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Geographic Variation in the Initiation of Commonly Used Opioids and Dosage Strength in United States Nursing Homes

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Abstract

Objectives: To examine and quantify geographic variation in the initiation of commonly used opioids and prescribed dosage strength among older United States nursing home residents.

Methods: We merged 2011 Minimum Data Set 3.0 to Medicare claims and facility characteristics data to conduct a cross-sectional study among long-stay nursing home residents who initiated short-acting opioids commonly used in nursing homes (oxycodone, hydrocodone, or tramadol). We examined geographic variation in specific opioids initiated and potentially inappropriate doses (< 50 mg oral morphine equivalents [OME]/day) across hospital referral regions (HRR). Multilevel logistic models quantified the proportional change in between-HRR variation and associations between commonly-initiated opioids and inappropriate doses after adjusting for resident characteristics, facility characteristics, and state.

Results: Oxycodone (9.4%) was initiated less frequently than hydrocodone (56.2%) or tramadol (34.5%) but varied dramatically between HRRs (range: 0–74.5%). In total, resident/facility characteristics and state of residence respectively explained 84.1%, 58.2%, 59.1%, and 46.6% of the between-HRR variation for initiating oxycodone, hydrocodone, tramadol, and inappropriate doses. In all cases, state explained the largest proportion of between-HRR variation. Relative to hydrocodone, residents initiating oxycodone were more likely (adjusted odds ratio (aOR)=5.00, 95% Confidence Interval (CI): 4.57–5.47) and those initiating tramadol were less likely (aOR=0.28, 95% CI: 0.25–0.31) to be prescribed potentially inappropriately high doses.

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Conclusions: We documented extensive geographic variation in the opioid and dose initiated for nursing home residents, with state explaining the largest proportion of the observed variation. Further work is needed to understand potential drivers of opioid prescribing patterns at the state level.

Keywords

opioids; opioid initiation; nursing homes; geographic variation

INTRODUCTION

During the last two decades, prescription opioid use in the United States (US) – along with opioid misuse, abuse, and overdose – dramatically increased in younger and older adults.^{1–3} The nationwide opioid crisis may be of particular importance in nursing homes, where pain has traditionally been undertreated and long-term opioid use is two-fold the prevalence documented in older community-dwelling adults.^{4–6} Nationally, extensive geographic variation in opioid prescribing and opioid-related mortality exists, raising concerns about inconsistent and potentially inappropriate prescribing dependent on place.^{7–12} However, the extent to which opioid use varies geographically among older adults living in US nursing homes is unknown.

Opioids are often the preferred approach to pain management for nursing home residents due to the limited availability of safe, effective, and practical alternatives.^{13,14} Yet, little is known about how the most commonly-used opioids are initiated in this setting (short-acting oxycodone, hydrocodone, and tramadol).⁴ Initial opioid selection may impact the extent to which appropriate pain control and improved physical functioning is achieved, as well as the risk of adverse events (fractures, overdose). This is due to differing pharmacokinetic and pharmacodynamics profiles between opioids including mu-opioid receptors affinity, elimination half-lives, and bioavailability.^{15–17} Further, little is known about the initially prescribed dosage strength that residents receive, which may modulate and enhance both the beneficial analgesic effects and risk of adverse opioid-related events.¹⁸

We conducted this study to understand the overall patterns and magnitude of geographic variability in the initiation of commonly used opioids and prescribed dosage strength across states and hospital referral regions (HRRs). We then sought to quantify: 1) the extent to which variation across HRRs could be explained by resident characteristics, facility characteristics, and state; 2) the strength of clustering in opioid prescribing practices within states versus within HRRs; and 3) whether the initial opioid choice was associated with differences in dosage strength in terms of oral morphine-equivalents (OME). We believed that geographic variation across HRRs may be present due to differing shared beliefs, values, and social networks across regional healthcare markets, which may affect how opioids are prescribed.^{11,19,20} Because states and state-specific policies may also influence opioid prescribing,^{10,21} we contrasted variation in opioid prescribing between HRRs and states.

