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Geographic Variation of Statin Use among U.S. Nursing Home Residents with Life-Limiting Illness

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Abstract

BACKGROUND: Medically compromised nursing home residents continue to be prescribed statins, despite questionable benefits.

OBJECTIVE: To describe regional variation in statin use among residents with life-limiting illness.

RESEARCH DESIGN: Cross-sectional study using 2016 Minimum Data Set 3.0 assessments linked to Medicare administrative data and health service utilization area resource files.

SETTING: Nursing homes (n=14,147) within hospital referral regions (n=306) across the U.S.

SUBJECTS: Long-stay residents (≥65 years old) with life-limiting illness (e.g., serious illness, palliative care, or prognosis < 6 months to live) (n= 361,170).

MEASURES: Prevalent statin use was determined by Medicare Part D claims. Stratified by age (65–75, ≥76 years), multilevel logistic models provided odds ratios with 95% confidence intervals.

RESULTS: Statin use was prevalent (age 65–75: 46.0%, ≥76: 31.6%). For both age groups, nearly all resident-level variables evaluated were associated with any and high-intensity statin use and three facility level variables (i.e., higher proportions of Black residents, skilled nursing care provided, average number of medications per resident) were associated with increased odds of statin use. While in residents 65–75 years, no associations were observed, residents aged ≥76 years located in HRRs with the highest healthcare utilization had higher odds of statin use than those in nursing homes in HRRs with the lowest health care utilization.

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CONCLUSIONS: Our findings suggest extensive geographic variation in U.S. statin prescribing across HRRs, especially for those aged ≥76 years. This variation may reflect clinical uncertainty given the largely absent guidelines for statin use in nursing home residents.

Keywords

statins; pharmacoepidemiology; geographic variation; long-term care; nursing homes

INTRODUCTION

Statins are one of the most commonly prescribed medications in the United States (US).[1] Prescriptions for statin pharmacotherapy have continued to increase.[2] This has, in turn, disproportionately impacted older adults.[3] From 2012 to 2013, almost half of all U.S. adults over age 75 years were prescribed a statin, nearly double the rate a decade earlier.[2] While the clinical benefit of statin pharmacotherapy for adults in the general population is well documented, the benefit for clinically complex, older adults is less clear.[4–7] For example, the United States Preventative Services Task Force guidelines report insufficient evidence to make any statin recommendations for adults over age 75 years.[8] Even so, statin use persists among clinically complex older adults including nursing home residents.[9,10]

In nursing homes, statin use is widespread even among those with life-limiting illness.[10–13] One in three U.S. nursing home residents with life-limiting illness are on statins.[12] However, statins appear unlikely to benefit these older, clinically compromised nursing home residents.[4,14,15] Moreover, common musculoskeletal statin side effects often reported in the general adult population could be particularly harmful to compromised nursing home residents, exacerbating frailty and physical decline.[16] This use of statins with questionable benefits and known harms may contribute to concerns regarding polypharmacy and overprescribing in nursing homes.[12] To address the potential overprescribing of statins in this setting, we must understand what else beyond clinical indication is driving statin use. Among Medicare beneficiaries, contextual factors such as facility or regional practice characteristics appear to influence statin prescribing.[17–19] Nonetheless, research on the contextual forces driving use of statins for those in nursing homes is lacking.

The purpose of this study was to evaluate the extent to which potential overuse of statins in U.S. nursing homes varies by contextual factors on the facility- and regional- level. Using a national sample of nursing home facilities, we focused on statin use in clinically complex older adult residents with a limited life expectancy or life-limiting illness as this subset of the population is less likely to benefit from statins. We hypothesized that in the absence of clear clinical statin guidelines for adults over age 75 years, regional factors would play a larger role in use for this older portion of the nursing home population.

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METHODS

Study Design

This study used a cross-sectional design to evaluate statin use in the nursing homes via multilevel modeling with resident-, facility-, and regional- levels. The study was approved by the University of Massachusetts Medical School Institutional Review Board.

Data Sources

Nursing home assessment data from the Minimum Data Set (MDS) 3.0 were linked to Medicare administrative data including the Beneficiary Summary File (Medicare eligibility), Medicare Part A inpatient claims, and Medicare Part D prescription drug claims. These data were merged to Nursing Home Compare 2016 annual files,[20] the 2016 Provider of Service file,[21] and the 2016 Dartmouth Atlas End-of-life Chronically Ill Care file (Methods Appendix).[22] The Nursing Home Compare and Provider of Services files are largely based on information from the Certification and Survey Provider Enhanced Reports, comprised of survey reports from mandatory inspections of all U.S. Medicare- and Medicaid- certified nursing home facilities. The files include operational characteristics, regulatory compliance, and quality of care measurements for each facility. Nursing Home Compare uses these data to assign facilities quality star ratings. The Dartmouth Atlas End-of-life Chronical Ill Care data files provided data at the Hospital Referral Region (HRR) level. The Dartmouth Atlas files are built largely from figures provided by the Medicare files, specifically Medicare fee-for-service beneficiary eligibility and claims files, in addition to regional files from US Census reports and Tele Atlas zip code boundary files. Nursing home facilities were matched by their zip codes to HRRs.

Setting

In the United States, all nursing homes that receive federal funding from the Center for Medicare and Medicaid Services (CMS) must complete standardized nursing home assessments for all admitted residents. This pertains to 98% of all U.S. nursing home facilities. CMS-certified facilities were included if MDS data on residents eligible for the study were linkable to the facility and regional level.

Life-Limiting Illness Definition

Life-limiting illness was used to identify nursing home residents not likely to benefit from statins, specifically those clinically compromised near the end of life. Conceptually, life-limiting illness was defined as a progressive, incurable condition that results in a prognosis less than one year.[23] While mortality risk scores have been developed for nursing home residents,[24,25] an operational definition matching the conceptualization of life-limiting illness used in this study has yet to be validated. Given that most long-stay nursing home residents have a limited average remaining life expectancy,[11,26] multiple definitions were used to avoid excluding appropriate residents. A diagnosis of a life-limiting illness or condition was confirmed if ≥ one criterion was met (Supplemental Table 1):

1. Physician documentation of life expectancy <6 months based on MDS 3.0 prognosis item J1400

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2. Receipt of hospital palliative care consultation based on ICD-10 diagnosis code Z51.5
3. ≥1 condition on the Veterans Health Administration Palliative Care Index[13,27]
4. ≥1 "serious illness" as defined by Kelley et al. (2019)[28]

Study Population

Nursing home residents were included if they: 1) resided in a CMS- certified nursing home facility on September 30, 2016 (last date of the year prior to implementation of MDS 3.0 changes), 2) had a quarterly assessment, 3) were aged ≥65 years, 4) had continuous Medicare Fee-for-Service coverage in July, August, September 2016, and 4) had a life-limiting illness. Exclusion criteria included: 1) hospital-based facility residence due to substantial practice differences from free-standing nursing homes, and 2) receipt of skilled nursing or hospice services (no Medicare Part D claims). Supplemental Figure 1 shows the construction of study sample (n= 361,170).

