Title

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Journal

Journal of the American Geriatrics Society, 62(8)

ISSN

0002-8614

Authors

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Publication Date

2014-08-01

DOI

10.1111/jgs.12943

Peer reviewed

Published in final edited form as:
J Am Geriatr Soc. 2014 August ; 62(8): 1442–1450. doi:10.1111/jgs.12943.

Abbreviated Care-Process Quality Indicator Sets Linked with Survival and Functional Status Benefit in Older Ambulatory-Care Patients

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Abstract

Objectives—Better quality-of-care measured by 140 care-process quality indicators (QIs) from the Assessing Care of Vulnerable Elders Study (ACOVE-1) predicts better survival. A subsequent study (ACOVE-2) reduced the measures to 69 ambulatory-care QIs. We identified further need to prioritize and reduce the QIs to facilitate future quality improvement efforts. We aimed to identify subsets of ambulatory QIs associated with better survival and physical function outcomes.

Design—Observational cohort study

Setting and participants—1015 older ambulatory-care patients in ACOVE-1 and ACOVE-2

Measurements—To develop the QI subsets, we first convened an expert panel to rate each of 69 ambulatory-care QIs for strength of process-benefit link, defined as: (1) direct trial evidence on older patients, or(2) high expectation of benefit if a trial were conducted in older patients. This resulted in three reduced QI sets, reflecting their intended benefit: 17 QIs for survival (ACOVE-Quality-for-Survival, AQS-17), 5 QIs to preserve function (AQF-5), and 16 QIs to improve

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Paper presentation: These results were presented at the 2011 American Geriatrics Society Annual Scientific Meeting.

Conflict of Interest: The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper.

Author Contributions: All of the authors meet uniform criteria for authorship: Lillian Min (data acquisition, design, analysis, interpretation, drafting/revision, and final approval), David Reuben (interpretation, drafting/revision, and final approval), Arun Karlamangla (design, analysis, interpretation, drafting/revision, and final approval), Katherine Prenovost (design, analysis, interpretation, drafting/revision, and final approval), Pearl Lee (interpretation, drafting/revision, and final approval), and Neil Wenger (data acquisition, interpretation, drafting/revision, and final approval).

quality-of-life related to physical health and symptoms(AQQ-16). We first tested whether AQS-17 would predict3-year survival in 1015 pooled ACOVE-1 and ACOVE-2 patients. Second, we tested whether AQF-5(n=74) and AQQ-16(n=359) would predict change in the physical component score (PCS) ofShort-Form-12 at one-year in the ACOVE-2cohort. Controls: age, function-based vulnerability, co-morbidity.

Results—Each20 percentage-point increment inAQS-17 was associated with survival (HR .83, p=.014)up to 500 days, but not thereafter. AQF-5, but not AQQ-16, predicted 1-year improvement in PCS (1.13-points per 20 percentage-point increment in AQF-5, p=.021).

Conclusion—Subsets of care processes can be linked with outcomes important to older patients.AQS-17 and AQF-5 are potential tools for improving ambulatory care for older adults.

Keywords

Quality indicators; geriatric; mortality; physical function

Introduction

Better comprehensive quality of medical care for complex older adults with multiple chronic conditions has been linked to better outcomes in few studies.[1-3] In the Assessing the Care of Vulnerable Elders (ACOVE-1) study, composite scores based on 140 care-process quality indicators [Qis] spanning 22 conditions, ambulatory and hospital care[4] were associated with better 3-year survival.[1] Similarly, better quality-of-care (composite of 120 QIs) of middle-aged chronically-ill adults has been linked to better health-related quality-of-life (HRQOL).[2]In older nursing-home eligible patients, high-quality care was linked to better physical function and survival.[3]

However, there is increasing concern that older adults with multiple chronic conditions are overburdened by application of multiple clinical guidelines and QIs.[5,6] In ACOVE-1, patients with ≥3 conditions qualified for over 30 QIs[7]- with nearly all QIs representing more (not less) recommended care. Furthermore, we identified the need to reduce the ACOVE QIs to a core set of high-priority ambulatory QIs (e.g., < 30) that could be implemented feasibly as a starting point for quality improvement for a patient population.

One proposed approach is to prioritize care-processes with the greatest clinical benefit.[8] However, ambulatory-care QIs vary greatly with respect to intended clinical benefits. While some QIs are aimed at improving survival, other QIs, e.g., counseling about advanced directives, are unlikely to be associated with improved survival. Therefore, we used survival, HRQOL, and functional status to identify smaller subsets of QIs that would be associated with these outcomes, therefore guiding future efforts to improve care. Addressing older patients' varying preferences for health care benefits would enhance our quality improvement toolbox.

Methods

Overview

This is a secondary analysis of data pooled from two longitudinal ACOVE studies, approved by appropriate institutional review boards.

