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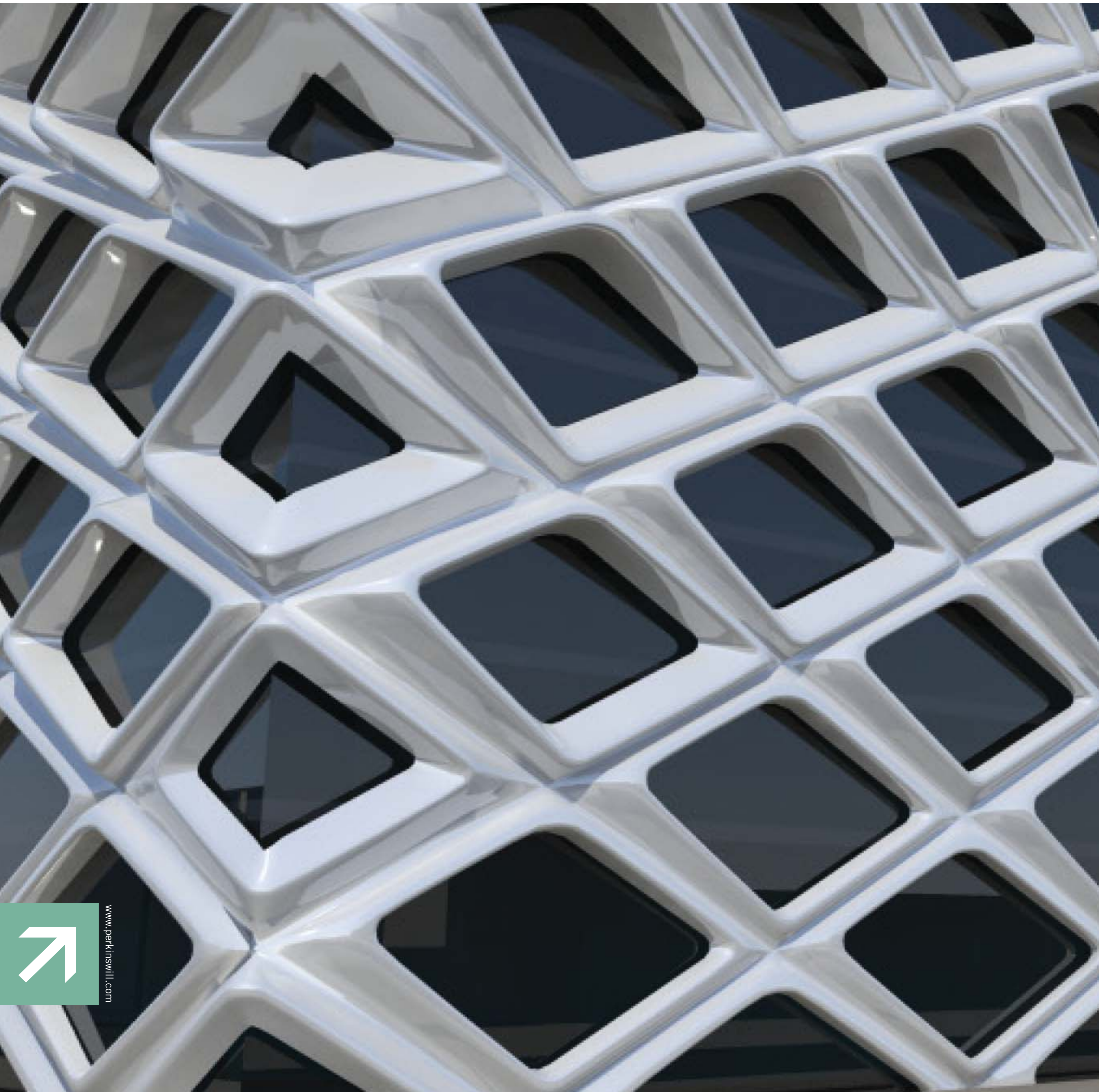

