Use of a Real-Time Location System to Understand Resident Location in an Academic Medical Center

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ABSTRACT

Background There is great interest in understanding how residents spend their time in the hospital, but traditional time and motion studies are resource intensive and limited in scale.

Objective We determined whether a real-time location system (RTLS) that uses infrared emitting badges can be used to track resident time and location.

Methods Residents rotating on an internal medicine service in January 2018 were given the option to wear an RTLS badge. RTLS data were compared to the call schedule for each participating resident in a deidentified manner. Rules were created to identify work periods to be manually reviewed for data integrity. Reviewed work periods where there were extended periods of time without RTLS badge movement (eg, greater than 300 minutes) were excluded from analysis.

Results Data were collected from 18 residents and included 236 work periods (2922 hours). Based on prespecified rules, 146 work periods were included, representing 83% of total eligible residents (n = 15) and 82% of total hours recorded (2397 hours). Residents spent the highest percentage of their time in physician workrooms (44%, SD 15%), followed by ward hallways (25%, SD 7%) and patient rooms (17%, SD 7%). Several work periods were excluded because residents left their RTLS badge in physician workrooms after the work period ended.

Conclusions This study demonstrates the potential utility of RTLS to measure resident time and location in the hospital.

Introduction

There is great interest in how physicians spend their time in the hospital. Work hour restrictions on residents,[1] coupled with the rising costs of health care,[2] underscore the need to understand workflow and operational efficiency. There is also concern that physicians do not spend enough time with patients. Residents spend as little as 12% of their time at the bedside,[3,4] which contributes to diagnostic error, unnecessary testing, lower quality patient-physician relationships, and physician burnout.[5,6]

Traditional time and motion studies are resource intensive and limited in scale, as they require observers to follow residents throughout the work day. Automated measurements of work activities have validity evidence for use with nurses,[7] but few studies have been conducted with physicians. We used a real-time location system (RTLS) to measure the time residents spend in different locations in a hospital. Although RTLS does not provide information about specific activities, location data can inform questions about workflow and behavior.

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Editor's Note: The online version of this article contains a figure showing data collected by shift and individuals.

Methods

A convenience sample of residents on an internal medicine service at a large academic medical center in Baltimore, Maryland, in January 2018 were eligible for the study. Participation was voluntary and not compensated. The primary outcome was percent of time spent at each location in the hospital.

Observation Tool

We used the hospital's RTLS (Executone Systems, Metairie, LA) to track resident location during inpatient work periods. This system is used to track nurses and equipment. RTLS badges emit infrared pulses every 3 seconds that are detected by stationary receivers. Receivers continuously upload data to determine a badge's location to within 3 feet. Tracking is not possible outside of the hospital.

Each participant was provided with an RTLS badge at the beginning of the rotation and asked to attach it to personal property that is continuously on their body while in the hospital (eg, white coat).

Privacy Protections

Participants were randomly assigned a badge with a unique ID. One individual (A.K.B.) had access to a key linking badge ID and name. Participants could be identified by visualization of the tracking device on

TABLE 1
Summary Statistics by Shift

Statistic	Minutes	Hours
Mean	978.58	16.31
SD	482.32	8.04
Median	810.55	13.51
IQR	786.38	13.11
25th percentile	681.98	11.37
75th percentile	1468.36	24.47

Abbreviation: IQR, interquartile range.

their person, but badge numbers were not visible. Data were reported by badge ID and in aggregated form.

The Johns Hopkins Institutional Review Board deemed this study exempt from review.

Data Integrity and Analysis

RTLS data were compared to the call schedule for that month. Any shift where an individual was recorded arriving at the hospital 90 minutes earlier or later than expected was flagged for review. Any shift where an individual was recorded leaving the hospital 200 minutes earlier or later than expected triggered a review. A review consisted of looking at the RTLS data to evaluate if there was reasonable movement of the badge. For example, if the system recorded an individual in a single location for 300 minutes after their shift was supposed to end, it was likely that the badge itself remained in that location, but the individual had already departed (ie, the badge was left in a workroom). Any shift deemed invalid by a single reviewer was excluded.

Descriptive statistics were run to compare mean and variance for percent time spent in various locations. Wilcoxon signed rank tests were used to compare time in the hallway, patient room, and physician workroom. Analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, NC).

Results

Out of 34 eligible residents, 18 (52%; 12 PGY-1s and 6 PGY-3s) volunteered to wear an RTLS badge. Each badge and battery cost approximately $40.

Data were collected on 236 work periods (2922 hours). Two work periods were excluded because the resident was not on the medicine service. Of the remaining 234 work periods, 108 triggered a review and 88 were excluded. The most common reason for exclusion was a stationary badge for more than 300 minutes. Two residents had all of their work periods excluded. One hundred forty-six work periods were included (62%), representing 83% of original participants (n = 15), and 82% of total hours recorded (2397 hours). A figure detailing the available data is provided as online supplemental material. TABLE 1 provides summary statistics for included work periods.