Samples (Table 1)—ACOVE-1[4] and ACOVE-2[9] have previously been described. ACOVE-1 tested the feasibility of measuring 13 months of ambulatory and acute quality-of-care (QOC) using medical records from 372 patients age ≥ 65. Using the Vulnerable Elders-13 Survey (VES-13), a 13-item questionnaire based on functional status,[10] ACOVE-1 screened two large managed-care organizations for the top-third of patients most vulnerable to death and functional decline. ACOVE-1 identified that older patients received poorer care for geriatric conditions (falls, dementia, and urinary incontinence) than general medical conditions. [4]Therefore ACOVE-2 was conducted to improve geriatric care in primary care practices.

ACOVE-2 measured ambulatory QOC using medical records from 644patients age ≥ 75 in two large multi-specialty practices. In contrast to ACOVE-1, the patients were prospectively screened for three geriatric conditions (urinary incontinence, dementia, and falls) rather than with the VES-13. Other differences are summarized in Table 1. ACOVE-2 included a controlled practice-improvement intervention that targeted the care-process of primary care clinicians and administrative staff rather than patients themselves.[11] The intervention improved the QOC of falls and urinary incontinence but not dementia[9] and did not result in unintended decrement in QOC for non-intervention conditions.[12]

By combiningACOVE-1 and ACOVE-2 data (1015total patients, Figure 1) we testedthe effects of QOC and co-morbidity effects on survival. We usedACOVE-2 data only (Figure 1, n=644) to test QOC measures aimed at preserving physical function and HRQOL.

Quality measurement—Quality indicator (QI) development for vulnerable elders has been previously described.[10] ACOVE QIs measure whether clinical care-processes (e.g., prescribing medications or ordering tests) were performed, rather than outcomes of health care (e.g., glycemic control, mortality).[4]In ACOVE-2, the 140 QIs were streamlined to 69 ambulatory-care QIs[4](Figure 1) concerning 12areas of outpatient preventive and chronic disease management (Table 1).

In both ACOVE studies, we applied the QIs to measure QOC for 13 months of documented medical care. Of the 69 QIs, 12 were aimed at primary prevention (e.g., vaccinations) or continuity of care (e.g., advanced directives), and therefore were measured on a greater number of patients. The remainder were measured based on eligibility criteria (i.e., “triggered”) based on a patient's medical diagnoses. Therefore, a patient with multi-morbidity triggered a greater number of QIs than a patient with no chronic conditions. If a patient refused or could not tolerate recommended care, the QI was still considered as passed. A subset of QIs was excluded from scoring (i.e., not triggered) based on appropriateness criteria for patients with advanced dementia or <6 months life-

expectancy. [13]For each patient, we calculated a patient-level quality score as number of QIs passed divided by number of QIs triggered.

Expert panel voting for intended clinical benefit—We previously used literature review and expert panel voting to establish the validity and appropriateness[14-17] of ACOVE QIs in older patients and categorize the QIs by condition (e.g., diabetes, dementia) and care-process (e.g., ordering tests, counseling).[4,18,19]For this project, we convened a panel of five physicians (geriatrics, internal medicine) with expertise inQI development and health outcomes of older adults. The panel re-considered the evidence for eachQI and 3 specific benefits: survival, preservation of functional status, and HRQOL or physical symptoms. Using literature that previously supported each ACOVE ambulatory-care QI, the panel voted on whether or not each QI was: (1) *known* to have direct link to the benefit in prior clinical trials of old patients, or (2) *strongly expected* to be linked to the benefit if a trial of vulnerable old patients were conducted. A QI with neither rating indicated that the care-process was *not linked* to that benefit. We defined a link between a QI and a benefit if at least 4 of the 5 raters rated the QI as either *known* or *strongly expected* to be linked with the benefit. A QI could be linked to none, one, or more than one benefit. The expert panel linked 18 QIs to survival, 5 to preserving functional status, and 16 to preserving HRQOL/ symptoms (Table 2 and Figure 1), considering a <5-year timeframe. The QIs linked with any benefit were considered for inclusion as part of a new benefit-oriented composite QOC score.

Predictor Measures: Our primary predictors of interest were patient-level QOC scores, calculated as the number of QIs passed divided by the number of QIs for which that patient was eligible.Of 18 QIs rated as linked to survival (Table 2, top), 17 were measured in both ACOVE-1 and ACOVE-2 studies and used to calculate the ACOVE Quality-for-Survival Score (AQS-17). We used 5 QIs linked to better function to calculate the ACOVE Quality-for-Function Score (AQF-5), and 16 QIs linked to better HRQOL/symptoms to calculate the ACOVE-Quality for QOL Score (AQQ-16). A patient was eligible for a QOC score if he/she was eligible for at least one QI in that QOC score.

Outcome measures: We calculated survival (in days) from enrollment with censoring at 1143 days (∼3 years, the duration of the shorter study, ACOVE-1).Survival data was obtained in ACOVE-1 using names, birthdates, and social security numbers matched to the National Death Index and Social Security Master Death Files (SS-MDF), whereas ACOVE-2 used names, birthdates, and place of residence to death dates in the SS-MDF supplemented by obituary searches.

