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Infection Trends in United States Nursing Homes, 2006 – 2013

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Abstract

Objectives—The objectives of this study were to estimate trends in the prevalence of infections in nursing home (NH) residents using 2006 – 2013 Minimum Data Set (MDS) data, estimate the number of all infections in 2013, and evaluate differences in trends between MDS versions 2.0 and 3.0.

Design—Retrospective study.

Setting—NHs in the United States.

Participants—All NH residents with a quarterly or annual MDS assessment in 2006 – 2013 (n=30,366,807 assessments).

Measurements—MDS 2.0 and 3.0 quarterly and annual assessment data (2006–2013) from over 15,000 NHs were used to estimate the 7-day prevalence of multidrug-resistant organism (MDRO) infection, pneumonia, septicemia, viral hepatitis, and wound infection and 30-day prevalence of urinary tract infection (UTI). Admission assessments were excluded. Annual infection counts were estimated using 2013 data. Changes in the prevalence of reported infections over time and differences in trends between MDS 2.0 and 3.0 were examined using tests of linear trends.

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Conflicts of interest: None.

Results—In 2013, there were an estimated 1.13 to 2.68 million infections in NH residents. UTI and pneumonia were the most commonly reported infections in every quarter ranging from 5.6 – 8.1% and 1.4 – 2.5%, respectively. Prevalence of all infections increased in 2006 – 2010 (P -values <0.01). In 2011 – 2013, prevalence of UTI, MDRO, and wound infections decreased and viral hepatitis increased (P -values <0.0001). Between MDS 2.0 and 3.0, the prevalence of UTI, MDRO, and wound infections decreased and the prevalence of viral hepatitis increased (P -values <0.0001).

Conclusion—Infections are a major and persistent problem in NHs. While MDS data are useful for identifying trends in infection prevalence, revisions in definitions need to be accounted for when evaluating trends over time. Additional research is needed to identify factors that contribute to changes in infection prevalence.

Keywords

nursing homes; long term care; infections; minimum data set

Introduction

Healthcare-associated infections (HAIs) are a leading cause of morbidity and mortality among nursing home (NH) residents in the US. In 2000, it was estimated that between 1.6 – 3.8 million occurred annually among the approximately 1.5 million NH residents.¹ However, these estimates were based on small cross-sectional studies conducted in the 1970's to 1990's. Using 2004 National Nursing Home Survey data, Dwyer et al. estimated that 12% of residents had an infection at the time of the survey.² In light of these data, there has been increasing focus on infections that occur in NHs. In 2013, the US Department of Health and Human Services updated the National Action Plan to Prevent HAIs: Road Map to Elimination to address HAIs that occur in long-term care (LTC) settings and recommended that baseline HAI incidence data be obtained.³ In 2012, the CDC launched the National Healthcare Safety Network (NHSN) LTC facility component that uses standardized HAI definitions for web-based infection surveillance. As of December 2016, almost 12% of the 15,700 NHs across the country had enrolled.⁴ And in 2016, the Centers for Medicare & Medicaid Services revised the requirements for LTC facilities; by November 2019 all facilities will be required to have an infection prevention and control program with a trained infection preventionist and that includes antibiotic stewardship and infection surveillance.⁵

In the US, recording resident health using the Minimum Data Set (MDS) is federally mandated for all residents of Medicare- or Medicaid-certified nursing facilities. Assessments are required at admission, quarterly, and upon significant change in status to broadly measure resident acuity level and functional status. The MDS serves as a source of information for reimbursement purposes as well as to assess individual resident needs, track changes in clinical status, and develop individualized care plans. The uses of MDS data have expanded since its introduction in 1990^{6,7} and studies assessing item reliability and validity have, overall, supported using these data to evaluate resident outcomes.^{8–14} Indeed, a number of studies have used MDS data to measure infection-related outcomes including the presence of venous ulcers,¹⁵ pneumonia,¹⁶ urinary tract infection (UTI),^{11,17,18} human immunodeficiency virus,¹⁹ *Clostridium difficile* infection (CDI),^{20–23} and antibiotic resistance.^{20,24}

