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Journal

Journal of the American Geriatrics Society, 70(7)

ISSN

0002-8614

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Publication Date

2022-07-01

DOI

10.1111/jgs.17735

Peer reviewed

Received: 18 November 2021 | Revised: 2 February 2022 | Accepted: 12 February 2022

DOI: 10.1111/jgs.17735

Journal of the
American Geriatrics Society

Glycemic treatment deintensification practices in nursing home residents with type 2 diabetes

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Funding information
The authors were supported by the following grants: K24AG049057, R24AG064025, P30 AG044281, K24AG066998, VA HSR&D IIR 15-434.

Abstract

Background: Older nursing home (NH) residents with glycemic overtreatment are at significant risk of hypoglycemia and other harms and may benefit from deintensification. However, little is known about deintensification practices in this setting.

Methods: We conducted a cohort study from January 1, 2013 to December 31, 2019 among Veterans Affairs (VA) NH residents. Participants were VA NH residents age ≥65 with type 2 diabetes with a NH length of stay (LOS) ≥ 30 days and an HbA1c result during their NH stay. We defined overtreatment as HbA1c <6.5 with any insulin use, and potential overtreatment as HbA1c <7.5 with any insulin use or HbA1c <6.5 on any glucose-lowering medication (GLM) other than metformin alone. Our primary outcome was continued glycemic overtreatment without deintensification 14 days after HbA1c.

Results: Of the 7422 included residents, 17% of residents met criteria for overtreatment and an additional 23% met criteria for potential overtreatment. Among residents overtreated and potentially overtreated at baseline, 27% and 19%, respectively had medication regimens deintensified (73% and 81%, respectively, continued to be overtreated). Long-acting insulin use and hyperglycemia ≥300 mg/dL before index HbA1c were associated with increased odds of continued overtreatment (odds ratio [OR] 1.37, 95% confidence interval [CI] 1.14–1.65 and OR 1.35, 95% CI 1.10–1.66, respectively). Severe functional impairment (MDS-ADL score ≥ 19) was associated with decreased odds of continued overtreatment (OR 0.72, 95% CI 0.56–0.95). Hypoglycemia was not associated with decreased odds of overtreatment.

Conclusions: Overtreatment of diabetes in NH residents is common and a minority of residents have their medication regimens appropriately deintensified. Deprescribing initiatives targeting residents at high risk of harms

This article comments on an article by Lam et al. and an editorial by Lega et al. in this issue.

and with low likelihood of benefit such as those with history of hypoglycemia, or high levels of cognitive or functional impairment are most likely to identify NH residents most likely to benefit from deintensification.

KEYWORDS
diabetes, nursing home, overtreatment

INTRODUCTION

Nursing home (NH) residents with diabetes represent a large, growing population at high-risk for adverse events from glucose-lowering medications (GLMs). Approximately 1.3 million adults resided in an NH in 2016[1]; an estimated 25%–34% of these NH residents have diabetes.[2] Despite the large and growing numbers of NH residents with diabetes, little is known about GLM prescribing and deprescribing practices in this population.

Clinical guidelines from the American Diabetes Association, American Geriatrics Society, and Veterans Affairs (VA) recommend less aggressive glycemic treatment for frail older adults and NH residents[2–5] as overly tight glycemic control can lead to substantial harms. Given the lack of benefit for macrovascular outcomes, the long time to benefit for tight glycemic control to decrease microvascular complications and the documented harms of tight glycemic control,[6–8] guidelines generally recommend hemoglobin A1c (HbA1c) treatment targets from 7.5% to 9% in this population, and that glycemic goals in older frail adults should reflect patient preferences, comorbidity burden, life expectancy and minimize the risk of hypoglycemia. The 2021 American Diabetes Association guidelines for the treatment of diabetes in older adults have new emphasis on the importance of deintensification and deprescribing, noting that among long-term care NH residents, deintensification of high hypoglycemic risk agents is essential as there is no benefit of tight glycemic control in this population.[3] In addition, deintensification and deprescribing may avoid harms (such as hypoglycemia[9,10]) and burdens (such as the need for frequent fingerstick monitoring) leading to an improved quality of life.

