Received: 7 March 2022 | Revised: 31 August 2022 | Accepted: 5 September 2022

DOI: 10.1111/jgs.18062

CLINICAL INVESTIGATION

Journal of the American Geriatrics Society

Excess deaths from COVID-19 among Medicare beneficiaries with psychiatric diagnoses: community versus nursing home

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Funding information
National Institutes of Health, Grant/Award Numbers: P30AG024832, UL1-TR001439, 1K01AG070329

Abstract

Background: Psychiatric illness may pose an additional risk of death for older adults during the COVID-19 pandemic. Older adults in the community versus institutions might be influenced by the pandemic differently. This study examines excess deaths during the COVID-19 pandemic among Medicare beneficiaries with and without psychiatric diagnoses (depression, anxiety, bipolar disorder, and schizophrenia) in the community versus nursing homes.

Methods: This is a retrospective cohort study of a 20% random sample of 15,229,713 fee-for-service Medicare beneficiaries, from January 2019 through December 2021. Unadjusted monthly mortality risks, COVID-19 infection rates, and case-fatality rates after COVID-19 diagnosis were calculated. Excess deaths in 2020, compared to 2019 were estimated from multivariable logistic regressions.

Results: Of all included Medicare beneficiaries in 2020 ($N = 5{,}140{,}619$), 28.9% had a psychiatric diagnosis; 1.7% lived in nursing homes. In 2020, there were 246,422 observed deaths, compared to 215,264 expected, representing a 14.5% increase over expected. Patients with psychiatric diagnoses had more excess deaths than those without psychiatric diagnoses (1,107 vs. 403 excess deaths per 100,000 beneficiaries, $p < 0.01$). The largest increases in mortality risks were observed among patients with schizophrenia (32.4% increase) and bipolar disorder (25.4% increase). The pandemic-associated increase in deaths with psychiatric diagnoses was only found in the community, not in nursing homes. The increased mortality for patients with psychiatric diagnoses was limited to those with medical comorbidities. The increase in mortality for psychiatric diagnoses was associated with higher COVID-19 infection rates (1-year infection rate = 7.9% vs. 4.2% in 2020), rather than excess case fatality.

Conclusions: Excess deaths during the COVID-19 pandemic were disproportionally greater in beneficiaries with psychiatric diagnoses, at least in part due to higher infection rates. Policy interventions should focus on preventing

This research reported in this manuscript was presented at the AcademyHealth 2022 Annual Research Meeting in Washington, DC.

COVID-19 infections and deaths among community-dwelling patients with major psychiatric disorders in addition to those living the nursing homes.

KEYWORDS
COVID-19, epidemiology, excess deaths, nursing home, psychiatric diagnoses

INTRODUCTION

As of July 2022, there have been over 90 million COVID-19 cases, and over 1 million COVID-19 deaths in the United States.[1] Since the start of the pandemic, there have been four major waves of COVID-19 infection and death: April 2020, December 2020, September 2021, and January 2022.[2,3] Older adults are at greater risk of COVID-19 infection and death.[4,5] Some Medicare beneficiaries require nursing home care.[6–8] Compared to community-dwelling residents, nursing home residents tend to be older, with more functional limitations, and have more physical and mental conditions.[7–10] Those factors made nursing homes the epicenter of the COVID-19 pandemic, with nearly one-third of all COVID-19 deaths occurring in nursing home residents.[11–17]

The COVID-19 pandemic led to excess deaths in both direct and indirect ways: (1) COVID-19 infection and complications directly led to deaths[18]; (2) the pandemic disrupted or delayed routine medical care for patients without COVID-19.[19] A recent analysis reported 1.13 million total excess deaths in the United States during 2020–21, representing a 37% increase in mortality rate.[20] Among Medicare fee-for-service beneficiaries, 110,990 excess deaths (11.5% increase in mortality rate) were found from February to September 2020.[4] For the nursing home population, the excess mortality based on Medicare claims in 2020 was 32%, resulting in 169,291 more deaths compared to 2019.[16]

Individuals with psychiatric illnesses are at high risk of COVID-19 hospitalization and death.[21–26] Patients with schizophrenia had worse COVID-19 outcomes compared to those with mood disorders, possibly because of their immunological profile and antipsychotic treatments.[22,23,25,26] Despite high mortality, excess deaths among patients with psychiatric conditions during the COVID-19 pandemic remain understudied. Mortality data from the National Center for Health Statistics do not have information on psychiatric diagnoses at the individual level.[18,20] The estimate of excess deaths in the Medicare population did not examine the impact of psychiatric conditions and only included data through September 2020, which missed the period with the largest number of COVID-19 cases and deaths.[4] Also, it is unclear whether excess deaths with psychiatric conditions among residents in nursing homes differ from those in the community, due to large differences in the underlying health status.[13–15] Nursing homes may offer more structured support for psychiatric behaviors during the pandemic, hence alleviating the mortality risk.

