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CLINICAL INVESTIGATION OPEN ACCESS

Patient Outcomes Associated With a Composite Measure of 4Ms Care Adherence in the Inpatient Setting

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Correspondence: Benjamin I. Rosner (benjamin.rosner@ucsf.edu)**Received:** 24 December 2025 | **Revised:** 25 July 2026 | **Accepted:** 2 August 2026**Keywords:** 4Ms | adherence | age-friendly health care | older adults | outcomes

ABSTRACT

Background: The 4Ms (what matters, medication, mentation, and mobility) is a widely adopted age-friendly care framework. However, there is no evidence on inpatient 4Ms adherence thresholds associated with improved outcomes.**Methods:** In a retrospective cross-sectional analysis, we measured encounter-level adherence to the 4Ms for inpatients 65+ at the University of California San Francisco between January 1, 2021 and December 31, 2024. Outcomes included 30-day unplanned readmissions, 30-day emergency department (ED) visits, length of stay (LOS), and community admissions discharged to a facility. Using fixed effects regression models, we estimated the effect on outcomes of adherence to 100% of 4Ms assessments (what matters, medication, mentation, and mobility screening) plus 25%, 50%, and 75% of shifts with full adherence to 4Ms Act Ons (actions, such as de-prescribing high-risk medications, ambulating). We conducted subgroup analyses by age and medical versus surgical admissions.**Results:** Our study sample included 34,923 inpatient encounters for 22,949 unique patients aged 65+ (mean age 75.3; 49.0% female). We observed lower 30-day readmissions at Act On adherence of 50% (4.1% reduction; 95% CI: 1.8–6.4) and 25% (1.9%; 0.3–3.6). We also found lower 30-day ED visits at 50% Act On adherence in the overall group (3.3%; 0.9–5.8), and in those 85+ (5.0%; 0.4–9.7). Act On adherence and LOS demonstrated a dose-response-like relationship, with 1.0 (0.8–1.1), 1.5 (1.3–1.7), and 1.9 (1.6–2.2) day reductions associated with 25%, 50%, and 75% Act On adherence respectively. No associations were observed between Act On adherence and discharge to facility.**Conclusions:** Higher inpatient adherence to 4Ms care is associated with meaningful reductions in post-acute care utilization and LOS. Our analyses offer clinical leaders guidance on deploying limited resources to positively influence outcomes. They suggest that fully adherent assessments and 25%–50% of shifts with fully adherent Act Ons represent target thresholds.

1 | Introduction

The 4Ms framework (what matters, medication, mentation, and mobility) is the foundation for age-friendly care for older adults. The Framework has been rapidly adopted, with over 5900 care sites recognized by the Institute for Healthcare Improvement (IHI) as age-friendly [1]. Prior work examining the relationship between geriatric care practices (e.g., individual Ms) and outcomes (e.g., the effect of high-risk medication (HRM) de-prescribing on older adults' hospitalization rates)

served as the Framework's evidence base [2–6]. However, given that the 4Ms are conceptualized as complementary assessments and actions designed to be delivered together at specified frequencies [7], there is a need for evidence on their impact as a set. Prior work in the inpatient setting has examined the associations between implementation of a general medicine age-friendly program and facility-free days post-discharge [8], and between the implementation of a geriatric orthopedic program and delirium, mortality, length of stay (LOS), and readmissions [9, 10]. These studies, however, do

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Summary

- Key points
 - There is limited evidence on the relationship between 4Ms care and patient outcomes in the inpatient setting, and no prior studies specifically assess the encounter-level relationship between adherence to 4Ms care delivered and patient outcomes.
 - We developed an encounter-level composite measure across 4Ms care processes and then examined its association with four inpatient outcomes in a sample of 34,923 inpatient encounters at a large academic medical center.
 - Higher adherence to 4Ms care in the inpatient setting was associated with lower 30-day unplanned hospital readmissions and shorter length of stay. We also found evidence of lower 30-day emergency room visits among the oldest age cohort.
- Why does this paper matter?
 - Beyond providing evidence on the association between 4Ms care and improved inpatient outcomes, our work also identifies thresholds of 4Ms adherence at which these benefits accrue—specifically when 4Ms assessments (e.g., screening for what matters, medications, mentation, and mobility) are completed for all shifts and all associated actions (e.g., de-prescribing high risk medications, ambulating, orienting patient, adjusting care plan to what matters) occur concurrently in at least 25% of shifts within the encounter.
 - This approach can serve as a model for empirically identifying adherence levels at which 4Ms care may improve outcomes.

not measure encounter-level adherence to 4Ms care—precluding an understanding of the adherence level needed to achieve benefits. Such evidence is particularly critical given the Centers for Medicare and Medicaid Services' age-friendly Inpatient Quality Reporting program measure based on the 4Ms [11]. Evidence of the level of 4Ms adherence needed to impact outcomes would bolster hospitals' implementation interest and also offer guidance on how to deploy limited resources when doing so (i.e., the frequency of 4Ms care processes needed to achieve meaningful benefits).

Generating such evidence requires two decisions. *First, what are the meaningful, applicable, and readily measurable outcomes that should be examined in assessing the impact of 4Ms care?* IHI guidance suggests several hospital setting outcomes, including healthcare utilization, patient satisfaction, LOS, delirium prevalence, and delivery of goal-concordant care [12]. Others have suggested outcomes including facility-free days post-discharge [8]. A subset of these outcomes, readily available within structured electronic health record (EHR) fields, and upon which we focus, includes post-acute healthcare utilization (30-day unplanned readmissions and return visits to the emergency department (ED)), new discharge to a facility, and LOS.

