

RESEARCH ARTICLE

Measuring the burden of multimorbidity among Medicare beneficiaries via condition counts and cumulative duration

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Objective: The study's purpose was to describe the cumulative duration of 19 chronic conditions among Medicare fee-for-service (FFS) beneficiaries and examine variation in total expenditures explained by cumulative duration and condition counts.

Design, Setting, Study Design, and Data Extraction: In a retrospective cohort of FFS beneficiaries age ≥ 68 , 2015 Medicare enrollment and claims data (N = 20 124 230) were used to identify the presence or absence of 19 diagnosed chronic conditions, and to construct MCC categories (0-1, 2-3, 4-5, 6+) and cumulative duration of each of 19 conditions from the date of first possible occurrence in claims (1/1/1999) to the end of follow-up (date of death or 12/31/2015). Total Medicare expenditures were estimated using linear models adjusted for demographic characteristics.

Principal Findings: Multimorbidity was common (71.7 percent with 2+ conditions). The mean cumulative duration of all 19 conditions was 23.6 person-years, which varied greatly by age and number of conditions. Condition counts were more predictive of Medicare expenditures than cumulative duration (R -squared for continuous measures = 0.461 vs 0.272; R -squared for quartiles = 0.408 vs 0.266).

Conclusions: The cumulative duration of chronic conditions varied widely for Medicare beneficiaries, especially for those with 6+ conditions, but was less predictive of total expenditures than condition counts.

KEYWORDS

expenditures, Medicare, multimorbidity

1 | INTRODUCTION

A foundational paper on multiple chronic conditions (MCC)¹ demonstrated that multimorbidity is common in older adults and that risk of hospital admission and Medicare expenditures in 1999 increased exponentially with the number of chronic conditions. These findings were important developments in understanding the prevalence and risks of multimorbidity among the elderly who are most likely to have two or more conditions.² Studies have since reported MCC prevalence in the United States,^{3,4} Canada,⁵ and Europe.^{6,7} The

Centers for Medicare & Medicaid Services (CMS) now generates public-use MCC statistics, based on conditions with recent diagnoses⁸ to provide a better understanding of beneficiaries' burden of chronic conditions.⁹ These MCC statistics have been used to inform CMS physician payments for Chronic Care Management.¹⁰

Condition counts are appealing because they are a simple, uniform way to compare multimorbidity between patients based on data (diagnosis codes) available in all health systems. This simple approach has at least three drawbacks. First, counts aggregate different conditions (eg, diabetes and cancer) regardless of their concordance¹¹ or cumulative association with outcomes. Second, counting chronic conditions at a point in time pools people with the same number of incident conditions (eg, two newly diagnosed

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conditions) and prevalent conditions (eg, two conditions diagnosed 10 years ago), which masks heterogeneity in underlying risk for adverse events. Third, beneficiaries with few conditions may differ from beneficiaries with many conditions by a small number of conditions that mask a large difference when considered by years of prevalence.

Given these limitations, it may be useful to conceptualize multimorbidity in ways that complement condition counts, such as the duration of comorbidity exposure as a proxy for disease severity and risk for adverse events. For example, prior work has shown that duration of diabetes has been associated with risk for stroke,¹² cognitive impairment,¹³ erectile dysfunction,¹⁴ and coronary heart disease mortality.¹⁵ It may be particularly useful to conceptualize multimorbidity in terms of duration of comorbidity exposure among elderly populations, for whom MCC burden is the greatest. Examining the duration of comorbidity exposure is feasible for the Medicare population, because the earliest date (since 1999) that a beneficiary was identified as having an initial diagnosis of a chronic condition is available but not previously used for assessing multimorbidity. Cumulative duration can complement multimorbidity as represented with condition counts by leveraging longitudinal data systematically tracked on Medicare beneficiaries.

The purpose of this study was to examine condition counts and cumulative duration of chronic conditions (in person-years) among elderly Medicare fee-for-service (FFS) beneficiaries. We describe how cumulative duration varies by category of chronic conditions (0-1, 2-3, 4-5, 6+) and demographic characteristics, and examine whether condition counts or cumulative duration explains more variation in total Medicare expenditures.

