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Prescriptions for Potentially Inappropriate Medications from the Beers Criteria Among Older Adults Hospitalized for Heart Failure

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Abstract

Objectives: To better understand patterns of potentially inappropriate medications (PIMs) from the Beers criteria among older adults hospitalized with heart failure (HF).

Design/Setting: Observational study of hospitalizations derived from the geographically-diverse REasons for Geographic and Racial Differences in Stroke (REGARDS) cohort.

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Author Contributions:

All authors meet the criteria for authorship stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. Dr. Goyal had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Jaber, Nguyen, Zarzuela, Musse, Goyal
Acquisition, analysis, or interpretation of data: Jaber, Vargas, Nguyen, Zarzuela, Musse, Kwak, Goyal
Drafting of the manuscript: Jaber, Vargas, Goyal
Critical revision of the manuscript for important intellectual content: All authors
Statistical analysis: Ringel
Administrative, technical, or material support: Levitan, Maurer, Lachs, Safford, Goyal
Study supervision: Maurer, Lachs, Safford, Goyal

Conflict of Interest

Dr. Levitan reports research support from Amgen for observational research related to heart failure treatment, and consulting for a research study on heart failure treatment funded by Novartis. Dr. Safford reports research support from Amgen, unrelated to the topic of this work. Dr. Goyal receives personal fees for medico-legal consulting in heart failure, and has received honoraria from Akcea inc and Bionest inc. The other authors report no conflicts.

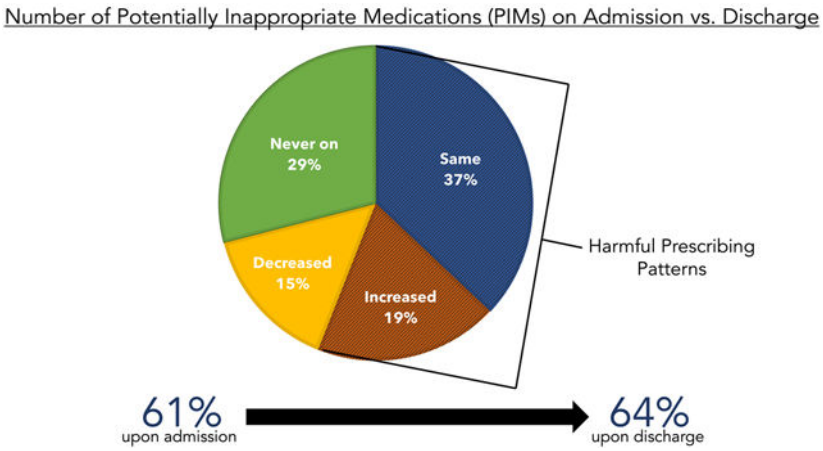
Participants: We examined participants aged ≥65 years with an expert-adjudicated hospitalization for HF.

Measurements: Beers criteria medications were abstracted from medical records.

Results: The prevalence of PIMs was 61.1% at admission and 64.0% at discharge. Participants were taking a median of 1 (IQR: 0–1) PIM at hospital admission and a median of 1 (IQR: 0–2) PIM at hospital discharge. Between admission and discharge, 19.1% of patients experienced an increase in the number of PIMs, 15.1% experienced a decrease, and 37% remained on the same number between hospital admission and discharge. The medications with the greatest increase from admission to discharge were proton pump inhibitors (32.6% to 38.6%) and amiodarone (6.2% to 12.2%). The strongest determinant of potentially harmful prescribing patterns was polypharmacy (RR: 1.34, 95% CI: [1.16–1.55], p<0.001).

Conclusions: PIMs are common among older adults hospitalized for HF and may be an important target to improve outcomes in this vulnerable population.

Graphical Abstract



Keywords

PIMs; adverse reactions

Introduction

Optimizing medication prescribing patterns has become an important priority in heart failure (HF) management. While most previous efforts have focused on improving guideline-directed medical therapy (GDMT),[1,2] recent work has emphasized the importance of avoiding harmful medications through careful review and reconciliation of the medications.[3,4,5] For example, medications that can incite or precipitate HF were recently shown to be common at both hospital admission and hospital discharge among older adults with HF, highlighting an important area that merits further attention.[3]

Yet another set of medications taken by older adults with HF that likely warrants further attention are those that appear on the Beers criteria. The Beers Criteria (last updated in

2019) contains a list of potentially inappropriate medications (PIMs) that the American Geriatrics Society recommends avoiding in older adults in most circumstances due to high risk for harm and limited benefit.[6] Many prior studies have examined the prevalence of such medications in older adults, but none to our knowledge from the United States have specifically examined this in adults hospitalized for HF, a subpopulation where polypharmacy is nearly universal[4] and the mean age exceeds 70 years.[7] With the objective to identify opportunities to improve post-hospitalization outcomes of adults with HF, which remain poor despite a decade of research in this area,[8] we sought to describe prescribing patterns of PIMs from the 2019 Beers list among a cohort of older adults hospitalized for HF at the time of admission and at hospital discharge, and identify risk factors associated with their use.

