cost of these deaths was calculated using mortality cost and expected death distribution. Finally, expected life tables were obtained using yearly mortality. We assessed the overall trends of the seven modifiable risk factors over the last 16 years in the US and found putatively more than 1 million premature mortalities. This study also showed VLTEL associated with premature mortalities to be almost \$400 billion on an annual basis. Smoking and obesity were the two most common risk factors. Illicit drug use and misuse of alcohol have been increasing quite rapidly over the last decade. There are several noteworthy trends in the data. Smoking is one modifiable risk factor that has been decreasing among US citizens. In contrast, several other risk factors, such as illicit use of drugs, have been increasing in both incidence and monetary costs. The premature deaths examined in this study are important from a public health and health management perspective because they represent potentially preventable loss of life.

Introduction

There has been a long-term secular decline in mortality rates in the United States due to treatment, prevention and behavioral change (Case, 2015; Cutler, 2006; Deaton, 2013; Lee, 1992). There are many available interventions that likely have contributed to this increase in longevity such as improvements in medical chronic disease diagnoses and treatments, public health preventive strategies, media and policy advocacy, environmental interventions, and an increased emphasis on healthy lifestyles (Molinari, 2004; McKenna, 2010; CDC, 2017; AHRQ, 2017; NCI, 2005; Remington, 2005). Nevertheless, despite these interventions and improvements, modifiable risk factors such as tobacco smoking, misuse of alcohol, poor diet and physical inactivity still appear to be responsible for approximately 40% of the total annual mortalities in the United States (McGinnis, 1993; Mokdad, 2004; Cohen, 2008). This represents more than one million deaths annually in the United States of which may at least be partially attributable to modifiable risk factors (Putzer, 2017, Putzer, 2015, Kenney, 2008).

Health spending in the United States has been steadily rising over the past several decades (Jaramillo, 2017; Martin, 2016). According to the Altarum Institute (2016), health spending reached 18.2% of gross domestic product in 2016. Health resources are valuable, yet finite and limited so there is an associated opportunity cost with using a resource and/or corresponding finances for one endeavor vis-à-vis another alternative endeavor. Thus, health policies that promote increased awareness and education regarding risk in a transparent fashion highlight the necessity to reduce premature mortality costs attributable to modifiable behavioral factors. Moreover, these policies, often, further encourage implementing additional cost-effective preventive measures. Consequently, reducing the number of individuals engaging in modifiable risk factors through enhanced awareness, education and policy presumably should have a tangible effect on improved health status, employee productivity and a more effective utilization of limited public health resources.

In this study, we evaluated seven modifiable behavioral risk factors [tobacco smoking, misuse of alcohol, poor diet and physical inactivity which may lead to obesity (Lauby-Secretan, 2016), motor vehicle crashes, suicide, illicit use of drugs, and risky sexual behaviors which may lead to sexually transmitted infections] which presumably lead to premature mortalities and examined the associated amount of lifetime earnings lost (VLTEL). Thus, we used the VLTEL to approximate financial costs attributable to premature deaths. Moreover, we assessed the trends of these factors over the last 16 years in the United States.

Methods

Mortality data used in this research was obtained from the US Centers of Disease Control and Prevention (2018). Mortality data was disaggregated using the methodology used in Keeney (16) to obtain deaths causes by modifiable behavioral risk factors. Value of Life Time Earnings Lost (VLTEL) was estimated using Mortality Cost from the US Census Bureau (2012). This study uses 2009 mortality costs – the most recent published costs from the US Census Bureau. Life expectancies were calculated according to Chiang (1972).

In this study, we estimated US annual deaths caused by modifiable behavioral risk factors for the period of years inclusive of 2000-2016 and it was stratified by age groups. Annual deaths per modifiable risk factor and age group were used to estimate trends on mortality. Potential economic cost of these deaths was calculated using mortality cost and expected death distribution. Finally, expected life tables were obtained using yearly mortality.

Results

Mortality due to modifiable behavioral risk factors accounts for approximately 40% of total annual mortality in the United States. Table 1 shows the distribution of mortality between 2000 and 2016.

