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Why did life expectancy decline in the United States in 2015? A gender-specific analysis

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Abstract

In 2015, age-adjusted mortality rates increased for 8 of the 10 leading causes of death in the United States. As a result, life expectancy declined by 0.17 years for both women and men. The decline could be just an anomaly, or it could represent the start of a new trend of stagnation or decline in life expectancy, as some scholars have warned. The first step is to determine the sources of the decline. In this study we analyze the contribution of specific causes of death to the decline in men's versus women's life expectancy, as well as the mechanisms that generated the decline. With regard to mechanisms, we examine whether the decline in life expectancy resulted from reductions in the average age at death for most causes of death, or from a greater risk of dying of causes that disproportionately affect the young and middle-aged. Using CDC mortality data, we construct life tables for men and women separately, based on 20 different underlying causes of death. We find that men's reduction in life expectancy was attributable primarily to changes in midlife mortality, with a greater risk of dying of causes such as accidental poisoning or homicide. The reduction in women's life expectancy, on the other hand, was attributable primarily to changes in old-age mortality, where the mean age at death for most causes (such as heart disease and mental illnesses) was lower in 2015 than it was in 2014. These gender-specific mechanisms that contributed to the decline in life expectancy are common to the major racial/ethnic groups, but the magnitude of the decline differs greatly across racial/ethnic groups. Future research can use the tools provided here to investigate in more detail how the gender-specific mechanisms of the 2015 decline differ by race.

Keywords

Life expectancy; gender; causes of death; mortality; age-risk decomposition; accidental poisoning

INTRODUCTION

In 2015 life expectancy at birth (e_0) in the United States was lower than it was in 2014 (Xu et al., 2015). The previous reductions in life expectancy observed in the United States date

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back to 1993, during the HIV/AIDS epidemic, and to 1980, a year characterized by a particularly deadly influenza (OECD, 2017; The Associated Press, 2016). The decrease in life expectancy observed in 2015 is particularly worrisome for two reasons. First, unlike the declines in 1980 and 1993, the 2015 decline in life expectancy was not generated by an anomalous spike in a specific cause of death. Instead, the age-adjusted death rates increased for 8 of the 10 leading causes of death—heart disease, chronic lower respiratory diseases, accidents, stroke, Alzheimer's, diabetes, kidney disease, and suicide (Xu et al., 2015). Second, the decrease in life expectancy in 2015 occurred after several years of stagnation in the life expectancy trend, as life expectancy rose very little from 2010 to 2014 (NCHS, 2016; OECD 2017).

The five year long period of stagnation in life expectancy followed by an actual decline represents a clear discontinuity in the secular trend of life expectancy in the United States. Indeed, life expectancy in the United States increased throughout the 20th century and the first decade of the 21st century (Kinsella, 1992). Men and women born in 1900 could expect to live on average 48.3 and 51.1 years, respectively. By 1950 life expectancy had risen by over 20 years for women ($e_0=71.7$) and by almost 18 years for men ($e_0=66$). This unprecedented increase in life expectancy derived from a substantial decrease in the mortality rate of infectious diseases, fostered by improved nutrition (McKeown, 1976), population-wide public health actions (e.g. water sanitation, vaccination campaigns, introduction of antibiotics), and increasingly widespread socioeconomic well-being (Cutler et al., 2006; Riley, 2001). These factors significantly lowered infant and young-age mortality (Cutler et al., 2006; Oeppen and Vaupel, 2002). On the other hand, in recent decades the rise in life expectancy has been generated mostly by lower mortality rates at older ages (i.e. 65+) (Cutler et al., 2006; Oeppen and Vaupel, 2002; Riley, 2001), thanks to medical improvements in the detection and treatment of chronic and degenerative diseases—the most common causes of death.

In the current paper we focus on the 2015 decline in life expectancy by analyzing the changes in the mortality regime of the two major subgroups of the population—men and women. This distinction is important because men and women differ significantly in terms of life expectancy as well as in cause- and age-specific mortality rates. Therefore, overall trends might mask gender-specific patterns. The overarching goal of the paper is to compare the drivers of the 2015 decline in men's and women's life expectancy. First we compare the contributions of the most common and relevant causes of death to the decline in men's versus women's life expectancy. Then we investigate the underlying mechanisms that generated the decline for women versus men by distinguishing between changes in cause-specific mean age at death and changes in the cause-specific probability of dying. In other words, we address the following question: Did life expectancy for women (men) decline because of a greater risk of dying of causes that disproportionately affect the young (*lifetime risk component*), or because women (men) are dying of the same causes as before, but at a younger age (*age component*)?

