Research and Applications

Toward ensuring care quality and safety across settings: examining time pressure in a nursing home with observational time motion study metrics based on the Omaha system

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ABSTRACT

Background: Meaningful data to determine safe and efficient nursing workload are needed. Reasoning a nurse can accomplish a finite number of interventions and location changes per hour, examination of time pressure using time motion study (TMS) methods will provide a comparable indication of safe and efficient workload for an individual nurse.

Methods: An observer shadowed 11 nurses at a 250-bed nursing home in the Southeastern United States and recorded 160 h of observations using TimeCaT, web-based TMS data recording software. Predefined Omaha System nursing interventions (N = 57) and locations (N = 8) were embedded within TimeCaT. The time-stamped data were downloaded from TimeCaT and analyzed using descriptive and inferential statistics. Five time pressure metrics were derived from previous TMS findings in acute care settings.

Results: Overall, nurses spent 66 s for each intervention, performed 65 interventions per hour, stayed 130 s at each location, changed locations 28 times per hour, and multitasked for 29% of working time. Computed hourly time pressure metrics enabled visualization of variability in time pressure metrics over time, with differences in multitasking by licensure, unit/role, and observation session time.

Conclusions: Nursing home nurses consistently experienced a high degree of time pressure, especially multitasking for one-third of their working time. To inform staffing decision making and improve the quality of care, resident outcomes, and nurse satisfaction, it is critical to identify ways to mitigate time pressure. Additional research is needed to refine and extend the use of the time pressure metrics.

Key words: time and motion studies, time pressure, nursing homes, standardized nursing terminology

INTRODUCTION

Given that nursing homes serve 1.3 million residents in the United States1, it is alarming that over half of the nursing homes experience nursing shortages, and are unable to meet minimum staffing requirements.2 To ensure care quality and a safe work environment, the Centers for Medicare and Medicaid Services (CMS) established an initiative to reform the minimum nursing home staffing requirements and launched a nationwide staffing study.3,4 The initiative will require meaningful data to establish such standards.

Safe and effective staffing levels for patients have been largely studied using nurse-to-patient ratios and hours per patient day metrics.5-9 Nurses are highly likely to experience increasing workload, burnout, and job dissatisfaction when additional patients are assigned8,10; however, a safe and efficient workload for an individual nurse has rarely been examined. A nurse is a human being with personal limits and abilities, thus the nurse can safely and correctly execute a finite number of interventions and location changes within a given time limit.10,11 When nurses must provide many interventions within defined time constraints, they experience time pressure.12,13 High numbers of interventions and multitasking (time pressure) may lead to nurse burnout and turnover, poor quality of care, and negative patient outcomes.11,12,14 Furthermore, a high cognitive workload is inherent during multitasking and has been linked to clinical errors and adverse drug events.15-18 Metrics illuminating granular-level workflow data should be available to healthcare administrators and policy makers in order to better understand the safe and efficient workload for nurses and to establish optimal, safe staffing levels.

Time motion study (TMS) methods are ideally suited to examine time pressure by observing and quantifying nursing interventions and multitasking.19 Of 3 TMS methods: observational TMS, self-report study, and automatic timestamps; observational TMS has been widely used to capture
comprehensive workflow data.20 Using a standardized nursing terminology and digital software, Schenk and colleagues conducted continuous observational TMS in a 450-bed, non-profit acute care hospital located in California, where the state mandated nurse-to-patient ratios (Telemetry = 1:4; Medical-surgical = 1:5; Intensive care unit = 1:2).21–23 The average duration of interventions differed by nursing unit, ranging from 54 to 81 s (Telemetry = 81 s; Medical-surgical = 77 s; Intensive care unit = 54 s). The counts of interventions per hour ranged from 44 to 67 interventions per hour (Telemetry = 44; Medical-surgical = 47; Intensive care unit = 67).21–23 The average duration in a location ranged from 83 to 94 s (Telemetry = 83 s; Medical-surgical = 88 s; Intensive care unit = 94 s).21–23 Location changes per hour ranged from 24 to 35 (Telemetry = 24; Medical-surgical = 29; Intensive care unit = 35).21–23 Nurses multitasked from 11% to 16% of the time (Telemetry = 11%; Medical-surgical = 12%; Intensive care unit = 16%).21–23

