




ORIGINAL RESEARCH

# Risk Model for Decline in Activities of Daily Living Among Older Adults Hospitalized With Acute Myocardial Infarction: The SILVER-AMI Study

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**BACKGROUND:** Functional decline (ie, a decrement in ability to perform everyday activities necessary to live independently) is common after acute myocardial infarction (AMI) and associated with poor long-term outcomes; yet, we do not have a tool to identify older AMI survivors at risk for this important patient-centered outcome.

**METHODS AND RESULTS:** We used data from the prospective SILVER-AMI (Comprehensive Evaluation of Risk Factors in Older Patients With Acute Myocardial Infarction) study of 3041 patients with AMI, aged  $\geq 75$  years, recruited from 94 US hospitals. Participants were assessed during hospitalization and at 6 months to collect data on demographics, geriatric impairments, psychosocial factors, and activities of daily living. Clinical variables were abstracted from the medical record. Functional decline was defined as a decrement in ability to independently perform essential activities of daily living (ie, bathing, dressing, transferring, and ambulation) from baseline to 6 months postdischarge. The mean age of the sample was  $82 \pm 5$  years; 57% were men, 90% were White, and 13% reported activity of daily living decline at 6 months postdischarge. The model identified older age, longer hospital stay, mobility impairment during hospitalization, preadmission physical activity, and depression as risk factors for decline. Revascularization during AMI hospitalization and ability to walk a quarter mile before AMI were associated with decreased risk. Model discrimination ( $c=0.78$ ) and calibration were good.

**CONCLUSIONS:** We identified a parsimonious model that predicts risk of activity of daily living decline among older patients with AMI. This tool may aid in identifying older patients with AMI who may benefit from restorative therapies to optimize function after AMI.

**Key Words:** acute myocardial infarction ■ patient-centered outcomes ■ physical function

Older adults comprise the majority of patients hospitalized for acute myocardial infarction (AMI), and over a third are aged  $\geq 75$  years.<sup>1</sup> Although it is well established that older AMI survivors are at high risk for mortality<sup>2</sup> and rehospitalizations,<sup>3</sup> recent evidence shows that AMI may also increase risk of functional decline.<sup>4–6</sup> Functional decline after AMI has been defined as new-onset or worsening disability in

performing activities of daily living (ADLs) and other tasks related to independence. It is common, occurring in a third to half of older patients with AMI,<sup>4–6</sup> and associated with poor long-term outcomes of death<sup>4,7</sup> and institutionalization.<sup>8</sup>

Maintenance of function and independence are outcomes of higher priority than survival for many older adults,<sup>9</sup> and the need for clinicians to appreciate

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## CLINICAL PERSPECTIVE

### What Is New?

- One in 8 patients aged  $\geq 75$  years reports decline in essential activities of daily living 6 months after hospitalization for acute myocardial infarction.
- Activities of daily living decline after acute myocardial infarction was predicted by age, pre-acute myocardial infarction function and activity status, mobility status during hospitalization, length of hospitalization, and coronary revascularization received during hospitalization.

### What Are the Clinical Implications?

- The risk model described in this study may aid in identifying older patients with acute myocardial infarction who are at risk for functional decline and may benefit from enhanced postdischarge services, including participation in physical/occupational therapy or cardiac rehabilitation.

## Nonstandard Abbreviations and Acronyms

<b>ADL</b>	activity of daily living
<b>GRACE</b>	Global Registry of Acute Coronary Events
<b>SILVER-AMI</b>	Comprehensive Evaluation of Risk Factors in Older Patients With Acute Myocardial Infarction

and evaluate these outcomes in older cardiac patients has been highlighted in a recent Scientific Statement from the American Heart Association.<sup>10</sup> Yet, knowledge about the factors that put older AMI survivors at risk for functional decline is limited. Prior studies examining functional decline after AMI have focused on younger populations,<sup>4</sup> have been single-site studies,<sup>7</sup> or have not examined geriatric and psychosocial impairments, which are highly prevalent and impactful on outcomes in the older adult population. Therefore, the aim of this study was to describe the incidence of functional decline among older people hospitalized for AMI in a nationwide cohort study and to develop a risk model for functional decline using a wide array of predictors (eg, demographic, cardiac, geriatric, psychosocial, and lifestyle) to aid identification of patients at risk for this important outcome.

## METHODS

This study used data from the SILVER-AMI (Comprehensive Evaluation of Risk Factors in Older Patients With Acute Myocardial Infarction) study, a

prospective longitudinal study of 3041 adults aged  $\geq 75$  years hospitalized with AMI. SILVER-AMI study data are available from the corresponding author on request and approval by the study steering committee. Details of the study have been published previously.<sup>11</sup> Briefly, participants were recruited from 94 academic and community hospitals across the United States. Site coordinators reviewed hospital admission records daily to identify potentially eligible participants and performed medical record review to confirm AMI diagnosis in accordance with the Third Universal Definition of Myocardial Infarction.<sup>12</sup> Site coordinators approached eligible patients, explained the scope of the study, and obtained written informed consent. The University of California, San Diego, Brief Assessment of Capacity to Consent<sup>13</sup> was administered to patients with decisional capacity concerns, and proxy consent was obtained for patients with diminished capacity. Patients were ineligible if they had initial troponin elevation  $>24$  hours after admission, were transferred from another hospital after  $>24$  hours, experienced AMI as a result of an in-hospital procedure, were incarcerated, or were unable to provide informed consent with no proxy available. Study protocols were approved by the Institutional Review Boards at Yale and all participating sites.