Methods

Study Population

We examined Medicare beneficiaries (continuous Medicare Part A through 90 days following hospital discharge) aged ≥65 years who were discharged alive after experiencing an adjudicated HF hospitalization from 2003 to 2017, derived from the REasons for Geographic And Racial Differences in Stroke (REGARDS) study. The REGARDS study is a community-based study that includes 30,239 white and black men and women aged ≥45 years who were originally recruited in 2003–2007 from across all 48 contiguous United States and have ongoing follow-up.[9] The REGARDS study was initially designed to examine risk factors associated with higher stroke incidence and mortality in the Southeastern US and among Black participants. Participants were randomly sampled with recruitment from commercially available lists of US residents using mail and telephone contact methods. In addition to baseline information related to demographic characteristics, health behaviors, and medical history, follow-up data related to cardiovascular outcomes and related hospitalizations and cognition are collected every 6 months through routine telephone calls to participants and/or their next-of-kin. For reported hospitalizations related to the heart or a potential stroke, medical records are retrieved for expert adjudication by 2 clinicians to determine the principal contributors to a hospitalization; disagreements are resolved by a third adjudicator. Institutional review boards of all collaborating institutions approved the REGARDS study protocol. All REGARDS participants provided informed consent during the time of enrollment. Several ancillary cardiovascular studies have stemmed from the REGARDS cohort due to the overlapping risk factor used to assess stroke and cardiovascular disease. This ancillary study was approved by the Weill Cornell Institutional Review Board.

For the present study, we examined participants with medication data at both admission and discharge. We have previously shown that characteristics of patients with missing medication data in this cohort were similar to those with medication data.[3] We included the index hospitalization only for each unique participant, regardless of the duration of stay. We excluded participants referred to hospice at hospital discharge.

Data Sources

This study included data from 4 sources: 1) the REGARDS study baseline assessment; 2) the medical charts for each HF-adjudicated hospitalization; 3) the American Hospital Association (AHA) Annual Survey Database, and 4) the Hospital Compare website, created through the efforts of Medicare and the Hospital Quality Alliance.[10]

Baseline data in REGARDS were collected through computer-assisted telephone interviews (CATI) at the time of enrollment, an in-home examination, and self-administered questionnaires. Additional details of the study design have been previously published.[9] Following verbal consent at the time of enrollment, the medical history was collected by telephone interview. For the purposes of this study, variables derived from the medical history component of the REGARDS baseline assessment include age, sex, race, annual household income, education, functional impairment, cognitive impairment, and history of falls (defined as at least one self-reported fall). Functional impairment was defined by a physical component summary score of <30 from the Short Form-12 questionnaire.[11] Cognitive impairment was defined as a score <5 on the 6-item screener,.[12]

Review and abstraction of medical records for each adjudicated HF-exacerbation in REGARDS was performed to collect information for the following: medical conditions, admission and discharge vital signs, laboratory values, and echocardiogram parameters including left ventricular ejection fraction (LVEF); discharge disposition and length of stay; hospital-based events including cardiac arrest and mechanical ventilation; intensive care unit (ICU) stay; and use of consultative services including cardiology. Hypoalbuminemia, based on albumin ≤3.3 g/dL, was included as a marker of frailty.[13] HFpEF was defined as LVEF ≥50% or a qualitative description of normal systolic function;[14] and HFrEF was defined as LVEF ≤40% or a qualitative description of abnormal systolic function. Participants with heart failure with borderline ejection fraction (LVEF of 40% to 50%) were considered to have abnormal systolic function and grouped accordingly with those with HFrEF for the purposes of this analysis, given shared pathophysiologic features.[15] To determine LVEF and/or qualitative description of systolic function, we reviewed all chart-level data available at the time of the hospitalization—we preferentially relied upon echocardiograms, but also accepted other diagnostic modalities including nuclear scans and ventriculograms, and accepted clinician reports when other modalities were unavailable.

Medications prescribed upon hospital admission and hospital discharge were collected through review of all sources within the medical chart, including medication reconciliation forms, admission and discharge notes, and progress notes. The medication at “hospital discharge” refers to medication that participants were prescribed to take following hospitalization, not necessarily what was administered on their day of hospital discharge. We included both prescribed and over-the-counter scheduled medications because both contribute to medication burden and complexity. Medications taken as-needed were not included.

For the present study, mortality national comparison and hospital rating (scored within a range of 1 to 5) were identified from Medicare’s Hospital Compare, a consumer-oriented website that provides data on the quality of care for over 4,000 Medicare-certified hospitals

across the United States. Hospital rating is a measurement consisting of several different quality metrics used to compare hospitals, with a score of 3 being average and higher scores reflecting higher quality care.

Hospital size (small hospital size was defined as <200 beds), academic status, population density (urban or rural), presence of geriatric or palliative care service, and availability of a licensed pharmacist were identified from the AHA Annual Survey Database. The AHA Annual Survey Database collects information directly provided by more than 6,200 hospitals and 400 health care systems across the United States. Academic status was defined as inclusion in the Association of American Medical Colleges (AAMC) Council of Teaching Hospitals and Health Systems (COTH) or certification by the Accreditation Council for Graduate Education (ACGME).

