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Medicare Beneficiaries with a High Risk of a Poor Outcome from COVID-19

3M Clinical and Economic Research

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Executive Summary

The COVID-19 pandemic has created extraordinarily high demand for essential products, such as personal protective equipment, ventilators, and diagnostic and antibody tests, that far exceeds supply, leading to the need for strategic planning for the allocation of these scarce resources. In addition, managing the health and economic consequences of COVID-19 requires a broad range of targeted population management efforts such as the identification of individuals who should be isolated because they are at high risk for a poor COVID-19 prognosis. In the Medicare population, common risk factors like hypertension and diabetes are so prevalent that a more refined and clinically precise identification is needed to determine the individuals who have the highest risk of a poor COVID-19 prognosis that leads to hospitalization, critical care/ICU admission, mechanical ventilation or death**.**

Early COVID-19 studies indicate that when older people contract the virus, they have a poorer prognosis, especially those 80 years or more and those with diabetes, chronic respiratory or cardiac diseases, immunosuppression or with multiple major comorbid chronic conditions. These COVID-19 risk factors were analyzed in conjunction with a comprehensive identification of patients with multiple high-severity comorbid chronic conditions to develop an operational definition of individuals with a high risk of a COVID-19 poor prognosis.

Using a five percent sample of Medicare beneficiaries from 2017, the prevalence of high-risk Medicare beneficiaries was examined across geographic regions. The high-risk model was very targeted with beneficiaries considered high risk if they had known COVID-19 risk factors in two or more different organ systems, or had multiple major comorbid chronic conditions at high severity. Based on this definition of high risk, 16.1 percent of Medicare beneficiaries were found to be at high risk. When beneficiaries 85 or older who had no COVID-19 risk factors or major chronic comorbidities where included, the percent of high-risk beneficiaries increased to 23.8 percent.

The variation in the proportion of high-risk Medicare beneficiaries was examined across census region and individual states. The percent of high-risk Medicare beneficiaries ranged from 6.89 percent higher than the national average in the Middle Atlantic region to 18.3 percent below the national average the Mountain region. The percent of high-risk Medicare beneficiaries by state ranged from 14.47 percent higher than the national average to 34.18 percent lower than the national average. The relatively substantial level of variation in the percent of high-risk beneficiaries is important to take into consideration as governments, insurers and healthcare providers proactively plan and prioritize COVID-19 related efforts. The percent of high-risk Medicare beneficiaries by race, gender and across states was found to be consistent with the reported COVID-19 mortality rates in these populations, suggesting that the definition of high risk developed in this report reflects the risk of a poor COVID-19 prognosis. The model used in this report to identify individuals at high risk for a poor COVID-19 prognosis provides a standard definition of high-risk Medicare beneficiaries that can be readily implemented and adapted to non-Medicare populations.

Introduction

The COVID-19 pandemic has created high demand for products such as personal protective equipment (PPE), mechanical ventilators, vaccines and pharmaceuticals as well as services such as diagnostic and antibody testing, hospitalizations and intensive care unit beds. When demand surges past supply, policy makers in governments, health ministries, insurers and health systems must prioritize the allocation of scarce resources.

Definitive studies of epidemics and pandemics come long after the event, but timely scientific guidance is urgently needed to guide policies and clinical decisions. The identification of individuals who are most at risk for a poor COVID-19 prognosis requiring hospitalization and mechanical ventilation, and potentially a higher risk of mortality, is essential for both proactive planning and prioritization of the distribution of scarce resources. Clear identification of high-risk individuals facilitates answers to critical questions: Which individuals and population segments might benefit from extended sequestration to avoid exposure to COVID-19? How might an employer, health insurer, or health authority prioritize distribution of PPE? Who might be advised to call for assistance rather than attempt to deal with COVID-19 illness at home due to their high risk of a poor prognosis? When a vaccine becomes available, who gets it earlier rather than later? Can geographic variations in the proportion of the population at high risk be used as the basis for planning the distribution of scarce resources? As hospitals return to providing elective surgeries, should low risk COVID-19 individuals be prioritized first?

The identification of high-risk COVID-19 individuals must account for age, presence of high risk COVID-19 related conditions, comorbidities (the burden of chronic illnesses), as well as severity of illness. This report applied a modification of a widely-used clinical categorical model – Clinical Risk Groups (CRGs) – to identify the proportion of Medicare beneficiaries at high risk of a poor COVID-19 prognosis.

The CRGs have already been applied to a population in Spain for the purpose of prioritizing the distribution of PPE across geographic locations. The health authorities of the Valencian Community of Spain are using CRGs to identify individuals at greatest risk of a poor COVID-19 prognosis and are using the results as the basis of PPE distribution[1].

Background

Some individuals who contract COVID-19 have a worse prognosis due to their age or pre-existing chronic conditions. Early studies indicate that when older people contract COVID-19, especially those 80 years or more, and those with diabetes, chronic respiratory or cardiac diseases, or immunosuppression, they have a greater likelihood of hospitalization, critical care/ICU admission, mechanical ventilation or death than people without these pre-disposing high-risk factors. The term “high risk” is used to refer to individuals who are likely to have a poor COVID-19 prognosis. The use of this term is *not* intended to:

- Identify individuals most likely to contract COVID-19
- Be a basis for deciding who receives life-saving interventions in a hospital
- Identify and track people who have contracted COVID-19

This report has the following objectives:

- Develop an operational standard definition of high-risk Medicare beneficiaries
- Determine the prevalence of high-risk beneficiaries in the Medicare population
- Examine the geographic variation in the prevalence of high-risk Medicare beneficiaries across census regions and states and by beneficiary race and gender

The presence of diabetes, chronic respiratory or cardiac disease or immunosuppression have been reported as risk factors for a COVID-19 poor prognosis and are conditions that could be used to identify high--risk Medicare beneficiaries. However, these conditions are very prevalent in the Medicare population, so basing the analysis on just these factors would result in a significant portion of Medicare beneficiaries being identified as high risk. At the same time there are many other high-risk conditions that exist that have not yet been identified as COVID-19 risk factors because they occur less frequently. In addition, reporting of risk factors during the early stages of the pandemic failed to account for the severity of these underlying risk factors. For example, a diabetic experiencing severe uncontrolled diabetes with end-organ damage would be expected to have greater risk of a poor COVID-19 prognosis than a person with mild well-controlled diabetes.