Studies in community dwelling older adults have shown that glycemic overtreatment is common and can cause significant harms. Recent studies have documented increased risk of mortality, severe hypoglycemia, cognitive impairment, and falls as potential negative consequences of overtreatment.[11–14] Appropriate deintensification of GLMs when HbA1c suggests overly tight glycemic control may decrease the risks of overtreatment and available evidence suggests it is not associated with significant harms.[13] However available evidence in community dwelling older adults suggests that appropriate deintensification is uncommon.[12,15–18]

Significantly less is known about overtreatment and deintensification practices in the NH population. We have previously shown that overtreatment of diabetes occurs in 14% or greater VA NH residents.[19] A recent systematic review reported that among NH residents worldwide, rates of overtreatment and undertreatment vary widely (5%–86% and 1%–35%, respectively).[20] Although one previous study examined deintensification practices among NH residents with life expectancy <6 months or advanced dementia,[21] little is known about deintensification practices in a general population of NH residents.

Key points

- Among 7422 VA nursing home residents, most had an index HbA1c suggesting tight control (<7.5%) and a majority of residents were on insulin at baseline.
- Deintensification was uncommon: 27% of overtreated and 19% of potentially overtreated residents had their glucose-lowering medications regiments appropriately deintensified.
- Hyperglycemia and long-acting insulin use were associated continued overtreatment while history of hypoglycemia, older age, comorbidity burden and cognitive impairment were not associated with decreased odds of continued overtreatment.

Why does this paper matter?

Many NH residents who are unlikely to benefit from tight glycemic control and are at high risk of hypoglycemia continue to receive insulin and other medications that increase hypoglycemia risk even after HbA1c results suggest overtreatment. In addition to hypoglycemia risk, factors such as cognitive and functional impairment should be considered when identifying patients for treatment deintensification.

Upon NH admission, the admitting clinician assesses the appropriateness of each medication in context of the whole person which includes laboratory results, vital signs, treatment goals, comorbidities and functional status. Since NH admission represents a time when clinicians review medications in light of the new NH resident's goals of treatment, NH admission is an especially important time to examine changes in GLMs and deprescribing.

Thus, in a recently admitted VA NH population, our objectives were to (a) determine the rates of glycemic overtreatment, potential glycemic overtreatment, appropriate glycemic treatment and potential glycemic undertreatment; (b) determine the rates of appropriate modification of GLMs in response to HbA1c; and (c) identify factors that predict continued glycemic overtreatment. We chose continued overtreatment as our outcome of interest because identifying predictors of continued overtreatment will help clinicians and institutions decide where to focus deprescribing efforts.

METHODS

Population and data sources

We identified all VA NH (also known as Community Living Center) residents admitted from January 1, 2013 to December 31, 2019, over age 65 with a diagnosis of type 2 diabetes (T2DM). We identified newly admitted NH residents with diabetes using standard criteria: HbA1c >6.5%, or International Classification of Diseases (ICD) 9 or 10 diagnosis codes for T2DM. ICD codes were reviewed within 1 year of NH admission using VA MedSAS data. We excluded residents admitted for hospice care, those with a NH length of stay (LOS) <30 days and NH residents with ICD codes for type 1 diabetes. We also excluded NH residents who did not have a HbA1c measurement during their NH stay, since NH clinicians would not have clear indication of glycemic over- or undertreatment.

Data sources

We linked multiple VA data sources to create our analytic cohort. We utilized the VA MedSAS files for demographics, comorbidities, and diagnosis codes. Laboratory results including, HbA1c and glucose values, were obtained from the VA Decision Support System Laboratory Results file. We used bar code medication administration (BCMA) data to determine medications and doses. BCMA data is generated when a nurse scans a medication and a patient's wristband before medication administration; the dose and timing of medication administration are automatically documented. The Minimum Data Set (MDS) 3.0 is a quarterly assessment of NH residents covering a broad range of measures; we used MDS 3.0 data to obtain information about cognitive and physical functioning.

