Multiple Chronic Conditions and Life Expectancy
A Life Table Analysis

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Background: The number of people living with multiple chronic conditions is increasing, but we know little about the impact of multimorbidity on life expectancy.

Objective: We analyze life expectancy in Medicare beneficiaries by number of chronic conditions.

Research Design: A retrospective cohort study using single-decrement period life tables.

Subjects: Medicare fee-for-service beneficiaries (N = 1,372,272) aged 67 and older as of January 1, 2008.

Measures: Our primary outcome measure is life expectancy. We categorize study subjects by sex, race, selected chronic conditions (heart disease, cancer, chronic obstructive pulmonary disease, stroke, and Alzheimer disease), and number of comorbid conditions. Comorbidity was measured as a count of conditions collected by Chronic Conditions Warehouse and the Charlson Comorbidity Index.

Results: Life expectancy decreases with each additional chronic condition. A 67-year-old individual with no chronic conditions will live on average 22.6 additional years. A 67-year-old individual with 5 chronic conditions and ≥ 10 chronic conditions will live 7.7 fewer years and 17.6 fewer years, respectively. The average marginal decline in life expectancy is 1.8 years with each additional chronic condition—ranging from 0.4 fewer years with the first condition to 2.6 fewer years with the sixth condition. These results are consistent by sex and race. We observe differences in life expectancy by selected conditions at 67, but these differences diminish with age and increasing numbers of comorbid conditions.

Conclusions: Social Security and Medicare actuaries should account for the growing number of beneficiaries with multiple chronic conditions when determining population projections and trust fund solvency.

Key Words: chronic illness, life expectancy, multimorbidity

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The Social Security Administration estimates the solvency of the Medicare and Social Security trust funds based on many factors including their projected estimates of Americans' longevity. Life expectancy, the average number of "additional" years a person surviving to a given age will live, is the preferred measure to quantify longevity.[1] The number of people over age 65 with multiple chronic conditions is increasing at an unprecedented rate, which could dramatically affect life expectancy estimates. Considerable work on the effects of demographic and socioeconomic factors on life expectancy has been performed. However, our understanding of the burden of multiple chronic conditions on life expectancy is less clear and of importance to policymakers responsible for the financial solvency of these federal programs.

In recent years, life expectancy in the United States has increased approximately 0.1 years per year.[2] The gains in life expectancy reflect improvements in public health and medicine.[3] However, compared with other industrialized countries, life expectancy in the United States is increasing at a slower pace.[4,5] There have been numerous attempts to explain the slower rate of increase in life expectancy focusing on demographic and socioeconomic determinants of health. Several studies have documented the disparities in life expectancy in the United States by sex and race.[6–8] Other studies suggest that socioeconomic determinants of health such as income and education may in fact be widening, creating further disparities in life expectancy.[9,10]

Less attention has been given to the impact of the growing burden of chronic conditions and life expectancy, especially the impact of multiple chronic conditions. In 2000, experts projected that 26% of all Americans would be living with multiple chronic conditions by 2030.[11] Just 6 years later, 28% of Americans were already living with >1 chronic condition. The burden of multiple chronic conditions is especially high and growing among the elderly. In 1998, 62% of Americans aged 65 and older were living with

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multiple chronic conditions.[12] In 2006, nearly 3 in 4 adults over age 65 (73%) were living with multiple chronic conditions.[11]

Few studies have examined whether life expectancy varies by number of chronic conditions. Most of these studies used limited older datasets[13,14] and focused on a sample with a specific chronic condition.[15–19] Previous studies have aggregated conditions together in broad groupings or top-coded the number of chronic conditions to 3, limiting our understanding of how life expectancy may differ among individuals with greater levels of morbidity.[13,14,16] These studies use the most common approach to dealing with comorbidities, which is to use summary measures accounting for the number of chronic conditions. Condition count has been found to be strongly predictive of health care spending and health care utilization.[11,20] Other studies using summary measures where diseases are weighted by severity have also found a strong and consistent relationship between level of morbidity and mortality.[21,22]

Our objective is to quantify average life expectancy in elderly Medicare beneficiaries living with multiple chronic conditions. If life expectancy estimates vary substantially by morbidity, then accounting for current and expected disease burden may provide more accurate demographic forecasts. In addition, life expectancy estimates by morbidity can serve as a benchmark for tracking how well public health and medical technology improve quantity of life for this growing population.