In addition to specific high-risk COVID-19 diagnoses, early COVID-19 studies showed that people with multiple comorbid conditions are at greater risk for a poor prognosis. Just as a diagnosis with no indication of severity obscures the heterogeneity of the disease, so will a non-specific identification of the presence of multiple comorbidities obscure the heterogeneity of overall illness burden. For example, a person with two relatively minor chronic conditions (e.g. well-controlled hypertension and migraines) is likely not at the same risk as a person with two major conditions (e.g. congestive heart failure and chronic obstructive pulmonary disease) even though both of these are examples of an individual with multiple comorbid conditions.

Development of a Standard Definition of High-risk Beneficiaries

To better identify the risk of a poor COVID-19 related prognosis, a standard definition of high risk was developed. A beneficiary identified as high risk would be more likely to have a poor COVID-19 prognosis requiring hospitalization, admission to a critical care unit/ICU, mechanical ventilation or death. The following risk factors were used to designate a person as high risk:

- Presence of a COVID-19 specific high-risk condition
- Presence of significant comorbidity
- Presence of high-severity illness burden
- Age greater than 80 or 85 years

These four risk factors were evaluated to determine beneficiaries at high risk.

Clinical Risk Groups (CRGs)

To identify high-risk COVID-19 conditions, significant comorbidity and high severity of illness burden, the CRG classification system was utilized. CRGs are a categorical clinical model that analyzes historical claims data to assign patients to a single mutually exclusive category that defines an individual's chronic disease burden[2]. Appendix A contains CRG research articles and studies using CRGs. Each CRG is composed of a base CRG that describes the patient's most significant chronic conditions and two to six explicit severity levels that distinguish differences in chronic disease burden due to severity of illness (see Appendix B for a more detailed description of CRGs.) For a beneficiary, the CRGs identify the presence of any of 966 conditions referred to as Diagnostic Sub Groups (DSGs). The CRGs summarize an individual's burden of comorbid chronic disease into nine status levels with each status level having between two and six severity levels. The DSGs, the CRG statuses and severity levels can be used to identify high-risk conditions, significant comorbidity and high severity beneficiaries.

Identifying High-risk COVID-19 Conditions

A review of the available literature (see Appendix C) was conducted to identify high-risk COVID-19 related conditions that are readily available in administrative data. Following the literature survey, a clinical review team of five physicians and three nurses reviewed the list of 966 DSGs from CRGs, using a modified Delphi method to select 109 DSGs that would increase the risk of a poor COVID-19 prognosis. These DSGs are pre-existing chronic risk factors and do not include acute complications of COVID-19 such as sepsis. The 109 high-risk DSGs are contained in Appendix D. Many of the COVID-19 related DSGs like hypertension and diabetes can have a wide range of clinical significance and are very prevalent in the Medicare population, potentially making them difficult to use for identifying a narrow segment of the Medicare population as high risk. This necessitated a more restrictive application of the DSGs with a focus on individuals with significant comorbid conditions in order for the DSG to be effective in identifying individuals with a high risk of a poor COVID-19 prognosis.

Identifying Comorbidities

The nine status levels and severity levels from the CRGs can be used to identify significant comorbidity and high severity of illness individuals as shown in Table 1, which identifies beneficiaries with significant chronic comorbidities (CRG status 6 and 7) and beneficiaries with severe underlying illness (CRG status 8 and 9):

- **Status 6** - Dominant or Moderate Chronic Disease in Multiple Organ Systems, e.g., Diabetes, and COPD
- **Status 7** - Dominant Chronic Disease in Three or More Organ Systems, e.g., CHF, Diabetes, and COPD
- **Status 8** - Malignancy, Under Active Treatment, e.g., Lung Cancer
- **Status 9** - Catastrophic Conditions, e.g., Major Organ Transplant

Table 1: *High-risk (HR) comorbidities based on CRG status and severity level*

CRG Status		Severity Level 1	2	3	4	5	6
1.	Healthy						
2.	History of Significant Acute Disease						
3.	Single Minor Chronic Disease						
4.	Minor Chronic Disease in Multiple Organ Systems						
5.	Single Dominant or Moderate Chronic Disease						
6.	Dominant or Moderate Chronic Disease in Multiple Organ Systems	HR	HR	HR	HR	HR	HR
7.	Dominant Chronic Disease in Three or More Organ Systems	HR	HR	HR	HR	HR	HR
8.	Dominant and Metastatic Malignancies under Active Treatment	HR	HR	HR	HR	HR	HR
9.	Catastrophic Conditions	HR	HR	HR	HR	HR	HR

Because many Medicare beneficiaries have multiple underlying chronic conditions, there will be a large volume of status 6 beneficiaries.

Beneficiary Age

Patient age is frequently cited as a COVID-19 risk factor. However, that may be largely due to the high frequency of comorbid chronic conditions in the elderly population. Age will be evaluated as an additional factor after first characterizing beneficiaries in terms of COVID-19 risk factors, comorbidities and severity.