Potentially Inappropriate Medications

We defined PIMs using the 2019 update to the American Geriatrics Society's Beers Criteria. Of note, the Beer's criteria were first developed in 1991, and have undergone several updates over the last 30 years. We chose the most updated version from 2019 which provides the most comprehensive list to date. Based on an extensive review of more than 1,400 studies by 13 expert panelists, the 2019 AGS Beers Criteria includes more than 100 medications or medication classes divided into 6 categories: medications that are potentially inappropriate in older adults, medications that may exacerbate a disease or syndrome, drugs to be used with caution in older adults, medications with clinically important drug interactions, those that should be avoided or have their dose reduced due to renal function, and those with strong anticholinergic properties.[6] For this study, we specifically examined medications and medication classes listed in Table 2 from the 2019 update which were characterized as potentially inappropriate in older adults. In total, our analysis included 130 medications, which accounted for both those explicitly listed and those that corresponded with a specific medication class described in Table 2.[6] Since we were unable to determine whether clonidine was used as a first-line agent for hypertension, and whether digoxin was used as first-line agents for atrial fibrillation, we did not include these medications as PIMs for this study. We also did not include aspirin, since this is only considered a PIM above a dosage of 325mg and we did not have dosage on all patients.

Statistical Analysis

We calculated medians and interquartile ranges (IQRs) for continuous variables and percentages for categorical variables to summarize participant characteristics, hospital characteristics, and medication patterns. We used the Wilcoxon rank-sum test to compare medians, and chi-square to compare percentages. A p-value < 0.05 was considered significant.

We conducted a modified Poisson regression with robust standard errors to identify factors associated with harmful prescribing practice at hospital discharge. Harmful prescribing practice was defined as the initiation or continuation of a potentially-inappropriate medication(s) from the Beers criteria at discharge. "Initiation" refers to the addition of a new PIM(s) to a patient's medication regimen that was not initially present at admission.

"Continuation" indicates that PIM(s) that were present at hospital admission remained on a patient's medication regimen at the time of discharge (i.e., deprescribing of PIMs was not performed during hospital stay). The model included covariates chosen based on published literature[3–7]; these were patient demographics (age, sex, race, income, and education); heart failure subtype (HFrEF vs. HFpEF); geriatric conditions (functional impairment, cognitive impairment, history of falls, hypoalbuminemia, polypharmacy defined as taking at least 10 total medications, and comorbidity count); hospital-related events (year of admission, ICU stay, length of stay); and hospital characteristics (Medicare hospital rating <3, presence of a geriatric/palliative service, use of licensed pharmacist, hospital size, and population density). The results of the regression analysis were reported as relative risk (RR) and 95% confidence intervals (CIs). To account for missing covariate values, we used multiple imputation via chained equations. We managed the data in SAS version 9.4 (SAS Institute, Cary, NC) and performed statistical analysis using STATA version 14 (IBM corporation, Armonk, NY). The variables with missing values were cognitive impairment (26%), hypoalbuminemia (24%), income (12%) and use of a licensed pharmacist (12%), functional impairment (7%), heart failure subtype (6%), and overall hospital rating (6%). All other variables were less than 1% missing.

Results

Participant characteristics

We identified 648 participants that met study inclusion criteria (Figure 1). The median age was 77 years (IQR: 70–84); 45.7% of the participants were female, 33.6% were Black, 26.7% of participants reported an annual household income of less than $20,000, and 21.8% of participants reported an education level less than college (Table 1). The median number of comorbidities per participant was 8 (IQR: 7–10). The comorbidities with the highest prevalence included hypertension (78.1%), coronary artery disease (69.8%), diabetes (43.3%), atrial fibrillation/flutter (41.4%), and COPD/asthma (37.8%). Participants who were prescribed PIMs on either admission or discharge were more likely to have several comorbid conditions, including benign prostatic hyperplasia, chronic kidney disease, and depression. Participants were taking a median of 9 (IQR: 6–12) standing medications at hospital admission and a median of 10 (IQR: 8–13) at hospital discharge. The median length of stay was 5 days (IQR 3–8).

Potentially-inappropriate medications

The prevalence of PIMs was 61.1% at hospital admission and 64.0% at discharge. At hospital admission, the most common PIMs were proton pump inhibitors (32.6%), benzodiazepines (14.2%), and analgesics (8.6%); and at hospital discharge, the most common PIMs were proton pump inhibitors (38.6%), benzodiazepines (15.6%), and amiodarone (12.2%) (Table 2). The medication with the greatest increase between admission and discharge was proton pump inhibitors (32.6% to 38.6%) followed by amiodarone (6.2% to 12.2%). The medication with the greatest decrease between admission and discharge was non-steroidal anti-inflammatory drugs (NSAIDs) (8.6% to 4.2%).

Participants were taking a median of 1 (IQR: 0–1) PIM at hospital admission and a median of 1 (IQR: 0–2) PIM at hospital discharge. The percentage of patients taking 1 PIM was 36.7% at hospital admission and 37.8% at hospital discharge, 2 PIMs was 18.1% at admission and 18.7% at discharge, and ≥3 PIMs was 6.3% at admission and 7.6% at discharge.