Index HbA1c identification

We defined index HbA1c as the first HbA1c more than 24 h after NH admission, to allow for the collection of 24 h of baseline medication data prior to HbA1c result and any resulting medication changes. The first HbA1c after this period was used because comprehensive medication review is an essential component of NH admission and assessing appropriateness of diabetes medication regimen generally necessitates HbA1c evaluation.

Glycemic medication categories

We then categorized NH residents into five mutually exclusive categories based on GLM use on the index HbA1c date: (1) no GLMs, (2) metformin use alone, (3) use of other GLMs (but without insulin use), (4) any short-acting insulin use (in combination with GLMs or alone, but without use of long-acting insulin), (5) any long-acting insulin use. "Other GLMs" in category 3 above (any combination of non-insulin GLMs) included sulfonylureas, dipeptidyl peptidase-4 inhibitor (DPP-4) inhibitors, glucagon-like peptide 1 (GLP-1) receptor agonists, sodium-glucose transport protein 2 (SGLT2) inhibitors, thiazolidinedione, and glucosidase inhibitor classes; however, sulfonylureas comprised the overwhelming majority of medications in this category (Table S1). We used BCMA data to extract residents' medication administration information. Short-acting insulins included regular insulin, aspart and lispro; long-acting insulins included insulin glargine, detemir, and NPH. Since long-acting insulin use superseded short-acting insulin in our medication categorization, we classified NH residents receiving mixed insulins (70/30) into the long-acting insulin category.

Defining glycemic over- and undertreatment

Overtreatment and undertreatment were defined by first categorizing NH residents into four groups based on index HbA1c: <6.5%, 6.5%–7.4%, 7.5%–8.4%, and ≥8.5%. We defined overtreatment as HbA1c <6.5 with any insulin use, and potential overtreatment as HbA1c < 7.5 with any

TABLE 1 Baseline characteristics

N = 7422	Mean (SD) or *N* (%)
Resident characteristics	
Age, mean (SD)	74.6 (7.9)
Male, *N* (%)	7303 (98.4%)
Charlson Comorbidity Index (CCI) *N* (%)	
<4	1941 (26.2%)
4–5	2091 (28.2%)
6–7	1877 (25.3%)
≥8	1513 (20.4%)
Minimum Data Set-Activities of Daily Living score[a] (MDS-ADL) N(%)	
Minimal functional impairment (<8)	1853 (25.0%)
Mild functional impairment[8–14]	1907 (25.7%)
Moderate functional impairment[15–18]	1563 (21.1%)
Severe functional impairment (≥19)	2099 (28.3%)
Cognitive Functional Scale (CFS) N(%)	
Cognitively intact	3971 (53.5%)
Mildly impaired	2477 (33.4%)
Moderately impaired	500 (6.7%)
Severely impaired	474 (6.4%)
Length of NH stay, *N* (%)	
30–59	1515 (20.4%)
60–89	1069 (14.4%)
90+	4838 (65.2%)
Emergency Department visit during NH stay, *N* (%)	198 (2.7%)
Diabetes factors	
Time from NH admission to index HbA1c[b] measurement, *N* (%)	
1–30 days	3701 (49.9%)
>30 days	3721 (50.1%)
Hemoglobin A1c, mean (SD)	7.1 (1.4)
Hemoglobin A1c, N(%)	
<6.5	2602 (35.1%)
6.5–7.4	2260 (30.5%)
7.5–8.4	1442 (19.4%)
≥8.5	1118 (15.1%)
Glucose-lowering medication (GLM) category, *N* (%)[c]	
No GLM	1491 (20.1%)
Metformin alone	448 (6.0%)
Other GLMs	531 (7.2%)
Short acting insulin use	1185 (16.0%)
Long-acting Insulin use	3767 (50.8%)
Hypoglycemia before index HbA1c (glucose ≤70 mg/dL), *N* (%)	2349 (31.7%)
Hyperglycemia before index HbA1c (glucose ≥300 mg/dL), *N* (%)	3006 (40.5%)

Abbreviation: NH, nursing home.

