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Impact of Age and Comorbidity on Colorectal Cancer Screening Among Older Veterans

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Abstract

Background—The Veterans Health Administration, the American Cancer Society, and the American Geriatrics Society recommend colorectal cancer screening for older adults unless they are unlikely to live 5 years or have significant comorbidity that would preclude treatment.

Objective—To determine whether colorectal cancer screening is targeted to healthy older patients and is avoided in older patients with severe comorbidity who have life expectancies < 5 years.

Design—Cohort study.

Setting—Minneapolis, Durham, Portland, and West LA VA's with linked national VA and Medicare administrative claims.

Patients—27,068 patients > 70 years who had an outpatient visit in 2000 and an outpatient visit at 1 of 4 VA's during 2001–2002 and due for screening.

Measurements—The main outcome was receipt of fecal occult blood testing (FOBT), colonoscopy, sigmoidoscopy, or barium enema during 2001–2002 based on national VA and Medicare claims. Charlson comorbidity scores were used to stratify patients into 3 groups ranging from no comorbidity (score=0) to severe comorbidity (score > 4) and 5-year mortality was determined for each group.

Results—46% of patients were screened during 2001–2002. Only 47% of patients with no comorbidity were screened despite having life expectancies > 5 years (5-year mortality=19%). While the incidence of screening declined with age and worsening comorbidity, it was still 41% for patients with severe comorbidity who had life expectancies < 5 years (5-year mortality=55%).

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The number of VA outpatient visits predicted screening independent of comorbidity, such that patients with severe comorbidity and > 4 visits had similar or higher screening rates than healthier patients with fewer visits.

Limitations—Some tests may have been performed for non-screening reasons. The generalizability of findings to persons who do not use the VA is uncertain.

Conclusions—Advancing age was inversely associated with colorectal cancer screening while comorbidity was a weaker predictor. More attention to comorbidity is needed to better target screening to older patients with substantial life expectancies and avoid screening older patients with limited life expectancies.

INTRODUCTION

Colorectal cancer screening guidelines recommend screening older adults who have substantial life expectancies according to age and/or comorbid conditions.[1] For example, the US Preventive Services Task Force recommends routine screening until age 75 years, while the Veterans Health Administration, the American Cancer Society, and the American Geriatrics Society recommend colorectal cancer screening for older adults unless they are unlikely to live 5 years or have significant comorbidity that would preclude treatment.[2–5] Targeting screening to healthy persons who are likely to live at least 5 years is recommended because randomized trials of fecal occult blood testing (FOBT) suggest that a difference in colorectal cancer mortality between screened and unscreened persons does not become noticeable until at least 5 years after screening.[6,7] Therefore, persons with a life expectancy < 5 years are not likely to benefit from screening but remain at risk for harms which may occur immediately (e.g. complications from procedures and treatment of clinically unimportant disease).[8,9] However, it remains unclear whether screening is being targeted to healthy older persons with substantial life expectancies and avoided in older persons with significant comorbidity for whom the risks of screening outweigh the benefits.

Prior studies evaluating associations between age, comorbidity, and receipt of cancer screening have found that age is a stronger determinant of screening than comorbidity. For example, while advancing age is consistently associated with lower screening rates, worsening comorbidity has had little impact on the use of screening mammography, Papanicolaou smears, or prostate-specific antigen (PSA).[10–12] Previous studies of the relationship of colorectal cancer screening and comorbidity have been limited by their small sample size, short follow-up times, and their focus on FOBT rather than measuring all types of colorectal cancer screening tests.[13,14] In addition, previous VA studies have not measured colorectal cancer screening performed outside the VA health care system in Medicare.[14–16] Having a better understanding of how comorbidity and age impact overall screening use is particularly important for colorectal cancer screening because tests and follow-up procedures are often more invasive than those for other cancers and may result in substantial harms (e.g., major bleeding, colon perforation, stroke), especially in elders with limited life expectancies.[8,17,18]

Therefore, we examined VA data and Medicare claims for patients > 70 years seen at 4 geographically diverse VA facilities to characterize the use of colorectal cancer screening across a prognostic spectrum of advancing age and comorbidity. Specifically, we determined 2-year screening rates and 5-year mortality rates for subgroups of older patients without significant comorbidity for whom guidelines recommend screening as well as for subgroups of older patients with severe comorbidity for whom most guidelines agree the risks of screening outweigh the benefits.

METHODS

Data Sources and Subjects

We identified a cohort of screen-eligible patients on 1/1/01 and followed them for 2 years for the performance of colorectal cancer screening. Data for this cohort study were obtained from 1) National VA Data Systems, 2) clinical data extracted from 4 VA's (Minneapolis, Durham, Portland, and West Los Angeles) electronic record system, VISTA (Veterans Health Information Systems and Technology Architecture), and 3) Medicare claims. National VA data included the National Patient Care Database (which captures all inpatient and outpatient claims within the VA), Fee Basis Files (which capture claims for non-VA services paid for by the VA) and the Vital Status File (which captures mortality data for veterans).[20] Clinical data extracted from the 4 VA's included text data entered by clinicians in response to computerized clinical reminders about colorectal cancer screening.[21] We used linked Medicare claims () from the VA Information Resource Center to capture services provided to our cohort by Medicare. [19]