METHODS

Study design and data sources

This study was approved by the University of Massachusetts Institutional Review Board. Using a cross-sectional study design, nursing home residents “entered” the study on the prescription fill date of their first opioid initiation episode (described below). The data to identify and characterize residents was drawn from four data sources from 2011: the Minimum Data Set (MDS) 3.0, Medicare (eligibility, Part B, Part D), the Certification and Survey Provider Enhanced Reporting (CASPER), and Nursing Home Compare. The MDS is a federally-required assessment that is conducted at nursing home admission and 90 day intervals thereafter by nurses who interview residents and their caregivers. Assessments provide information on residents’ pain, cognitive and physical functioning, mood, comorbidities, and other measures.^{22–24} Medicare Part B was used to operationalize painful comorbidities recorded in outpatient claims. Part D provided information on opioids and other prescribed medications. We used CASPER, a repository for federally mandated nursing home surveys, to provide information on facility characteristics. Nursing Home Compare, a system developed for consumers to find and compare nursing homes, provided information on facility quality.²⁵

Study sample

Shown in Supplementary Figure 1, we included Medicare beneficiaries (Part A/B/D coverage for 90 days preceding opioid initiation; no Medicare Advantage) who were long-stay nursing home residents (90 consecutive days in the same facility). We focused on long-stay residents because they generally require long-term assistance to manage their chronic comorbidities.²⁶ We restricted our sample to residents who were 65 years old and initiated a commonly-used opioid (oxycodone, hydrocodone, tramadol).⁴ Initiation was defined using Part D claims as being prescribed a study opioid with no opioid prescription claim in the preceding 90 days.

We excluded residents who were hospitalized or received skilled nursing facility care (services typically covered by Medicare Part A) during 2011 in the 90 days preceding initiation because medications received during these stays would predominantly be bundled into the Part A per diem rate; therefore, opioid prescriptions during this time would not appear as a Part D claim. We excluded: residents with no MDS assessment in the 90-day lookback period; those living in facilities with no recent CASPER data; residents living in standalone skilled nursing facilities or provider-based facilities (e.g., hospital-based long-term care units); those with cancer or receiving hospice care in the year before initiation; those who were comatose; those with any missing data; those initiating implausibly high doses (>180 mg OME/day); and those living in small geographic areas (states/districts with <50 residents or hospital referral regions with <30 residents). The final sample size was 62,889 residents.

Opioid Use

Commonly used opioids were short-acting, oral formulations of oxycodone (oxycodone, oxycodone/acetaminophen, oxycodone/ non-steroidal anti-inflammatory drug [NSAID]),

hydrocodone (hydrocodone/acetaminophen, hydrocodone/NSAID), or tramadol (tramadol, tramadol/acetaminophen). These medications are used by >90% of residents prescribed opioids and may be interchangeably used in nursing homes.⁴ From medications dispensed on the index date, we estimated the average daily dose in OME. See Supplementary Table 1 for detail on OME and study/non-study opioids.²⁷ We categorized residents prescribed doses 50 mg OME/day as receiving potentially inappropriately high doses based on recommendations for opioid-naïve patients.¹⁸

Geographic Variation

We examined geographic variation across US states and HRRs. We grouped residents into HRRs based on nursing home ZIP codes.^{28,29} We used HRRs because prior studies show substantial variation in opioid and overall medication prescribing within-states and across healthcare markets.^{11,19,20} An HRR can cross state lines.

Resident characteristics

We identified the most recent 2011 MDS assessment in the 90 days preceding opioid initiation to characterize resident demographics (age, gender, race/ethnicity), cognitive impairment (none/mild, moderate, severe),³⁰ physical limitations (requiring no/limited assistance, extensive assistance, physically dependent),³¹ pain (none, self-reported, or staff-assessed; within the five days preceding the MDS assessment) and dementia. Residents who were Medicaid dual-eligible at opioid initiation were identified using Medicare enrollment files.