To mitigate these knowledge gaps, we analyzed a 20% random sample of national fee-for-service Medicare claims to determine the monthly trends in all-cause mortality risks, COVID-19 infection rates, and COVID-19 case-fatality rates. We estimated the excess deaths among all Medicare beneficiaries and separately for patients with psychiatric diagnoses. We also calculated the excess deaths by psychiatric diagnoses in the community versus nursing homes. We hypothesized that beneficiaries with

Key points

- In this cohort study of a 20% random sample of fee-for-service Medicare beneficiaries in the United States, there were 246,422 observed deaths in 2020, compared to 215,264 expected, representing a 14.5% increase over expected deaths.
- Excess deaths were higher among patients with psychiatric diagnoses than those without (1,107 vs. 403 excess deaths per 100,000 enrollees), especially among patients with schizophrenia and bipolar disorders.
- The pandemic-associated increase in deaths with psychiatric diagnoses was only found in the community, not in nursing homes; the increased mortality for community-dwelling patients with psychiatric diagnoses was limited to those with medical comorbidities.

Why does this paper matter?

The analysis of over 15 million Medicare beneficiaries suggests that excess deaths during the COVID-19 pandemic were disproportionally greater in community-dwelling beneficiaries with psychiatric diagnoses.

psychiatric diagnoses had larger increases in deaths than those without the diagnoses, and that the relative increases in deaths with psychiatric diagnoses were larger in the community than that in nursing homes.

METHODS

Data sources

We analyzed a 20% random sample of fee-for-service Medicare claims from January 1, 2017, through December 31, 2021, including the Medicare Beneficiary Summary File (MBSF), Inpatient Standard Analytic File, Skilled Nursing Facility (SNF) claims, Outpatient Standard Analytic File, Carrier File, Hospice File, and the nursing home Minimum Data Set data, with updates to the data through May 15, 2022. This study was approved by the University of Texas Medical Branch Institutional Review Board with a Data Use Agreement with the Centers for Medicare & Medicaid Services. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cohort studies.

Study population

We created three cohorts of Medicare beneficiaries who were alive on January 1 of 2019, 2020, and 2021 (Figure S1). We restricted the sample to those with Medicare Parts A and B coverage and without Medicare Advantage enrollment during the previous 2 years and throughout the investigation year or until death. The 2-year look-back period is used by the Centers for Medicare & Medicaid Services Chronic Condition Data Warehouse to identify psychiatric conditions.[27] We excluded the beneficiaries who were enrolled at any time in hospice in the last 3 months of the previous year. Finally, we excluded individuals who did not have complete data on sociodemographic variables, comorbidities, or survival.

Outcomes

Primary outcomes included all-cause annual and monthly mortality risks, calculated from the date of death in MBSF. COVID-19 infections were identified as the first Medicare claim (inpatient, SNF, outpatient, and carrier claims) with a diagnosis code of U07.1 in the10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10-CM) on or after April 1, 2020.[28] COVID-19 fatality was defined as death within 30 days of first COVID-19 diagnosis. A sensitivity analysis using death within 60 days was also conducted.

Medicare beneficiary characteristics

Psychiatric diagnoses, including depression, anxiety, bipolar disorder, and schizophrenia/other psychoses, were identified using Medicare claims from a 2-year look-back period.[27] The other Elixhauser comorbidities and dementia were determined using Medicare claims in the previous year.[29] We calculated a claim-based frailty index using ICD, Current Procedural Terminology (CPT), and Healthcare Common Procedure Coding System (HCPCS) codes in Medicare claims in the previous year.[30,31] We identified residential location as a long-term care nursing home if a resident stayed in a nursing home for at least 45 days (after excluding SNF days) during the last quarter of the previous year.[32] All others were considered community-dwelling residents. We extracted beneficiary characteristics including age, gender, and race/ethnicity from MBSF. Medicaid eligibility was measured using the state buy-in information in the MBSF. The percentage of high school graduates in the beneficiary ZIP code was obtained from the 2019 American Community Survey.[33]

Statistical analysis

We described monthly mortality risk for all beneficiaries who were alive as of the first day of each month for the entire cohort and separately for community-dwelling and nursing home residents, from January 2019 to December 2021. We also described time trends in COVID-19 infection rates from April 2020 to December 2021 for all beneficiaries not previously infected with COVID-19 for the entire cohort and separately for community-dwelling and nursing home residents. We reported fatality rates in the 30 or 60 days after a COVID-19 infection.