Participants underwent a structured interview and physical assessment during AMI hospitalization and at 6 months postdischarge to collect information on geriatric impairments (mobility, hearing, vision, and cognition), functional status, demographics, and psychosocial factors.

Our primary outcome was defined as a decline in ability to independently perform  $\geq 1$  essential ADLs<sup>14</sup> at 6 months posthospital discharge, relative to pre-morbid ability. Participants were asked how much help they needed from another person to bathe, dress, transfer (get in and out of a chair), and walk around their home<sup>15</sup> during the baseline interview (participants reported on function 1 month before admission) and the 6-month follow-up interview. Response options were “no help,” “help,” and “unable to do.” Decline in ADLs was characterized as any decrement in ability to perform these tasks from baseline to 6 months postdischarge (ie, transition from “no help” to “help,” “help” to “unable to do,” or “no help” to “unable to do”).

We examined an array of demographic, cardiac, geriatric, psychosocial, and lifestyle factors with risk of ADL decline at 6 months postdischarge. These factors were selected on the basis of clinical insight or association with functional disability or decline in other populations,<sup>4,16–20</sup> with special effort taken to include factors that are potentially amenable to intervention.<sup>21</sup> All factors considered as candidates for risk of functional decline are listed in the Table.

**Table. Participant Characteristics, by Decline in ADL Status at 6 Months Postdischarge**

	Full Cohort	ADL Decline at 6 mo		
	(N=2558)	No Decline (N=2228)	Decline (N=327)	P Value
Demographic				
Age, mean (SD), y	81.3 (4.9)	81.1 (4.7)	83.0 (5.7)	<0.001
Sex, men	1450 (56.7)	1296 (58.1)	154 (47.1)	<0.001
Race, non-White	244 (9.7)	199 (9.1)	45 (14.1)	0.005
Ethnicity, Hispanic	73 (2.9)	59 (2.7)	14 (4.4)	0.10
Education, ≤12 y	1434 (56.5)	1241 (56.0)	193 (59.9)	0.19
Marital status, married	1331 (52.1)	1190 (53.4)	141 (43.1)	<0.001
Cohabitation status, alone	957 (37.4)	836 (37.5)	121 (37.1)	0.90
Clinical				
MI type				0.019
STEMI	702 (27.4)	630 (28.2)	72 (22.0)	
NSTEMI	1856 (72.6)	1601 (71.8)	255 (78.0)	
Presentation variables				
Chest pain	1043 (42.1)	920 (42.3)	123 (40.5)	0.54
Killip class II–IV	286 (11.2)	221 (9.9)	65 (19.9)	<0.001
Systolic BP, mean (SD), mm Hg	147 (31)	147 (30)	143 (32)	0.017
Diastolic BP, mean (SD), mm Hg	78	79 (17)	75 (18)	0.001
Heart rate, mean (SD), bpm	83 (23)	82 (22)	86 (23)	0.004
Initial hemoglobin, g/dL, mean (SD)	13.0 (2.0)	13.1 (2.0)	12.3 (2.1)	<0.001
Comorbidities				
Arrhythmia	614 (24.0)	500 (22.4)	114 (34.9)	<0.001
Heart failure	424 (16.6)	323 (14.5)	101 (30.9)	<0.001
Hypertension	2158 (84.4)	1873 (84.0)	285 (87.2)	0.14
Peripheral vascular disease	276 (10.8)	236 (10.6)	40 (12.2)	0.37
Stroke	357 (14.0)	283 (12.7)	74 (22.6)	<0.001
Prior MI	692 (27.1)	590 (26.5)	102 (31.2)	0.07
COPD	327 (12.8)	265 (11.9)	62 (19.0)	<0.001
Chronic kidney disease	1477 (57.9)	1263 (56.7)	214 (65.4)	0.003
Diabetes mellitus	922 (36.1)	786 (35.3)	136 (41.6)	0.026
Charlson score, median (IQR)	3 (2–5)	3 (2–5)	4 (2–6)	<0.001
Length of stay, median (IQR), d	4 (2–7)	4 (2–7)	5 (3–9)	<0.001
In-hospital revascularization				
None	307 (12.0)	227 (10.2)	80 (24.5)	<0.001
Catheterization only	413 (16.2)	354 (15.9)	59 (18.0)	
PCI	1516 (59.3)	1358 (61.0)	158 (48.3)	
CABG	319 (12.5)	289 (13.0)	30 (9.2)	
In-hospital complications				
Arrhythmia	445 (17.2)	381 (17.1)	64 (19.6)	0.27
Heart failure	316 (12.4)	263 (11.8)	53 (16.2)	0.024
Cardiogenic shock	90 (3.5)	74 (3.3)	16 (4.9)	0.15
Bleeding event	639 (25.0)	551 (24.7)	88 (26.9)	0.40
AKI	531 (20.8)	448 (20.1)	83 (25.4)	0.029
Geriatric impairments				
Preadmission ADL impairment	273 (10.7)	191 (8.6)	82 (25.1)	<0.001
Not able to walk 0.25 miles preadmission	785 (30.8)	620 (27.9)	165 (50.6)	<0.001
Mobility impairment (TUG >15 s)	1342 (52.5)	1095 (49.1)	247 (75.6)	<0.001