Assuming these granular workflow data show an optimal amount of work for an individual nurse working at full capacity under optimal nurse staffing levels, a greater amount of work beyond these reference points may indicate that the nurse is likely to experience time pressure. A simulation study supports this assumption, which shows a significant increase in the number of pending nursing tasks and the walking distance when the nurse-to-patient ratio increases.10 The use of standardized terminology and digital software has enabled study of granular, standardized workflow data across settings.21–25 The standardized data provide a foundation for an assessment and a comparison of nursing workflow.21–23,25 which can be used for an analysis of safe and efficient nursing workflow by staffing levels. Even with variability by care setting, layout, patient census, patient acuity, different care needs of patients, and nurse competence, such data may provide a baseline and metrics for knowledge discovery related to time pressure for nurses in nursing homes.5

OBJECTIVE

Building on the TMS methods and the metrics from previous studies,21–23 this continuous observational TMS aimed to examine time pressure of licensed nurses working in a nursing home.

MATERIALS AND METHODS

Study setting

The setting was a 250-bed, nonprofit nursing home located in the Southeastern United States. The nursing home had 3 long-term care (LTC) units which provided nursing care and assistance with activities of daily living and 3 short-term care (STC) units which provided postacute care or orthopedic rehabilitation. During the study period, an average daily census of short-stay residents was 40 with an average 19 days of length of stay (LOS), while that of long-stay residents was 125 with an average LOS of 190 days. Compared to state and national averages, the nursing home had higher licensed practical nurse (LPN) hours per resident day (HPRD: total working hours per resident for a 24-h period; 1.23), and lower registered nurse (RN) HPRD (0.1).26,27 The average nurse-to-resident ratio (RNs and LPNs excluding unit managers and wound care nurses) was 1:12. Additionally, there were 3 wound care nurses providing daily wound care services for all units, 6 unit managers (2 RNs and 4 LPNs), and 1 wound care manager (1 RN) on duty during the 7 AM to 7 PM shift.

Ethical consideration and recruitment process

The study was approved by the University of Minnesota institutional review board (IRB) (STUDY00004543/MOD00011389). The administrator and the nursing director permitted a nurse researcher/trained observer (YK), who had 4 years of clinical experience in nursing homes to conduct the study and agreed to support nurse recruitment. Flyers introducing the study were posted throughout the nursing home to recruit day-shift nurses who were not unit managers. Before the observation sessions began, the nursing director identified nurses from the daily schedule for the observer. The observer reached out to those nurses and explained the purpose and procedures of the study and the monetary incentive. Nurses were informed that the study was only for academic purposes and irrelevant to their employment or performance review, and the participation was voluntary. When a nurse agreed to participate, the observer obtained verbal consent per university IRB protocol and started the observation. A monetary incentive ($20 gift card per session) was provided to nurses who participated in the study.

Observer training

To ensure validity of observation, an experienced Omaha System TMS researcher (KAM) provided training on the use of TimeCaT, web-based digital TMS data recording software to accurately record communication and task interventions and locations. Using interobserver reliability assessment (IORA) functionality within TimeCaT, KAM, and YK individually recorded their observations while simultaneously viewing 8 videos of nursing cases, which were frequently performed in nursing homes.28 For each joint observation, TimeCaT IORA calculated Cohen’s $\kappa$ value and the proportion of agreement between the 2 observers’ recordings. After 22 joint observation sessions, KAM and YK reached Cohen’s $\kappa$ value over 0.4 and proportion agreement over 60% for all 8 nursing cases, ensuring the accuracy of field data collection.28

Design

This continuous observational TMS was designed using the suggested time and motion procedures checklist as a framework.24 One external observer shadowed nurses and recorded all nursing interventions using TimeCaT.19 Fifty-seven previously validated Omaha System nursing interventions were embedded within TimeCaT (Figure 1).28 Time-stamped intervention and location data were downloaded from TimeCaT and analyzed using descriptive and inferential techniques.