Second, how can 4Ms care adherence be measured to then guide resource utilization and adherence targets? Based on IHI inpatient setting guidance, 4Ms care includes one assessment each for What Matters, Mentation, and Mobility and one set of Medication assessments for 8 classes of HRMs [13]. Assessments for three of the 4Ms have IHI-suggested frequencies of once per encounter; the fourth (Mentation) is recommended at the shift level (Table 1). Given these frequencies, we propose as a baseline, 100% adherence to all Assessment components of 4Ms. IHI guidance for actions (Act Ons) includes a minimum of one Act On associated with some Ms. (e.g., for Medication, either HRM de-prescribing or a pharmacy consult), and multiple Act Ons associated with other Ms. (e.g., for Mentation, orienting the older adult, ensuring sufficient hydration, and providing personal adaptive equipment) at frequencies that may vary. Therefore, given the complex workflows associated with 4Ms Act On adherence, we propose examining increasingly stringent thresholds for Act On adherence layered on top of a baseline of full Assessment adherence.

Our study assesses the encounter-level relationship between 4Ms adherence in the inpatient setting at 100% Assessment + 25%, 50%, and 75% of shifts with full Act On adherence, and four outcomes available in structured EHR data. We also stratify relationships by age group and admission type (medical vs. surgical) based on work suggesting opportunities to reduce post-acute utilization among the oldest old [14–16] and among those admitted to medical (vs. surgical) units [17]. Our approach leverages a previously developed composite measure that uses a near-complete set of 4Ms Assessment and Act On measures that goes beyond what has been included in prior studies [12, 18].

2 | Methods

2.1 | Setting

This study was conducted at the University of California San Francisco (UCSF), an urban academic medical center that treats a large inpatient population of older adults. UCSF received IHI Age-Friendly Health System (AFHS) recognition in 2019. The study was approved by the UCSF Institutional Review Board.

UCSF's 4Ms implementation was guided by the IHI "Age-Friendly Health Systems: Guide to Using the 4Ms in the Care of Older Adults," describing four Assessments and nine Act On care practices [7]. (This guidance was updated in 2024, in which Assessment for Medication—that had initially required the assessment of ≥ 1 of seven classes of HRMs—was expanded to require assessment of all eight HRM classes [13].) UCSF's implementation of standardized 4Ms care for Medication, Mentation, and Mobility spread hospital-wide by late 2020. During the study period, UCSF did not yet have a standardized approach to What Matters, meaning that clinicians individually decided whether and how to discuss and document patient goals of care. We therefore used a previously developed What Matters proxy measure [18] (Table S1).

TABLE 1 | 4Ms inpatient care processes from the IHI's age-friendly health systems: 4Ms care description worksheet—hospital form [7, 13], consisting of 11 Assessment processes (one each for What Matters, Mentation, and Mobility; and eight for Medication), and nine Act On processes.

	What matters	Medication	Mentation	Mobility
Assess	List the question(s) you ask to know and align care with each older adult's specific outcome goals and care preferences. (Question(s) cannot focus only on end-of-life forms.)	Check the medication you screen for regularly in all older adults. Minimum requirement: <i>All first eight boxes must be checked.</i> • Benzodiazepines • Opioids • Highly-anticholinergic medications (e.g., diphenhydramine) • All prescription and over-the-counter sedatives and sleep medications • Muscle relaxants • Tricyclic antidepressants • Antipsychotics • Mood stabilizers • Other	Check the tool used to screen for delirium for all older adults. Minimum requirement: <i>At least one box be checked.</i> • UB-CAM • CAM • 3D-CAM • CAM-ICU • bCAM • Nu-DESC • Other	Check the tool used to screen for mobility limitations for all older adults. Minimum requirement: <i>One box must be checked.</i> If screening/assessment is done by physical therapy, please identify the tool used. • Timed Up and Go (TUG) • Johns Hopkins High Level of Mobility (JH-HLM) • Tinetti Performance Oriented Mobility Assessment (POMA) • Screening and assessment forms per physical therapy • Other
Act On	Align the care plan with What Matters most	Minimum frequency: Once per stay and upon significant change of condition with a change of medication. Minimum requirement: <i>First box must be checked.</i> • Deprescribe (includes both dose reduction and medication) • Pharmacy consult	Minimum frequency: Every 12h. Delirium prevention and management protocol including, but not limited to: Minimum requirement: <i>First five boxes must be checked.</i> • Ensure sufficient oral hydration. • Orient older adult to time, place, and situation on every nursing shift, if appropriate. • Ensure older adult has their personal adaptive equipment (e.g., glasses, hearing aids, dentures, walkers) • Prevent sleep interruptions, use non-pharmacological interventions to support sleep. • Avoid high-risk medications • Other	Minimum frequency: Once per stay and upon change of condition. Minimum requirement: <i>Must check first box and at least one other box.</i> • Mobilize 3 times a day and/or as directed (walking, unless bed- or chair-bound or otherwise directed to promote the highest practicable level of mobility) • Out of bed or leave room for meals • Physical therapy (PT) intervention (balance, gait, strength, gait training, exercise program) • Avoid restraints (physical or chemical) • Remove catheters and other tethering devices • Avoid high-risk medications • Other
	Minimum frequency: Not specified	Minimum frequency: Not specified	Minimum frequency: Not specified	Minimum frequency: Not specified