Based on these data sources we identified a cohort of 60,933 patients aged > 70 years who had at least 1 outpatient visit within the VA healthcare system or Medicare between 1/1/00–12/31/00 (the period during which we measured comorbidity) and at least 1 outpatient visit at 1 of the 4 VA's between 1/1/01–12/31/02 (the period during which we measured the performance of colorectal cancer screening)(See Figure 1). The 4 VA's were selected for geographic diversity. We excluded 11,817 (19%) patients who were enrolled in Medicare managed care at any point during 1/1/00 to 12/31/02 because they lacked Medicare claims. In addition, for inclusion in our cohort patients had to be eligible for screening. Therefore, we used VA and Medicare inpatient and outpatient claims during the 8-year period prior to the start of 2001 (dating back to 10/1/92 for VA claims and 1/1/99 for Medicare claims) to exclude 11,200 (18%) patients with a history of colorectal cancer, colitis, colorectal polyps, colectomy or colostomy and 8,153 (13%) patients who had a history of a colonoscopy or had had a sigmoidoscopy or barium enema within 5 years and therefore were not due for screening at the start of 2001. We also used claims during the 6 months before their index test to exclude 2,695 (4%) of patients who had signs or symptoms that would justify the performance of a test for non-screening purposes (see Figure 1). This left a final screen-eligible cohort of 27,068.

Data Collection and Measurement

Outcome Variables—Receipt of colorectal cancer screening between 1/1/01–12/31/02 was assessed for our cohort across the VA healthcare system and Medicare because many elderly veterans use more than one VA, and most are enrolled in Medicare.[22] Colorectal cancer screening was identified in National VA Data Systems and linked Medicare payment data (hospital outpatient and physician/supplier files) using International Classification of Disease, Ninth Revision (ICD-9) codes, Current Procedural Terminology (CPT) codes, and Level II Healthcare Common Procedure Coding System (HCPCS) codes for 1) FOBT (CPT: 82270, 82273, 82274; HCPCS: G0107), 2) colonoscopy (ICD-9: 45.22, 45.23, 45.25, 45.41, 45.42, 45.43; CPT: 44388–44394, 45355, 45378–45385; HCPCS: G0105, G0121), 3) sigmoidoscopy (ICD-9: 45.24, 48.22–48.24, 48.26, 48.35, 48.36; CPT: 45300, 45303, 45305, 45308, 45309, 45315, 45320, 45330–45334,45337–45339; HCPCS: G0104), or 4) barium enema (ICD-9: 87.64; CPT: 74270, 74280; HCPCS:G0106, G0120, G0122).[23–26] Patients were assigned to one of the four screening procedures based on their first test during 2001–2002. A 2-year screening period was chosen to allow sufficient time for screening tests to be scheduled and performed, and this is the screening interval used in randomized trials of FOBT.[6,7]

Vital status through 12/31/05 was obtained from the VA Vital Status File in order to determine 5-year mortality rates. The VA Vital Status File is highly comparable to the National Death Index in terms of accuracy and completeness.[27] 5-year mortality rates were used descriptively to identify conditions associated with having a life expectancy < 5 years (i.e., 5-year mortality rate > 50%).

Predictor Variables—Age on 1/1/01 was categorized into 3 groups: 70–74 years, 75–79 years, and > 80 years. Burden of comorbidity was defined by the Charlson-Deyo Comorbidity Index, which is a summary measure of 19 chronic disease diagnoses from administrative data selected and weighted according to their association with mortality.[28,29] Charlson scores were calculated from VA and Medicare inpatient and outpatient claims during the 12 months prior to the start of 2001. Patients were categorized as having no significant comorbidity if they had a Charlson score = 0, average comorbidity if they had a Charlson score = 1–3, and severe comorbidity if they had a Charlson score > 4. These cutoffs were chosen a priori to assess how extremes in comorbidity influence screening and have been used in prior studies.[12,30] Another measure of illness included being home-bound as defined by enrollment in VA Home-Based Primary Care at the start of 2001. We also measured whether a clinician responded to VA clinical reminders that colorectal cancer screening was “refused or contraindicated” during 2001–2002.[31]

Other factors known to influence the use of cancer screening were also ascertained from VA and Medicare administrative data and linkage to the 2000 US Census (Table 1).[32] The number of outpatient visits during the 2-year screening interval was based on primary care, gastroenterology, or general surgery clinic codes from national VA data. We included General Medicine, Cardiology, Endocrinology, Diabetes, Hypertension, Pulmonary, and Women’s Clinic as primary care clinics because they are defined as such by the VA colorectal cancer screening quality indicator. The Committee on Human Research at the University of California, San Francisco, and the Committee for Research and Development at the San Francisco VA approved the study. The funding source had no role in the design, conduct, or analysis of this study or in the decision to submit the manuscript for publication.

Analyses

For all estimates of colorectal cancer screening incidence, patients were observed from baseline (1/1/01) until the first screening test, death, or the end of the screening period (12/31/02). Patients were not censored for reasons other than death or the end of the screening period because there was no reason to assume that screening would not be recorded otherwise, since we had access to both VA and Medicare claims for all patients up until these times. We first used Kaplan-Meier analysis to estimate the unadjusted 2-year cumulative incidence and 95% confidence intervals of colorectal cancer screening according to baseline characteristics. Next, we used Cox regression models to estimate 2-year cumulative incidence of colorectal cancer screening with bootstrapped 95% confidence intervals adjusting for age, gender, race, marital status, VA site, education, income, Charlson comorbidity category and an age-site interaction. We chose not to adjust for number of visits or home-bound status because we felt these were likely in the causal pathway for how age and comorbidity impact screening. In addition, to describe the association of age and comorbidity combined, we categorized patients into 9 subgroups on the basis of age (3 categories) and Charlson score (3 categories) and plotted the Kaplan-Meier estimates of 5-year mortality versus screening incidence for each age-Charlson subgroup. We used logrank and trend tests where appropriate when comparing Kaplan-Meier rates across categories. SAS statistical software (version 9.1) and Stata/SE (version 10.0) were used for all analyses.