In the ACOVE-2 study only, we collected HRQOL using the Short Form (SF-12[20]) via 564 interviews during the year after enrollment (mean 10 months). Using the SF-12 responses, we calculated each patient's Physical Component Score (PCS), which ranges between 0 to 100, and a score of 50 indicating median HRQOL related to physical function.[20] The PCS is correlated with severity of chronic disease symptoms[20] and with function[21-23] and has been used previously as an outcome of quality of chronic disease care.[2] Therefore, we used the PCS as a potential outcome of better AQQ-16 and AQF-5 scores.

Co-variables: Both ACOVE studies collected 12 chronic conditions (Table 1). Because ACOVE-2 enrolled participants based on three geriatric conditions (dementia, falls, and incontinence), ACOVE-2 had a greater mean number of conditions than ACOVE-1, which enrolled based on disabilities rather than co-morbidity. Therefore, we divided each study into tertiles by co-morbidity counts: low (0-1 conditions for ACOVE-1, 0-2 for ACOVE-2), moderate (2-3 conditions for ACOVE-1, 3-4 for ACOVE-2), versus severe (≥ 4 conditions for ACOVE-1, ≥5 for ACOVE-2) co-morbidity. Co-morbidity was tested as both a main and interaction effect with quality scores.

Other co-variables we tested were: age (in years), gender, an indicator for ACOVE-1 versus ACOVE-2, and a modifiedVES-13[10] score (age points omitted because we tested age as a co-variable).

Analysis—We analyzed the data at the level of the patient. We examined the associations of AQS-17 with survival and both the AQF-5 and AQQ-16 with change in PCS (Figure 1). We considered a p-value of .05 as statistically significant. To present the results in clinically-meaningful units, we presented QOC scores per increments of 20 absolute percentage points (%-points). If a patient were eligible for 5 AQS-17 QIs, then 20%-points is achievable by passing one additional QI.

To examine AQS-17 association with survival, we used Cox proportional hazard analysis. Since AQS-17 violated proportional hazards assumptions, we split the time domain into two periods, fitting two separate Cox regression models. The first model tested survival from 0 to 500 days; the second from 501 to 1143 days. We selected the 500-day cutoff by visually examining the unadjusted relationship between quality and time until death. The slope changed at around 500 days. Within each of the two time periods, we ensured that QOC no longer violated the proportional hazard assumption.

We first controlled for core co-variables (age, gender, modified VES-13 score, co-morbidity). We included a co-morbidity x QOC interaction term to test for differences in benefit between the highest versus least-morbid patients. We also included ACOVE-1 versus ACOVE-2 as both a main and interaction effect with QOC in all survival analyses, which represented differences in study design and secular changes in medical care in the three years between the two studies (2000 and 2003, respectively). We also tested models for consistency between men versus women.

To examine the individual QIs in the AQS-17 score, we performed two exploratory QI-level sensitivity analyses regarding mortality. The first QI-level analysis was to compare mortality among those who passed versus failed and review for direction of effect (Appendix 2). We used the binomial probability test (appropriate for small samples) to review for large differences in mortality between those who passed versus those who failed each QI, conservatively using $p<.01$ as the criterion rather than $p<.05$ because most QI-level comparisons were based on small samples with risk of type-I error. The second QI-level analysis examined whether the vaccination QIs (pneumonia and influenza) were driving the survival benefit because nearly all patients were eligible for them. By contrast, the 15 non-

vaccination QIs in the AQS-17 were triggered by only half of patients in the sample with co-morbidities.

To examine AQF-5 and AQQ-16 associations with PCS (available for ACOVE-2 only at baseline and 1-year), we used general linear models to predict change in PCS, controlling for age, gender, ACOVE-2 intervention versus control site, and co-morbidity count. We tested co-morbidity for interaction effects with QOC. We did not use VES-13 due to suspected co-linearity with the outcome variable. Preliminary hierarchical modeling (with patients clustered within physicians and physicians within sites) were tested but did not change results compared to linear models. We used SAS and SPSS for all analyses.

Results

The pooled ACOVE-1 and ACOVE-2 population's mean age was 81, two-thirds female (Table 1). Figure 1 displays how the new composite measures were applied tomedical records, determining various samples from ACOVE-1 and ACOVE-2.Of 1016 with an AQS-17 score in the pooled datasets, we had full data for 1015 patients. These patients were eligible for a total of 3268 AQS-17 QIs (mean 3.2±1.7, range 1-11 QIs per patient) and the mean AQS-17 score was 62% (SD 34%, IQR 50%-100%). Of the 644 ACOVE-2 patients, we measured the AQQ-16 on 513, of which we had a baseline and follow-up PCS interview for 359 patients. The AQQ-16 included one QI (pain treatment) that could be triggered multiple times per patient. These 359 patients triggered a total of 2613AQQ-16 QIs (mean 7.3±4.9, range 1-24 QIs per patient), and the mean AQQ-16 score was 59% (SD 31%, IQR 40%-83%). In addition, we measured the AQF-5 on 114 patients, of which there were 74 with a baseline and follow-up PCS interview. These 74 patients triggered a total of 122AQF-5 QIs (mean 1.6±0.6, range 1-3), and the mean AQF-5 score was 43% (SD 43%, IQR 0%-100%).