We used Part B claims from the 90 days preceding initiation to describe painful comorbidities including injuries, pressure ulcers, diagnosed chronic pain, abdominal pain, musculoskeletal pain, and neuropathic pain (see Supplementary Table 2 for definitions); whether residents had any emergency department visits; and number of Part B claims.

Part D claims from the 90 days before opioid initiation were used to classify any prescribed psychopharmacologic (antidepressants, antipsychotics) or pain adjuvants (NSAID, anticonvulsants, corticosteroids, muscle relaxants) that may affect type of opioid initiated (see Supplementary Table 3 for definitions).^{13,18} Because benzodiazepines were not covered by Part D in 2011, we used the resident's MDS assessment before opioid initiation to classify receipt of anxiolytics or hypnotics in the seven days before the assessment.

Facility characteristics

Nursing home facility characteristics are associated with quality of care and may affect prescribing.^{32,33} Using CASPER and Nursing Home Compare, we included the following variables: rural location, facility size, ownership, whether the facility was part of a chain, occupancy, proportion of residents with Medicaid as primary payer, proportion of residents receiving skilled care, proportion of residents with facility-acquired bed sores, proportion of residents restrained, and quartile indicators of the number of minutes per resident day of nursing home staff including registered nurses, physicians, and physician extenders, and overall five-star rating for nursing home quality measures. See Supplementary Table 4 for detail on how variables were categorized.

Analysis

We first conducted crude and stratified descriptive analyses of resident and facility characteristics by opioid initiated. We then categorized the proportion of residents initiating different opioids and doses ≥ 50 mg OME/day into quartiles and generated US maps to visually examine the geographic variation in prescribing by HRR.

We were interested in understanding whether the variation in prescribing observed across HRRs could be explained by resident characteristics, facility characteristics, and state of residence. Thus, we fit multilevel logistic models for each commonly used opioid versus other study opioids (e.g., initiating oxycodone vs. hydrocodone or tramadol) and measured between-HRR variation by incorporating HRRs into the model as random intercepts. After fitting random intercept only models for each outcome, we sequentially adjusted for resident characteristics, facility characteristics, and state.³⁴ Since HRRs can cross state lines (Figure 1), we fit cross-classified multilevel logistic models with separate random intercepts for HRRs and states for the final model.³⁵ For adjusted models, we estimated the proportional change in cluster variation (PCV) to quantify the proportion of between-HRR variation that can be explained by covariates in the model. For example, if adjusting for resident characteristics resulted in a PCV of 10.0% for a specific prescribing practice, we would conclude that 10.0% of the geographic variation was due to differences in resident characteristics between HRRs.

We estimated intraclass correlation coefficients (ICC) for all models to understand the strength of clustering within HRRs (ICC_{HRR}). The ICC_{HRR} measures the correlation among two persons chosen at random from within the same HRR.³⁴ As the ICC increases from 0 towards 1, it indicates that residents within the same HRR have an increased propensity to be prescribed the same opioid. For cross-classified models, we decomposed the variance to separately estimate ICC_{HRR} (i.e., the ICC among persons in the same HRR but different states) and ICC_{state} , measuring the strength of clustering for persons in the same states but different HRRs.

To quantify the PCV and ICCs in those initiating doses ≥ 50 mg OME/day versus lower doses, we used the same sequential multilevel modeling strategy as above. To additionally examine the association between specific opioids initiated and prescribed dosage strength, we fit a separate fully adjusted cross-classified model that included specific opioid initiated to estimate adjusted odds ratios (aOR) and 95% confidence intervals (CI). Hydrocodone was chosen as the reference because it was the most commonly initiated study drug. See Methods Appendix for further detail.

RESULTS

In 2011, 62,889 long-stay residents initiated opioids (oxycodone: 9.4%; hydrocodone: 56.2; tramadol: 34.5%). These residents lived within 12,345 nursing homes (median residents per home: 4, 25th-75th percentile: 2-7) nested within 298 HRRs (of 306 HRRs; median facilities per HRR: 29, 25th-75th percentile: 16-49); 113 HRRs crossed state lines.