Resident-level Variables

Resident-level variables included: age (65–75, ≥76 years), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic/Latino, other), functional dependence (none to limited assistance required, extensive assistance required, complete assistance required/ dependent), cognitive impairment (none/intact, mild, moderate, severe), and atherosclerotic cardiovascular disease (ASCVD) risk (no risk factors, ≥1 risk factors, ASCVD diagnosis).

Facility-level Variables

Facility-level variables included organizational and operational (process, staffing, and outcome) nursing home characteristics that could affect quality of care provided.[29,30] Categorization of continuous variables was informed by previous literature.[29,31] Organizational variables included structural characteristics such as facility ownership status, facility size by number of beds, % occupancy, etc. Operational variables included process variables (% residents with skilled nursing care, % residents on hospice, and average number of medications per resident), staffing variables (full-time medical director availability, physician extender availability, and average staff care time per resident-day), and outcome variables (quality indicators, number of facility deficiencies, and overall Nursing Home Compare star ratings quality score).

Regional-level Variables

Regional-level variables included: census-defined regions (Northeast, Midwest, South, West), U.S. states (+ DC), and HRR end-of-life healthcare utilization (quartiles).[32] Per the Dartmouth Atlas,[22] HRRs are regional health care markets for tertiary care, with each HRR having ≥ one hospital where neurosurgery and major CVD procedures can be performed. The HRR end-of-life variables included: hospital days per decedent, % deaths occurring in the hospital, % deaths with included time in the intensive care unit, intensive care unit days per decedent, skilled nursing facility days per decedent, % enrolled in hospice, total physician visits per decedent, % patients seeing ≥10 physicians, and ratio of medical specialty to primary care.

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Statin Use

Statin use was defined as a binary (yes/no) variable for any use or high-intensity use as of September 30th 2016 (target date). High-intensity statin use was based on a daily dose LDL-C reduction >50%, outlined in the recent American College of Cardiology/American Heart Association (ACC/AHA) guidelines for each generic statin available (Supplemental Table 2).[33] Statin use was defined by the presence of Medicare Part D prescription claim for any generic statin or combination in the 90 days preceding the target date, in which the fill date + number of days supply overlapped with the target date.

Statistical Analysis

Analyses were stratified by age categories based on commonly defined guideline age groups:[34] 65–75 years and ≥76 years. Descriptive analyses were initially run to estimate the distribution of resident, facility, and regional characteristics in the sample. This was in addition to crude estimates of any statin use and high intensity statin use. To visually evaluate the geographic variation of statins, figures of statin use prevalence were generated by U.S. census regions, states, and HRRs. This included U.S. maps of statin use by HRRs with statin use categorized into quartiles.

Before multilevel modeling, the potential for multicollinearity was evaluated in several ways. First, correlations between the determinants of interest were examined. Second, regression models with binary outcome variables (separate models for any and high intensity statin use) were used to generate variance inflation factors for all determinants of interest. No variables exceeded the threshold of 10 for the variance inflation factors. Lastly, the standard errors in the multilevel models were evaluated as additional variables were added to the models to see if any appeared inflated.

Separate multilevel logistic models with random intercepts that account for HRR and state variation were developed for each age group and the outcomes of interest (i.e., any statin use, high intensity statin use). This process included first estimating crude odds ratios (OR) and 95% confidence intervals (CI) followed by models which included all resident- and facility- level variables, with separate models for each HRR variable.

Lastly, to estimate the amount of between HRR variation explained by model covariates, models were run with the random intercept only in addition to those fit sequentially for resident-, facility-, and HRR- level variables. We then calculated the proportional change in cluster variation and intraclass correlation coefficients.[35] For more detail, see Methods Appendix.

RESULTS

Sample Characteristics

Table 1 shows that the sample was mostly women, non-Hispanic white with functional and/or cognitive impairment. Most (90.8%) had diagnosis of cardiovascular disease (CVD) or at least one risk factor. In terms of facility characteristics, most were for-profit with ≥100

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beds and ≥80% occupancy. The majority of facilities were concentrated in non-rural regions. For distributions of all quartiles in regional HRR variables, see Supplemental Table 4.

Overall Statin Use

Overall, the rate of any statin use was 34.7% (65–75 years: 46.0%, ≥76 years: 31.6%) and high-intensity use was 6.6% (65–75 years: 11.4%, ≥76 years: 5.3%). Table 2 (any statin use) and Table 3 (high-intensity statin use) provide the percent use and odds ratios for selected resident-, (structural) facility-, and regional- level characteristics typically of interest, with the complete list given on Supplemental Table 5. A summary of these findings by level of analysis is provided below.

Resident-level Statin Use Associations

On the resident-level, almost all variables evaluated appeared to be associated with any and high-intensity statin use for both age groups. In residents ≥ 76 years, men and racial/ethnic minorities (versus non-Hispanic Whites) had higher odds of statin use. For both age groups, residents with functional dependence, severe cognitive impairment, and those without a CVD diagnosis or risk factors had reduced odds of statin use. (Supplemental Table 5). However, residents without a CVD diagnosis and no risk factors comprised <10% of the sample.

Facility- Level Statin Use Associations

Both age groups appeared to have some facility-level characteristics that were associated with any and high-intensity statin use. The extent to which facility variables were associated with any statin use differed by age group (65–75 years: 5 of 18 facility variables; ≥76 years: 13 of 18 facility variables) (Supplement Table 5). There were few associations with high-intensity statin use across age. For both age groups and statin types, three facility level variables (i.e., higher proportions of African American/Black residents, skilled nursing care provided, and average number of medications per resident) were consistently associated with increased odds of statin use (Supplemental Table 5).

