

## Heights of occupied patient beds: a possible risk factor for inpatient falls

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### Heights of occupied patient beds: a possible risk factor for inpatient falls

**Aims.** The aim of this study was to ascertain the average height of occupied patient beds in a general medical ward and to investigate the relationship between staff working-height for patient beds, time and whether the patient was on fall precaution.

**Background.** The height of occupied patient beds can be an overlooked contributor to inpatient falls. Better physical design of hospital equipment such as patient beds may reduce patient falls and injuries.

**Methods.** This study took place in an acute medical ward of a Michigan medical center. One researcher collected all the data and used the same metric for all the measurements. Univariate analyses were performed.

**Results.** The average staff working-height measurement taken at the weekend was significantly higher than that taken on weekdays. The average height of patient beds on fall precaution was significantly higher than of those not on fall precaution.

**Conclusions.** A higher patient/nurse ratio at weekends than on weekdays may result in fewer bedside nursing hours and nurses being less conscientious about keeping beds in the low position after treatments. In an effort to prevent high-fall-risk patients from falling, nurses may have consciously or unconsciously kept their beds in higher positions.

**Relevance to clinical practice.** If the patient bed can be manually or automatically adjusted, nurses must lower the height of the bed to the lowest position after completing treatments or tasks. This after-procedure activity should be enforced and monitored regularly as part of a hospital's patient fall prevention programme. Low beds should be used for patients at high risk of falling. Future research should investigate patients' and staff's views on hospital equipment to provide evidence-based information for policy-makers determining the design-regulation standard for hospital bedframes.

**Key words:** beds, falls, nurses, nursing, patient, safety

## Background

Safety refers to the condition of being protected from experiencing or causing injury, hurt or loss (Merriam-Webster online dictionary 2007). The question therefore arises as to whether a better physical facility design would lead to better healthcare outcomes, such as fewer patient falls in acute care hospitals. A safety-driven, patient-centered facility design should be based on the evidence to promote quality care and patient safety. This should be a hospital design principle which takes account of both patient and staff points of view. Some research has suggested that the design-regulation height and staff working-height for patient beds used in acute care wards may cause patient falls and contribute to the severity of fall-related injuries (Tzeng & Yin 2006). Given that the height of occupied patient beds can be an overlooked contributor to inpatient falls, developing strategies or interventions to address the height of patient beds are imperative (Tzeng & Yin 2007).

The Joint Commission Board of Commissioners approved National Patient Safety Goals for 2007 which emphasise the need to reduce the risk of patient harm resulting from falls and to implement a fall reduction programme that includes an evaluation of its effectiveness (The Joint Commission 2007). Although hospitals have devoted quality improvement and research efforts to prevent falls, patient falls still consistently comprise the largest single category of reported incidents in hospitals (The Joint Commission 2005). It may be that the height of patient beds is an overlooked cause of inpatient falls.

### Patient safety strategies and fall prevention in acute care settings

Hospital can be a dangerous and erratic place for inpatients, including the unfamiliar physical environment (different from their home setting) and changes in their medical condition. Patient falls, defined as the rate at which patients fall during their hospital stay per 1000 patient days, are a nursing-sensitive quality indicator in the delivery of inpatient services [American Nurses Association 2002]. Among the nursing quality indicators identified by American Nurses Association (2002), patient fall rates are perceived as the indicator that could be most improved through nurse-led interventions or safety strategies.

The Joint Commission (2005) categorised individual risk factors for falls as follows: (1) intrinsic risk factors (reduced vision, unsteady gait, musculoskeletal system deficit, mental status deficit, acute illness, chronic illness, etc.); and (2) extrinsic risk factors (medications, height of beds, bedside

rails, lack of support equipment in bathtubs and toilets, condition of ground surface, poor illumination, inadequate assistive devices, etc.). As part of a continuing effort to promote patient safety and reduce falls, The Joint Commission (2005) suggested several environmental strategies related to bed height, mattresses and support devices, including: (1) the use of adjustable-height, high-low beds or fixed low-deck-height beds where applicable; (2) when feasible, keeping beds in their lowest position and providing mattresses firm enough to support safe bed transfers; and (3) providing a bed footboard to help patients as they transfer in and out of bed. Rather than using bed rails, JCAHO recommends that hospitals use adjustable beds that can be raised and lowered to enable patients to easily get in and out of beds and for staff to assist in this process.

