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Population-Based Estimates of 1-Year Mortality After Major Surgery Among Community-Living Older US Adults

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Invited Commentary

Supplemental content

IMPORTANCE Despite their importance to guiding public health decision-making and policies and to establishing programs aimed at improving surgical care, contemporary nationally representative mortality data for geriatric surgery are lacking.

OBJECTIVE To calculate population-based estimates of mortality after major surgery in community-living older US adults and to determine how these estimates differ according to key demographic, surgical, and geriatric characteristics.

DESIGN, SETTING, AND PARTICIPANTS Prospective longitudinal cohort study with 1 year of follow-up in the continental US from 2011 to 2018. Participants included 5590 community-living fee-for-service Medicare beneficiaries, aged 65 years or older, from the National Health and Aging Trends Study (NHATS). Data analysis was conducted from February 22, 2021, to March 16, 2022.

MAIN OUTCOMES AND MEASURES Major surgeries and mortality over 1 year were identified through linkages with data from the Centers for Medicare & Medicaid Services. Data on frailty and dementia were obtained from the annual NHATS assessments.

RESULTS From 2011 to 2017, of the 1193 major surgeries (from 992 community-living participants), the mean (SD) age was 79.2 (7.1) years; 665 were women (55.7%), and 30 were Hispanic (2.5%), 198 non-Hispanic Black (16.6%), and 915 non-Hispanic White (76.7%). Over the 1-year follow-up period, there were 206 deaths representing 872 096 survey-weighted deaths and 13.4% (95% CI, 10.9%-15.9%) mortality. Mortality rates were 7.4% (95% CI, 4.9%-9.9%) for elective surgeries and 22.3% (95% CI, 17.4%-27.1%) for nonelective surgeries. For geriatric subgroups, 1-year mortality was 6.0% (95% CI, 2.6%-9.4%) for persons who were nonfrail, 27.8% (95% CI, 21.2%-34.3%) for those who were frail, 11.6% (95% CI, 8.8%-14.4%) for persons without dementia, and 32.7% (95% CI, 24.3%-41.0%) for those with probable dementia. The age- and sex-adjusted hazard ratios for 1-year mortality were 4.41 (95% CI, 2.53-7.69) for frailty with a reduction in restricted mean survival time of 48.8 days and 2.18 (95% CI, 1.40-3.40) for probable dementia with a reduction in restricted mean survival time of 44.9 days.

CONCLUSIONS AND RELEVANCE In this study, the population-based estimate of 1-year mortality after major surgery among community-living older adults in the US was 13.4% but was 3-fold higher for nonelective than elective procedures. Mortality was considerably elevated among older persons who were frail or who had probable dementia, highlighting the potential prognostic value of geriatric conditions after major surgery.

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As the geriatric population in the US steadily increases,[1,2] the number of older persons requiring major surgical intervention will also increase.[3,4] For these older patients, preserving functional independence, maintaining health-related quality of life, and relieving symptom burden are the outcomes of primary importance.[5,6] Achieving such goal-concordant care for this patient population has become a core tenet of surgical decision-making[7,8] and is a major focus of the recently established American College of Surgeons Geriatric Surgery Verification Program.[9]

Although mortality may not be the outcome of greatest importance for many older persons,[6,10] accurate and timely nationally representative mortality data are vitally important for at least 2 reasons. First, population-based mortality estimates are easily interpretable indicators of the welfare of older persons, including those undergoing major surgery. These estimates are essential to comprehending the scope and scale of mortality after major geriatric surgery, to understanding surgical quality and safety among older persons, and to assessing mortality differences by demographic and geriatric-specific characteristics. Second, nationally representative mortality data for geriatric surgery are critical to guiding public health decision-making and policies, to allocating resources and interventions, to setting goals for mortality reduction, and to establishing programs aimed at improving surgical care among older persons. For these reasons, population-based mortality data are fundamental to achieving more optimal outcomes among older persons undergoing major surgery. Current estimates, however, are based on only a handful of operations or single institutional experiences, focus solely on specific older age groups, are outdated or lack mortality data beyond 30 days, or do not include meaningful geriatric-specific conditions such as frailty and dementia.[11-18]

The objectives of the current study were 2-fold: first, to calculate population-based estimates for 1-year mortality after major surgery among community-living older US adults across the spectrum of surgical disciplines, including both elective and nonelective operations; and second, to determine how these estimates differ according to key demographic, surgical, and geriatric characteristics, including frailty and dementia. To accomplish these objectives, we used data from the National Health and Aging Trends Study (NHATS)[19] linked to records from the Centers for Medicare & Medicaid Services (CMS).

Key Points

Question What are the population-based estimates of 1-year mortality after major surgery among community-living older US adults?

Findings In this cohort study of 1193 major surgeries identified from 992 community-living participants, overall 1-year mortality was 13.4%. More than 1 of 4 community-living older US adults who were frail and nearly 1 of 3 who had probable dementia died in the year after major surgery.