In the absence of a widely adopted national infection surveillance system, the MDS currently provides the most comprehensive source of data to evaluate national infection trends in NH residents; however, revisions pose a potential problem for the development of trend estimates. The most recent version, MDS 3.0, was implemented in 2010 and includes significant changes in clinical items from MDS 2.0, which have been described elsewhere.^{25,26} A national test of MDS 3.0 items was conducted in 71 NHs and demonstrated very good to excellent reliability between research and facility nurse assessments and the items tended to perform better than equivalent MDS 2.0 items.^{27,28} In addition, items in MDS 3.0 that measure cognition, behavior, and mood were found to have improved validity compared with MDS 2.0 items.^{28–30} With the increasing focus on infections in NH settings and the need to assess baseline infection outcomes, the objectives of this study were to (1) estimate trends in the prevalence of specific infections in NH residents in the US from 2006 through 2013, (2) estimate the prevalence of all infections in NH residents in 2013, and (3) evaluate differences in infection trends between MDS 2.0 and 3.0.

Methods

Sample and setting

Routinely scheduled annual and quarterly MDS 2.0 (2006 Quarter [Q] 1 – 2010 Q3) and MDS 3.0 (2010 Q4 – 2013 Q4) NH resident assessment data were used. Admission assessments were excluded to reduce the likelihood of including infections present on admission to the NH. For most items, resident status is captured during a look-back period that varies depending upon the item (e.g., 7, 14, or 30 days). Infections that occur outside the MDS look-back period for routine quarterly and annual assessments do not consistently trigger significant change in status assessments because they might not meet all of the criteria.³¹ Therefore, infection prevalence was determined based on the routinely scheduled assessments. The MDS infection items evaluated were: antibiotic resistant infection/multidrug-resistant organisms (MDRO), pneumonia, septicemia, UTI, viral hepatitis, and wound infection. Additionally, infection items in the MDS 2.0 and 3.0 were examined and compared based on definition, look-back period, and response coding (see Appendix for detailed description).

Estimation of infection prevalence and evaluation of trends

To be consistent with MDS infection definition look-back periods, measures of prevalence were defined as 7-day prevalence for each quarter with the exception of UTI, which has a 30-day look-back period and, therefore, 30-day prevalence was estimated. Assessment-level linear regression models were used to estimate reported infection prevalence per quarter and, separately, to identify prevalence trends over time. Robust standard errors, clustered at the NH level, were calculated to account for correlation within facilities.

Using the most recent data available (2013 Q4), the total number of resident assessments during that quarter, and estimates of 7-day prevalence (30-day prevalence for UTI), we estimated the total number of infections in 2013. We extrapolated the data to approximate the number of infections that are not captured in the MDS because the routine assessments

are performed quarterly and the look-back periods are 7 and 30 days. These extrapolations were calculated assuming two infection durations: 1 week and 1 month.

Tests of linear trends over time were used to assess changes in infection prevalence over the MDS 2.0 and 3.0 periods, separately. We specified models that allowed for the shift from MDS 2.0 to 3.0 by including a separate intercept and time trend for MDS 3.0, and we tested for shifts (i.e., changes in the intercept) and differences in the time trends during the two periods. To account for the transition from MDS 2.0 to 3.0, and potential problems associated with the implementation of definitional changes and variations in data collection and reporting, the first four quarters of MDS 3.0 data (i.e., 2010 Q4 – 2011 Q3) were considered a “transitional period” and were not included in our analyses of trends.

A post hoc analysis was conducted to evaluate trends in indwelling urinary catheter use given its potential contribution to changes in UTI. The indwelling catheter item has a 14-day and 7-day look-back period on the MDS 2.0 and 3.0, respectively. Prevalence and tests of linear trends were estimated as described above for infections. All analyses were conducted in Stata, Version 12.0 (College Station, TX) and a significance level of 0.05 was set a priori. The institutional review boards at Columbia University Medical Center and RAND Corporation approved the study and a waiver of consent was obtained.