RESULTS

Participant Characteristics

Baseline characteristics of the 27,068 patients are presented in Table 1. Consistent with the elderly veteran population 96% were men and 87% were white. The median age was 77 years (IQR=73–80). The median Charlson score was 1.0 (IQR=0–2) with scores ranging from 0 to 16. 36% of patients had a Charlson score=0 and 12% of patients had a Charlson score > 4 (severe comorbidity). Only 261 (1%) patients in our cohort would have been defined as inappropriate for screening by the VA colorectal cancer screening quality indicator which only excludes patients with cancer of the liver, pancreas, or esophagus, or hospice eligibility. Based on responses to clinical reminders, only 599 (2%) patients had documentation that screening was refused or contraindicated. 22,253 (82%) patients were seen by VA primary care, gastroenterology, or general surgery during 2001–2002.

31% of patients (8,518/27,068) died within 5 years (19% of patients with no comorbidity; 55% of patients with severe comorbidity). Combining age and Charlson score resulted in 5-year mortality rates that ranged from 13% (495/3846) for patients aged 70–74 without comorbidity to 66% (585/893) for patients aged > 80 with severe comorbidity (Figure 2). Patients who had congestive heart failure, dementia, chronic renal failure, metastatic cancer, or were home-bound had 5-year mortality rates greater than 50%.

Colorectal Cancer Screening Rates

46% of patients (12,354/27,068) received colorectal cancer screening during the 2-year period from 2001–2002; 31% (8,288/27,068) were screened in the first year. Of those screened, 68% (8,346/12,354) had their index screening test during the 2-year period performed in the VA healthcare system [45% (5,585/12,354) at one of the 4 VA's and 22% (2,761/12,354) at another VA] whereas 33% (4,008/12,354) were performed within Medicare. Among the 12,354 patients who were screened, 77% had FOBT as their index screening test, whereas 13% had colonoscopy, 8% had sigmoidoscopy, and 2% had a barium enema. 5.4% had both FOBT and sigmoidoscopy.

Advancing age was associated with decreased colorectal cancer screening while worsening comorbidity was a weaker predictor (Table 2). For example, even for elderly patients with severe comorbid conditions, the incidence of screening did not fall below 30% except among the small number of patients who were home-bound or had dementia. On the other hand, even among patients with characteristics predictive of living more than 5 years (e.g., aged 70–74, Charlson score=0) screening incidence was only around 50%. When combining age and Charlson score, screening incidence ranged from 51% in patients aged 70–74 without comorbidity to 34% in patients aged > 80 with severe comorbidity ($P < 0.001$) (Figure 2). Figure 2 shows that within each age group, screening incidence varied little with worsening comorbidity even over a wide range of 5-year mortality. For example, screening incidence among persons aged > 80 without comorbidity (5-year mortality = 31%) and with severe comorbidity (5-year mortality= 66%) were similar at 38% and 39% respectively ($P= 0.064$). In multivariate analyses, the association of age and comorbidity on colorectal cancer screening incidence remained similar after adjustment for gender, race, marital status, VA site, education, and income, and an age-site interaction ($P<0.001$) which reflects that the incidence of screening at the LA site did not differ as much across age groups as it did at the other sites (Table 2).

The number of VA outpatient visits to primary care, gastroenterology, or general surgery during the study interval was one of the strongest predictors of screening in unadjusted and adjusted analyses (Table 2). Colorectal cancer screening incidence increased with increasing visits, ranging from 23% for patients with no visits to these clinics to 55% for patients with

> 4 visits (P for trend <0.001). Yet, persons with severe comorbidity had more medical visits than those without comorbidity. For example, 43% (1253/2885) of patients with > 4 visits had severe comorbidity. Only 24% (1305/5459) of patients without comorbidity had > 4 visits. Because the number of visits predicted screening independent of comorbidity, screening incidence increased with number of visits even among patients with severe comorbidity (Figure 3). As a result, patients with severe comorbidity and > 4 visits had a screening incidence of 50% which was similar or higher than screening rates for healthier patients with fewer visits.

DISCUSSION

Less than half of veterans aged > 70 years received colorectal cancer screening during the 2-year period from 2001 to 2002. Advancing age was strongly and inversely associated with screening while comorbidity was a weaker predictor. As a result, many healthy older patients with substantial life expectancies are not being screened while some patients with severe comorbidity are being screened. For example, only 47% of patients aged > 70 years without comorbidity were screened despite having a high probability of living > 5 years (5-year survival=81%). In addition, the number of VA outpatient visits was a strong predictor of screening independent of comorbidity, such that patients without comorbidity who did not attend one of the primary care, gastroenterology, or general surgery clinics had a lower incidence of screening than patients with severe comorbidity who attended these clinics.

