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Determining Nurse Aide Staffing Requirements to Provide Care Based on Resident Workload: A Discrete Event Simulation Model

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A B S T R A C T

Background: Nursing aides provide most of the labor-intensive activities of daily living (ADL) care to nursing home (NH) residents. Currently, most NHs do not determine nurse aide staffing requirements based on the time to provide ADL care for their unique resident population. The lack of an objective method to determine nurse aide staffing requirements suggests that many NHs could be understaffed in their capacity to provide consistent ADL care to all residents in need. Discrete event simulation (DES) mathematically models key work parameters (eg, time to provide an episode of care and available staff) to predict the ability of the work setting to provide care over time and offers an objective method to determine nurse aide staffing needs in NHs.

Objectives: This study had 2 primary objectives: (1) to describe the relationship between ADL workload and the level of nurse aide staffing reported by NHs; and, (2) to use a DES model to determine the relationship between ADL workload and nurse aide staffing necessary for consistent, timely ADL care.

Design: Minimum Data Set data related to the level of dependency on staff for ADL care for residents in over 13,500 NHs nationwide were converted into 7 workload categories that captured 98% of all residents. In addition, data related to the time to provide care for the ADLs within each workload category was used to calculate a workload score for each facility. The correlation between workload and reported nurse aide staffing levels was calculated to determine the association between staffing reported by NHs and workload. Simulations to project staffing requirements necessary to provide ADL care were then conducted for 65 different workload scenarios, which included 13 different nurse aide staffing levels (ranging from 1.6 to 4.0 total hours per resident day) and 5 different workload percentiles (ranging from the 5th to the 95th percentile). The purpose of the simulation model was to determine the staffing necessary to provide care within each workload percentile based on resident ADL care needs and compare the simulated staffing projections to the NH reported staffing levels.

Measures: The percentage of scheduled care time that was omitted was estimated by the simulation model for each of the 65 workload scenarios using optimistic assumptions about staff productivity and efficiency.

Results: There was a low correlation between ADL workload and reported nurse aide staffing (Pearson = .11; $P < .01$), which suggests that most of the 13,500 NHs were not using ADL acuity to determine nurse aide staffing levels. Based on the DES model, the nurse aide staffing required for ADL care that would result in a rate of care omissions below 10% ranged from 2.8 hours/resident/day for NHs with a low workload (5th percentile) to 3.6 hours/resident/day for NHs with a high workload (95th percentile). In contrast, NHs reported staffing levels that ranged from an average of 2.3 to 2.5 hours/resident/day across all 5 workload percentiles. Higher workload NHs had the largest discrepancies between reported and predicted nurse aide staffing levels.

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Conclusions: The average nurse aide staffing levels reported by NHs falls below the level of staffing predicted as necessary to provide consistent ADL care to all residents in need. DES methodology can be used to determine nurse aide staffing requirements to provide ADL care and simulate management interventions to improve care efficiency and quality.

There is significant variability between nursing home (NH) staffing levels, which are now publicly reported annually.[1] This variability in staffing levels, has led multiple consensus groups to call for minimum staffing regulations at the federal level.[2,3] However, Centers for Medicaid and Medicare Services (CMS) has not yet adopted such regulations based on the rationale that staffing should be based on resident acuity and, hence, should vary between facilities. CMS has further called for efforts to develop objective acuity-based methods to determine staffing for individual facilities because it is not clear how or if NHs currently use resident acuity measures to determine staffing needs.[4]

There is a resident acuity system currently used to reimburse NHs for skilled nursing care; however, NH providers are not required by CMS to base their staffing levels on this system. The reimbursement system is based on resource utilization groups (RUGs), which uses data self-reported by NH providers related to the time required to provide care to residents with different characteristics as measured by the Minimum Data Set (MDS).[5] These data are converted into RUGs categories with different reimbursement levels. However, the RUGs data are also used to calculate expected staffing levels for all residents in long-term care and CMS publicly reports data for each NH that compares expected staffing to the actual staffing reported by the facility. Based on recent national data (November 2015), there is significant variability between NHs, with over 50% of facilities reporting staffing below the level projected by the RUGs as necessary to provide care to all residents.[6]

It is unclear why most NHs do not appear to be using the RUGs data to determine their staffing levels, although it should be noted that the RUGs system has weaknesses as a method to determine staffing needs. The most notable weakness is that the RUGs categories were developed based on data from multiple facilities whose time-to-provide-care data reflected routine NH care practices. Consequently, there were no assurances that the time-to-provide routine care met standards for acceptable quality.