MATERIAL AND METHODS

Data

We used the mortality data and population denominators from the Multiple Cause of Death Mortality files of the National Center for Health Statistics (NCHS, 2016) to construct gender-specific multiple-decrement life tables for 2014 and 2015. Our life tables are based on 5-year age groups (but age 0–4 is separated into 0–1 and 1–4) until age 85, plus an open age group (85+). We include virtually the entire U. S. population; the only omissions are non-Hispanic Native Americans and Alaska Natives, and individuals whose Hispanic origin or age at death is unknown.

Methods

Our classification of causes of death is based on the tenth revision of the International Classification of Diseases (ICD10) (WHO, 2008). We started with the ten leading causes of death as defined by the CDC (Centers for Disease Control and Prevention) (Heron, 2016), to which we added other relevant causes (septicemia; chronic liver disease and cirrhosis; HIV/AIDS; homicide; infant conditions; mental and behavioral disorders; diseases of the digestive system; ill-defined causes) and a residual category (minor causes not elsewhere classified). In addition, we split “accidents” – one of the CDC’s ten leading causes – into three separate causes (accidental poisoning; transport accidents; falls). Death due to accidental poisoning has been increasing at an alarming rate over the past 15 years (Case and Deaton, 2015), reducing the growth in life expectancy observed between 2000 and 2014, for men particularly. Therefore, we suspect that accidental poisoning could be a key driver of the 2015 decline in life expectancy, especially for men. We also distinguished between falls and traffic accidents because these causes have different age and gender profiles. Lastly, we moved Alzheimer’s into a larger cause category labeled “mental illnesses”, which also includes all other mental and behavioral disorders. Overall, we distinguish among 19 different causes of death plus a residual category (see Appendix Table 1 for the specific ICD10 coding).

When multiple causes of death are involved, life expectancy at birth (e_0) is the weighted average of the cause-specific mean ages at death, where the weights are the cause-specific lifetime risks. In symbols, $e_0 = \sum_k a_k r_k$, where a and r indicate the mean age death and lifetime risk, respectively, and the subscript k ($k=1, \dots, 20$) refers to the cause of death. The lifetime risks are, by definition, the probability of dying of each cause, derived from the period life table. Therefore, $\sum_k r_k = 1$ when, as in the current study, the causes of death are exhaustive and mutually exclusive.

Any change in the cause-specific mean ages at death or in the cause-specific probabilities of dying will alter the overall life expectancy. These two processes usually operate simultaneously and, as previous work (Acciai et al., 2015; Firebaugh et al., 2014) has shown, it is possible to separate and quantify their contribution to the total change in life expectancy:

$${}_{2015}^r e_0 - {}_{2014}^r e_0 = \text{Age Component} + \text{Risk Component}.$$

Distinguishing between these two components provides useful insights into how the mortality regime has changed over time. Specifically, we can quantify the proportion of the decline in life expectancy that was generated by lower mean ages at death (*age component*) and the proportion generated by a change in the cause-specific probabilities of dying—with a reallocation of deaths toward younger-age causes (*lifetime risk component*). Furthermore, it is possible to make the distinction between age and risk component for each cause of death separately (Acciai et al., 2015; Firebaugh et al., 2014). The total age and risk components are, in fact, the sum of the cause-specific age and risk components: $Age\ Component = \sum_k Age_k$; $Risk\ Component = \sum_k Risk_k$.

RESULTS

Descriptive Results

Table 1 reports the cause-specific lifetime risks and average ages at death from the life tables for 2014 and 2015, for both men and women. The total mean age at death (last row of the table) corresponds to life expectancy at birth. Importantly, men and women experienced a decline of the same magnitude—for both groups life expectancy in 2015 was 0.17 years lower than it was in 2014. The descriptive statistics can help determine why this occurred. For instance, the risk of dying of most of the midlife causes, such as traffic accidents or accidental poisoning, is greater in 2015. This pattern is observed for both genders, but was more marked for men. Another element that depressed life expectancy in 2015 was the decline in the average age at death of the most common—and therefore most relevant—causes, such as heart disease and cancers. Since these two causes combined account for over 47% of all deaths for men and over 42% of all deaths for women, even a small reduction in their mean age at death can have a noticeable negative effect on life expectancy.