Prior studies of the associations between age, comorbidity, and receipt of cancer screening have found similar problems with the targeting of cancer screening tests to healthy older patients. We identified English-language literature related to cancer screening, age, and comorbidity published between January 1998 and December 2008 using MEDLINE. While cancer screening generally decreases with advancing age, increasing comorbidity has been shown to have little impact on the relatively high rates of mammography, Papanicolaou smears, and PSA screening. In contrast, colorectal cancer screening rates have been found to be generally low across the U.S., especially in older adults, and the impact of comorbidity on screening had not been well described. [39,40] In our study the use of colorectal cancer screening was based on the actual performance of screening and is lower than that reported in national surveys which frequently overestimate screening due to the desire of patients to report behaviors in a favorable light.[41,42] Our screening rates are consistent with those of prior claims-based studies.[15,43,44] For example, we found that 31% of veterans > 70 years were screened in 2001, while a study of veterans aged 49–75 years found that annual screening incidences were 19%-31% during 1998–2004.[15] An advantage of our study over prior studies using national VA databases is that we were able to identify patients who had screening outside VA paid for by Medicare, which accounted for 32% of veterans screened. Based on this comprehensive view of colorectal cancer screening in elderly veterans we found that, as with other cancer screening tests, age was a stronger predictor of colorectal cancer screening than comorbidity. [33]

There are several possible explanations for our findings that colorectal cancer screening is not optimally targeted to healthy older patients or avoided in older patients with severe comorbidity. First, consistent with other studies we found that more frequent medical visits increased the likelihood of receiving cancer screening independent of a patient's comorbidity.[34] This contributes to underscreening of healthy older patients, who see doctors less frequently, and to overscreening of patients with severe comorbidity. Second, clinicians may have difficulty estimating life expectancy because all available methods for predicting an individual's life expectancy are imperfect. However, even among patients aged 70–74 years without comorbidity, who few clinicians would expect to die in 10 years,[8,35] the 2-year cumulative incidence of screening was still only 51%. This may in part be driven by

perspectives that colorectal cancer screening is more unpleasant and invasive compared to other cancer screening tests.[36,37] For example, annual rates of PSA screening, a blood test, are more than double the rates of colorectal cancer screening among male veterans aged 70–74 years without comorbidity.[12] Third, healthy older patients visit clinicians less often and may be less willing to accept recommendations for screening. However, we found that less than 2% of patients in our cohort had documentation that screening was refused. Fourth, quality indicators, which are used extensively by the VA, promote colorectal cancer screening regardless of comorbidity, which may contribute to overscreening patients with severe comorbidity.[31,38] For example, the VA's 2001–2002 colorectal cancer screening quality indicator would have encouraged screening all patients in our cohort seen in primary care clinics except for the 1% of patients who had cancer of the esophagus, liver, or pancreas, or were eligible for hospice.(31) Since almost a third of our cohort died in 5 years this quality indicator encouraged screening in many patients who were unlikely to benefit given their short survival. In fiscal year 2005 an upper age limit of 80 was instituted which appropriately excludes more patients with limited life expectancies.[14,35] However, it does not encourage clinicians to better target colorectal cancer screening to healthy older patients. A better quality indicator would encourage high screening rates in older patients without comorbidity and low rates in older patients with severe comorbidity.[31]

In addition, the USPSTF published colorectal cancer screening guidelines in 2008 which recommend continuing screening only until age 75 years based on a decision model which used chronologic age rather than comorbidity-adjusted life expectancy. The strong relationship between comorbidity and life expectancy and our findings that the use of colorectal cancer screening varied little across dramatically different levels of comorbidity suggest refinements to the guidelines are needed to explicitly encourage or discourage screening based on the severity of comorbidity rather than solely on the age of the patient. Similarly, optimizing the targeting of colorectal cancer screening will likely require changes in how preventive care is delivered. The current strategy relies on finding opportunities for screening when patients visit clinicians for a medical illness, which targets screening to patients with worse comorbidity and misses healthy older patients who see clinicians less frequently.

Our study has several limitations. First, claims data do not give reasons why a test was ordered or the purpose of medical visits such that some tests may have been performed for non-screening reasons. However, we used claims data to exclude patients who had diagnoses or symptoms that would justify a test being performed for a non-screening purpose (Figure 1).[15] In addition, FOBT is the predominant mode of screening in the VA and prior studies have found that only 3% of FOBT ordered by VA clinicians were for non-screening reasons.[45] Second, while our data sources completely capture screening within the VA healthcare system some tests performed outside the VA may have been missed. For example, Medicare claims do not capture tests paid for by other sources. Third, while the Charlson Comorbidity Index is strongly predictive of 5-year mortality, it does not include all factors that may determine life expectancy, such as functional status.[30] However, an advantage of our study is that we calculated actual 5-year mortality rates that confirmed patients without comorbidity had a life expectancy greater than 5 years while those with severe comorbidity had less than a 5-year life expectancy. Fourth, our cohort is primarily men who use the VA, so the generalizability of our findings to persons who do not use the VA is uncertain. However, understanding screening within the VA is important in its own right given the VA is the largest healthcare system in the U.S. and a leader in improving healthcare quality.[46]

In conclusion, colorectal cancer screening should be better targeted to older patients based on considerations of comorbidity in addition to age. Cancer screening guidelines should be

more explicit about which combination of age and comorbid conditions identify older patients who have substantial life expectancies and those who are likely to die within 5 years.[47] Clinicians could then consider such characteristics in concert with clinical judgment to estimate an older individual's potential risks and benefits from screening and use shared decision making to help older patients arrive at an informed screening decision.

