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Feasibility of a Nursing Home Antibiotic Stewardship Intervention

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Abstract

Objective: To evaluate a bundled electronic intervention to improve antibiotic prescribing practices in US nursing homes.

Design: Prospective mixed-methods quality improvement intervention.

Setting and Participants: Nursing staff and residents in 13 nursing homes, and residents in 8 matched-control facilities (n = 21 facilities total, from 2 corporations).

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Supplementary Data

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Methods: This study involved a 2-month design period (n = 5 facilities) focused on the acceptability and feasibility of a bundled electronic intervention consisting of 3 tools, followed by a 15-month implementation period (n = 8 facilities) during which we used rapid-cycle quality improvement methods to refine and add to the bundle. We used mixed-methods data from providers, intervention tools, and health records to assess feasibility and conduct a difference-in-difference analysis among the 8 intervention sites and 8 pair-matched controls.

Results: Nurses at 5 pilot sites reported that initial versions of the electronic tools were acceptable and feasible, but barriers emerged when 8 different facilities began implementing the tools, prompting iterative revisions to the training and bundle. The final bundle consisted of 3 electronic tools and training that standardized digital documentation to document and track a change in resident condition, infections, antibiotic prescribing, and antibiotic follow-up. By the end of the implementation phase, all 8 facilities were using at least 1 of the 3 tools. Early antibiotic discontinuation increased 10.5% among intervention sites, but decreased 10.8% among control sites.

Conclusions and Implications: The 3 tools in our bundled electronic intervention capture clinical and prescribing data necessary to assess changes in antibiotic use and were feasible for nurses to adopt. Achieving this required modifying the tools and training before the intervention reached its final form. Comparisons of rates of antibiotic use at intervention and control facilities showed promising improvement in antibiotic discontinuation, demonstrating that the intervention could be evaluated using secondary electronic health record data.

Keywords

Antibiotic stewardship; nursing home; prescribing; deprescribing; electronic health record

Antibiotic stewardship represents a set of commitments and actions designed to optimize the treatment of infections and reduce adverse drug events associated with antibiotic use. In 2015, the Centers for Disease Control and Prevention (CDC) released guidance to support nursing home antibiotic stewardship programs (ASPs).[1] The following year, in 2016, the Centers for Medicare & Medicaid Services (CMS) revised the requirements of participation for the Medicare and Medicaid programs, so that nursing homes are now required to have ASPs.[2] The requirements specify that ASPs be part of nursing homes' overall infection prevention and control programs, include antibiotic use protocols and a system to monitor antibiotic use, and are led by an infection preventionist, most of whom are nurses.[3,4]

Guidance from CDC,[1] the Society for Post-Acute and Long-Term Care,[5] and the Society for Healthcare Epidemiology of America (SHEA)[6] is intended to help nursing home staff implement ASPs; however, most strategies are geared towards hospitals. One, proposed by SHEA, involves integrating computerized clinical decision support into the electronic health record (EHR) to inform antibiotic prescribing.[6] Although it is feasible to target such decision support at hospital-based prescribers, nursing homes face barriers to using EHRs[7,8] and nursing home prescribers are frequently off-site while making prescribing decisions. They therefore rely heavily on nurses' report of residents' change in conduction, rather than engaging with the EHR.[9] Computerized clinical decision support targeted to nurses instead of prescribers *does* hold potential; Katz et al. (2017), for example,

concluded that integrating pre-prescription clinical data collection into nurses' workflow and postprescriptive recommendations into prescribers' workflow were effective nursing home antibiotic stewardship strategies.[10] Using a structured approach to capture and summarize resident assessments may help nurses communicate with prescribers and mitigate the diagnostic uncertainty prescribers face when caring for nursing home residents—people who may not manifest typical signs or symptoms of infections or be able to describe symptoms they experience.[11]

CDC contracted with Brown University to develop and test an intervention to help nursing homes implement the antibiotic stewardship practices outlined in its *Core Elements of Antibiotic Stewardship in Nursing Homes*. With input from nurses, prescribers, and context experts, we created a bundled electronic intervention that ultimately consisted of 3 tools designed to integrate into nursing homes' pre- and post-antibiotic workflow. We present the results of a mixed-methods study to evaluate the effect of the final bundle on antibiotic use in nursing homes.