TABLE 2
Statistics for the 3 Most Common Locations

Time (%)	MD Workroom	Ward Hallway	Patient Room
Mean	43.97[a]	25.16[b]	16.73
Median	48.08	25.00	14.65
Standard deviation	14.87	7.43	7.39
Variance	221.08	55.14	54.63
Range	59.19	27.59	32.14

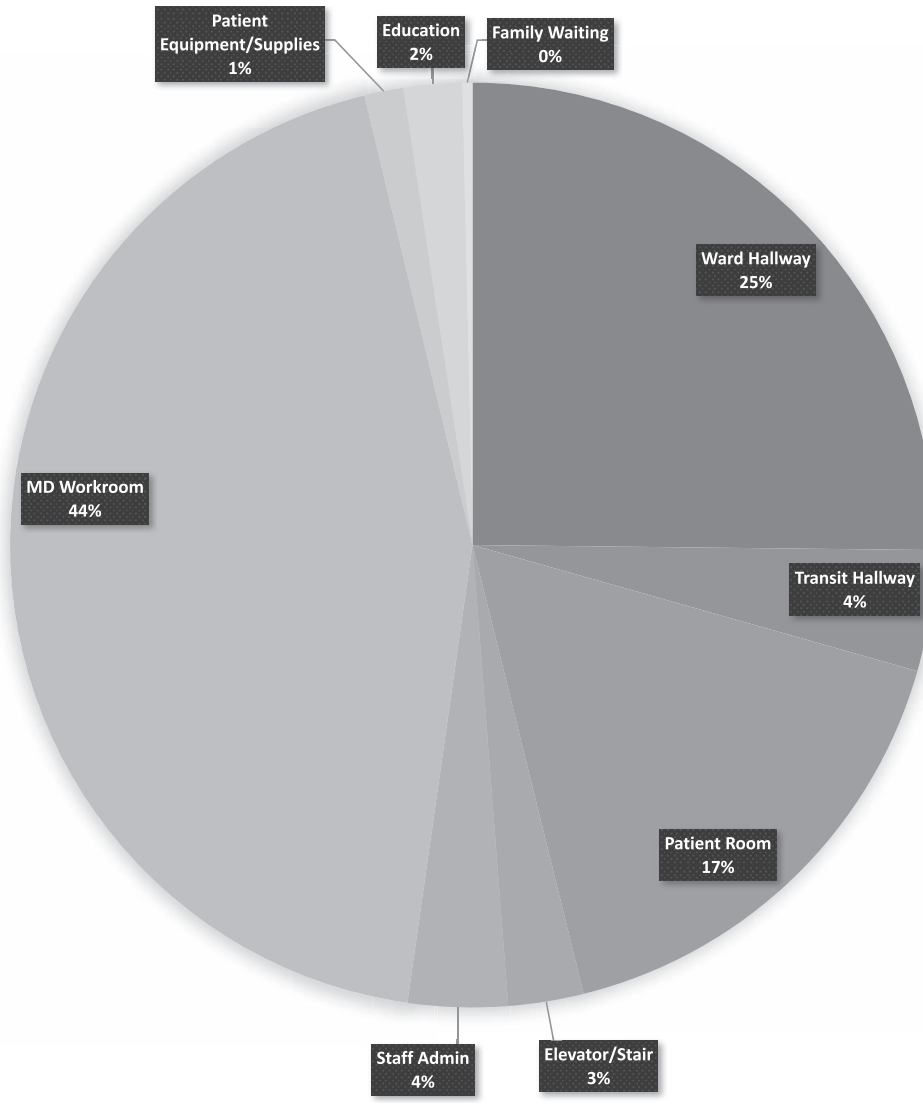
[a] $P < .0001$ MD workroom versus patient room using Wilcoxon signed rank test.
[b] $P = .002$ Ward hallway versus patient room using Wilcoxon signed rank test.

Residents spent the highest percentage of time in physician workrooms (44%, SD 15%), followed by ward hallways (25%, SD 7%) and patient rooms (17%, SD 7%). These percent times were significantly different (TABLE 2). The remaining categories each constituted less than 5% (FIGURE). The variance for percent time at the bedside was high at 54.6 (range 9% to 42%). Only 2 participants spent more than 20% of their time at the bedside. PGY-3s spent 18% (SD 10.5%) of their time at the bedside while PGY-1s spent 14% (SD 2.3%); this difference was not significant ($P = .07$).

Discussion

This study of an electronic tracking system to examine where internal medicine residents spend time in the hospital found that the majority of time was spent in physician workrooms and hospital hallways—not at the bedside. The tracking produced inaccurate information if the device was not worn consistently. To our knowledge, this is the largest time and motion study, in terms of collected hours of observation, conducted in graduate medical education. These results are in agreement with traditional time and motion studies that indicate less time is spent at the bedside compared to other activities.[3,4,8–11]

RTLS data could be used to improve the experience of residents and to examine the effectiveness of specific interventions. For example, time at the bedside could be compared to measures of physician burnout, clinical skill, patient satisfaction, test utilization, and cost of care. RTLS could also be leveraged to monitor work hours, understand resident workflow, and evaluate organizational ergonomics.



FIGURE

Representation of Residents' Percentage of Time in Hospital by Location

Note: Exit point category was excluded as it represented 0.03% of total time.

Advantages include ease of use, lack of recall bias, reduced Hawthorne effect, relatively low cost, and the ability to track large cohorts over extended periods of time.

The study findings are limited by the use of a small convenience sample of volunteers. Other residents may not be as reliable in wearing a badge. One inpatient floor and all outpatient locations lack sensors. These factors likely introduced error. We also had to exclude a sizeable number of work periods, likely related to improper wearing of the RTLS badges.

A major limitation is that an electronic tracker is unable to determine specific activities in a given location. For example, time in the patient room reflects a minimum amount of time that a resident could interact with a patient, but does not capture time spent with patients outside of the room. RTLS is unable to determine behavior outside the hospital. We do not know how much time residents spend in the electronic health record (EHR) via remote access.

In order to ensure accurate data collection, we are conducting a follow-up study in which RTLS badges are preattached to hospital ID badge lanyards to see if this decreases the number of shifts that are excluded. We will include EHR data to understand the amount of time residents work outside of the hospital. An additional question to explore relates to privacy: we did not ask residents whether this was a concern or factored into their decisions to not wear an RTLS badge.

Conclusion

A real-time location system offers a scalable approach to understand where residents spend their time in the hospital.

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