This potential weakness in the RUGs system is particularly evident for care provided by unlicensed staff [ie, certified nursing assistants (CNAs)], who are typically responsible for the majority of activities of daily living (ADL) care to residents (eg, assistance with dressing, bathing, eating, toileting, and walking). Multiple studies have shown that documentation of ADL care provided by CNAs is erroneous and consistently overestimates the amount of care actually provided to individual residents.[7,8] Studies also have demonstrated frequent ADL care omissions at the unlicensed staff level and low staffing levels have been shown to be predictive of care omissions in both the NH and hospital care settings.[9–11] Furthermore, NH residents who need more labor-intensive care, as defined by requiring 2 nurse aides for assistance out of bed, are more likely to experience care omissions or, minimally, longer wait times to receive care.[12] Thus, suboptimal care frequencies and/or care omissions could have occurred in the context of these data, which would result in an underestimate of the nurse aide resources required for care provision.

There are alternative, more direct methods available to estimate staffing requirements based on resident care needs than the strategies previously used in the RUGs studies or other strategies used to infer staffing needs based on the correlation between staffing levels and outcomes self-reported by NH providers.[13] One of the most direct, objective methods is to use discrete event simulation (DES) modeling and work input data collected under defined care conditions that reflect acceptable care quality.

DES has been recommended as an important health management tool by the National Academy of Engineering and the Institute of Medicine and has been used in many health care settings including emergency rooms, operating rooms, out-patient clinics, and acute care wards.[14–19] DES does not involve creating mock data or predicting theoretical outcomes but, instead, takes known data and/or defined assumptions about care delivery to predict outcomes about care occurrence. Given accurate data about the required workload of a resident population, DES can be used to determine how many staff is necessary under different work efficiency scenarios, such as how staff and/or resident care is scheduled over the course of the day. The key workload data necessary to predict nurse aide staffing to provide ADL care include (1) the types of care required by the resident population based on ADL dependency (eg, level of staff assistance required for getting in/out of bed, toileting, eating); and (2) the time required to provide each aspect of care and the frequency and/or time of day the care should be provided (eg, toileting assistance every 2 hours throughout the day, feeding assistance during regularly scheduled meals).

Staffing simulation modeling techniques were first applied to the long-term care setting in a 2001 report to CMS.[20] This original staffing simulation modeling showed that a range of 2.8 to 3.2 nurse aide hours per resident per day (HPRD) was needed to provide all scheduled care in NHs with lower (ie, fewer residents in the workload categories that required time intensive ADL assistance) to higher workloads.[20]

The staffing simulation model used in this prior study has since been updated and applied to the current study to estimate care omissions in 13,533 NHs nationwide, which are representative of a full range of staffing and ADL workload categories based on MDS data from 2008 to 2014. The ProModel simulation software, which was used in both this and the original CMS study, also has been applied to numerous health care settings and details about the technology is described in Simulation Using Promodel, 3rd edition.[21]

The intent of updating and re-applying the staffing simulation modeling techniques to nurse aide staffing in NHs is to describe an ADL acuity-based staffing system that could use quarterly staffing reports to estimate care quality based on residents' ADL care needs, which are also measured quarterly via the MDS. Per the recommendation of both CMS and multiple consensus groups, the methodology described in this study offers an objective, acuity-based method driven by ADL care needs to determine nurse aide staffing requirements. The intent of this study is to illustrate the potential value of this approach and its application to the NH setting. The following research questions were addressed:

(1) What is the association between workload based on resident ADL care needs and nurse aide (NA) staffing data reported from 2008 to 2014, and does this association provide evidence that NHs are currently determining NA staffing levels based on resident acuity?

(2) What is the relationship between NA staffing levels and projections of care omissions based on the range of ADL care needs and average staffing levels reported from 2008 to 2014?

Methods

Setting

To determine resident ADL care needs, de-identified quarterly MDS data related to ADL dependencies (ie, MDS, section G, Functional Status, ADL Assistance) were requested from CMS for every NH in the United States from October 1, 2008 to October 1, 2014. Data were retrieved for 211,424 MDS quarters from 13,533 NHs nationwide. Two-quarters of MDS data during the transition from MDS version 2.0 to 3.0 were excluded from analyses. The combinations of ADL assistance residents received (section G, column 2, Staff Support) or performed (section G, column 1, Self-Performance) was identified with algorithms similar to those used in the original CMS study,[20] although minor changes were made due to the implementation of a revised MDS (version 3.0) since 2001. The MDS staff support and self-performance data were comparable in identifying the level of resident dependencies for each ADL care area so the self-performance data was used in the analyses. Each MDS item related to a resident's self-performance in ADLs is rated by staff as follows in section G0110 of MDS version 3.0: 0 = independent (no help or oversight needed); 1 = supervision (oversight, encouragement, or cueing); 2 = limited assistance (resident involved in activity, staff provided nonweight bearing assistance); 3 = extensive assistance (resident involved in activity, staff provided weight-bearing support); and, 4 = total dependence (full staff assistance every time activity occurred). In addition, there is also the option for a code of 8 to indicate that the activity was not performed at all by the resident or the staff during the week prior to the MDS assessment.