Methods

Study Design

We conducted a prospective quality improvement intervention to assess a bundle of 3 electronic tools to improve antibiotic prescribing practices in US nursing homes. The study included a 2-month design period (May and June 2018) to refine the proposed electronic tools using stakeholder nurses' input, followed by a 15-month intervention period to implement and evaluate the tools. The intervention included early (June-December 2018), middle (January-May 2019), and late phases (June-August 2019) (Figure 1), corresponding to changes made to the tools and training protocol.

Setting and Participants

Nurses at 13 nursing homes (5 pilot facilities and 8 intervention facilities) from 2 multifacility, multistate corporations in the Midwest participated in the project. The 8 intervention facilities implemented the intervention as an embedded quality improvement intervention, applicable to all residents with suspected or diagnosed infections. These staff were the frontline nurses (ie, registered nurses or licensed practical nurses) who participate in clinical charting and communication with prescribers (ie, physicians, nurse practitioners, physician assistants), or who supervise such communication (ie, nurse managers, directors of nursing) and use the information (eg, infection preventionists). An additional 8 facilities were designated matched controls based on days of antibiotic use in the year prior to baseline (2017), for a total of 21 facilities (n = 5 pilot facilities, n = 8 intervention facilities, and n = 8 control facilities).

Eligibility Criteria

Corporate eligibility criteria included (1) use of the PointClickCare EHR and (2) commitment of corporate leadership to randomize facilities to serve as intervention or control sites, provide resident-level data, and assign a corporate point of contact to train nursing staff at intervention sites.

Intervention

We used expert input and frontline nurse and nursing leadership feedback to design an intervention bundle consisting of 2 EHR tools (change in condition and antibiotic follow-up tools) that integrated existing clinical algorithms[10,11] for pre- and post-antibiotic review and a third, stand-alone tool (infection tracking log) that enabled staff to electronically track infections. During the design and early implementation phases, the bundle consisted of the 2 EHR tools[10,12]; recognizing the need to digitize clinical data needed for pre- and post-prescription review, we added the infection tracking log at one corporation in the middle implementation phase and at the other corporation in the late implementation phase. Together, the 3 tools standardized how nursing staff captured data necessary to identify and link the infectious episodes and antibiotic prescriptions that together defined episodes of care. The intervention was delivered by corporate trainers in the pilot and early implementation phases and with increasing research support (education, coaching, and site visits) to nurses in the middle and late implementation phases, because of low adoption.

The *Change in Condition Tool* captured information related to residents' initial presentation and organized the information to support structured nurse-prescriber communication (Supplementary Material). The nurse responsible for contacting the resident's prescriber completed the tool, which prioritized active monitoring when Loeb's minimum criteria for starting antibiotics were not met. When Loeb's criteria were met and an antibiotic might be indicated, even if that infection had not yet been confirmed by diagnostic testing, follow-up and prompting for antibiotic consideration were instead prioritized.[12,13] An initial version in the pilot phase focused on changes in condition related to suspected infections; based on pilot feedback, we broadened it to encompass all resident changes in condition (eg, gastrointestinal, soft tissue infections, oral and ophthalmologic, behavioral, cardiovascular, and neurologic changes, use of warfarin, international normalized ratio results) before the early implementation phase.

The *Antibiotic Follow-Up Tool* captured information regarding antibiotics prescribed for residents' changes in condition, including indications, start dates, and stop dates (Supplementary Material). Similar to the change in condition tool, this tool organized the information to support structured nurse-prescriber communication. The director of nursing or infection preventionist completed this tool 48 to 72 hours after any antibiotic initiation (regardless of whether or not the change in condition tool had been completed). Clinical situations that did not meet Loeb's criteria triggered an antibiotic review.[8,13,14]

The *Infection Tracking Log* (publicly available at brown.edu/go/infectionlog) standardized digital documentation of information necessary for tracking infections and antibiotic review that was previously captured by staff at participating facilities using paper logs. The *Infection Tracking Log* linked data necessary for review of antibiotic appropriateness, and (after iterative revisions throughout the late implementation phase) generated prescriber and facility graphs and a visual map of infections throughout the facility. The log was deployed by one corporation during the late implementation phase and was iteratively modified in GoogleSheets, whereas the other corporation used Microsoft Excel. The director of nursing or infection preventionist updated this log for every resident change in condition.