Between admission and discharge, 19.1% of patients had an increase in number of PIMs; 15.1% had a decrease in the number of PIMs prescribed; 37.0% of patients were on the same number of PIMs from admission to discharge; and 28.7% were never prescribed PIMs at either admission or discharge (Figure 2). The prevalence of potentially harmful prescribing patterns, defined as initiation or continuation of PIMs between admission and discharge, was 56.1%.

A multivariable regression analysis revealed that polypharmacy at hospital admission (RR: 1.34, 95% CI: [1.16–1.55], $p<0.001$) was the strongest determinant of potentially harmful prescribing patterns (Table 3). Notably, geriatric conditions including cognitive and functional impairment were not associated with potentially harmful prescribing patterns. Similarly, hospital characteristics including size, academic status, and availability of licensed pharmacist were not associated with potentially harmful prescribing patterns.

Discussion

In this analysis of a national cohort of older adults hospitalized for HF with a median age of 77 years, we found that the use of PIMs based on the Beers criteria exceeded 50%. This is a concerning finding given the well-known associations between PIMs on the Beers criteria and adverse outcomes in older adults, including higher rates of mortality, hospitalizations, and adverse drug reactions.[16] Some studies in the United States have examined the prevalence of Beers criteria medications in individuals with cardiovascular disease.[5,17] As far as we know, this is the first report from the United States describing the prescribing patterns of medications that appear on the Beers criteria in older adults hospitalized for HF. Given the poor post-hospitalization outcomes observed among patients with HF irrespective of ejection fraction[18] and the observation that a high proportion of hospital readmissions[19] and deaths are non-cardiovascular in nature,[20] these findings highlight a serious problem that merits increased attention.

For almost two decades, extensive efforts have been put forth to improve prescribing practice among adults with HF, with a particular focus on improving the use of guideline-directed medical therapy.[21,22] Recent work has demonstrated the prevalence of polypharmacy[4] and the high prevalence of HF-exacerbating medications[4] highlighting other aspects of prescribing practice that have received less attention. Our findings here provide additional data to support the urgent need to develop strategies that can facilitate comprehensive medication reconciliation inclusive of cardiovascular and non-cardiovascular medications, as a means to improve the efficacy and safety of medication prescribing practice among older adults with HF.

Issues such as polypharmacy, cognitive impairment, and falls may be important reasons for underutilization of GDMT in heart failure given the potential of these agents to exacerbate such conditions. Yet, patients who do not receive GDMT may still receive medications on the Beers criteria that contribute to these issues without providing the potential benefits that GDMT can provide. Indeed, GDMT has the potential to substantially increase life expectancy even among adults aged at least 65 years.[23] Whether supervised discontinuation, also known as deprescribing,[24] of selected PIMs can ultimately lower the risk of polypharmacy, cognitive impairment, and falls, and subsequently facilitate increased use of GDMT is unknown and warrants further investigation.

The Beers criteria are meant as a guide to identify medications in which the harms may outweigh the benefits; naturally, risks and benefits must be weighed on a case-by-case basis within the context of each individual patient's health priorities and goals.[6,25] For example, amiodarone is part of the Beers criteria but is frequently used to treat arrhythmias. Accordingly, the potential benefits of amiodarone may outweigh its risks in many patients with HF. PPIs are also a part of the Beers criteria, but may be used for prophylaxis against gastrointestinal bleeding among patients taking antiplatelet therapy like aspirin. These examples further emphasize the complexity of medication management in older adults with HF[4,5] and underscore the importance of developing unique strategies and/or tools to assist clinicians and patients to make informed decisions about common potentially high-risk medications.

Although our study could not provide data on the shared decision-making process between patient and clinician, the concern is that many PIMs were continued as a consequence of clinical inertia. Clinical inertia is the failure to initiate or discontinue therapy when appropriate to do so.[26] Combatting clinical inertia and engaging in deprescribing to improve the quality of medication prescribing have recently become important priorities in cardiovascular medicine.[24] While physicians across different specialties are generally amenable to deprescribing cardiovascular medications, especially in the settings of adverse drug reactions and limited life-expectancy, a frequently reported barrier to deprescribing is the concern of interfering with another provider's treatment plan. [27–32] This concern is especially important as older adults with HF are frequently comanaged by multiple physicians including a primary care physician and cardiologist. Shared communication between specialists is clearly important when considering deprescribing, especially since different specialties offer different perspectives regarding the benefits of continuing or discontinuing medications.[27] Additional physician-reported barriers to deprescribing include lack of awareness, lack of self-efficacy, and the perception that patients are reluctant to stop medications.[28–32] Strategies that integrate risk-benefit assessment and deprescribing processes into routine clinical care are needed in the primary and specialty care settings. Future work in this area will hopefully yield important insights on optimal strategies for addressing these complex aspects of caring for older adults with heart failure in due time.

Our observation that polypharmacy was the strongest predictor of harmful prescribing patterns was not surprising. Prior work has shown that as the number of medications increase, the risk for harmful prescribing patterns such as use of PIMs, excessive medication doses, drug-drug interactions, and drug-disease interactions also rises.[33] Given prior work

showing that multimorbidity and polypharmacy are increasing in prevalence over time among older adults with HF, the use of PIMs is likely to continue to increase. Myriad of interventions, many of which focus on providing patients with information on deprescribing recommendations and risks of drug use, are under development to reduce the use of PIMs.[34,35]

While some show promising results, whether these interventions can be applied specifically to the HF population to improve their outcomes is unknown and warrants investigation.