Overall, 53.0% of residents were 85 years old, 75.8% were women, and 82.3% were non-Hispanic white (Table 1; see Supplementary Table 4 for further description of resident and facility characteristics). Nearly 40% and 21.5% had severe cognitive impairment and were physically dependent, respectively. One-third of residents had self-reported or staff-assessed pain, with three-quarters of residents having recorded diagnoses of painful comorbidities from Part B claims. Most residents lived in for-profit facilities (73.1%).

When stratifying by opioid initiated, those initiating tramadol were more commonly women and 85 years old compared to the other initiators. Oxycodone initiators had a lower prevalence of severe cognitive impairment and more self-reported pain on the MDS, as well as painful comorbidities documented in Part B claims than other initiators. Oxycodone initiators were less commonly in facilities that were rural; part of a chain; <80% occupancy; or in the lowest quartiles of registered nurse, physician, and physician extender staffing relative to other opioid initiators.

Several patterns emerged when examining the crude proportion of specific opioids initiated by HRR. The top quartile of oxycodone initiating HRRs was largely concentrated in Northeast states, which contained 18 of the top 20 prescribing HRRs (Figure 2, Panel A). Nationally, the proportion of residents initiating oxycodone ranged from 0% (in 28 different HRRs) to 74.5% in Manhattan, New York (5th-95th percentile, 0–34.7%). Oxycodone was rarely initiated in HRRs within Texas. Alternatively, the top quartile of hydrocodone initiating HRRs largely extended across the middle of the continental US, with prescribing ranging from 3.5% (Bronx, New York) to 90.2% in Redding, California (5th-95th percentile, 23.9–81.1%; Figure 2, Panel B). Tramadol initiation was largely concentrated in Midwest states, Florida, Maryland, and northern New England states (Figure 2, Panel C), ranging from 5.8% (Alameda County, California) to 72.1% in Salisbury, Maryland (5th-95th percentile, 12.0%–53.8%).

The overall proportion of residents initially prescribed doses 50 mg OME/day was 6.7% with substantial geographic variation (Figure 3). The top quartile of initiators prescribed doses 50 mg OME/day were largely concentrated in western US states. However, many HRRs throughout the continental US were in the highest quartile of prescribing, and overall, the practice ranged from 0.0% (4 different HRRs) to 27.6% (Boise, Idaho; 5th-95th percentile, 1.6–14.4%). See Supplementary Figures 2–5 for further detail on prescribed opioid and dosage strength by state.

Resident and facility characteristics explained 7.5%, 0.2%, –2.5% (i.e., an increase in variance), and 9.4% of between-HRR variation for initiating oxycodone, hydrocodone, tramadol, and doses 50 mg OME/day, respectively (Table 2). For initiating oxycodone or doses 50 mg OME/day, facility characteristics explained a larger proportion of between-HRR variation than resident characteristics. In all cases, adjusting for state of residence resulted in large reductions in between-HRR variation for oxycodone (PCV=84.1%), hydrocodone (PCV=58.2%), tramadol (59.1%), and initiating doses 50 mg OME/day (PCV=46.6%). In fully adjusted cross-classified models, the propensity to initiate oxycodone was more strongly correlated among two residents in the same state but different HRRs ($ICC_{state}=0.24$) than among residents within the same HRR but different states

($ICC_{HRR}=0.06$). These patterns were similar but less pronounced for the propensity to initiate hydrocodone ($ICC_{state}=0.09$; $ICC_{HRR}=0.07$) and tramadol ($ICC_{state}=0.06$; $ICC_{HRR}=0.04$). For initiating doses ≥ 50 mg OME/day the ICCs were similar ($ICC_{state}=0.03$; $ICC_{HRR}=0.03$). In general, resident and facility characteristics were weakly associated with opioid or dose initiated, with $>85\%$ of the adjusted odds ratios between 0.80–1.20 (see Supplementary Tables 5–6 for further information on effect estimates and Supplementary Table 7 for variance components).

