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BRIEF REPORT

Stepping Toward Discharge: Level of Ambulation in Hospitalized Patients

Robert Sallis, MD[1], Yvonne Roddy-Sturm, RN, MSN, CCRN[2], Eziaku Chijioke, RN, MSN[2], Kerry Litman, MD[1], Michael H. Kanter, MD[3], Brian Z. Huang, MPH[4], Ernest Shen, PhD[4], Huong Q. Nguyen, PhD, RN[4]*

[1]*Kaiser Permanente Southern California, Fontana Medical Center, Fontana, California;* [2]*Kaiser Permanente Southern California, Ontario Medical Center, Ontario, California;* [3]*Quality and Clinical Analysis, Kaiser Permanente Southern California, Pasadena, California;* [4]*Department of Research and Evaluation, Kaiser Permanente Southern California, Pasadena, California.*

Little information is available on how active adult patients are during their hospitalization. The purpose of this study is to describe the level of ambulation in hospitalized patients. This was a cohort study of ambulatory patients from 3 hospital medical-surgical units conducted March 2014 through July 2014. Patients wore an accelerometer upon admission to the unit until discharge to home. Sensor placement and data review were performed as part of routine care. Step counts were merged with administrative and clinical data for analysis. Data were available on 777 patients who had at least 24 hours of monitoring prior to discharge. The sample included 57% females, and 55% were nonwhite. The median total step count over 24 hours was 1158 (interquartile range: 636–2238). Patients who were older accrued fewer steps compared to younger patients (962 vs 1294, $P < 0.0001$). For patients who had at least 48 hours of monitoring (n = 378), there was an increase from 811 steps in the first 24 hours to 1188 steps in the final 24 hours prior to discharge. More frequent documentation was associated with higher step counts ($P \leq 0.001$). We found that a diverse sample of hospitalized adult patients accrued over 1000 steps in the 24 hours prior to discharge home. *Journal of Hospital Medicine* 2015;10:384–389. © 2015 Society of Hospital Medicine

A number of observational studies have documented the association between prolonged bed rest during hospitalization with adverse short- and long-term functional impairments and disability in older patients.[1–4] However, the body of evidence on the benefits of early mobilization on functional outcomes in both critically ill patients and more stable patients on medical-surgical floors remains inconclusive.[5–9] Despite the increased emphasis on mobilizing patients early and often in the inpatient setting, there is surprisingly little information available regarding how typically active adult patients are during their hospital stay. The few published studies that are available are limited by small samples and types of patients who were monitored.[10–14] Therefore, the purpose of this real-world study was to describe the level of ambulation in a large sample of hospitalized adult patients using a validated consumer-grade wireless accelerometer.

METHODS

This was a prospective cohort study of ambulatory patients from 3 medical-surgical units of a community hospital from March 2014 through July 2014. The study was approved by the Kaiser Permanente Southern California Institutional Review Board. All ambulatory medical and surgical adult patients were eligible for the study except for those with isolation precautions. Patients wore an accelerometer (Tractivity; Kineteks Corp., Vancouver, BC, Canada) on the ankle from soon after admission to the unit until discharge home. The sensors were only removed for bathing and medical procedures, at which time the devices were secured to the patient's bed and reworn upon their return to the room. The nursing staff was trained to use the vendor application to register the sensor to the patient, secure the sensor to the patient's ankle, transfer the sensor data to the vendor server, review the step counts on the web application, and manually key the step count into the electronic medical records (EMRs) as part of routine nursing workflow. The staff otherwise continued with usual patient mobilization practices.

We previously validated the Tractivity device in a field study of 20 hospitalized patients using a research-grade accelerometer, Stepwatch, as the gold standard (unpublished data). We found that the inter-Tractivity device reliability was near perfect (intraclass correlation = 0.99), and that the Tractivity step counts correlated highly with the nurses' documentation on a paper log of distance walked measured in feet ($r = 0.76$). A small number of steps (<100) were recorded over 24 hours when the device was worn by 2 bed bound patients. The 24-hour Tractivity step count had acceptable limits of agreement with the Stepwatch (+284 [standard deviation: 314] steps; 95% limits of agreement −911-343). In addition, for the current study, when we examined the step counts between patients who were classified by the nursing team as being able to walk <50 feet (n = 320)

*Address for correspondence and reprint requests: Huong Nguyen, PhD, Department of Research and Evaluation, Kaiser Permanente Southern California, 100 S. Los Robles, Pasadena, CA 91101; Telephone: 626-564-3935; Fax: 626-564-39648; E-mail: huong.q2.nguyen@kp.org

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compared to patients who were able to walk >50 feet (n = 434), we found a significant difference in the median number of steps over a 24-hour period (854 vs 1697, $P < 0.0001$).