Data Sources

Descriptive—We characterized corporations and participating facilities using publicly available data from (1) LTCfocUS.org, a publicly-available Brown University database that contains aggregated information for all nursing homes nationwide from resident Minimum Data Set assessments and facility data state inspection data and (2) Nursing Home Compare, a Medicare website that rates nursing homes from 1 (worst quality) to 5 (best quality).

Implementation—We used qualitative feedback from nurses and directors of nursing to identify, prioritize, implement, and test revisions and additions to the bundled electronic intervention. We began with a design phase to refine the proposed tools before implementation. During the pilot and early implementation phases, we captured feedback via phone calls and site visits with nursing staff. In the middle implementation phase, as the result of low adoption, we added structured agendas and prompts to elicit staff feedback regarding barriers and facilitators affecting adoption, make changes, monitor adoption, and repeat the process of eliciting feedback. In the implementation phase, we also used monthly reports generated through the EHR to track submissions of the 2 EHR tools.

Evaluation—We used EHR data to assess the impact of the intervention on antibiotic use in intervention and control facilities. Data included clinical and prescribing information, specifically medication orders with starting and ending dates, dose, route, and indication for use. These data were used to define the infectious episode(s) for which 1 or more antibiotics were prescribed, to calculate antibiotic days of therapy (DOT), and to examine antibiotic use after review for early discontinuation. We linked files by resident and analyzed data in aggregate at the facility level.

Measures

Episode of care—An episode of care was the infectious episode for which 1 or more antibiotics were prescribed, calculated by identifying the period of time during which 1 or more antibiotics were prescribed with no more than a 3-day gap, until antibiotics were discontinued. This definition was used because nursing homes often begin a resident's antibiotic course with a substitute medication that is available on-site in a limited quantity, and then switch to the preferred prescribed antibiotic when pharmacy delivery occurs.

Antibiotic days of therapy (DOT)—Antibiotic DOT were total number of days on antibiotics for an episode of care, calculated by adding 1 day to the duration between the starting date of an episode of care and the discontinuation or the end date (whichever was earlier) of the last antibiotic order in an episode of care. We calculated DOT per 1000 resident-days, using methods similar to those previously described.[15]

Percentage of care episodes involving early discontinuation (primary outcome)—The percentage of care episodes involving early discontinuation were the proportion of episodes of care with discontinuation of an antibiotic prescription on a date earlier than the end date in the original prescription.

Analysis

Qualitative analysis—We used information from the structured conversations with nursing staff to identify, prioritize, implement, and test revisions and additions to the bundled electronic intervention. These calls were audio recorded and facilitated by 2 research team members, who took contemporaneous notes, identified preliminary themes using an inductive approach, and then discussed these themes with the broader investigative team and CDC project officers, to identify and act on identified barriers.

Quantitative analyses—We compared changes in total antibiotic DOT/1000 resident-days and antibiotic discontinuation at intervention and matched-control facilities between the first (June-August 2018) and last (June-August 2019) 3 months of the 15-month implementation phase. We used a difference-in-difference approach with generalized estimating equations to account for potential within-facility correlations. In our models, we included indicators of the study period and related interaction terms. We compared change in performance over time for the 2 study groups (intervention vs control). We completed all analyses using Microsoft Excel, IBM SPSS Statistics for Windows, version 24.0 (Armonk, NY), and SAS, version 9.4 (Cary, NC).

The Brown University Institutional Review Board provided a waiver of authorization for the use of protected health information for the period from January 1, 2017, through August 31, 2019.

Results

Nursing Home Characteristics

The 5 pilot sites had, on average, 79.0 beds, 85.3% occupancy, 4.0 star ratings, and 22.3% 30-day readmission rates (Table 1). The 8 intervention facilities were, on average, smaller than the control facilities (80.0 vs 90.0 beds), had a greater proportion of residents with Medicare (10.9% vs 7.5%), higher 5-star quality ratings (3.0 vs 2.0 stars), and lower 30-day readmission rates (18.0% vs 23.0%).