[a]Minimum Data Set-Activities of Daily Living (ADL) score ranged from 0 (completely independent) to 28 (totally dependent) with maximum of 4 points awarded for 7 total ADLs.

[b]HbA1C, hemoglobin A1C.

[c]Escalating categories of glucose-lowering medication (GLM) use are mutually exclusive. That is, residents in the "short acting insulin use" category maybe taking metformin or other oral GLMs but are by definition not using long-acting insulins.

insulin use or HbA1c <6.5 on any GLM other than metformin alone. We initially defined undertreatment as HbA1c >9.5% with no GLM use and potential undertreatment as HbA1c ≥8.5 with no GLM use; however, due to small numbers in the undertreated category ($n = 19$), these two categories were combined into a potentially undertreated category defined as HbA1c >8.5% and no GLMs.

Defining deintensification

Glycemic deintensification was determined by comparing baseline and follow-up period GLM regimens. Baseline regimen was the GLM regimen on the day before the index HbA1c. If baseline medications were held or refused on the day prior HbA1c draw, we looked back up to two more days. Follow-up medications were GLMs taken day 8 through day 14 after index date, to allow ample time for reviewing and responding to lab results in the NH setting. Follow-up dose was the median daily dose over the 7-day follow-up period.

A follow-up GLM regimen was considered deintensified if a medication was discontinued or decreased. A follow-up GLM regimen was considered intensified if a GLM was started or increased. A GLM was considered decreased (or increased) if the median total daily dose during follow-up was decreased (or increased) by >20%. If multiple changes occurred, changes in the highest intensity GLM group trumped changes in lower intensity groups in the following order from highest to lowest intensity: long-acting insulin, short-acting insulin, other GLMs, metformin. For example, a NH resident who had metformin discontinued but had an >20% increase in dosage of long-acting insulin would be considered to have intensified treatment. In the case of short-acting

insulin, only initiations/discontinuations (not dose increases/reductions) were considered since short-acting insulin doses frequently fluctuated due to the use of sliding scale.

Primary outcome and covariates

The primary outcome for our multivariate analysis was continued overtreatment, defined as NH residents who were overtreated at baseline and not deintensified during the follow-up period.

Covariates included "resident characteristics" and "diabetes factors." "Resident characteristics" included age, multimorbidity, measured by the Charlson Comorbidity Index (CCI), functional status measured by Minimum Data Set-Activities of Daily Living (MDS-ADL) score, cognitive status measured by MDS 3.0 Cognitive Functional Scale (CFS), LOS and ED visit during NH stay. CCI was calculated using ICD-9 and -10 diagnosis codes.[22] MDS-ADL score was calculated from MDS data and ranges from 0 (completely independent) to 28 (totally dependent) across 7 ADLs (bed mobility, transferring, locomotion, dressing, eating, toilet use, personal hygiene). CFS was also calculated from MDS data and stratifies NH residents into 1 of 4 cognitive categories: no impairment, mild impairment, moderate impairment, or severe impairment. We did not evaluate sex as <2% of our cohort were female. "Diabetes factors" included long-acting insulin use, presence of hypoglycemia (glucose ≤70 mg/dL) or hyperglycemia (glucose ≥300 mg/dL) after NH admission but before index HbA1c date.