Regional- Level Statin Use Associations

i. **Census Regions**. For the regional-level data, patterns of statin use appeared to have the most variation on the HRR-level (Figure 1) as opposed to larger scaled analyses with U.S. census regions (**Figure 2**) and states (Supplemental Figures 2 and 3). Residents living in facilities other than those in the Northeast had lower odds of high-intensity statin use (e.g., vs. South for any statins, 65–75 years: aOR 0.86, 95% CI 0.78–0.94; ≥76 years: aOR 0.85, 95% CI 0.73–1.00).

ii. **U.S. States**. When breaking down census regions by U.S. state, statin use appeared to remain relatively consistent with the exception of some outlier states (Supplemental Figures 2 and 3). For those 65–75 years, Arkansas appeared to have the highest average statin prescribing rates for any and high-intensity use. For those ≥76 years, DC appeared to have the highest average statin prescribing for any statin use and Delaware for high-intensity use.

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iii. **HRRs**. When the U.S. is further divided into HRRs, rates appear most variable, crossing state lines. Referring to geographic maps of HRR-level statin use (Figure 1), statin use (any and high-intensity) appeared most concentrated in the eastern half of the United States in both age groups. However, use varied widely across HRRs, even those in neighboring states. For those aged 65–75 years, any statin use ranged from 25% (Hickory, NC) to 63% (Lacrosse, WI) across HRRs with a range of 0% to 33% for high-intensity statin use. For the ≥76 age cohort, any statin use ranged from 7% (St Cloud, MN) to 49% (Houma, LA) with a range of 0% to 12% for high-intensity statin use (Supplemental Table 3).

In reference to statin use by HRR characteristics (end-of-life healthcare utilization variables; Tables 2–3), distinct patterns in variation emerged via age group and statin type. With regards to age, the most variation in statin use by HRR characteristics appeared in residents aged ≥76 years, with all but one factor associated with use. More specifically, nursing home residents ≥76 years residing in nursing homes located in HRRs with the highest quartile of healthcare utilization consistently had higher odds of statin utilization than residents living in nursing homes located in HRRs with the lowest quartile (with the exception of hospice utilization). No associations between HRR end-of-life utilization variables and statin use were observed among residents aged 65–75 years. For high-intensity statin use, HRR characteristics were associated with use in some categories for both age groups.

Proportional Change in Regional Variation

When evaluating proportional change in variation (PCV) in cross-classified models for any statin use (Table 4), adding regional- level variables to resident- and facility- adjusted models resulted in reductions in between-HRR and between-state variation. This was especially true for any statin use in the older 76+ age group, in which HRR characteristics alone (PCV_{HRR}: 26.5%, PCV_{STATE}: 37.2%) appeared to explain a larger percentage of the between-HRR and between-state variation than facility or resident characteristics alone (resident: PCV_{HRR}: 22.9%, PCV_{STATE}: 21.8%; facility: PCV_{HRR}: 23.9%, PCV_{STATE}: 26.0%). For high-intensity statin use, resident- level characteristics alone appeared to explain a larger portion of between-region variation than the other levels of characteristics alone. The intraclass correlation coefficients (ICCs) were small (e.g., age ≥76 – high-intensity statin use: ICC_{HRR}: 0.014, ICC_{STATE}: 0.011).

DISCUSSION

U.S. nursing home statin use varied by HRRs, crossing state lines. While overall prevalence of statin use was 35%, rates varied across HRRs including up to 63% in residents aged 65–75 years and 49% in residents aged ≥76 years. The resident-level factors associated with statin use in this study (e.g., sex, race/ethnicity, functional limitations, cognitive impairment, and ASCVD) were consistent with previous research.[10] The most variation by HRRs was observed in the ≥76 age group, in which HRR-level variables appeared to explain more variation compared to resident and facility variables.

We found that statin use persisted in the nursing home even among those with life-limiting illness, which is consistent with our previous work.[12] Moreover, variation in statin use

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by geographic region among U.S. older adults has been shown in other studies.[17,19,36,37] However, these other studies focused on dually eligible Medicare and Medicaid beneficiaries on dialysis,[19] Medicare beneficiaries after hospitalization for a myocardial infarction,[17,18,36] and all Medicare Part D beneficiaries.[37] None evaluated older adults near the end of life or in nursing homes. In addition, none evaluated their target population on the HRR level, instead measuring statin use by U.S. census region,[17] state,[19] county,[37] and zipcode.[18] Our study shows that clustering was strongest within HRRs than within states, of which end-of-life healthcare spending measured at the HRR level appeared to explain most of the variation in statin prescribing for residents aged ≥76 years. Interestingly, a study on the geographic variation in carotid endarterectomy and carotid stenting (treatment for extracranial carotid artery disease) showed similar use patterns across HRRs as in our study.[38] Perhaps this is because coronary artery disease and peripheral artery disease are risk factors for the metabolic manifestations that statins are designed to treat and thus, treatment patterns are similar. This supports our hypothesis that in the absence of clinical guidelines for advanced age adults, regional prescribing practices rather may drive statin utilization patterns.

Facility level variables associated with increased statin use include having a high proportion of skilled nursing care residents and the average number of medications per resident in the facility ≥ 6. It is possible that in nursing homes with high volume of skilled nursing care (post-acute care), there is less emphasis on considering deprescribing in residents with life-limiting illness than in homes predominantly servicing long stay residents. Further, residents in nursing homes with a greater medication burden per resident overall may be indicative of less focus on reducing the complexity of drug regimens. Our data did not allow us to explore the reasons for the facility-level associations observed.

We found that HRR characteristics relating to end-of-life healthcare utilization appeared to affect statin use in residents aged ≥76 years. This pattern is consistent with the fact that U.S. national guidelines for statin pharmacotherapy largely excludes older adults beyond 75 years of age, often using this age as the upper limit for population-level recommendations. Guidelines, such as the United States Preventative Services Task Force, have cited insufficient evidence as a justification to abstain from providing any statin use recommendations for adults older than 75 years of age. This pattern suggests that clinical uncertainty could lead to more variation in prescribing, allowing other contextual factors to potentially drive prescribing behavior. Our findings highlight the need for evidence to inform U.S. recommendations for statin use in adults beyond age 75 years, especially those most vulnerable to overtreatment, particularly the long-term care population near the end of life. With evidence regarding the risks and benefits of statins in nursing home residents, guidelines should be updated to include recommendations for nursing home residents. Guidelines affect healthcare utilization, including that of statins.[39–41] In addition, there should be a concerted effort to elicit a standard of regular patient-provider communication with goals of care and risk-benefit discussions to aid in deprescribing efforts and reduce potential for overprescribing.