2.2 | Study Cohort

Using an approach we have previously described [18], we identified 48,038 inpatient encounters for individuals aged 65+ admitted to an acute care, nonpsychiatric service at UCSF's Hellen Diller Medical Center between January 1, 2021 and December 31, 2024. We removed encounters meeting exclusion criteria (Described in [Supporting Information](#) and Figure S1) Additionally, because we could not track patients with 30-day post-acute healthcare utilization outside of UCSF Health or who may have died within 30 days of discharge, we excluded patients without post-acute utilization and either a death date within 30 days of discharge or without UCSF healthcare utilization of any kind between 30 days post-discharge and July 15, 2025—the date of data extraction.

For each encounter in our final sample ($n = 34,923$), we identified qualifying inpatient nursing shifts: “day shifts” 7 a.m.–7 p.m. and “night shifts” 7 p.m.–7 a.m. during which the patient was admitted to an included service for ≥ 8 h. The 8-h requirement avoided penalties for incomplete 4Ms adherence if a patient arrived to the room with inadequate time remaining to complete required shift-level 4Ms. We also excluded from 4Ms adherence assessment: time in peri-operative departments, intensive care units, and boarding in the ED, where 4Ms care was not expected to be consistently delivered.

2.3 | 4Ms Adherence Process Measures and Composite

Shift-level 4Ms process measures were developed in prior work capturing adherence to IHI-recommended inpatient care practices [18] (Table S1). Our encounter-level composite measure of 4Ms care also relied on prior work [19]. Given the goal of understanding whether the 4Ms delivered as a set is associated with improved outcomes, we used dichotomous measures of 4M care delivery adherence. For Assessment, this required that: (1) What Matters screening documentation was recorded at least once per encounter; and (2) prior-to-admission medication reconciliation was performed at least once per encounter; and (3) patient mobility was assessed at least once per 24 h (a frequency at our institution that exceeds the IHI suggested minimum of once per encounter); and (4) delirium screening was performed at least once per shift, reflecting 100% adherence to IHI minimum frequencies [13].

We then layered thresholds for Act On adherence in alignment with IHI minimum frequencies for all shift-level Ms in at least 25%, 50%, and 75% of shifts. For example, the 100% Assessment + 25% Act On adherence level requires What Matters assessment and Medication reconciliation at least once during the hospital encounter, Mobility assessment at least once daily, Mentation screening at least once per shift, and at least 25% of shifts in which all shift-level Act Ons are done in the same shift, *irrespective* of the findings of each Assessment. Each Act On performance level is a category minimum. *Actual* Act On performance achieved within each category ranges between the minimum of that category and the next. The resulting dichotomous measures were coded as 1 when the threshold was met or exceeded, and

0 otherwise (i.e., the reference level) as follows: (1) 100% versus < 100% adherence to 4Ms Assessment care practices (agnostic to Act On adherence); and (2) 100% adherence to 4Ms Assessment care practices and X% or more shifts with full, synchronous adherence to 4Ms Act On care practices versus < 100% Assessment adherence and/or < X% Act On adherence where X = 25%, 50%, or 75%.

2.4 | Outcomes

Outcomes included: (1) Unplanned 30-day UCSF hospital readmissions; (2) 30-day UCSF ED visits; (3) discharge to a post-acute care facility when the patient had been admitted from the community; and (4) inpatient LOS measured as days present in a qualifying inpatient care setting.

2.5 | Control Variables

We captured 22 covariates to address potential bias in who receives higher adherence to 4Ms care, including patient demographics, descriptors of clinical complexity, and encounter characteristics (Table S2).

2.6 | Analytic Approach

Our overall analysis included four fixed-effect regression models per outcome, one for each of the four thresholds of 4Ms adherence. Models included all covariates, patient-level fixed effects, and robust standard errors. We generated post-estimation mean marginal effects. Dichotomous outcome variables were modeled using a fixed-effects logistic regression (melogit function in Stata), and LOS was modeled using a fixed-effects generalized linear model with a gamma distribution (meglm, family (gamma)). We adjusted for multiple comparisons within each outcome using a Holm-Bonferroni correction.

2.7 | Subgroup Analysis

Prior work has suggested a higher likelihood of 4Ms adherence with patient age [16], as well as differential outcomes based on age [14, 15] and admission type [17]. Therefore, we conducted a subgroup analysis using two models with interaction terms for each 4Ms threshold and: (1) age cohort (65–74, 75–84, and 85+), and (2) admit type (surgical vs. medical). An insufficient number of encounters met the 75% Act On threshold ($n = 150$) to include in subgroup analyses. We then generated mean marginal effects using post-effects estimation. We adjusted for multiple comparisons within each subgroup analysis outcome using a Holm-Bonferroni correction.

2.8 | Sensitivity Analyses

We conducted two sensitivity analyses: (1) impact on post-acute utilization outcomes of excluding encounters for patients lost to follow-up, and (2) effect of relaxing the

TABLE 2 | Study cohort demographics.