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A SIMPLE MODEL FOR COMPARING HEALTHCARE STAFF WALKING EFFICIENCIES ACROSS DIFFERENT HOSPITAL FLOOR PLAN DESIGNS

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ABSTRACT

With healthcare facility design trending toward increasing patient space in new construction, there can be concomitant increases in healthcare staff workloads. This study used simple pedometry step counts to compare staff walking effort in double-loaded and racetrack corridor floor plan designs. It was demonstrated that the racetrack floor plan outperformed the double-loaded corridor in human energy efficiency regardless of staff position or work shift. The racetrack corridor floor plan proved to be the better of the two designs for increasing patient space while minimizing the increase in healthcare staff walking workload.

KEYWORDS: evidence-based design, healthcare staff workloads, double-loaded corridor, racetrack corridor, floor plan design efficiency

1.0 INTRODUCTION

Within the major context of evidence-based design (EBD), two major trends in healthcare delivery are prevalent today and are influencing modern hospital design and construction: (1) healthcare delivery is being practiced in a more competitive environment resulting in a trend toward more patient/family-oriented building designs; (2) consideration of the environmental impact of new building design is focusing attention on energy efficiency and the net carbon "footprints" of building designs and construction. In fact, references to building performance and building efficiency deal more with traditional energy efficiency than with "human energy" expenditure and conservation[1].

More "patient friendly" designs require increased room size to facilitate patient comfort as well as that of family and visitors. From a healthcare practice perspective, today's more acutely ill patients require more floor area around beds for medical equipment and in-room procedures. Yet, these patient-centered design trends have paradoxical impacts on hospital constituencies. Patients and their families benefit from more spacious and comfortable rooms, while staff can be negatively impacted by having a larger floor space to cover in daily patient care delivery. It is relatively easy to quantify the physical parameters, such as room size, temperature, humidity, lighting and noise levels that contribute to patient/family comfort and to design new facilities accordingly. It is also possible, through insightful placement of supply storage and other floor plan considerations, to optimize staff work effort. However, no simple means of quantifying the effectiveness of these "staff-centered," work-saving innovations is readily available. In order to have practical utility, such a measurement tool must be simple and inexpensive to employ while having broad applicability across different building designs with different staffing levels. The protocol presented here builds upon the previous work of Shepley[2] and provides a relatively simple technique for comparing staff workloads that should be applicable in differing healthcare delivery scenarios.

In 2009, Gwinnett Medical Center in Lawrenceville, Georgia and Perkins+Will completed the construction of a new North Tower addition, consisting of 155 new patient beds. This building addition provided an opportunity for a prospective study of the comparative staff workloads in two dramatically different hospital floor plans. Although the original South Tower, constructed in 1983, met the codes of its time, the minimum size requirements for patient rooms and the needs for support space have increased substantially over the years. The older South Tower was designed as a double-loaded corridor with a single, centralized nurse station, while the new North Tower employed a racetrack design with duplicate nurse stations and supply storage areas at each end of the unit. To preemptively address staff/patient visualization concerns, satellite charting stations with 12 inches wide windows were situated between each pair of patient rooms to enhance patient observation while moving charting activity closer to patient rooms further reducing walking workload (Figure 1). It was hypothesized that this design would accommodate the desired larger patient spaces while minimizing the increased walking required for staff to cover the larger floor space.

Figure 1: Satellite charting station.

2.0 METHODOLOGY

In order to control as many variables as possible between the two different floor plans, a cardiac care unit was selected from the various healthcare specialties housed in the two facilities. This unit proved ideal for study since it would relocate from the old building into the new addition with no change in healthcare tasking and it would retain most of the same staff members.

The older double-loaded corridor unit housed 35 patient beds attended by four patient care technicians (PCTs) and nine registered nurses (RNs) during the day and three PCTs and eight RNs at night. The new racetrack corridor facility accommodated 31 beds attended by three PCTs on all shifts with eight or seven RNs on day and night shifts, respectively. Therefore, the same staff at comparable levels would be performing the same healthcare delivery protocols in both facilities. Differences in staffing levels, differing floor plan designs and daily fluctuations in patient census became the major variables determining staff workloads. All these variables had to be considered in developing a method for quantifying staff walking workloads.