Results

Infection prevalence

MDS data from 32 quarters (15,122 – 15,228 NHs per quarter; $n = 30,366,807$ assessments total) were used to calculate the prevalence of reported infections. In 2013, there were an estimated 1.13 to 2.68 million infections in NH residents (Table 1). Table 2 summarizes the number of NHs, residents, assessments, and the infection prevalence for the fourth quarter of each year of the study period. Because some residents had more than one assessment within a calendar quarter, the number of assessments per quarter exceeded the number of residents. UTI was the most common infection in all time periods, followed by pneumonia; 30-day prevalence of UTI ranged from 5.6 – 8.1% and 7-day prevalence of pneumonia ranged from 1.4 – 2.5%, across all 32 quarters.

Infection trends over time

Table 3 and the Figure show trends in reported infections over time. Based on the MDS 2.0 data, from 2006 to 2010 there were increases in the prevalence of all infection types (P -values <0.01), with the greatest annual increase in infections for MDRO and UTI (0.049 and 0.046 percentage points per year, respectively). Based on the 2011 to 2013 MDS 3.0 data, there were decreases in UTI, MDRO, and wound infections over time and the prevalence of viral hepatitis increased (P -values <0.0001). The greatest annual change in infection was seen for UTI, with a 0.82 decrease per year. The prevalence of indwelling catheter use ranged from 5.1 – 5.5% across all 32 quarters and there was a 0.041 per year percentage point decrease across the study period (P -value <0.0001 ; data not shown).

There were differences in infection trends between MDS 2.0 and 3.0. UTI, MDRO, and wound infections decreased (-0.866 , -0.086 , and -0.050 percentage points per year,

respectively; P -values <0.0001) and viral hepatitis increased (0.028 percentage points, P -values <0.0001), after accounting for potential shifts in infection measures attributable to the revised MDS 3.0. A detailed summary and comparison of infection items in the MDS 2.0 and 3.0 are in the Appendix. Key changes in the revised MDS 3.0 were the definition of UTI, which included more specific signs or symptoms as well as evidence that the resident received UTI treatment, and the look-back period for active diagnoses (which includes the infections evaluated here). In MDS 2.0, active diagnosis items had only a single look-back period; equivalent items in the MDS 3.0 had two look-back periods: (1) a 60-day disease identification period and (2) a 7-day active diagnosis period (30-day for UTI) to determine if the diagnosis is active.

Discussion

In this comprehensive and nationally representative report we estimated that during 2013 there were between 1.13 and 2.68 million infections in NH residents. While this estimate is slightly lower than previous ones from before 2000 (1.6 to 3.8 million), it demonstrates that infections in US NHs are still a frequent and persistent problem.¹ Between 2006 and 2010, increases in reported prevalence were identified for all six infections evaluated; however, between 2011 and 2013, only the prevalence of viral hepatitis increased and UTI, MDROs, and wound infections decreased. Our finding that UTI and pneumonia were the most commonly reported infections is consistent with a previous NH survey conducted in 2004.² Furthermore, similar to the findings presented here, significant increases in the annual prevalence of antibiotic-resistant bacteria and CDI were identified using MDS data from 2000 – 2004²⁰ and, in a separate study, the quarterly prevalence of MDRO infection decreased from October 2010 to December 2011.²⁴

Viral hepatitis was the only infection with increasing prevalence across the entire study period. Centers for Disease Control and Prevention (CDC) reports of hepatitis outbreaks in LTC from 1998 to 2013 show that almost all outbreaks were related to hepatitis B virus acquisition resulting from patient-to-patient transmission due to breaches in infection control guidelines during assisted blood glucose monitoring.^{32,33} Furthermore, the CDC recently augmented hepatitis C virus screening recommendations to include those born between 1945 and 1965.³⁴ The MDS does not distinguish between hepatitis virus types so it is uncertain what drove the observed increases, however, they likely reflect outbreaks, an increasing burden of chronic hepatitis C virus infection in aging populations, increased surveillance as well as a cumulative effect of these chronic infections.^{35–37}