To estimate excess deaths in 2020, we first calculated the expected number of deaths that would have occurred in 2020 in the absence of COVID-19. We generated 10-fold cross-validated training sets using the 2019 cohort and conducted a logistic regression model to predict 1-year deaths for each training set. The model included all patient characteristics, residential location, geographic division, psychiatric conditions, and other comorbidities. The expected deaths among the 2020 cohort were the average of predicted deaths from the 10 cross-validated 2019 models. The C statistic for the 2019 cohort was 0.832. The observed-to-expected (O/E) ratio for the 2020 cohort was calculated as observed deaths/expected deaths. We calculated excess deaths per 100,000

beneficiaries as 100,000 × (observed deaths-expected deaths)/total number of beneficiaries. The 95% confidence intervals (CI) for the O/E ratio and excess deaths were calculated using estimates from the 10-fold cross-validated logistic regression models. Separate estimates were produced for all beneficiaries, beneficiaries with or without any psychiatric diagnosis, and for individual psychiatric diagnoses. We also generated separate models to estimate excess deaths and O/E ratios for community-dwelling and nursing home residents by psychiatric diagnoses. In the sensitivity analyses, we calculated excess deaths by psychiatric diagnoses for beneficiaries without other medical comorbidities; we also estimated excess deaths for all beneficiaries by adding the frailty index in the predictive model.[30] We did not estimate excess deaths in 2021 because psychiatric and other comorbidities rely on Medicare claims in 2020 when usual medical care was disrupted. Because of the large sample sizes, even small differences would be statistically significant, so we focus more on the magnitude of the differences. All analyses were performed with SAS Enterprise version 7.1 (SAS Institute Inc., Cary, NC) at the CMS Virtual Research Data Center.

RESULTS

Beneficiary characteristics

The cohorts consisted of 5,200,041 beneficiaries in 2019, 5,140,619 beneficiaries in 2020, and 4,889,053 beneficiaries in 2021 (Figure S1). In 2020, 1,484,306 (28.87%) beneficiaries had at least one psychiatric diagnosis, including depression (20.24%), anxiety (17.43%), bipolar disorder (3.19%), and schizophrenia or other psychoses (2.55%). Most beneficiaries were 70 years or older (63.13%), female (55.47%), and Non-Hispanic White (81.21%). The majority of beneficiaries lived in the community (98.30%) with 87,417 (1.70%) living in nursing homes. Minor differences were found in beneficiary characteristics (e.g., age, Medicaid coverage) between 2019, 2020, and 2021 (Table S1). Individuals living in nursing homes were older, with higher rates of dementia and other comorbidities (Table S2).

Trends of monthly all-cause mortality risks

Figure 1 presents the monthly unadjusted mortality risks from January 2019 to December 2021 for Medicare beneficiaries, stratified by psychiatric diagnoses. The one-year mortality risk for all beneficiaries was 4.18% in 2019, which increased to 4.79% in 2020 (14.6% increase). Beneficiaries without psychiatric diagnoses had mortality risks ranging between 0.23% and 0.33% per month in 2019. Beneficiaries with schizophrenia had mortality risks 2–3 times higher. Beneficiaries with other psychiatric diagnoses had mortality risks between those with schizophrenia and those without a psychiatric diagnosis. Coincident with the pandemic, mortality risks in early 2020 rose among all enrollees, but the relative and absolute increases were greater among those with psychiatric diagnoses. For example, the April 2020 mortality risk for those with schizophrenia was 1.48%, a 95% relative increase compared to April 2019. The April 2020 mortality risk for beneficiaries without a psychiatric diagnosis was 0.35%, a 25% increase over the April 2019 rate of 0.28%. The relative increases in mortality from April 2019 to April 2020 were also greater among those with bipolar disorder, depression, and anxiety. During the December 2020 peak, the relative increase in mortality was 43% among all beneficiaries, 77% among beneficiaries with schizophrenia and 69% among beneficiaries with bipolar disorder. Mortality risks started to drop in February 2021 but began rising again in June 2021.