Implementation

During the design phase (May-June 2018), we used a train-the-trainer approach in which corporate trainers trained nursing staff. When vetting the proposed change in condition and antibiotic follow-up EHR tools, nursing staff said that they believed the proposed *Change in Condition* and *Antibiotic Follow-Up* EHR tools would be feasible to complete, feasible to incorporate into nursing workflow, and could improve communication with prescribers. However, they advised that the *Change in Condition* tool, which initially focused on suspected infections, be broadened to include all changes in resident condition to replace existing documentation requirements. The *Change in Condition* tool was therefore modified prior to the implementation phase.

A train-the-trainer approach was also used in the early implementation phase (June-December 2018) in the intervention sites. Nursing staff reported that, although the 2 tools were useful, they were time-consuming and duplicative. Probing revealed that most

nursing staff were continuing to enter progress notes into the EHR in addition to the *Change in Condition* and *Antibiotic Follow-Up* tools that were meant to replace additional documentation. In this phase, intervention sites submitted the change in condition an average of 1.7 times per month (range of monthly average: 0–3.7 submissions) and the antibiotic follow-up tool an average of 5.0 submissions per month (range: 2.1–11.3 submissions) (Table 2).

During the middle implementation phase (January-May 2019), we began providing direct support in the form of education, coaching, and site visits to nursing staff in addition to the train-the-trainer approach. This modification was made to overcome identified barriers, with training information not reaching nurses and as a result of low uptake of the tools. We also modified the *Change in Condition* tool to automatically generate an EHR progress note. During this phase, intervention sites submitted the *Change in Condition* an average of 5.6 times per month (range: 0–11.4 submissions) and the *Antibiotic Follow-Up* tool an average of 8.0 submissions per month (range: 1.4–13.4 submissions). Feedback from nursing staff indicated ongoing barriers to completing the tools, most related to gaps in real-time access to information. Nurses reported that they completed the tools during shift changes, which meant that they were completed after speaking with prescribing clinicians, not before, and those conversations did not benefit from the structured nurse-to-prescriber guidance the tools generated.

During the late implementation phase (June-August 2019), we added a computer-based infection tracking log to allow tracking of infection data in real-time. The final version of the log captured and linked the data necessary for nursing staff to track completion of the EHR tools, linked the tools with infectious episodes of care, and produced performance reports of antibiotic appropriateness at the prescriber and facility level. Nursing staff reported that the final intervention bundle (nowcomprising 3 tools) addressed their needs for real-time information prior to nurse-prescriber conversations, was feasible to complete, and supported antibiotic stewardship activities as part of their Quality Assurance & Performance Improvement (QAPI) programs. By the end of this 3-month period, intervention sites submitted the change in condition an average of 9.0 times per month (range: 0–30.7 submissions) and the antibiotic follow-up tool an average of 8.1 submissions per month (range: 0.7–18.0 submissions). Six of the 8 intervention sites were also using the infection tracking log.

Evaluation

Table 3 examines changes in antibiotic use outcomes between the first and last 3 months of the implementation phase (June-August 2018 vs June-August 2019) for intervention sites and pair-matched controls. Early antibiotic discontinuation demonstrated significant differences, with a 10.5% increase at intervention sites compared to a 10.8% decrease at control sites. Rates of total antibiotic use did not differ between the intervention and control sites.

Discussion

Our findings demonstrate the feasibility of implementing and evaluating an EHR-based intervention that documents and links clinical and antibiotic prescribing information for nursing home antibiotic review. Uptake of this bundled electronic intervention, while initially low, increased throughout a 15-month implementation phase, as we iteratively adapted the training and tools based on nursing staff feedback. We used a mixed-methods approach to monitor implementation, elicit nursing staff feedback, and test rapid-cycle changes intended to overcome barriers, such as the need to capture information for all changes in condition and the perception that the tools required double charting. Although finalized only 2 months before the implementation phase ended, the final intervention bundle is grounded in feedback from nurses about nursing homes' workflow and systems for monitoring changes in resident condition, suggesting that it may be possible to implement elsewhere and at scale. Early antibiotic discontinuation improved among intervention sites compared to the pair-matched controls, suggesting that the intervention may improve antibiotic review. Furthermore, our ability to conduct such an evaluation using EHR data demonstrates the feasibility of using pragmatic methods to test the final bundled electronic intervention in future trials.