Hignett and Masud (2006) took an ergonomic system perspective and applied Maslow's hierarchy of needs (e.g. fulfilling physiological and safety needs) when analysing inpatient falls. From a patient-centered perspective, the first hazard interaction is the bed (rails and height) in a patient ward. Previous studies in Western countries also concluded that 42–60% of inpatient falls were either bed-related or patients were found in their bed spaces after the falls (Masud 2003, Fonda *et al.* 2006). In summary, patient beds, as hospital equipment that patients spend most of their hospitalization time using, constitute an extrinsic risk factor for falls that hospital administrators might have overlooked.

### Difference in heights between home bedframes and hospital bed frames

As indicated in Table 1, the height of a home bedframe may be as low as four inches (one inch = approximately two centimetres). However, the height of hospital bedframes in the low position ranges from 12–16 inches, and only two out of seven styles are 13 inches or lower in the low position (see the footnotes of Table 1 for the actual US bed manufacturer websites). According to British Standards BS4886 (The British Standards Institute 1988), an adjustable bedstead in the horizontal position is required to have at least two positions: 29.92–31.89 inches in the high position and 12.99–15.94 inches in the low position. The design-regulation heights of most hospital beds sold in the USA are comparable with the specifications of BS4886. Thus, hospital bedframes are still 8–12 inches higher than those of home bedframes. The difference in heights may contribute to inpatient falls related to getting in and out of bed, and to the severity of fall-related injuries.

Attempts have been made to establish how low a hospital bed should ideally be in the low position. Alexander *et al.*

**Table 1** Body and knee height of American males and females, and height specifications of home bed and hospital beds (see the footnotes for the actual US bed manufacturer websites)

Variable	Male	Female	Data source
Average age (in years)	52.7	53.6	
Average body height*	67.64 inches	62.52 inches	
Average knee height*	21.3 inches	19.49 inches	
Home bed frame: height from floor to top of deck**	<i>Bed frame specification</i> Low profile bed frame with feet: 4–5 inches off the floor Bold-on rails/frames: 6–11 inches		
Mattress**	<i>Mattress specification in height</i> Mattress in firm style: 7.5–16.5 inches (most of the styles are in 12 inches) Regular box spring: 9 inches Low profile box spring: 5–5.25 inches		
Electric high-low hospital bed: height from floor to top of deck in the low position and in the high position (low-high)***	<i>Company A: bed frame specification</i> Style S (medical/surgical bed): 16–30 inches Style G (medical/surgical bed): 14.5–29 inches Style E (medical/surgical bed): 13–30 inches Style L (medical/surgical bed): 12–28 inches <i>Company B: bed frame specification</i> Style V (medical/surgical bed): 18–37 inches Style C (medical/surgical bed): 15.75–32.5 inches Style T (ICU bed; this style is the one used in the study ward of this project, which goes into the chair position that allows the patient to be passively moved into a sitting position): 17.5–36.5 inches		
Mattress***	<i>Company A: mattress specification in height</i> Style S: 7 inches Style X: 8.5 inches Style I: 6 inches Style P: 8 inches Style R: 6.25 inches <i>Company B: mattress specification in height</i> Style A: 8 inches Style P: 8 inches Style C: 7 inches		

\*Body height refers to the distance from the floor to the top of the head in a standing person. Knee height refers the distance between the bottom of the heel pad and the top of the knee when both are flexed at 90° (Roubenoff & Wilson 1993).

\*\*Data are collected from the internet websites of the US based-companies for home bed and mattress retail (e.g. <http://www.esleepshop.com/>, <http://www.us-mattress.com/>, <http://www.thebeddingsite.com/>).