ADL Workload Categories and Nurse Aide Staffing Levels

The MDS item codes and scoring algorithms used to identify resident ADL dependencies for each of the 7 workload categories are listed in the second column of Table 1, while the other columns provide a description of the assistance required for each ADL within each category. For example, workload category 1 is comprised of residents rated by NH staff as completely independent (rating = 0) for toileting (MDS item G1I), eating (MDS item G1H) and morning/evening ADL care (MDS items G1G and G1J). Prior analyses showed that a resident rated by NH staff as completely independent in each of these areas also did not require repositioning assistance. However, all categories of residents, including category 1, were counted as requiring physical exercise to maintain their current level of functioning (ie, walking assistance for those who were ambulatory, range-of-motion for those who were wheelchair or bedbound). This subset of MDS items used to categorize residents (Table 1) was selected from the larger set of MDS items in section G0110 (functional status, ADL assistance, items A–J) based on prior analyses, which demonstrated that these items allowed for the categorization of all residents within the 7 workload categories because of highly significant intercorrelations between these items and the remaining MDS items in this section. Lastly, the numbers in parentheses (Table 1, column 1) reflects the percentage of residents in each workload category averaged across all NHs (eg, 3.6% category 1), which will be further described in the Results section.

To determine staffing in each of the 13,533 NHs, the self-reported nurse aide staffing levels were retrieved from the CMS Form 671, which reflects the annual staffing level during the 2-week period of the federally required survey. These annual staffing reports are expressed in the metric of total HPRD, which reflects the total nurse aide staffing hours available for each resident per day, as reported by NH staff.

Discrete Event Staffing Simulation Model: Analytical Approach

The rationale of the analytic approach applied in this study was to conduct simulations across the full range of staffing levels and the full range of ADL workload categories that characterize the nation's NHs to illustrate the relationship between nurse aide staffing and the likelihood of ADL care omissions. In addition, this analysis also illustrates how this approach could be used to project nurse aide staffing needs for individual NHs based on the unique ADL care needs of their resident population.

Identifying the Range of Workload Categories and the Time to Provide Care per Category

Table 2 shows each ADL care area in the first column followed by the workload categories of residents who require assistance in this area in the second column (ie, categories 1–7 from Table 1). The time to provide care (per resident per care episode) that is used in the DES model is shown in the third column, while the frequency of care and other relevant workload issues are listed in the fourth column of Table 2. Staff workload constraints, such as care windows, are described in a later section. The rationale and sources for the time data (Table 2) were first described in the 2001 CMS staffing report and are expressed in Table 2 as a triangular distribution (minimum, mode, and maximum values per resident per care episode) to reflect the inherent variability in the time to provide care to a frail NH population, many of whom have dementia. The literature supporting these time data have been updated based on more recent randomized controlled trials or other publications related to ADL care, although the original time data remained comparable in most cases. The references supporting the times used in this study are listed in Table 2 (column 3). If there were no studies that reported the modal time to provide care, limited preliminary data (eg, random events, staff travel time, bathing) were

Table 1
Definition of Resident Workload Categories Based on ADL Dependencies

Resident Workload Categories	Workload Description and MDS (Version 3) Algorithm	ADL Care Required				
		Incontinent Toileting Assistance	Repositioning Assistance	Eating Assistance	AM/PM Dressing Hygiene Assistance	Exercise or Range of Motion
1 (3.6%)	Lightest (MDS items G1I = 0; G1H = 0; G1G and G1J1 = 0)	No	No	No	No	Yes
2 (3.6%)	Light (MDS items G1I = 0; G1H = 0; G1G and G1J ≥ 1 but ≠ 8)	No	No	No	Yes	Yes
3 (1%)	Moderate (MDS Items G1I = 0; G1H ≥ 1 but ≠ 8; G1G and G1J ≥ 1 but ≠ 8)	No	No	Yes	Yes	Yes
4 (21.2%)	Heavy (MDS items G1I ≥ 1 but ≠ 8; G1H = 0; G1G1 and G1J ≥ 1 but ≠ 8)	Yes	Yes	No	Yes	Yes
5 (60.2%)	Heaviest (MDS G1I ≥ 1 but ≠ 8; G1H ≥ 1 but ≠ 8; G1G and G1J ≥ 1 but ≠ 8)	Yes	Yes	Yes	Yes	Yes
6 (1.4%)	Moderate (MDS Items G1I ≥ 1 but ≠ 8; G1H = 0; G1G and G1J = 0)	Yes	No	No	No	Yes
7 (7.9%)	Heavy (bedbound) (MDS item G1B = 8)	Yes	Yes	Yes	Yes	Yes

AM/PM care, morning and evening care, respectively, to include (un)dressing and personal hygiene assistance.