(Continues)

**Table. Continued**

	Full Cohort	ADL Decline at 6 mo		
	(N=2558)	No Decline (N=2228)	Decline (N=327)	P Value
Hearing impairment	316 (12.4)	272 (12.2)	53 (16.2)	0.013
Vision impairment	191 (7.5)	150 (6.7)	41 (12.5)	<0.001
Grip strength weakness	1480 (60.3)	1252 (58.3)	228 (74.3)	<0.001
Global cognitive impairment (TICS)	360 (14.3)	274 (12.5)	86 (26.6)	<0.001
History of falls	473 (18.6)	362 (16.3)	111 (34.2)	<0.001
Unintentional weight loss	509 (20.0)	420 (18.9)	89 (27.4)	<0.001
Psychosocial and lifestyle				
Self-rated health				<0.001
Excellent/very good	764 (30.0)	697 (31.3)	67 (20.6)	
Good	968 (37.9)	852 (38.3)	116 (35.6)	
Fair	622 (24.4)	525 (23.6)	97 (29.8)	
Poor	199 (7.8)	153 (6.9)	46 (14.1)	
Depressive symptoms	325 (13.1)	243 (11.2)	82 (26.1)	<0.001
Social support, median (IQR)	24 (20–25)	24 (20–25)	23 (19–25)	0.09
Low physical activity	355 (14.0)	272 (12.3)	83 (25.7)	<0.001
BMI (categorical), obese	702 (27.5)	593 (26.6)	109 (33.3)	0.004
Smoking status, ever	1402 (55.2)	1240 (56.0)	162 (50.0)	0.043

All statistics are reported as number (percentage), unless otherwise stated. *t*-Tests, Wilcoxon tests, and  $\chi^2$  tests were used to compare differences between groups for continuous, ordinal/nonnormally distributed, and categorical variables, respectively. ADL indicates activity of daily living; AKI, acute kidney injury; BMI, body mass index; BP, blood pressure; bpm, beats per minute; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; MI, myocardial infarction; NSTEMI, non-ST-segment-elevation MI; PCI, percutaneous coronary intervention; STEMI, ST-segment-elevation MI; TICS, telephone interview for cognitive status; and TUG, Timed Up and Go.

Demographic information (ie, age, sex, race, ethnicity, marital status, residence [alone or with others], education, and income) was collected from the medical record or participant report during the hospital interview. Cardiac status at presentation (vitals, symptoms, comorbidities, troponin level, and other relevant laboratory values) was collected from intake assessments, physical examination findings, and laboratory tests. AMI type (ST-segment-elevation myocardial infarction or non-ST-segment-elevation myocardial infarction) was adjudicated by physician interpretation of the initial ECG. Cardiac procedures and complications were collected from procedural records and progress notes. The GRACE (Global Registry of Acute Coronary Events)<sup>22</sup> risk score, a validated tool to predict risk of mortality within 6 months of AMI, and the Charlson comorbidity index<sup>23</sup> were calculated from admission and discharge records. Length of hospitalization and discharge location were collected from discharge documentation.

## Statistical Analysis

Information on geriatric conditions was collected during the in-hospital interview, via performance-based testing or participant report. Preadmission ADL status was assessed by asking participants

about their independence with performing essential ADLs and neighborhood mobility<sup>15</sup> (ability to walk a quarter mile or 2–3 blocks) in the month before AMI. Hearing and vision impairment were collected via selected questions from the Hearing Handicap Inventory for the Elderly-Screening questionnaire<sup>24</sup> and the Visual Function Questionnaire,<sup>25</sup> respectively. Cognitive status was assessed with the Telephone Interview for Cognitive Status.<sup>26</sup> History of falls within the past year was collected via participant report. In-hospital mobility was assessed via performance of the Timed Up and Go test<sup>27</sup> and grip strength was measured as the best of 3 trials with a hand-held dynamometer.<sup>28</sup>

Depressive symptoms were assessed with the Patient Health Questionnaire,<sup>29</sup> and social support was measured with the Medical Outcomes Study Social Support Scale.<sup>30</sup> Self-rated health status<sup>31</sup> was collected as part of the Short Form-12.<sup>31</sup> Physical activity,<sup>32</sup> tobacco use, and alcohol use were collected via participant report. Body mass index was calculated on the basis of height and weight in the medical record.