High-risk Models

Two models for identifying high-risk beneficiaries were evaluated. In Model 1, beneficiaries are considered high risk if they have any of the 109 DSGs or are assigned to CRG status 6-9. In the more restrictive Model 2, beneficiaries are considered high risk if they have DSGs impacting two or more different organ systems or are assigned to CRG status 7-9. The organ systems are defined in Appendix D and are based on the CRG Major Diagnostic Categories described in Appendix B.

Data

The data used in the study was the Medicare Standard Analytic Files (Limited Data Set (LDS)) for calendar year 2017. The LDS files contain 100 percent of Medicare fee-for-service claims data for inpatient, outpatient, skilled nursing facilities and home health agencies. The LDS carrier file

contains Medicare fee-for-service claims data for professional providers, including physicians, physician assistants, clinical social workers, and nurse practitioners for a random sample of five percent of Medicare beneficiaries. The LDS Master Beneficiary Summary File (MBSF) contains enrollment data on all Medicare beneficiaries enrolled in or entitled to Medicare within a given calendar year.

To identify the burden of chronic disease and identify high-risk Medicare beneficiaries, it was necessary to build a complete longitudinal record of all fee-for-service claims for each Medicare beneficiary. Because the LDS carrier file was limited to a five percent sample of Medicare beneficiaries, the data in this study was limited to the beneficiaries in the LDS carrier file. There were 2,125,425 Medicare beneficiaries in the LDS carrier file. The carrier file is a sample across all types of beneficiaries including beneficiaries in Medicare Advantage plans. To create a sample of FFS beneficiaries with a complete year of data, the following edits were applied:

- Exclude beneficiaries who were not enrolled in both Part A and B for the full year (i.e., newly enrolled during 2017, dis-enrolled during 2017 or reported died in 2017)
- Exclude beneficiaries who were enrolled in a managed care plan for one or more months
- Exclude beneficiaries who were enrolled in hospice

After these exclusions were applied, there were 1,410,274 beneficiaries in the analysis data.

Overall Results

Table 2 summarizes the counts and percentages of beneficiaries for Models 1 and 2. For Model 1, 71.5 percent of beneficiaries have a high-risk DSG or CRG, with the percent of beneficiaries considered high risk increasing to 73.0 percent if beneficiaries over 85 are included as high risk and 74.8 percent if beneficiaries over 80 are included as high risk. Such a high percent of beneficiaries categorized as high risk makes Model 1 impractical for identifying high-risk beneficiaries and taking targeted actions.

For Model 2, 16.1 percent of beneficiaries have a high-risk DSG or CRG with the percent of beneficiaries considered high risk increasing to 23.8 percent if beneficiaries over 85 are considered high risk and 32.0 percent if beneficiaries over 80 are considered high risk. In Model 2, the addition of age as a risk factor has a much more dramatic impact on the volume of beneficiaries considered high risk. The inclusion of age means that beneficiaries with no reported COVID-19 risk factors or major comorbidities are consider high risk. Model 2 with age 85 or over is a conservative approach to using age as a risk factor that also results in the volume of beneficiaries identified as high risk being at a reasonable level (23.8 percent) for taking targeted actions. More complete details on the composition of the factors in each Model are contained in Appendix E.

Table 2: *Counts and percent of beneficiaries for Models 1 and 2*

	Model 1		Model 2	
	Count	Percent	Count	Percent
HR DSG	953,075	67.6	116,862	8.3
HR CRG	725,588	51.5	185,411	13.1
Either HR DSG/CRG	1,008,691	71.5	226,743	16.1
Add Age > =85	1,028,994	73.0	335,137	23.8
Add Age > =80	1,054,977	74.8	451,388	32.0

Geographic Variation in COVID High-risk Beneficiaries

Using Model 2 with age greater or equal to 85, Table 3 contains the percent (rate per hundred) of high-risk beneficiaries in each census region. The last column in Table 3 is the percent difference for each census region of the rate of high-risk beneficiaries per hundred beneficiaries compared to the national rate of high-risk beneficiaries per hundred beneficiaries of 23.8. The percent of high-risk Medicare beneficiaries varies from 25.4 percent for the Middle Atlantic region (6.89 percent higher than the national percent) to 19.4 for the Mountain region (18.3 percent below the national percent).

Table 3: *Percent of high-risk beneficiaries by census region for Model 2 with age >= 85*

Region	Count	HR DSG	HR CRG	Age>=85	HR DSG CRG Age	Percent High Risk	Percent Diff
New England	82,119	5,741	10,081	8,922	19,355	23.6	-0.82
Middle Atlantic	180,062	14,558	23,902	20,791	45,736	25.4	6.89
South Atlantic	307,567	26,337	41,878	28,339	73,655	23.9	0.77
E North Central	220,653	19,832	31,005	21,513	55,003	24.9	4.90
E South Central	103,497	9,486	14,538	7,947	24,189	23.4	-1.65
W South Central	152,447	14,666	21,605	12,859	36,967	24.2	2.04
W North Central	101,682	7,977	12,879	10,541	24,515	24.1	1.45
Mountain	92,232	6,127	9,635	7,373	17,908	19.4	-18.30
Pacific	170,015	12,138	19,888	16,821	37,809	22.2	-6.42
Total	1,410,274	116,862	185,411	231,763	335,137	23.8	0.00