A notable strength of this study was a high degree generalizability given that this study population was derived from REGARDS, which included participants from all regions of the contiguous 48 United States.[15] Another strength was the collection of chart-level data for each hospitalization, which permitted detailed collection of medication and comorbidity data. This study also had important limitations. First, the observational nature of this study precluded establishing a causal relationship between variables. Second, only scheduled medications were included in our analysis, as it was not possible to accurately determine how frequently patients took medications as-needed. This likely led to an underestimation of the prevalence of PIMs. This study included documented admission and discharge medications, representing prescribed medications – not medications actually taken, for which we did not have information. Future studies should investigate the prevalence of PIMs among medications actually taken by patients. Third, we did not include medications that had specific conditions that were required to be considered a PIM. For example, we did not include aspirin (only considered a PIM above a dosage of 325mg) or clonidine (only considered a PIM when used as first-line for hypertension). In total, five of 130 medications we examined on the Beers criteria were not included in the count of PIMs for our analysis.

In conclusion, we found that PIMs, defined as medications from the Beer's criteria, were common among older adults hospitalized for HF. These findings highlight the need to develop strategies that can facilitate comprehensive medication reconciliation and subsequently optimize prescribing patterns in this population.

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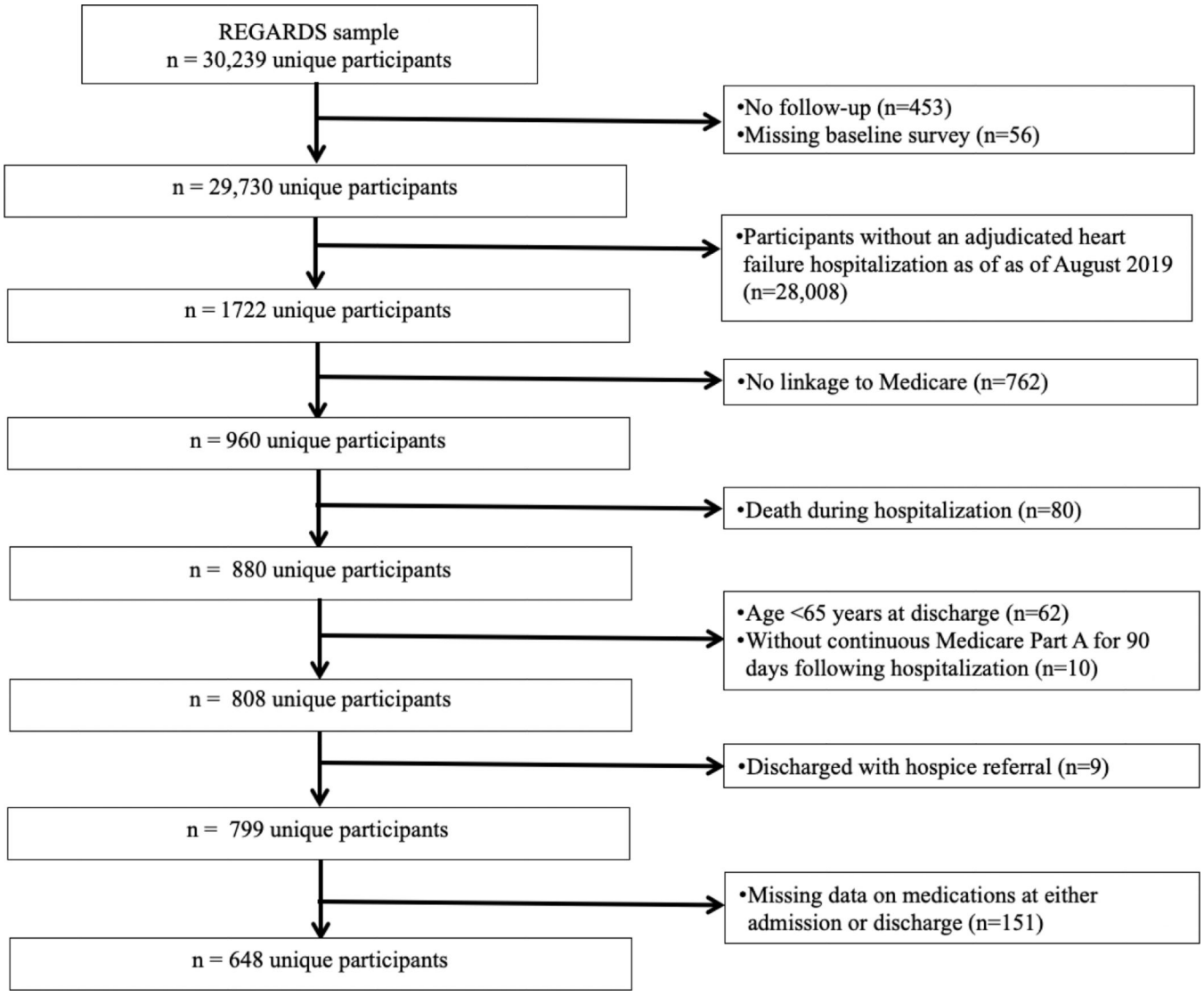