Pedometry was determined to be the simplest and least labor-intensive way to monitor staff workloads. Six Omron, Model HJ-112 pedometers were acquired and a number of volunteer RNs and PCTs were recruited to wear them during their normal work shifts. An effort was made to ensure as many different individuals as possible were involved in the data collection in sufficient numbers to adequately cover all shifts for the two-week study interval in each facility.

Instructions to staff participants emphasized the importance of clearing the pedometer settings before each new wearer and the need to record only in “step mode.” Step counting was preferable to avoid having to recalibrate the pedometers for each new participant’s stride length. To incentivize participation, the pedometers were raffled off to participating staff at the end of the study. Pedometer measurements were suspended for 90 days pre- and post-relocation until staff had adequate time to acclimate to their new surroundings and to avoid any atypical activity associated with the relocation.

A spreadsheet was provided at each nursing station for study participants to record their first name, pedometer number, date, staff position, shift start time, shift end time and total number of steps at the end of their shift. A section of the spreadsheet was dedicated to “trips off floor” where study participants could record the number of trips off the floor to the cafeteria, lab and other commonly visited sites. This spreadsheet addition was important to ensure that recorded steps were accumulated only in patient care delivery on the floor in question. For the final computation of adjusted patient care Steps, previously measured steps to each “off floor” destination were subtracted from the subjects’ recorded totals. The two-week data recording interval generated between 150-175 individual records, which was sufficiently large that a few aberrant data entries, should they occur, would not appreciably skew the means in final analysis. Special cause variations yielding conspicuously “out of range” data points, commonly due to accidental pedometer resets or failures to reset the devices at the beginning of a new shift, could be easily detected by visual inspection and deleted.

Figure 2 shows the calculations used to determine each study participant’s relative efficiency. Efficiency calculations were considered “relative” because they were dependent upon floor plan design, staff position, staffing levels and patient census during the study time frame. Mean percent occupancy levels over the study intervals were 92 percent and 100 percent in the double-loaded and racetrack corridors, respectively. Load was determined by simply multiplying the total floor plan square footage by the average percent of maximal occupancy and dividing by the number of staff members of a given position category assigned to cover the floor on each shift. That value, when divided by the calculated effort, provided an approximation of each individual’s relative efficiency.

Averaging the relative efficiencies for any staff position on any work shift over the study time interval gave an indication of how each floor plan design was functioning for a particular staff group under normal work conditions. Mean relative efficiencies for each staff group were also compared statistically across the two floor plans using a Mann Whitney Rank Sum nonparametric analysis protocol. Simple efficiency calculations such as these should be applicable to any building design or staffing combination and should allow for simple comparisons across differing healthcare delivery scenarios.

$$\textbf{Relative Efficiency} = \frac{\text{Load}}{\text{Effort}}$$

$$\textbf{Load} = \frac{(\text{Floor plan ft}^2) \times (\text{Mean \% occupancy}/100)}{\text{Staff position number}}$$

$$\textbf{Effort} = \frac{\text{Adjusted patient care steps}}{\text{Hours worked}}$$

Figure 2: Healthcare staff workload (walking) efficiency calculation.

3.0 RESULTS

The cardiac care unit selected for this study occupied a floor with 25,405 square feet in the new building, an 82 percent increase over their 13,972 square feet space allocation in the old facility. Typical patient room size increased from 167 square feet to 285 square feet. Since the unit size nearly doubled in the new building, it would not be unreasonable to assume a comparable increase in staff workload, given comparable staffing levels in the two facilities. However, the pedometry data did not support this assumption.