Meaning In this study, mortality after major surgery was found to be elevated among older persons who are frail or who have probable dementia, highlighting the potential prognostic value of geriatric conditions.

Methods

Data Sources

The NHATS is a prospective nationally representative longitudinal study of Medicare beneficiaries.[20] On September 30, 2010, NHATS drew a random sample of persons aged 65 years or older living in the contiguous US (excluding Alaska, Hawaii, and Puerto Rico) from the Medicare enrollment file. Counties were sampled from regional strata, and non-Hispanic Black individuals and persons aged 90 years or older were oversampled within zip codes. Baseline (round 1 in NHATS terminology) assessments, completed from May through November 2011, yielded a sample of 8245 persons with a 71% weighted response rate. Proxy respondents were interviewed when the participant could not respond (n = 583 or 5.8% [weighted]). Follow-up assessments were completed annually by trained research staff. Data analysis was conducted from February 22, 2021, to March 16, 2022.

The NHATS is sponsored by the National Institute on Aging through a cooperative agreement with the Johns Hopkins Bloomberg School of Public Health. The Johns Hopkins University institutional review board approved the NHATS protocol, and all participants provided written informed consent. Use of NHATS data for this analysis was approved by the Yale University institutional review board. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

The CMS records of fee-for-service claims, cross-linked to NHATS data, were used to identify participants who underwent major surgery. Comparable data were not available in NHATS from Medicare Advantage, which are plans offered by private companies that have been approved by the CMS to serve Medicare beneficiaries.[21] Major surgery was defined as any procedure in an operating room requiring the use of general anesthesia for a nonpercutaneous nonendoscopic invasive operation. This definition, which has been previously implemented in research by several authors of the present study,[3,22] is consistent with other definitions of high-risk surgery in older persons.[11,23] We categorized each procedure into 1 of 6 types: (1) musculoskeletal; (2) abdominal (including gastrointestinal); (3) vascular (including endovascular, non-coronary bypass grafts, and amputations); (4) neurologic (including brain and spine); (5) cardiothoracic; and (6) other (including major endocrine, gynecologic, urologic, breast, plastic, otolaryngologic, and transplant surgery). Major surgeries were categorized as elective (planned) or nonelective (unplanned) based on a CMS indicator variable.[3,22] Ophthalmology procedures did not meet criteria for major surgery.

Study Population

Among the 7609 NHATS participants who were living in settings other than nursing homes (ie, community living) at the time of their round 1 assessment, we identified those who were enrolled for at least 1 month in fee-for-service Medicare during the subsequent 6-year surveillance window from 2011 to

Table. Characteristics of Major Surgeries Contributed by Community-Living Participants From 2011 to 2017[a]

Characteristic	No. (%) All surgeries	Elective surgery	Nonelective surgery
No. of observations	1193	661	532
Weighted No. of observations[b]	6 497 766	3 864 795	2 632 971
Age, mean (SD), y	79.2 (7.1)	77.6 (6.4)	81.1 (7.4)
Age group, y			
65-69	80 (6.7)	52 (7.9)	28 (5.3)
70-74	248 (20.8)	164 (24.8)	84 (15.8)
75-79	277 (23.2)	178 (26.9)	99 (18.6)
80-84	276 (23.1)	150 (22.7)	126 (23.7)
85-89	200 (16.8)	87 (13.2)	113 (21.2)
≥90	112 (9.4)	30 (4.5)	82 (15.4)
Sex			
Female	665 (55.7)	363 (54.9)	302 (56.8)
Male	528 (44.3)	298 (45.1)	230 (43.2)
Race and ethnicity[c]			
Hispanic	30 (2.5)	15 (2.3)	15 (2.8)
Non-Hispanic Black	198 (16.6)	85 (12.9)	113 (21.2)
Non-Hispanic White	915 (76.7)	540 (81.7)	375 (70.5)
Other	50 (4.2)	21 (3.2)	29 (5.5)
Educational level			
Less than high school	254 (21.3)	121 (18.3)	133 (25.0)
High school or equivalent	332 (27.8)	187 (28.3)	145 (27.3)
Beyond high school	596 (50)	348 (52.7)	248 (46.6)
Medicaid eligible	198 (16.6)	92 (13.9)	106 (19.9)
No. of chronic conditions, mean (SD)[d]	2.8 (1.4)	2.8 (1.4)	2.8 (1.4)
Frailty phenotype			
Nonfrail	276 (23.1)	182 (27.5)	94 (17.7)
Prefrail	610 (51.1)	344 (52.0)	266 (50.0)
Frail	307 (25.7)	135 (20.4)	172 (32.3)
Dementia status			
No dementia	917 (76.9)	552 (83.5)	365 (68.6)
Possible dementia	127 (10.6)	61 (9.2)	66 (12.4)
Probable dementia	149 (12.5)	48 (7.3)	101 (19.0)
Type of surgery			
Musculoskeletal	482 (40.4)	253 (38.3)	229 (43.0)
Abdominal (including gastrointestinal)	210 (17.6)	79 (12.0)	131 (24.6)
Vascular	146 (12.2)	93 (14.1)	53 (10.0)
Neurologic	99 (8.3)	72 (10.9)	27 (5.1)
Cardiothoracic	104 (8.7)	67 (10.1)	37 (7.0)
Other	152 (12.7)	97 (14.7)	55 (10.3)