Application of a standardized nursing terminology and digital software

The Omaha System has been successfully employed in the continuous observational TMS to define and observe nursing tasks in diverse care settings.21–23,25,28,29 The components of the Omaha System: Problem Classification Scheme and Intervention Scheme enabled structuring nursing interventions in a standardized format.30 Each Omaha System nursing intervention consisted of one each of 42 problems, 4 categories, and 75 targets. Detailed descriptions of nursing interventions were defined in the care description. This hierarchical structure enabled researchers to describe and compare interventions...
across care settings.21–23,25,28,29 The 57 Omaha System nursing interventions for nursing homes were refined and validated based on 66 interventions used in acute care settings with minor changes in a few care descriptions.28

Following conventions established in previous TMS, these hierarchical Omaha System nursing interventions were categorized as either communication or task and embedded in the interface of TimeCaT software for data collection.21–23,25,28,29 Figure 1 shows the interface of TimeCaT software, which enabled observers to record communication and task interventions with associated locations.19 Supplementary Table S1 describes definitions of each TimeCaT dimension: communication, task, and location. TimeCaT has been successfully used in various acute and community care settings.14,21,22,23,31–34

Time motion datasets
Time motion data were downloaded from TimeCaT. Separate datasets for interventions, transitions, and multitasking were created from the downloaded data. The intervention dataset included all the data points recorded as either 24 communication or 33 task interventions. Transitions referred to the moment when nurses stopped both communication and task interventions to move to a different location or switch to a different intervention. When the observer stopped recording communication and task interventions, TimeCaT automatically recorded the time as an item “other.” These data points were extracted from the downloaded data. When the timestamps of the data points from each dimension overlapped, the data points were included in the transition dataset. The timestamps of data points recorded as “break” under the location dimension were matched to the transition dataset. These overlapped data points were excluded from the transition dataset since these data points were breaks that did not involve any interventions. Similarly, when the timestamps of communication and task observations overlapped, the data points were included in the multitasking dataset.

Time pressure metrics
Duration and count of datapoints are unit measures available in the time motion datasets. Using these measures for each TimeCaT dimension, the following time pressure metrics as described above were computed: average duration of interventions,21–23 counts of interventions per hour,21–23 average duration in locations,21–23 counts of locations per hour,21–23 and percentage of multitasking time (Supplementary Table S1).14,21–23
These 5 metrics from the previous studies provided definitions and reference points for comparison; additionally, the metrics were computed every hour to examine variability over time between 7 AM and 7 PM.

Data collection
A total of 41 observation sessions were conducted during the weekdays between 7 AM and 7 PM from September 2019 to March 2020. The amount and the number of observation sessions aligned with or exceeded those of previous studies. Each observation session was 4 h. One observation session was 1.7 h due to a personal issue of a nurse, thus another 3-h session was conducted with the same nurse. Of 41 observation sessions, 13 sessions were conducted from 7 AM to 11 AM, 15 sessions were conducted from 11 AM to 3 PM, and 13 sessions were conducted from 3 PM to 7 PM.

The LPNs were observed for 21 sessions, while the RNs were observed for 20 sessions. Thirteen sessions were conducted with the STC unit nurses, 18 sessions with the LTC unit nurses, and 10 sessions were conducted with wound care nurses. According to the facility administrator, this wound care nurse model was implemented at the facility to reduce pressure ulcer events and time pressure for nurses working in LTC and STC units.

In accordance with best practices, the observer remained as unobtrusive as possible throughout the data collection. The nurses were only asked to briefly describe what they were doing when they were using a computer as part of their work. When the observer encountered the residents for the first time, the nurses introduced the observer to the residents as a researcher observing nursing workflow and asked the residents’ permission to observe. When nurses or residents requested privacy, the observer stopped observing and left resident rooms until invited to return.

The observer recorded time motion data using TimeCaT software on a hand-held tablet device. For example, when a nurse taught a resident about their medications while administering them in the resident’s room, the observer simply selected and deselected the relevant icons in the communication, task, and location sections of TimeCaT interface. Doing so, the observer recorded the beginning and end of the medication administration task intervention, the beginning and end of the patient teaching on medication communication intervention, and the beginning and end of time that the nurse was in the resident room location. Timestamps of all 3 dimensions were recorded when they began and ended, enabling measurement of multitasking when a communication intervention and a task intervention occurred at the same time.