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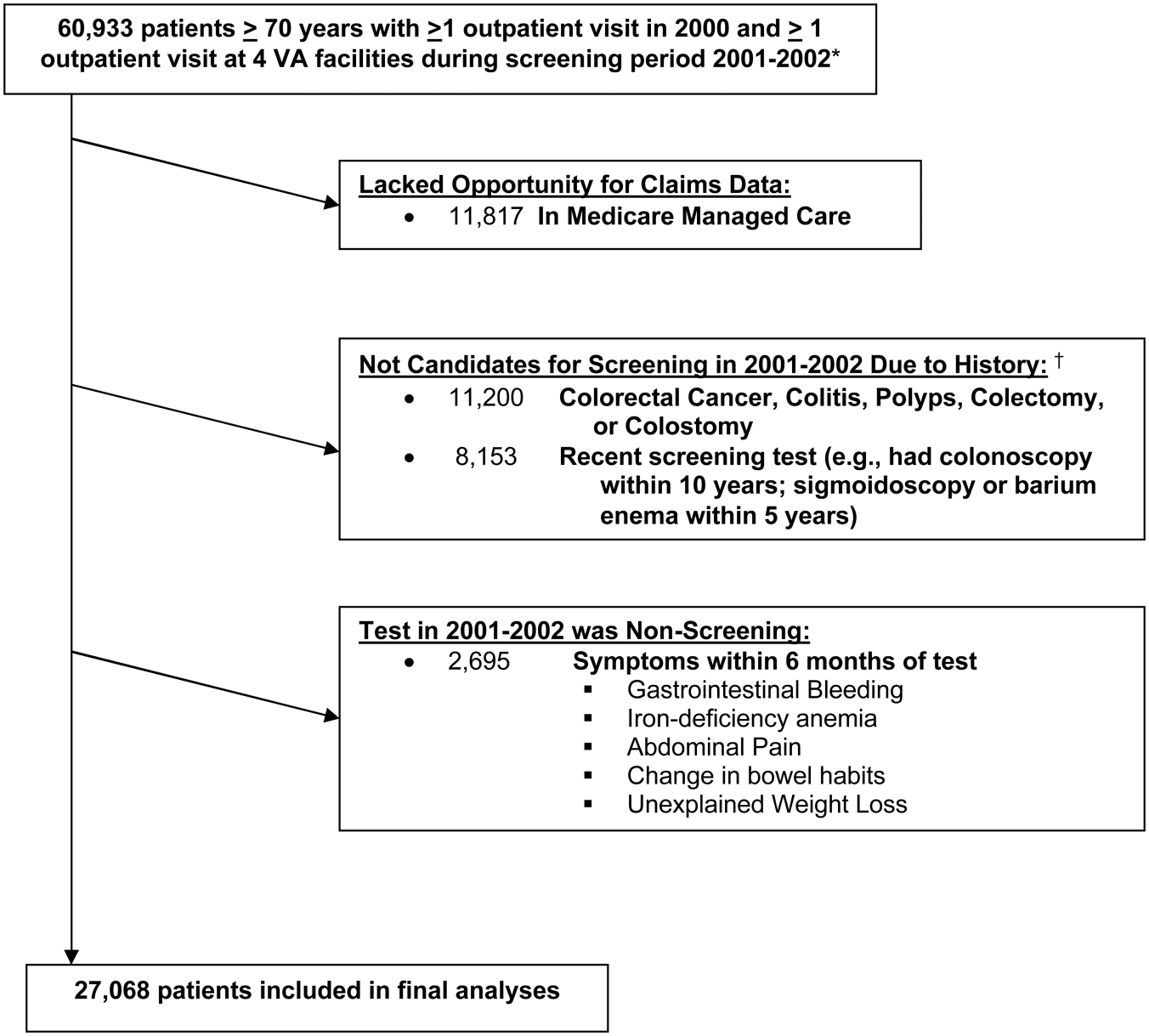

Figure 1. Criteria used to define the final cohort of elderly patients eligible for a colorectal cancer screening during 2001–2002

*Eligibility criteria included having been seen in an outpatient clinic at 1 of 4 VA's during 1/1/01–12/31/02 which indicated that the VA was at least partially responsible for medical care, but data on colorectal cancer screening was gathered during the entire 2-year interval from both national VA and Medicare claims. Additional eligibility criteria included having at least 1 outpatient visit during 1/1/00–12/31/00 to define comorbidity as of 1/1/01.

†History was defined by searching VA and Medicare inpatient and outpatient claims prior to 1/1/01, dating as far back as 10/1/92 for VA claims and 1/1/99 for Medicare claims.