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Strengths and Limitations

This is the first study to evaluate geographic variation in statin use in a national sample of U.S. nursing home residents, particularly those with life-limiting illness. We were able to evaluate statin use on a more specific geographic scale than previous studies, specifically on the HRR level using multilevel analyses. This study is not without limitations. Analyses are based on data from 2016. Nevertheless, although guidelines and regulations around Medicare are quickly changing, any recent updates seem unlikely to have significantly changed statin prescribing. Our study is observational and therefore at risk for unmeasured confounding. Aside from lacking prescriber information, the inclusion of a limited number of resident variables may have lessened the power of resident-level variables in the ICC analyses. While HRR- level data appear more effective in evaluating regional variation associated with healthcare utilization compared to larger regions of analysis (e.g., states), interventions may be more effectively targeted at smaller levels than HRRs. A 2012 study showed that there was substantial variation in drug spending between hospital service areas within HRRs.[42]

CONCLUSION

For nursing home residents with life-limiting illness and over ≥76 years of age, there is substantial geographic variation in statin prescribing. HRR regional characteristics appeared to play a role in statin utilization for this population. Our findings highlight the need to implement interventions and policies to better manage prescribing practices for older populations with clinical uncertainty.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Lapane, KL: Dr. Lapane serves on an external advisory board to the University of Maryland Lamy Center on work funded by Emperion. Her role is to review and provide comments on monographs for medications used in post-acute care settings.

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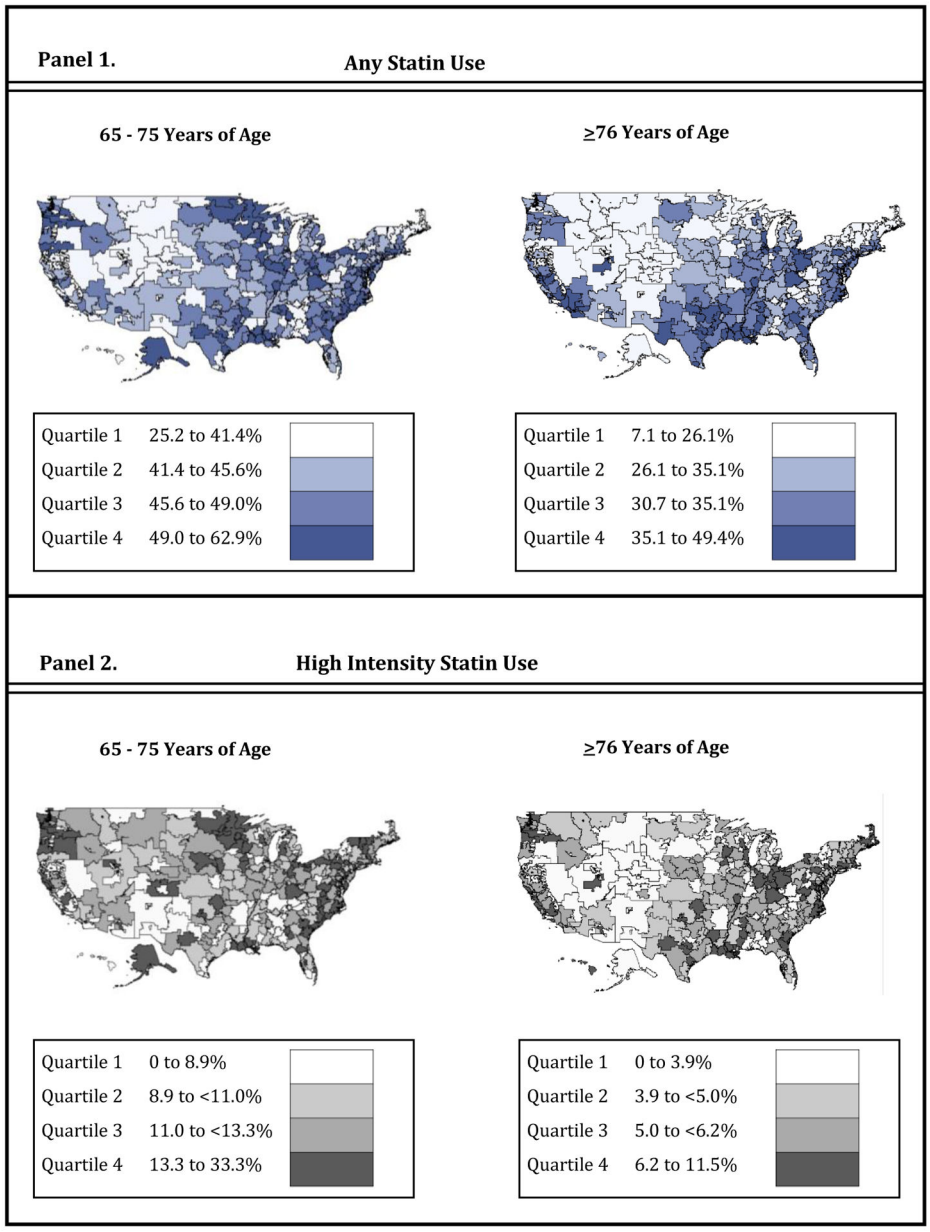

Figure 1.

Prevalence of statin: 1. any use and 2. high intensity use, among long stay nursing home residents with life limiting illness across hospital referral regions stratified by age (65–75 years and ≥76 years). High intensity statin use is defined as LDL-C daily dose reduction >50%.

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Table 1.

Characteristics of long-stay nursing home residents with life-limiting illness. N= 361,170 residents, 14,147 facilities, 306 hospital referral regions (HRRs)

Characteristics (%*)	Overall (n=361,170)	65–75 years-olds (n=77,819)	≥76 years-olds (n=283,351)
Resident- level			
Women	71.5	54.5	76.1
Race/ethnicity			
Non-Hispanic white	79.8	72.3	81.8
Non-Hispanic black	13.0	20.1	11.1
Hispanic/Latino	5.0	5.6	4.9
Other	2.3	2.1	2.3
Functional dependence			
None to limited assistance required	21.2	26.3	19.8
Extensive assistance required	57.9	51.7	59.6
Complete assistance required/dependent	20.9	22.0	20.6
Cognitive impairment			
None/Intact	25.1	41.2	20.7
Mild	24.3	25.2	24.0
Moderate	42.2	26.9	46.4
Severe	8.4	6.7	8.9
Atherosclerotic Cardiovascular Disease (ASCVD) risk			
ASCVD diagnosis	29.9	35.9	28.2
≥1 risk factor for ASCVD without the dx	60.9	55.6	62.3
No risk factors for ASCVD	9.3	8.5	9.5
Facility- level			
Ownership			
For-profit	71.0	79.5	68.7
Government	21.3	13.6	23.4
Non-profit	7.7	6.9	7.9
Chain status			
Part of chain	56.1	59.9	55.0
Facility specialty services			
Alzheimer/dementia care unit	21.0	18.3	21.7
No special care unit	76.7	78.6	76.2
Facility size (no. beds)			
<50	3.5	2.5	3.8
50–100	27.5	25.6	28.0
100–200	55.4	57.4	54.8
>200	13.6	14.6	13.4
Occupancy			
<80%	28.1	31.5	27.2
% Black/African American residents			