Data analyses
Descriptive statistics were calculated for the overall average duration of interventions and locations; the counts of interventions and locations per hour; percentage of multitasking time. In addition, hourly averages for all calculated metrics were computed. We examined the degree of time pressure by licensure, unit, role, and session time using standard descriptive and inferential statistics at a significance level of 0.05. We used analysis of variance with Tukey HSD post hoc test for comparisons. We also created a heatmap and line charts to visualize the data. All analyses were performed in R (4.2.2), and visualizations were created in Tableau.

RESULTS
Eleven licensed nurses (4 RNs and 7 LPNs) participated in the study (Supplementary Table S2). The majority were female (91%) and over the age of 40 (73%), with 1–5 years of working tenure at the nursing home (46%). Over 75% of the RNs had a bachelor’s degree or higher, while about 30% of the LPNs had a bachelor’s degree. Nurses were observed for 160 h. Nurses performed interventions for 132 h (82.4% of total time); they transitioned between interventions or locations for 14 h (8.8% of total time); and they took breaks for 14 h (8.8% of total time). The final dataset of 146 h of observations consisted of intervention and transition time and excluded breaks.

Overall time pressure metrics were computed as per previous studies. Nurses performed 65 interventions per hour, spent 66 s (SD = 127) per intervention, changed locations 28 times per hour, stayed 130 s (SD = 253) at each location, and multitasked for 29% of working time. Compared to the averages computed from research in acute care settings (74 s intervention and location duration, 53 interventions and 30 location per hour, and 13% multitasking), the nursing home nurses worked at a faster pace in a location, and multitasked more than twice as much.

Interventions and locations
The nurses performed 9559 interventions (Communication = 4611; Task = 4948) and changed locations 4039 times (Supplementary Tables S3–S5). For communication interventions, the nurses frequently communicated with residents (N = 1191, 26%) and other nurses (N = 997, 22%). The lengthiest communication interventions were managing nonresident-related workflow (267 s/intervention) and documenting nursing notes (118 s/intervention). The wound care nurses performed lengthier communication interventions compared to other nurses (LTC = 57 s; STC = 62 s; Wound = 89 s, F = 20.3, P < .001) (Supplementary Table S3).

For task interventions, the nurses frequently performed hand hygiene (N = 951, 19%) and prepared medications (N = 791, 16%). The lengthiest task interventions were preparing medications (138 s/intervention) and performing wound care (133 s/intervention). The RNs performed lengthier task interventions compared to LPNs (LPN = 62 s; RN = 71 s, F = 6.8, P < .05) (Supplementary Table S4). The nurses frequently spent their time in the hallway (N = 1762, 44%) and resident rooms (N = 1007, 25%). The lengthiest location observations were in the med room (216 s/location) and team area (257 s/location). The wound care nurses spent more time in a location compared to other nurses (LTC = 125 s; STC = 113 s; Wound = 176 s, F = 16.4, P < .001) (Supplementary Table S5).

Hourly time pressure metrics
We examined variability of nurse time pressure over time (7 AM to 7 PM) by computing the average of time pressure metrics every hour (Supplementary Table S6). Intervention duration and counts did not differ by licensure, unit, role, or observation time. The average duration in locations per hour differed by unit/role (LTC = 167 s; STC = 144 s; and Wound = 319 s, P < .05) and session time (7 AM to 11 AM = 148 s; 11 AM to 3 PM = 170 s; 3 PM to 7 PM = 285 s, P < .05). The average percentage of multitasking time per hour differed by licensure (RN = 37%; LPN = 20%, P < .05), unit/role (LTC = 22%;
STC = 26%; and Wound = 46%, P < .001), and session time (7 AM to 11 AM = 36%; 11 AM to 3 PM = 25%; 3 PM to 7 PM = 27%, P < .05).