[a] Unless otherwise stated, the data in the Table are presented as unweighted values. The values for number of chronic conditions, frailty phenotype, and dementia status were obtained during the annual assessment immediately prior to the surgery. Some percentages may not sum to 100 because of missing data. The 1193 observations were contributed by 992 participants, as described in the Methods.

[b] Estimates after applying National Health and Aging Trends Study analytic survey weights to the total count of hospital admissions for major surgery.

[c] Race and ethnicity were self-reported and included as part of the sociodemographic description of the cohort. Race data were collected in the following categories: Alaska Native, American Indian, Black or African American, Native Hawaiian, Other Pacific Islander, White, and other. Ethnicity data were collected in the following categories: Cuban American, Mexican American or Chicano, Puerto Rican, and other. Race and ethnicity data were combined into categories and reported as Hispanic, non-Hispanic Black, non-Hispanic White, and other. The other category includes participants who reported their race/ethnicity as Asian, American Indian, Native Hawaiian, Other Pacific Islander, other, do not know, or more than 1 race and ethnicity.

[d] Includes 9 self-reported, physician-diagnosed chronic conditions, including heart attack, high blood pressure, arthritis, osteoporosis, diabetes, lung disease, stroke, cancer, and hip fracture since age 50 years.

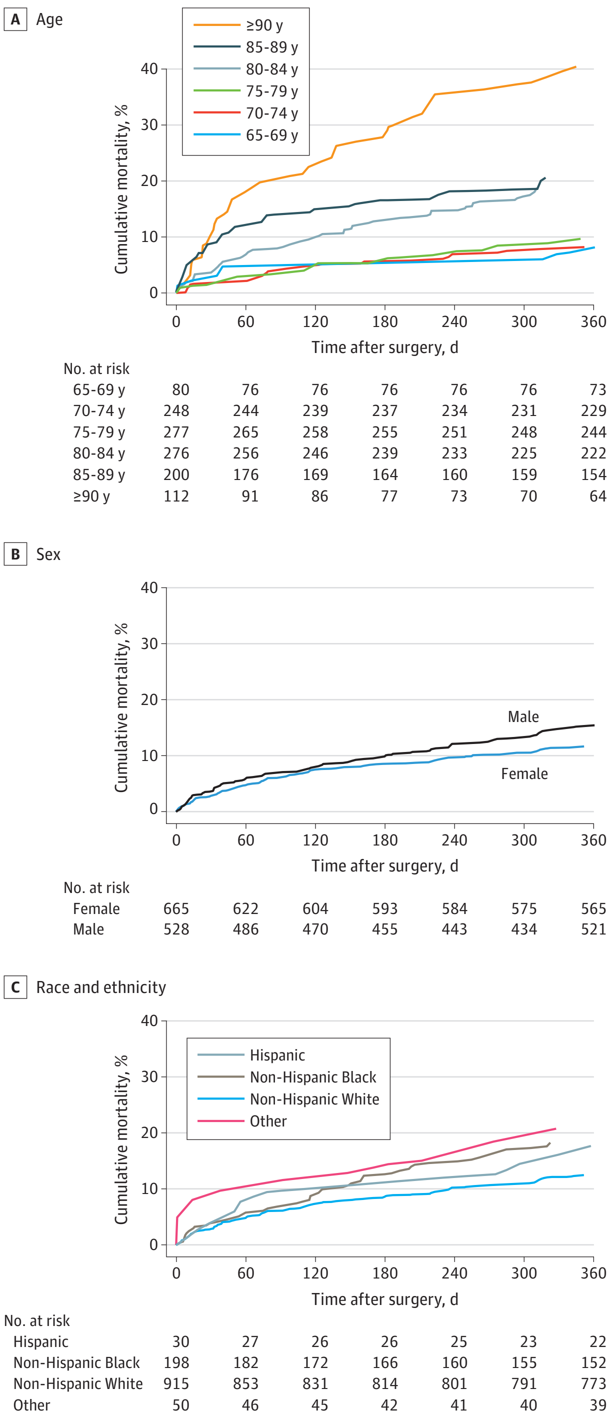
2017. The number of participants with continuous fee-for-service Medicare was 4418 (58.1%), a combination of fee-for-service Medicare and Medicare Advantage was 1172 (15.4%), and Medicare Advantage was 2019 (26.5%).