Table 2
Time to Provide Care and Simulation Model Input Data by Resident Workload Category

ADL Care Area	Resident Workload Categories	Time to Provide Care Per Resident Per Care Episode Triangular Distribution	Required Care Frequency/Care Delivery Window
AM/PM care	Categories 1 and 6 (Completely independent)	Minimum: 1 minute Mode: 2 minutes Maximum: 3 minutes	×2 per day 4-hour care window Receives OT – 0 minutes
AM/PM care	Categories 2–5, and 7 (Supervision to total dependence)	Minimum: 8 minutes Mode: 11 minutes Maximum: 14 minutes (Source[22–24])	×2 per day 4-hour care window Receives OT– 0 minutes
Bathing	All categories	Minimum: 10 minutes Mode: 15 minutes Maximum: 20 minutes (Source[20,25])	1-×2 per week (or, every 4th day) 8-hour care window, which expires at 10 PM
Incontinence care and/or repositioning	Categories 4–7 (Supervision to total dependence) (Exception is category 6, which only requires incontinence care and not repositioning)	Daytime care: 40% are toileted at: Minimum: 5 minutes Mode: 7.5 minutes Maximum: 10 minutes and 60% are changed at: Minimum: 3 minutes Mode: 5.5 minutes Maximum: 8 minutes OR Nighttime care: Minimum: 3 minutes Mode: 5.5 minutes Maximum: 8 minutes Repositioning without incontinence care: Minimum: 2 minutes Mode: 3.5 minutes Maximum: 5 minutes (Source[26–32])	Incontinence Care: ×8 per 24 hours 2-hour care window (day) 3-hour care window (night) Repositioning without incontinence care: ×3 per 24-hours to yield a total of 11 repositioning episodes (8 combined with incontinence care + 3 repositioning alone)
Meal set-up only	Categories: 1, 2, 4, and 6 (Independent in eating)	Minimum: 0.3 minutes Mode: 1.2 minutes Maximum: 2.2 minutes	×3 per day 2-hour care window
Eating assistance	Categories 3, 5, and 7 (Supervision to Total dependence in eating)	For 1:3 ratio in dining room or other common area: 50% receive 7,15, and 32 minutes 22.5% receive 1,3, and 20 minutes 27.5% receive .3, 1.25, and 2.2 minutes for meal set-up only (Source[33–36])	×3 per day 2-hour care window
Walking exercise	Categories 1–3 (Independent in mobility)	Minimum: 10 minutes Mode: 15 minutes Maximum: 20 minutes (Source[37])	×3 per week 8-hour care window, which expires at 10 PM
Other exercise	Categories 4–6 (Requires mobility assistance)	Minimum: 4 minutes Mode: 8 minutes Maximum: 18 minutes (Source[26])	×3 per day (If provided with incontinence care, 2-hour window expires at 10 PM) Receives PT = 0 minutes
Range-of-motion only	Category 7 (Bedbound)	Minimum: 1 minute Mode: 2 minutes Maximum: 3 minutes	×3 per day 2-hour care window, which expires at 10 PM Receives PT = 0 minutes

AM/PM care, morning and evening care, which includes (un)dressing and personal hygiene; OT, occupational therapy; PT, physical therapy.

collected by the investigative team or original data was accessed to obtain the mode (eg, exercise, incontinence care, eating assistance). There were instances wherein published data showed different time estimates for some aspects of ADL care because of differences in the targeted resident population,[22] or oral hygiene was not included in ADL care or the timing did not capture the entire care routine.[23] In these cases, we generally used the lower time estimates for this report to reflect a conservative estimate; however, in all cases, the times used were within the reported ranges across studies. In a few cases, there were sparse data about the time to provide care (eg, range of motion exercise) so we used very low time estimates based on observations of usual care.