Survival analysis results

There were 68 deaths in the first 500 days: 32 (8.6%) in ACOVE-1 and 36 (5.6%) in ACOVE-2. Between 501 days and 3 years, there were 127 deaths: 54 in ACOVE-1 (15.9%) and 73 (12%) in ACOVE-2.

In the first 500 days, AQS-17 scores (Table 3 and Figure 2) independently predicted survival (HR = .83 per 20%-point increment, p =.014). After 500 days, there was no effect(HR = .98 per 20%-point increment, p =.78). The VES-13 scorealso predicted death (HR = 1.29 per point, p < .0005). Having the highest versus lowest level of comorbidity (but not the middle versus lowest level) was associated with worse survival (HR = 2.19, p = .03). Age and gender were not related to survival. There was no difference in AQS-17 effect on survival by co-morbidity strata ($HR_{QOC \times \text{moderate morbidity}} = 1.08$, p = .161; $HR_{QOC \times \text{high morbidity}} = 1.07$, p=.314).

QI-level sensitivity analyses

Of the 17 AQS QIs, 2 QIs (influenza and pneumonia vaccination) were required on all patients regardless of co-morbidity and were associated with more crude survival benefit than the 15 non-vaccination QIs (Appendix 2). Therefore, we tested them as two separate

composite QOC scores, the AQS-vaccination versus AQS-non-vaccination QOC scores. Approximately half (n=482) was only eligible for the vaccination AQS-QIs (“simple” patients). The remainder of the sample was eligible for vaccinations and at least 1 non-vaccination AQS-QI (534“complex” patients). The AQS-vaccination QOC score was not independently predictive in the simple, complex, or total sample. The AQS-non-vaccination QOC score was not predictive in the complex sample (Table 3).

Physical health-related quality of life results

The mean follow-up PCS was 36.7 (SD 11.3). PCS was stable over time (mean change of +. 4 points, p>.37 for t-test of difference of two means; SD of change scores = 8.7, range 23-point decline to 28-point improvement). In our generalized linear models, the AQF-5 (but not the AQQ-16) predicted PCS change (i.e., more improvement or less decline). An increment of 20 %-points in the AQF-5 score was associated with less decline in PCS (β=1.13point improvement [SE .49], p=.021), controlling for age, gender, ACOVE-2 intervention versus control group, and co-morbidity. The effect size for this for this result was .27 (a small effect by Cohen's criteria[24]).There was no interaction between AQF-5 and intervention group. There was no effect of AQQ-16 on the PCS change score (β=.43 points [SE .3] per 20 %-point increment in AQQ-16 score, p>.15). None of the co-variables (age, gender, co-morbidity, intervention)predicted PCS in either AQF-5 nor AQQ-16 models.

Discussion

In this study we aimed to reduce 69 ambulatory-care QIs into smaller subsets of QIs aimed at improving outcomes important to older patients. Using expert panel review, we classified 17 primary care-processes as linked to survival, and analyzed whether a composite measure of survival-oriented QIs, the ACOVE Quality-for-Survival-17 score, would predict better survival. A 20 percentage-point improvement on theAQS-17 was associated with 17% improved 500-day survival, independent of co-morbidity, gender, age, or the VES-13 in older primary-care patients. This modest effect was not detected inthe later observational window (500 days to 3 years). However, the early benefit was consistent among those with higher versus lower levels of co-morbidity burden, gender, age, and vulnerability, as well asbetweenACOVE-1 and ACOVE-2. The effect of the AQS-17 was not driven by particular individual QIs; rather, the effect was shared between primary prevention (e.g., vaccinations) and condition-based care. We also found a small effect of 5 QIs aimed at improving functional status (1.13 points on the PCS score per 20%-points on the AQF-5), but not 16 QIs aimed at improving HRQOL in a smaller sample of ACOVE-2 patients.

This observational study extends prior observational research linking better performance on care-process measures to clinical benefits, including research on vulnerable older patients,[1]middle-age patients with chronic diseases,[2]hospitalized geriatric patients,[25] and nursing home-eligible populations.[3]However, the process-outcome link among complex, multi-morbid patients[26] with geriatric conditions(falls, urinary incontinence, and dementia)has been limited to geriatric condition-specific care with condition-specific outcomes (incontinence quality-of-life[27] and falls efficacy[28]). We believe that we were able

to link function and survival with better performance on a composite QOC measure across conditions because we focused on care-processes by their intended benefits.

The implication of this research is that two high-priority subsets of the ACOVE QIs can be used as a starting point for future ambulatory-care initiatives to improve care and outcomes of complex older adults. The AQS-17 consisted mostly of cardiovascular care-processes, but also considered non-cardiovascular care: preventing death in dementia (due to unsafe driving) and depression (screening for suicide). These data suggest, but do not prove, that one approach to prolonging survival might include, as a starting point, by insuring that these care-process QIs are met in the care of vulnerable older patients. A 20%-point improvement in QOC, the degree of improvement that we considered as clinically-meaningful in this study, is feasible in primary care.[9] Although many of theAQS-17 indicators are similar to current systems-level measures (e.g., cholesterol control), these results do not suggest that existing QIs for younger patients should be extended indefinitely in complex geriatric patients. Rather, the less-stringent targets for vulnerable elders in the ACOVE QIs could potentially be adopted as patients become vulnerable (as in ACOVE-1) or develop geriatric conditions (as in ACOVE-2).