Participants who were impaired in all ADLs at baseline (n=35) were excluded, as were participants who died during the index hospitalization (n=35). The cohort was randomized into derivation (n=1705) and

validation cohorts (n=853). Standard descriptive statistics (ie, *t*-tests, Wilcoxon tests, and  $\chi^2$  tests) were used to examine differences in demographic, cardiac, geriatric, psychosocial, and lifestyle-related characteristics among participants who did and did not report ADL decline, as well as between derivation and validation cohorts. Correlations between all predictor variables were examined to rule out multicollinearity. Missing data, <1% for most covariates and 16% for in-hospital mobility status, were addressed via multiple imputation using chained equations.<sup>33</sup>

Backward selection ( $P<0.05$ ) was used in a multi-variable-adjusted logistic regression model<sup>34</sup> to identify independent and statistically significant predictors of functional decline in 20 imputed data sets. Each regression yielded a model with 7 to 9 covariates; the vast majority of covariates overlapped substantially among models. All covariates that were present in >50% of the 20 imputed models were included in the final model. The final model was tested among the alternatives and found to have the lowest Akaike Information Criterion while retaining statistical significance of all predictors, based on analysis in a randomly selected imputed data set. The corresponding multivariable model was assessed with c-statistics to evaluate discrimination and the Hosmer-Lemeshow test to evaluate calibration, along with graphical representation of calibration in a calibration plot. A sensitivity analysis to demonstrate the robustness of model discrimination was performed by calculating c-statistics in 1000 bootstrapped samples of the derivation and validation cohorts in one randomly selected imputed data set (of 20 imputed data sets used in primary analyses). To address competing risk of death with our outcome at 6 months postdischarge (n=266; 9.4% of cohort), we used sensitivity analyses to evaluate the robustness of associations of the variables in the final risk model with ADL decline in 2 extreme simulated scenarios: (1) 100% of decedents experiencing the outcome and (2) 0% of decedents experiencing the outcome.<sup>35</sup> We also performed sensitivity analyses to evaluate the influence of adding sex as a covariate in the risk model. All analyses were performed in Stata SE 15 (College Station, TX).

## RESULTS

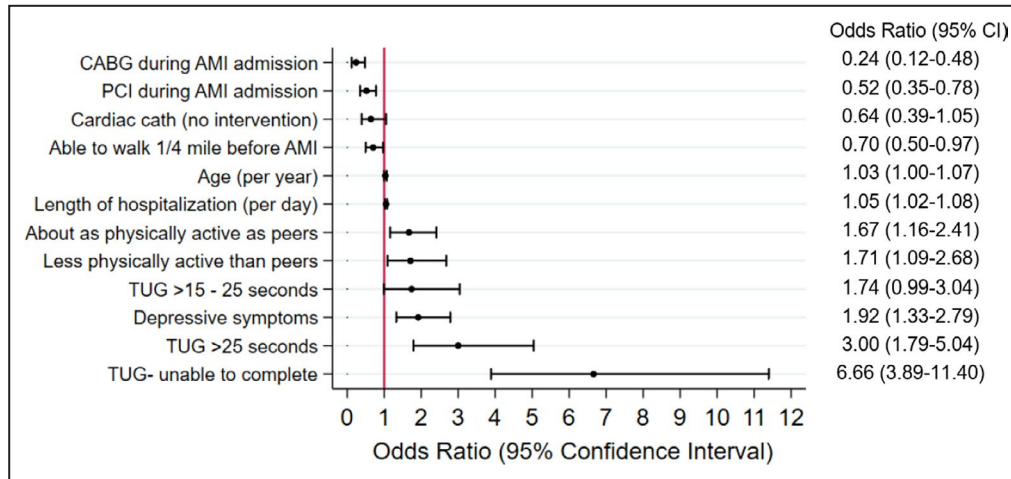
Among the 3041 participants enrolled in the SILVER-AMI study, 301 died (35 during hospitalization and 266 during follow-up), 150 were lost to follow-up for reasons other than death, and 35 were impaired in all ADLs at baseline, leaving 2555 participants for the main analyses. The mean age of participants was 81.3 (SD, 4.9) years, slightly more than half were women, and 90%

identified as White (Table). Nearly three quarters of the cohort was hospitalized for non-ST-segment-elevation myocardial infarction. Comorbidity burden was expectedly high in this aged cohort: nearly 85% had hypertension, 58% had chronic kidney disease, 36% had diabetes mellitus, and 27% had history of AMI. Average length of stay was 4 days (interquartile range, 2–7 days), and a great majority of the cohort (84%) underwent cardiac catheterization, percutaneous coronary intervention, and/or coronary artery bypass grafting (CABG) during the index admission. Of the cohort, 11% were impaired in 1 or more ADLs (but not all 4, by design) at baseline. Mobility impairment and weak grip strength were present in more than half of participants, whereas cognitive, hearing, and vision impairment were present in 10% to 20%. More than a third of participants reported their health status as “fair” or “poor,” and 13% endorsed symptoms of depression.