It is important to note that the time per resident per care episode shown in Table 2 reflects the staff time required to provide care consistent with federal regulations and the ADL care practices described in nurse aide training materials, as opposed to routine and/or self-reported NH care practices.[38]

The range of workload categories for each of the 13,533 NHs was determined by first calculating the total number of residents in each NH who met the criteria for each of the 7 workload categories shown in Table 1 for each quarter MDS data was available. Second, the staff time to provide care for residents in each workload category for each quarter was calculated by multiplying the modal time to provide care by the frequency of care provision and the number of residents in that category. For example, residents in workload category 1 were ambulatory and only required staff assistance with exercise for 15 minutes 3 times per week. Thus, if a NH had 20 residents who met criteria for category 1 based on the first quarter of MDS data available, the total staff time to provide exercise care per day for that NH was calculated as 15 minutes (mode), multiplied by 1 time per day for the 20 residents in the category to yield a total of 300 minutes per day on each of the 3 days exercise was provided. Workload was calculated for all days when care was scheduled to occur even if care was scheduled less than daily (eg, walking exercise and bathing). The third step in this process was to divide the total number of minutes residents required care across all 7 categories in each NH by the census (ie, total resident population short-stay + long-term care), which generated the average care time each resident required per day, per quarter.

It is important to note that this conservative approach ignores the variability in time to provide care as well as staff travel time (ie, amount of staff time required to walk from one resident's room to another or to transport a resident from their room to the dining room for meals) and other important factors that influence the ability of staff to provide care (see Simulating the Relationship of Staffing to Care Omissions). However, this approach still provides a valid method to rank NHs in order based on workload. Simulations were then conducted for NHs with workloads that included the full range to include the 5th percentile (low workload) to the 25th, 50th, 75th, and 95th percentiles (high workload).

Determining Workloads for NHs within Each Percentile Ranking

Because there were 13,533 NHs, each of which generated multiple quarterly MDS data, there were multiple NHs within each percentile ranking (ie, 5th to the 95th percentiles) that were similar in their overall workload score for a specific MDS quarter but which could differ in the distribution of residents across the 7 workload categories. Thus, data within each workload category was averaged across all of the NHs within each percentile ranking to identify a facility that was representative of the types of residents that fell into that percentile ranking.

Identifying the Range of Staffing

The staffing levels used in this study are reported as the number of nurse aide HPRD, as this is the same metric required by CMS for NHs nationwide via publicly reported data, as described previously. The range of nurse aide staffing HPRD reported for the sample of 13,533 NHs ranged from 1.6 to 4.0; thus, total nurse aide staffing levels from 1.6 to 4.0 (excluding outliers) in 0.2-hour increments (to yield 13 total staffing levels) were simulated for each workload percentile ranking. For example, simulations were conducted for NHs within the 5th workload percentile for 13 different staffing levels, and these simulations were repeated at each staffing level for the NHs within the 25th, 50th, 75th, and 95th percentiles to yield a total of 65 different workload–staffing scenarios. Each of these scenarios reflects a different workload and staffing level that captured the full range of possible workloads and staffing levels based on the reported quarterly MDS data for this large sample of 13,533 NHs.

Simulating the Relationship of Staffing to Care Omissions

A major advantage of staffing simulations is that inputs defining a work scenario are transparent and can be easily varied to determine how outcomes would change if different work factors were in place (eg, less staff or different assumptions about work schedules, efficiency, or other events). In this study, we elected to simulate the same maximally efficient work environment for each of the 65 different work scenarios, which varied only staffing levels and resident ADL acuity. In short, a conservative model was designed to simulate a work environment in which the most care could be provided, given different levels of both staffing and resident acuity. Each scenario assumed a 100-bed facility with a H shaped floor plan (2 long halls around nursing station), as this is a typical plan of NHs nationwide.

In regard to staff efficiency, it was assumed staff spend all of their time providing care with exception of a 30-minute food break, and staffing was distributed across shifts to minimize omitted care. In addition, all residents except the bedbound ate in common areas so that the most efficient form of assistance could be provided (1 aide to 3 residents responsive to assistance).

In regard to patient acuity, it was assumed there were no residents who required 2 person assists and that residents receiving either occupational therapy or physical therapy did not require ADL assistance in the morning by CNAs or exercise during the day delivered by CNAs. Similarly, residents with catheters were not scheduled for incontinence care.

The schedule for care was set to conform to regulatory guidelines (incontinence care every 2 hours during day) or research describing the care schedule that produced a positive outcome (eg, walking exercise for ambulatory residents). These schedules and care windows are listed in Table 2. Care was not counted as omitted if it occurred any time within the care windows. For example, lunch was not counted as missed unless assistance was predicted to occur 2 hours after the scheduled time.