Using Model 2 with age greater or equal to 85, Table 4 contains the percent of high-risk beneficiaries in each state. The last column in Table 4 is the percent difference for each state compared to the national percent of 23.8. Connecticut (14.47 percent higher than the national percent), DC (10.98 percent higher than the national percent) and Florida (9.53 percent higher than the national percent) have the highest percent of high-risk Medicare patients. Alaska (34.18 percent lower than the national percent), Montana (21.46 percent lower than the national percent) and New Mexico (18.63 percent lower than the national percent) have the lowest percent of high-risk Medicare patients. While the states with the largest percent of high-

Table 4: *Percent of high-risk beneficiaries by state for Model 2 with age >= 85*

State	Count	HR DSG	HR CRG	HR Age	HR DSG CRG Age	Percent High Risk	Percent Diff
Alabama	28,340	2,316	3,483	2,114	6,020	19.5	-10.61
Alaska	3,222	158	294	182	504	14.8	-34.18
Arizona	26,874	1,851	2,735	2,150	5,204	17.9	-18.51
Arkansas	18,362	1,503	2,313	1,474	4,065	20.4	-6.84
California	114,892	8,754	14,241	11,899	26,849	21.8	-1.66
Colorado	18,665	1,224	1,921	1,501	3,554	17.9	-19.87
Connecticut	17,458	1,393	2,389	2,372	4,749	25.8	14.47
Delaware	6,908	564	911	575	1,605	21.2	-2.23
DC	2,476	210	373	275	653	25.1	10.98
Florida	93,182	8,460	13,468	10,140	24,255	24.2	9.53
Georgia	39,242	3,515	5,413	3,055	9,109	21.3	-2.32
Hawaii	4,386	287	471	556	1,036	22.3	-0.60
Idaho	7,714	489	798	653	1,530	18.7	-16.54
Illinois	61,299	5,306	8,370	6,274	15,259	23.2	4.75
Indiana	34,320	3,169	5,039	3,209	8,646	23.5	6.01
Iowa	19,320	1,490	2,322	2,153	4,705	22.6	2.48
Kansas	16,835	1,309	2,048	1,785	4,006	22.1	0.13
Kentucky	24,973	2,547	3,801	1,928	6,198	22.9	4.44
Louisiana	20,892	2,180	3,218	1,648	5,274	23.0	6.23
Maine	8,855	612	1,039	877	1,987	21.2	-5.57
Maryland	31,929	2,615	4,196	3,187	7,700	22.5	1.48
Massachusetts	36,944	2,632	4,619	3,860	8,696	22.2	-0.95
Michigan	48,826	4,707	7,386	4,713	12,645	24.1	8.98
Minnesota	14,707	988	1,816	1,649	3,551	23.0	1.60
Mississippi	19,033	1,791	2,794	1,409	4,529	21.7	0.13
Missouri	30,901	2,745	4,404	2,778	7,598	22.8	3.47
Montana	6,563	368	636	543	1,225	17.6	-21.46
Nebraska	11,101	827	1,277	1,222	2,599	21.9	-1.48
Nevada	10,842	818	1,307	727	2,160	18.5	-16.16
New Hampshire	9,443	538	994	851	1,894	19.0	-15.60
New Jersey	47,605	3,849	6,216	5,469	12,001	23.4	6.08
New Mexico	9,267	613	1,039	687	1,792	18.1	-18.63
New York	75,392	5,993	10,014	8,878	19,246	23.8	7.42
North Carolina	49,690	4,244	6,928	4,083	11,692	21.8	-0.98
North Dakota	3,927	306	481	478	999	23.6	7.05
Ohio	50,960	4,756	7,235	4,910	12,794	23.4	5.65
Oklahoma	21,938	2,206	3,193	1,730	5,357	22.2	2.76
Oregon	15,695	917	1,658	1,277	3,037	18.4	-18.57
Pennsylvania	57,065	4,716	7,672	6,444	14,489	23.8	6.84
Rhode Island	4,416	318	529	494	1,044	22.1	-0.52
South Carolina	29,110	2,145	3,441	2,064	5,906	18.6	-14.62
South Dakota	4,891	312	531	476	1,057	20.3	-9.06

State	Count	HR DSG	HR CRG	HR Age	HR DSG CRG Age	Percent High Risk	Percent Diff
Tennessee	31,151	2,832	4,460	2,496	7,442	22.0	0.53
Texas	91,255	8,777	12,881	8,007	22,271	22.4	2.70
Utah	8,350	511	785	776	1,664	18.7	-16.14
Vermont	5,003	248	511	468	985	18.7	-17.15
Virginia	43,003	3,361	5,290	4,035	9,742	21.1	-4.67
Washington	31,820	2,022	3,224	2,907	6,383	18.9	-15.59
West Virginia	12,027	1,223	1,858	925	2,993	22.9	4.72
Wisconsin	25,248	1,894	2,975	2,407	5,659	21.0	-5.68
Wyoming	3,957	253	414	336	779	19.0	-17.16

risk beneficiaries tend to be states with large urban populations, there are notable exception such as California, Virginia and Wisconsin with a percent of high-risk beneficiaries that is lower than the national average (-1.66, -4.67 and -5.68 percent, respectively).

The COVID-19 mortality rate in a state is influenced by a complex interaction of many factors including the proportion of high-risk patients, population density, the extent of travel in and out of the state and compliance with social distancing and stay at home policies. Because over 75 percent of all COVID-19 deaths occur in the 65 or older population[3], the overall COVID-19 mortality rate in a state is highly impacted by the Medicare population. Therefore, the overall COVID-19 mortality rate in a state should be related to the proportion of the state's Medicare population who are at high risk for a poor COVID-19 prognosis.