Characteristic	100% Assessment only			100% Assessment + 50% or more shifts with full act on adherence		
	Below standard, N = 29,695	Meets standard, N = 5228	<i>p</i> ^a	Below standard, N = 34,302	Meets standard, N = 621	<i>p</i> ^a
N, unique patients (%)	19,473	3476		22,579	370	
Admissions, patient age (%)			< 0.001			< 0.001
65–74	16,162 (54.4%)	2388 (45.7%)		18,349 (53.5%)	201 (32.4%)	
75–84	9585 (32.3%)	1855 (35.5%)		11,225 (32.7%)	215 (34.6%)	
85+	3948 (13.3%)	985 (18.8%)		4728 (13.8%)	205 (33.0%)	
Admissions, female (%)	14,426 (48.6%)	2700 (51.6%)	< 0.001	16,816 (49.0%)	310 (49.9%)	0.7
Race/Ethnicity (%)			0.076			< 0.001
White	16,381 (55.2%)	2863 (54.8%)		18,943 (55.2%)	301 (48.5%)	
Asian	6270 (21.1%)	1168 (22.3%)		7255 (21.2%)	183 (29.5%)	
Latinx	2938 (9.9%)	510 (9.8%)		3393 (9.9%)	55 (8.9%)	
Black or African American	1989 (6.7%)	343 (6.6%)		2291 (6.7%)	41 (6.6%)	
Southwest Asian and North African	319 (1.1%)	49 (0.9%)		360 (1.0%)	8 (1.3%)	
Native Hawaiian or Other Pacific Islander	94 (0.3%)	9 (0.2%)		102 (0.3%)	1 (0.2%)	
Native American or Alaska Native	79 (0.3%)	5 (0.1%)		84 (0.2%)	0 (0.0%)	
Other	1625 (5.5%)	281 (5.4%)		1874 (5.5%)	32 (5.2%)	
Admissions, limited English proficiency (%)	5247 (17.7%)	922 (17.6%)	> 0.9	6022 (17.6%)	147 (23.7%)	< 0.001
Admissions, Medicaid (%)	6537 (22.0%)	1189 (22.7%)	0.2	7558 (22.0%)	168 (27.1%)	0.003
Admissions, Charlson Comorbidity Index ≥ 4 (%)	14,159 (47.7%)	2457 (47.0%)	0.4	16,276 (47.4%)	340 (54.8%)	< 0.001
Admissions, existing evidence of dementia (%)	1827 (6.2%)	495 (9.5%)	< 0.001	2246 (6.5%)	76 (12.2%)	< 0.001
MS-DRG weight, mean (SD)	2.9 (3.4)	2.4 (2.7)	< 0.001	2.8 (3.4)	1.8 (1.2)	< 0.001
Year of admission (%)			< 0.001			0.013
2021	7475 (25.2%)	1040 (19.9%)		8398 (24.5%)	117 (18.8%)	
2022	7268 (24.5%)	1155 (22.1%)		8267 (24.1%)	156 (25.1%)	
2023	7508 (25.3%)	1432 (27.4%)		8768 (25.6%)	172 (27.7%)	
2024	7444 (25.1%)	1601 (30.6%)		8869 (25.9%)	176 (28.3%)	
Days in inpatient care setting during index admission, mean (SD)	5.4 (3.9)	3.8 (2.7)	< 0.001	5.2 (3.8)	3.4 (2.3)	< 0.001
30-day unplanned readmission (%)	3430 (11.6%)	524 (10.0%)	0.001	3900 (11.4%)	54 (8.7%)	0.037

(Continues)

TABLE 2 | (Continued)

Characteristic	100% Assessment only			100% Assessment + 50% or more shifts with full act on adherence		
	Below standard, N = 29,695	Meets standard, N = 5228	<i>p</i> ^a	Below standard, N = 34,302	Meets standard, N = 621	<i>p</i> ^a
30-day emergency department revisit (%)	3935 (13.3%)	669 (12.8%)	0.4	4524 (13.2%)	80 (12.9%)	0.8
Admissions, patient was discharged to a facility (%)	4911 (16.5%)	917 (17.5%)	0.073	5731 (16.7%)	97 (15.6%)	0.5

^aPearson's Chi-squared test; Wilcoxon rank-sum test.

100% Assessment + 50% Act On threshold to 75% + 50%, respectively.

3 | Results

3.1 | Study Cohort

Our final sample included 22,949 unique patients aged 65+ with 34,923 inpatient encounters between January 1, 2021 and December 31, 2024 (Figure S1). Patient demographics are shown in Table 2. 15.0% (5228/34,923) of encounters met 100% Assessment adherence (agnostic to Act On threshold), decreasing to 3.7% (1306/34,923) at 25% Act On, 1.8% (621/34,923) at 50% Act On, and 0.4% (150/34,923) at 75% Act On thresholds respectively (Figure 1). Overall, the 30-day unplanned hospital readmission rate was 11.3% (3954/34,923), the 30-day ED visit rate was 13.2% (4604/34,923), the new discharge to facility rate was 16.7% (5828/34,923), and the mean (SD) LOS was 5.2 (3.8) days.