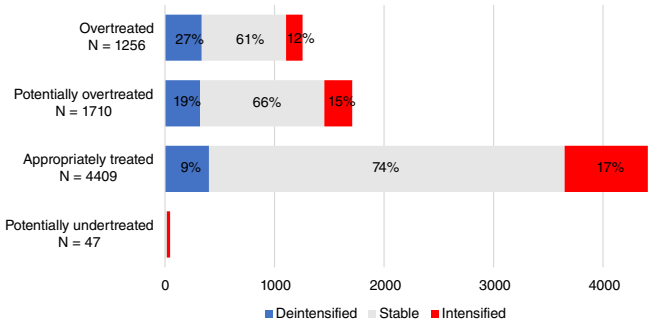

FIGURE 1 Treatment changes by baseline treatment appropriateness group

TABLE 2 Rates of glycemic treatment by hemoglobin A1C category (%[a])

	HbA1c <6.5%	HbA1c 6.5–7.4%	HbA1c 7.5–8.4%	HbA1c ≥8.5%
No GLM ($N = 1491$)	38%	16%	6%	**4%**[b]
Metformin alone ($N = 448$)	7%	7%	5%	2%
Use of other GLMs ($N = 531$)	**7%**[c]	8%	7%	7%
Short acting insulin use ($N = 1185$)	**19%**[d]	**17%**[c]	14%	10%
Long-acting insulin use ($N = 3767$)	**29%**[d]	**51%**[c]	68%	77%
Total ($N = 7422$)	2602	2260	1442	1118

Abbreviation: GLM, glucose-lowering medication.
[a]Percent by column.
[b]Potentially undertreated.
[c]Potentially overtreated.
[d]Overtreated.

TABLE 3 Medication change leading to deintensification determination among overtreated and potentially overtreated NH residents whose regimens were deintensified[a]

	Total[b] *N* (%) ($n = 656$)	Overtreated *N* (%) ($n = 336$)	Potentially overtreated *N* (%) ($n = 320$)
Short acting insulin discontinued	284 (43.3)	161 (47.9)	123 (38.4)
Long-acting insulin discontinued	82 (12.5)	47 (14.0)	35 (10.9)
Long-acting insulin dose decreased	223 (34.0)	109 (32.4)	114 (35.6)
Other medication discontinued	25 (3.8)	6 (1.8)	19 (5.9)
Other medication dose decreased	42 (6.4)	13 (3.9)	29 (9.1)

Abbreviation: NH, nursing home.
[a]If multiple deintensification changes occurred, NH resident is represented by the change in the highest drug class.
[b]Total column includes all residents deintensified, including those appropriately treated at baseline.

Statistical analysis

To determine the factors associated with continued overtreatment without deintensification, we focused on NH residents overtreated at baseline. We compared those who had been appropriately deintensified (reference group) to those who had stable or intensified medication regimens (continued overtreatment). We used multivariable logistic regression to calculate adjusted odds ratios of continued overtreatment without deintensification.

Adjusted analyses included the covariates listed above. We conducted a sensitivity analysis, accounting for clustering by region; however, accounting for clustering did not alter our results, so we present un-clustered results. We utilized multiple imputation with chained equations for missing MDS-ADL score (0.13%) and CFS (0.26%). We performed statistical analyses using SAS 9.4. This study was reviewed and approved by the University of California, San Francisco Committee on Human Research.

RESULTS

Between 2013 and 2019, we identified 20,605 veterans with T2DM, age ≥ 65 who were admitted to VA NHs (also known as Community Living Centers or CLCs) with a length of NH stay ≥30 days. We excluded 8863

TABLE 4 Odds of continued overtreatment vs deintensification in overtreated and potentially overtreated NH residents with type 2 diabetes