The step count data were exported from the vendor's server, examined for irregularities, and merged with administrative and clinical data for analysis. Data extracted from the EMR system included sociodemographic (age, gender, marital status, and race/ethnicity) and clinical characteristics (LACE score [readmission risk score based on length of stay ("L"); acuity of the admission ("A"); comorbidity of the patient (measured with the Charlson comorbidity index score) ("C"); and emergency department use (measured as the number of visits in the six months before admission) ("E"),[15] Charlson Comorbidity Index, length of stay, principal discharge diagnosis, and body mass index), and nursing documentation of functional status (bed bound, sit up in bed, stand next to bed, walk <50 feet, and walk >50 feet).

Descriptive statistics and nonparametric tests (Kruskal-Wallis and Wilcoxon signed rank) were used to analyze the non-normally distributed step count data. Quantile regression[16] was used to determine the association between the frequency of the care team's review and documentation of steps, with median total step count adjusting for age, gender, LACE score, and medicine/surgical service line. Whereas linear regression allows one to describe how the mean of a given outcome changes with respect to some set of covariates in circumstances where data are normally distributed, quantile regression allows one to assess how a set of covariates are related to a prespecified quantile (eg, 50% percentile median) of an outcome distribution. This modeling is especially appropriate here, because step count data are not normally distributed. Because step counts can vary with a number of factors, such as age and principal admitting and discharge diagnoses, we stratified our analyses by age (<65 or ≥65 years) and service lines (medical or surgical) due to the relatively small numbers of patients in each of the diagnostic groupings. Statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC); P values <0.05 were considered statistically significant.

RESULTS

A total of 1667 patients wore the activity sensor during their hospital stay. We included 777 patients in our analysis who had lengths of stay long enough for 24 hours of continuous monitoring, and almost half of these patients had at least 48 hours of monitoring (n = 378). The demographic and clinical characteristics of the sample are detailed in Table 1. The sample included mostly medical patients (77%), with a mean age of 60 ± 17 years, 57% females, and 55% nonwhites. Nearly all patients (97%) were classified as ambulatory at discharge based on the EMR data. Approximately 44% of the sensors were lost, mostly

TABLE 1. Sample Characteristics of Patients With ≥24 Hours of Monitoring Discharged to Home (n = 777)

Variables	Value
Sociodemographics	
Age	
18–40 years	111 (15%)
41–65 years	325 (42%)
65–75 years	187 (24%)
≥75 years	151 (19%)
Females	444 (57%)
Race/ethnicity	
White	349 (45%)
Hispanics	277 (35%)
African American	101 (13%)
Asian/Pacific Islander	37 (5%)
Other	13 (2%)
Marital status	
Partnered	435 (56%)
Unpartnered	332 (43%)
Other/unknown	10 (1%)
Clinical characteristics	
Medical (principal discharge diagnoses)	
Cardiovascular	116 (15%)
Respiratory	84 (11%)
Gastrointestinal	122 (16%)
Genitourinary	31 (4%)
Metabolic/electrolytes	26 (3%)
Septicemia	92 (12%)
Nervous system	21 (3%)
Cancer/malignancies	13 (1%)
Other*	103 (13%)
Surgical	
Orthopedic surgery	60 (8%)
Other surgeries	109 (14%)
LACE score	9.3 ± 3.5
Charlson index	
0–1	665 (85%)
2–3	98 (13%)
4+	14 (2%)
Length of stay, d	3.98 ± 3.80
Body mass index	30.2 ± 7.5
Functional status	
Preadmission level of function	
1, bed bound	3 (0.5%)
2, able to sit	6 (1%)
3, stand next to bed	3 (0.5%)
4, walk <50 feet	113 (14%)
5, walk >50 feet	651 (84%)
Missing	1 (0%)
Current level of function	
1, bed bound	1 (0%)
2, able to sit	6 (1%)
3, stand next to bed	7 (1%)
4, walk <50 feet	320 (41%)
5, walk >50 feet	434 (56%)
Missing	9 (1%)