Using the COVID-19 mortality rate per 100,000 as of May 18, 2020 for each state[4], the correlation between the mortality rate per 100,000 and the percent (rate per 100) of high-risk Medicare patients is 0.4546 (significant at the 99 percent confidence level) suggesting that the definition of high risk developed in this report reflects the risk of a poor COVID-19 prognosis. The COVID-19 mortality rate across states is changing at different rates because states can be at different stages in the COVID-19 pandemic, with some states experiencing a decreasing rate of new COVID-19 cases and other states seeing an increasing rate of new COVID-19 cases. The ultimate correlation between the COVID-19 population mortality rate and percent of high-risk beneficiaries cannot be determined until all states have reached the end stage of the COVID-19 pandemic.

The COVID-19 mortality rate has been reported to differ by both race[5] and gender[6]. The COVID-19 mortality rate for black Americans has been reported to be 2.6 times higher than for white Americans[7] and globally the mortality rate for men has been estimated to be 50 percent higher than for women[6]. The beneficiary race and gender were obtained from the Master Beneficiary Summary File. The percent of high-risk beneficiaries by race and gender is summarized in Table 5. The 20,035 beneficiaries who had gender reported as "other" or race reported as "unknown" are not included in the counts in Table 5.

Table 5: *Percent of high-risk beneficiaries by race and gender*

	Races						
	White	Black	Hispanic	Asian	Nat Am	Other	All Races
Count							
Male	517,996	55,495	12,242	9,798	3,602	10,786	609,919
Female	660,038	75,923	14,205	14,611	4,534	11,009	780,320
Male + Female	1,178,034	131,418	26,447	24,409	8,136	21,795	1,390,239
HR DSG or CRG							
Male							
HR Count	89,301	13,006	2,586	1,659	823	1,815	109,190
%High Risk	17.24	23.44	21.12	16.93	22.85	16.83	17.90
Female							
HR Count	91,915	16,940	2,769	1,904	943	1,309	115,780
%High Risk	13.93	22.31	19.49	13.03	20.80	11.89	14.84
Male + Female							
HR Count	181,216	29,946	5,355	3,563	1,766	3,124	224,970
%High Risk	15.38	22.79	20.25	14.60	21.71	14.33	16.18
HR DSG or CRG or Age>=85							
Male							
HR Count	119,827	14,525	3,224	2,427	927	2,148	143,078
%High Risk	23.13	26.17	26.34	24.77	25.74	19.91	23.46
Female							
HR Count	157,854	21,565	4,042	3,522	1,160	1,973	190,116
%High Risk	23.92	28.40	28.45	24.11	25.58	17.92	24.36
Male + Female							
HR Count	277,681	36,090	7,266	5,949	2,087	4,121	333,194
%High Risk	23.57	27.46	27.47	24.37	25.65	18.91	23.97

Using Model 2 with age 85 or greater, the percent of high-risk beneficiaries based on high-risk DSGs or CRGs was 48.2 percent higher for black beneficiaries as compared to white beneficiaries (22.79 versus 15.38 percent). The percent of high-risk beneficiaries based on high-risk DSGs or CRGs was 20.6 percent higher for males as compared to females (17.90 versus 14.84 percent). When beneficiaries 85 years and older who do not have high-risk DSGs or CRGs were included, the race and gender difference became less pronounced primarily because age 85 or higher increased the number of high-risk white beneficiaries by 53.2 percent and only increased the number of high-risk black beneficiaries by 20.5 percent. This reflects, in part, that the life expectancy of white Americans is 3.5 years longer than black Americans.[8] The percent of high-risk beneficiaries by race and gender is consistent with the reported COVID-19 mortality rates by race and gender, suggesting that the definition of high risk based on high-risk DSGs and CRGs reflects the risk of a poor COVID-19 prognosis.

The results in Tables 2 and 5 illustrate the challenges related to prioritizing limited COVID-19 related resources. For example, as the initial supplies of a COVID-19 vaccine become available,

which Medicare beneficiaries should be prioritized? As Table 2 shows, Medicare beneficiaries with at least one COVID-19 related condition encompass 67.6 percent of Medicare beneficiaries. Using older age beneficiaries, such as those 85 or older, would under-identify black beneficiaries who have been found to be more susceptible to a poor COVID-19 prognosis. The model used in this report to identify individuals at high risk for a poor COVID-19 prognosis can provide a standard definition of high risk that can be used for resource prioritization.

Applicability to Other Populations

The general approach used in this study to identify the high-risk population for a poor COVID-19 prognosis with minor modifications can be applied to other populations such as Medicaid or commercial payers. The CRGs are applicable to all age groups. To reflect a younger population, some additional DSGs like sickle cell anemia could be added to the list of high-risk DSGs. The age of an individual is not likely to be needed as an independent category for a non-Medicare population. Because these populations have far fewer comorbidities than the Medicare population, Model 1 may be more appropriate for the non-Medicare populations.

Limitations

Identification of risk factors impacting COVID-19 prognosis is based on currently available studies. It is possible that currently unrecognized conditions, combinations of comorbidities, and as-yet unrecognized factors could lead to different beneficiaries being identified as high risk. Further research is needed to develop a more complete understanding of risk factors and their relative impact on the likelihood of poor COVID-19 prognosis.

Factors not readily accessible in administrative data might also impact the likelihood of poor COVID-19 prognosis such as smoking or vaping status, socio-economic status, race, ethnicity, living in close proximity to people unable to actively participate in social distancing (e.g. nursing homes, cruise ships, prisons).