Cause-specific analysis

Cause-specific analysis reveals that some of the major contributors to the decline in e_0 are common to men and women. Figures 1A and 1B summarize the causes that contributed to lowering life expectancy in 2015 by at least 0.01 years (or over 5% of the decline) for women and for men, respectively. (Table 3, below, reports results for all 20 causes.) Except for diabetes (only relevant for women) and homicide and suicide (only relevant for men), the other five major contributors to the decline in e_0 are the same for both genders. These are heart diseases, transport accident, accidental poisoning, mental illnesses, and ill-defined causes. However, these causes contribute to the decline in life expectancy to a different extent for men and women. For women the major contributors are heart disease and mental illness, followed by accidental poisoning. For men the major contributors are accidental poisoning, mental illnesses, and homicide, in that order. Overall, women's life expectancy decreased mostly because of old-age causes of death, whereas men's life expectancy was more affected by midlife causes of death, with the exception of mental illnesses.

Midlife mortality vs old-age mortality

To further explore whether, and how, women and men differed in the mortality patterns that led to a reduction in life expectancy, we determine whether the 2015 reduction in life expectancy at birth (e_0) mostly occurred before or after age 65 (Table 2). Since $e_0 = e_{0-64}$

+ e_{65} we can easily determine what portion of the change in e_0 is attributable to changes in old age mortality, captured by change in life expectancy at age (e_{65}). Although the decline in e_0 was the same for women and men, the mechanisms were quite different. In fact, changes in old-age mortality generated most of the decline (0.136/0.174, or 78%) for women, but only 33% (0.057/0.175) of the decline for men. This pattern is in line with the findings of our cause-specific analysis, where we found that the major contributors of the decline were primarily old-age causes of death for women, and midlife causes of death for men.

Age-Risk decomposition results

Although the principal causes of death (e.g. heart disease, mental illnesses, accidental poisoning) responsible for the decline in life expectancy were largely the same for men and women, the mechanisms of the decline were very different. The age-risk decompositions show that the risk component drove the decline for men while the age component drove the decline for women (Table 3, last row). In other words, men's life expectancy decreased largely because younger-age causes were more common in 2015 than they were in 2014, whereas women's life expectancy fell largely because women tended to die of the same causes but at younger ages in 2015 than in 2014.

Detailed results of the cause-specific age-risk decomposition are reported in Table 3. For each cause the decomposition provides the age and the risk components, the sum of which corresponds to the cause-specific total contribution (in years) to the decline in life expectancy. Notably, only one cause—influenza and pneumonia—significantly offset the decline in life expectancy, with a non-trivial positive contribution for both men and women. One might have expected that cancer—a cause that accounts for about one in five deaths in the U.S.—would also have offset the decline in life expectancy, since the age-adjusted death rate for cancer decreased in 2015 (Xu et al., 2015). However, as Table 3 shows, the decline in cancer death rates—captured by a positive risk component—is offset by the fact that cancer victims tended to be somewhat younger in 2015 (see Table 1), as shown by the negative age component.

Finally, we note that our results closely align with results for whites, who represent the largest share of the population. However, race-specific analyses reveal that, for every racial/ethnic group, the risk component dominated for men while the age component dominated for women. The magnitudes of the age and risk components nonetheless varied across the groups (Figures 2A and 2B). The risk component was particularly striking for black men: The greater risk of dying of midlife causes was responsible for reducing blacks' life expectancy by 0.28 years (Figure 2B), nearly half of which was due to homicide (cause-specific results for racial groups are not shown here, but are available upon request). In contrast, the greater risk of dying of midlife causes reduced life expectancy by a little over 0.10 years for white men and Hispanic men, with accidental poisoning being the main culprit. In the case of women, the age component was largest for white women (Figure 2A), due mainly to reductions in the ages of white women who died of older-age causes such as heart disease or mental disorder. While the age component is much smaller for black and Hispanic women, it still accounts for most of their decline in life expectancy.

DISCUSSION

2015 marked the first decline in life expectancy in the United States in over two decades. Despite an historical trend of rising life expectancy in the U.S., some scholars had in fact warned of the possibility that this trend might soon be reversed. For instance, over a decade ago Olshansky and colleagues (2005) argued that if the prevalence of obesity continues to increase, life expectancy will be negatively affected at some point during the first half of the 21st century. Their forecast was corroborated by more recent work (Ludwig, 2016; Stewart et al., 2009). But even though the death rates for obesity-related causes were higher in 2015 than they were in 2014 (Ludwig, 2016) the decline in life expectancy observed in 2015 does not seem to be closely related to obesity, because (1) most causes of death contributed to the decline, and (2) most of the decline for men was attributable to external causes of death.