Furthermore, our results suggest that measures used in quality improvement initiatives can be tailored to benefits most important to that population. For vulnerable or multi-morbid older adults, personal preference may help determine whether to prioritize some care-processes such as those aimed at improving function above survival. Also, because the AQS-17 can be applied to patients across varying burden of chronic conditions, this suggests a future approach to improving clinical outcomes in older patients with multi-morbidity, who have traditionally been excluded from clinical trials. Future quality improvement aimed at improved survival or function can target the prioritized care-processes we identified in the AQS-17 or AQF-5, using clinical nurse specialists or care managers within primary care practices to coordinate better performance.

We review several limitations to interpreting our results. First, it is important to consider alternative explanations, for example, if poorer care was provided to patients who were sicker, e.g., due to preference or less-aggressive care. In prior work, however, we have found the opposite: sicker patients with greater co-morbidity and greater condition severity received better QOC.[7,19,29] Therefore, we do not believe that our results are due to withholding high-quality care for those with multi-morbidity.

Second, the link between a 20% absolute improvement in AQF-5 with a 1-point improvement in PCS was limited by its measurement on a fraction of the eligible ACOVE-2 sample. A care-process link with quality-of-life of similar magnitude has been reported in a study of middle-aged (rather than geriatric) patients with chronic medical conditions.[2] The literature on complex interventions to improve functional status also show very small or mixed benefit.[30] It is imperative that better functional status outcomes measures be developed that are more sensitive to medical interventions[31] and quality-of-life measures that reflect older patients' values with late-life disability.[32] Therefore, if a patient highly values preserving function above survival, then the focus might transition to QI sets more closely matched to his/her preferences. Third, future survival-oriented efforts will need to be

updated in response to new emerging evidence of survival benefit in older patients. The newer ACOVE-3 quality indicator set includes hundreds of new QIs not included in our expert panel review.[33] New evidence has emerged since our expert panel that hypertension control improves mortality,[34] however, we could not include this QI in the AQS-17as it was not measured until ACOVE-2. All the AQS-17QIs, such as daily aspirin for diabetes,[35] need to be updated. Fourth, this was an observational study. In contrast to trials, when the intervention start date is known, we had to presume that QOC was constant over time. Patients also could have been receiving better QOC years before our observation. The diminished survival benefit after 500 days is likely a limitation of our methods, and should not be interpreted as a reason to stop providing high AQS-17 care after 500 days. Fifth, our sample was predominately white, limiting generalizability of our results to minority groups. Last, we were unable to link better AQQ-16 scores with PCS. The PCS has limited evidence of responsiveness to changes in HRQOL in older patients.[36] This possibility further emphasizes the critical need to develop universal measures of HRQOL and symptoms for older patients with multi-morbidities[37] and the health care system needed to improve those global outcomes.[38]

In conclusion, we identified a smaller set of ambulatory care-processes associated with survival even among older multi-morbid and vulnerable ambulatory care patients. Future effort to improve outcomes in these populations should consider improving and measuring these core subsets of care-processes prioritized by intended clinical benefit.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We would like to acknowledge the technical assistance of Patty Smith, Caren Kamberg, and Chiao-Li Chan for their technical support.

This project was funded by the Agency for Health Care Research and Quality (Min R21 HS017621). Dr. Min was also supported by the Claude Pepper Older Americans Independence Centers at UCLA (NIA K12 2006-10 AG001004), University of Michigan (NIA AG024824 2010-12), and the John A Hartford Foundation. The original ACOVE-1 and ACOVE-2 studies were funded by RAND through a grant by Pfizer corporation.

Sponsor's Role: The original Assessing the Care of Vulnerable Elders (ACOVE-2) study was supported by a contract from Pfizer Inc to RAND. Pfizer did not serve a role in the design, analysis, or preparation of this study.