During round 1 of NHATS, information was collected on demographic characteristics, including age, sex, self-reported race and ethnicity (for descriptive purposes and sampling), and educational level; 9 self-reported, physician-diagnosed chronic conditions, including heart attack, high blood pressure, arthritis, osteoporosis, diabetes, lung disease, stroke, cancer, and hip fracture since age 50 years; and 2 geriatric conditions—frailty and dementia. Participant status was categorized as nonfrail, prefrail, and frail according to the Fried phenotype[24] and as having no dementia, possible dementia, or probable dementia based on a validated assessment strategy.[19,25] Data on chronic conditions, frailty, and dementia were updated as needed during the annual assessments and were 100% complete. Medicaid eligibility was obtained from the CMS records.

Assembly of Analytic Sample

Major surgeries were included through December 2017. The 5590 participants with fee-for-service Medicare could contribute more than 1 major surgery to the analysis based on the following criteria: (1) participant had to be community living

Figure 1. Cumulative Mortality Over 1 Year Following Major Surgery by Demographic Characteristics



National Health and Aging Trends Study–weighted Kaplan-Meier mortality curves end after the last death within a specific subgroup.

at the time of the prior annual assessment; (2) participant was not admitted from a nursing home; (3) observation represented the first major surgery within the 1-year interval; (4) participant did not die within 12 months of a prior major surgery; and (5) participant did not contribute a major surgery within the prior 3 months because the prior observation may have altered key participant characteristics from the prior annual assessment. Of the 1937 major surgeries, 745 were excluded: 547 were not community living, 63 were admitted from a nursing home, 125 were not the first major surgery in an interval, 8 were observations within 12 months of a prior major surgery resulting in death, and 1 followed a prior major surgery within 3 months, leaving 1193 observations from 992 participants in the analytic sample.

Outcome

Time to death within 1 year of major surgery was determined from the Medicare enrollment files. For the 58 observations with missing data on date of surgery (4.9%), date of hospital admission was substituted.

Statistical Analysis

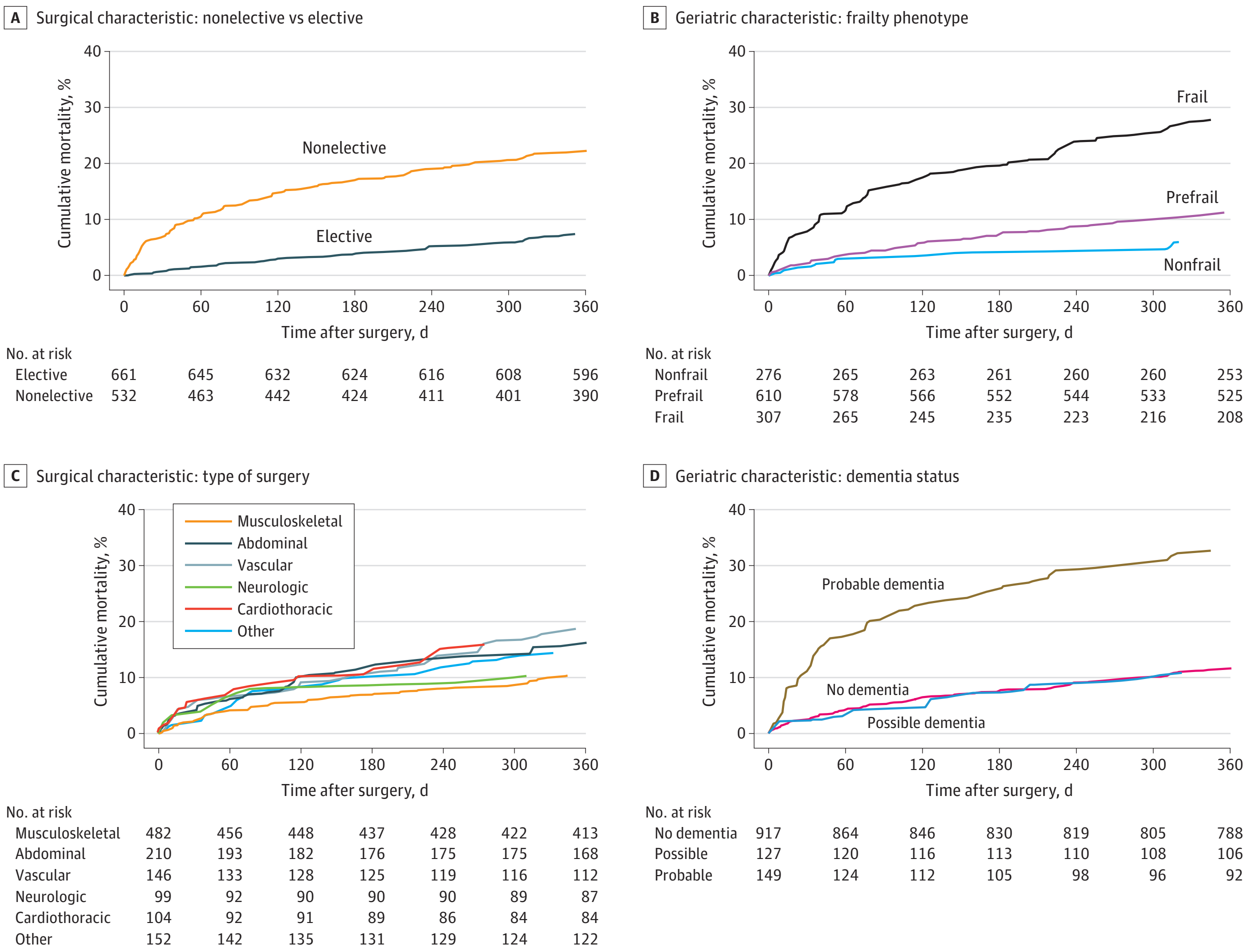
Unweighted descriptive statistics of the analytic sample were calculated. NHATS-weighted 1-year mortality rates and Kaplan-Meier curves were generated according to key demographic, surgical, and geriatric characteristics. For each person-year of NHATS data, we used the specific analytic weights that adjust for differential probabilities of selection and nonresponse within the context of each strata (region) and cluster (zip code within county), thereby permitting national estimates.[26,27] Unadjusted Cox proportional hazards regression models were used to generate hazard ratios (HRs). Robust SEs and their corresponding CIs were calculated by fitting each Cox proportional hazards model using the balanced repeated replication approach.[28] This approach accounts for the complex survey design[29] and multiple observations based on a small number of participants,[30] and it overcomes potential bias in estimated variance when proportional hazards assumptions are violated.[29]