In fact, obesity is not the only risk factor that has raised concerns. Socioeconomic hardship and instability is considered one of the drivers of the *deaths of despair*—a group of external causes that includes accidental poisoning, suicide, and chronic liver diseases (Case and Deaton, 2015; Masters et al., 2017). For all these causes, though to different extents, the death rates have increased over the past 15 years, with white males aged 45–54 being especially affected (Case and Deaton, 2015). This trend is particularly worrisome because even small increases in the age-adjusted death rates for midlife causes can have a non-trivial impact on life expectancy. Extending the findings of Case and Deaton (2015), we find that the rise in accidental poisoning has significantly depressed life expectancy for all Americans, and not just for white men. This is even more striking if we consider that accidental poisoning accounts for only about 1.3% of men's deaths and 0.75% of women's death. The other deaths of despair, suicide and alcoholic liver diseases, also contributed to lowering life expectancy in 2015 (Table 3), but with the exception of suicide for men, their contribution was only marginal. However, other external causes such as homicide (especially for black men) and transport accidents also contributed to the decline in life expectancy.

To summarize, the increase in mortality that produced the 2015 decline in life expectancy was not limited to one or two causes of death. To the contrary, the mean age at death decreased for most causes of death (14 of 20 causes for men, and 15 of 20 causes for women), resulting in a large negative age component, especially for white women. For men the negative age component was compounded by an even larger negative risk component fueled by rising rates of accidental poisoning among whites and Hispanics, and homicide among blacks. To gain further insights on the trends and mechanisms of the 2015 decline in life expectancy, future studies should examine race- and gender-specific patterns in more detail. The methods we use here could also be employed to study regional patterns as well as to determine whether the decline has affected individuals from different socioeconomic backgrounds differently.

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APPENDIX

Appendix Table 1

ICD10 coding scheme utilized to create the relevant cause categories

Cause of death	ICD10 code
Chronic and degenerative diseases	
Heart diseases	I00–I09, I11, I13, I20–I51
Cancers	C00–C97
Mental illnesses	G30, F00–F99
Chronic lower respiratory diseases	J40–J47
Cerebrovascular diseases	I60–I69
Diabetes	E10–E14
Diseases of the digestive system	K00–K69, K71–72, K75–K93
Nephritis, nephrotic syndrome and nephrosis	N00–N07, N17–N19, N25–N27
Communicable diseases	
Influenza and pneumonia	J09–J18
Septicemia	A40–A41
HIV/AIDS	B20–24
External causes	
Suicide	X60–X84, Y87, U03
Alcoholic liver diseases and cirrhosis	K70, K73–K74
Accidental poisoning	X40–X45, Y10–Y19, Y45, Y47, Y49, T36–T50, T96
Transport accident	V00–V99
Falls	W00–W19
Homicide	X85–X99, Y00–Y09, U01–U02
Other causes	
Infant conditions	P00–P96, Q00–Q99
Ill-defined causes	R00–R99
NEC - Not elsewhere classified	All remaining causes

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RESEARCH HIGHLIGHTS

- ✓ 2015 marked the first decline in life expectancy in the United States since 1993
- ✓ Men and women experienced a decline in life expectancy of similar magnitude
- ✓ Women's decline was driven mostly by an increase in old-age mortality (age 65+)
- ✓ Men's decline was driven mostly by an increase in midlife mortality
- ✓ Key drivers are accidental poisoning for men and mental illnesses for women

Figure 1A.

Causes that significantly contributed to the 2015 *decline* in women's life expectancy

Figure 1B.

Causes that significantly contributed to the 2015 *decline* in men's life expectancy

Note: The longer the bar, the greater the *reduction* in life expectancy attributable to the cause.

Figure 2A.
Age-risk decomposition for women by racial/ethnic group

Figure 2B.
Age-risk decomposition for men by racial/ethnic group

Table 1

Gender-specific proportions (lifetime risks) and mean ages at death, by cause of death: US 2014–2015.