Figure 1. Exclusion cascade of REasons for Geographic And Racial Differences in Stroke (REGARDS) cohort

We examined individuals aged at least 65 years who were discharged alive after experiencing an adjudicated HF hospitalization from 2003 to 2017 (n=648), derived from the REGARDS study. We restricted our cohort to Medicare beneficiaries with completed baseline survey and on continuous Medicare Part A for 90 days following hospital discharge. We excluded individuals referred to hospice at hospital discharge and those without medication data at both admission and discharge. Abbreviations: REGARDS - Reasons for Geographic And Racial Differences in Stroke study

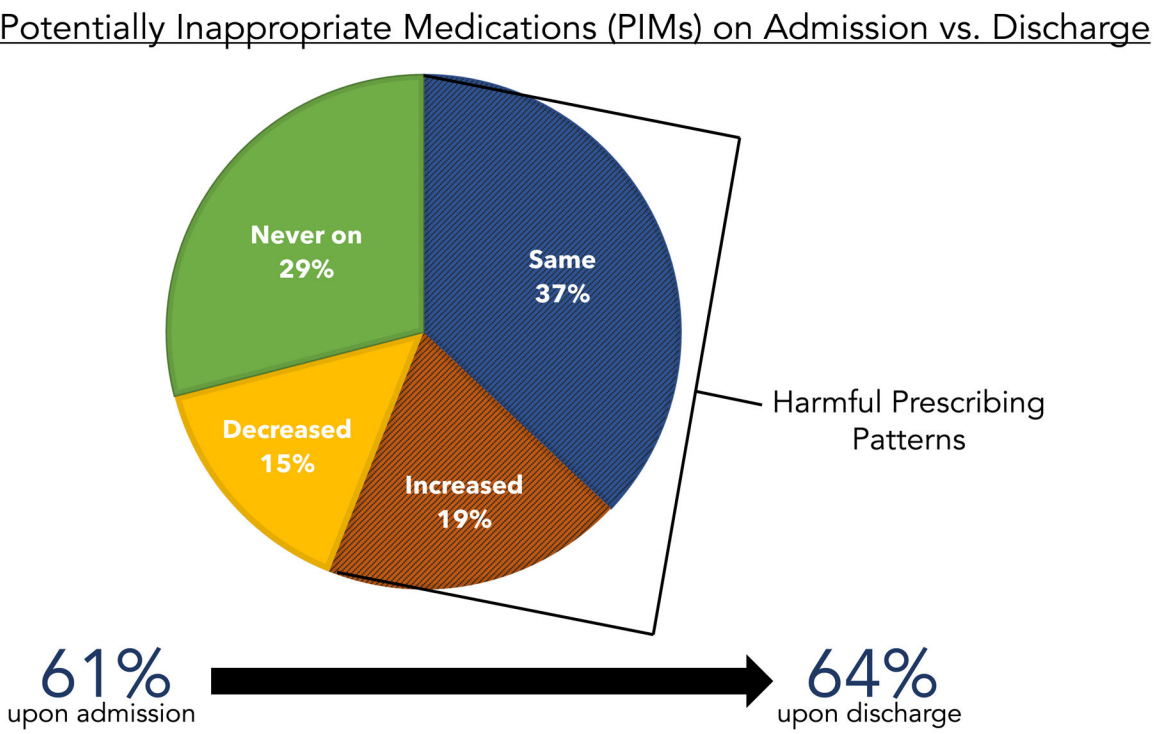

Figure 2. Change in the number of potentially inappropriate medications (PIMs) between hospital admission and discharge

We examined the prescribing patterns of potentially inappropriate medications (PIMs) between admission and discharge. 19.1% of patients had an increase in number of PIMs; 15.1% had a decrease in the number of PIMs prescribed; 37.0% of patients were on the same number of PIMs from admission to discharge; and 28.7% were never prescribed PIMs at either admission or discharge. The prevalence of potentially harmful prescribing patterns, defined as initiation or continuation of PIMs between admission and discharge, was 56.1%, as represented by the shaded portion on the figure.

Table 1.

Baseline characteristics according to potentially inappropriate medication (PIM) prescription