In fully adjusted cross-classified models that included study drug initiated, being prescribed oxycodone versus hydrocodone was associated with increased odds of being prescribed doses ≥ 50 mg OME/day (aOR=5.00, 95% CI: 4.57–5.47). Initiating tramadol versus hydrocodone was inversely associated with higher doses (aOR=0.28, 95% CI: 0.25–0.31).

DISCUSSION

We found that opioid initiation practices among long-stay nursing home residents during 2011 differed from what has been documented in community-dwelling populations,^{36,37} with substantial geographic variation in initiating specific opioids and potentially inappropriate doses. In multilevel models, state of residence explained the largest proportion of variation between HRRs, with most opioid prescribing practices more strongly clustered within state than within HRR. Most resident and facility characteristics were weakly associated with prescribing practices in adjusted models. Initiating potentially high inappropriate doses of opioids was associated with choice of starting oxycodone or tramadol versus hydrocodone.

Overall, opioids initiated in nursing homes differ from community settings. Although hydrocodone is initiated similarly across settings,^{36,37} tramadol was prescribed to 34.5% of initiators in nursing homes versus 8.7% and 20.2% of commercially insured and Medicare Advantage initiators, respectively.³⁷ Conversely, oxycodone was prescribed less frequently to nursing home residents initiating opioids (9.4%) compared to 17–18.8% of commercially insured and 16.6% of Medicare Advantage initiators.^{36,37} It is unclear how these differences in prescribing affect pain management and safety in nursing homes because most studies exclude nursing home residents and/or compare opioids to placebo rather than conducting head-to-head comparisons of different opioids.^{17,38–40}

That clustering was stronger within states than HRRs and states explained the majority of variation in opioid prescribing practices across HRRs suggests that factors unique to different states— including the implementation and enforcement of laws, policies, and regulations – are strong drivers of how opioids are initiated in this setting. Laws and policies that may have affected prescribing include the implementation of prescription drug monitoring programs, prescription limits restricting the quantity of opioids that can be dispensed, requirements for physician examinations before opioid prescribing, patient identification requirements, pain clinic regulations, and doctor shopping restrictions.²¹ These laws varied by state, drastically increased during 2010–2011,⁴¹ and may have affected older nursing home residents even if they were not the primary target of such legislation, as most overdose deaths occur in those <65 years old.³ However, our results must be

interpreted cautiously, as it was beyond the scope of the current study to examine the role of specific state policies on opioid prescribing.

We found that the proportion of opioid initiators prescribed oxycodone varied more widely between HRRs than other study drugs, with similar geographic patterns documented in younger disabled Medicare beneficiaries.¹¹ This may be because oxycodone was the only schedule II drug during 2011 and would have been uniquely affected by state laws such as triplicate prescribing programs which are present in low oxycodone prescribing states such as Texas and California. However, there may be additional important state differences in the number, type, and enforcement of laws intended to curb opioid prescribing. For example, among younger commercially insured adults, rescheduling hydrocodone from schedule III to schedule II in 2014 resulted in a larger reduction of hydrocodone prescribing in Texas than in other states.⁴² It is unclear if such legislative changes had the same impact on nursing home residents.

Differences in resident characteristics between HRRs explained little of the observed variation, suggesting that resident characteristics had limited influence on the type and dose of opioid initiated. We are uncertain if such observations are unique to nursing homes because multilevel models have not been used to quantify variation of opioid initiation in other studies. In some cases (being prescribed oxycodone or potentially inappropriate doses), facility characteristics explained a larger proportion of the observed variation than resident characteristics. Facility characteristics may affect prescribing directly (e.g., increased staffing leading to fewer residents initiating inappropriate doses due to increased oversight) or indirectly through their influence on organizational culture including the shared behaviors, beliefs, values, and assumptions of each facility.^{43,44} Further work is needed, but targeting facility culture may be important for improving opioid prescribing.