Much of the evidence for efficacy of ASPs is based in acute care settings,[5] where the resources and infrastructure differ from nursing homes. Systematic reviews of nursing home ASPs attest to the promise of multifaceted interventions but describe interventions that frequently include on-site expertise or researcher-provided resources and support that cannot be readily replicated in routine clinical practice.[16,17] They also emphasize the importance of engaging frontline staff, integrating antibiotic stewardship tools into nursing home staff workflows, and of using data-driven approaches for monitoring and accountability.

To integrate antibiotic stewardship into routine care delivery, we created a bundled electronic intervention that digitized and linked the data necessary for antibiotic review. We focused on antibiotic review, rather than antibiotic starts, based on feedback from prescribers that changing initial prescribing decisions would be difficult; this decision is also supported by national guidelines for stewardship.[14] Although the clinical and prescribing information necessary for antibiotic review were routinely documented in participating nursing homes prior to this project, much of the documentation was in narrative format, not available as discrete data, or completed asynchronously, which prevented nurses from using it to structure their conversations with prescribers. Our bundle included tools that we embedded in the EHR to standardize documentation of necessary data and organize it for structured communication.[18] We also later replaced facilities' paper-based infection tracking logs with an electronic version, to enable staff, among other functions, to link data in near real-time. This bundle of electronic tools could prompt and support the antibiotic review process to optimize antibiotic prescribing practices, improve resident safety, and potentially be scaled.

Despite designing our intervention in collaboration with nursing staff, who repeatedly attested to its value and feasibility, uptake was low when we transitioned from the 2-month design phase to the 15-month implementation phase. This underscores the importance of multiple, iterative rounds of "on the ground" testing and feedback prior to launching an

intervention more broadly. the 2-month design phase time frame may have been too short to identify some of the implementation barriers we later encountered, many of which centered on workflow and training. Or we may have overestimated the intervention's feasibility and readiness for wider adoption, because we relied on nurses' general feedback during the pilot and did not formally measure adoption until the implementation phase.

Another lesson learned centers on the importance of training and engaging providers and being flexible and responsive to barriers that arise. We initially used a train-the-trainer approach, in which corporate nurses provided training to facility nursing staff. We elected to use this approach because it is commonly used by multifacility corporations (which account for approximately 60% of US nursing homes) to disseminate practice changes throughout their networks of facilities. Yet, when nursing homes began implementing the tools in the implementation phase, important information was not communicated to nurses at the participating facilities and perceived barriers were not reported back to us. Once we began to directly train frontline nursing staff and probed for feedback, we were able to better clarify expectations, modify the tools for better integration into nursing workflows, and add the infection tracking log—all of which likely contributed to increased uptake of the tools.

We note additional limitations. This feasibility study was not designed to establish efficacy. The analyses we conducted were intended to demonstrate that it was possible to evaluate the intervention using EHR data; a larger evaluation could include subanalyses that provide more nuanced understanding of implementation across facilities and corporations. The bundled electronic intervention and training protocol were not finalized until shortly before the end of the implementation phase. Additionally, although our qualitative data gave us insight into facility-level barriers and facilitators, these findings may not be generalizable. We need formal evaluation of antibiotic use rates and resident outcomes after a period of sustained adoption of the intervention, coupled with an implementation evaluation, and to explore how training can be delivered remotely with minimal researcher support. That said, our ability to calculate early antibiotic discontinuation using EHR data demonstrates that the intervention can be tested using pragmatic methods.