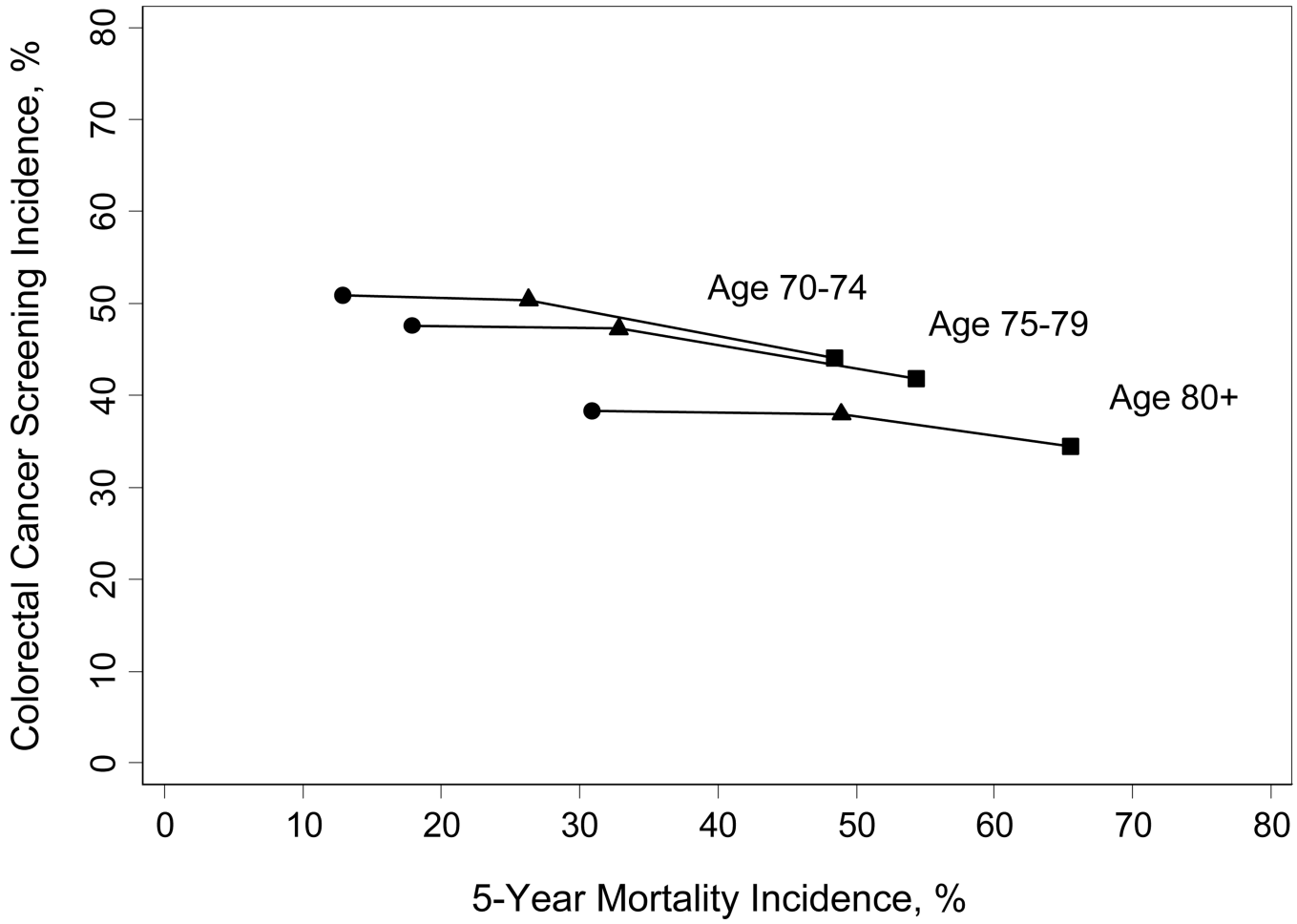

Figure 2. Colorectal cancer screening incidence versus 5-year mortality for different age groups as comorbidity increases (n=27,068)

Circles (●) indicate no comorbidity (Charlson score = 0); Triangles (▲) indicate average comorbidity (Charlson score 1–3); Squares (▪) indicate severe comorbidity (Charlson score > 4).*

*Within each age group screening incidence declined only a small amount with worsening comorbidity. The lines are included in the figure to illustrate the relatively flat incidence of screening between patients without comorbidity (●), average comorbidity (▲), and severe comorbidity (▪) for each age group. This is despite the substantial increase in 5-year mortality that occurs with worsening comorbidity. If screening was targeted to older patients with substantial life expectancies and away from those with severe comorbidity all lines would start much higher and slope down more steeply.