This analysis excluded Medicare beneficiaries who were newly enrolled, died, enrolled in a Medicare Advantage plan or in hospice during the analysis year. Further study is necessary to understand the impact the excluded beneficiaries would have on the volume of beneficiaries identified as high risk and the geographic distribution of high-risk beneficiaries.
The data used in this study was calendar year 2017. The underlying chronic disease burden and age distribution of large populations are not subject to rapid changes and is likely to be stable over a several year period. Significant migratory population changes tend to evolve slowly.

Summary

Medicare beneficiaries were identified to be at high risk of a poor COVID-19 prognosis if they had known COVID-19 risk factors in two or more different organ systems, had multiple major comorbid chronic conditions at high severity or were 85 or older. Based on this definition of

high risk, 16.1 percent of Medicare beneficiaries were found to be high risk because of COVID-19 risk factors or major chronic comorbidities. When beneficiaries 85 or older who had no COVID-19 risk factors or major chronic comorbidities were included, the percent of high-risk beneficiaries increased to 23.8 percent. A substantial level of variation was found in the proportion of high-risk beneficiaries across geographic regions and states. This level of variation is important to take into consideration as governments, insurers and healthcare providers proactively plan and prioritize COVID-19 related efforts.

The percent of high-risk Medicare beneficiaries by race, gender and across states was found to be consistent with the reported COVID-19 mortality rates in these populations, suggesting that the definition of high risk developed in this report reflects the risk of a poor COVID-19 prognosis. Because of the high proportion of Medicare beneficiaries with a COVID-19 related condition and the association of gender and race with a COVID-19 poor prognosis, a targeted method of identifying beneficiaries with a high burden of severe chronic comorbid disease is essential for resource prioritization in the Medicare program. The model used to identify individuals at high risk for a poor COVID-19 prognosis used in this report can provide a standard definition of high risk that can be readily implemented and adapted to non-Medicare populations.

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Appendix A: Clinical Risk Groups (CRGs) Research Articles and Studies

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Appendix B: Description of Clinical Risk Groups (CRGs)

Clinical Risk Groups (CRGs) are a categorical clinical model that uses historical claims data to assign patients to a single mutually exclusive category that defines an individual's chronic disease burden. Each CRG is composed of a base CRG that describes the patient's most significant chronic conditions and two to six explicit severity levels that distinguish differences in disease burden due to severity of illness. The CRG logic follows the logical progression of a disease. The CRG assignment process is summarized in the CRG Logic Overview below. A complete description of the CRG logic with rationale can be found at: https://www.3m.com/3M/en_US/health-information-systems-us/providers/grouping-and-classification/crgs/?utm_term=hcbg-his-bg-en_us-edu-cer-own-cersite-na-learn-na-ne20-na

CRG Logic Overview

Phase 1: Categorize diagnoses and procedures

- All diagnoses area assigned to one of 36 MDCs (Major Diagnostic Category)
- Within each MDC diagnoses are assigned to one of 523 EDCs (Episode Diagnostic Categories)
- Each EDC is further subdivided into 966 DSGs (Diagnostic Sub Group)
- All procedures are assigned to one of 612 EPCs (Episode Procedure Category)
- Each EDC is categorized as dominant chronic, moderate chronic, minor chronic, chronic manifestation, significant acute or minor acute
- Only one diagnosis from an inpatient admission is needed to establish an EDC/DSG
- Two diagnoses from different days are needed to establish an EDC/DSG from outpatient visits except for diagnoses for selected conditions and diagnosis codes which are in fact procedures (e.g., history of a heart transplant)
- For inpatient services diagnoses from physician and other professional claims are not used (i.e., only the hospital claim is used).
- Diagnoses from "other" providers (e.g., ambulances, freestanding laboratory, etc.) are not used.
- Some diagnosis codes create multiple EDCs. (e.g., the ulcerative colitis with abscess code will generate the chronic EDC for inflammatory bowel syndrome and the acute EDC for major acute GI diagnosis.
- Conditionality rules are also applied and affect diagnosis or severity assignment:
    - Persistence and recurrence rules (e.g., Convulsions must persist over a period of time to be considered an establish chronic diagnosis)
    - Demographic (e.g., congestive heart failure among children vs. adults)
- The temporal relationship between EDCs and EPCs is used to establish final EDCs
    - EDCs can cause other EDCs to be "ignored"
        - Acquired hemiplegia removes stroke from contributing to the severity of illness logic
- EPCs can cause EDC and EPCs to be "ignored"

- Angioplasty removes Angina from the severity logic
- Kidney transplant causes renal dialysis to be removed from the severity logic

Phase 2: **Identify chronic illnesses and specify their severity of illness**

- Each MDC with a chronic EDC will be assigned a PCD (Primary Chronic Disease)
- Only one PCD can be assigned per MDC. If there is more than one EDC within an MDC, the PCDs will be selected in hierarchical order within the MDC (e.g., dominant chronic EDCs selected before moderate chronic EDCs)
- Some chronic EDCs cannot become PCDs if a certain other EDC is present (e.g., skin ulcers cannot be a PCD if diabetes is present)
- After a PCD is selected it is assigned a severity of illness level
- The severity level assignment for each PCD is establish by the presence of related conditions (e.g., skin ulcers in a diabetic). The DSGs are used to make severity of illness distinctions.

Phase 3: **Assign the CRG**

- Assignment to one of 332 base CRGs based on the combination of PCDs that are present
- The highest volume diseases or combinations of diseases are assigned a unique base CRG, for example:
  - Diabetes
  - Diabetes with CHF
  - Diabetes with CHF and COPD
- All CRGs are assigned to one of nine hierarchical health statuses
- The nine health statuses range from catastrophic to healthy
- Assignment is done from most serious (catastrophic) to least serious (healthy)
- Each base CRG is subdivided into discrete severity subclasses based on the severity levels of the PCDs

In CRG version 2.1 used in this analysis there are 332 base CRGs which were subdivided into up to six severity of illness levels for a total of 1,414 CRGs. For the purpose of the COVID-19 analysis, the nine CRG statuses and severity levels plus selected DSGs were used to identify individuals with the greatest risk of poor COVID-19 outcome (hospitalization, ICU admission, mechanical ventilation, death).