Differences in walking workloads were seen with different staff positions and with the same staff positions when day and night shifts were compared (Table 1). As anticipated, the larger floor plan in the new addition did increase the walking workload of PCTs and RNs on both day and night shifts, but the increases were not as much as expected given the large difference in floor plan areas and the slight reduction in staff levels in the racetrack corridor unit. PCTs, whose job description requires more walking, showed mean step counts per hour of work to increase from 882 to 1010 on day shifts, a 14.5 percent increase. On night shifts, their step counts increased from 735 to 923 per hour of work, a 25.6 percent increase. RN's step counts averaged 536 per hour of work on day shifts in the double-loaded corridor and increased to 631 in the larger, racetrack design, an increase of only 17.7 percent. On night shifts, RN's walking increased from 482 steps per hour to 611, an increase of 26.7 percent. Considering all staff positions and both shifts, walking in the new racetrack design increased within the range of 14.5 to 26.7 percent, considerably less than anticipated given the 82 percent floor plan square footage disparity between the two designs.

Table 1: Comparison of staff walking efficiencies between double-loaded corridor and racetrack floor plan designs.

Staff Position by Work Shift	Effort	Load	Reletive Efficiency
Patient Care Technicians (PCTs)			
	Double-Loaded Corridor		
Day Shift	882	3213	3.64
Night Shift	735	4284	5.83
	Racetrack Corridor		
Day Shift	1010	8468	8.38
Night Shift	923	8468	9.17
Registered Nurses (RNs)			
	Double-Loaded Corridor		
Day Shift	536	1428	2.66
Night Shift	482	1607	3.33
	Racetrack Corridor		
Day Shift	631	3175	5.03
Night Shift	611	3629	5.94

This observation suggested that, even with its larger size, the racetrack design was more efficient in staff effort expenditure, meaning that fewer staff could cover more square footage with fewer steps. To test this assumption, mean relative efficiency values (Table 1) were compared statistically for significant differences between the two floor plan designs. In every comparison of equivalent staff groups and work shifts between the two facility designs, the racetrack corridor efficiencies were significantly higher ($p=<0.001$) than those seen in the double-loaded corridor floor plan.

Night shift PCTs in the racetrack corridor design showed the highest relative efficiency estimate of 9.17. That value represented a 57 percent increase over their efficiency in the double-loaded corridor (Figure 3). However, the best improvement in efficiency was seen with the day shift PCTs. Their efficiency improved 130 percent in the racetrack design. RNs, who typically walk less in performing their duties, also showed dramatic increases in efficiency in the racetrack design ranging from 89 to 78 percent improvements on day and night shifts, respectively.