Simulation Outcomes

Sixty-five different workload scenarios that varied 13 nurse aide staffing levels (range from 1.6 to 4.0 HPRD in 0.2-hour increments) for each workload percentile (5th, 25th, 50th, 75th, and 95th percentiles) were simulated using the input data described above. We report the results of 100 replications of the simulation for each work scenario reflecting 100 different 3-week periods because outcomes did not change with more replications, and 95% confidence intervals within the replications were low (ranged from 1.5% for high omitted care to 0.5% for low omitted care scenarios). The input variables that varied across the 100 replications included the order of unexpected events and the specific times required for care as defined by the triangular distributions (Table 2, column 3).

Multiple outcomes can be generated from each simulation replication, such as the amount of time a resident has to wait to receive scheduled care and the frequency of care omissions. For the purpose of this study, the primary outcome was defined as the percentage of care omission time across all scheduled ADL care activities. This number was calculated by determining the total amount of omitted care minutes in a simulation replication and dividing by the total number of minutes that care was scheduled. For example, if 1 scheduled incontinence care episode was missed and the time required for that missed care episode was selected by the simulation replication from the triangular distribution to be 7 minutes, then the missing care minutes would be 7. If all of the scheduled care for the day for that resident within the simulation totaled to 250 minutes, the percentage of omitted care would be about 3% for that resident on that day (ie, 7 missed care minutes/250 total care minutes). Thus, an outcome of a 50% rate of care omissions would mean that 50% of all scheduled care minutes were missed by the staff. This omitted care measure can be calculated per resident or across all residents in a given NH. The percentage of care omission times was averaged across all residents for each work scenario to derive a measure of omitted care for each of the 65 staffing level– resident acuity scenarios.[21]

Results

Relationship of Current Reported Staffing to Resident ADL Acuity

Table 1 (column 1) shows the percentage of residents in each workload category (number in parentheses) based on an average across all available, quarterly MDS data (2008-2014) for the 13,533 NHs. The distribution of residents across the 7 workload categories is similar to the distribution reported in the original CMS simulation based on 1996 MDS data even though there is evidence of increased resident acuity since that time. For example, a higher percentage of residents fell into the lower workload categories (Table 1, categories

1–3) based on the original 1996 MDS data (range 4%– 14%) relative to the current data (range 1%–3.6%). Most importantly, the majority of residents (98%) were captured by these 7 workload categories in both data sets. In this report, the 2% of the residents not captured in the 7 categories were placed in the lowest workload category (category 1) to conduct the simulations.

The workload of each NH per quarter was estimated by multiplying the number of residents in each category by the mode time to provide care for each ADL area (Table 2). The range of workload scores (ie, average total number of care minutes required per resident per day) across a total of 55,926 MDS quarters for which there also was a corresponding annual staffing report ranged from 73 to 158 minutes with an average of 137 (±13.8) total minutes per resident per day. The nurse aide staffing reports for these same NHs during the same quarters that workload data was available ranged from 1.6 to 4.0 HPRD (mean = 2.4). The Pearson correlation between the workload estimate for each NH and the nurse aide staffing reported for that NH was .11 ($P < .000$) reflecting a statistically significant low correlation.

Relationship of Staffing and Workload to Omitted Care

Simulations were conducted across the 65 different workload scenarios that varied 13 levels of staffing for NHs in the 5th, 25th, 50th, 75th, and 95th workload percentiles. The number of MDS quarters for which NHs were within each workload percentile ranged from 227 to 276, with over 220 different NHs contributing quarterly MDS data to each workload percentile. The average range of nurse aide staffing reported across the same percentiles for those quarters was low (2.3–2.5 HPRD) reflecting the low correlation between resident ADL acuity and nurse aide staffing levels.

Figure 1 shows the results of the simulations on the outcome “omitted care percentage” across the range of nurse aide HPRD, with each line representing a different workload percentile. For example, the average percentage of omitted care was approximately 38% for NHs in the lowest workload percentile (5th) for a given quarter if nurse aide staffing was 1.6 HPRD, which means that 38% of all scheduled care time was not provided by staff. So, for example, approximately 1 in 3 scheduled incontinence care events were missed in a NH with this workload and staffing level. A staffing level of 2.8 HPRD at the same workload percentile was necessary for the percentage of care omissions to fall below 10% (Figure 1).

NHs within the 2 lowest workload percentiles (ie, 5th, 25th) had a rate of care omissions under 10% when assigned a nurse aide staffing level of 3.0 HPRD. In comparison, the average staffing level reported for these NHs during these same quarters varied from 2.3 to 2.5 HPRD. During quarters in which NHs were at the 2 highest workload percentiles (ie, 75th and 95th), care omissions did not fall below 10% until nurse aide staffing reached a level of 3.6 HPRD or higher. In contrast, the actual average staffing levels reported for these NHs during these same quarters were 2.5 and 2.4 HPRD, respectively (Figure 1). Thus, with the exception of NHs within the lowest workload percentile (ie, average reported staffing of 2.3 and care omissions <10% at a 2.8 HPRD), most NHs within each of the workload percentile categories would result in care omissions well above 10% based on their actual reported nurse aide staffing levels (Figure 1).