METHODS

Study Population and Data

We used the Medicare 5% sample, a nationally representative sample of Medicare beneficiaries. We linked the 2008 Beneficiary Summary and Chronic Condition Warehouse (CCW) files with Medicare claims data files, called the MedPAR, Carrier, and Outpatient files, for 2007 and 2008. These data contain beneficiary demographic characteristics, date of death, chronic condition diagnosis history, diagnosis codes, procedure codes, and dates of service. The CCW was created in 2006 by the Centers for Medicare & Medicaid Services to support research on Medicare beneficiaries with chronic conditions.[23] In 2008, the CCW using established claims-based algorithms included 21 predefined chronic condition indicators: Alzheimer disease and dementia, acute myocardial infarction, atrial fibrillation, colorectal cancer, endometrial cancer, breast cancer (females only), prostate cancer (males only), lung cancer, cataract, chronic kidney disease, chronic obstructive pulmonary disorder, depression, diabetes, glaucoma, heart failure, hip and pelvic fracture, ischemic heart disease, osteoporosis, rheumatoid arthritis and osteoarthritis, and stroke and transient ischemic attack. For more information about the algorithms, see https://www.ccwdata.org.

Eligible beneficiaries were alive as of January 1, 2008, aged 67 or older, and not enrolled in a Medicare Advantage (MA) plan. We exclude individuals enrolled in MA and those younger than 67 because the clinical information from claims data for these beneficiaries may be incomplete. From the initial sample of 2,623,691 beneficiaries enrolled in Medicare in 2008, our study sample included 1,372,272 Medicare beneficiaries.

Measures

We used 2 measures of multimorbidity. Our primary measure was a 0–10 count of the 21 predefined chronic conditions collected in the CCW diagnosed as of January 1, 2008. An advantage of the CCW is that it provides the first date of diagnosis for every condition even if there was not a paid claim with that diagnosis during the study period. This approach reduces the opportunity for observation bias.[24]

We used the coding algorithm described by Quan and colleagues to build the Charlson Comorbidity Index (CCI), a weighted score based on the presence of 17 different chronic conditions.[25–28] Conditions associated with higher mortality receive greater weight (Table 1, Supplemental Digital Content 1, http://links.lww.com/MLR/A774). The CCI measure relies on the diagnosis codes included on physician, outpatient, and hospital claims data. We considered a physician and outpatient diagnosis code to be valid if it appeared on ≥ 2 claims occurring at least 30 days apart.[29] All hospital diagnoses codes were considered valid.

We used the Beneficiary Summary file to identify beneficiary race, age, date of birth, date of death, and MA enrollment. Race was categorized as white, black, or other. Age was calculated in years from date of birth to January 1, 2008.

The 5 leading causes of chronic disease death in the United States in 2010 were disease of the heart, cancer, chronic lower respiratory diseases (COPD), cerebrovascular disease (stroke), and Alzheimer disease.[30] To examine individuals with these conditions, we classified individuals using the CCW indicators (Table 2, Supplemental Digital Content 2, http://links.lww.com/MLR/A775). Individuals with ≥ 2 of the conditions within a category, for example, acute myocardial infarction and ischemic heart disease, were identified as having 2 chronic conditions.

Analytic Approach

Life table methods were used to estimate life expectancy at age 67 and 75. There are 2 approaches to constructing life tables. Period life tables use cross-sectional data from a given time to estimate the mortality experience of a population at that particular moment. Cohort life tables use the complete mortality data on a birth cohort (eg, everyone born in 1943), which is available after the last member has died. We use period life tables because they can be constructed using the most current data and it is the standard approach used for national vital statistics and actuarial modeling.[1]

Life tables simulate the survival experience of a cohort of 100,000 people aged 67 who are exposed to the observed age-specific death rates throughout their life. We assume deaths are distributed evenly throughout the year at each age interval. Death rates are calculated as the ratio of the total number of observed deaths during the year divided by the population's amount of exposure to the risk of dying, or person-years. Life expectancy at age x is the ratio of the

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person-years lived after age i divided by the number of individuals surviving to age x. We estimate a 95% confidence interval (CI) around each mortality rate as $m(x) \times e^{1.96/\sqrt{dx}}$ and $m(x)/e^{1.96/\sqrt{dx}}$.[31] Consistent with the Centers for Disease Control and Prevention (CDC) approach, we use 100 as the open (or terminal) age interval to complete the life table.[2] Grouping the information in an open-age interval helps avoiding the problem of unreliable death rates yielding from the few survivors beyond age 100. In this approach, the number of person-years lived in the interval is the sum of the person-years lived from age 100 to age 120.