Overall, residents initiating opioids had a relatively low prevalence of potentially inappropriate doses (6.7%) in nursing homes compared to commercially insured (19.9%) and Medicare Advantage populations (17.0%).³⁶ That residents predominantly “start low” may be unsurprising given the high prevalence of frailty and concerns of adverse drug events in nursing homes.^{45,46} Dose also exhibited less clustering within HRRs and states compared to initiating specific opioids, suggesting that the chosen dose may be less regionally driven than specific opioid initiated. However, overall geographic patterns of residents initiating higher doses were in many ways similar to patterns documented in community-dwelling adults.^{7,9,11} Within the same state and HRR, initiating oxycodone was strongly associated with being prescribed potentially inappropriate doses whereas tramadol was strongly inversely associated with higher doses. These findings may be driven by differences in opioid potency,²⁷ though further contextualizing the relationship between specific opioids and doses is warranted given that many adverse opioid-related events are dose-dependent.¹⁸

National efforts to reduce opioid prescribing must not forget that nursing homes have historically undertreated resident pain^{5,6} and have only recently shown potential improvements.⁴⁷ In this setting, opioids may often be appropriate because older residents have a high burden of painful comorbidities and lack safe and effective pharmacologic and non-pharmacologic alternatives.^{4,13} Further, nursing homes are medically supervised

settings where resident access to medication is mediated through staff, which may limit the risk of adverse opioid-related events. Broader national policy changes must consider this vulnerable population so that the pendulum does not swing back towards undertreating pain.

The strengths of this study include focusing on opioid initiation in an important, understudied population; the national, comprehensive data on facility and resident characteristics; and using multilevel models to examine geographic variation. There are also limitations. Data are from 2011, and opioid legislation is rapidly changing. However, we believe it is unlikely that the strong geographic variation observed in this study could dissipate so rapidly. We had limited data on prescribers. Although we included prescriber staffing levels as facility characteristics, we may not adequately capture prescriber variation in opioid initiation practices.^{48,49} Part B claims provided limited information on severity of painful comorbidities. Yet, we were able to supplement these measures with data from the MDS 3.0, including any self- or staff-reported pain, which are not available in traditional claims-based analyses. We assumed that medications were used as prescribed. This is a common assumption^{36,37} but may overestimate our potentially inappropriate dose findings if many initiators use opioids as needed. We did not examine the effects of specific state policies. We had no or limited data on analgesics not typically covered by Part D (acetaminophen, lidocaine, over-the-counter NSAIDs) and whether residents previously used opioids long-term. Given our limited follow-up, cross-sectional study design, and focus on resident and facility characteristics, it was beyond the scope of the current study to examine the influence of specific county- and state-level drivers of opioid initiation. Further work is needed.

Our findings call attention to the complex geographic variation observed by type and dose of opioid initiated in older nursing home residents. The largest driver of observed variation was state of residence, suggesting that state laws, policies, and regulations play the largest role in how opioids are initiated in this setting, though further work is needed to understand how specific laws may affect prescribing in nursing homes. Finally, although the specific opioid initiated was strongly associated with dose and higher doses are associated with increased risks in community dwelling adults,¹⁸ few studies have examined opioid effectiveness and safety in nursing homes, and further work is needed in these areas to guide clinical decision making.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Visualizing the overlap between states and hospital referral regions (HRRs) – Massachusetts as a case study. HRRs (light grey lines) can cross state boundaries (thick black lines) and are therefore not nested within states. Within Massachusetts, there are five unique HRRs (shown in color; see legend), but two – Albany, New York and Providence, Rhode Island – are primarily based in neighboring states. Similarly, two Massachusetts HRRs (Springfield and Boston) extend into neighboring states. This non-nested data structure can be exploited with cross-classified multilevel models to measure the magnitude of clustering within states versus within HRRs and the extent to which variation in opioid prescribing across HRRs is driven by resident characteristics, facility characteristics, and state of residence.

A. Oxycodone

B. Hydrocodone

C. Tramadol

Figure 2.

Variation in the proportion of commonly used opioids initiated by hospital referral region (N=62,889 residents in 12,345 facilities within 298 hospital referral regions). Panel A, oxycodone; Panel B, hydrocodone; Panel C, tramadol. Note: excluded areas include hospital referral regions with <30 residents and areas with no designated hospital referral regions (e.g., northwestern Maine).