Sensitivity Analyses of Key Work Scenario Variables

Sensitivity analyses in which input data is changed to reflect different unique work scenarios are typically conducted in simulation applications to examine the internal validity of the simulation model or to plan new management strategies. To illustrate this simulation feature, we reduced the time to provide all ADL care shown in Table 2 for NHs in the 50th workload percentile and staffed at the reported average (2.4 HPRD) by 10% and 20%. For example, the mode incontinence care time of 7.5 minutes was reduced by .75 minutes in the 10% reduction analysis and 1.5 in the 20% reduction analysis (or mode values of 6.8 and 6.0 minutes, respectively). The sensitivity analysis showed that the omitted care time percentages declined in these new work scenarios from 23% with the care times shown in Table 2 to 20% and 17%, respectively, for the 10% and 20% reduction scenarios. Alternatively, we reduced the time nurse aides had available to provide care from 7.5 hours to 7.0 hours per shift, which would more realistically model the effects of a meal break plus two 15-minute work breaks. This change resulted in a 4% increase in omitted care, which provides a more realistic estimate of care delivery if all nurse aides in a facility take all available breaks. Both of these sensitivity analyses demonstrate that the model results changed in the expected direction.

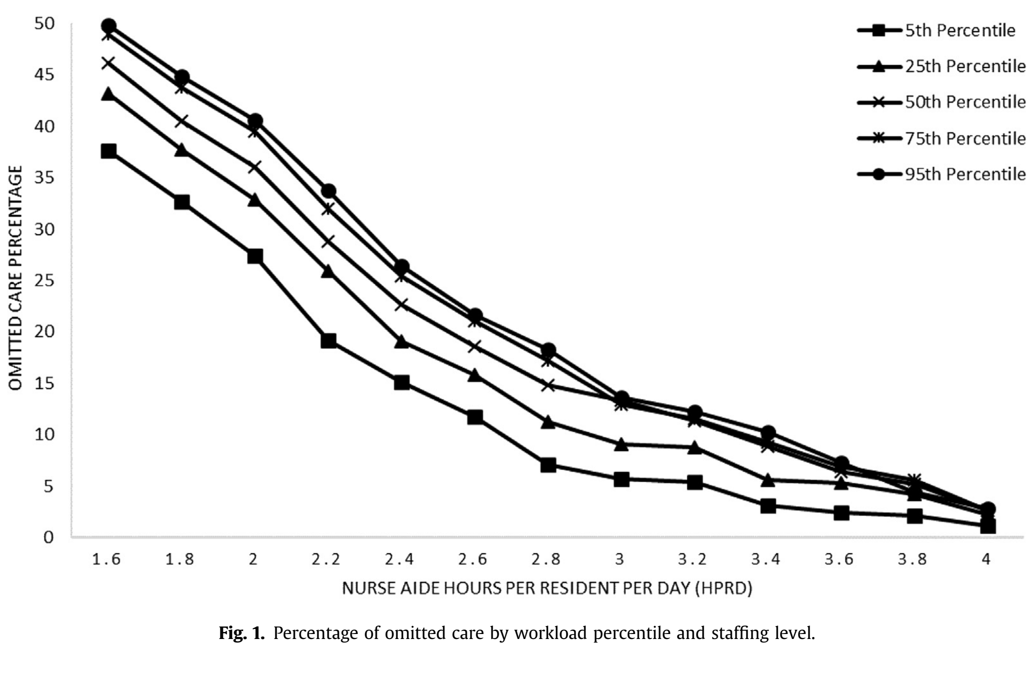

Fig. 1. Percentage of omitted care by workload percentile and staffing level.

Discussion

The methodology described in this study offers an objective, method to determine nurse aide staffing needs across a broad range of NHs with different levels of resident acuity as defined by varying ADL care needs. Results suggest that most NHs do not currently use acuity-based methods based on ADL care needs to determine nurse aide staffing levels. This is evident by the low correlation between nurse aide staffing and resident ADL workloads and the low range of staffing reported for NHs during quarters when their workloads ranged from the 5th to the 95th percentiles (2.3–2.5 HPRD).