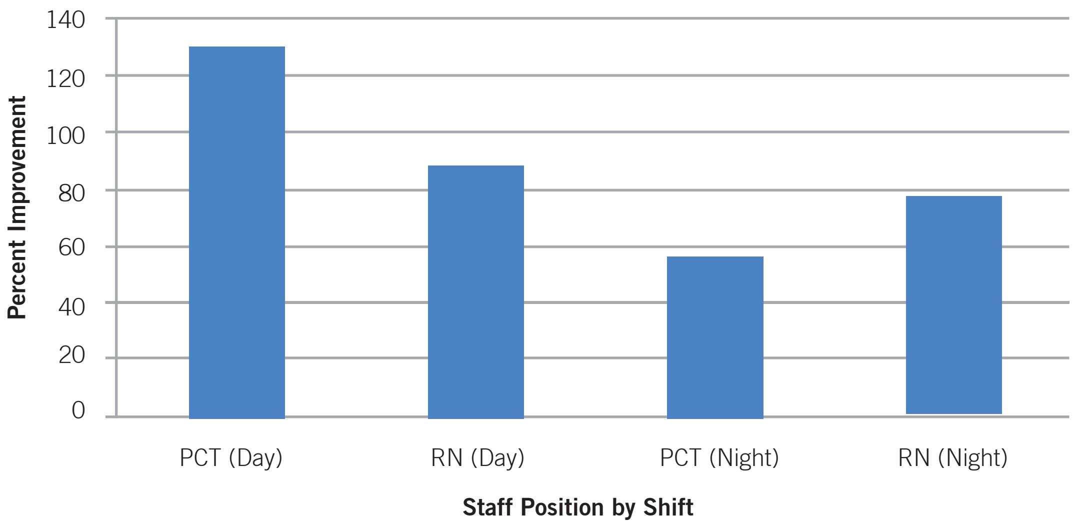
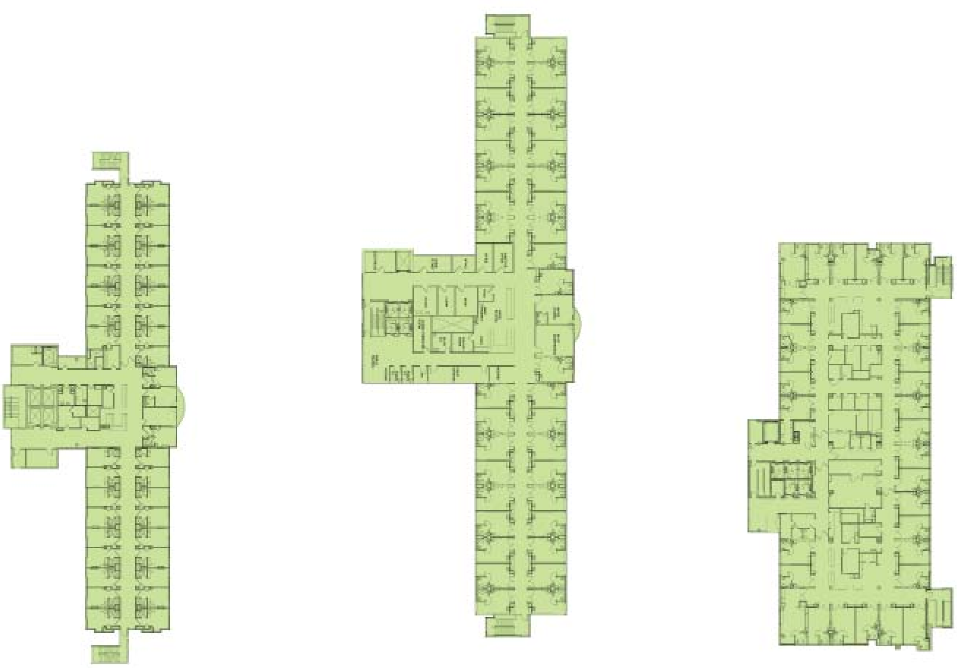


Figure 3: Staff racetrack walking efficiency improvement over double-loaded corridor floor plan.

4.0 DISCUSSION

Historically speaking, with the advent of mechanical ventilation, cross-ventilation needs ceased to be a determining factor in healthcare facility design. This innovation allowed designers the freedom to experiment with a variety of new floor plan configurations informed primarily by staff mobility and patient visualization issues. More recently, changing healthcare building codes are further expanding patient spaces in modern hospital designs. Consequently, more spacious floor plans are now required to accommodate a comparable number of patients in these newer facilities and are directing design attention toward mobile staff walking workloads. This is not to imply that human workload has been neglected in the past[3]. For several decades workload has been an integral part of facility planning, being innate to the learned conceptual paradigms for designing navigable configured spaces[4]. Although it did direct attention to the need for centrality in healthcare space configuration and staff assignments, the more complex contemporary paradigm of Space Syntax has proven to be too complex and inconsistently reliable for widespread utility in healthcare design[5]. Given that both floor plan layouts and staff assignments can influence how nurses move through a unit,[6] it is valuable to have comparative measurements of real human workloads across different hospital floor plans.

Figure 4 illustrates the paradoxical impact of accommodating patient expectations with larger, more comfortable rooms while inadvertently increasing the walking workload of healthcare practitioners caring for these patients. Comparing the floor plans in this study demonstrates how large the older, double-loaded corridor design would have to be in order to meet current patient space specifications. Simply building the same design according to current codes would increase the square footage by a factor of 2.1 from 13,354 square feet to 27,568 square feet. With a single, centrally positioned nursing station in that older corridor design, the walking workload of attending staff would increase to burdensome levels. In fact, simply building a larger facility to meet patient space expectations without considering the increased staff workload could result in the necessity of adding additional staff, which might diminish any financial return realized from the new construction. In contrast, the racetrack corridor design allowed for increased patient space with only modest increases in staff walking.