Cause of death	MEN				WOMEN			
	Proportion (risk)		Mean age at death		Proportion (risk)		Mean age at death	
	2014	2015	2014	2015	2014	2015	2014	2015
Chronic and degenerative diseases								
Heart diseases	0.2592	0.2582	80.02	79.96	0.2378	0.2373	85.19	84.98
Cancers	0.2231	0.2176	76.18	76.13	0.1910	0.1868	76.46	76.37
Mental illnesses	0.0806	0.0782	86.12	85.92	0.1483	0.1442	89.26	89.05
Chronic lower respiratory diseases	0.0566	0.0569	80.39	80.35	0.0596	0.0616	81.61	81.65
Cerebrovascular diseases	0.0465	0.0474	81.33	81.43	0.0648	0.0663	85.52	85.44
Diabetes	0.0291	0.0294	75.90	75.72	0.0255	0.0253	79.44	78.96
Diseases of the digestive system	0.0216	0.0213	77.34	77.11	0.0256	0.0255	81.68	81.44
Nephritis, nephrotic syndrome and nephrosis	0.0038	0.0036	81.11	80.87	0.0037	0.0037	83.66	83.20
Communicable diseases								
Influenza and pneumonia	0.0226	0.0228	81.78	82.65	0.0231	0.0242	84.26	85.21
Septicemia	0.0140	0.0144	78.11	78.29	0.0153	0.0154	80.39	80.31
HIV/AIDS	0.0023	0.0022	53.20	54.18	0.0008	0.0008	50.79	51.50
External causes								
Suicide	0.0169	0.0170	52.61	52.05	0.0046	0.0049	49.04	48.82
Alcoholic liver diseases and cirrhosis	0.0129	0.0132	63.92	63.89	0.0074	0.0078	66.64	66.42
Accidental poisoning	0.0126	0.0144	43.01	42.62	0.0073	0.0078	46.44	45.59
Transport accident	0.0133	0.0139	48.71	48.64	0.0055	0.0058	51.76	51.02
Falls	0.0137	0.0140	81.84	81.83	0.0136	0.0137	86.63	86.61
Homicide	0.0055	0.0063	34.90	34.39	0.0016	0.0017	40.60	40.62
Other causes								
Infant conditions	0.0058	0.0058	11.69	12.95	0.0051	0.0051	13.50	13.74
III-defined causes	0.0107	0.0104	71.51	69.86	0.0140	0.0131	81.00	80.00
NEC - Not elsewhere classified	0.1492	0.1530	77.85	77.89	0.1454	0.1493	81.30	81.26
Total	1.0000	1.0000	76.926	76.752	1.0000	1.0000	81.760	81.586

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Table 2

Life expectancy at birth and at age 65 for men and women

	Life expectancy at birth (e_0)			Life expectancy at 65 (e_{65})		
	2014	2015	Change	2014	2015	Change
Men	76.926	76.752	-0.175	18.529	18.472	-0.057
Women	81.760	81.586	-0.174	21.145	21.009	-0.136

Table 3

Cause-specific age-risk decomposition results. US 2014–2015, men and women.

Cause of death	MEN			WOMEN		
	Risk	Age	TOTAL	Risk	Age	TOTAL
Chronic and degenerative diseases						
Heart diseases	−0.003	−0.014	−0.017	−0.002	−0.050	−0.052
Cancers	0.004	−0.010	−0.006	0.023	−0.018	0.005
Mental illnesses	−0.022	−0.016	−0.038	−0.030	−0.031	−0.061
Chronic lower respiratory diseases	0.001	−0.002	−0.001	0.000	0.002	0.002
Cerebrovascular diseases	0.004	0.005	0.009	0.006	−0.005	0.001
Diabetes	0.000	−0.005	−0.005	0.001	−0.012	−0.012
Diseases of the digestive system	0.000	−0.005	−0.005	0.000	−0.006	−0.006
Nephritis, nephrotic syndrome and nephrosis	−0.001	−0.001	−0.002	0.000	−0.002	−0.002
Communicable diseases						
Influenza and pneumonia	0.001	0.020	0.020	0.003	0.022	0.026
Septicemia	0.001	0.002	0.003	0.000	−0.001	−0.001
HIV/AIDS	0.002	0.002	0.004	0.002	0.001	0.002
External causes						
Suicide	−0.003	−0.009	−0.012	−0.007	−0.001	−0.008
Alcoholic liver diseases and cirrhosis	−0.004	0.000	−0.004	−0.007	−0.002	−0.009
Accidental poisoning	−0.061	−0.005	−0.066	−0.018	−0.006	−0.025
Transport accident	−0.020	−0.001	−0.020	−0.007	−0.004	−0.011
Falls	0.002	0.000	0.001	0.000	0.000	0.000
Homicide	−0.031	−0.003	−0.034	−0.003	0.000	−0.003
Other causes						
Infant conditions	−0.002	0.007	0.005	−0.001	0.001	0.001
Ill-defined causes	0.002	−0.017	−0.015	0.001	−0.014	−0.012
NEC - Not elsewhere classified	0.004	0.005	0.009	−0.002	−0.007	−0.009
TOTAL	−0.127	−0.048	−0.175	−0.042	−0.133	−0.174