Tukey post hoc analyses showed that the average duration in locations from 3 PM to 7 PM was longer than those of 7 AM to 11 AM and 11 AM to 3 PM observations (P < .05). The average duration in locations of wound care nurses was longer than those of LTC and STC nurses (P < .05); likewise, the location counts of wound care nurses were lower than those of LTC and STC nurses (P < .05). The average percentage of multitasking time 7 AM to 11 AM was greater than 11 AM to 3 PM (P < .05). The average percentage of multitasking time of wound care nurses was greater than those of LTC and STC nurses (P < .05).

Figures 2 and 3 show time pressure metrics over time. Relatively longer intervention duration occurred between 9 and 10 AM and between 4 and 5 PM, and the fewest interventions occurred between 1 PM and 2 PM (Figure 2). The average percentages of multitasking time remained fairly constant over time in STC and LTC units (Figure 3). The LPNs multitasked less later in the day, while RNs multitasked more, and throughout the day. The wound care nurses multitasked the most, with increasing multitasking later in the day (Figure 3).

DISCUSSION

This study examined time pressure of licensed nurses in a nursing home using the 5 metrics derived from TMS observations employed TimeCaT and the Omaha System.\textsuperscript{21-23} Overall time pressure metrics showed a high degree of time pressure for nurses working in a nursing home in comparison with previous studies.\textsuperscript{21-23} Further exploration of hourly time pressure metrics showed the metrics remained constant and high from 7 AM to 7 PM. Further research is needed to identify whether these findings would be consistent in other nursing homes. There is potential to use these metrics in future studies to examine nurses’ perceived time pressure in comparison to time motion data\textsuperscript{34}; as well as quality of resident care and
resident health and safety outcomes relative to varying levels of time pressure.

The consistent use of the Omaha System and TimeCaT enabled researchers to compare time motion data across different care settings. Given the obvious differences in patients and care contexts across settings, the comparison with reference points derived from acute care settings offers only a preliminary estimate of time pressure in nursing homes. Three time pressure metrics: average duration of interventions, counts of interventions per hour, and percentage of multitasking time, exceeded the reference points from acute care nurses. Particularly, the counts of interventions observed in a nursing home exceeded those of community care settings and another acute care setting (postsurgical unit); and was comparable to the ICU where nurses constantly provided treatments and monitored critically ill patients. The nurses also multitasked 2–3 times as much in nursing homes compared to acute care settings. Given the pervasiveness of burnout and poor staff retention in nursing homes, the high levels of time pressure suggested by this study seem plausible. Especially concerning is the finding of multitasking for one-third of nurses’ working time, as multitasking is known to increase the risk of clinical errors.

The findings of differences in duration of interventions for wound care nurses showed that the nursing interventions related to wound care required more time, which aligns with previous TMS literature. The finding of greater multitasking time for wound care nurses may be related to the longer duration of wound care task interventions, and as such, more communication may be natural in wound care workflow. This suggests that multitasking as defined in this study should be further evaluated to determine the type of communications that occur during wound care task interventions vs. other task interventions. Further research is also needed to

Figure 3. Hourly trends of multitasking time pressure metric. (A) Average percentage of multitasking time per hour by nursing licensure over time. (B) Average percentage of multitasking time per hour by nursing unit/role over time.
examine time pressure in the absence of the wound care team. Such study may provide crucial information for workflow optimization in nursing homes.

The finding that only multitasking and location metrics differed significantly by observation session time when hourly time pressure metrics were compared was somewhat surprising, given the dynamic nature of the nursing home workflow and known high activity at the beginning of the day. Despite not differ statistically, heatmap patterns and line charts suggest nurses seemed to experience more time pressure from 7 to 11 AM as they performed more interventions in less time and multitasked while changing locations quickly. This aligns with the literature in that this timeframe included a morning round of medication administration which involved administration of numerous medications; and that nurses must complete medication administration rounds within constrained timeframes while calculating dosages, adhering to correct dispensing and administration methods, and dealing with resident refusals. A similar pattern, the greater number of briefer interventions and location changes, was observed between 5 PM and 7 PM when nurses completed the evening round of medication administration, hand-off reports, and unfinished work. This finding should be confirmed with more data from different nursing homes. To mitigate time pressure at times when multitasking and location changes are at their peaks, administrators should allocate resources and support to address the needs suggested by these patterns.