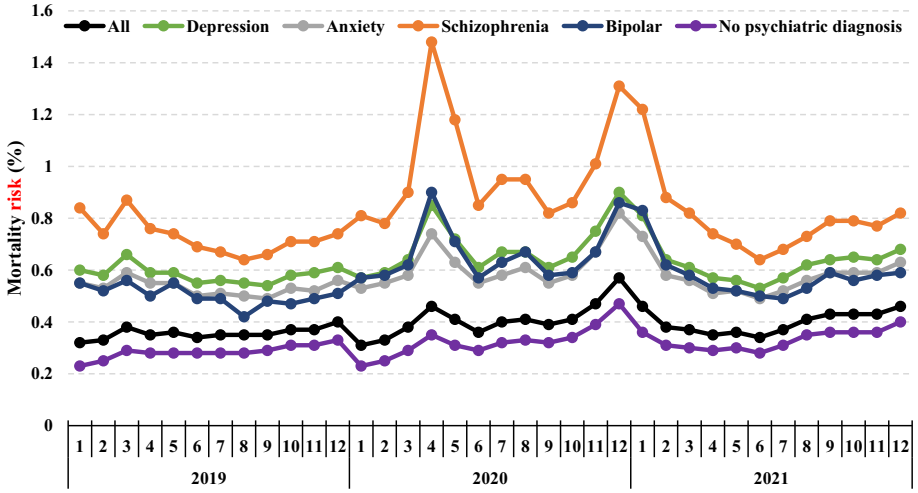

FIGURE 1 Time trends in monthly mortality risks among Medicare fee-for-service beneficiaries from January 2019 to December 2021. Separate plots are shown for all beneficiaries, those without a psychiatric diagnosis, and those with specific psychiatric diagnoses; the denominator is the beneficiaries who were still alive on the first day of each month; the numerator is the beneficiaries who died within each month; The 1-year mortality risk for all beneficiaries was 4.18% in 2019, and 4.79% in 2020 (14.6% increase).

Because beneficiaries with psychiatric diagnoses are overrepresented in nursing home populations, we examined the monthly unadjusted mortality risks separately for community-dwelling (Figure 2) and nursing home beneficiaries (Figure 3). The patterns for the community cohort were similar to those for the entire cohort in Figure 1. However, among nursing home residents, those without a psychiatric diagnosis had slightly higher mortality risks compared to those with psychiatric diagnoses, both in the prepandemic and pandemic periods.

Estimating excess deaths during the COVID-19 pandemic

We built logistic regressions of 2019 data to predict one-year all-cause deaths, controlling for all beneficiary characteristics (Table S3). We then used parameters from the 2019 models to generate expected deaths in 2020. Table 1 presents the observed vs. expected deaths during 2020 for all beneficiaries and stratified by specific psychiatric diagnoses. In 2020, there were 246,422 observed deaths, compared to 215,264 expected deaths, a 14.5% increase (O/E ratio = 1.145; 95% CI: 1.144–1.152), which would extrapolate to 155,790 (95% CI: 155,500–156,085) total excess deaths in all Medicare fee-for-service population. Patients with psychiatric diagnoses experienced more excess deaths per 100,000 beneficiaries than those without psychiatric diagnoses (1,107 vs. 403 excess deaths, $p < 0.01$). The greatest increases in mortality were seen in beneficiaries with a diagnosis of schizophrenia (32.4% increase) and bipolar disorder (25.4% increase).

Table S4 presents analyses of excess deaths, stratified by community versus nursing home. For community-dwelling residents, those with any psychiatric condition experienced a larger increase in excess mortality compared to beneficiaries without psychiatric conditions (13.3% vs. 11.0%). The largest increases in mortality in