3.2 | Relationship Between 4Ms Adherence and Outcomes

One hundred percent Assessment only, plus 25% and 50% Act On were significantly associated with 30-day unplanned readmission reductions of 1.3% (95% CI: 0.2–2.3), 1.9% (0.3–3.6), and 4.1% (1.8–6.4), respectively (Figure 1A). Thirty-day ED visits had a significant reduction of 3.3% (0.9–5.8) at the 100% Assessment + 50% Act On level (Figure 1B). There were no significant associations between the level of 4Ms adherence and discharge to facility (Figure 1C). For LOS, all levels of adherence were associated with reductions, with a dose-response-like pattern from 25% to 50% to 75% Act On levels reflecting 1.0 (0.8–1.1), 1.5 (1.3–1.7), and 1.9 (1.6–2.2) days reduction, respectively (Figure 1D). The mean Act On performance for each category (100% Assessment only, plus 25%, 50%, and 75% Act On adherence) was 13.5%, 48.4%, 64.7%, and 87.9%, respectively.

3.3 | Subgroup Analysis

In subgroup analysis, at the 100% Assessment + 50% Act On level (Figure 2A), we observed significant reductions in 30-day unplanned readmissions in all subgroups (age and admission type)

except the youngest age cohort (65–74). At 100% Assessment + 25% Act On (Figure S2A), the overall cohort had a readmission reduction of 1.9% (0.3–3.6), without subgroup readmission reductions. For 30-day ED visits, there was a significant reduction of 3.3% (0.9–5.8) at the Assessment + 50% Act On level (Figure 1B), while in the subgroup analysis, the oldest age (85+), and medical admissions demonstrated significant reductions (Figure 2B). At the Assessment + 25% Act On level, no subgroup had significant reductions in ED visits (Figure S2B). For new discharge to a facility, there were no significant associations at the Assessment + 50% Act On level (Figure 2C), and an isolated association favoring greater facility discharge rate in the 85+ cohort at the Assessment + 25% Act On level (Figure S2C). 4Ms adherence at all levels was significantly associated with shorter LOS, including across all subgroups (Figures 2D and S2D).

3.4 | Sensitivity Analyses

In our sensitivity analysis assessing the effect of excluding patients lost to follow-up on post-acute healthcare utilization, we observed only 3 of 32 results with any change in statistical significance, but the clinical significance of these changes was small (Table S3).

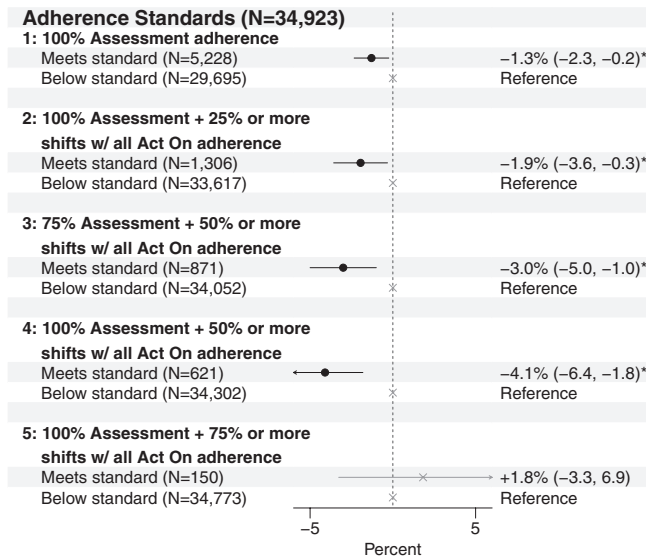
In our sensitivity analysis of reducing 100% to 75% Assessment, we observed that 2.5% of encounters (871/34,923) met the 75% + 50% performance threshold, relative to 15.0% (5228/34,923), 3.7% (1306/34,923), and 1.8% (621/34,923) for 100% Assessment only, plus 25% and 50% Act On, respectively (Figure 1). Comparing the 75% Assessment + 50% Act On performance threshold to the 100% + 50% threshold demonstrated sustained reductions in readmissions, ED visits, and LOS, with the latter being of smaller magnitude 0.9 (0.7–1.1) versus 1.5 (1.3–1.7) days.

4 | Discussion

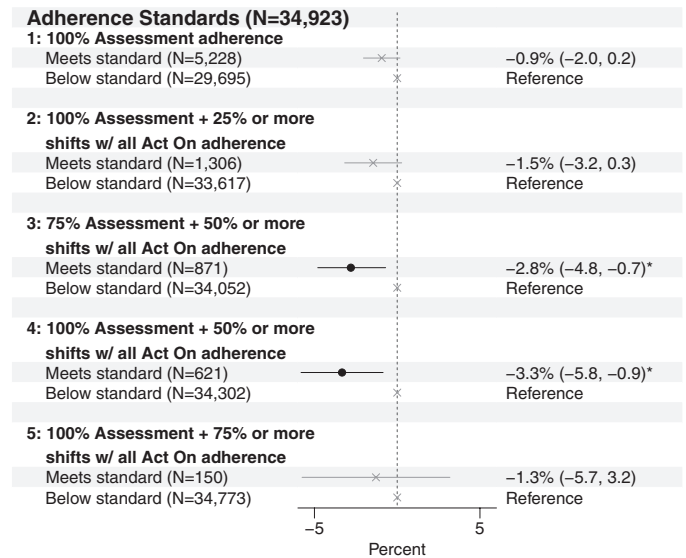
In this study, we assessed the relationship between a composite measure of adherence to 4Ms care in the inpatient setting and patient outcomes including 30-day unplanned hospital readmissions, 30-day ED visits, new discharge to a facility, and LOS.