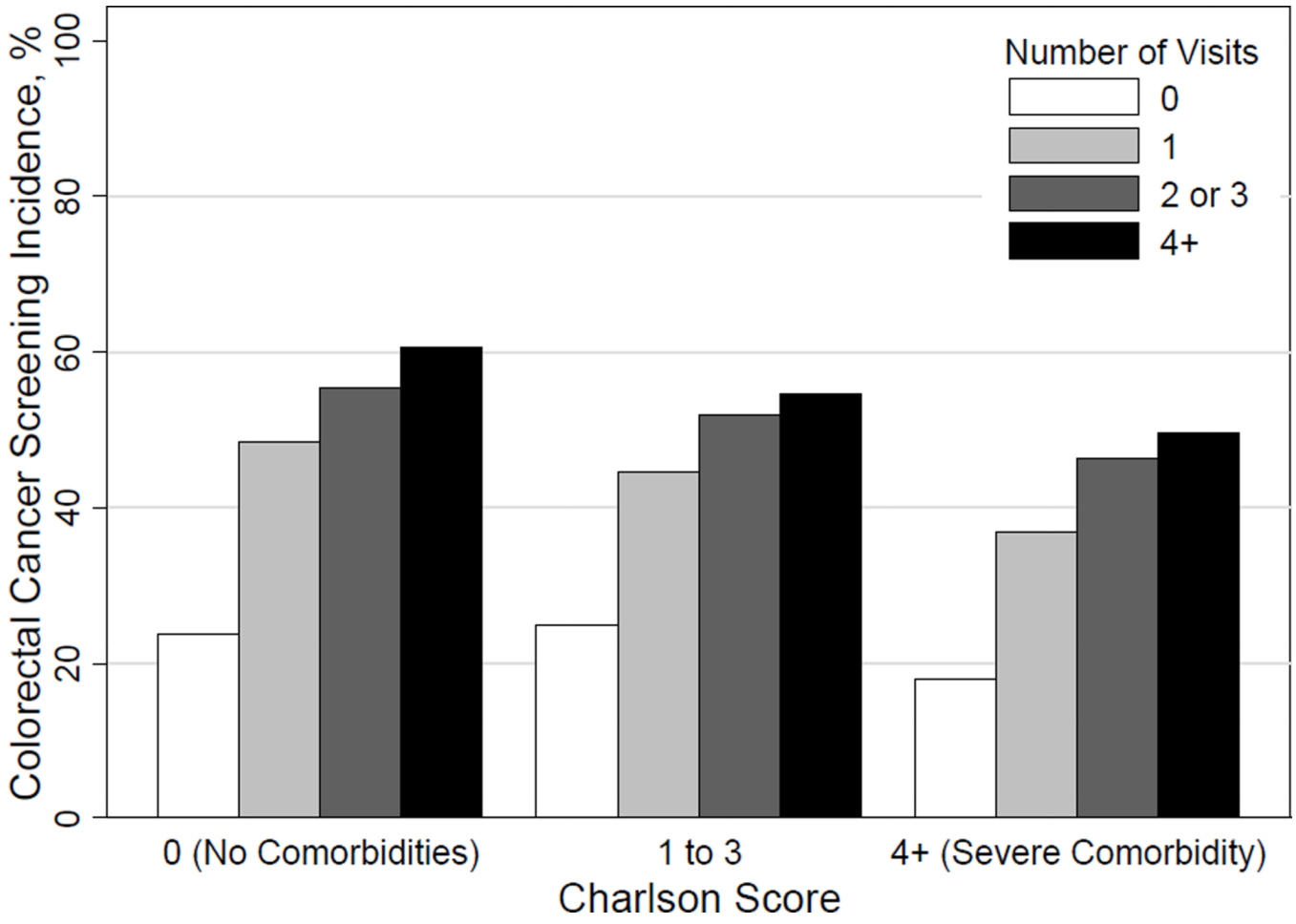

Figure 3. Patients aged > 70 years who had colorectal cancer screening during 2001–2002, according to comorbidity and number of VA outpatient medical visits (n=27,068)*

*Number of visits was defined by the number of visits during 1/1/01–12/31/02 to VA primary care, gastroenterology, or general surgery clinics (clinic codes 301, 303, 305, 306, 307, 309, 312, 321–323, and 401).

Table 1

Baseline Characteristics of Study Participants (N=27,068)

Characteristic	N (%)
Age, years	
70–74	10091 (37)
75–79	10234 (38)
≥ 80	6743 (25)
Gender	
Men	26119 (96)
Women	949 (4)
Race/Ethnicity	
White	23595 (87)
Black	2394 (9)
White Hispanic	261 (1)
Other	545 (2)
Charlson Score	
0 (no comorbidity)	9698 (36)
1–3 (average comorbidity)	14126 (52)
≥ 4 (severe comorbidity)	3244 (12)
Selected Charlson Comorbidities *	
Congestive Heart Failure	3420 (13)
Peripheral Vascular Disease	2366 (9)
Cerebrovascular Disease	3114 (12)
Dementia	586 (2)
Chronic Obstructive Pulmonary Disease	5765 (21)
Diabetes	6623 (24)
Diabetes with Complications	1673 (6)
Chronic Renal Failure	1031 (4)
Metastatic Solid Tumor	343 (1)
Home-bound †	858 (3)
Married	
Yes	17161 (63)
No	9907 (37)
Lived in ZCTA in which ≥ 25% of Adults Had a College Education ‡	
Yes	9847 (36)
No	17221 (64)
Median Income of ZCTA ‡	
Highest tertile (≥$29,194)	8729 (32)
Middle tertile	8977 (33)

Characteristic	N (%)
Lowest tertile (≤$21,169)	8721 (32)
VA Site	
Minneapolis	10911 (40)
Durham	5651 (21)
Portland	4158 (15)
West Los Angeles	6348 (23)
Distance to nearest VA clinic[§]	
<10 miles	13052 (48)
10–49 miles	12655 (47)
≥50 miles	1312 (5)

[*] The categories are not mutually exclusive because patients could have more than 1 condition

[†] Enrolled in VA Home Based Primary Care at the start of 2001.

[‡] ZCTA = Zip Code Tabulation Area

[§] Distance to the nearest VA clinic was measured as a straight-line distance between the location of the VA clinic and the center of the zip code of the patient's residence. The following variables had missing data: Distance to nearest VA clinic (0.2%); Income (2.4%); Education (2.4%); Married (3.3%); Race/Ethnicity (1.0%).