A similar set of procedures was used for the age- and sex-adjusted models. However, the model for age was adjusted only for sex, whereas the model for sex was adjusted only for age. The adjusted results are also reported separately for elective and nonelective surgeries. To enhance clinical interpretability, we calculated restricted mean survival times for each of the statistically significant subgroups and corresponding reference group from the adjusted models,[31] and we determined the differences between these values, which can be interpreted as differences in survival time or mortality. Statistical significance was defined as a 95% CI excluding 1 for the HRs. All analyses were performed using SAS version 9.4 (SAS Institute).

Results

The characteristics of the analytic sample are provided in the **Table**. Of the 1193 major surgeries, the mean (SD) age was 79.2 (7.1) years; 665 were women (55.7%), and 30 were Hispanic (2.5%), 198 non-Hispanic Black (16.6%), and 915 non-Hispanic White (76.7%). Approximately half had a high school education or less, and 1 of 6 was Medicaid eligible. Participants who had elective surgery generally had a more favor-

Figure 2. Cumulative Mortality Over 1 Year Following Major Surgery by Surgical and Geriatric Characteristics



National Health and Aging Trends Study–weighted Kaplan-Meier mortality curves end after the last death within a specific subgroup. Abdominal includes gastrointestinal surgeries.

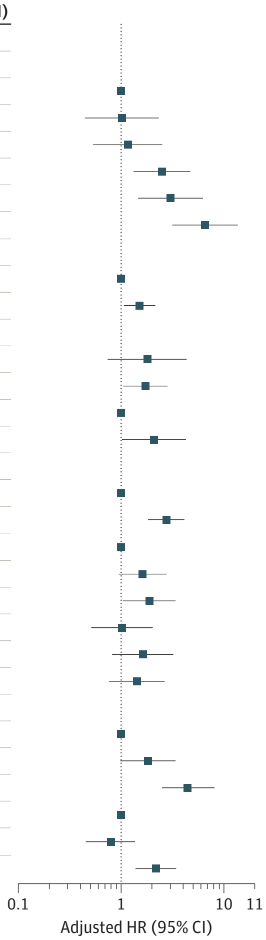
able profile than those who had nonelective surgery, as evidenced by their younger age, higher educational attainment, and lower prevalence of Medicaid eligibility, frailty, and possible or probable dementia. The 3 most common types of surgery were musculoskeletal, abdominal (including gastrointestinal), and vascular. Differences in the types of surgery between elective and nonelective procedures were modest except for abdominal (including gastrointestinal), which was twice as common for nonelective than elective procedures.