		Unadjusted odds OR (95% CI)	Adjusted odds OR (95% CI)
Resident characteristics			
Age			
	65–69	REFERENCE	REFERENCE
	70–79	0.86 (0.70, 1.05)	0.88 (0.72, 1.08)
	80+	0.82 (0.66, 1.03)	0.89 (0.71, 1.13)
Charlson Comorbidity Index			
	<4	REFERENCE	REFERENCE
	4–5	1.02 (0.80, 1.30)	0.96 (0.75, 1.23)
	6–7	1.10 (0.86, 1.41)	0.98 (0.77, 1.27)
	≥8	1.22 (0.94, 1.59)	1.12 (0.86, 1.46)
MDS-ADL score			
Minimal functional impairment	<8	REFERENCE	REFERENCE
Mild functional impairment	8–14	0.80 (0.62, 1.04)	0.81 (0.62, 1.05)
Moderate functional impairment	15–18	1.04 (0.79, 1.37)	1.04 (0.79, 1.38)
Severe functional impairment	≥19	0.72 (0.56, 0.92)	0.73 (0.56, 0.95)
Cognitive Functional Scale			
	Cognitively intact	REFERENCE	REFERENCE
	Mildly impaired	1.127 (0.93, 1.37)	1.15 (0.94, 1.41)
	Moderately impaired	0.99 (0.69, 1.43)	1.12 (0.77, 1.66)
	Severely impaired	0.65 (0.46, 0.92)	0.74 (0.51, 1.08)
LOS ≥90 days		1.32 (1.11, 1.58)	1.18 (0.97, 1.44)
Diabetes factors			
Time from NH admission to HbA1c measurement, *N* (%)			
	1–30 days	REFERENCE	REFERENCE
	>30 days	1.39 (1.17, 1.66)	1.165 (0.94, 1.44)
Long-acting insulin use		1.48 (1.24, 1.77)	1.37 (1.14, 1.65)
Hypoglycemia before index A1C (glucose ≤70 mg/dL), *N* (%)		1.21 (1.01, 1.45)	0.93 (0.76, 1.15)
Hyperglycemia before index A1C (glucose ≥300 mg/dL), *N* (%)		1.55 (1.29, 1.86)	1.35 (1.10, 1.66)

Abbreviations: CI, confidence interval; LOS, length of stay; MDS-ADL, Minimum Data Set-Activities of Daily Living; NH, nursing home; OR, odds ratio.

residents without a HbA1c result during their NH stay. We required 1 day of baseline medication data in the NH before A1C draw and follow-up medication data from day 8–14. For this reason, residents who had their A1C drawn before day 2 of NH admission ($N = 2506$) or were discharged/hospitalized before the follow-up period were excluded ($N = 854$). Lastly, excluding NH residents admitted for hospice care ($n = 960$) resulted in our final cohort of 7422 NH residents (Figure S1).

Table 1 shows the baseline characteristics of the analytic cohort. Mean age was 74.6 years, more than 98% were male and 65% had NH LOS >90 days. Emergency department visits during NH stay were uncommon (2.7%). Our cohort had a high comorbidity burden, nearly half with a CCI of ≥6. Half of residents had moderate or severe functional impairment (MDS-ADL >14.0, equivalent to total dependence in >3 of 7 ADLs). Mild cognitive impairment was present in 33% of residents, while only 7% and 6% had moderate and severe impairment, respectively.

Most residents had an index HbA1c suggesting tight control and a majority of residents were on insulin at baseline (Table 1). Half of residents had an HbA1c drawn during the first 30 days of NH stay. Twenty percent of residents were not on any GLMs, 6% were on metformin alone, 7% were on other GLMs without insulin and 67% were on any insulin. Among residents in the "other GLM" category (i.e., GLM other than metformin alone but not on insulin) sulfonylurea use (specifically glipizide) vastly outnumbered other medication classes (Table S1).

Hypoglycemia (≤70 mg/dL) was common in our cohort (Table 1). One third of our cohort ($n = 2349$) had at least 1 episode of hypoglycemia (glucose ≤70 mg/dL) before index HbA1c draw. Of residents admitted to NH for at least 7, 14, and 30 days before index HbA1c, 39%, 42%, and 44%, respectively had hypoglycemia between NH admission and index HbA1c (Table S2).

In total, 1256 (17%) of residents met criteria for overtreatment, an additional 1720 (23%) met criteria for potential overtreatment, and just 47 (0.6%) met criteria for potential undertreatment. Table 2 presents rates of glycemic treatment by HbA1c category highlighted by treatment-appropriateness. Of those with an index HbA1c <6.5% nearly half (48%) were on insulin and thus considered overtreated. Of those with an index HbA1c 6.5%–7.4%, 68% were on insulin and considered potentially overtreated.