The incidence of ADL decline at 6 months postdischarge, relative to 1 month before AMI, was 12.8% (12.7% and 13.0% in derivation and validation cohorts, respectively). Participants who experienced ADL decline were on average older, more likely to be women, and less likely to be White or married than participants who did not experience ADL decline. They were more likely to present with non-ST-segment-elevation myocardial infarction, had higher comorbidity burden, and were less likely to undergo coronary angiography (66.3% versus 77.0%) or CABG (9.2% versus 13.0%). Participants who experienced ADL decline were more likely to have ADL impairment at baseline (25.1% versus 8.6%) and were more likely to exhibit all of the geriatric conditions studied, including impairments in mobility, grip strength, cognition, hearing, and vision, as well as greater fall risk, unintentional weight loss, depressive symptoms, worse health status, and lower physical activity levels than their peers.

Characteristics of the randomly assigned derivation (n=1709) and validation (n=846) cohorts are presented in Table S1. With the exception of smoking history (58.1% versus 49.5% in derivation and validation cohorts, respectively;  $P<0.001$ ) and unintentional weight loss of >10 pounds (21.2% versus 17.6%;  $P=0.04$ ), the compositions of the derivation and validation cohorts were similar.

Our model selection strategy in the derivation cohort yielded 7 independent predictors of ADL decline at 6 months post-AMI: age, length of hospital stay, receipt of coronary revascularization, depressive symptoms, physical activity level before AMI, ability to walk a quarter mile in the month before AMI, and mobility status during the index admission (Figure). Higher age (odds ratio [OR], 1.03; 95% CI, 1.00–1.07 per year), length of admission (OR, 1.05; 95% CI, 1.02–1.08 per day), depressive symptoms (OR, 1.92;



**Figure.** Independent predictors of activity of daily living decline at 6 months post-acute myocardial infarction (AMI) in the SILVER-AMI (Comprehensive Evaluation of Risk Factors in Older Patients With Acute Myocardial Infarction) study derivation cohort.

CABG indicates coronary artery bypass grafting; cath, catheterization; PCI, percutaneous coronary intervention; and TUG, Timed Up and Go.

95% CI, 1.33–2.79), and moderate (OR, 3.00; 95% CI, 1.79–5.04) or severe mobility impairment (OR, 6.67; 95% CI, 3.89–11.40), based on the Timed Up and Go test, were associated with increased risk of ADL decline. Participants who reported being “about as active” (OR, 1.67; 95% CI, 1.16–2.41) or “less active” (OR, 1.71; 95% CI, 1.09–2.69) relative to their peers were more likely to experience ADL decline than those who reported being “more active” than their peers. Conversely, participants who reported being able to walk a quarter mile one month before AMI were less likely to report ADL decline (OR, 0.70; 95% CI, 0.50–0.97). Participants who underwent percutaneous coronary intervention (OR, 0.52; 95% CI, 0.35–0.78) or CABG (OR, 0.24; 95% CI, 0.12–0.48) were less likely to report ADL decline relative to participants whose AMI was managed with medications only.

The c-statistic for this 7-variable model of ADL decline after AMI was 0.78 in the derivation cohort (c-statistic in 1000 bootstrapped samples, 0.80; 95% CI, 0.77–0.83) and 0.78 in the validation cohort (c-statistic in 1000 bootstrapped samples, 0.78; 95% CI, 0.74–0.85). Model calibration was acceptable (*P* values of Hosmer-Lemeshow tests >0.05) in both derivation and validation cohorts, as supported by the calibration plot (Figure S1). The sensitivity analysis to account for competing risk of death that simulated 100% of decedents as experiencing ADL decline at 6 months yielded results similar to the main analysis (Table S2). The complementary competing risk analysis of the highly improbable clinical scenario in which 0% of decedents experienced ADL decline was also similar to the main analyses, except

that baseline physical activity level and length of hospitalization lost statistical significance as predictors (Table S3). Adding sex as an adjustment variable in the final model did not substantially change the magnitude or statistical significance of other parameters in the model (Table S4).

## DISCUSSION

In this multicenter prospective cohort study, we found that 1 in 8 patients aged  $\geq 75$  years reported ADL decline 6 months after hospitalization for AMI, and that decline was predicted by age, pre-AMI function and activity status, mobility status during hospitalization, length of hospitalization, and coronary revascularization received during hospitalization. Collectively, these risk factors performed well, according to standard metrics of model performance, in a risk model to identify older patients with AMI at risk for functional decline at 6 months postdischarge.