Table 1: Mortality (in thousands) in the United States

Mortality in United States [000]																	
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total	2403.0	2416.0	2443.0	2447.9	2397.3	2447.8	2426.0	2423.5	2471.8	2436.9	2468.3	2515.3	2543.1	2596.9	2626.3	2712.5	2744.1
Natural	1360.6	1375.0	1392.7	1400.7	1372.2	1409.3	1404.7	1408.1	1447.0	1429.3	1454.8	1492.4	1512.0	1550.3	1570.8	1627.1	1649.1
Risk Factors	1042.4	1041.0	1050.3	1047.2	1025.1	1038.5	1021.3	1015.4	1024.8	1007.6	1013.5	1022.9	1031.1	1046.5	1055.4	1085.4	1095.0
Percent	43.38	43.09	42.99	42.78	42.76	42.43	42.10	41.90	41.46	41.35	41.06	40.67	40.54	40.30	40.19	40.02	39.91

Table 2 summarizes mortality attributable to each modifiable behavioral risk factor during the period of years inclusive of 2000 -2016.

Table 2: Annual mortality (in thousands) of each modifiable behavioral risk factor

Mortality to Modifiable Behavioral Risk Factors [000]																	
Age\Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Smoking	454.0	451.9	455.0	454.2	442.6	451.9	440.1	437.7	447.7	438.6	439.4	442.8	443.7	450.3	448.7	458.7	454.5
Obesity	434.4	431.5	432.3	428.4	416.8	417.9	409.3	405.6	405.8	400.1	402.5	404.2	407.1	411.8	416.0	425.4	427.2
Illicit Drugs	9.4	10.0	12.2	13.5	14.0	15.1	17.6	16.6	15.9	15.4	15.2	16.2	16.9	18.3	20.2	23.7	31.0
Alcohol Misuse	56.6	57.7	58.4	59.2	59.0	60.3	60.1	61.0	62.7	63.0	65.5	67.6	69.4	71.7	74.1	77.7	79.5
STDs	20.6	20.2	20.2	19.8	19.1	18.8	18.7	18.0	17.2	16.3	15.4	15.1	14.9	14.9	14.6	14.5	14.2
Accidents	38.1	39.0	40.6	40.7	41.2	41.8	42.2	42.0	39.5	37.2	37.1	37.6	38.6	38.4	39.1	41.2	43.7
Suicide	29.3	30.6	31.6	31.5	32.4	32.6	33.3	34.6	36.0	36.9	38.4	39.5	40.6	41.1	42.8	44.2	45.0
Total	1,042.4	1,041.0	1,050.3	1,047.2	1,025.1	1,038.5	1,021.3	1,015.4	1,024.8	1,007.6	1,013.5	1,022.9	1,031.1	1,046.5	1,055.4	1,085.4	1,095.0

Figure 1 shows mortality trends by behavioral risk factors (the y-axis represents the yearly mortality / 2000 mortality). Obesity and smoking mortality has remained stable over the last 16 years while there has been an important reduction in mortality due to STD's.

On the other hand, there has been a large incremental increase in mortality due to illicit drug use. Notice that mortality due to illicit drugs has increased by more than 200% and the slope of the curve is increasing exponentially after the year 2012.

Figure 1: Trends in modifiable behavioral risk factors. Y axis is (yearly mortality) / (2000 mortality)