Table 2

Rates of colorectal cancer screening in persons 70 years of age or older according to patient characteristics (N=27,068)

Characteristic	Colorectal Cancer Screening 2-Year Cumulative Incidence* % (95% CI)	Adjusted Colorectal Cancer Screening 2-Year Cumulative Incidence† % (95% CI)
Age, years		
70–74	49.9 (48.9–50.8)	47.2 (46.9–47.4)
75–79	46.7 (45.7–47.7)	46.3 (45.8–46.8)
≥ 80	37.6 (36.5–38.8)	43.9 (43.4–44.3)
Gender		
Men	45.9 (45.3–46.5)	45.7 (45.5–45.8)
Women	38.6 (35.6–41.8)	44.1 (43.5–44.8)
Race/Ethnicity		
White	46.8 (46.2–47.5)	46.5 (46.3–46.6)
Black	39.8 (37.9–41.8)	39.6 (39.1–40.1)
White Hispanic	27.2 (22.2–33)	30.3 (29.1–31.6)
Other	38.9 (34.9–43.1)	42.5 (41.3–43.7)
Charlson Score		
0 (best health)	46.7 (45.7–47.7)	47.0 (46.8–47.3)
1–3 (average health)	46.0 (45.2–46.9)	45.8 (45.6–46.0)
≥ 4 (worst health)	40.6 (38.9–42.3)	40.7 (40.4–41.0)
Selected Charlson Comorbidities‡		
Congestive Heart Failure	39.6 (38–41.2)	41.2 (40.7–41.7)
Peripheral Vascular Disease	45.7 (43.7–47.7)	47.2 (46.7–47.7)
Cerebrovascular Disease	42.8 (41.1–44.5)	44.4 (44.0–44.8)
Dementia	17.4 (14.6–20.7)	19.2 (18.5–19.9)
COPD	43.2 (41.9–44.5)	43.8 (43.5–44.1)
Diabetes	46.7 (45.5–47.9)	47.2 (46.8–47.5)
Diabetes with Complications	46.4 (44.1–48.9)	48.6 (47.9–49.2)
Chronic Renal Failure	36.4 (33.5– 39.4)	39.4 (38.6– 40.3)
Metastatic Solid Tumor	33.2 (28.5– 38.5)	36.9 (35.9– 37.9)
Home Bound§		
No	46.3 (45.7– 46.9)	46.1 (46.0– 46.3)
Yes	24.2 (21.5– 27.3)	26.5 (25.7– 27.2)
Married		
No	38.9 (37.9– 39.9)	40.2 (40– 40.5)
Yes	49.8 (49.1–50.6)	48.6 (48.5–48.7)
Lived in ZCTA in which ≥ 25% of Adults Had a College Education ¶		

Characteristic	Colorectal Cancer Screening 2-Year Cumulative Incidence* % (95% CI)	Adjusted Colorectal Cancer Screening 2-Year Cumulative Incidence† % (95% CI)
No	46.6 (45.9–47.4)	46.3 (46.1–46.5)
Yes	44.3 (43.3–45.3)	44.4 (44.2–44.7)
Median Income of ZCTA ¶		
Highest Tertile (> $29,194)	47.4 (46.4–48.5)	46.5 (46.2–46.8)
Middle Tertile	45.5 (44.5–46.5)	45.5 (45.3–45.7)
Lowest Tertile (< $21,169)	44.3 (43.3–45.4)	44.5 (44.2–44.8)
VA Site		
Minneapolis	47.6 (46.7–48.5)	46.4 (46.1–46.6)
Durham	51.8 (50.5–53.1)	52.0 (51.7–52.3)
Portland	43.6 (42.1–45.1)	43.5 (43.3–43.8)
West Los Angeles	38.0 (36.8–39.2)	40.6 (40.3–41.0)
Distance to Nearest VA Clinic		
< 10 miles	41.9 (41.1–42.7)	44.5 (44.3–44.7)
10–49 miles	49.1 (48.3–50)	46.7 (46.6–46.9)
≥ 50 miles	48.6 (46–51.4)	47.1 (46.6–47.7)
Number of VA Outpatient Visits (Primary Care, GI, or Surgery), 2001–2002 /		
0	23.7 (22.6–25.0)	23.0 (22.7–23.3)
1	45.5 (44.5–46.6)	43.9 (43.7–44.1)
3	52.5 (51.4–53.6)	52.1 (51.8–52.3)
≥ 4	55.1 (53.8–56.5)	57.4 (57.1–57.6)
Type of VA Outpatient Visit, 2001–2002		
Seen in Primary Care, GI, or Surgery Clinic	50.1 (50.0–50.3)	50.1 (50.0–50.3)
Never attended Primary Care, GI, or Surgery Clinic	23.7 (22.6–25.0)	23.0 (22.7–23.3)

*Cumulative incidence at 2 years converted to percent, estimated from Kaplan-Meier analysis. Complete-case analyses were conducted because missing data were minimal. The following variables had missing data: Distance to nearest VA clinic (0.2%); Income (2.4%); Education (2.4%); Married (3.3%); Race/Ethnicity (1.0%).

†Estimated 2-year cumulative incidence from Cox regression models adjusted for age, gender, race, marital status, VA site, education and income categories, Charlson comorbidity category as well as an interaction between age (continuous and centered) and VA site. Adjusted estimates for each site represent the incidence at the mean age of the cohort (77 years).

‡The comparison group is all patients without the comorbidity of interest.

§Enrolled in VA Home Based Primary Care at the start of 2001.

¶ZCTA = Zip Code Tabulation Area

/Defined by VA clinic codes 301, 303, 305, 306, 307, 309, 312, 321–323, and 401 representing primary care clinics subjected to the 2001–2002 VA colorectal cancer screening performance measure (e.g., General Medicine, Cardiology, Endocrinology, Diabetes, Hypertension, Pulmonary, Women's Clinic) as well as Gastroenterology and General Surgery.