Figure 3.
Variation in the proportion of residents prescribed doses of 50 mg OME/day by hospital referral region (N=62,889 residents in 12,345 facilities within 298 hospital referral regions).
Note: excluded areas include hospital referral regions with <30 residents and areas with no designated hospital referral regions (e.g., northwestern Maine).

Table 1.

Individual characteristics of long-stay residents initiating opioids in 2011, overall and stratified by opioid initiated (N=62,889 residents in 12,345 facilities within 298 hospital referral regions).

Characteristic ¹ , %	Overall (N=62,889)	Stratified by opioid initiated		
		Oxycodone (n=5,891)	Hydrocodone (n=35,326)	Tramadol (n=21,672)
Resident characteristics				
85 years	53.0	48.6	51.1	57.2
Women	75.8	73.0	74.3	79.1
Race/ethnicity				
Non-Hispanic white	82.3	80.3	82.1	83.2
Non-Hispanic black	11.7	13.7	11.7	11.1
Hispanic/Latino	4.5	4.6	4.5	4.6
Other	1.5	1.4	1.7	1.1
Medicaid dual-eligibility	87.6	90.1	87.7	86.8
Physical limitations ²				
Extensive assistance required	50.7	52.9	50.5	50.4
Physically dependent	21.5	25.3	21.9	20.0
Cognitive impairment ³				
Moderate	31.5	31.5	31.5	31.5
Severe	39.5	34.4	40.6	39.2
Psychopharmacologic medications ⁴				
Antidepressants	62.3	64.9	63.1	60.4
Antipsychotic	27.5	24.5	28.3	26.9
Antianxiety	21.3	20.5	22.0	20.4
Hypnotics	6.5	6.7	6.7	6.1
Other medications prescribed for pain ⁴				
Anticonvulsants	15.5	19.5	15.7	13.9
Corticosteroids	7.2	7.8	7.1	7.1
Muscle relaxants	4.1	5.1	4.3	3.6
Nonsteroidal anti-inflammatory drugs	11.6	10.7	11.2	12.6
Pain recorded on Minimum Data Set ⁵				
Any self-reported pain	28.8	33.4	28.6	28.0
Any staff-assessed pain	4.2	4.6	4.5	3.6
Painful comorbidities ^{5,6}				
Any injury (excludes poisonings)	18.3	22.6	19.0	15.8
Pressure ulcers	7.4	11.3	7.2	6.5
Diagnosed chronic pain	2.7	4.0	2.5	2.6
Abdominal pain	5.5	7.2	5.2	5.3
Musculoskeletal pain	64.0	67.5	62.6	65.4
Neuropathic pain	7.3	8.2	7.3	6.9

Characteristic ¹ , %	Overall (N=62,889)	Stratified by opioid initiated		
		Oxycodone (n=5,891)	Hydrocodone (n=35,326)	Tramadol (n=21,672)
Any emergency room use	16.2	18.0	17.7	13.3
<i>Facility characteristics</i>				
Rural location	31.6	19.1	33.6	31.9
200 beds	11.0	21.3	9.3	11.0
For profit ownership	73.1	68.2	75.0	71.3
Part of a chain	57.6	49.6	59.1	57.3
<80% occupancy ⁷	26.4	16.0	28.4	25.9
80% of residents have Medicaid as primary payer ⁷	15.6	16.5	16.0	14.2
<10% of facility receiving skilled nursing care ⁷	35.6	34.3	37.1	35.6
Nursing Home Compare quality rating much below average (1 star)	9.4	8.0	10.0	8.7
5% of residents have facility-acquired bed sores ⁷	19.2	17.4	19.7	18.8
5% of residents restrained ⁷	20.5	19.8	21.6	19.1
<27.3 registered nurse minutes per resident day ⁸	27.9	17.2	30.1	28.1
<0.3 physician minutes per resident day ⁸	25.9	20.1	26.5	26.4
No physician extender minutes per resident day ⁸	57.5	51.5	58.6	57.3

¹ Column percentages may not add to 100% due to rounding.