2 | METHODS

2.1 | Data source and cohort

We used the CMS Master Beneficiary Summary File (MBSF) to define the study population and identify chronic conditions among Medicare beneficiaries. The MBSF Base (A/B/C/D) segment includes beneficiary enrollment information, which we used to define the study population for this retrospective cohort study. We began with 100 percent population of Medicare enrollees ($n = 58\,349\,105$) in 2015 (Appendix S1). Beneficiaries were excluded due to enrollment in only Part A or Part B ($n = 5\,305\,358$), enrollment in Medicare Advantage for at least 1 month in 1999-2015 ($n = 27\,755\,577$), or if they had invalid data on years of follow-up ($n = 135$). Beneficiaries were also excluded ($n = 19\,113\,084$) if they were less than 68 years old as of 12/31/2015 because one of the 19 chronic conditions considered below had a 3-year claims data lookback that would have resulted in incomplete condition identification. We did not exclude beneficiaries first eligible for Medicare prior to 1999 to provide the most generalizable estimates possible.

The final analytic cohort ($n = 20\,124\,230$) included beneficiaries enrolled in 2015, who were at least 68 years of age, and had continuous fee-for-service (FFS) enrollment between 1999 and 2015. The

MBSF Chronic Conditions and Other Chronic or Potentially Disabling Conditions segments include condition variables (CCW flags) that are developed from algorithms that search Medicare claims data for specific International Classification of Diseases (ICD) diagnoses codes.¹⁶ We examined 19 conditions that are consistent with other CMS data products: Alzheimer's/dementia and related disorders, arthritis (rheumatoid and osteoarthritis), asthma, atrial fibrillation, autism spectrum disorders, cancer, chronic kidney disease, chronic obstructive pulmonary disease, depression, diabetes, heart failure, ischemic heart disease, hepatitis (chronic viral B and C), HIV/AIDS, hyperlipidemia, hypertension, osteoporosis, schizophrenia and other psychotic disorders, and stroke. Cancer was constructed as a composite of breast, lung, colorectal, and prostate cancer.¹⁷ A beneficiary was identified as having a condition in 2015 if the algorithm criteria were met, with cancer being indicated if at least one of the four cancer types was identified. In addition, for the conditions identified, the date of first occurrence in the Medicare claims is available, which we used to calculate the duration of the condition. More information on the CCW flags and the condition algorithms can be found at www.ccwdata.org.¹⁷

2.2 | Defining multimorbidity

We examined multimorbidity in terms of conventional condition counts and also the cumulative duration of exposure. Using our set of 19 conditions, we constructed condition counts as MCC categories as reported by CMS (0-1, 2-3, 4-5, 6+).^{9,18} To construct cumulative duration across all 19 conditions, first we calculated the duration of exposure to each of the 19 conditions (in person-years), which was calculated from the date of first possible occurrence (01/01/1999) to the end of follow-up (date of death or 12/31/2015). Next, we aggregated each of these duration estimates across all 19 conditions. It is worth noting that beneficiaries may have 0 years of cumulative duration if the beneficiary has none of the 19 chronic conditions. In addition, beneficiaries who have conditions counts greater than 0 may have 0 years of cumulative duration if the date of first occurrence for the chronic condition is the same as the beneficiary's date of death or is 12/31/15, which is the last day of follow-up.

2.3 | Analysis

We summarize sociodemographic characteristics available in the Medicare enrollment data of the final analytic cohort and present the prevalence of the 19 conditions and MCC categories (0-1, 2-3, 4-5, 6+). We then present variation in cumulative duration overall, as well as within each of the MCC categories, and across sociodemographic characteristics (age, sex, race/ethnicity, and Medicaid dual enrollment) to understand whether the cumulative duration differed by beneficiary characteristics.

Then, regression analysis on total Medicare expenditures in 2015 via ordinary least squares was conducted to examine whether cumulative duration explains more, similar or less variation in expenditures than condition counts, adjusted for age, sex,

race/ethnicity, and Medicaid status. Total expenditures were transformed with the cubic root given the non-normality. Condition counts and cumulative duration were entered into two separate models as continuous covariates and two additional models categorized into approximate quartiles (0-1, 2-3, 4-5, 6+ for counts and 0-4, >4-16, >16-36, and >36 person-years for cumulative duration). Exemption for this study was obtained from the Duke University Institutional Review Board.