Prior 4Ms work has largely focused on process measure outcomes such as clinical performance and documentation of 4Ms in the ambulatory setting [20–23], capture of the percent of visits

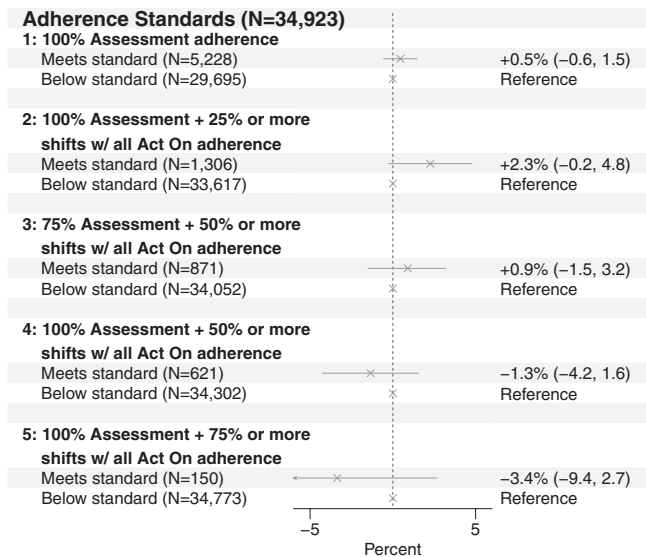
A. 30-day Unplanned Readmissions



B. 30-day Emergency Department Visits



C. New Discharge to Facility



D. Inpatient Length of Stay

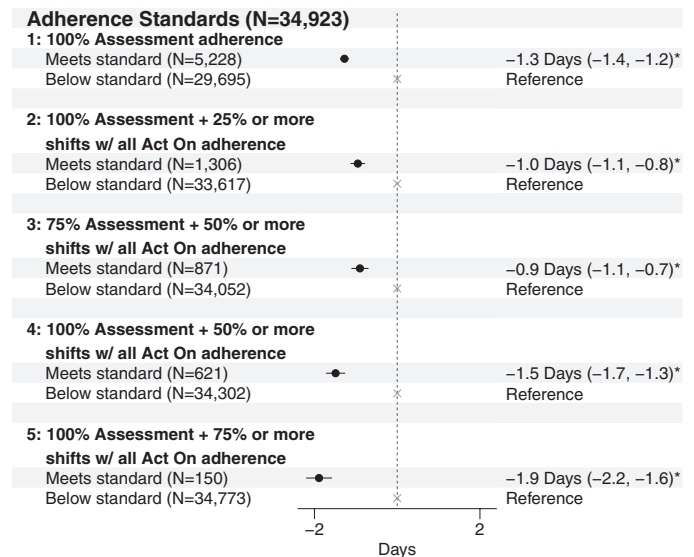


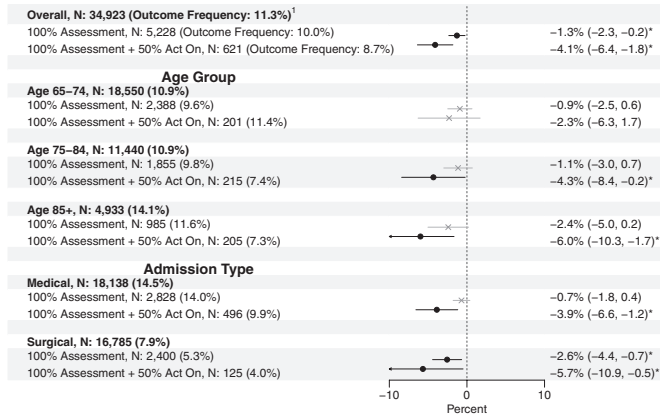
FIGURE 1 | Mean marginal effects (95% CI) of 4 levels of increasing 4Ms adherence on: (A) 30-day unplanned readmissions, (B) 30-day emergency department visits, (C) New discharge to facility, and (D) length of stay. Asterisks and bold indicate statistical significance assessed at $p < 0.05$, correcting for multiple comparisons with Holm-Bonferroni.

in which 4Ms care was delivered and documented [24], and adherence to follow-up care [25]. These may offer upstream, directional indications of the impact of 4Ms on patient outcomes, but reports of the impact of 4Ms on such outcomes themselves have been limited. They include, for example, hospital LOS, 30-day readmissions, delirium, and mortality. However, these studies have primarily examined outcomes as a function of patient *enrollment* in a 4Ms program or admission to a facility with AFHS recognition, rather than the encounter-level adherence to 4Ms care that was actually *delivered*. For example, a study of a 4Ms Geriatrics Fracture Program found an average of 2.2 days LOS reduction (similar to our range of 0.8–2.2), but no reductions in 30-day readmissions or mortality [10]. In addition, patients treated at Veterans Affairs medical centers with IHI AFHS recognition had a small increase in facility-free days relative to those treated at facilities without this recognition [26]. However, the true *potential* effect of 4Ms on these outcomes may be masked for