² Physical limitations were defined using the Activities of Daily Living Self-Performance Hierarchy (range: 0–6) to categorize residents as requiring no to limited assistance (0–2), extensive dependence (3–4), or being physically dependent (5–6).

³ Cognitive impairment was defined using the Brief Interview for Mental Status (BIMS; range:0–15) when the resident could self-report and the Cognitive Performance Scale (CPS; range:0–6) otherwise: none/mild (BIMS 13–15 or CPS 0–2), moderate (BIMS 8–12 or CPS 3–4) or severe impairment (BIMS 0–7 or CPS 5–6).

⁴ Subcategories are not mutually exclusive and may add to >100%.

⁵ Derived as a 3-level variable (0: no pain documented, 1: pain documented from resident, 2: pain documented by staff) from the most recent Minimum Data Set assessment preceding opioid initiation.

⁶ Based on Part B claims from the 90 days prior to opioid initiation (see Supplementary Table 2 for further information on definitions used). The total number of Part B claims (median and interquartile range [IQR]) varied by opioid initiated: hydrocodone (8, IQR: 5–14), oxycodone (11, IQR: 6–18), tramadol (8, IQR: 5–13).

⁷ Derived from the most recent Certification and Survey Provider Enhanced Reporting resident census preceding the study period, which collects information on all residents living in the facility.

⁸ Only lowest staffing quartile shown. See Supplementary Table 3 for cutoffs of other quartiles.

Table 2.

Measuring the proportion change in between-HRR variation explained by resident characteristics, facility characteristics, and state and the strength of clustering within HRRs and state for initiating commonly used opioids or doses 50 mg OME/day (N=62,889 residents in 12,345 facilities within 298 hospital referral regions).¹

	Characteristics included in multilevel model ²			
	Null model	Resident	Resident + Facility	Resident + Facility + State
Initiating oxycodone				
PCV ³	Referent	1.3%	7.5%	84.1%
ICC ⁴ _{HRR}	0.37	0.36	0.35	0.06
ICC ⁵ _{state}	-	-	-	0.24
Initiating hydrocodone ⁶				
PCV	Referent	-2.0%	0.2%	58.2%
ICC _{HRR}	0.16	0.17	0.16	0.07
ICC _{state}	-	-	-	0.09
Initiating tramadol ⁶				
PCV	Referent	-3.8%	-2.5%	59.1%
ICC _{HRR}	0.10	0.10	0.10	0.04
ICC _{state}	-	-	-	0.06
Initiating doses 50 mg OME/day				
PCV	Referent	1.5%	9.4%	46.6%
ICC _{HRR}	0.06	0.07	0.06	0.03
ICC _{state}	-	-	-	0.03

Abbreviations: HRR, hospital referral region; ICC, Intraclass correlation coefficient; OME; oral morphine equivalent; PCV, proportional change in cluster variation

¹ See Methods Appendix for further detail on multilevel model building.

² Multilevel logistic models with a random intercept for hospital referral region were sequentially fitted using resident and facility characteristics as described in Supplementary Table 3. The final model was a cross-classified multilevel model including a second random intercept for state.

³ PCV described the proportional change in HRR variation explained by the multilevel model and was estimated as (variance of random intercept in null model – variance of random intercept in adjusted model) / variance of random intercept in null model.

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⁴ ICC_{HRR} estimates the correlation in the propensity to initiate the same opioid or dose between two individuals randomly selected from each HRR. The ICC_{HRR} for the final model is an estimate of the correlation between two persons in the same HRR but different states.

⁵ ICC_{state} was estimated using a cross-classified logistic model and estimates the correlation in the propensity to initiate the same opioid or dose between two individuals in the same state but different HRRs.

⁶ Adding resident and facility characteristics to this model increased the variance. This can occur when there is negative correlation between the opioid initiated and resident/facility factors within HRRs.⁴⁸