Appendix C: Literature on Risk Factors for a Poor Outcome from COVID-19

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Appendix D: High-risk Diagnostic Sub Groups (DSGs)

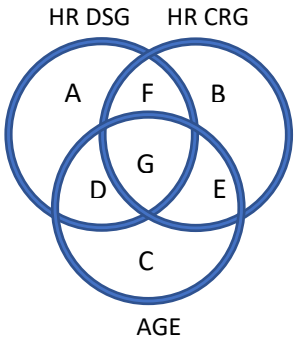
DSG	DSG Desription	MDC	MDC Description
913301	Bronchiectasis	41	Respiratory System
913302	Chronic Obstructive Pulmonary Disease	41	Respiratory System
913401	Obesity Hypo-Ventilation Syndrome	41	Respiratory System
913402	Chronic Respiratory Failure	41	Respiratory System
913403	Environmentally Acquired Lung Disorder	41	Respiratory System
913404	Pulmonary Alveolar Diagnoses	41	Respiratory System
913405	Pulmonary Hemosiderosis	41	Respiratory System
913406	Chronic Pulmonary Embolism Disorder	41	Respiratory System
913407	Tracheostomy Status	41	Respiratory System
913802	Severe Asthma	41	Respiratory System
913803	Status Asthmaticus	41	Respiratory System
914101	Chronic Bronchitis	41	Respiratory System
914201	Laryngotracheal Anomalies and Diagnoses	41	Respiratory System
915502	Pulmonary Embolism with Acute Cor Pulmonale	41	Respiratory System
915601	Respiratory Failure and Lung Edema	41	Respiratory System
916501	Dependence on Supplementary Oxygen	41	Respiratory System
916801	Lung Transplant Status	42	Major Respiratory
916802	Complication of Lung Transplant	42	Major Respiratory
916901	Cystic Fibrosis	42	Major Respiratory
917201	Dependence on Respirator	42	Major Respiratory
918004	Hypertrophic Obstructive Cardiomyopathy	51	Cardiovascular
918005	Cardiomyopathy except Hypertrophic Obstructive	51	Cardiovascular
918006	Pulmonary Hypertension	51	Cardiovascular
918101	Rheumatic and Syphilitic Valve Disorders	51	Cardiovascular
918301	Angina and Ischemic Heart Disease	51	Cardiovascular
918302	Unstable Angina	51	Cardiovascular
918303	Coronary Graft Atherosclerosis with Unstable Angina	51	Cardiovascular
918304	Coronary Graft Atherosclerosis with Other Angina	51	Cardiovascular
918703	High Grade Heart Block	51	Cardiovascular
918704	Long QT Syndrome	51	Cardiovascular
918706	Sick Sinus Syndrome	51	Cardiovascular
919101	History of Coronary Artery Bypass Graft	51	Cardiovascular
919102	History of Percutaneous Transluminal Coronary Angioplasty	51	Cardiovascular
919103	Other Coronary Atherosclerosis Diagnoses	51	Cardiovascular
919104	Coronary Graft Atherosclerosis	51	Cardiovascular
919109	Malfunction Coronary Bypass Graft	51	Cardiovascular
919201	Malignant Hypertension	51	Cardiovascular
919202	Hypertensive Heart Disorder	51	Cardiovascular
919203	Hypertensive Heart and Kidney Disorder	51	Cardiovascular
920901	Acute Myocardial Infarction except Subendocardial - Initial	51	Cardiovascular
920902	Additional Acute Myocardial Infarction except Subendocard	51	Cardiovascular
921001	Acute Myocardial Infarction except Subendocardial - Subsequent/Unspecified	51	Cardiovascular
921101	Subendocardial Infarction - Initial	51	Cardiovascular
921102	Additional Subendocardial Infarction	51	Cardiovascular