\*\*\*The heights of selected electric hospital beds and mattresses are collected from the web sites of two US based companies (<http://www.hill-rom.com/usa/>, <http://www.us-mattress.com/> and <http://med.stryker.com/>).

(2000) found that all elders with a mean age of 82 years, in their study, could rise from sitting to standing from a seat at knee height using only their hands to assist them. This finding suggests that the height of the hospital bed from the floor to the top of the bed surface in the horizontal position should be adjustable to the patients' knee height (about 21 inches for males and 19 inches for females) (Roubenoff & Wilson 1993). Using these two figures as references, the design-regulation heights of hospital beds sold in the USA are indeed

too high for physically frail patients to get in and out of bed safely and without fear of the distance from the floor to the bed edge (Table 1).

### Why do patients continue to fall?

Depending on the styles of patient beds (e.g. the control panel for adjusting the overall height of the bedframe is not reachable by a patient who is lying on the bed), the patient

might need to call someone to adjust the bed, if he or she is concerned about its height when moving out of, or back to, bed. This could lead to fear and insecurity (Tzeng & Yin 2006, 2008). However, little research has systematically addressed the issue of the staff working-height, and design-regulation height, for patient beds used in acute care settings, as possible causes for patient falls that result in injury.

## Purposes of this study

This exploratory study aimed to illustrate the link between staff working-height for patient beds, time (weekday vs. weekend and time of day) and whether the patient was on fall precaution. The research questions were: (1) what is the average height of occupied patient beds in a general medical ward? and (2) what is the relationship between the staff working-height for patient beds, time, and whether patients were on fall precaution? This project was part of a patient safety improvement initiative in the study ward. The number of falls reported per 1000 patient days was 4.4 in August 2006.

## Method

This study was conducted in a 32-bed, acute medical ward of a Michigan medical centre in October 2006. The bed-height measurements were taken only on occupied patient beds when nurses and physicians were not delivering bedside care at pre-determined time periods for data collection. After obtaining permission from the study ward's nursing manager, measurements were taken on two weekdays and one weekend day at three pre-determined time points on each day. As the study did not involve human or animal subjects, institutional review was waived.

Data were collected in one week. To ensure trustworthy measurement, one researcher collected all the data and used the same metric for measurements across all nine data collection time points. It was noted that one of this hospital's policies on fall prevention related to bed-height is that all beds should be left in the lowest position when actual patient care is not being provided.

## Data sources

All the beds in the study ward are in the same style – an electric, high-low bed system, which is 23.5 inches high at its lowest position (including the heights of the bedframe [17.5 inches] and the mattress [six inches]). Only occupied beds, whether or not patients were lying on them, were measured from floor to the top of the middle part of the

surface. If a nurse or physician was at the bedside (e.g. implementing procedures or administering medications or treatments) when the measurement was taken, this measurement was not included in the analyses. Any reminder notes of fall precaution indicated above the headboards were recorded.

Studied variables included bed-height in inches, weekday vs. weekend (weekday = 1; weekend = 0), time of data collection (morning: 9:30 AM to 10:30 AM = 1, afternoon: 1:30 PM to 2:30 PM = 2, and evening: 6:30 PM to 7:30 PM = 3), and being on the fall precaution programme (yes = 1, no = 0).

## Analyses

MICROSOFT OFFICE EXCEL was used for data entry and SPSS was used for analyses. Descriptive, independent *t*-tests and one-way ANOVA analyses were performed by using the staff working-height of patient beds as the dependent variable.

## Results

Two hundred and eighty-eight measurements were included in the analysis. As shown in Table 2, the independent *t*-test demonstrated that the average staff working-height measurement taken at the weekend (mean = 26.01 inches) was significantly higher than that taken on weekdays (mean = 25.32 inches) ( $t = -2.75$ ,  $p = 0.006$ ). The average bed-height of patient beds that were on fall precaution (mean = 26.34 inches) was significantly higher than those that were not on fall precaution (mean = 25.41 inches) ( $t = 2.743$ ,  $p = 0.007$ ). One-way ANOVA indicated that there was no statistically significant difference on the staff working-height measurements taken at different times ( $F = 2.243$ ,  $p = 0.108$ ).