The simulations suggest that average nurse aide staffing should vary between 2.8 HPRD during quarters when NHs are at the lowest level of resident acuity to 3.6 HPRD during quarters when NHs are at the highest level of resident acuity to maintain a rate of care omissions below 10%. It is important to recognize that most simulation methods do not attempt to reduce outcomes, such as care omissions, to zero because of the high costs of achieving perfection and 10% represents a somewhat arbitrary performance standard, which can be easily adjusted. In the current study, this rate of care omissions would translate into approximately 1 of 10 scheduled care episodes not occurring within the designated care window.

There are 2 immediate uses for this technology. First, individual NHs already report the quarterly MDS data necessary to calculate the 7 workload categories shown in Table 1, which capture 98% of the typical NH resident population. In addition, NHs soon will be required by CMS to report staffing data, which also will be audited by CMS for accuracy, on a quarterly basis instead of the current annual basis. Thus, the data necessary for NH providers to simulate staffing needs for an individual facility based on a specific MDS quarter, as done in this study, will soon be available, and NHs could use this acuity-based simulation method to determine staffing needs for an individual facility. If NHs believe the input data used in this study is not applicable to their facility (eg, feeding assistance times are too high), these input data can be easily changed as we demonstrated in the sensitivity analyses, although we should note that such time reductions should be defended because most of the care times reflect all components recommended in training manuals and/or demonstrated in clinical trials to improve outcomes. In fact, the advantage of the simulation approach is that all of the input variables can be adjusted to reflect the work processes of a specific facility and staffing projections can then be conducted with minimal costs. For example, additional analyses are currently being conducted to examine the impact of scheduling extra staff during high workload periods (eg, mealtimes) on care omissions. This type of simulation application can be used to illustrate the potential impact of quality improvement efforts (eg, hiring single task workers or part-time staff to overlap with certain shifts) on care outcomes prior to implementation.

The second major use of these data is to augment the public-reporting and regulatory compliance systems already being implemented by CMS for NHs nationwide. Current public-reporting systems do not provide information about the quality of care processes but, instead, focus more so on outcomes (eg, prevalence of falls or ADL decline). These outcomes, unlike the work processes that are the focus of this study, are impossible for NH consumers or federal/state surveyors to directly observe when visiting the NH. In contrast, the approach used in this study predicts that observable processes of care related to these outcomes will occur less frequently (to result in a higher rate of care omissions) in NHs with staffing levels that do not match their resident acuity levels. NH consumers likely are interested in knowing if staff will provide aspects of daily care, such as feeding assistance or incontinence care, on a timely basis. Both the frequency and timeliness of ADL care processes can be predicted via a simulation using known staffing HPRD and resident acuity and then observed by consumers and quality assurance personnel. Several publications describe how to conduct standardized observations of care quality.[8,39,40] For example, a NH staffed at the average of 2.4 HPRD but with high resident acuity (95%) would be projected to have high levels of omitted care, even with the most optimistic work assumptions (Figure 1, 22%).

There are several important limitations of this study. First, DES measures the capacity of a NH to provide care under specifically defined work conditions, all of which in this study maximized the efficiency and productivity of nurse aide staff. Thus, if the input data are not reflective of the actual work environment in a given facility, the rate of care omissions will be different from what is predicted by the model. Because we purposely designed a conservative model, this means that, in most cases, we would expect the actual rate of care omissions to be higher than what we presented here. Secondly, we were able to use realistic data that covered the range of actual staffing and workloads for NHs nationwide but otherwise used only a limited set of conservative assumptions to define the work scenarios used in the simulation, which could actually vary widely between different NHs. For example, it is likely that NHs vary widely in how much time nurse aides spend providing care, with more poorly managed facilities having higher nonwork times and more work breaks and, thus, a higher rate of care omissions.

Simulation models are typically designed to fit the unique work characteristics of a specific setting; however, many of the ADL care assumptions used in this study were defined based on regulatory guidelines, which will not vary between NHs (eg, incontinence care every 2 hours). It is much more likely that NHs will differ on measures of staff productivity (eg, how much time nurse aides spend on care delivery vs other tasks and/or breaks) or staff organization (eg, use of nontraditional staff to provide some aspects of ADL care, such as trained feeding assistants). Despite these qualifications, one would still not expect a NH with a high resident workload and low nurse aide staffing level to achieve a low rate of care omissions, even with the most optimistic assumptions about staff efficiency and other work input data.

In summary, using the simulation approach described in this study, it would be relatively simple to generate a report of the rate of predicted care omissions for each NH in the country based on their quarterly reports of staffing, resident ADL dependencies based on the MDS, and different assumptions about other work input variables that could realistically influence ADL care delivery. These data could be generated at an individual facility level and evaluated as to its usefulness to NH managers, federal and state surveyors, and NH consumers.

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