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Characteristics (%*)	Overall (n=361,170)	65–75 years-olds (n=77,819)	≥76 years-olds (n=283,351)
0 to <15%	73.2	62.5	76.2
15 to <50%	21.0	28.3	19.0
≥50%	5.8	9.2	4.8
% of residents dependent in activities of daily living (ADLs)			
>50%	11.0	11.6	10.8
% skilled nursing care			
≥50%	36.0	30.0	37.7
% hospice use			
<5%	15.3	13.8	15.7
5–10%	15.8	14.8	16.1
10–20%	30.1	29.7	30.2
≥20%	38.9	41.8	38.0
Facility average # of medications per resident			
≥6 medications	71.5	73.5	70.9
Staffing			
No Full-time medical director	95.3	95.0	95.4
No physician extender	27.1	25.8	27.5
Registered nurse < 30 minutes per resident per day	53.7	59.7	52.0
Direct care < 3 hours per resident per day	7.9	10.0	7.3
Nursing homes quality measures			
≥5% bed sores	53.3	59.1	51.7
≥5% residents restrained	3.6	4.2	3.5
Facility average # of deficiencies in 2016 survey			
0–1	17.8	15.8	18.3
2–5	31.9	29.5	32.5
≥6	50.4	54.7	49.2
Overall Nursing Home Compare Star rating			
1	18.6	23.5	17.3
2	19.4	21.7	18.7
3	19.3	19.6	19.2
4	23.2	20.4	24.0
5	19.6	14.8	20.9
Regional- level			
Rural location	26.7	24.9	27.2
US census region			
Northeast	23.2	20.1	24.0
Midwest	27.5	25.0	28.2
South	39.2	43.4	38.0
West	10.2	11.5	9.8
Highest HRR quartile of end-of-life healthcare			
Hospital days per decedent	33.5	33.6	33.5
% deaths occurring in the hospital	26.6	25.8	26.8

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Characteristics (%*)	Overall (n=361,170)	65–75 years-olds (n=77,819)	≥76 years-olds (n=283,351)
% deaths with included time in intensive care unit	27.0	28.3	26.7
Intensive care days per decedent	24.6	25.7	24.2
SNF days per decedent	35.5	34.7	35.7
% enrolled in hospice	22.3	23.6	21.9
Total physician visits per decedent	31.3	32.6	30.9
% of patients seeing ≥10 different physicians	37.2	37.1	37.2
Ratio of medical specialty to primary care	30.6	31.2	30.5

*May not round to 100% because of rounding.

ADL indicates activities of daily living; ASCVD, atherosclerotic cardiovascular disease; HRR, hospital referral regions; SNF, skilled nursing facility.

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Table 2.

Association between **select** nursing home resident, facility, and hospital referral region (HRR) characteristics and **any statin use** by age.

Characteristics	65–75 years-old				≥76 years-old			
	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]
Overall	77,819	46.0	-	-	283,351	31.6	-	-
Resident- level								
Atherosclerotic Cardiovascular Disease (ASCVD) risk								
ASCVD diagnosis	27,924	54.7	*	*referent	79,942	39.1	*	*referent
≥1 risk factor for ASCVD	43,267	46.1	0.71	0.69 (0.67–0.71)	176,488	32.2	0.75	0.74 (0.73–0.76)
No risk factors for ASCVD	6,628	9.3	0.08	0.09 (0.08–0.10)	26,921	5.7	0.10	0.10 (0.10–0.11)
Facility- level								
Ownership								
For-profit	61,866	46.1	*	*referent	194,671	32.4	*	*referent
Government	10,544	46.8	1.O3	1.05 (1.00–1.10)	66,431	29.5	0.91	0.96 (0.94–0.98)
Non-profit	5,399	44.4	0.93	0.95 (0.89–1.02)	22,249	30.4	0.95	0.95 (0.92–0.98)
Facility size (no. beds)								
<50	1,913	43.9	0.92	0.93 (0.83–1.04)	10,770	27.6	0.90	0.96 (0.91–1.02)
50–100	19,940	46.1	1.01	0.97 (0.92–1.03)	79,363	31.1	1.00	1.02 (0.99–1.06)
100–200	44,640	46.1	1.00	0.97 (0.92–1.02)	155,387	31.9	1.01	1.01 (0.98–1.04)
>200	11,326	46.2	*	*referent	37,831	32.5	*	*referent
Occupancy								
<80%	24,481	46.1	1.01	1.01 (0.96–1.06)	77,127	31.6	1.02	1.02 (0.99–1.05)
80 to <90%	23,515	46.2	1.02	0.99 (0.95–1.04)	85,795	31.6	1.01	1.01 (0.98–1.03)
90 to <95%	16,655	46.0	1.02	1.01 (0.96–1.06)	65,738	31.4	0.99	0.99 (0.97–1.02)
≥95%	13,168	45.7	*	*referent	54,691	31.7	*	*referent
% Black/African American residents								
0 to <15%	48,644	45.5	*	*referent	215,795	30.6	*	*referent
15 to <50%	22,030	46.5	1.03	1.05 (1.00–1.09)	53,828	34.0	1.09	1.06 (1.03–1.09)
≥50%	7,145	48.3	1.10	1.13 (1.06–1.21)	13,728	37.3	1.23	1.14 (1.09–1.20)
Overall Nursing Home Compare Star rating								
1	18,305	45.5	*	*referent	48,958	31.7	*	*referent
2	16,886	46.7	1.06	1.03 (0.98–1.08)	53,011	32.3	1.03	1.04 (1.01–1.07)
3	15,213	47.1	1.08	1.05 (1.00–1.10)	54,409	32.0	1.01	1.04 (1.01–1.07)
4	15,882	45.2	1.00	0.98 (0.93–1.03)	67,862	31.5	0.99	1.04 (1.01–1.07)
5	11,533	45.7	1.03	1.01 (0.96–1.07)	59,111	30.7	0.95	1.02 (0.99–1.06)
Regional- level								
Rural location	19,399	46.3	1.02	1.01 (0.97–1.06)	77,141	30.4	1.02	0.99 (0.96–1.01)
US census region								
Northeast	15,666	46.4	*	*referent	68,013	31.5	*	*referent