Conclusions and Implications

We demonstrated that a bundled electronic intervention to improve antibiotic stewardship was feasible for nursing home staff to adopt and for researchers to evaluate. Although uptake was initially slowed by barriers related to training and staff workflow, rapid-cycle quality improvement methods allowed us to make and test iterative revisions intended to ensure the final 3 tools reflected providers' needs. We recommend that others creating or deploying ASP interventions in this setting engage participants directly to elicit important contextual information that will inform intervention design and uptake, and use a similar, iterative approach that measures and demonstrates adoption to ensure feasibility and sustainability. Our approach may make it possible to effectively deploy and evaluate this bundled electronic intervention in additional facilities. We noted promising early antibiotic discontinuation that, with broader adoption, could translate into improved antibiotic use and care for nursing home residents.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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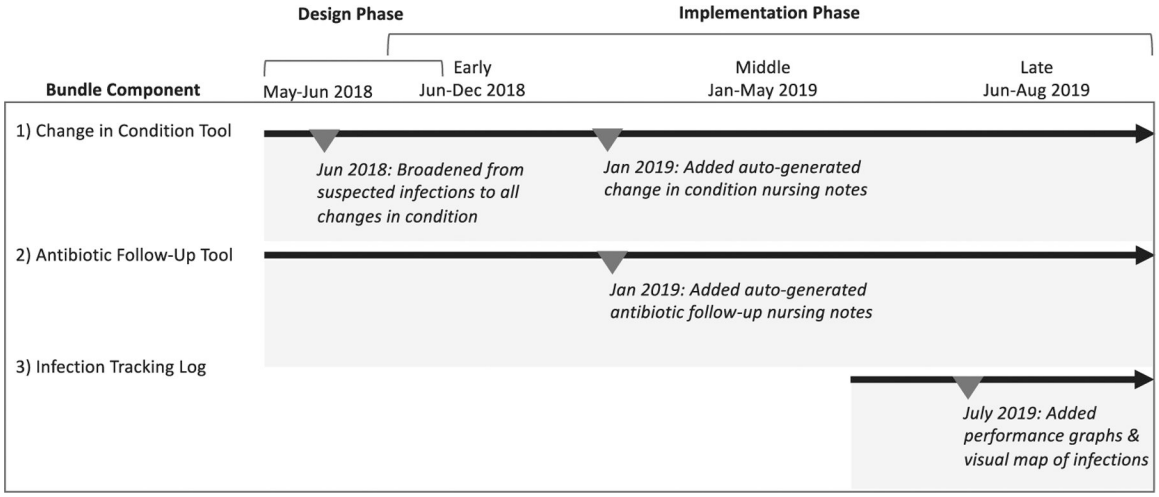

Fig. 1.

The bundled electronic intervention was developed in partnership with nursing home nurses during an initial design phase and then implemented in subsequent implementation phases, during which the bundled components were modified to address implementation barriers.

Table 1

Characteristics of Participating Nursing Homes, by Intervention Phase

Characteristic	2-mo Pilot Phase	15-mo Implementation Phase	
	Pilot Sites (n = 5)	Intervention Sites (n = 8)	Control Sites (n = 8)
Beds	79.0 (68.0)	80.0 (37.0)	90.0 (58.0)
Occupancy, %	85.3 (12.3)	71.5 (10.1)	68.2 (13.3)
Medicare	11.6 (6.3)	10.9 (7.1)	7.5 (7.6)
Medicaid	75.3 (12.4)	64.7 (12.8)	69.8 (18.9)
5-star rating, median (IQR)	4.0 (1.5–5)	3.0 (2.3–4.8)	2.0 (1.3–3.5)
30-day rehospitalization, %	22.3 (5.9)	18.4 (7.3)	23.1 (10.2)

IQR, interquartile range.

Unless otherwise noted, values are mean (standard deviation).

Table 2

Monthly Submissions of EHR Tools During the Implementation Phase (n = 8 Facilities)

Tool	15-mo Implementation Phase		
	Early (Jun-Dec 2018)	Middle (Jan-May 2019)	Late (Jun-Aug 2019)
Change in condition tool, mean (range)	1.7 (0.0–3.7)	5.6 (0.0–11.4)	9.0 (0.0–30.7)
Antibiotic follow-up tool, mean (range)	5.0 (2.1–11.3)	8.0 (1.4–13.4)	8.1 (0.7–18.0)

Table 3

Antibiotic Use Outcomes Among Nursing Homes Implementing the Intervention and Pair-Matched Controls, First vs Last 3 Months of the 15-Month Implementation Phase

Outcome	June-August 2018		June-August 2019		Difference, June-August 2018 to June-August 2019		
	Intervention	Control	Intervention	Control	Intervention	Control	*P* value
Antibiotic days of therapy per 1000 resident-days, mean	30.5	27.7	31.3	32.1	0.7	4.5	.5
% of care episodes involving early discontinuation, mean	26.6	37.7	37.1	26.9	10.5	−10.8	<.001