We construct separate life tables for each subgroup. First, we stratify the sample by number of chronic conditions, race, sex, and/or the leading causes of death subgroups. Then, we build a period life table using single-year age groups and report life expectancy at age 67, the youngest age of the study sample, and 75.

We conducted several sensitivity analyses to assess the robustness of these results. First, we compare our results to the published CDC estimates for 2008. Second, we examine the relationship of life expectancy and morbidity using the CCI. Third, we conducted this analysis in the 2007 Medicare CCW to assess the consistency of these estimates.

The Johns Hopkins School of Public Health Institutional Review Board deemed this study not human subjects research.

RESULTS

Nearly 80% of Medicare beneficiaries in the sample have ≥ 2 chronic conditions, and >60% have >2 chronic conditions (Table 1). We observe some differences in the distribution of comorbidities by race and sex. Females are more likely than males to have multiple chronic conditions and whites are more likely than blacks. Females are nearly twice as likely as males to have ≥ 10 conditions (2.7% of females compared with 1.7% of males). Most likely this is because females live longer and are more likely to acquire additional chronic conditions. Among individuals living with heart disease, cancer, COPD, stroke, or Alzheimer disease, the proportion of individuals living with only 1 chronic condition ranged from 1.1% in individuals with stroke, to as high as 3.4% among individuals with cancer.

Overall, we find an inverse relationship between number of chronic conditions and overall life expectancy. Table 2 presents the life expectancy results for the full sample, males, females, whites, and blacks at age 67 and 75 by number of comorbidities. For comparison, the first column reports life expectancy estimates published by CDC and the second column reports the life expectancy estimates in each group. At age 67, in the overall sample, the addition of each chronic condition reduces life expectancy by an average of 1.8 years (1.9 for females and 1.7 for males). The average decline in life expectancy at age 67 with an additional comorbidity is somewhat larger in blacks (1.8 y) than whites (1.7 y). At 75, the average difference in life expectancy with each additional chronic condition diminishes.

The marginal difference in life expectancy varies by level of morbidity. Figure 1 presents average life expectancy and 95% CI estimates for a 67-year-old individual living with no chronic conditions to ≥ 10 conditions. The slope of the line indicates the relative impact of each additional condition on life expectancy. Life expectancy is similar among individuals with none, 1, and 2 chronic conditions (the marginal differences in life expectancy are 0.4 and 0.5 y, respectively). Life expectancy declines substantially (1.6 y) for individuals living with 3 chronic conditions compared with 2 chronic conditions. The largest decline in life expectancy is 2.6 years comparing individuals with 6 chronic conditions to those with 5 chronic conditions. We observe similar patterns by sex and race (Figures 1 and 2, Supplemental Digital Contents 3 and 4 http://links.lww.com/MLR/A776; http://links.lww.com/MLR/A777).

A 67-year-old individual with no chronic conditions will live an additional 22.6 years. Consistent with established differences in sex, we find that the healthiest females, those with no chronic conditions, at 67 live longer than males [23.9 additional years (95% CI, 20.4, 28.1) compared with 21.3 y (95% CI, 17.6, 26.0), respectively]. We find that the healthiest blacks at 67 live on average 0.6 years longer than whites. This pattern is reversed when we compare blacks and whites with chronic conditions, reflecting known racial disparities in life expectancy.[7–10]

Life expectancy at 67 for people living with the 5 leading causes of chronic disease death are presented in Figure 2, stratified by number of comorbidities. There are substantial differences in life expectancy among those living with only 1 of these specific conditions. For example, at 67 years, an individual is estimated to live 21.2 (95% CI, 17.3, 25.7) additional years with heart disease, but only 14.2 (95% CI, 10, 20.2) additional years with COPD. At 67, an individual diagnosed with Alzheimer disease had the shortest life expectancy—12 (95% CI, 6.5 17.7) additional years. However, as mentioned earlier, Medicare beneficiaries with only 1 chronic condition are relatively uncommon. With increasing morbidity and age, initial differences in life expectancy by the leading causes of chronic disease death diminish. At 75 years, we find similar patterns in life expectancy by number of chronic conditions (Appendix Figure 3, Supplemental Digital Content 5, http://links.lww.com/MLR/A778).