	All (N = 648)	Admission			Discharge		
		Present (N = 396)	Absent (N = 252)	p-value	Present (N = 415)	Absent (N = 233)	pvalue*
Age, median (IQR)	77 (70, 84)	77 (7.2)	78 (7.4)	0.23	77 (7.2)	78 (7.4)	0.20
Female, n (%)	296 (45.7)	169 (42.7)	127 (50.4)	0.05	188 (45.3)	108 (46.4)	0.80
Black, n (%)	218 (33.6)	132 (33.3)	86 (34.1)	0.83	131 (31.6)	87 (37.3)	0.14
Income less than $20K, n (%)	173/568 (30.5)	107 (30.7)	66 (30.0)	0.85	114 (31.8)	59 (28.2)	0.38
Education less than college, n (%)	141 (21.8)	81 (20.5)	60 (23.8)	0.31	85 (20.5)	56 (24.0)	0.29
HFrEF	334/611 (54.7)	198 (53.2)	136 (56.9)	0.37	209 (53.0)	125 (57.6)	0.28
Comorbid Conditions, n (%)							
Comorbidity count, median (IQR)	8 (7, 10)	8 (6, 10)	9 (7, 10)	<0.001	8 (6, 10)	9 (7, 10)	<0.001
Hypertension	505/647 (78.1)	309 (78.2)	196 (77.8)	0.89	325 (78.3)	180 (77.6)	0.83
Atrial fibrillation/Atrial flutter	268 (41.4)	164 (41.4)	104 (41.3)	0.97	182 (43.9)	86 (36.9)	0.09
Coronary artery disease	452 (69.8)	276 (69.7)	176 (69.8)	0.97	291 (70.1)	161 (69.1)	0.79
Peripheral vascular disease	118 (18.2)	73 (18.4)	45 (17.9)	0.85	73 (17.6)	45 (19.3)	0.59
Cancer	104 (16.0)	63 (15.9)	41 (16.3)	0.90	71 (17.1)	33 (14.2)	0.33
COPD/Asthma	245 (37.8)	91 (36.1)	154 (38.9)	0.48	85 (36.5)	160 (38.6)	0.60
Diabetes	306/647 (47.3)	116 (46.0)	190 (48.1)	0.61	108 (46.4)	198 (47.8)	0.72
Osteoarthritis	178 (27.5)	120 (30.3)	58 (23.0)	0.04	119 (28.7)	59 (25.3)	0.36
Gout	78 (12.0)	54 (13.6)	24 (9.5)	0.12	54 (13.0)	24 (10.3)	0.31
CVA/TIA	122 (18.8)	79 (19.9)	43 (17.1)	0.36	82 (19.8)	40 (17.2)	0.42
Eye conditions	121 (18.7)	76 (19.2)	45 (17.9)	0.67	80 (19.3)	41 (17.6)	0.60
Anxiety	37 (5.7)	26 (6.6)	11 (4.4)	0.24	23 (5.5)	14 (6.0)	0.81
Depression	82 (12.7)	64 (16.2)	18 (7.1)	<0.001	65 (15.7)	17 (7.3)	0.002
Peptic ulcer disease	26 (4.0)	18 (4.5)	8 (3.2)	0.39	22 (5.3)	4 (1.7)	0.03
Chronic kidney disease	240 (37.0)	161 (40.7)	79 (31.3)	0.02	171 (41.2)	69 (29.6)	0.003
Benign prostatic hypertrophy	68 (10.5)	55 (13.9)	13 (5.2)	< 0.001	53 (12.8)	15 (6.4)	0.01
Geriatric Assessment, n (%)							
Polypharmacy (≥ 10 standing medications)	287 (44.3)	222 (56.1)	65 (25.8)	<0.001	223 (53.7)	64 (27.5)	<0.001
Number of standing medications at admission, median (IQR)	9 (6, 12)	10 (7, 13)	7 (4.5, 10)	<0.001	10 (7, 13)	7 (5, 10)	<0.001
Number of standing medications at discharge, median (IQR)	10 (8,13)	9 (6, 11)	11 (9, 14)	<0.001	8 (6, 11)	11 (9, 14)	<0.001
Cognitive impairment	63/479 (13.2)	36 (12.2)	27 (14.8)	0.41	35 (11.2)	28 (16.8)	0.09
Functional impairment	136/601 (22.6)	90 (24.4)	46 (19.8)	0.19	95 (24.4)	41 (19.3)	0.15

	All (N = 648)	Admission			Discharge		
		Present (N = 396)	Absent (N = 252)	p-value	Present (N = 415)	Absent (N = 233)	pvalue*
Hypoalbuminemia	265/492 (53.9)	166 (53.5)	99 (54.4)	0.86	180 (55.9)	85 (50.0)	0.21
History of Falls	137/646 (21.2)	96 (24.4)	41 (16.3)	0.01	91 (22.0)	46 (19.8)	0.52
Hospital Events							
Year of admission				0.23			0.58
2003–2007	221 (34.1%)	125 (31.6)	96 (38.1%)		136 (32.8)	85 (36.5)	
2008–2012	291 (44.9%)	185 (46.7)	106 (42.1%)		192 (46.3)	99 (42.5)	
2013–2017	136 (21.0%)	86 (21.7)	50 (19.8%)		87 (21.0)	49 (21.0)	
Length of Stay, median (IQR)	5 (3, 8)	5 (3, 8)	5 (3, 8)	0.76	5 (3, 8)	5 (3, 7)	0.13
Intensive Care Unit Stay, n (%)	133 (20.5)	80 (20.2)	53 (21.0)	0.80	93 (22.4)	40 (17.2)	0.11
Hospital Characteristics							
Hospital rating, median (IQR) **	3 (2, 3)	3 (2, 3)	3 (2, 4)	0.35	3 (2, 4)	3 (2, 3)	0.09
Presence of geriatric/ palliative service, n (%)	460/644 (71.4)	280 (71.4)	180 (71.4)	1.00	297 (72.3)	163 (70.0)	0.53
Use of licensed pharmacist, n (%)	556/571 (93.4)	348 (97.8)	208 (96.7)	0.47	360 (97.6)	196 (97.0)	0.70
Rural location, n (%)	99/647 (15.3)	62 (15.7)	37 (14.7)	0.73	67 (16.2)	32 (13.7)	0.41
Academic status, n (%)	326/645(50.5)	191 (48.6)	135 (53.6)	0.22	205 (49.6)	121 (52.2)	0.54
Small hospital size, n (%) (less than 200 beds)	154/645 (23.9)	98 (24.9)	56 (22.2)	0.43	97 (23.5)	57 (24.6)	0.76

Abbreviations: Heart failure with reduced ejection fraction (HFrEF); Interquartile range (IQR); Chronic Obstructive Pulmonary Disease (COPD)

*The Wilcoxon rank-sum test was used to compare medians, and chi-square was used to compare percentages.