The incidence of functional decline reported in our study,  $\approx 13\%$ , is lower than incidences of  $\approx 28\%$  reported in previous studies<sup>4,36</sup> of cohorts with acute coronary disease. We believe that this discrepancy is attributable to differences among studies in definitions of functional decline. We defined functional decline as a decrease in ability to perform essential ADLs (bathing, dressing, transferring, and walking around home), which is a conservative definition (ie, identifies more severe forms of decline). Previous studies have defined functional decline using scales that assess loss of independence in higher-level activities (eg, climbing several flights of stairs<sup>4</sup>) or in

broader domains, such as “self-care” or “usual activities.”<sup>36</sup> Although there is no universally accepted definition of functional decline after AMI, we posit that our conservative definition identified participants whose independence was severely limited by functional loss, and thus may be more likely to experience deleterious outcomes, such as institutionalization or death.<sup>37,38</sup>

Our model building strategy identified 7 factors that were independently related to risk of functional decline in our sample. Some of these factors (ie, age,<sup>4,7,16</sup> depression,<sup>4,39</sup> and receipt of coronary angiography/revascularization<sup>4,7</sup>) have previously been linked to disability or functional decline in populations with AMI. Increasing age and depression have been consistently identified as risk factors for functional decline, and our findings corroborate this evidence in AMI. The relationship between receipt of coronary angiography and/or revascularization and disability after AMI is more nuanced. Patients with AMI who undergo CABG report greater disability during hospitalization,<sup>16</sup> but in the present study were less likely, along with participants who underwent percutaneous coronary intervention, to report functional decline 6 months after leaving the hospital (relative to their pre-AMI status). We hypothesize that short-term disability post-CABG may be attributable to the trauma of open-heart surgery, whereas the longer-term lower risk of functional decline may be explained by indication bias (ie, more robust patients are seen as better candidates for percutaneous coronary intervention/CABG than frailer patients) or by the direct benefits of these treatments to circulatory health and function-limiting symptoms (eg, pain and dyspnea).

In-hospital mobility status, ability to walk a quarter mile before AMI, and pre-AMI physical activity level were identified as novel predictors of functional decline in older patients with AMI. Baseline functional status has been previously identified as an important predictor of hospitalization-associated functional decline,<sup>5,40–42</sup> with patients who are functionally impaired at baseline more likely to experience further decline as a result of hospitalization. More recent studies have found that measurement of mobility status during hospitalization is a strong “geriatric biomarker” for risk of functional decline,<sup>43,44</sup> and this is enhanced by our findings that in-hospital mobility, measured by the Timed Up and Go, was the strongest predictor of functional decline after AMI. Notably, our measurements of pre-AMI functional status, pre-AMI physical activity, and in-hospital mobility consist of just a few open-license questions and a brief physical assessment that do not require any specialized equipment, making their integration into usual care feasible without undue burden on staff or resources.

Length of hospital stay, found to be associated with increased risk of functional decline, may reflect a complicated clinical course beyond the occurrence of discrete complications (eg, heart failure and acute kidney injury, which were included as candidate variables in the model) that could influence risk of functional decline. Alternatively, longer length of hospitalization may lead to functional decline through its association with prolonged immobilization and subsequent deconditioning.<sup>45</sup>

We were surprised to find that some factors that we had hypothesized to be important contributors to ADL decline after AMI did not exhibit independent associations with our outcome. Previous studies<sup>4,5,7,16,36</sup> have consistently reported female sex to be associated with a greater risk of disability or functional decline after AMI, although some of these previous analyses<sup>7</sup> were bivariate in nature and did not control for potential confounders. We similarly reported (Table) that female participants in the SILVER-AMI study were more likely to experience ADL decline than male participants, although this association did not remain statistically significant in the multivariable-adjusted model. We posit that geriatric impairments may moderate the association between sex and vulnerability to functional decline, and thus our consideration (and ultimate selection) of geriatric impairments into the risk model superseded sex as an influential covariate. Our hypothesis is supported by the higher prevalence of geriatric impairments<sup>44</sup> in women than men in our cohort.

Notably, there was a general paucity of cardiac factors, besides receipt of revascularization, independently related to risk of ADL decline after AMI in our cohort. Previous studies that did not evaluate geriatric impairments found significant associations between cardiac factors, such as heart failure,<sup>16</sup> with disability or functional decline in the context of heart disease, whereas others did not.<sup>5</sup> We believe, similar to our hypothesis for sex, that cardiac factors, although significant in bivariate analyses (Table), are superseded by geriatric impairments in their ability to predict functional decline after AMI. As functional status is a “universal outcome” that reflects the overall health of an organism, it may be less sensitive to factors that reflect the health of a single organ system.

Maintenance of function and independence are outcomes of higher value than survival for many older adults,<sup>9</sup> yet functional outcomes have been less often targeted as a principal goal of treatment in patients with heart disease compared with prevention of mortality or adverse cardiovascular events.<sup>10,46,47</sup> Our study provides clinicians caring for older patients with AMI with a well-performing model to identify patients who may be at risk for functional decline, and identifies a concise set of risk factors that clinicians can easily assess in the course of regular care for their patients. Identification

of these patients may help to facilitate early or more intensive physical therapy, stronger recommendations to participate in cardiac rehabilitation (center or home based<sup>48</sup>), or other considerations of how disease or treatment burden may impact a patient's goal to remain functionally independent after AMI.