Over the 1-year follow-up period, there were 206 deaths representing 872 097 survey-weighted deaths and 13.4% mortality (95% CI, 10.9%-15.9%). The corresponding values were 286 219 survey-weighted deaths and 7.4% (95% CI, 4.9%-9.9%) for elective and 585 878 and 22.3% (95% CI, 17.4%-27.1%) for nonelective surgery. The median time to death was 96 (IQR, 33-223) days for all major surgeries, 169 (IQR, 72-276) days for elective surgeries, and 62 (IQR, 15-171) days for nonelective surgeries. Information on 1-year mortality for each of the demographic, surgical, and geriatric subgroups is provided in the eTable in the Supplement. For the geriatric subgroups, 1-year mortality ranged from 6.0% (95% CI, 2.6%-9.4%) for persons who were nonfrail to 27.8% (95% CI, 21.2%-34.3%) for those who were frail and from 11.6% (95% CI, 8.8%-14.4%) for persons without dementia to 32.7% (95% CI, 24.3%-41.0%) for those with probable dementia.

Figure 1 shows cumulative mortality over 1 year for the demographic characteristics. Mortality was highest for persons aged 90 years or older, intermediate for those aged 80 to 84 and 85 to 89 years, and lowest for those in the youngest 3 age groups (Figure 1A). With persons aged 65 to 69 years as the reference group, mortality was statistically greater only for the 3 oldest age groups, with unadjusted HRs of 2.44 (95% CI, 1.30-4.57) for those aged 80 to 84 years, 2.89 (95% CI, 1.41-5.91) for those aged 85 to 89 years, and 6.06 (95% CI, 2.93-12.6) for those aged 90 years or older. Men had higher mortality than women (Figure 1B), although this difference was not statistically significant, with an unadjusted HR of 1.34 (0.93, 1.93). For race and ethnicity (Figure 1C), mortality was highest for persons classified as other and lowest for non-Hispanic White individuals. With the latter as the reference group, unadjusted mortality was not statistically greater for any of the 3 other racial and ethnic groups.

Figure 3. Adjusted Hazard Ratios (HRs) for 1-Year Mortality Following Major Surgery According to Demographic, Surgical, and Geriatric Characteristics

Characteristic	Adjusted HR (95% CI)
Demographic	
Age group, y	
65-69	1 [Reference]
70-74	1.02 (0.45-2.30)
75-79	1.16 (0.54-2.48)
80-84	2.50 (1.34-4.66)
85-89	3.03 (1.48-6.19)
≥90	6.56 (3.19-13.5)
Sex	
Female	1 [Reference]
Male	1.51 (1.08-2.13)
Race and ethnicity	
Hispanic	1.80 (0.75-4.29)
Non-Hispanic Black	1.73 (1.06-2.80)
Non-Hispanic White	1 [Reference]
Other	2.09 (1.03-4.24)
Surgical	
Elective	1 [Reference]
Nonelective	2.75 (1.85-4.08)
Musculoskeletal	1 [Reference]
Abdominal	1.62 (0.96-2.74)
Vascular	1.88 (1.05-3.35)
Neurologic	1.02 (0.52-2.01)
Cardiothoracic	1.63 (0.83-3.19)
Other	1.42 (0.77-2.63)
Geriatric	
Nonfrail	1 [Reference]
Prefrail	1.83 (1.00-3.35)
Frail	4.41 (2.53-7.69)
No dementia	1 [Reference]
Possible dementia	0.79 (0.46-1.35)
Probable dementia	2.18 (1.40-3.40)



The model for age was adjusted for sex, whereas the model for sex was adjusted for age. All other models were adjusted for age and sex. Abdominal includes gastrointestinal surgeries.

Figure 2 provides mortality curves for the surgical and geriatric characteristics. As expected, mortality was considerably higher for nonelective than elective surgeries, with an unadjusted HR of 3.35 (95% CI, 2.31-4.85). For the subtypes, mortality was highest for vascular and cardiothoracic surgery and lowest for musculoskeletal surgery. With the latter as the reference group, the risk of mortality was statistically greater only for vascular surgery, with an unadjusted HR of 1.88 (95% CI, 1.05-3.35). As shown in the right upper panel, mortality was highest for persons who were frail and lowest for those who were nonfrail. With nonfrail as the reference group, the risk of mortality was statistically greater for persons who were prefrail, with an unadjusted HR of 1.94 (95% CI, 1.01-3.73), and frail, with an adjusted HR of 5.31 (95% CI, 2.91-9.69). In contrast, with no dementia as the reference group, the risk of mortality was increased for persons who had probable dementia, with an unadjusted HR of 3.29 (95% CI, 2.08-5.19) but not for those who had possible dementia.

Figure 3 provides the adjusted HRs for 1-year mortality following major surgery according to the demographic, surgical, and geriatric characteristics. The age- and sex-adjusted HRs for 1-year mortality were 4.41 (95% CI, 2.53-7.69) for frailty and 2.18 (95% CI, 1.40-3.40) for probable dementia. Relative to their respective reference group, mortality remained significantly elevated for age groups 80 to 84 years, 85 to 89 years, and 90 years or older for nonelective surgery and vascular surgery and for frail and probable dementia; statistically significant associations were newly observed for male sex, non-Hispanic Black, and other race and ethnicity. Although power was diminished, comparable findings were generally observed for elective and nonelective surgeries, as shown in the eFigure in the Supplement.