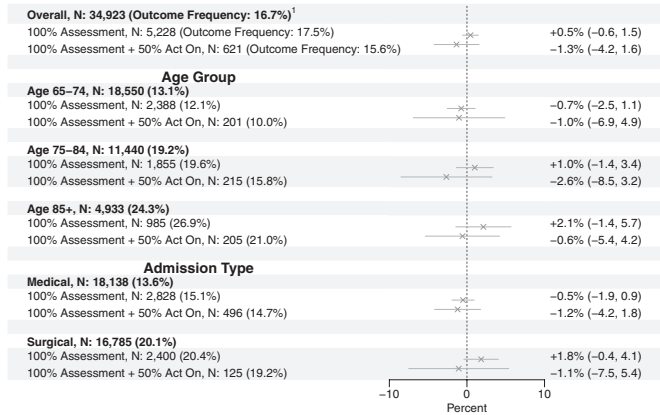
subgroups or for those with high 4Ms care adherence. Therefore, not only is identifying target adherence thresholds for ongoing quality improvement essential, but findings from studies focusing purely on exposure to an AFHS, in which such subgroup signals may be diluted in the overall cohort, could lead to inaccurate conclusions about intervention effectiveness.

4Ms implementation is not without barriers, including operational silos, the need for multi-level leadership engagement, and cultural and infrastructural changes [27]. Even after implementation, measuring 4Ms adherence itself is not straightforward. Our methods offer a starting point for evolution toward encounter-level measures, and our approach of examining different adherence thresholds enables nuanced insights into dose–response style relationships between 4Ms adherence and outcomes. Such results have pragmatic implications because they enable clinical leaders to identify outcome ceilings, and

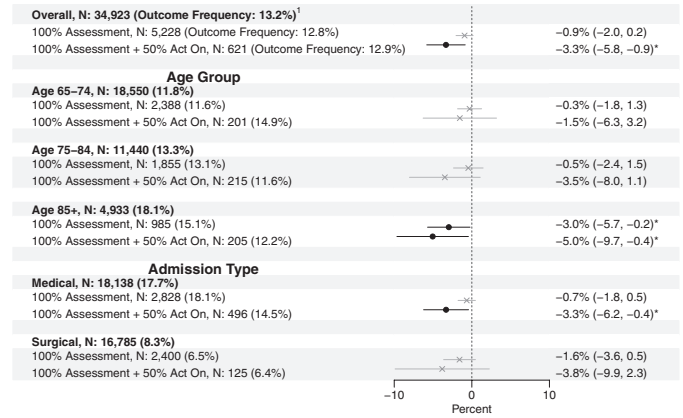
A. 30-day Unplanned Readmissions



C. New Discharge to Facility



B. 30-day Emergency Department Visits



D. Inpatient Length of Stay

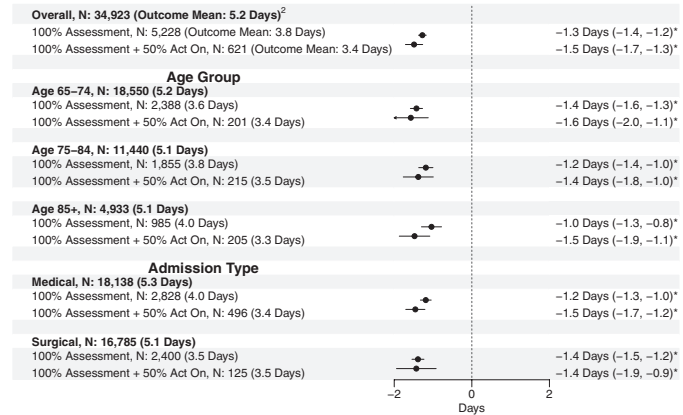


FIGURE 2 | Mean marginal effects (95% CI) of different levels of 4M care process adherence for subgroup analyses of 100% Assessment and 100% Assessment + 50% Act Ons for: (A) 30-day unplanned readmissions, (B) 30-day ED visits, (C) New discharge rate to a facility, and (D) Length of stay spent in a qualifying inpatient setting. For panels A, B, and C, N refers to the number of hospital encounters meeting the adherence threshold associated with each subgroup, while the percentage in parentheses refers to the prevalence of the outcome itself within each subgroup. For panel D, N refers to the number of hospital encounters associated with each subgroup, while the number in the parentheses is the unadjusted mean inpatient length of stay for that subgroup. Asterisks and bold markers indicate statistical significance at $p < 0.05$, correcting for multiple comparisons with Holm-Bonferroni.

they shed light on where to set realistic and achievable adherence targets.

Considering our specific findings, for readmissions, adherence to 100% Assessments and 50% Act Ons was associated with the largest magnitude reduction, but this level of adherence was achieved in only 1.8% (621/34,923) of encounters, suggesting that it is a high bar. On the other hand, 3.7% of encounters (1306/34,923) also achieved significant readmission reduction at the 100% Assessment + 25% Act On threshold, suggesting a more realistic target that still achieves meaningful reductions.

With respect to ED visits, our results suggest that the overall cohort and patients 85+ benefitted from 4Ms care adherence at 100% Assessment + 50% Act On adherence, and that even when Assessment adherence dropped to 75%, benefits were still achieved. New discharge to a facility had no association with 4Ms care adherence. We hypothesize that this may occur, for example, in cases of frailty where the time needed to regain functional mobility or strength for a safe return home exceeds the time required to treat the medical or surgical condition. In such cases, even higher levels of 4Ms adherence over the term of the inpatient encounter may not change the need for discharge

to a facility. Although this does not necessarily mean that new discharge to a facility is not an appropriate 4Ms outcome, instead it may be most relevant to the subset of patients who are on the cusp of requiring discharge to a facility, and for whom greater adherence during the limited inpatient window might be influential.