In sensitivity analyses, we examine life expectancy by level of morbidity using the CCI. Consistent with our primary analysis, we find that as morbidity level increases life expectancy decreases (Table 3, Supplemental Digital Content 6, http://links.lww.com/MLR/A779; Figure 4, Supplemental Digital Content 7, http://links.lww.com/MLR/A780). The average decline in life expectancy at 67 by CCI is 2.4 years in the overall sample (2.5 y in females and 2.3 y in males). Unlike the count of chronic conditions, we find that the largest difference in life expectancy is between those with CCI scores of 0 and 1 (6.4 y in the overall sample). With each point increase in CCI, subsequent differences in life expectancy attenuate. These results are consistent by race and sex. In comparing the sensitivity of our results to study year, we find the 2007 results to be qualitatively similar to our main analysis (Table 4, Supplemental Digital Content 8, http://links.lww.com/MLR/A781).

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TABLE 1. Distribution of Chronic Conditions Among US Medicare Beneficiaries Aged 67 and Older by Race, Sex, and Selected Conditions, 2008 (%)

		No. Chronic Conditions										
	N	0	1	2	3	4	5	6	7	8	9	10+
Overall	1,372,272	11.9	11.3	14.4	14.9	13.3	10.9	8.4	6.1	4.1	2.5	2.3
Sex												
Female	854,505	9.4	10.1	14.2	15.3	14.0	11.5	9.0	6.6	4.5	2.8	2.7
Male	517,767	16.1	13.3	14.8	14.1	12.3	9.8	7.4	5.2	3.4	2.0	1.7
Race												
White	1,192,438	10.9	11.4	14.7	15.2	13.6	11.0	8.5	6.1	4.0	2.5	2.3
Black	100,635	15.9	10.8	13.0	13.1	12.3	10.4	8.4	6.3	4.4	2.8	2.6
Selected conditions												
Heart disease	707,312		2.7	7.8	13.2	16.7	16.8	14.6	11.3	7.7	4.8	4.4
Cancer	162,952		3.4	8.8	13.8	16.2	15.2	13.2	10.5	7.7	5.2	6.0
COPD	266,339		1.8	5.3	9.3	12.9	14.7	15.0	13.7	10.9	7.8	8.7
Stroke	180,962		1.1	3.7	7.5	11.2	14.1	15.1	14.5	12.2	9.4	11.2
Alzheimer Disease	181,183		1.3	4.1	7.7	11.2	13.7	14.8	14.2	12.1	9.4	11.5

Row percentages may not sum to 100 due to rounding.
COPD indicates chronic obstructive pulmonary disease.
Source: Medicare Beneficiary Summary File and Chronic Condition Warehouse File, 2008.

DISCUSSION

We find that living with multiple chronic conditions has a negative impact on life expectancy. Life expectancy is reduced by an average of 1.8 years with each additional chronic condition. We observe similar patterns by sex and race. Further, we find the life expectancy varies substantially among beneficiaries living with heart disease, cancer, COPD, stroke, and Alzheimer disease among those with low morbidity, but these variations diminish with increasing numbers of chronic conditions. These results are consistent with known life expectancy gaps between males and females, and whites and blacks.[6–10]

There are some exceptions to the overall pattern. Average life expectancy is somewhat shorter among Medicare beneficiaries with only Alzheimer disease, COPD, and cancer, compared with an individual with these conditions and a second comorbidity. This discrepancy may reflect greater disease severity in individuals with only 1 condition. For example, among individuals with cancer we find that individuals diagnosed with only cancer within the past 5 years experience higher death rates than those diagnosed with cancer >5 years ago (Table 5, Supplemental Digital Content 9, http://links.lww.com/MLR/A782). In addition, individuals diagnosed with only one of these conditions tend to be younger and have higher observed death rates at older ages.