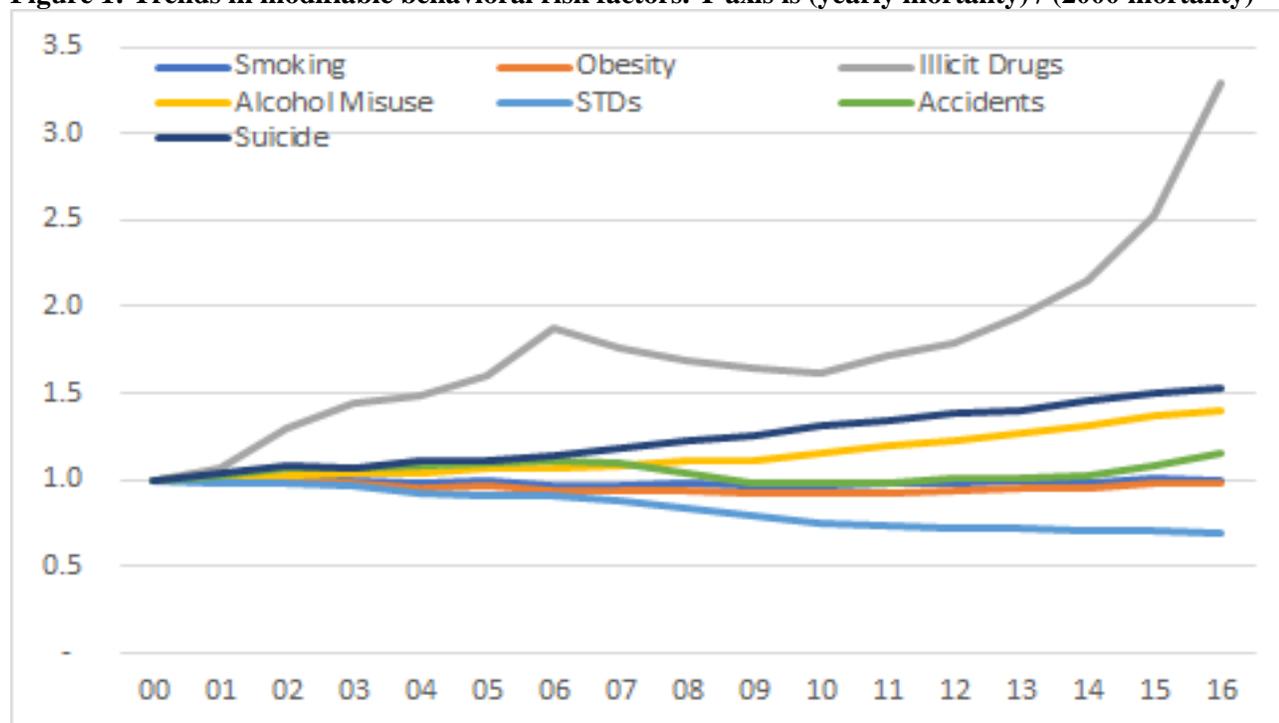


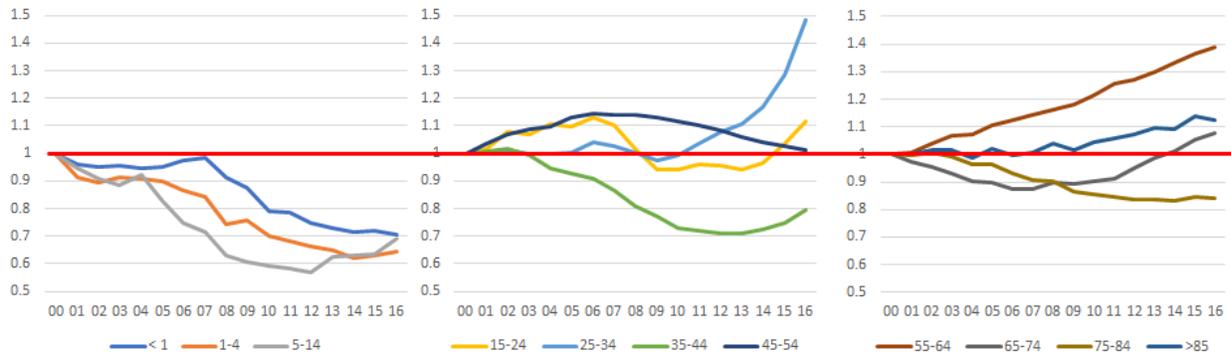
Table 3 shows total mortality by age groups. There has been an increase in mortality among the 15-24, 25 -34, and 55 – 64 age groups. There has been a decline among age group 35 – 44 years of age.

Table 3: Annual mortality (in thousands) due to modifiable behavioral risk factors by age groups

Mortality to Modifiable Behavioral Risk Factors [000]																	
Age\Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
<1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1-4	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.6
5-14	1.9	1.8	1.7	1.7	1.7	1.6	1.4	1.3	1.2	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.3
15-24	12.6	12.8	13.6	13.5	14.0	13.8	14.2	13.9	12.8	11.9	11.8	12.1	12.0	11.9	12.2	13.1	14.0
25-34	17.7	17.8	17.9	17.7	17.7	17.7	18.4	18.2	17.7	17.2	17.6	18.4	19.1	19.6	20.7	22.8	26.2
35-44	47.5	47.9	48.4	47.2	45.0	44.1	43.3	41.1	38.5	36.6	34.7	34.2	33.8	33.8	34.4	35.6	37.8
45-54	88.5	91.7	94.5	96.4	97.3	99.9	101.3	100.7	100.8	100.1	98.7	97.6	95.9	93.6	92.1	90.8	89.7
55-64	140.6	141.3	146.3	150.4	150.8	155.7	158.2	160.6	163.7	166.4	170.5	176.5	179.0	182.6	187.4	192.2	195.4
Subtotal	310.8	315	324.1	328.6	328.3	334.6	338.7	337.6	336.3	334.9	335.9	341.2	342.3	344	349.2	356.9	365.8
65-74	218.0	212.4	208.2	203.1	196.8	195.8	191.0	190.3	195.6	194.7	196.7	199.2	206.8	215.0	220.7	229.7	234.5
75-84	291.5	291.1	292.7	289.9	281.1	281.4	270.7	264.3	262.5	252.4	249.2	247.1	243.5	244.2	242.6	246.0	244.6
>85	222.1	222.6	225.4	225.6	218.9	226.8	220.9	223.1	230.4	225.5	231.7	235.5	238.5	243.3	242.9	252.8	250.1
Total	1042.4	1041.0	1050.3	1047.2	1025.1	1038.5	1021.3	1015.4	1024.8	1007.6	1013.5	1022.9	1031.1	1046.5	1055.4	1085.4	1095.0