Examining the adherence levels across all outcomes, there is a balance between maximizing the *magnitude* of effect achieved at high 4Ms adherence and reaching the *greatest number of patients* for whom benefit can be achieved at lower adherence levels. 100% Assessment + 25% Act On adherence is a favorable target in that it achieved reductions in readmissions and LOS while approximately doubling the number of patients for whom benefit was achieved relative to 50% Act On adherence level. In addition, reducing the Assessment threshold from 100% to 75% suggested that the 75% Assessment + 50% Act On threshold might offer a “middle ground” between the 100% Assessment + 50% Act On and 25% Act On levels in terms of this balance. Relative to the 100% Assessment + 50% Act On threshold, the 75% Assessment + 50% Act On threshold maintained reductions in readmissions, ED visits, and LOS (although the magnitude of the LOS reduction is smaller). Relative to the 100% Assessment

+ 25% Act On threshold, it resulted in fewer patients achieving benefit (2.5% vs. 3.7%) with no statistical changes—either positive or negative—for readmissions and LOS, but a significant reduction in ED visits. The key takeaway is that operational leaders who feel that 100% Assessment adherence is difficult to achieve could instead focus on increasing Act On adherence to at least 50%.

Finally, one notable finding merits further exploration. This was the observed association between 100% Assessment adherence alone and 30-day unplanned readmissions as well as LOS. Because it is not an intervention, Assessment would not be expected to impact outcomes directly. There are several explanations. First, each Act On performance threshold represents a performance floor for that category, and the *actual* average Act On performance for each was above that floor. Second, there are many activities that occur in the clinical setting that may impact outcomes, even though they may not map specifically to the 4Ms Framework and be picked up by our adherence measures. For example, a UCSF EHR delirium orderset is used to promote both wakefulness during the day and sleep at night, but the day wakefulness component has no distinct correlate in the Act Ons for Mentation (Table 1). Third, because our criterion for Act On adherence requires synchrony of all Act Ons within the same shift as part of the concept of delivering 4Ms as a package [19], it is possible that some patients received asynchronous, incomplete Act Ons (e.g., only 4 of the 5 Act Ons for Mentation) in a given shift. Adherence to 4 of 5 synchronous Act Ons might still generate some positive effects on outcomes, even though it would not qualify as meeting full Act On adherence according to our rubric. Nevertheless, for those responsible for 4Ms implementation, it should not necessarily be interpreted that 100% Assessment adherence can serve as a surrogate for any specific degree of Act On adherence.

Key limitations of our study include that this was a single site that may not generalize to other settings. Second, our measures of hospital readmissions and ED visits included only those that occurred at UCSF Health hospitals. However, our sensitivity analysis suggested insensitivity to excluding patients lost to follow-up. Another limitation is that some Assessments and Act-Ons may have been performed but not universally documented. Finally, although our composite measure included measures of nearly all of the 4Ms care practices, including a higher bar for mobility than defined by IHI, our health system had not implemented a standard for What Matters during the study period. Thus, our measures and their association to outcomes do not capture What Matters directly and instead used proxy measures.

5 | Conclusion

As the AFHS movement matures, it is increasingly important to ascertain the effect of the 4Ms as a set on patient outcomes. By measuring the degree of adherence to the 4Ms at the encounter level, we can gain greater insight into the level of 4Ms care delivery that is associated with improved patient outcomes and use these insights to establish meaningful quality improvement targets. Our study suggests that there are meaningful reductions

in readmissions, ED visits, and LOS associated with 100% adherence to 4Ms Assessments coupled with at least 25% of shifts with adherence to Act Ons.

Author Contributions

All authors contributed to study concept and design, acquisition of subjects and/or data, analysis, interpretation of results, and preparation of the manuscript.

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The corresponding author affirms that he has listed everyone who contributed significantly to the work and obtained written consent from all contributors who are not authors and are named in the Acknowledgment section.

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Conflicts of Interest

B.R., R.T., and J.A.-M. report no relevant conflicts of interest. S.R. is paid by the Institute for Healthcare Improvement as a faculty consultant and was paid for presentations in their 2024 4Ms Spread Collaborative Cohort.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** IHI Care practice measures and UCSF measures: Mappings by M. **Table S2:** Control variables. **Table S3:** Sensitivity analysis of the impact on post-acute healthcare utilization outcomes when including or excluding patients lost to follow-up. **Figure S1:** CONSORT-style flow diagram of study cohort (unit=inpatient encounters). LOS=Length of stay. **Figure S2:** Mean marginal effects (95% CI) of different levels of 4M care process adherence for subgroup analyses of 100% Assessment and 100% Assessment + 25% Act Ons for: A. 30-day unplanned readmissions, B. 30-day ED visits, C. New discharge rate to a facility, and D. Length of stay spent in a qualifying inpatient setting. For panels A, B, and C, N refers to the number of hospital encounters meeting the adherence threshold associated with each subgroup, while the percentage in parentheses refers to the prevalence of the outcome itself within each subgroup. For panel D, N refers to the number of hospital encounters associated with each subgroup, while the number in the parentheses is the unadjusted mean inpatient length of stay for that subgroup. Asterisks and bold markers indicate statistical significance at the 95% confidence intervals, corrected for multiple comparisons using a Holm-Bonferroni correction.