This study differs from previous work in the field in several important ways. We use a large nationally representative dataset of noninstitutionalized and institutionalized older adults in the United States. As the Medicare 5% sample includes over 1 million observations, we are able to analyze the effect of multiple chronic conditions by race, sex, and leading causes of chronic disease death. Furthermore, this is the first study to examine the marginal difference beyond 3 chronic conditions on life expectancy.

We assessed the validity of our results by comparing our findings to other studies in the field. Our estimate of life expectancy at ages 67 and 75 are somewhat lower than those published by CDC. We exclude individuals enrolled in MA who are healthier than the general Medicare population (Table 6, Supplemental Digital Content 10, http://links.lww.com/MLR/A783). These differences may also reflect differences in the construction of death rates. We calculate death rates based on the observed sample. CDC uses a blended mortality rate using vital statistics and Medicare data, as well as statistical methods to smooth observed population and death counts, and observed mortality rates at older ages.[2,32] Our findings generally agree with Gross and colleagues and Cho and colleagues that individuals with more comorbidities have shorter life expectancies. We provide additional insight, as neither of these previous studies examines differences in life expectancy by chronic conditions and race.

There are alternative interpretations of our results. There is a well-established link between functional impairments and reduced life expectancy in the elderly.[33,34] It is possible that higher mortality rates in older adults with multiple chronic conditions reflects the association between chronic conditions and functional impairment.[35] Cutler et al[33] found that the presence of one of several major chronic conditions did not have a meaningful impact on life expectancy; however, functional impairments were associated with higher mortality. However, we believe the more likely explanation is that there is a substantial independent effect of multimorbidity on mortality, which may be in part mediated by functional impairment. The question of how much of this relationship is due to the independent effect of disability is not discernable in these data.

The rise of the chronic disease burden can also be seen as a function of our own success in medicine and public health.[36] Conditions that were once deadly are now chronic and can be managed through health behavior and medical technology. The consequence of these improvements is that older adults are able to accumulate more chronic conditions over their lifetime. However, the results of this study suggest that all else being equal (holding age, sex, and race constant)

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TABLE 2. Life Expectancy By Number of Comorbidities, Race, and Sex at Age 67 and 75 for US Medicare Beneficiaries, 2008