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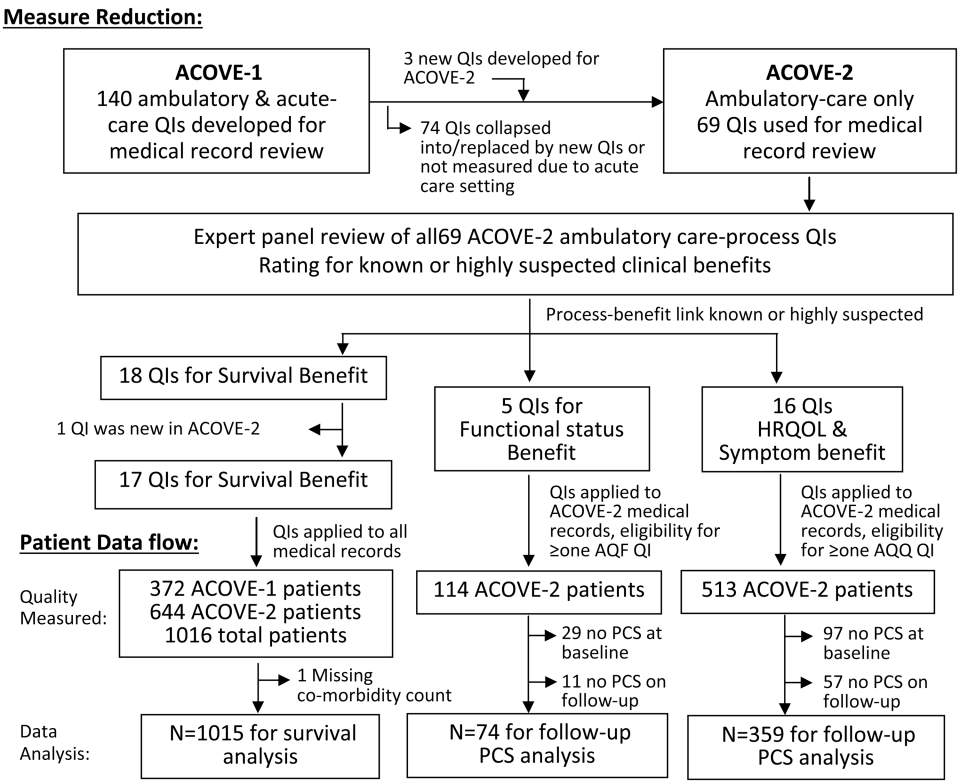

Figure 1. Measure Reduction and Flow of Patient Data

Quality indicator (QI) measure development in the Assessing Care of Vulnerable Elders Study (ACOVE-1) originally included acute and ambulatory care measures, and was later reduced to ambulatory-care only measures in ACOVE-2. Only QIs measured in common to both studies were considered for the survival analysis on the pooled ACOVE-1 and 2 datasets, of which 17 were rated as linked (known or highly likely to be associated) with 3-year survival benefit in older adults. For 5 QIs rated as linked to better function and 16 QIs with health-related quality of life (HRQOL) or physical symptom benefits, we testedcomposite measures of quality on ACOVE-2 patients with available baseline and follow-up interviews using the physical component summary score (PCS) of the Short-Form 12.

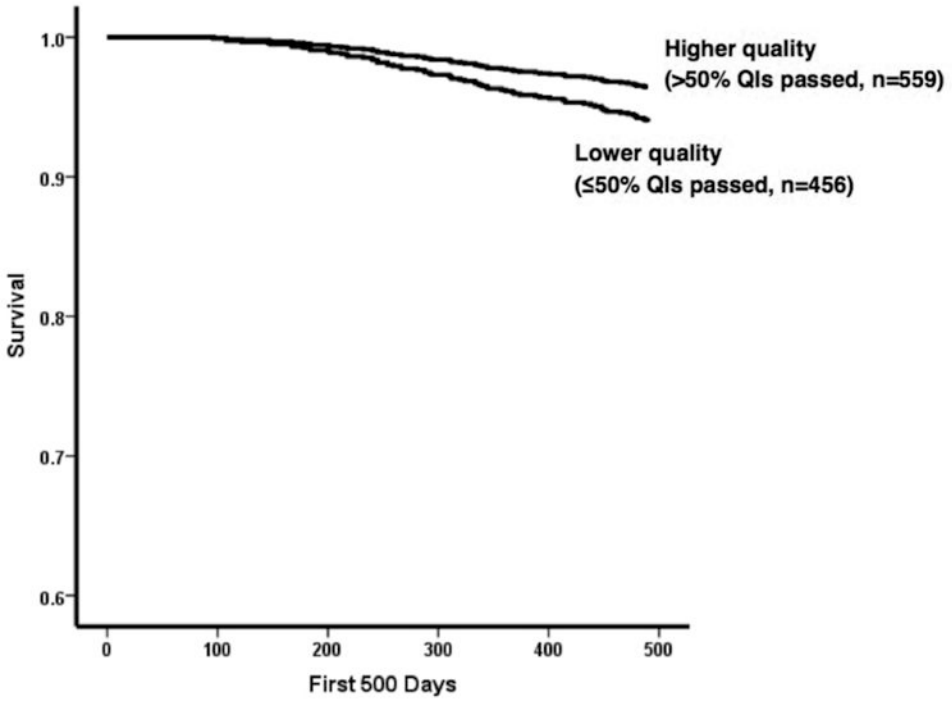

Figure 2. Survival among older ambulatory-care patientswith better versus poorer quality of care using the ACOVE-Survival Quality (AQS-17) Score

Adjusted Kaplan-Meier curve up to 500 days, with 1015 participants in pooled ACOVE-1 and 2 samples divided into two groups: high (score > 50%, upper curve) versus low (score ≤ 50%, lower curve) quality. Curves adjusted for co-morbidity, gender, age, ACOVE-1 versus ACOVE-2 study, and function-based risk (the Vulnerable Elders-13 Survey score).