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Characteristics	65–75 years-old				≥76 years-old			
	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]
Midwest	19,462	47.4	1.06	0.96 (0.87–1.07)	79,861	30.8	0.98	0.83 (0.71–0.98)
South	33,767	45.9	1.01	0.86 (0.78–0.94)	107,731	32.2	1.09	0.85 (0.73–1.00)
West	8,924	43.2	0.86	0.91 (0.81–1.02)	27,746	31.7	0.82	0.80 (0.67–0.95)
Hospital days/decedent								
Q1	11,366	44.7	*	*referent	47,800	27.0	*	*referent
Q2	17,569	46.9	1.07	1.03 (0.96–1.10)	64,071	31.1	1.14	1.11 (1.03–1.19)
Q3	22,734	45.3	1.02	0.95 (0.88–1.02)	76,604	32.3	1.21	1.15 (1.07–1.24)
Q4	26,150	46.8	1.10	1.03 (0.96–1.11)	94,876	33.7	1.32	1.27 (1.18–1.38)
% deaths occurring in the hospital								
Q1	15,807	46.2	*	*referent	58,662	31.2	*	*referent
Q2	21,318	46.8	1.07	1.05 (0.98–1.12)	77,346	31.9	1.06	1.03 (0.96–1.11)
Q3	20,658	45.3	0.99	0.96 (0.89–1.02)	71,356	30.9	1.01	0.99 (0.92–1.06)
Q4	20,036	45.9	1.02	1.02 (0.94–1.10)	75,987	32.3	1.10	1.09 (1.00–1.18)
% deaths w/included time in intensive care unit								
Q1	12,250	45.7	*	*referent	50,129	28.7	*	*referent
Q2	18,091	46.8	1.04	1.01 (0.94–1.08)	66,904	31.5	1.09	1.07 (1.00–1.15)
Q3	25,493	46.1	1.00	0.97 (0.91–1.04)	90,793	31.8	1.10	1.07 (1.00–1.15)
Q4	21,985	45.6	0.99	0.95 (0.88–1.03)	75,525	33.4	1.21	1.15 (1.06–1.25)
Intensive care days/decedent								
Q1	12,729	45.1	*	*referent	54,038	27.6	*	*referent
Q2	21,646	46.5	1.04	1.02 (0.96–1.09)	82,276	30.7	1.08	1.06 (0.99–1.14)
Q3	23,432	46.1	1.03	0.99 (0.92–1.06)	78,376	32.4	1.21	1.16 (1.08–1.25)
Q4	20,012	46.1	1.04	0.99 (0.92–1.07)	68,661	34.9	1.29	1.22 (1.13–1.32)
Skilled nursing facility days/decedent								
Q1	10,046	45.2	*	*referent	37,678	27.3	*	*referent
Q2	16,640	45.0	1.00	0.97 (0.90–1.04)	58,059	30.5	1.12	1.06 (0.98–1.14)
Q3	24,107	46.6	1.05	1.00 (0.93–1.07)	86,467	31.8	1.16	1.09 (1.01–1.18)
Q4	27,026	46.6	1.08	1.01 (0.93–1.09)	101,147	33.7	1.33	1.22 (1.12–1.32)
% enrolled in hospice								
Q1	18,787	45.3	*	*referent	74,465	30.8	*	*referent
Q2	21,209	45.8	1.01	1.00 (0.94–1.07)	79,719	31.1	1.01	0.99 (0.92–1.06)
Q3	19,423	45.8	1.03	1.01 (0.94–1.09)	67,191	31.6	1.05	1.03 (0.95–1.11)
Q4	18,400	47.3	1.10	1.06 (0.98–1.15)	61,976	33.3	1.08	1.05 (0.97–1.14)
Total physician visits/decedent								
Q1	10,010	44.8	*	*referent	42,755	25.9	*	*referent
Q2	19,031	46.2	1.05	0.99 (0.92–1.07)	71,339	30.2	1.14	1.08 (1.00–1.16)
Q3	23,380	46.3	1.06	0.96 (0.89–1.04)	81,802	32.2	1.29	1.18 (1.09–1.27)
Q4	25,398	46.2	1.08	0.98 (0.90–1.06)	87,455	35.0	1.43	1.31 (1.21–1.42)

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Characteristics	65–75 years-old				≥76 years-old			
	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]
% of patients seeing ≥10 different physicians								
Q1	11,078	45.3	*	*referent	46,678	27.8	*	*referent
Q2	16,222	45.5	1.01	0.96 (0.89–1.03)	56,632	30.8	1.12	1.07 (1.00–1.15)
Q3	21,672	45.8	1.01	0.94 (0.88–1.01)	74,699	31.1	1.16	1.09 (1.01–1.18)
Q4	28,847	46.9	1.07	1.00 (0.83–1.08)	105,342	34.1	1.36	1.27 (1.18–1.38)
Ratio of medical specialty to primary care								
Q1	13,333	45.3	*	*referent	53,702	28.1	*	*referent
Q2	18,795	45.3	0.97	0.98 (0.92–1.05)	65,442	30.0	1.03	1.02 (0.96–1.09)
Q3	21,399	46.6	1.01	1.01 (0.94–1.08)	77,864	31.7	1.11	1.09 (1.02–1.16)
Q4	24,292	46.5	1.02	1.02 (0.95–1.09)	86,343	34.9	1.24	1.22 (1.14–1.31)

[a]No. = number of residents with each characteristic in the sample- serves as a denominator for the row %, indicating the % of residents on statin pharmacotherapy;

[b]OR = crude odds ratio;

[c]aOR (95% CI) = adjusted odds ratio (95% Confidence Interval), All odds ratios were estimated via cross-classified multilevel logistic models with random intercepts for state and HRR. Crude models that failed to converge without adjustments included the following for the ≥76 year-old age group: ASCVD risk (sex-adjusted), occupancy (sex-, race-, functional dependence- adjusted), hospital days/decedent (sex-, race- adjusted), skilled nursing facility/decedent (sex-, race-, functional dependence- adjusted), % enrolled in hospice (sex- adjusted), total physician visits/decedent (sex-adjusted). For resident-level and facility-level variables, adjusted odds ratios are derived from models that include adjustments for all resident-level and facility-level variables included in Supplemental Table 5 and the rural/urban indicator variable. For HRR-level variables, adjusted odds ratios are derived from separate models for each HRR-level variable that include all the resident- and facility- level variables adjusted for previously.

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Table 3.