We identified shifts in the prevalence of all infections in the transition from MDS 2.0 to 3.0, and these shifts are likely a reflection of definitional changes. Unlike in the MDS 2.0, for an infection to be recorded in the MDS 3.0 both a documented diagnosis in the previous 60 days and a determination that the diagnosis is still active in the last 7 days (30 days for UTI) is required. Because disease diagnoses are subject to this 60-day identification look-back period as well as to the shorter active diagnosis status period, this would likely result in a change in the identification and recording of infections in the MDS 3.0. Additionally, some items included in both versions of the MDS had different definitions or response coding.

Therefore, observed trends between MDS 2.0 and 3.0 likely reflect definitional changes as well as true shifts in trends.

Of particular importance is the finding that UTI decreased following implementation of the revised definitions. While both sets of criteria required significant laboratory findings, MDS 3.0 criteria include more specific signs or symptoms as well as evidence that the resident received UTI treatment (see Appendix). UTI is repeatedly identified as the most commonly reported infection in NH populations^{2,11,38}; however, their diagnosis and treatment are often challenging.³⁹ Based on our results, implementation of more stringent UTI criteria in MDS 3.0 resulted in lower measured prevalence, suggesting that MDS 3.0 might have greater utility in correctly identifying patients with symptomatic UTI. However, because of the high prevalence of asymptomatic bacteriuria in NHs, it is possible that the prevalence estimates for UTI are still overestimated.³⁹ Also notable was the downward trend in indwelling catheter use in the MDS 3.0 data. Presence of an indwelling catheter is a major risk factor for UTI among NH residents⁴⁰ and the decline in indwelling catheter use likely contributed to the decline in UTI identified here. However, the decrease in indwelling catheter use was much smaller than for UTI and, furthermore, most UTI in NHs occur among residents without indwelling catheters.¹⁷ Together, this suggests that additional factors contributed to the decrease in UTI prevalence.

The MDS infection definitions are not consistent with the CDC-recommended HAI surveillance definitions for LTC.⁴¹ Furthermore, a national survey of 990 NHs conducted in 2014 reported there was substantial variation in how facilities define and track infections.⁴² There is a need in these settings for harmonization of surveillance definitions and methods of data collection and, as more facilities join NHSN LTC, it will be necessary to monitor the reliability and validity of reported data. However, until better data are available, the MDS provides the best and most comprehensive data to track infection trends.

This study had several limitations. First, it is possible that infections that required hospitalization and then re-admission were not captured because MDS admission assessments were excluded from the analysis to increase the likelihood that the results represent infections acquired in NHs (because MDS assessments record active diagnoses). Therefore, infections that occurred prior to the first quarterly assessment were excluded. Infections that require hospitalization are not readily identifiable using MDS data. Furthermore, although we accounted for the most common infections, the MDS does not have items for all infection types included in previous prevalence estimates (e.g., acute gastroenteritis). Overall, this likely resulted in an underestimate of infection prevalence. Second, infection prevalence estimates were based on routine assessments and did not account for infections that occurred outside of the 7-day (30-day for UTI) look-back period. Therefore, these estimates cannot be interpreted as quarterly infection prevalence, which would be expected to be higher depending upon the duration of the infection. We addressed this in the count of infections in 2013 by assuming that infections lasted 1 week or 1 month. Finally, although MDS coordinators receive training and are provided with guidelines and resources to help them complete assessments in an accurate and consistent manner, differences in how MDS data are collected and reported across facilities are likely to exist and might further compromise the interpretation of the results.⁴³ Despite these limitations,

our findings demonstrate that MDS data are useful for identifying trends in infection prevalence over time.