3 | RESULTS

3.1 | Characteristics of 2015 Medicare population

Our study cohort of Medicare FFS beneficiaries had an average age of 77.1, 56.3 percent were female, and 11.2 percent were dually enrolled in Medicaid in 2015 (Table 1). A vast majority (84.8 percent) were non-Hispanic white, 6.5 percent were black, 4.5 percent were Hispanic, 2.3 percent were Asian/Pacific Islander, and 0.5 percent were American Indian/Alaska Native. Nearly one-third (32.1 percent) of beneficiaries were enrolled prior to 2000, 35.6 percent initially enrolled in 2000-2007, and the remaining 33.3 percent were enrolled between 2008 and 2015 (Appendix S2).

Among the set of 19 conditions (Table 2), the most prevalent conditions were hypertension (61.5 percent), hyperlipidemia (50.4 percent), arthritis (33.4 percent), ischemic heart disease (30.9

percent), and diabetes (27.7 percent). The prevalence of two or more conditions (eg, MCC) was 71.7 percent, with 17.3 percent having six or more chronic conditions.

3.2 | Condition counts and cumulative duration of FFS beneficiaries

When examining the cumulative duration of the 19 chronic conditions among our study population (Table 3), the mean duration was 23.6 person-years, with a median of 16.4 and a maximum of 216.9 person-years. The mean and median cumulative duration varies considerably across each of the standard MCC categories. The mean cumulative duration was 2.6 person-years (median = 0) for beneficiaries with 0-1 conditions, 17.4 (median = 15.5) for beneficiaries with 2-3 conditions, 32.9 (median = 31.9) for those with 4-5 conditions, and 56.5 (median = 55.6) for beneficiaries with 6+ conditions. The proportion of beneficiaries in this cohort with different counts was similar but not identical to national CMS statistics on multimorbidity prevalence (0-1 conditions: 32.3 percent of beneficiaries in this cohort vs 32.3 percent; 2-3 conditions: 31.1 percent in this cohort vs 30.0 percent; 4-5 conditions: 23.2 percent in this cohort vs 21.6 percent; and 6+ conditions: 17.3 percent in this cohort vs 16.2 percent).

The mean cumulative duration within MCC categories varied by age, gender, race, and dual eligibility (Table 4). Medicare eligibility bounded the measurable exposure to conditions, so younger beneficiaries in each MCC category had a lower mean cumulative duration of conditions than older beneficiaries. For example, beneficiaries with 0-1 conditions age 68-69 had a mean duration of 1.0 person-years compared to the oldest old (85+ years), who had an average of 5.1 person-years. Beneficiaries with 6+ conditions age 68-69 had a mean of 28.1 person-years compared to 69.0 person-years of cumulative duration in the oldest old. Male beneficiaries had a modestly lower mean cumulative duration than women for all condition categories.^{18,19}

Across race/ethnic groups, there were modest differences in cumulative duration. Non-Hispanic whites tended to have higher cumulative duration on average across all MCC categories than other race/ethnic groups, while Hispanic beneficiaries had lower average cumulative duration, especially among beneficiaries with lower condition counts. Beneficiaries dually enrolled in Medicaid had higher cumulative duration of conditions across all MCC categories compared to non-duals.

3.3 | Are condition counts or cumulative duration more predictive of total expenditures?