			No. Chronic Conditions										
	CDC	Overall	0	1	2	3	4	5	6	7	8	9	10+
Overall													
Age 67	17.3	16.6 (16.3, 16.9)	22.6 (19.9, 25.7)	22.2 (20.6, 24.4)	21.7 (20.4, 23.2)	20.1 (19.1, 21.3)	17.9 (16.9, 18.9)	15.4 (14.5, 16.5)	12.8 (11.8, 13.9)	10.3 (9.2, 11.3)	8.4 (7.3, 9.6)	6.9 (5.7, 8.2)	5 (4, 6.1)
Age 75	11.8	11.3 (11.0, 11.5)	16.6 (13.9, 19.7)	15.9 (14.5, 18.1)	15.8 (14.7, 17.1)	14.6 (13.8, 15.6)	13.2 (12.5, 14)	11.6 (10.9, 12.3)	10.1 (9.5, 10.7)	8.5 (7.9, 9.1)	7.1 (6.5, 7.7)	5.9 (5.3, 6.6)	4.5 (4, 5)
Female													
Age 67	18.4	17.6 (17.2, 18.0)	23.9 (20.4, 28.1)	23.6 (21.5, 26.5)	22.8 (21.3, 24.6)	21.4 (20.1, 22.9)	19.2 (17.9, 20.5)	16.9 (15.6, 18.2)	14.1 (12.7, 15.4)	11.5 (10, 13)	9.6 (8, 11.1)	7.5 (5.8, 9.3)	5.4 (4.1, 6.9)
Age 75	12.6	11.9 (11.6, 12.3)	17.3 (14, 21.4)	17 (15.2, 19.7)	16.5 (15.1, 18)	15.4 (14.4, 16.6)	13.9 (13.1, 14.9)	12.3 (11.5, 13.2)	10.8 (10, 11.6)	9.4 (8.6, 10.2)	7.8 (7.1, 8.6)	6.6 (5.7, 7.4)	4.9 (4.3, 5.5)
Male													
Age 67	15.9	15.2 (14.8, 15.7)	21.3 (17.6, 26)	20.1 (18, 22.8)	19.9 (18, 22.5)	18 (16.4, 19.8)	15.8 (14.4, 17.5)	13.3 (11.8, 14.8)	11.1 (9.6, 12.6)	8.6 (7.2, 10.1)	6.9 (5.4, 8.5)	6 (4.4, 7.8)	4.1 (2.8, 5.7)
Age 75	10.7	10.1 (9.8, 10.6)	15.6 (11.9, 20.5)	14.1 (12.1, 16.6)	14.4 (12.7, 16.9)	13 (11.7, 14.6)	11.8 (10.7, 13.1)	10.2 (9.3, 11.4)	8.9 (8, 9.9)	7.1 (6.3, 8)	5.9 (5.2, 6.8)	4.9 (4.1, 5.8)	3.8 (3.2, 4.6)
White													
Age 67	17.3	16.7 (16.3, 17.0)	22.1 (19.3, 25.5)	22.3 (20.6, 24.6)	21.9 (20.5, 23.4)	20.2 (19.1, 21.5)	17.9 (16.9, 19)	15.4 (14.4, 16.5)	12.9 (11.7, 14)	10.2 (9, 11.3)	8.3 (7, 9.6)	6.8 (5.4, 8.2)	4.9 (3.8, 6.2)
Age 75	11.8	11.3 (11.0, 11.5)	16 (13.3, 19.4)	16 (14.5, 18.1)	15.9 (14.7, 17.3)	14.7 (13.8, 15.7)	13.2 (12.5, 14.1)	11.6 (10.9, 12.3)	10.1 (9.5, 10.8)	8.4 (7.8, 9.1)	7.1 (6.5, 7.7)	5.8 (5.2, 6.5)	4.4 (4, 5)
Black													
Age 67	16.1	15.3 (14.2, 16.5)	22.7 (15.7, 32.3)	20.7 (15.9, 26.5)	19.9 (15.7, 25.1)	18.7 (14.9, 23.1)	16.3 (13, 20.2)	14.8 (11.4, 18.6)	11.6 (8.6, 15.1)	10.2 (7.2, 13.7)	8.2 (5.4, 11.5)	6.8 (3.8, 10.5)	4.9 (2.6, 7.9)
Age 75	11.3	10.5 (9.6, 11.6)	17.3 (10.4, 26.8)	14.7 (10.6, 20.1)	14.4 (10.8, 19.1)	13.6 (10.6, 17.4)	12.1 (9.6, 15.3)	11 (8.7, 14.1)	9.4 (7.3, 12.1)	8.1 (6.2, 10.5)	6.4 (4.7, 8.5)	5.7 (3.9, 8)	4.5 (3.1, 6.4)

Source: Authors' analysis of the Medicare Beneficiary Summary File and Chronic Condition Warehouse File, 2008; Arias E.[2]

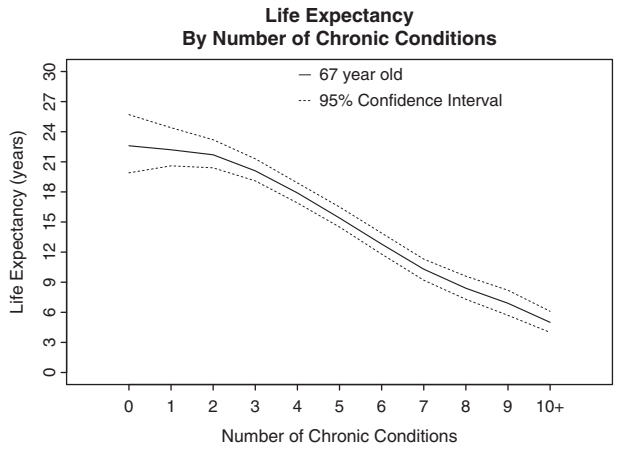

FIGURE 1. Average life expectancy and 95% confidence intervals by number of chronic conditions at age 67, 2008. *Source*: Medicare Beneficiary Summary File and Chronic Condition Warehouse File, 2008.

a consequence of living with more conditions is higher mortality and thus shorter life expectancy.