This study is strengthened by use of data from the largest prospective cohort study to date of patients aged  $\geq 75$  years hospitalized for AMI, recruited from a nationwide network of academic and community hospitals. The SILVER-AMI study rigorously collected a rich array of demographic, cardiac, and geriatric information, allowing us to examine new risk factors in this population while accounting for important traditional risk factors. We applied a rigorous variable selection process, which resulted in a risk model with good discrimination and calibration. Follow-up was complete in 94% of participants who survived to 6 months, limiting the risk of attrition bias, and we used well-established sensitivity analysis methods to evaluate the potential competing influence of death on our analyses.<sup>35</sup> These strengths are balanced by some limitations. We operationalized "baseline" functional status as participants' report of function 1 month before hospitalization, and were thus unable to precisely identify whether the functional decline reported by participants at 6-month follow-up first occurred immediately before AMI hospitalization, during hospitalization, or afterward. Prior studies have shown that retrospective report of premorbid functional status (ie, from a time before onset of illness) is a better indicator of baseline function than functional status during hospitalization, and a stronger predictor of posthospitalization outcomes.<sup>49</sup> We acknowledge that some participants may have experienced functional decline around the time of their hospitalization for AMI, but subsequently recovered before the 6-month assessment, thereby underestimating the incidence of functional decline. Although we used split sample methods to internally validate our model, external validation is needed before these findings can be implemented in clinical settings.

## CONCLUSIONS

We developed a parsimonious risk model composed of novel predictors of ADL decline among older adults hospitalized with AMI. After external validation, use of this tool may improve treatment planning and shared decision-making for older patients with AMI at risk for this important patient-centered outcome.

## ARTICLE INFORMATION

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## Disclosures

None.

## Supplementary Materials

Tables S1–S4

Figure S1

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# **Supplemental Material**

**Table S1. Characteristics of the Derivation and Validation Subsamples in SILVER-AMI.**

Variable	Derivation (n= 1709 )	Validation (n= 846 )	p
<b>Demographic</b>			
Age, in years	81.3 (4.9)	81.3 (4.9)	.83
Sex, male	976 (57.1)	471 (55.7)	.49
Race, non-white	169 (10.1)	74 (8.9)	.32
Ethnicity, Hispanic	51 (3.1)	22 (2.7)	.57
Education, ≤12 years	965 (57.0)	469 (55.8)	.59
Marital status, married	875 (51.3)	390 (46.2)	.23
Cohabitation status, alone	657 (38.5)	299 (35.4)	.13
<b>Clinical</b>			
MI type			.77
STEMI	472 (27.6)	229 (27.1)	
NSTEMI	1237 (72.4)	617 (72.9)	
Presentation Variables			
Chest pain	709 (42.9)	334 (40.5)	.27
Killip Class II-IV	195 (11.4)	91 (10.8)	.62
Systolic BP, mean (SD)	146.6 (30.7)	146.6 (30.8)	.98
Diastolic BP, mean(SD)	78.2 (17.3)	78.7 (18.0)	.46
Heart rate, means(SD)	82.5 (22.7)	83.4 (22.3)	.37
Initial hemoglobin, means(SD)	12.9 (2.0)	13.0 (2.1)	.29
Comorbidities			
Arrhythmia	413 (24.2)	200 (23.6)	.77
Heart failure	297 (17.4)	125 (14.8)	.10
Hypertension	1446 (84.6)	709 (83.8)	.60
Peripheral vascular disease	187 (10.9)	88 (10.4)	.68
Stroke	226 (13.2)	131 (15.5)	.12
Prior MI	478 (28.0)	214 (25.3)	.15
COPD	214 (12.5)	113 (13.4)	.55
Chronic kidney disease	977 (57.2)	500 (59.2)	.34
Diabetes mellitus	628 (36.8)	294 (34.8)	.32
Charlson score, median (IQR)	3 (2-5)	3 (2-5)	.75
Length of stay in days, median (IQR)	4 (2-7)	4 (2-7)	.23
In-hospital revascularization			
None	215 (12.6)	92 (10.9)	
Catheterization only	262 (15.3)	151 (17.9)	
PCI	1021 (59.7)	495 (58.5)	
CABG	211 (12.4)	108 (12.8)	
In-hosp complications			
Arrhythmia	305 (17.9)	140 (16.6)	.42
Heart Failure	204 (11.9)	112 (13.2)	.35
Bleeding event	434 (25.4)	205 (24.2)	.52
AKI	360 (21.1)	171 (20.2)	.62
<b>Geriatric Impairments</b>			
Pre-admission ADL impairment	187 (10.9)	86 (10.2)	.55
Not able to walk ¼ mile pre-admission	536 (31.5)	249 (29.5)	.32
Mobility impairment (TUG >15 sec)	883 (51.8)	459 (54.3)	.40
Hearing impairment	200 (11.5)	116 (13.7)	.08
Vision impairment	128 (7.5)	63 (7.5)	.60
Grip strength weakness	991 (60.5)	489 (59.9)	.76
Global cognitive impairment	242 (14.4)	118 (14.1)	.84
History of Falls (>1 in past year)	311 (18.2)	162 (19.2)	.56
Unintentional weight loss	360 (21.2)	149 (17.6)	<b>.04</b>