In least-squares regression that adjusted for age, sex, race/ethnicity, and Medicaid status only (Table 5), model fit was modest ($R^2 = 0.056$). The model with continuous counts had greater predictive power ($R^2 = 0.461$) than a model with a continuous measure of cumulative duration ($R^2 = 0.272$). Models based on quartiles of condition counts had less predictive power than continuous counts

TABLE 1 Characteristics of Medicare Fee-for-Service Beneficiaries, 2015

Total study population	N = 20 124 230
Age in y, mean (Standard deviation)	77.1 (7.5)
Age categories	
Age 68-69, number (%)	3 305 331 (16.4)
Age 70-74, number (%)	5 930 816 (29.5)
Age 75-79, number (%)	4 291 281 (21.3)
Age 80-84, number (%)	2 932 088 (14.6)
Age 85+, number (%)	3 664 714 (18.2)
Sex	
Male, number (%)	8 804 917 (43.8)
Female, number (%)	11 319 313 (56.3)
Race/Ethnicity	
Non-Hispanic white, number (%)	17 063 348 (84.8)
Black (Or African-American), number (%)	1 314 619 (6.5)
Hispanic, number (%)	906 574 (4.5)
Asian/Pacific Islander, number (%)	459 445 (2.3)
American Indian/Alaska Native, number (%)	93 017 (0.5)
Dual Medicaid Enrollment	
Yes, number (%)	2 256 723 (11.2)
No, number (%)	17 867 507 (88.8)

TABLE 2 Prevalence and duration of chronic conditions among Medicare Fee-for-Service Beneficiaries: N = 20 124 230

	Number (%)	Cumulative duration (person-years 1999-2015)		
		Mean	Median	Std Dev
Specific conditions				
Hypertension	12 380 464 (61.5)	9.4	9.3	5.0
Hyperlipidemia	10 137 474 (50.4)	8.9	8.7	4.9
Arthritis (rheumatoid and osteoarthritis)	6 716 469 (33.4)	7.4	6.6	5.2
Ischemic heart disease	6 222 408 (30.9)	8.1	7.7	5.3
Diabetes	5 568 006 (27.7)	7.9	7.3	4.9
Chronic kidney disease	4 037 001 (20.1)	4.2	3.0	3.8
Heart failure	3 104 822 (15.4)	5.6	4.2	4.9
Depression	2 813 990 (14.0)	6.0	4.8	5.0
Alzheimer's disease/dementia	2 489 017 (12.4)	3.9	2.7	3.7
Chronic Obstructive Pulmonary Disease (COPD)	2 350 889 (11.7)	6.4	5.6	5.0
Atrial fibrillation	2 110 444 (10.5)	5.8	4.7	4.8
Cancer (breast, colorectal, lung, prostate)	1 948 613 (9.7)	6.7	5.5	5.0
Asthma	1 570 667 (7.8)	4.8	2.9	5.2
Osteoporosis	1 475 072 (7.3)	6.7	5.9	5.2
Stroke	901 896 (4.5)	3.9	1.7	4.6
Schizophrenia/other psychoses	510 461 (2.5)	3.4	1.4	4.6
Hepatitis (Chronic viral B and C)	64 449 (0.3)	5.1	3.7	4.4
HIV/AIDS	14 796 (0.1)	7.2	6.0	5.1
Autism	3008 (0.0)	4.4	2.0	5.0
Number of chronic conditions				
0-1 Chronic conditions	5 698 784 (28.3)			
2-3 Chronic conditions	6 263 676 (31.1)			
4-5 Chronic conditions	4 676 475 (23.2)			
6+ Chronic conditions	3 485 295 (17.3)			

Notes: Chronic conditions are identified based upon the Chronic Condition Data Warehouse (CCW) "end-of-year" indicators, which indicate whether a beneficiary met the CCW criteria for the condition algorithm as of the end of the calendar year. These variables are available from the CCW Master Beneficiary Summary—Chronic Conditions segment. Duration of exposure to each of the 19 conditions (in person-years) is calculated from the date of first possible occurrence (01/01/1999) to the end of follow-up (date of death or 12/31/2015).

($R^2 = 0.408$), but more power than the model with continuous cumulative duration. The model with quartiles of cumulative duration had the least predictive power of all models ($R^2 = 0.266$).

4 | DISCUSSION

Assessing multimorbidity via condition counts was an important advance in our understanding of the prevalence and burden of multimorbidity in older adults, which has enabled population surveillance in Medicare.⁹ This simple approach to measuring comorbidity

burden can be complemented by measures that address some of its limitations, such as the cumulative duration of multiple conditions described here.