The restricted mean survival times for the statistically significant subgroups and respective reference group from the adjusted Cox proportional hazards regression models are provided in **Figure 4**, along with the corresponding differences between these values. Mean survival times were lowest for age 90 years or older, probable dementia, and frailty, leading to large differences relative to the respective reference groups, with values of 48.8 days for frailty, 44.9 days for probable dementia, and 83.7 days for age 90 years or older. Differences greater than 30 days (ie, 1 month) were also observed for age group 85 to 89 years and nonelective surgery.

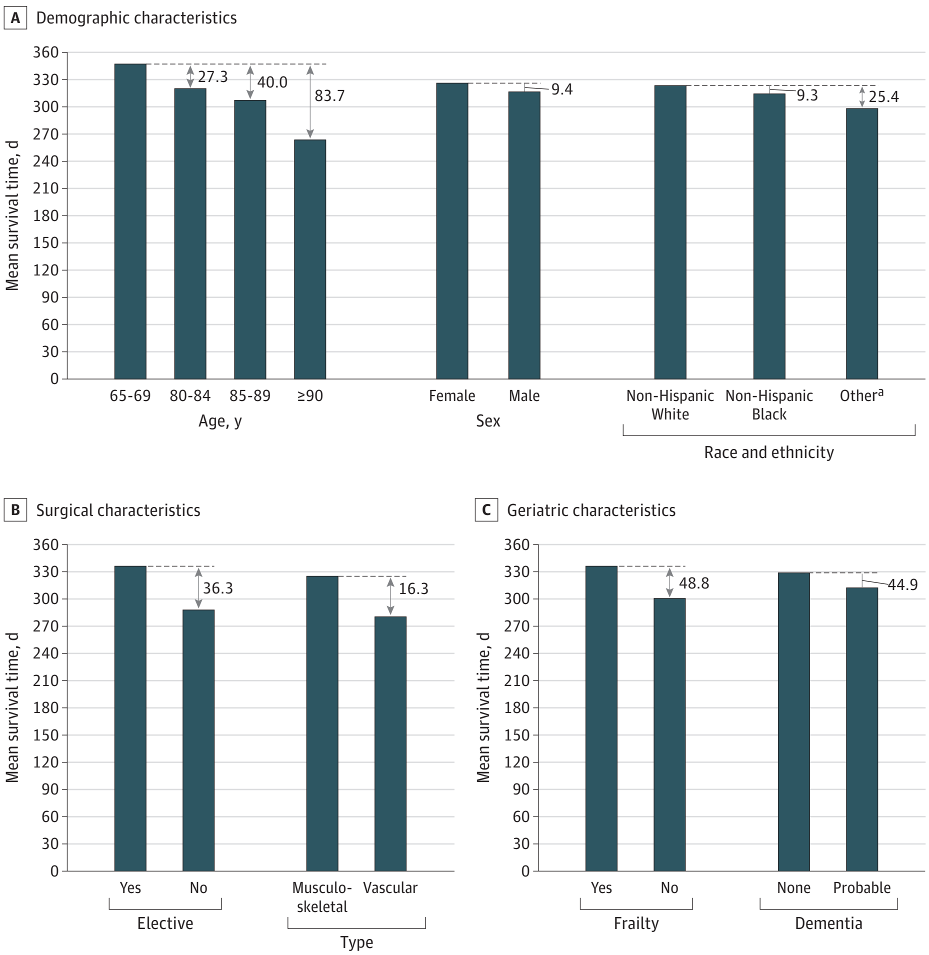
Discussion

In this nationally representative sample of community-living older US adults, we estimated 1-year mortality after major surgery across the spectrum of surgical disciplines and evaluated these population-based estimates according to key demographic, surgical, and geriatric characteristics. We found that nearly 1 of every 7 community-living older US adults died in the year after major surgery, including more than 1 of 4 who were frail and nearly 1 of 3 who had probable dementia. Mortality was 3-fold higher for nonelective than elective surgery and was especially elevated for persons who were 90 years or older. Our findings suggest substantial differences in 1-year mortality after major surgery across distinct subgroups of older persons and highlight the potential prognostic value of geriatric conditions such as frailty and dementia.

Population-based estimates of mortality after major surgery among older persons are relatively sparse. Prior studies have included only a subset of specific operations,[13,14,17] have been based at only a single institution,[14,16-18] have focused on a limited range of ages,[13-15] have not evaluated mortality beyond 30 days,[15,16,18] or are now outdated.[11,13-17] None, to our knowledge, has evaluated validated measures of geriatric-specific conditions such as frailty or dementia. By linking data from a well-phenotyped and nationally representative cohort of community-living older US adults to CMS records, we were able to address each of these limitations and, in turn, generate a robust set of population-based estimates of 1-year mortality after major surgery.