Table 1
Comparisons of the ACOVE 1 and 2 datasets before and after pooling

Element	Before pooling		Pooled sample for survival outcomes (N=1015)
	ACOVE-1 (N=372)	ACOVE-2 (N=644)	
Setting	Community-dwelling vulnerable elders screened from 2 managed care organizations	Large group practices (2 groups at 7 sites) screened for symptoms of 3 geriatric syndromes (falls, dementia, UI).	
Age	Age ≥65 Mean age 81 years (SD = 6.8)	Age ≥ 75 Mean age 81 years (SD = 4.8)	Mean age 81 years (SD =5.6, range 65-100)
Gender	64% women	65% women	65% women
% White race	97%	96%	96%
VES-13 score	Mean of 5.3 (SD 2.2, range 3-10)	Mean of 4.6 (SD 2.6, range 1-10) 460 elders (71%) had VES-13 scores ≥3	Mean score for full sample = 4.88 (SD=2.7, range 1-10)
Conditions collected	15 medical conditions: atrial fibrillation, coronary artery disease, congestive heart failure, chronic renal failure, dementia, diabetes, depression, emphysema, fall, hypertension, osteoarthritis, osteoporosis, pressure ulcers, stroke, urinary incontinence.	12 medical conditions: atrial fibrillation, coronary artery disease, congestive heart failure, dementia, diabetes, depression, fall, hypertension, osteoarthritis, osteoporosis, stroke, urinary incontinence.	12 medical conditions in common: atrial fibrillation, coronary artery disease, congestive heart failure, dementia, diabetes, depression, fall, hypertension, osteoarthritis, osteoporosis, stroke, urinary incontinence.
Total comorbidity count	Mean of 2.3 conditions (SD 1.5, range 0-7)	Mean of 3.5 conditions (SD 1.8, range 0-10)	Mean 3.1 (SD 1.8, range 0-10)
Quality Indicators	140 QIs covering 22 areas of care (depression, diabetes, dementia, falls, hearing loss, congestive heart failure, hypertension, coronary artery disease, osteoarthritis, osteoporosis, pneumonia, hospitalization, pressure ulcers, stroke and atrial fibrillation, urinary incontinence, continuity of care, end-of-life, malnutrition, medication management, pain, screening and prevention, and vision care). Elders were eligible for 8 to 54 QIs (mean 21).	69 QIs covering 13 areas of care (dementia, depression, diabetes, falls, hearing impairment, hypertension, malnutrition, osteoarthritis, osteoporosis, pain, urinary incontinence, medication use, screening and prevention). Elders were eligible for 4 to 27 QIs (mean 12).	61 QIs covering 13 areas of care (dementia, depression, diabetes, falls, hearing impairment, hypertension, malnutrition, osteoarthritis, osteoporosis, pain, urinary incontinence, medication use, screening and prevention). Elders were eligible for 4 to 30 QIs (mean 12).
Primary Aim	Observational study of feasibility of measuring ACOVE QIs	Intervention at 2 of 7 sites to improve care of dementia, falls, and UI; screening only at 5 control sites	Survival analysis of pooled data
Available outcomes	Survival (days) from 0 to 3 years	• Survival (days) from 0 to 5 years • Quality of life and function (SF-12 Physical Component Score) at 1 year	Survival (days) from 0 to 3 years
Hierarchical data	Participants were not nested within physician	Participants nested within 39 different primary care physicians. Physicians cared for 1 to 44 participants.	Preliminary testing for cluster effects of patients within physician and site but not included in final models

Element	Before pooling		Pooled sample for survival outcomes (N=1015)
	ACOVE-1 (N=372)	ACOVE-2 (N=644)	
Other co-variables	Income, education	Income, education	Income, education

Key: VES-13=Vulnerable Elders-13 Survey[10], SD= standard deviation, ACOVE=Assessing Care of Vulnerable Elders, QIs = quality indicators, SF-12 = Medical Health Outcomes Short Form-12[20], AQS-17 = ACOVE Quality-for-Survival-17 Score, AQF-5 = ACOVE Quality-for-Function Score, AQQ-16=ACOVE Quality-for Quality-of-Life Score, UI = Urinary Incontinence.

Table 2

Quality indicators (QIs) rated by expert panel as linked with intended clinical benefits in older ambulatory care patients