This analysis found that Medicare beneficiaries have significant variation in multimorbidity as measured by cumulative duration. For the 19 conditions examined, the mean cumulative duration in our Medicare study population was 23.6 person-years, based on a mean condition count of 3.2. This suggests that the average FFS beneficiary had each of these conditions an average of nearly 7.5 years in 2015. We also found that there was variation in cumulative duration by number of conditions, especially in the 6+ condition category in

TABLE 3 Chronic conditions counts and cumulative duration among Medicare Fee-for-Service Beneficiaries: N = 20 124 230

	N	Prevalence (%)	Cumulative duration (person-years 1999-2015)				
			Mean	Median	Std Dev	Min	Max
Overall	20 124 230		23.6	16.4	24.0	0	216.9
0-1 Chronic conditions	5 698 784	28.3	2.6	0	4.2	0	17.0
2-3 Chronic conditions	6 263 676	31.1	17.4	15.5	11.1	0	51.0
4-5 Chronic conditions	4 676 475	23.2	32.9	31.9	16.8	0	84.9
6+ Chronic conditions	3 485 295	17.3	56.5	55.6	26.4	0	216.9

Notes: Chronic conditions are identified based upon the Chronic Condition Data Warehouse (CCW) “end-of-year” indicators, which indicate whether a beneficiary met the CCW criteria for the condition algorithm as of the end of the calendar year. These variables are available from the CCW Master Beneficiary Summary—Chronic Conditions segment. Duration of exposure to each of the 19 conditions (in person-years) is calculated from the date of first possible occurrence (01/01/1999) to the end of follow-up (date of death or 12/31/2015). For beneficiaries with two or more conditions, a duration of zero can arise under two scenarios: (a) in the Medicare claims, the beneficiary has a date of death that is the same as the chronic condition “ever” date, (b) if the beneficiary is alive, the chronic condition “ever” date is 12/31/15, which is the last day of follow-up.

which the mean cumulative duration was 56.5 person-years but the maximum was 216.9 person-years.

There was also significant variation in cumulative duration by age, ranging from a mean of 7.3 person-years in beneficiaries aged 68-69 with 0-1 conditions to 26.4 person-years in beneficiaries aged 85+. This variation was even greater among those with 6+ conditions,

ranging from a mean of 28.1 person-years in beneficiaries aged 68-69 to 69.0 person-years in beneficiaries age 85+. This age variation was likely driven mostly by time since Medicare eligibility, which limits the upper bound of measurable exposure to conditions in the youngest beneficiaries. We found few differences in cumulative duration by sex, race/ethnicity, and dual eligibility.

TABLE 4 Cumulative duration by chronic condition counts for Medicare beneficiary characteristics in 2015: N = 20 124 230

Beneficiary characteristics	Number of chronic conditions							
	0-1 (N = 5 698 784)		2-3 (N = 6 263 676)		4-5 (N = 4 676 475)		6+ (N = 3 485 295)	
	Person-years (1999-2015)							
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Age (y)								
Age 68-69	1.0	0	7.3	6.4	14.4	12.0	28.1	19.9
Age 70-74	1.9	0	12.7	12.0	23.1	21.9	39.3	35.1
Age 75-79	3.5	0	20.3	20.2	35.1	35.3	55.1	53.6
Age 80-84	4.7	0	25.7	26.0	43.6	44.5	67.1	66.5
Age 85+	5.1	1	26.4	26.7	44.5	45.4	69.0	68.2
Sex								
Male	2.2	0	16.6	14.5	31.7	30.2	54.0	58.0
Female	2.9	0	18.0	16.2	33.8	33.2	58.4	57.5
Race/Ethnicity								
Non-Hispanic white	2.7	0	17.6	15.7	33.2	32.3	56.7	55.9
Black (Or African-American)	2.3	0	17.7	15.6	32.5	31.0	56.0	54.7
Hispanic	1.7	0	16.0	13.7	31.3	29.5	56.2	54.9
Asian/Pacific Islander	2.0	0	16.3	14.0	31.1	29.4	52.9	52.0
American Indian/Alaska Native	2.7	0	17.2	15.4	31.9	30.6	54.6	53.1
Dual Medicaid Enrollment								
Yes	2.9	0	18.9	17.2	34.7	34.2	60.8	60.0
No	2.5	0	17.3	15.3	32.6	31.5	55.2	54.5