Figure 2 shows mortality trends for varying age groups. Notice that y-axis is yearly mortality scaled with respect to year 2000. Values above 1 (i.e., the red line) indicate an increase in mortality; whereas, data values below the red line indicate a reduction.

Figure 2: Annual mortality due to modifiable behavioral risk factors trends by age. Y-axis is (yearly mortality) / (2000 mortality)



The life expectancy of an average American born in 2016 at the moment of birth was 78.6 years. Commonly, life expectancy is expressed as expected additional years of life after the current age. That is, a 30 year old, average 2016 American was expected to live for another 50.0 years. It is also possible to calculate life expectancies without including mortality due to behavioral risk factors. Figure 3 shows expected life for the population and for a population that “avoids” mortality due to behavioral risk factors. Notice that life expectancy would increase from 78.6 to 83.5 years at the moment of birth. Figure 3, in the left hand sided chart, the graph shows the difference in expected additional years at each age between both groups.

Figure 3: Expected years of life

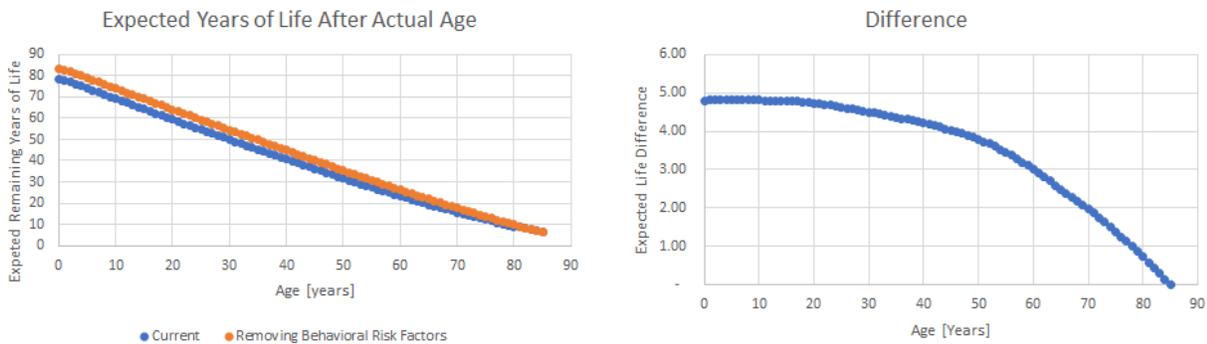


Table 4 shows VLTEL estimation using mortality costs from 2009. Mortality above 75 years old was removed from VLTEL. The largest contributor to VLTEL is the 45 - 64 age cohort. Notice that the highest cost per single death is for the age group 15 – 24.

Table 4: Estimated Mortality Cost Due to Behavioral Risk Factors

Age Group	Mortality [000]	Cost per Death [000]	VLTEL [Millions]
<5	1.3	1,154.82	1,513.5
5-14	1.3	1,457.17	1,891.8
15-24	14.0	1,732.51	24,313.0
25 - 44	64.0	1,370.20	87,715.3
45 - 64	430.0	634.99	273,015.1
65 - 75	250.1	18.96	4,742.2
Total	760.7		393,190.9

Discussion

There are several noteworthy trends shown in this study. The annual mortality attributable to modifiable behavioral risk factors has changed when categorized by age since the turn of the century. There has been an overall gradual decline in mortality due to behavioral risk factors for ages 15 and younger (notwithstanding year 2016).

In contrast, the data indicates a strong increase in age group 24-35 (approximately a 50% increase with respect to year 2000) and among the 55-64 (about 40% increase with respect to year 2000) age cohort in premature mortalities due to behavioral risk factors. The age group 15 – 24 also shows a mortality increase, but it does not begin until the year 2014.