DSG	DSG Desription	MDC	MDC Description
921201	Subendocardial Infarction - Subsequent/Unspecified	51	Cardiovascular
921301	Atrial Flutter	51	Cardiovascular
921401	Cardiac Arrest	51	Cardiovascular
921501	Endocarditis	51	Cardiovascular
921502	Other Cardiac Inflammation	51	Cardiovascular
921601	Cardiomegaly and Other Moderate Acute Cardiovascular	51	Cardiovascular
921901	Congestive Heart Failure	51	Cardiovascular
921902	Acute Heart Failure	51	Cardiovascular
921903	Heart Failure Diastolic	51	Cardiovascular
922101	Hypertension NOS/NEC	51	Cardiovascular
922401	Shock and Other Extreme Cardiac Events	51	Cardiovascular
922601	Ventricular Tachycardia	51	Cardiovascular
922602	Re-entry Ventricular Tachycardia	51	Cardiovascular
923801	Symptomatic Peripheral Vascular Disease	52	Peripheral Vascular
925101	Acute Disorders of Arteries and Veins - Extreme	52	Peripheral Vascular
926101	Heart Transplant Status	53	Heart Transplant
926102	Complication of Heart Transplant	53	Heart Transplant
926104	Heart Transplant with Atherosclerosis and Unstable Angina	53	Heart Transplant
926105	Heart Transplant with Atherosclerosis and Other Angina	53	Heart Transplant
931104	Hepatopulmonary Syndrome	71	Hepatobiliary
931107	Chronic Hepatitis w Coma	71	Hepatobiliary
939009	Systemic Lupus Erythematosus with Lung Manifestation	82	Connective Tissue
939010	Systemic Lupus Erythematosus with Renal Manifestation	82	Connective Tissue
939011	Polymyositis with Respiratory Involvement	82	Connective Tissue
939015	Systemic Lupus Erythematosus with Cardiac Manifestation	82	Connective Tissue
942401	Long Term Insulin Use	101	Diabetes Mellitus
942402	Uncomplicated Diabetes	101	Diabetes Mellitus
942403	Diabetes - Juvenile Onset	101	Diabetes Mellitus
942404	Diabetes I with Ketoacidosis	101	Diabetes Mellitus
942405	Diabetes II with Ketoacidosis	101	Diabetes Mellitus
942406	Secondary Diabetes with Ketoacidosis	101	Diabetes Mellitus
942407	Diabetic Coma	101	Diabetes Mellitus
942408	Diabetes with Circulatory Complication	101	Diabetes Mellitus
942409	Diabetic Nephropathy	101	Diabetes Mellitus
942410	Diabetic Neuropathy	101	Diabetes Mellitus
942411	Diabetic Retinopathy	101	Diabetes Mellitus
942412	Other Diabetic Complications	101	Diabetes Mellitus
947301	Chronic Renal Failure, Stage V or ESRD	111	Kidney and Urinary
947302	Chronic Kidney Disease Stage V	111	Kidney and Urinary
947303	End Stage Renal Disease	111	Kidney and Urinary
947401	Kidney Transplant Status	111	Kidney and Urinary
950001	Renal Dialysis Status	111	Kidney and Urinary
950002	Renal Dialysis Encounter/Procedure	111	Kidney and Urinary
950003	Complication of Renal Dialysis	111	Kidney and Urinary
965201	Chronic Lymphoid Leukemia NOS	172	Malignancies
965203	Chronic Lymphoid Leukemia without Remission	172	Malignancies
965204	Chronic Lymphoid Leukemia in Relapse	172	Malignancies

DSG	DSG Desription	MDC	MDC Description
965301	Chronic Non-Lymphoid Leukemia NOS	172	Malignancies
965303	Chronic Non-Lymphoid Leukemia without Remission	172	Malignancies
965304	Chronic Non-Lymphoid Leukemia in Relapse	172	Malignancies
965403	Multiple Myeloma without Remission	172	Malignancies
965404	Multiple Myeloma in Relapse	172	Malignancies
965504	Acute Lymphoid Leukemia without Remission	172	Malignancies
965505	Acute Lymphoid Leukemia in Relapse	172	Malignancies
965603	Acute Non-Lymphoid Leukemia without Remission	172	Malignancies
965604	Acute Non-Lymphoid Leukemia in Relapse	172	Malignancies
966001	Hodgkin's Lymphoma Multiple Sites	172	Malignancies
966002	Hodgkin's Lymphoma of Single/Unspecified Site	172	Malignancies
966501	Non-Hodgkin's Lymphoma Multiple Sites	172	Malignancies
968701	Kaposi's Sarcoma	172	Malignancies
969101	Radiation Therapy	172	Malignancies
969201	Chemotherapy	172	Malignancies
972301	Primary Tuberculosis with Significant Pulmonary Diagnoses	181	Infectious - Parasitic
972401	Primary Tuberculosis with Pulmonary Diagnoses	181	Infectious - Parasitic
986401	Thoracic Trauma - Extreme	251	Other Trauma

Appendix E: Overlap Among High-risk DSGs, High-risk CRGs and Age

The following Venn diagram shows the overlap among high-risk DSGs, high-risk CRGs and age. The tables below contain the counts in the Venn diagram for Models 1 and 2.



		Model 1 Age 85+		Model 1 Age 80+	
	Description	**Count of Beneficiaries**	**Percent Beneficiaries**	**Count of Beneficiaries**	**Percent Beneficiaries**
A	High-risk DSG Only	257,234	18.2	227,184	16.1
B	High-risk CRG Only	51,142	3.6	47,044	3.3
C	Age Only	20,303	1.4	46,286	3.3
D	Both High-risk DSG and Age	25,869	1.8	55,919	4.0
E	Both High-risk CRG and Age	4,474	0.3	8,572	0.6
F	Both High-risk DSG and High-risk CRG	585,512	41.5	501,614	35.6
G	High-risk DSG and High-risk CRG and Age	84,460	6.0	168,358	11.9
	No High-risk DSG, High-risk CRG or Age	381,280	27.0	355,297	25.2
	Total	1,410,274	100.0	1,410,274	100.0

		Model 2 Age 85+		Model 2 Age 80+	
	Description	Count of Beneficiaries	Percent Beneficiaries	Count of Beneficiaries	Percent Beneficiaries
A	High-risk DSG Only	35,933	2.5	29,827	2.1
B	High-risk CRG Only	97,475	6.9	85,560	6.1
C	Age Only	108,394	7.7	224,645	15.9
D	Both High-risk DSG and Age	5,399	0.4	11,505	0.8
E	Both High-risk CRG and Age	12,406	0.9	24,321	1.7
F	Both High-risk DSG and High-risk CRG	66,623	4.7	56,866	4.0
G	High-risk DSG and High-risk CRG and Age	8,907	0.6	18,664	1.3
	No High-risk DSG, High-risk CRG or Age	1,075,137	76.2	958,886	68.0
	Total	1,410,274	100.0	1,410,274	100.0

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