Using only weekday data, one-way ANOVA indicated a statistically significant difference on the staff working-height measurements across different times (morning: mean = 25.10 inches, SD = 1.17,  $n = 63$ ; afternoon: mean = 25.71, SD = 1.91,  $n = 60$ ; evening: mean = 25.13, SD = 1.29,  $n = 54$ ) ( $F = 3.159$ ,  $p = 0.045$ ). The average height during the weekday afternoon time points was the highest. No difference was found between the groups on fall precaution (mean = 25.75 inches, SD = 2.16,  $n = 13$ ) and not on fall precaution (mean = 25.28 inches, SD = 1.45,  $n = 164$ ) ( $t = 1.076$ ,  $p = 0.283$ ).

When analysing only weekend data, no statistically significant difference was found in the staff working-height measurements taken between the three times (morning: mean = 25.87 inches, SD = 2.31,  $n = 31$ ; afternoon: mean = 26.30, SD = 3.44,  $n = 28$ ; evening: mean = 25.86,

Table 2. Relationship between staff working-height of patient bed (in inches), time and fall precaution programme

Groups	Mean	SD	Frequency	Per cent
Bed height in inches (all subjects)	25.54	1.94	Range: 23–37.20	
Weekday vs. weekend				
Weekday	25.32	1.51	177	67.3%
Weekend	26.01	2.55	86	32.7%
Independent <i>t</i> -test for equality of means (equal variances assumed): $t = -2.75, p = 0.006^{**}$				
Patient on the fall precaution programme				
Yes	26.34	2.64	37	14.1%
No	25.41	1.77	226	85.9%
Independent <i>t</i> -test for equality of means (equal variances assumed): $t = 2.743, p = 0.007^{**}$				
Time of data collection				
Morning (9:30 AM to 10:30 AM)	25.35	1.66	94	35.7%
Afternoon (1:30 PM to 2:30 PM)	25.90	2.50	88	33.5%
Evening (6:30 PM to 7:30 PM)	25.38	1.45	81	30.8%
One-way ANOVA:				
	Sum of square	Degree of freedom	Mean square	
Between groups	16.71	2	8.35	
Within groups	968.07	260	3.72	
Total	984.77	260		

\*\* $p < 0.01$ .

$F = 2.243, p = 0.108$ .

SD = 1.65,  $n = 27$ ) ( $F = 0.266, p = 0.767$ ), and between the groups on fall precaution (mean = 26.66 inches, SD = 2.85,  $n = 24$ ) and not on fall precaution (mean = 25.75 inches, SD = 2.41,  $n = 62$ ) ( $t = 1.493, p = 0.139$ ).

## Discussion and conclusions

### Staff working-heights, weekday vs. weekend and different shifts

This study illustrates the relationship between the staff working-height for patient beds, times the measurements were taken, and whether the patient was on fall precaution. The findings of this study suggest that nurses have a tendency to keep patient beds higher at the weekend than on weekdays; the average bed-height measurement taken at the weekend was 26.01 inches and on weekdays 25.32 inches ( $t = -2.75, p = 0.006$ ). It is possible that for an acute inpatient ward (non-intensive care ward), fewer nurses are scheduled for work at weekends than during the week; reasons for this reduction in staff numbers include having fewer new admissions and discharges, scheduled procedures and treatments. Consequently the higher patient/nurse ratio at weekends may result in: (1) fewer bedside nursing hours and (2) nurses being less conscientious about keeping beds in the low position after treatments. One of the possible reasons why nurses tend to be less conscientious about keeping beds in the low

position after treatments is having a feeling of being pressurised through lack of time.

In addition, there are more family visitors at weekends than during the week, which may contribute to nurses spending fewer bedside hours with patients. Further research is required to test whether these interpretations of the results can be verified.