**denominator for Hospital rating = 572,

Table 2.

Prevalence of potentially inappropriate medication (PIM) use at hospital admission and discharge

	Admission	Discharge	Change (%)
Gastrointestinal medications	215 (33.2%)	254 (39.2%)	+6
Proton-pump inhibitors	211 (32.6%)	250 (38.6%)	+6
Metoclopramide	11 (1.7%)	13 (2.0%)	+0.3
Benzodiazepines	92 (14.2%)	101 (15.6%)	+1.4
NSAIDS, non-selective	56 (8.6%)	27 (4.2%)	−4.4
Antiarrhythmic medications	43 (6.6%)	80 (12.3%)	+5.7
Amiodarone	40 (6.2%)	79 (12.2%)	+6
Dronedarone	3 (0.5%)	1 (0.2%)	−0.3
Sulfonylureas, long-acting	37 (5.7%)	37 (5.7%)	0
Peripheral alpha-1 blockers	42 (6.5%)	38 (5.9%)	−0.6
Antihistamines, first-generation	40 (6.2%)	33 (5.1%)	−1.1
Nonbenzodiazepine hypnotics	30 (4.6%)	37 (5.7%)	+1.1
Antidepressant medications	29 (4.5%)	28 (4.3%)	−0.2
Amitriptyline	14 (2.2%)	13 (2.0%)	−0.2
Paroxetine	14 (2.2%)	13 (2.0%)	−0.2
Nortriptyline	3 (0.5%)	3 (0.5%)	0
Skeletal muscle relaxants	29 (4.5%)	22 (3.4%)	−1.1
Antipsychotic medications	15 (2.3%)	22 (3.4%)	+1.1
First generation (conventional)	3 (0.5%)	4 (0.6%)	+0.1
Second generation (atypical)	12 (1.9%)	18 (2.8%)	+0.9
Endocrine agents	19 (2.9%)	33 (5.1%)	+2.2
Estrogens	8 (1.2%)	6 (0.9%)	−0.3
Megestrol	6 (0.9%)	10 (1.5%)	+0.6
Desiccated thyroid	2 (0.3%)	2 (0.3%)	0
Insulin, sliding scale	4 (0.6%)	18 (2.8%)	+2.2
Antispasmodics	5 (0.8%)	3 (0.5%)	−0.3
Barbiturates	0	1 (0.2%)	+0.2

Abbreviations: Nonsteroidal anti-inflammatory drugs, non-cyclooxygenase-selective (NSAIDs)

Table 3.

Determinants of Potentially Harmful Prescribing Patterns

Predictor	Relative Risk	95% CI	p-value
Age	1.00	(0.99, 1.01)	0.399
Female	1.00	(0.86, 1.15)	0.965
Black	0.87	(0.74, 1.02)	0.08
Income less than $20,000	1.04	(0.88, 1.24)	0.619
Education less than college	1.17	(0.98, 1.41)	0.083
HFrEF	0.91	(0.78, 1.05)	0.177
Comorbid Conditions			
Comorbidity count	1.02	(1.00, 1.05)	0.084
Geriatric Assessment			
Polypharmacy at admission	1.34	(1.16, 1.55)	<0.001
Cognitive impairment (6 item screener <5)	0.84	(0.64, 1.12)	0.237
Functional impairment (SF-1 score < 30)	0.98	(0.82, 1.16)	0.773
Hypoalbuminemia	1.11	(0.95, 1.30)	0.18
History of falls	0.97	(0.81, 1.15)	0.701
Hospital Events			
Year of Admission			
2003–2007	Reference	--	--
2008–2012	0.97	(0.83, 1.14)	0.742
2013–2017	0.89	(0.72, 1.10)	0.285
Length of Stay	1.00	(1.00, 1.00)	<0.001
Intensive Care Unit Stay, n (%)	1.15	(0.98, 1.34)	0.092
Hospital Characteristics			
Hospital rating < 3	0.94	(0.80, 1.10)	0.43
Presence of geriatric / palliative care service	1.04	(0.87, 1.23)	0.685
Use of a licensed pharmacist	0.96	(0.63, 1.45)	0.829
Rural	1.14	(0.92, 1.40)	0.234
Academic status	0.97	(0.83, 1.13)	0.664
Small Hospital Size (less than 200 beds)	0.94	(0.78, 1.14)	0.548

Abbreviations: Heart Failure with reduced ejection fraction (HFrEF); 12-Item Short Form Health Survey (SF-12); Interquartile Range (IQR)