Conclusion

We identified substantial changes in the reported prevalence of all NH infections evaluated, and, to some extent those changes were likely attributable to definitional changes in the revised MDS 3.0. Furthermore, we demonstrated the utility of MDS data for evaluating infection trends in NH residents; however, MDS revisions need to be considered when evaluating trends over this time period. Harmonization of definitions used for infection surveillance and data collection is needed. Additional research should evaluate best practices for infection prevention as well as identify factors that contribute to changes in infection trends such as state and federal HAI reporting policies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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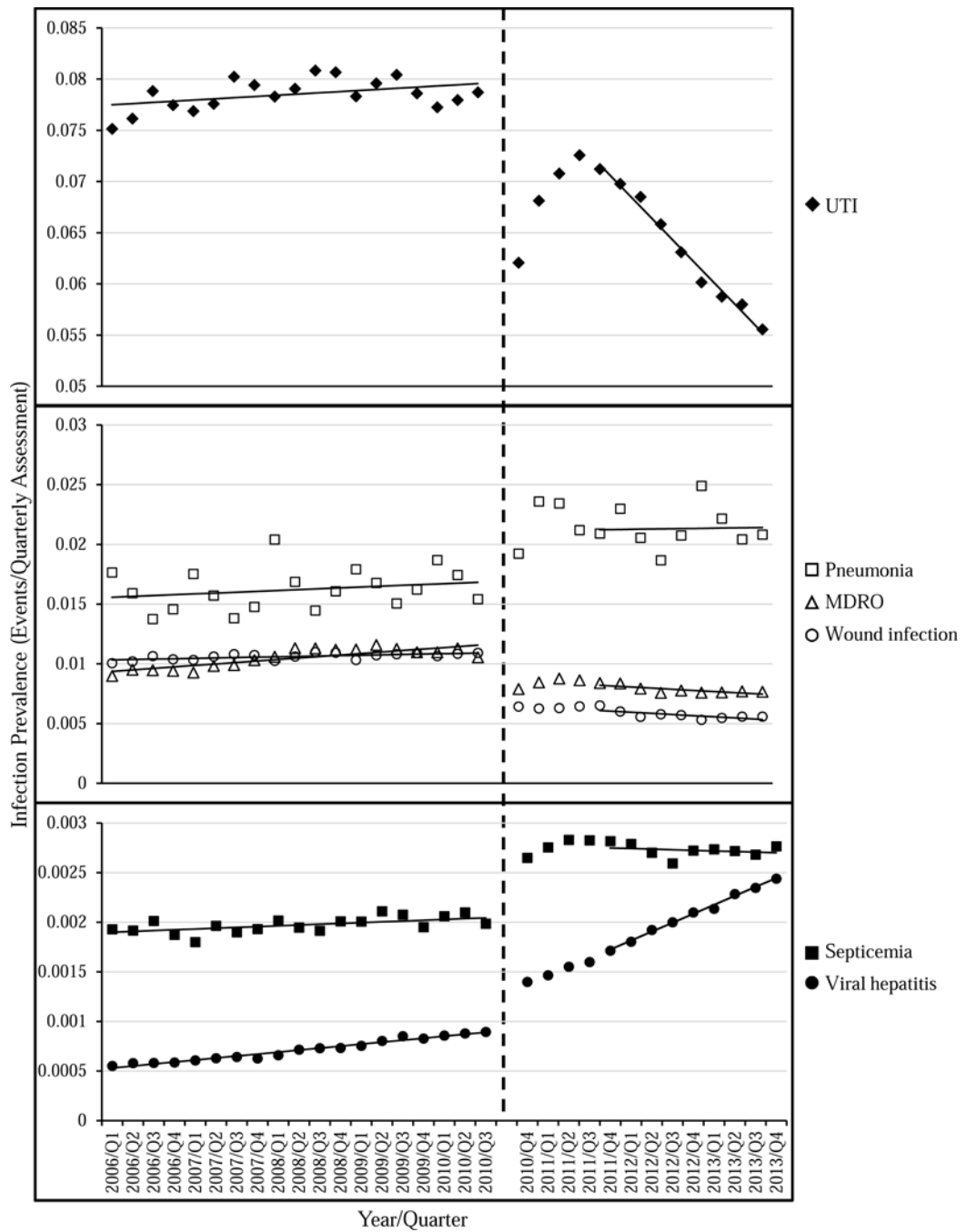