The increased risk of death observed in several distinct subgroups led to large reductions in mean survival times during the 1-year follow-up period, especially for the 2 oldest age groups (83.7 days for persons 90 years or older and 40.0 days

Figure 4. Restricted Mean Survival Times for Relevant Demographic, Surgical, and Geriatric Subgroups



Values are provided for each of the statistically significant subgroups and respective reference group from the adjusted Cox proportional hazards regression models, along with the corresponding differences in mean survival.

[a] For race and ethnicity, the Black and White subgroups are both non-Hispanic, while the other subgroup includes those who reported their race and ethnicity as Asian, American Indian, Native Hawaiian, Other Pacific Islander, other, do not know, or more than 1 race and ethnicity.

for those 85-89 years) and persons with frailty (48.8 days) and probable dementia (44.9 days). Notably, these values exceeded the reduction in survival time observed for nonelective surgery (36.3 days). Differences in 1-year mortality and the corresponding reductions in mean survival times were even smaller for subgroups defined on the basis of sex, race and ethnicity, and type of surgery. As shown in Figure 1 and Figure 2, large mortality differences were readily apparent within the first month after major surgery for the 2 oldest age groups and for persons who had frailty and probable dementia. These differences, which were comparable to that observed between elective and nonelective surgery, persisted over the following 11 months, suggesting the potential short-term and long-term prognostic value of these factors.

The current study was not designed to determine the reasons for these mortality differences or to identify independent risk factors associated with mortality. Nonetheless, our findings are notable because they define the scope and scale of mortality after major geriatric surgery in the US and because they suggest a mix of surgical quality and safety among older persons. With improved preoperative optimization and recognition as well as enhanced perioperative management strategies, it is possible that mortality after major surgery could be reduced among older persons, especially those in high-risk subgroups. Two surgical organizations, the American College of Surgeons through its Geriatric Surgery Verification Program and the Society for Perioperative Assessment and Quality Improvement, have recently provided recommendations to improve outcomes after geriatric surgery.[9,32]

Major surgery is a common event in the lives of community-living older persons, with a nationally representative incidence (per 100 person-years) of 8.8.[3] The 5-year cumulative risk of major surgery is 13.8%, representing nearly 5 million older persons in the US, including 12.1% in persons aged 85 to 89 years, 9.1% in those aged 90 years or older, 12.1% in those with frailty, and 12.4% in those with probable dementia.[3] These values, combined with the mortality estimates reported in the current study, highlight the public health relevance of major surgery in an aging society[1] and suggest that policies, resources, interventions, and programs aimed at optimizing the care and outcomes of older US adults undergoing major surgery may have utility in the US health care system.

Strengths and Limitations

Three unique strengths enhance the generalizability, validity, and applicability of our findings. First, by linking CMS data to the NHATS, a population-based cohort, we were able to generate nationally representative estimates of 1-year mortality after major surgery in Medicare beneficiaries for the contiguous US. Second, we used an established definition of major surgery in older persons that is clearly defined, clinically relevant, widely accepted, and encompasses the spectrum of surgical disciplines.[11,22,23,33] Third, we provide estimates for subgroups defined on the basis of validated measures of frailty and dementia, 2 key determinants of health and well-being in older persons.[22,33-36] These data were updated annually and were 100% complete.

This study has limitations. First, our results are limited to fee-for-service Medicare beneficiaries since CMS data on Medicare Advantage were not available. The penetrance of Medicare Advantage was approximately 25% in the current study but is projected to increase to 42% by 2028.[37] With the decision by the CMS to make Medicare Advantage claims data more broadly available,[38] it should be possible to base future estimates on all Medicare beneficiaries. Second, the current study focused solely on mortality. Future studies using population-based data may focus on additional outcomes of high importance to older persons after major surgery, including functional decline, quality of life, and days spent at home.[39] Third, information was not available on reason for surgery, postoperative complications, or cause of death, each of which could have had a role in the association between the surgical procedures and subsequent mortality. In addition, the current study did not include a control group. As described in the eAppendix in the Supplement, the expected 1-year mortality rate for our analytic sample, based on a 2014 actuarial life table from the Social Security Administration,[40] was only 4.9% (95% CI, 4.7%-5.1%), which is considerably lower than the 13.4% overall mortality rate reported in the current study.

Conclusions

In this study, the population-based estimate of 1-year mortality after major surgery among community-living older adults in the US was 13.4% but was 3-fold higher for nonelective than elective procedures. Mortality was considerably elevated among older persons who were frail or who had probable dementia, highlighting the prognostic importance of geriatric conditions after major surgery.

ARTICLE INFORMATION

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Concept and design: Gill, Becher.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Gill, Vander Wyk, Becher.
Critical revision of the manuscript for important intellectual content: Leo-Summers, Murphy, Becher.
Statistical analysis: Vander Wyk, Murphy.
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