CONCISE REPORT

How much do beds and mattresses sleep around? Automated measurement of bed frame and mattress movement in an acute care hospital

Colin D Furness,[1,2] Jocelyn A Srigley,[3,4] Michael Gardam[5,6]

[1] *Faculty of Information, University of Toronto;*
[2] *Institute for Health Policy, Management, and Evaluation, University of Toronto;*
[3] *BC Children's & Women's Hospitals, Vancouver;*
[4] *University of British Columbia, Vancouver;*
[5] *University Health Network, Toronto;*
[6] *Faculty of Medicine, University of Toronto*

Corresponding Author:
Colin D. Furness, Faculty of Information, University of Toronto, 140 St. George St., Toronto, ON M5S 3G6, Canada
colin.furness@utoronto.ca

ABSTRACT

Hospital mattresses and bed frames are potential vectors for transmission of pathogens; however, data are lacking on the relative contributions of bed frames and mattresses to transmission or the magnitude of risk associated with bed and mattress movement. This proof of concept study describes the use of a real-time location system to track both bed frame and mattress movement in an acute-care hospital. The results provide a basis for future research to determine the associated risks of infection transmission.

KEY WORDS:
bed frame, mattress, RTLS, contamination, nosocomial

INTRODUCTION

Hospital mattresses and bed frames are potential vectors for transmission of antibiotic-resistant organisms (AROs) and other pathogens (1). Organisms that have been found to colonize bed components include methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), *Clostridium difficile*, *Acinetobacter baumannii*, and norovirus (2,3). Contamination may occur because of suboptimal cleaning or disinfection practices, resilient pathogens, and because mattress covers are permeable and susceptible to damage (4,5).

Little work has been done to study the capacity for beds and mattresses to contaminate each other, nor the relative role of bed frames and mattresses in ARO transmission as they are moved between patient rooms. Mattresses may be moved to different bed frames for a variety of reasons, including a need to repair or replace one but not the other, and a patient requiring a specialized mattress. Reasons for moving beds between rooms may include transferring patients between units, patient isolation for infection control, and other bed management or patient flow issues. However, there are limited data on the frequency of mattress and bed frame movement. The gap in existing research may be partly due to difficulties in continuously tracking the movement and exchange of mattresses and beds.

This study used a real-time location system (RTLS) in one ward of an acute care hospital to study the rate of exchange of mattresses between beds and the rate of movement of beds between patient rooms.

METHODS

A RTLS was installed in the multi-organ transplant ward of an acute care hospital in southern Ontario. The system used small transponders (see Figure 1) attached to equipment that emitted ultrasound pings at regular intervals, which were heard by a network of wireless receivers situated in patient rooms and hallways. Signals were processed by a geographical information systems engine, which computed movement, location, and proximity of tags to each other. A total of 59 bed frames and mattresses were outfitted with tags, as part of a larger pilot project to study the movement of patients, staff and equipment, and their implications for infection control policies and practices.

Conflicts of Interest: Dr. Furness discloses that he was an employee of Infonaut Inc., maker of the software used to track beds and mattresses in this research.

TABLE I: Bed and mattress tag attrition during study period

	Beds	Mattresses
Initial tagged inventory	+59	+59
Tag absent entirely during study period (all causes)	-11	-29
Tag absent for >5 days during study period (all causes)	-4	-2
Untagged mattresses that were able to be included		+18
Totals used in analysis	44	46

After verifying reliability of the system, data were collected for a 32-day period. Bed frame tags that never appeared or that disappeared were excluded from analysis. Any bed that was absent from the ward for more than five days (15%) of the study period was also excluded. Beds stationed in hallways were excluded from analysis.

Measurement was done by counting the number of mattresses each bed frame held during the study period. Mattresses without tags were included in analysis if they were never swapped, or if they were swapped before or after a tagged mattress. However, no instances of untagged mattresses being replaced by another untagged mattress could be tracked.

To measure the number of rooms that a bed visited during the study period, the number of room changes was counted rather than the number of unique rooms. For example, if a bed moved from one patient room to another and then back, this was counted as two changes (i.e., three rooms visited). If a bed left the ward and then returned to the same patient room, this was not counted as a room change.

RESULTS

Tag attrition data appear in Table I. Tag attrition had two main causes: first, several tagged bed frames and mattresses were moved off the ward and were replaced by non-tagged beds and/or mattresses. Second, several tags either fell off or were inadvertently removed by staff. Because fallen tags could not be re-attached to the same mattress with certainty, no re-attaching was done.

FIGURE 1: Ultrasound transponder (Sonitor Corp., Olso, Norway)

There were 41 bed frames (93.2%) that had only one mattress. One bed frame (2.3%) had two mattresses, and two bed frames (4.5%) had three mattresses. No bed frame had more than three mattresses during the study period.

Data for the rate of movement of beds between patient rooms are shown in Table II. A majority of beds (65.9%) visited more than one room during the study period (mean = 2.39; SD=1.26).

DISCUSSION

By tracking bed and mattress movement using a novel RTLS, we found that 93.2% of bed frames never had more than one mattress, but 65.9% of beds were found in more than one patient room over a 32-day period.

Beds and mattresses have been established as vectors of infection. They have been found to be colonized by microorganisms in experimental studies and during outbreaks, and colonization may persist despite cleaning (2). One study of hospital bed frames and mattresses found that 56.4% of bed frames and 84.6% of mattresses contained a variety of organisms after terminal cleaning (4).

Hospitalized patients have been shown to have a higher risk of acquiring MRSA or VRE if the previous occupants of their room were carriers of those organisms (6). However, the absolute risk was small, with MRSA transmission increasing from 2.9% to 3.9% and VRE from 2.8% to 4.5%. Prior room occupants accounted for few transmission events, with a population attributable risk of less than 2% for both organisms. It is possible that previous occupants of the bed and/or mattress rather than the room may be more predictive of transmission events. A more recent study found that patients were more likely to develop *C. difficile* infection in hospital if the prior bed

TABLE II: Frequency of rooms visited by bed frames

Number of rooms	Bed count	Percent of total
1	15	34.1
2	9	20.5
3	10	22.7
4	8	18.2
5	2	4.5
TOTALS	44	100.0

occupant had received antibiotics, with an incidence of 0.72% compared to 0.43% ($p < 0.01$) (7). However, there was no information provided on the relative contributions of bed frames and mattresses to infection transmission or the magnitude of risk associated with bed and mattress movement.

To our knowledge, this is the first report describing bed and mattress movement in an acute care hospital and provides the basis for future research incorporating environmental sampling and patient data to determine the associated risks of infection transmission.

There are several limitations to this study. First, patient outcomes were not monitored during this pilot stage so it was not possible to link bed and mattress movement to infection transmission. Second, the study period was relatively short due to logistical issues, and there may be fluctuations in rates of movement that would be evident in looking at longer time periods. Finally, several mattress tags fell off, and it is possible that those mattresses were moved more frequently than those that retained their tags.

In conclusion, beds were observed to move frequently between rooms, but frames and mattresses tended to stay together. The RTLS system was able to monitor bed frame and mattress movement, which suggests it is a useful measurement tool for future time and motion studies in hospital wards.

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