Figure. Infection trends among residents in US nursing homes, 2006 – 2013

Trends in the 7-day infection prevalence (30-day prevalence for UTI) among residents in US nursing homes from 2006 through 2013. Observed prevalence values are denoted by symbols and trends are shown as solid lines (the first four quarters of MDS 3.0 data were excluded from the trend analyses). The vertical dashed line represents implementation of MDS 3.0. Note the y-axis scale varies across panels. UTI = urinary tract infection; MDRO = multidrug-resistant organism; Q = quarter.

Table 1

Estimated Number of Infections in United States Nursing Homes in 2013

Infection type	Count of infections	
	Assuming 1 month duration	Assuming 1 week duration
UTI	660,553	660,553
Pneumonia	1,071,603	247,293
MDRO	394,131	90,953
Wound infection	287,203	66,278
Septicemia	142,314	32,842
Viral hepatitis	125,523	28,967
Total	2,681,327	1,126,886

Note: MDRO = multidrug-resistant organism infection; UTI = urinary tract infection.

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Table 2
Infection Prevalence in Minimum Data Set Versions 2.0 and 3.0 in Quarter 4, 2006 – 2013

Year, Quarter	Number of NHs	Number of residents	Number of assessments	% of assessments with diagnosis*					
				UTI	Pneumonia	MDRO	Wound infection	Septicemia	Viral hepatitis
MDS 2.0									
2006 Q4	15,185	916,688	968,086	7.75	1.46	0.94	1.04	0.19	0.06
2007 Q4	15,169	903,980	957,141	7.94	1.48	1.03	1.07	0.19	0.06
2008 Q4	15,145	886,705	947,551	8.07	1.61	1.12	1.09	0.20	0.07
2009 Q4	15,149	875,927	940,696	7.86	1.62	1.10	1.09	0.19	0.08
MDS 3.0									
2010 Q4	15,168	930,111	987,659	6.21	1.92	0.79	0.64	0.28	0.14
2011 Q4	15,205	928,533	1,000,527	7.12	2.09	0.84	0.65	0.27	0.17
2012 Q4	15,202	919,951	996,952	6.31	2.07	0.78	0.57	0.27	0.21
2013 Q4	15,210	908,985	990,519	5.56	2.08	0.77	0.56	0.27	0.24

Note: NH = nursing home; UTI = urinary tract infection; MDRO = multidrug-resistant organism infection; MDS = Minimum Data Set; Q = quarter.

* Estimates are the 7-day prevalence for each infection type except for urinary tract infection, which are the 30-day prevalence.

Table 3

Infection Trends in Minimum Data Set Versions 2.0 and 3.0

Infection type	MDS 2.0 (2006 Q1 – 2010 Q3) Linear Trend	MDS 3.0 (2011 Q4 – 2013 Q4) Linear Trend	MDS 2.0 and 3.0 Difference in Trend
	Annual change in % P-value	Annual change in % P-value	Annual change in % P-value
UTI	0.046 <0.0001	-0.820 <0.0001	-0.866 <0.0001
Pneumonia	0.028 <0.0001	0.009 0.51	-0.019 0.21
MDRO	0.049 <0.0001	-0.037 <0.0001	-0.086 <0.0001
Wound infection	0.013 0.0001	-0.038 <0.0001	-0.050 <0.0001
Septicemia	0.003 0.01	-0.002 0.56	-0.006 0.19
Viral hepatitis	0.008 <0.0001	0.036 <0.0001	0.028 <0.0001

Note: MDS = Minimum Data Set; Q = quarter; MDRO = multidrug-resistant organism infection; UTI = urinary tract infection.