The overall percentage of mortalities (39.91% in 2016) associated with modifiable behavioral risk factors has been modestly declining over the last few decades, albeit it at a slow pace. Nevertheless, as shown in Table 1, the gross aggregate number of avoidable deaths is still increasing and represents an important percentage of total annual mortalities. Smoking and obesity continue to account for the majority of overall annual mortalities. Smoking and obesity are the most influential factors after age 45. According to the National Cancer Institute (2017), the overall number of cancer mortality rates, including lung cancer which is predominantly acquired from smoking, has been decreasing. Our study data shows that premature deaths associated with smoking have been declining; whereas, the general trend of mortality attributable to obesity continues to increase.

In contrast, children and teens are principally affected by accidents. For young adults – accidents, suicide and illicit drugs – are the principal behavioral factors leading to premature deaths. Each of these behavioral risk factors has been showing an increasing trend since year 2000. The mortality attributable to illicit drugs has increased by more than 200% presumably as a consequence of the opioid epidemic. Similarly, alcohol misuse and suicide are showing an increasing trend over the last few decades. Despite their relative low mortality overall rates, at least in comparison with the two most common modifiable risk factors of obesity and smoking, the mortality associated with alcohol misuse and illicit drug use has been increasing quite rapidly.

According to the National Health Interview Surveys (2017) spanning 1997-2014, there has been an upward trend in drinking among adults over 60. According to recent studies (Case, 2017; Case 2015) mortality from alcohol as well as illicit drug use has been on the rise among certain ethnicities. The reasons are complex, multifactorial and will require extensive research to more clearly elucidate. For example, as reported by the Brookings Institution (2017), the increased mortality is linked to resources, especially family income; and a long-standing evolution of “cumulative disadvantage for those with less than a college degree” (Case, 2017, page 3). Our data corroborates this finding as illicit drug use has been increasing especially within age groups 55-64 and 65 – 74 (increase of greater than 1,000 percent); whereas, for other age cohorts the increased range is between 100% and 300%. Similarly, alcohol misuse shows a strong increase with larger percentages for age groups 55 – 64, as well as the 25 – 35 age cohort. There has also been an increase among the age group of 15 – 24, but it is not showing the exponential behavior of the other two age cohorts.

There are several limitations associated with this study. First, the accuracy of the mortalities recorded on death certificates can vary by underlying cause (Maudsley, 1996). Moreover, conducting analyses using underlying causes of death categories may underestimate the burden for selected contributing causes of death listed on the mortality certificate (Redelings, 2006). An example would be obesity which can presumably increase the risk of cancer (Lauby-Secretan, 2016), and/or heart disease. There are also methodological limitations involved with extrapolating life expectancies based upon behavioral risk factors. Moreover, it is difficult to ascertain the contribution or actual attributable effects of imprudent lifestyle or behaviors on premature deaths. There are many confounding variables that may affect these relationships. Mortality records are an important data source for assessing a population because they include the whole population with corresponding information pertinent to the contributing causes of death. Yet, cause-specific mortality is ordinarily reported using traditional epidemiologic measures, (i.e., counts and rates), that are heavily influenced by mortalities among older citizens (Putzer, 2016; Aragon, 2008). Thus, for most causes, these conventional measures are not very sensitive to mortalities occurring among younger individuals, which presumably are more likely to be premature and/or preventable deaths. The premature deaths examined in this study are important from a public health and health policy perspective because they represent possible preventable loss of life. A challenge is how to reverse the trends and to reduce the number and rate of premature deaths due to behavioral risk factors. Naturally, prevention is an area that is often mentioned to reduce behavioral risk factors.

Preventive measures and services may provide an area that offers opportunities to improve health and save money simultaneously. There is evidence that suggests prevention does save money and improve health. For example, there is evidence from the U.S. Preventive Task Force which identified measures – such as counseling adults to stop smoking and screening for certain cancers – that reduced mortality and lower costs (Maciosek, 2006). Yet, other studies have concluded that preventive measures can also lead to higher costs unless these measures incorporate factors such as the targeting a higher-risk population (Russell, 2007; Cohen, 2008). Thus, incorporating preventive measures and treatments which are most effective is important, but equally important is providing intensified education to citizens and creating health policies that incentivize and reward medical protocols and practice dedicated toward an enhanced emphasis on reducing behavioral risk factors.

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