Association between **select** nursing home resident, facility, and hospital referral region (HRR) characteristics and **high intensity statin** use by age

Characteristics	65–75 years-old				≥76 years-old			
	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]
Overall	**77,819**	**11.4**	-	-	**283,351**	**5.3**	-	-
Resident- level								
Atherosclerotic Cardiovascular Disease (ASCVD) risk								
ASCVD diagnosis	27,924	15.1	*	*referent	79,942	7.7	*	*referent
≥1 risk factor for ASCVD	43,267	10.4	0.64	0.64 (0.61–0.67)	176,488	5.0	0.62	0.64 (0.62–0.66)
No risk factors for ASCVD	6,628	1.9	0.11	0.12 (0.10–0.14)	26,921	0.9	0.11	0.12 (0.11–0.14)
Facility- level								
Ownership								
For-profit	61,866	11.4	*	*referent	194,671	5.4	*	*referent
Government	10,544	11.8	1.01	1.03 (0.96–1.10)	66,431	5.1	0.96	1.02 (0.98–1.07)
Non-profit	5,399	10.4	0.88	0.94 (0.84–1.04)	22,249	5.2	0.98	1.01 (0.94–1.09)
Facility size (no. beds)								
<50	1,913	11.6	1.00	1.02 (0.86–1.21)	10,770	4.4	0.81	0.91 (0.81–1.02)
50–100	19,940	11.5	1.02	0.98 (0.89–1.07)	79,363	5.3	0.97	1.01 (0.95–1.08)
100–200	44,640	11.4	1.01	0.97 (0.90–1.04)	155,387	5.4	0.98	0.99 (0.94–1.05)
>200	11,326	10.9	*	*referent	37,831	5.3	*	*referent
Occupancy								
<80%	24,481	11.3	1.00	0.99 (0.92–1.06)	77,127	5.4	1.08	1.06 (1.00–1.12)
80 to <90%	23,515	11.5	1.02	0.99 (0.92–1.06)	85,795	5.3	1.03	1.02 (0.97–1.07)
90 to <95%	16,655	11.3	1.00	0.98 (0.91–1.06)	65,738	5.3	1.01	1.00 (0.95–1.06)
≥95%	13,168	11.2	*	*referent	54,691	5.2	*	*referent
% Black/African American residents								
0 to <15%	48,644	11.2	*	*referent	215,795	5.1	*	*referent
15 to <50%	22,030	11.4	1.05	1.06 (0.99–1.12)	53,828	5.9	1.17	1.13 (1.07–1.19)
≥50%	7,145	12.3	1.12	1.12 (1.01–1.23)	13,728	7.0	1.38	1.28 (1.17–1.39)
Overall Nursing Home Compare Star rating								
1	18,305	10.8	*	*referent	48,958	5.5	*	*referent
2	16,886	11.7	1.10	1.07 (1.00–1.14)	53,011	5.5	1.00	1.00 (0.95–1.06)
3	15,213	11.7	1.10	1.08 (1.00–1.16)	54,409	5.2	0.95	0.97 (0.92–1.03)
4	15,882	11.1	1.04	1.02 (0.95–1.10)	67,862	5.4	0.98	1.01 (0.95–1.07)
5	11,533	11.5	1.09	1.07 (0.98–1.17)	59,111	5.1	0.92	0.97 (0.91–1.04)
Regional- level								
Rural location	19,399	11.3	0.97	0.99 (0.93–1.05)	77,141	5.1	0.99	0.98 (0.94–1.03)
US census region								
Northeast	15,666	11.4	*	*referent	68,013	5.5	*	*referent

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Characteristics	65–75 years-old				≥76 years-old			
	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]
Midwest	19,462	12.1	1.03	0.98 (0.83–1.15)	79,861	5.2	0.82	0.73 (0.60–0.89)
South	33,767	11.0	0.94	0.83 (0.72–0.97)	107,731	5.3	0.91	0.75 (0.62–0.90)
West	8,924	11.0	0.94	0.97 (0.81–1.17)	27,746	5.1	0.77	0.78 (0.62–0.97)
Hospital days per decedent								
Q1	11,366	11.8	*	*referent	47,800	4.7	*	*referent
Q2	17,569	11.8	1.00	0.96 (0.86–1.07)	64,071	5.3	1.11	1.07 (0.96–1.20)
Q3	22,734	11.0	0.94	0.89 (0.80–0.99)	76,604	5.4	1.13	1.06 (0.95–1.19)
Q4	26,150	11.2	1.01	0.93 (0.83–1.05)	94,876	5.6	1.25	1.14 (1.01–1.29)
% deaths occurring in the hospital								
Q1	15,807	11.6	*	*referent	58,662	5.3	*	*referent
Q2	21,318	11.3	1.01	0.99 (0.90–1.10)	77,346	5.2	1.05	1.02 (0.92–1.14)
Q3	20,658	11.3	0.99	0.97 (0.87–1.07)	71,356	5.4	1.11	1.07 (0.97–1.20)
Q4	20,036	11.2	1.00	0.98 (0.87–1.10)	75,987	5.5	1.18	1.16 (1.03–1.31)
% deaths with included time in intensive care unit								
Q1	12,250	12.0	*	*referent	50,129	4.8	*	*referent
Q2	18,091	11.7	1.00	0.97 (0.88–1.07)	66,904	5.3	1.12	1.09 (0.98–1.21)
Q3	25,493	11.4	0.95	0.93 (0.84–1.02)	90,793	5.5	1.16	1.12 (1.01–1.24)
Q4	21,985	10.7	0.92	0.87 (0.78–0.98)	75,525	5.4	1.23	1.15 (1.02–1.29)
Intensive care days per decedent								
Q1	12,729	11.9	*	*referent	54,038	4.7	*	*referent
Q2	21,646	11.4	0.94	0.91 (0.82–1.01)	82,276	5.4	1.09	1.05 (0.95–1.17)
Q3	23,432	11.2	0.97	0.93 (0.84–1.03)	78,376	5.4	1.16	1.09 (0.97–1.21)
Q4	20,012	11.0	0.92	0.87 (0.78–0.98)	68,661	5.7	1.21	1.12 (1.00–1.26)
SNF days per decedent								
Q1	10,046	12.0	*	*referent	37,678	4.8	*	*referent
Q2	16,640	11.4	0.96	0.94 (0.85–1.05)	58,059	5.0	1.01	0.96 (0.86–1.07)
Q3	24,107	11.1	0.94	0.91 (0.81–1.01)	86,467	5.4	1.06	1.01 (0.90–1.13)
Q4	27,026	11.3	0.97	0.93 (0.83–1.04)	101,147	5.6	1.14	1.05 (0.93–1.18)
% enrolled in hospice								
Q1	18,787	11.0	*	*referent	74,465	5.2	*	*referent
Q2	21,209	11.5	0.96	0.95 (0.86–1.05)	79,719	5.3	0.95	0.92 (0.83–1.02)
Q3	19,423	11.2	1.00	0.98 (0.88–1.10)	67,191	5.3	0.99	0.95 (0.85–1.06)
Q4	18,400	11.7	1.05	1.02 (0.90–1.15)	61,976	5.6	0.99	0.95 (0.84–1.07)
Total physician visits per decedent								
Q1	10,010	12.3	*	*referent	42,755	4.6	*	*referent
Q2	19,031	11.5	0.92	0.88 (0.79–0.98)	71,339	5.2	1.06	1.00 (0.89–1.12)
Q3	23,380	11.5	0.92	0.86 (0.77–0.96)	81,802	5.6	1.14	1.02 (0.91–1.15)
Q4	25,398	10.7	0.91	0.83 (0.74–0.94)	87,455	5.5	1.17	1.04 (0.92–1.17)