Notes: Chronic conditions are identified based upon the Chronic Condition Data Warehouse (CCW) “end-of-year” indicators, which indicate whether a beneficiary met the CCW criteria for the condition algorithm as of the end of the calendar year. These variables are available from the CCW Master Beneficiary Summary—Chronic Conditions segment. Duration of exposure to each of the 19 conditions (in person-years) is calculated from the date of first possible occurrence (01/01/1999) to the end of follow-up (date of death or 12/31/2015).

TABLE 5 Model fit (*R*-squared) of Linear Regression on total Medicare expenditures

	Condition count	Cumulative duration
<i>R</i> -squared of model excluding count and duration (adjusts only for age, sex, race/ethnicity, Medicaid status)	0.0555	
<i>R</i> -squared in models with continuous count or duration	0.4609	0.2715
<i>R</i> -squared in models with quartiles of count or duration	0.4083	0.2656

Notes: Medicare expenditures include total Medicare payments for all Medicare covered services in Parts A and B.

Regression adjusted for age, sex, race/ethnicity, and Medicaid status.

Disease duration is a long-standing concept, which has been considered a proxy for severity of individual conditions. In prior epidemiologic studies, diabetes duration has been shown to be correlated with risk for stroke,¹² cognitive impairment,¹³ erectile dysfunction,¹⁴ and coronary heart disease mortality,¹⁵ but not cardiovascular disease mortality^{15,20} or lower limb amputation.²¹ This is the first study to apply disease duration to multiple conditions in Medicare FFS claims to represent the cumulative duration as a measure of multimorbidity as in this paper. Duration may be a reasonable proxy for severity for some of these 19 conditions, but may be more akin to lifetime prevalence for other conditions that are more episodic. For example, prior studies of depression have reported significant differences in lifetime and prevalent major depressive episodes.^{22,23}

Despite the considerable variation in cumulative duration to these 19 chronic conditions that we found, the count of current conditions was a better predictor of total Medicare expenditures in 2015 than cumulative duration. This result was surprising because cumulative duration was expected to be a reasonable proxy for the severity of multimorbidity (not just its presence) and the standard deviation of cumulative duration was nearly equal to the mean while the standard deviation of condition counts was less than the mean. However, duration may not be a reasonable proxy for severity for all of the conditions used in the cumulative duration measure. Cumulative duration may be more predictive for specific conditions (eg, diabetes) than for others (depression). A measure of cumulative duration that weights conditions according to their importance to the outcome of interest, as done in risk adjustment measures, may improve its predictive power. A multimorbidity index developed by Wei and colleagues constructed weights based on each condition's association with physical functioning²⁴ and showed it to be more predictive of future physical functioning than condition counts and the Charlson Comorbidity Index.²⁵

Despite cumulative duration being less predictive of Medicare expenditures than condition counts, this new measure could be useful in two ways. First, cumulative duration may be more predictive than condition counts for other outcomes to be examined in future work, such as medication refill adherence or hospitalization. Second, cumulative duration may be a useful way to conduct population surveillance of multimorbidity that complements current MCC statistics reporting.

When applied to populations, the clinical and cost implications of multimorbidity as measured by cumulative duration may be very different depending upon which of three general patterns are observed in a given condition category. The first potential pattern of the distribution of person-years, for the 6+ condition category for example, would be plurality of beneficiaries with cumulative duration of 6-10 years, which would suggest that most of these beneficiaries have incident conditions and may have yet to incur significant costs of caring for acute exacerbations or chronic worsening of these conditions. We did not find this pattern in this analysis of Medicare beneficiaries, but such a pattern might be observed in a younger or employed population. One clinical implication of such a pattern may be that care management strategies may be more homogeneous given this clustering of beneficiaries.