<b>Psychosocial &amp; Lifestyle</b>			
Self-rated health			.28
Excellent/very good	492 (28.8)	272 (32.2)	
Good	654 (38.3)	314 (37.1)	
Fair	430 (25.2)	192 (22.7)	
Poor	131 (7.7)	68 (8.0)	
Depressive symptoms	222 (13.4)	103 (12.5)	.53
Social support, median (IQR)	24 (20-25)	24 (19-25)	.52
Low Physical Activity	237 (13.9)	118 (14.1)	.39
BMI (categorical), obese	468 (27.4)	234 (27.7)	.80
Smoking status, ever	986 (58.1)	416 (49.5)	<b>&lt;.001</b>

**Table S2. Sensitivity Analysis for Competing Risk of Death on Association between Risk Model Variables and Outcome (Simulated Scenario: 100% of 266 post-discharge decedents experienced ADL decline)**

<b>Variable</b>	<b>Odds Ratio (95% CI)</b>
<b>Age (per year)</b>	1.05 (1.03-1.07)
<b>Pre-AMI Physical Activity Level</b>	
More active than peers	Reference
About as active as peers	1.23 (0.96-1.56)
Less active than peers	1.48 (1.10-2.00)
<b>Able to walk ¼ mile before AMI</b>	0.64 (0.51-0.80)
<b>Length of hospitalization (per day)</b>	1.07 (1.05-1.10)
<b>Depressive symptoms</b>	1.62 (1.24-2.11)
<b>In-hospital treatment of AMI</b>	
Non-invasive management only	Reference
Cardiac catheterization (no intervention)	0.55 (0.40-0.76)
Percutaneous coronary intervention	0.40 (0.31-0.53)
Coronary artery bypass grafting	0.15 (0.09-0.24)
<b>In-hospital mobility</b>	
No impairment	Reference
Mild impairment	1.14 (0.81-1.59)
Moderate impairment	2.16 (1.59-2.92)
Severe impairment	4.65 (3.37-6.44)

**Table S3. Sensitivity Analysis for Competing Risk of Death on Association between Risk Model Variables and Outcome (Simulated Scenario: 0% of 266 post-discharge decedents experienced ADL decline)**

<b>Variable</b>	<b>Odds Ratio (95% CI)</b>
<b>Age (per year)</b>	1.03 (1.01-1.06)
<b>Pre-AMI Physical Activity Level</b>	
More active than peers	Reference
About as active as peers	1.22 (0.91-1.62)
Less active than peers	1.30 (0.91-1.84)
<b>Able to walk ¼ mile before AMI</b>	0.74 (0.57-0.96)
<b>Length of hospitalization (per day)</b>	1.02 (0.998-1.04)
<b>Depressive symptoms</b>	1.79 (1.34-2.41)
<b>In-hospital treatment of AMI</b>	
Non-invasive management only	Reference
Cardiac catheterization (no intervention)	0.75 (0.50-1.10)
Percutaneous coronary intervention	0.71 (0.52-0.99)
Coronary artery bypass grafting	0.49 (0.29-0.82)
<b>In-hospital mobility</b>	
No impairment	Reference
Mild impairment	1.62 (1.05-2.51)
Moderate impairment	3.07 (2.06-4.59)
Severe impairment	5.53 (3.64-8.42)

**Table S4. Independent Predictors of ADL Decline at 6 Months Post-AMI in the SILVER-AMI Derivation Cohort, Adjusted for Sex.**

<b>Variable</b>	<b>Odds Ratio</b>	<b>95% CI</b>
Age (per year increase)	1.03	1.002-1.07
Physical activity		
More active than peers	Ref	Ref
About as active as peers	1.67	1.16-2.41
Less active than peers	1.71	1.09-2.68
Able to walk ¼ mile in the month before AMI		
No	Ref	Ref
Yes	0.70	0.50-0.98
Length of hospitalization (per day)	1.05	1.02-1.08
Depressive symptoms	1.91	1.32-2.78
Revascularization during AMI admission		
None	Ref	Ref
Cardiac catheterization only	0.64	0.39-1.05
Percutaneous coronary intervention	0.52	0.35-0.78
Coronary artery bypass grafting	0.25	0.12-0.49
Mobility impairment during AMI admission		
None	Ref	Ref
Mild impairment	1.74	0.99-3.04
Moderate impairment	2.98	1.77-5.00
Severe impairment	6.62	3.86-11.34
Sex		
Female	Ref	Ref
Male	0.95	0.69-1.30

**Figure S1. Predicted and Observed Probability of ADL Decline, according to Quintile of Risk Score.**