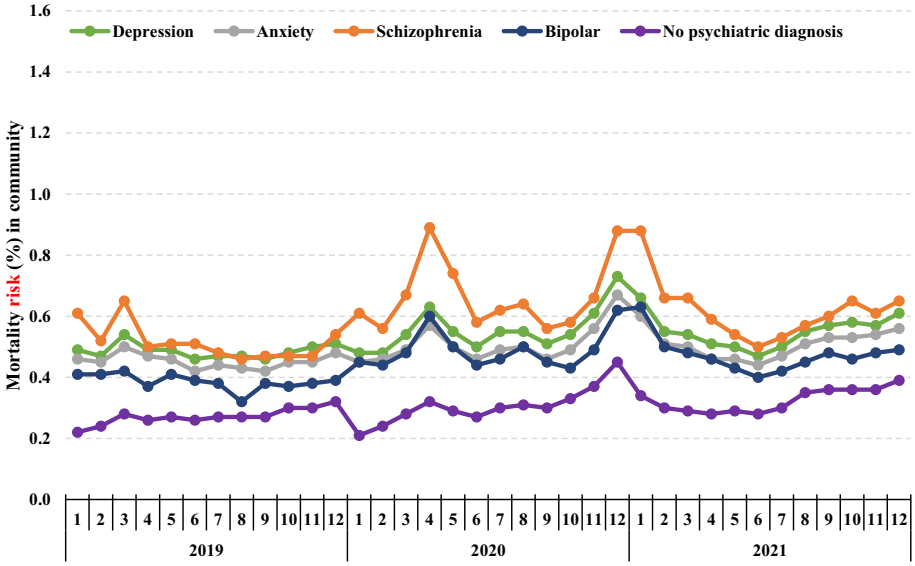

FIGURE 2 Time trends in monthly mortality risks among community-dwelling Medicare fee-for-service beneficiaries from January 2019 to December 2021. The denominator is the beneficiaries who were still alive on the first day of each month; the numerator is the beneficiaries who died within each month.

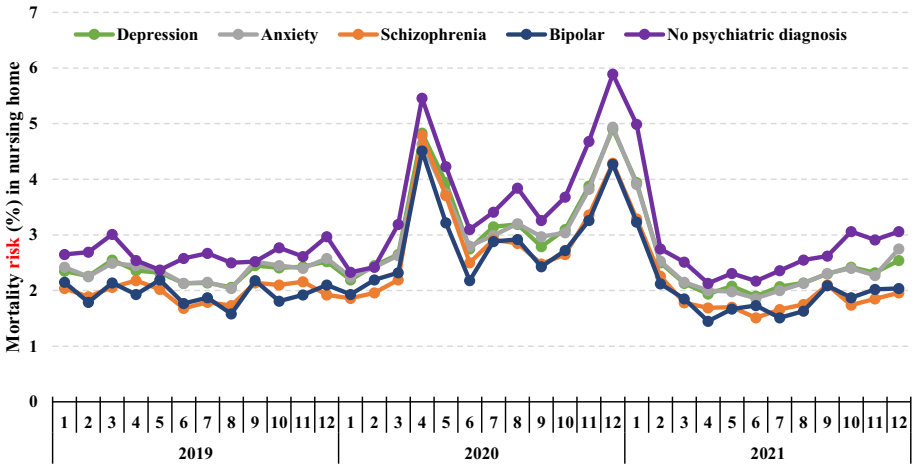

FIGURE 3 Time trends in monthly mortality risks among Medicare fee-for-service residents in nursing homes from January 2019 to December 2021. The denominator is the beneficiaries who were still alive on the first day of each month; the numerator is the beneficiaries who died within each month.

TABLE 1 Excess deaths in 2020 by psychiatric diagnoses (January to December)

Variables	Number of patients	Observed deaths *N* (%)	Expected deaths (95% CI)[a]	Observed/expected ratio (95% CI)[a]	Excess deaths per 100,000 population (95% CI)[a]
All	5,140,619	246,422 (4.79%)	215,264 (215,206, 215,322)	1.145 (1.144, 1.152)	606 (605, 607)
Any psychiatric diagnosis				$p < 0.001$	
Yes	1,484,306	106,795 (7.19%)	90,370 (90,378, 90,423)	1.182 (1.181, 1.182)	1,107 (1,103, 1,110)
No	3,656,313	139,627 (3.82%)	124,894 (124,841, 124,945)	1.118 (1.118, 1.119)	403 (402, 404)
Depression				$p < 0.001$	
Yes	1,040,551	82,311 (7.91%)	70,339 (70,294, 70,383)	1.170 (1.169, 1.171)	1,151 (1,146, 1,155)
No	4,100,068	164,111 (4.00%)	144,925 (144,872, 144,977)	1.133 (1.132, 1.133)	468 (467, 469)
Anxiety				$p < 0.001$	
Yes	896,090	63,932 (7.13%)	55,376 (55,329, 55,423)	1.154 (1.153, 1.155)	955 (916, 960)
No	4,244,529	182,490 (4.30%)	159,888 (159,827, 159,946)	1.142 (1.141, 1.142)	532 (531, 534)
Bipolar				$p < 0.001$	
Yes	164,054	12,572 (7.66%)	10,024 (10,001, 10,047)	1.254 (1.251, 1.257)	1,553 (1,539, 1,567)
No	4,976,565	233,850 (4.70%)	205,239 (20,5188, 20,5290)	1.140 (1.139, 1.140)	575 (574, 576)
Schizophrenia				$p < 0.001$	
Yes	130,982	14,744 (11.26%)	11,137 (11,109, 11,165)	1.324 (1.320, 1.327)	2,754 (2,732, 2,776)
No	5,009,637	231,678 (4.62%)	204,127 (204,069, 204,183)	1.135 (1.134, 1.145)	550 (549, 551)

Note: All-cause mortality risks were estimated from January to December of each year. Expected deaths were estimated using data in 2020 based on 2019 logistic regression model, adjusting for all beneficiary characteristics including age, gender, race, Medicaid, education, residential location, prior hospitalization, geographic division, psychiatric conditions, and 28 Keilhauer comorbidities. C statistic for 2020 model was 0.832 (95% confidence interval: 0.831, 0.833).