Among overtreated NH residents, less than one third had their treatment regimens deintensified (Figure 1). This figure presents the proportion of residents by treatment appropriateness group whose glycemic medications were deintensified, intensified or stable. Among the residents who were overtreated and potentially overtreated, 27% and 19%, respectively had their GLMs deintensified. *Intensification* occurred in 12% of overtreated and 15% of potentially overtreated residents. A significant majority of overtreated and potentially overtreated residents had stable treatment regimens (61% and 66%, respectively).

Among overtreated and potentially overtreated residents, discontinuation of short acting insulin and dose decreases of long-acting insulin accounted for the majority of treatment changes that lead to classification as deintensified (Table 3).

Diabetes factors were predictors of continued overtreatment (Table 4). Long-acting insulin use and hyperglycemia ≥300 mg/dL before index HbA1c were associated with increased odds of continued overtreatment (odds ratio [OR] 1.37, 95% confidence interval [CI] 1.14–1.66 and OR 1.35, 95% CI 1.10–1.66, respectively). However, hypoglycemia before index HbA1c was not associated with decreased odds of overtreatment.

Among resident characteristics, only severe functional impairment as measured by MDS-ADL score was associated with decreased odds of continued overtreatment (OR 0.73, 95% CI 0.56–0.95). Mild and moderate functional impairment were not associated with decreased odds of continued overtreatment. Severe cognitive impairment showed a trend toward an association with decreased odds of continued overtreatment (OR 0.74, 95% CI 0.51–1.08), while mild and moderate levels of impairment were not associated with continued overtreatment. Comorbidity burden (CCI) and age was not associated with continued overtreatment.

DISCUSSION

In this national sample of older VA NH residents, overtreatment and potential overtreatment of T2DM was very common. Although most NH residents had an initial index HbA1c suggesting tight glycemic control (<7.5%), the majority were on insulin. Of residents considered overtreated or potentially overtreated, only 27% and 19%, respectively had their GLMs deintensified within the follow-up period.

Our results indicate that prescribing inertia is strong: of residents who were overtreated and potentially overtreated at baseline 73% and 81% continued to be overtreated at 2 weeks after HbA1c measurement. Clinical inertia has been described in many contexts, and successful interventions to target deprescribing in the face of clinical inertia have focused on engaging and educating multiple stakeholders including patients and their families, pharmacists, nurses, and physicians.[23] Initiatives to deprescribe other medications in NH residents have been successful; for example, Gedde and colleagues[24] found

that an intervention involving interprofessional communication of goals, symptom review, and collegial medication review lead to a twofold greater rate of psychotropic medication discontinuation in the intervention vs control group. Similar interprofessional interventions for diabetes medication deprescribing, especially at the time of NH admission, may reduce the risk of harms of tight glycemic control in a NH population.

Our study did not identify strong predictors of continued overtreatment; however, the negative findings of our analysis are noteworthy. Although severe functional impairment was associated with appropriate deintensification, other resident characteristics associated with low likelihood of benefit and increased likelihood of harms from tighter glycemic control such as age, comorbidity burden, cognitive impairment and moderate functional impairment were not associated with appropriate deintensification.

In contrast to resident characteristics, certain diabetes factors were associated with continued overtreatment. Specifically, hyperglycemia and use of long-acting insulin were associated with continued overtreatment. The fact that diabetes factors such as hyperglycemia were associated with continued overtreatment while resident characteristics such as cognitive impairment were not associated with continued overtreatment suggests that clinicians may focus more on the characteristics of the "disease" rather than the person in glycemic treatment decisions.