Based on the analyses of the weekday data, the average staff working-height of patient beds in the afternoons was higher than that in the mornings and evenings. This may be because the height was left the same after 12:00 noon medication and treatment were administered. This finding suggests that further investigation may be needed to determine what kind of patient or nurse activities usually occur before and during this time period that require beds to be higher than in the morning and evening time periods.

### Bed height, fall precaution and use of restraint

As we have observed in clinical practice, nurses have been repeatedly and thoroughly educated about the dangers of restraints, and the increased likelihood that a restrained patient will fall. Despite this, Vassallo *et al.* (2005) found that 84.5% of British healthcare professionals agreed that restraint use is justified to prevent fall-related injuries. Most agree that restraint use is at the discretion of healthcare professionals. Keeping patient beds in a higher position may

be seen as a way to restrain high-fall-risk patients in bed by forcing them to call nurses when they need to leave the bed. Logically, however, if a patient falls from a higher bed, his or her fall-related injury is likely to be more severe than from a lower bed.

In this study, the average staff working-height of patient beds that were on fall precaution (mean = 26.34 inches) was significantly higher than those that were not on fall precaution (mean = 25.41 inches). This result may suggest that, in an effort to prevent high-fall-risk patients from falling, nursing staff consciously or unconsciously kept the beds in higher positions, possibly as a means of restraint which does not require physicians' order. Future research should address this possibility (e.g. by interviewing staff to ascertain their rationale for this practice).

### Practical implications

Hospital quality improvement initiatives that focus on patient care have often been approached by building or maintaining a facility and instituting policies that provide care under safe conditions (National Academy of Sciences 2004a,b). Applying this concept to practice with a focus on preventing bed-related inpatient falls, where the bed can be either manually or automatically adjusted, nurses and physicians must lower it to the lowest position after completing treatments or tasks. This after-procedure activity could help decrease patient fears when getting in and out of bed and prevent falls. In acute care settings, this action should be enforced and monitored regularly as part of a hospital's patient fall prevention programme.

Some hospitals are already using low beds (about six inches from the floor to the mattress surface) with patients who are at high risk for falls, particularly geriatric patients in areas such as transitional care units. In addition, nursing homes often purchase low-height beds for residents at high risk of falling; however, this practice has not yet been adopted in hospitals.

As indicated in Table 1, hospital beds which go into a 'chair' position are available, allowing patients to be passively moved into a sitting position. This type of bed has been used with almost all patients in the study hospital. However, during the data collection period on the study ward, the investigator only saw one nurse used the 'chair' function of the bed on one single patient. It seems that the 'chair' feature is seldom being used.

As indicated in Tables 1 and 2, the design-regulation height of hospital bedframes is much higher than the height of home bedframes. Nursing executives and hospital administrators need to keep in mind that, when purchasing new patient beds for acute care settings, the height of bedframes when in the

low position should be specified as low as possible and be comparable to the height of home beds. As indicated in Roubenoff and Wilson's (1993) study, the average knee height for their female participants was 19.49 inches. To prevent fall-related injuries effectively, it is suggested that the patient bed (frame and mattress) should be no higher than 19.5 inches in the low position. This specification is important for building a patient-centered care environment which puts patient safety first; it is, however, only a first step, and more research is needed to determine the safest height for patient bedframes in the low position to guarantee patient safety.

### Future research

To promote hospital patient safety (e.g. fall prevention), the design of hospital equipment (e.g. the height of beds) should be assessed for safety. Based on the results of this study, future research should investigate patients and staff's points of view about hospital equipment as related to patient safety. We also need to understand the relationship between the height of home beds and users' knee height, as users always make a choice of home beds based on their personal preferences, physical condition, and comfort levels (e.g. height of home bedframe and firmness of mattress). These future research efforts should estimate the safest height for patient bedframes to build a safe, patient-centered, home-like hospital care environment. The results of these efforts will provide evidence-based information to assist policy-makers to determine the practical design-regulation standard for the height of hospital bedframes.

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Not applicable.

### Contributions

Study design: HMT, CYY; data collection and analysis: HMT; manuscript preparation: HMT.

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