[a]95% confidence interval was estimated using 10-fold cross-validation.

community-dwelling beneficiaries were among patients with schizophrenia (23.4% increase) and bipolar disorder (18.3% increase). Nursing home residents with and without psychiatric diagnoses had almost identical increases in observed over expected deaths (37.5% vs. 37.4%). Among Medicare enrollees with no other comorbidities, those with a psychiatric diagnosis experienced no increase in observed over expected deaths (Table S5). Adjusting for frailty score in the predictive model only slightly changed our estimates of excess deaths (Table S6).

COVID-19 infection rates and case-fatality rates

To explore the reasons for the higher excess deaths in patients with psychiatric diagnoses, we examined monthly COVID-19 infection rates (Figures S2–S4) and fatality rates after a COVID-19 diagnosis (Figures S5–S10). Patients with psychiatric diagnoses were more like to be infected by COVID-19 than beneficiaries without a psychiatric diagnosis (1-year infection rate = 7.93% vs. 4.20% in 2020). The infection rates of beneficiaries with or without psychiatric diagnoses converged starting February 2021, after the introduction of COVID-19 vaccines. Community-dwelling residents shared the patterns of infection rates in the whole cohort. Nursing home residents were at very high risk of COVID-19 infection, regardless of psychiatric diagnoses. Case fatality rates were similar among beneficiaries with or without a psychiatric condition (Figures S5–S10).

DISCUSSION

Among Medicare fee-for-service beneficiaries, the COVID-19 pandemic was associated with a 14% increase in all-cause mortality in 2020, which extrapolates to over 155,000 excess deaths in all Medicare fee-for-service beneficiaries. Patients with psychiatric diagnoses accounted for less than 30% of the Medicare population but had over 50% of the excess deaths (an 18% increase in observed over expected deaths vs. a 12% increase in those without psychiatric diagnoses). Patients with major psychiatric disorders including schizophrenia and bipolar disorder experienced the largest increase in mortality rates. The pandemic-associated increase in deaths among beneficiaries with psychiatric diagnoses was only found in the community, not in nursing homes.

Our estimates of excess deaths during the COVID-19 pandemic are comparable to prior studies. A previous study on Medicare fee-for-service beneficiaries from February to September 2020 found 110,990 excess deaths, representing an 11.5% increase in mortality.[4] This would extrapolate to about 152,611 excess deaths in 2020 which is comparable to our estimate of 155,790 excess deaths. Our estimate of 606 excess deaths per 100,000 beneficiaries was more than three times higher than that reported for the general population (164–167 per 100,000 population[18,20]), which highlights the disproportional impact of the COVID-19 pandemic on older adults. The similar COVID-19 fatality rates by psychiatric diagnoses found in our study differ from those in the general population who were younger and healthier.[22,23,25]

What are the pathways linking psychiatric diseases to higher pandemic mortality? We found that psychiatric diagnoses were associated with higher COVID-19 infection rates, rather than excess case fatality. Thus, at least part of the increase in mortality was from higher COVID-19 infection rates. We also found that the increased mortality for those with psychiatric diagnoses was limited to those with medical comorbidities (Table 1 vs. Table S5). This suggests that the increased mortality is mediated via increased comorbidity in those with psychiatric diseases. The Lancet Psychiatry Commission[34] reviewed almost 100 systematic reviews and meta-analyses on the presence of medical comorbidities among people with mental illnesses. They reported substantially higher prevalence of obesity, diabetes, and cardiovascular disease across a wide spectrum of psychiatric disorders. Causative factors include higher rates of smoking, alcohol abuse, sleep disturbance, physical inactivity and poor nutrition; substantially impaired access to good medical care; as well as adverse drug reactions and missed diagnoses resulting from poor integration of physical and mental health services.[34] Another contributor to excess mortality during the pandemic is an increase in deaths from non-COVID-19 causes, presumably from disruption of regular medical care and social services.[28] A recent survey found that forgone medical care was more common among those with mental health problems.[35] The social isolation caused by the pandemic might also more negatively affect the health of patients with psychiatric disorders and can contribute to excess deaths.