If the burden of chronic disease in the elderly continues to increase, it is possible that life expectancy improvements in older ages could slow. Social Security Administration's current forecasting approach, which accounts for the historical mortality patterns for the leading causes of death, may not adequately capture higher mortality rates among people living with multiple chronic conditions, and therefore overestimate population life expectancy. Alternative approaches that account for changes in the prevalence of specific disease and numbers of extant chronic conditions could provide more accurate estimate. A similar approach has been used to estimate life expectancy in new cancer cases.[15]

This study has several limitations. Although the Medicare data files include detailed medical history for beneficiaries in traditional (fee-for-service) Medicare, we

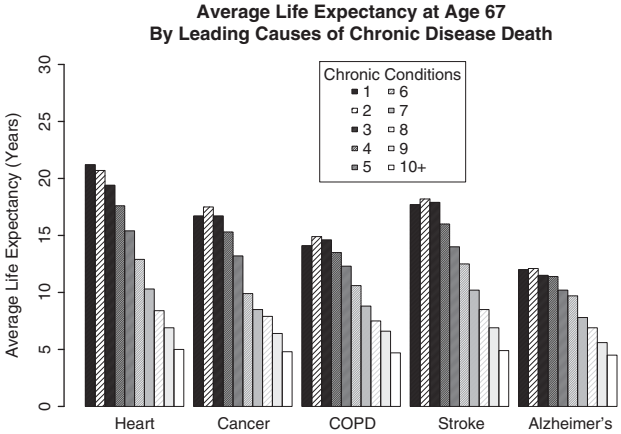

FIGURE 2. Average life expectancy among individuals with selected conditions by numbers of chronic conditions at age 67, 2008. *Source*: Medicare Beneficiary Summary File and Chronic Condition Warehouse File, 2008; Murphy et al.[30]

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cannot estimate chronic disease in Medicare beneficiaries enrolled in MA. Almost one third of Medicare beneficiaries are enrolled in MA and may be healthier than fee-for-service beneficiaries. In addition, we cannot account for the functional health state of study subjects. However, the larger sample of the Medicare 5% sample allows for more precise estimates of life expectancy for individuals with >3 chronic conditions and allows the assessment of differences by race or sex. Despite using a large dataset, some subgroup samples contained <5000 observations, which results in wide CIs. Life table analyses using small sample sizes can overestimate life expectancy, which would result in more conservative estimates of the marginal differences in life expectancy.[37]

We classify individuals using the count of conditions tracked in the CCW and other approaches may have identified different numbers of conditions. In sensitivity analyses, we explored the relationship between life expectancy and comorbidities as classified by the CCI. These results did not differ qualitatively from our main results. Our focus on summary chronic condition measures may not capture important differences among specific disease clusters. An alternative approach to studying multimorbidity is to examine various combinations of specific diseases. Previous work in this area has found that different disease combinations have heterogenous effects on mortality.[16,38,39] In some cases, the addition of a condition may have a protective effect or marginally negative effect on survival, whereas other combinations have a multiplicative effect. However, previous studies have found chronic condition counts to be a robust indicator of health.[11,35] Further work should consider developing life expectancy estimates that account for specific combinations of diseases. Researchers should consider life expectancy, but also examine the potential loss (or gain) in years with various disease combinations. Larger datasets, such as the Medicare 20% sample, may be necessary for this type of analysis.

This study does not address several important issues to policymakers about the nature of multimorbidity and life expectancy. This study cannot assess whether medical care can reduce differences in life expectancy among individuals with different levels of morbidity. Further research comparing life expectancy among individuals with multiple chronic conditions using different care delivery systems, such as integrated delivery systems and fee-for-service, or cross-country comparisons may provide additional evidence on this issue. In addition, this study does not address whether disease accumulation varies by race and sex. Understanding when individuals acquire comorbidities is important in targeting prevention programs.

CONCLUSIONS

Living with multiple chronic diseases is now the norm and not the exception in the Medicare program. These results suggest that preventing the development of additional chronic conditions in the elderly could have substantial impact on length of life. Given the increasing burden of chronic conditions in the elderly, it is important that the Social Security and Medicare actuaries consider approaches to account for the growing prevalence of multiple chronic conditions in the Medicare population when determining population projections and trust fund solvency.

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