The second potential pattern for the 6+ condition category would be a person-year distribution with a point mass near 75-90 years indicating that most beneficiaries have multiple conditions of long-standing prevalence that may be difficult to improve, which is what we found in this study of Medicare FFS beneficiaries in 2015. One clinical implication may be that care management strategies for these higher-risk patients could also be homogeneous, but more focused on treatment de-intensification. A third potential pattern would be a uniform distribution across person-years, which would suggest that there is a heterogeneous mix of prevalent and incident conditions for which a broader array of care management strategies must be tailored to the particular mix of conditions and durations of conditions.

Condition counts were an important first step in characterizing the health needs of Medicare beneficiaries, but there is growing recognition that beneficiaries are complex in ways beyond simple condition counts when measured by surveys.²⁶ There is a need to develop complementary methods to characterize the complexity of beneficiaries in the absence of population-wide survey data. This descriptive paper comparing cumulative duration and condition counts is a first step in that direction, as is the recent weighted measure by Wei and colleagues.^{24,25} The cumulative duration measure assumes that different conditions may have different impacts on patients, which is similar in spirit to the way that risk adjustment weights conditions differently, based on their importance in explaining the outcome of interest. Further, it is akin to lifetime prevalence

of conditions instead of truly “active” conditions that are currently prevalent. Cumulative duration may be a useful way to understand variation in Medicare expenditures because it shares many of the same advantages of ideal case mix measures (eg, intuitive, not gameable),²⁷ even though it was less predictive than condition counts. Future work could apply this cumulative duration to examine subgroups (eg, those with diabetes and depression) or other outcomes, such as mortality, that may be sensitive to variation in this measure.

There are limitations that must be acknowledged. First, these results may not generalize to Medicare Advantage enrollees because all beneficiaries with 1+ months of enrollment back to 1999 were excluded. However, FFS beneficiaries in 2015 represented 68 percent of the Medicare population. Medicare managed care enrollees were excluded from this analysis because due to the lack of encounter data it was not possible to observe the presence of chronic conditions while MA enrolled, which could significantly undercount their person-years of chronic conditions.


Second, the person-years of chronic conditions were based upon the first-identified date only back to 1999, which is an underestimate for beneficiaries enrolled prior to 1999 whose incidence of these 19 conditions occurred prior to 1999. There is no information available in Medicare claims on duration of conditions prior to Medicare enrollment. As a result, the duration estimates are subject to left censoring that results in means and variances being under-estimated. Relatedly, cumulative duration may not correlate with the severity of some conditions as well as it does with other conditions. For some conditions like diabetes, the duration of comorbidity exposure may be a reasonable proxy for disease severity, but may not be quite appropriate for others (depression) where lifetime prevalence is distinct from but related to current prevalence because of the possibility of remission (and relapse). Further, some older patients with high scores have been alive in 2015 because the severity of their conditions was modest, but we did not have the laboratory data to measure severity. These factors may partly explain why cumulative duration was less predictive of Medicare expenditures than condition counts. The ideal approach to addressing these issues would be to link Medicare claims to commercial claims in an all-payer database that includes laboratory and medication data to be able to characterize the actual first incidence of each condition via diagnoses, medication use, and laboratory values. Third, the point-prevalent estimates for the 19 conditions are based on diagnoses only and medications were not considered. If there were coding/billing changes over the 16-year study period, diagnosis of conditions may have occurred later than the date of the actual onset of certain conditions. As a result, the years of exposure to certain conditions would be undercounted, as would the cumulative duration measure. However, there do not appear to be major coding changes in Medicare claims in 2007-2015, based on the reported prevalence of chronic conditions reported by Medicare. Any changes in coding/billing that did occur were less likely to bias the condition counts, which were based on current diagnoses. Fourth, the lookback periods differed across the 19 conditions based upon validation studies that underpin the condition coding.

Medicare beneficiaries have tremendous variation in cumulative duration of common chronic conditions especially in the upper tail of the distribution, which is masked by conventional condition counts. However, condition counts were more predictive of total expenditures than cumulative duration. Yet, identification of distinct subgroups of high-risk beneficiaries by cumulative duration may be useful for more precise targeting of clinical interventions to patients who will realize the greatest benefit and whose health remains modifiable, which may inform payment and policy strategies to address the increasing prevalence of multimorbidity.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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