Individuals with major psychiatric disorders, especially schizophrenia, had the highest all-cause mortality and COVID-19 infection rates in 2020.[22,25,26] Both social and biological factors can contribute to their vulnerability. Patients with schizophrenia are less likely to practice preventive behaviors (e.g., stay at home, wear face masks), resulting in more exposures to virus.[36] Their particular immunological profile and antipsychotic treatments can be associated with worse prognosis and higher mortality after a COVID-19 infection.[23,26,36] Also, major psychiatric illness in community dwelling enrollees may be accompanied by severe socioeconomic deprivation, such as homelessness.[34]

The 1.7% beneficiaries who were long-stay nursing home residents experienced a 37% excess mortality in 2020 and contributed 26% of all excess deaths among Medicare beneficiaries. Psychiatric diagnoses did not introduce additional risk of mortality among nursing home residents, except for the major psychiatric disorders. Higher mortality among those with psychiatric diagnoses in the community was at least in part due to higher COVID-19 infection rates, but in an institutional setting like nursing homes with very high transmission rates, psychiatric diagnosis becomes a less important risk factor.

The excess mortality among long-stay residents was much higher than that in beneficiaries living in the community (12%) or assisted living facilities (14%).[37] Nursing home residents who are older, more functionally dependent, and with multiple comorbidities (e.g. dementia, chronic pulmonary disease, and diabetes) have been the most vulnerable population during the pandemic.[12,15,38] Fortunately, the prioritization of COVID-19 vaccine administration in nursing homes greatly reduced COVID-19 infection rates and deaths starting February 2021.

Strengths and limitations

Our study has several strengths. The 20% national sample of over 15 million fee-for-service Medicare beneficiaries provided robust estimates of excess deaths for older adults in the United States. The use of 10-fold cross-validated regressions enhanced the accuracy of our estimates. Different excess deaths among patients with specific psychiatric conditions and from the community versus nursing homes suggest a heterogenous effect of the COVID-19 pandemic on older adults.

Several limitations should be acknowledged. We studied Medicare fee-for-service claims, which limits generalizability to the Medicare Advantage population, accounting for 43% of overall Medicare population.[39] Compared to fee-for-service beneficiaries, Medicare Advantage beneficiaries are healthier,[40,41] have a lower prevalence of mental illnesses,[42] and use fewer acute and nursing home care.[39] Hence, our estimates of excess deaths per 100,000 beneficiaries will probably decrease if they were included. The exclusion of Medicare Advantage beneficiaries may have increased the differences in excess deaths between beneficiaries with versus without

psychiatric diagnoses, because Medicare advantage programs can provide better access to non-COVID care and possibly mitigated the risk of death for patients with psychiatric diagnoses.[43] The inclusion criteria of having at least 2 years' continuous Medicare coverage excluded newly enrolled older adults. The psychiatric diagnoses based on Medicare claims may underestimate the actual number of patients with psychiatric illnesses.[44] Because of the lack of information on causes of deaths in Medicare claims, we cannot determine the actual reasons of deaths. The performance of the predictive model of mortality for nursing home residents was not as good as that for the community (c-statistic = 0.693 vs. 0.822), which may lead to less accurate estimates of excess deaths in nursing homes. Estimates of COVID-19 infection rates can be highly dependent on rates of testing, particularly among those with few or no symptoms. Thus, between-group differences in infection rates are subject to selection biases on who gets tested and must be interpreted with caution. Finally, our method of excluding beneficiaries with prior COVID-19 infection in the estimates of monthly COVID-19 infection rates would exclude patients with re-infection.

In conclusion, excess deaths of the COVID-19 pandemic were disproportionally greater in beneficiaries with psychiatric diagnoses and those living in nursing homes. This appeared to be mediated by the increase in comorbidities in those with mental illness. Preventing COVID-19 infection remains important for reducing excess deaths among Medicare beneficiaries, especially for community-dwelling beneficiaries with major psychiatric disorders and those living in nursing homes. COVID-19 vaccination and boosters are critical for these high-risk groups, as well as for nursing home staff.

AUTHOR CONTRIBUTIONS

Conception and design: Xu, Li, and Goodwin; Acquisition of data: Goodwin and Li; Analysis: Li; Interpretation of data: Xu, Li, and Goodwin; Drafting the article: Xu, Li, Mehta, Hommel, and Goodwin; and Final approval: Xu, Li, Mehta, Hommel, and Goodwin.

CONFLICT OF INTEREST

All authors report no financial relationships with commercial interests.