Findings also reflected the individual workstyles of nurses. For example, 1 nurse stayed in a single location to document nursing notes for an entire hour, likely causing the unusual peak between 4 PM and 5 PM. As more data become available to examine time pressure and variability over time, such individual patterns would be less likely to bias findings.

Given that a high cognitive workload is inherent during multitasking and has been linked to clinical errors and adverse drug events, further research is needed to understand the high levels of multitasking found in this study. Little is known about the nuances of multitasking; therefore, pairs of multitasked interventions should be examined by intervention type to find patterns in communication with residents, families, and coworkers, as well as workflow interruptions.

This study has limitations common to observational studies in a single setting. Despite the large amount of data and the alignment of study findings with the existing literature, the findings only describe nursing practice during the weekdays from 7 AM to 7 PM in 1 nursing home. Thus, generalizability of findings is limited, and further observational TMS in different types of nursing homes and shifts are needed. As with all studies that gather data through in-person observations, the Hawthorne effect may bias the findings. To address this potential bias, the observer followed recommended strategies to minimize the Hawthorne effect. There was further potential for the data to be biased due to technical difficulties or the refusal by nurses or residents. These threats were limited to 2 observation sessions in which data recording was momentarily interrupted due to unstable internet access, and 1 session in which a resident asked the observer to leave the room for privacy while the nurse provided wound care for 20 min. The observer stepped out and recorded these time segments as refusal. These segments accounted for 0.2% of the data; thus, the authors decided to exclude them from the data analysis. Another limitation of observational studies is that not all nursing interventions are physically observable. For example, cognitive interventions related to nursing diagnosis, care planning, and nursing note documentation may not be differentiable to the observer. To avoid interruptions during the observations, these differences were not clarified and were all recorded as nursing documentation. A more interactive or think-aloud study design would be needed to further investigate and differentiate such cognitive processes.

CONCLUSION

This study examined time pressure of licensed nurses in a nursing home using time pressure metrics. The study findings suggest evidence of a constant, high degree of time pressure for nurses in the nursing home, referencing ideal time pressure data derived from previous literature for nurses in various settings. The findings also demonstrate the value of standardized time and motion dataset using the Omaha System and TimeCaT to understand patterns in care by licensure, unit/role, and observation time. Findings provide a baseline for future study of time pressure toward improving the quality of nursing care, nurse satisfaction, and resident outcomes in nursing homes. Further examination of time pressure metrics under different nurse-to-patient ratios in various settings is needed in order to extend the knowledge of nursing workload and optimal staffing levels in diverse care settings with the goal of developing data-informed strategies to alleviate time pressures of nurses.

FUNDING

This study was supported by National Institute of Nursing Research of the National Institutes of Health under award number 2T32NR012715, Jonas Philanthropies, and the University of Minnesota School of Nursing Foundation.

AUTHOR CONTRIBUTIONS

YK designed data collection procedures, collected and monitored data, wrote the statistical analysis plan, cleaned and analyzed the data, interpreted findings, and drafted and revised the paper. CAM designed data collection procedures, monitored data collection, interpreted findings, and drafted and revised the paper. JEG designed data collection procedures, wrote the statistical analysis plan, and interpreted findings. KAM designed data collection procedures, monitored data, wrote the statistical analysis plan, interpreted findings, and drafted and revised the paper. MAM monitored data collection procedures, monitored data collection, interpreted findings, and drafted and revised the paper. YK designed data collection procedures, collected and monitored data, wrote the statistical analysis plan, cleaned and analyzed the data, interpreted findings, and drafted and revised the paper. CAM designed data collection procedures, monitored data collection, interpreted findings, and drafted and revised the paper. JEG designed data collection procedures, wrote the statistical analysis plan, and interpreted findings. KAM designed data collection procedures, monitored data collection, interpreted findings, and drafted and revised the paper.

SUPPLEMENTARY MATERIAL

Supplementary material is available at Journal of the American Medical Informatics Association online.

ACKNOWLEDGMENTS

The authors acknowledge the University of Minnesota, Center for Nursing Informatics.
CONFLICT OF INTEREST STATEMENT
None declared.

DATA AVAILABILITY
The data underlying this article will be shared on reasonable request to the corresponding author, YJK.

REFERENCES