Condition	Short Description of QI*	Clinical benefit determined by the panel		
		Survival (17 QIs)	Function (5 QIs)	Quality of Life related to physical health or symptoms (16 QIs)
All patients	Annual flu vaccine	x		
	Pneumococcal vaccine	x		
All patients new to a clinic	Functional status evaluation on initial exam (ACOVE-2 only)		x	
	Hearing screen initial evaluation		x	x
CV disease	Anticoagulant or antiplatelet for high-risk atrial fibrillation	x		
	Cholesterol intervention for LDL>130 mg/dL if CAD and failed diet intervention	x		
	Aspirin for patient with CAD	x		
	Smoking cessation counseling	x		
	No 1st/2nd generation calcium channel blockers as 1st line hypertension treatment	x		
	Beta Blocker for heart failure	x		x
	Angiotensin Converting Enzyme Inhibitor (ACEI) or Receptor Blocker (ARB) for heart failure	x		x
	ACEI/ARB for hypertension and chronic renal disease	x		
	Beta blocker after recent (2 years) myocardial infarction	x		
	** Intervention for blood pressure> 160 mmHg (ACOVE-2 only)	x		
Dementia	New dementia and driving: counseling & notification	x		
	Cholinesterase inhibitor mild/moderate dementia		x	
	Check B12 & TSH for new dementia		x	x
	Depression screen at initial evaluation			x
Depression	New depression: Document suicidality & psychosis	x		
	Depression symptoms, screen within 2 weeks			x

Condition	Short Description of QI*	Clinical benefit determined by the panel		
		Survival (17 QIs)	Function (5 QIs)	Quality of Life related to physical health or symptoms (16 QIs)
	Treat new depression within 2 weeks			x
	Change depression treatment by 8 weeks if no response			x
Diabetes Mellitus	Intervention to decrease blood pressure	x		
	Daily aspirin therapy	x		
	ACEI/ARB for elevated cardiac risk	x		
	Cholesterol intervention if total cholesterol > 240 mg/dL	x		
Falls	Exercise/assist device for balance problem		x	x
	Exercise for strength/gait problem			x
Pain Management	Exam for pain within 1 month			x
	Offer treatment for new pain			x
	History for pain within 1 month			x
Urinary Incontinence (UI)	New/persistent incontinence: check urine analysis			x
	New incontinence: Discuss treatment options			x
	Behavior therapy for stress/urge/mixed incontinence			x

CV = cardiovascular

LDL= low-density lipoprotein

CAD = ischemic coronary heart disease

ACEI/ARB= Angiotensin converting enzyme inhibitor or angiotensin receptor blocker TSH=Thyroid-stimulating hormone

* The full text of each quality indicator is reproduced in the full table, in online Appendix A.

** This QI was the 18th QI rated as having known or highly suspected survival benefit, however it was not developed until ACOVE-2, and therefore not tested as part of the AQS-17 survival analysis on pooled ACOVE-1 and ACOVE-2 data.

Table 3

Multivariable Cox Proportional Hazard Models predicting Survival Benefit of QIs Linked with Intended Benefit

Hazard Ratios for Time to Death within 500 days of enrollment (95% CI)			
	AQS-17 as QOC predictor (N = 1015)	Supplementary Analysis	
		AQS-A Vaccination-only as QOC predictor (N = 1015)	QS-Non-Vaccination as QOC predictor (N = 534)
Age	1.01 (.97, 1.06)	1.02 (.97, 1.06)	1.04 (.98, 1.10)
Male versus female	1.57 (.97, 2.54)	1.52 (.94, 2.46)	1.07 (.58, 1.98)
Vulnerability	1.29*** (1.16, 1.43)	1.29*** (1.16, 1.44)	1.32*** (1.15, 1.51)
Co-morbidity (moderate vs low)	1.44 (.74, 2.8)	1.37 (.70, 2.66)	.64 (.24, 1.67)
Co-morbidity (high versus low)	2.19* (1.08, 4.46)	1.95 (.97, 3.91)	.85 (.32, 2.23)
ACOVE-2 (vs ACOVE-1)	.77 (.46, 1.28)	.73 (.44, 1.44)	.72 (.38, 1.36)
QOC Score (per 20% increment)	.83* (.71, .96)	.89 (.78, 1.02)	.89 (.76, 1.03)

Hazard Ratios for Time to Death after 501 days of enrollment (95% CI)			
	AQS-17 as QOC predictor (N = 947)	Supplementary Analysis	
		AQS-Vaccination-only as QOC predictor (N = 947)	AQS-Non-Vaccination as QOC predictor (N = 492)
Age	1.04* (.88, 1.11)	1.04* (1.01, 1.07)	1.06* (1.01, 1.10)
Male versus female	2.48*** (1.75, 3.52)	2.48*** (1.74, 3.52)	3.09*** (1.92, 4.98)
Vulnerability	1.17*** (1.09, 2.26)	1.17*** (1.09, 1.26)	1.13** (1.03, 1.23)
Co-morbidity (moderate vs low)	1.09 (.68, 1.73)	1.08 (.68, 1.72)	1.01 (.41, 2.49)
Co-morbidity (high versus low)	1.85* (1.14, 2.99)	1.83* (1.14, 2.95)	1.87 (.77, 4.56)
ACOVE-2 (vs ACOVE-1)	.72 (.50, 1.05)	.72 (.50, 1.05)	.97 (.59, 1.59)
QOC Score (per 20%-point increment)	.98 (.88, 1.11)	.99 (.90, 1.09)	.98 (.87, 1.11)

* p<.05

** p<.01

*** p<.001

QOC = quality of care

ACOVE study = Assessing Care of Vulnerable Elders study

AQS Score = ACOVE Quality for Survival Score