SPONSOR'S ROLE

The sponsor had no role in the design, methods, analysis, or preparation of the paper.

FINANCIAL DISCLOSURE

Funding supported by the National Institutes of Health (P30AG024832, UL1-TR001439, and 1K01AG070329).

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SUPPORTING INFORMATION

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

Table S1. Beneficiary characteristics in 2019, 2020, and 2021.
Table S2. Beneficiary characteristics by residential location in 2020.
Table S3. Multivariate logistic regressions on all-cause mortality in 2019.
Table S4. Stratified analysis of excess deaths in 2020 for beneficiaries living in the community and in nursing homes.
Table S5. Excess deaths in 2020 by psychiatric diagnoses among beneficiaries without medical comorbidities (January to December).
Table S6. Excess deaths in 2020 by psychiatric diagnoses adjusting for frailty index (January to December)
Figure S1. Cohort selection diagram for Medicare beneficiaries in 2019, 2020, and 2021
Figure S2. Time trends in COVID-19 infection rates among Medicare fee-for-service beneficiaries from April 2019 to December 2021. COVID-19 infections were identified from Medicare claims (inpatient, SNF, outpatient, and carrier claims), using the diagnosis code of U07.1; the nominator is the beneficiaries who were newly diagnosed with COVID-19 in each month; the denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the infection rate among all beneficiaries in 2020 was 5.28%, with 7.93% in beneficiaries with any psychiatric diagnosis and 4.20% in beneficiaries without a psychiatric diagnosis.
Figure S3. Time trends in COVID-19 infection rates among community-dwelling Medicare fee-for-service beneficiaries from April 2019 to December 2021. COVID-19 infections were identified from Medicare claims (inpatient, SNF, outpatient, and carrier claims), using the diagnosis code of U07.1; the nominator is the beneficiaries who were newly diagnosed with COVID-19 in each month; the denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the infection rate among community beneficiaries in 2020 was 4.60%, with 6.16% in beneficiaries with any psychiatric diagnosis and 3.99% in beneficiaries without a psychiatric diagnosis.
Figure S4. Time trends in COVID-19 infection rates among Medicare fee-for-service residents in nursing homes from April 2019 to December 2021. COVID-19 infections were identified from Medicare claims (inpatient, SNF, outpatient, and carrier claims), using the diagnosis code of U07.1; the nominator is the beneficiaries who were newly diagnosed with COVID-19 in each month; the denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the infection rate among nursing home beneficiaries in 2020 was 44.40%, with 45.74% in beneficiaries with any psychiatric diagnosis and 40.15% in beneficiaries without a psychiatric diagnosis.
Figure S5. Time trends in 30-day COVID-19 fatality rates among Medicare fee-for-service beneficiaries from April 2019 to December 2021. The denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the nominator is the beneficiaries who were newly diagnosed with COVID-19 and died within 30 days of infection in each month.
Figure S6. Time trends in 30-day COVID-19 fatality rates among community-dwelling Medicare fee-for-service beneficiaries from April 2019 to December 2021. The denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the nominator is the beneficiaries who were newly diagnosed with COVID-19 and died within 30 days of infection in each month.
Figure S7. Time trends in 30-day COVID-19 fatality rates among Medicare fee-for-service residents in nursing homes from April 2019 to December 2021. The denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the nominator is the beneficiaries who were newly diagnosed with COVID-19 and died within 30 days of infection in each month.
Figure S8. Time trends in 60-day COVID-19 fatality rates among Medicare fee-for-service beneficiaries from April 2019 to December 2021. The denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the nominator is the beneficiaries who were newly diagnosed with COVID-19 and died within 60 days of infection in each month.
Figure S9. Time trends in 60-day COVID-19 fatality rates among community-dwelling Medicare fee-for-service beneficiaries from April 2019 to December 2021. The denominator is the beneficiaries who were still alive and

had not infected on the first day of each month; the nominator is the beneficiaries who were newly diagnosed with COVID-19 and died within 60 days of infection in each month.

Figure S10. Time trends of 60-day COVID-19 fatality rate among Medicare fee-for-service residents in nursing homes from April 2019 to December 2021. The denominator is the beneficiaries who were still alive and had not infected on the first day of each month; the nominator is the beneficiaries who were newly diagnosed with COVID-19 and died within 60 days of infection in each month.

How to cite this article: Xu H, Li S, Mehta HB, Hommel EL, Goodwin JS. Excess deaths from COVID-19 among Medicare beneficiaries with psychiatric diagnoses: community versus nursing home. *J Am Geriatr Soc*. 2022;1-11. doi:10.1111/jgs.18062