Our findings are supported by the findings of Niznik et al. which evaluated VA NH residents with less than 6-month prognosis or advanced dementia.[21] In this subpopulation, 43% were potentially overtreated and of those 45% were appropriately deintensified by 90 days. Higher baseline HbA1c levels were associated with ongoing overtreatment and long-acting insulin use. They concluded that overall medications prescribed (diabetes factors) were stronger predictors of deintensification practice than resident specific characteristics.

It is alarming that in our study hypoglycemia was not associated with decreased odds of continued overtreatment. Reducing the risk of hypoglycemia is an important goal of diabetes deintensification. One study of NH residents with diabetes found that 43% experienced hypoglycemia <70 mg/dL and that this was associated with longer LOS, more ER or hospital transfers and mortality.[25] The burden of hypoglycemia in our study was substantial, with more than 30% experiencing at least one episode of glucose ≤70 mg/dL between NH admission and index HbA1c. We propose that NH residents with an episode of hypoglycemia should be required to undergo a medication review to determine whether GLMs should be deintensified.

Our results should be interpreted in light of our study's strengths and limitations. Strengths include our large national cohort NH residents with diabetes and our use of medication and laboratory data which allowed us to identify medication intensification and deintensification.

Limitations of our study include the following. First, this almost entirely male VA population maybe less generalizable to a non-VA NH population. Although, previous studies have found diabetes to be slightly more prevalent in men across age groups.[26] Among NH residents differences are small (26% and 23% among male and female NH residents, respectively), although it is unknown how sex may affect overtreatment and deprescribing.[27] Second, our focus on administered medications led to an inability to distinguish between (1) clinician-ordered dose changes in short-acting insulin and (2) dose changes due to different fingerstick readings in residents receiving sliding scale insulin. For short-acting insulin, we focused on initiation or discontinuation; thus, our result may underestimate deintensification if clinicians were ordering decreased doses of scheduled short acting insulin. However, since the short-acting insulin category only made up 16% of our cohort, we believe this effect is unlikely to substantially impact our overall results. Finally, as recently highlighted by Stasinopoulous et al.,[20] the lack of a standardized definition for over- and undertreatment complicates study in this area.

In conclusion, we found that overtreatment of T2DM is common in VA NH residents and that a minority of NH residents have their medication regimens appropriately deintensified. Based on our study results, it will be important to develop deprescribing initiatives in NHs at time of admission that use behavior change principles to overcome prescribing inertia in overtreated residents. Our results suggests that these initiatives should target NH residents at high risk for harms from overtreatment, including those with a history of hypoglycemia, high levels of functional dependence or cognitive impairment.

AUTHOR CONTRIBUTIONS

Lauren Lederle and Sei Lee contributed significantly to conception, design, analysis, interpretation, primary drafting, and revisions of the submitted manuscript. Bocheng Jing and Brian Nguyen contributed significantly to design, acquisition, and analysis of data as well as manuscript revisions and final approval of version submitted for publication. Michael Steinman made significant contributions to interpretation and presentation of data and contributed critical revisions as well as approval of the final manuscript.

ACKNOWLEDGMENTS

Dr. Lauren Lederle was supported by the VA Quality Scholars fellowship, through the VA Office of Academic Affiliations Advanced Fellowships Program. The content is solely the responsibility of the authors and does not necessarily represent the official views of the VA Quality Scholars or the Department of Veterans Affairs. The authors were supported by the following grants: K24AG049057, R24AG064025, P30 AG044281, K24AG066998, VA HSR&D IIR 15-434.

CONFLICT OF INTEREST

Dr. Michael Steinman receives honoraria from the American Geriatrics Society for his service as co-chair of the AGS Beers Criteria and royalties from UpToDate for chapter authorship.

SPONSOR'S ROLE

Funders were not involved in study design, methods, analysis, or manuscript preparation.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

Appendix S1: Supporting information.

How to cite this article: Lederle LI, Steinman MA, Jing B, Nguyen B, Lee SJ. Glycemic treatment deintensification practices in nursing home residents with type 2 diabetes. *J Am Geriatr Soc*. 2022;70(7):2019-2028. doi:10.1111/jgs.17735