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Characteristics	65–75 years-old				≥76 years-old			
	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]	No.[a]	Row % on statins	OR[b]	aOR (95% CI)[c]
% of patients seeing ≥10 different physicians								
Q1	11,078	11.7	*	*referent	46,678	4.6	*	*referent
Q2	16,222	11.3	0.98	0.93 (0.84–1.04)	56,632	5.2	1.09	1.04 (0.93–1.16)
Q3	21,672	11.3	0.97	0.91 (0.82–1.02)	74,699	5.4	1.15	1.07 (0.95–1.20)
Q4	28,847	11.3	1.00	0.93 (0.82–1.04)	105,342	5.6	1.20	1.08 (0.95–1.22)
Ratio of medical specialty to primary care								
Q1	13,333	11.2	*	*referent	53,702	4.8	*	*referent
Q2	18,795	11.3	1.05	1.05 (0.95–1.16)	65,442	5.1	1.04	1.01 (0.91–1.12)
Q3	21,399	11.7	1.05	1.04 (0.94–1.25)	77,864	5.4	1.03	0.98 (0.89–1.09)
Q4	24,292	11.1	1.04	1.02 (0.91–1.13)	86,343	5.8	1.18	1.11 (1.00–1.24)

[a] No. = number of residents with each characteristic in the sample- serves as a denominator for the row %, indicating the % of residents on statin pharmacotherapy;

[b] OR = crude odds ratio;

[c] aOR (95% CI) = adjusted odds ratio (95% Confidence Interval). All odds ratios were estimated via cross-classified multilevel logistic models with random intercepts for state and HRR. For resident-level and facility-level variables, adjusted odds ratios are derived from models that include adjustments for all resident-level and facility-level variables included in Supplemental Table 5 and the rural/urban indicator variable. For HRR-level variables, adjusted odds ratios are derived from separate models for each HRR-level variable that include all the resident- and facility- level variables adjusted for previously.

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Table 4.

Cross-classified model variance components including proportional change * estimates in between-hospital referral region (HRR) and between-state variation, explained by resident-, facility-, and regional- level characteristics. N= 361,170 residents, 14,147 facilities, 306 HRRs

Age 65–75 years						
Model Classification:	**Null**	**Resident**	**Facility**	**HRR**	**Resident + Facility**	**Resident + Facility + HRR**
any statin						
T^2_{HRR}	0.01533	0.01201	0.01194	0.01436	0.01044	0.00991
PCV_{HRR}	-	21.66%	22.11%	6.33%	31.90%	35.36%
T^2_{STATE}	0.00979	0.00651	0.00987	0.01002	0.00872	0.0065
PCV_{STATE}	-	33.50%	−0.82%	−2.35%	10.93%	33.61%
ICC_{HRR}	0.004624	0.003630	0.003605	0.004333	0.003155	0.002997
ICC $_{STATE}$	0.002953	0.001968	0.002980	0.003023	0.002635	0.001966
high-intensity statin						
T^2_{HRR}	0.02654	0.0236	0.02551	0.03105	0.02342	0.02772
PCV_{HRR}	-	11.08%	3.88%	−16.99%	11.76%	−4.45%
T^2_{STATE}	0.01682	0.01512	0.02188	0.01569	0.01900	0.01523
PCV_{STATE}	-	10.11%	−30.08%	6.72%	−12.96%	9.45%
ICC_{HRR}	0.007962	0.007090	0.007644	0.009306	0.007028	0.008317
ICC $_{STATE}$	0.005046	0.004542	0.006556	0.004702	0.005702	0.004570
Age ≥76 years						
Model Classification:	**Null**	**Resident**	**Facility**	**HRR**	**Resident + Facility**	**Resident + Facility + HRR**
any statin						
T^2_{HRR}	0.04110	0.03167	0.03126	0.03020	0.02691	0.02149
PCV_{HRR}	-	22.94%	23.94%	26.52%	34.53%	47.71%
T^2_{STATE}	0.04109	0.03215	0.03040	0.02582	0.02583	0.01902
PCV_{STATE}	-	21.76%	26.02%	37.16%	37.14%	53.71%
ICC_{HRR}	0.01219	0.00944	0.00933	0.00903	0.00805	0.00645
ICC $_{STATE}$	0.01219	0.00959	0.00907	0.00772	0.00773	0.00571
high-intensity statin						
T^2_{HRR}	0.05135	0.04364	0.04948	0.04907	0.04513	0.04558
PCV_{HRR}	-	15.01%	3.64%	4.44%	12.11%	11.24%
T^2_{STATE}	0.03779	0.03288	0.04057	0.03604	0.03576	0.03716

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PCV_{STATE}	-	12.99%	−7.36%	4.63%	5.37%	1.67%
ICC_{HRR}	0.01520	0.01296	0.01464	0.01454	0.01339	0.01351
ICC_{STATE}	0.01118	0.00977	0.01200	0.01068	0.01061	0.01102

*Proportional change was estimated via cross-classified multilevel logistic models with random intercepts for state and HRR, systematically fit using resident-, facility-, and regional HRR- level characteristics

Abbreviations defined: T^2 is the variance of the random intercept; PCV is the proportion change in variation (PCV) explained by the multilevel model with the following formula: (T^2 in null model - T^2 in adjusted model)/T^2 in null model; ICC is the intraclass correlation coefficient (ICC); ICC_{HRR} estimates the correlation in the propensity to use statins between two randomly selected individuals from each HRR, but different states; ICC_{STATE} estimates the correlation in the propensity to use statins between two individuals in the same state, but different HRR.