1983 South Patient Tower
13,354 SF
381 SF/Bed

Per 2010 Codes
27,568 SF
745 SF/Bed

2009 North Patient Tower
24,367 SF
786 SF/Bed

Figure 4: Floor plan comparisons by building code specifications.

This study confirmed how a racetrack corridor design, with its duplicate nursing stations and supply storage areas as well as satellite charting stations, allowed for increased patient space without dramatically increasing staff walking workload. That is not to say that staff walking did not increase in the racetrack design. Different staff constituencies and different work shifts did walk more in the larger facility, with the extent of that increased effort determined by their healthcare delivery responsibilities.

Since most medical procedures and physician's rounds occur on day shifts, this shift should require more walking regardless of building design. Additionally, staff numbers, which influence the "load" calculations for individuals, can vary with employee position. The more people sharing a given workload, the fewer square feet would have to be covered by each individual in carrying out their duties. PCTs typically walk more than RNs in carrying out their responsibilities and there were fewer of them on each shift. Not surprisingly, they showed the largest improvement in efficiency in the new racetrack corridor design. Staff members who walk less in their jobs will not benefit as much by floor plans designed to minimize walking. However, the racetrack corridor design consistently outperformed the double-loaded corridor configuration regardless of staff position or work shift.

In fact, the hospital was able to reduce slightly the number of PCTs and RNs on each shift in the new facility without sacrificing workload efficiency, patient satisfaction or patient care. That patient care did not suffer in the larger unit is evidenced by several indices. Patient falls per patient day decreased from 0.0063 in the old facility to 0.0046 in the new racetrack floor plan, an improvement of 27 percent. Although the racetrack floor plan with its remote charting stations and viewing windows likely played a role in reducing patient falls, this study did not differentiate among the various innovations also employed by staff in the new unit to address this patient care issue. Additionally, average lengths of stay decreased from 5.5 days in the old unit to 4.7 in the new facility with no increase in hospital-acquired infection rate. This reduction in length of stay could be attributed, in part, to the on-site availability of social workers and case managers, spaces for whom were provided in the new racetrack floor plan.

Pedometers, such as those employed here, have historically been used to establish normative data for individuals engaging in walking as aerobic exercise and to monitor general physical activity[7,8] and they proved the simplest and most inexpensive means of monitoring workload activity in this study. However, they are not precision instruments. Tyron et al.[9] subjected pedometers to accuracy tests under controlled laboratory conditions and found their readings in step mode to be off as much as five percent. Variations in gait can yield erroneous step counts with these devices. Since our study protocol employed the same pedometers with the same staff in both facilities being compared, errors should be equally probable in both data samples with no bias in favor of one over the other. Moreover, it was not the purpose of this study to determine definitively and with absolute accuracy the human energy efficiency of different healthcare work environments. Instead, this study required a simple, inexpensive, participant-friendly method of obtaining a general estimation of staff walking effort and workload efficiency that could be reproduced and applied across differing healthcare facility designs. The pedometer proved adequate for that purpose.

5.0 CONCLUSIONS

The pedometry experimental protocol employed in this study provided valuable insights into hospital staff energy expenditure in execution of their daily work activities and how their individual workloads were impacted by different building designs. Data confirmed that day shift employees walked more than their night shift cohort and that patient care technicians had a more walking-intensive workload than registered nurses irrespective of building design. More importantly, it was possible to apply employee walking activity measurements to compare the relative design efficiencies of double-loaded corridor and racetrack corridor floor plans. In every aspect of this study, the racetrack corridor floor plan outperformed the double-loaded corridor and proved to be the better of the two designs for expanding patient space while minimizing its impact on attending staff workloads.

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