NOTE: Data are presented as either mean ± standard deviation or count (%).Preadmission level of function that was documented closest to admission time was used. The modal current level of function score in last 24 hours prior to discharge was used. LACE is the readmission risk score based on length of stay ("L"); acuity of the admission ("A"); comorbidity of the patient (measured with the Charlson comorbidity index score) ("C"); and emergency department use (measured as the number of visits in the six months before admission) ("E"). *Other categories include complications of pregnancy/childbirth, hematologic, other musculoskeletal and skin/subcutaneous disorders, injuries and poisoning, mental illness, other ill-defined conditions.

TABLE 2. Total Step Count in the Last 24 Hours Prior to Discharge to Home for Patients With ≥24 Hours of Monitoring

	Total Steps Last 24 Hours		
Service	Mean	SD	Median
Medicine			
<65 years old (n = 321)	1,972	1,995	1,284
≥65 years old (n = 287)	1,367	1,396	968
Surgical			
<65 years old (n = 118)	2,238	2,082	1,378
≥65 years old (n = 51)	1,485	1,647	890
Total (n = 777)	1,757	1,818	1,158

NOTE: **Abbreviations:** SD, standard deviation.

TABLE 3. Total Step Count in the First 24 Hours of Admission to the Medical-Surgical Unit and Last 24 Hours Prior to Discharge to Home for Patients With ≥48 Hours of Monitoring

	Total Steps					
	First 24 Hours			Last 24 Hours		
Service	Mean	SD	Median	Mean	SD	Median
Medicine						
<65 years old (n = 168)	1,427	1,690	953	2,005	2,006	1,287
≥65 years old (n = 127)	1,004	1,098	676	1,260	1,291	904
Surgical						
<65 years old (n = 53)	1,722	1,696	1060	2,553	2,142	1,882
≥65 years old (n = 30)	1,184	1,470	704	1,829	1,996	1,053
Total (n = 378)	1,307	1,515	811	1,817	1,864	1,188

NOTE: **Abbreviations:** SD, standard deviation.

due to nursing staff forgetting to remove the devices at discharge; device failure was minimal (n = 10).

Patients accrued a median of 1158 (interquartile range: 636–2238) steps over the 24 hours prior to discharge to home (Table 2). Approximately 13 (2%) patients registered zero steps in the last 24 hours; this may have been due to patients truly not accruing any steps, device failure, or the device was registered but never worn by the patient. Patients who were 65 years and older on both the medicine and surgical services accrued fewer steps compared to younger patients (962 vs 1294, $P < 0.0001$). For patients who had at least 48 hours of continuous monitoring (n = 378), there was a median increase of 377 steps from the first 24 hours from admission to the unit to the final 24 hours prior to discharge (811 steps to 1188 steps, $P < 0.0001$) (Table 3 and Figure 1). The average length of stay for these patients was 5.7 ± 4.9 days. Despite the longer length of stay, the level of ambulation at discharge was similar to patients with shorter stays. This is further illustrated in Figure 2 in the spaghetti plots of total steps over 4, 24-hour monitoring increments. Ignoring the outliers, the plots suggest the

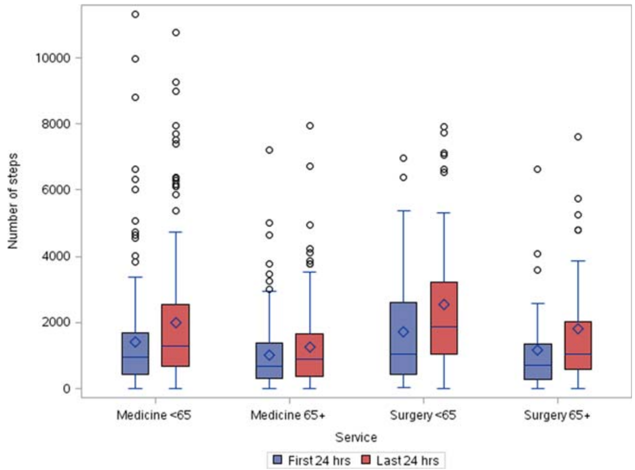

FIG. 1. Box plots of total step counts in the first 24 hours of admission to the medical-surgical unit and last 24 hours prior to discharge to home for patients with ≥48 hours of monitoring by age and service line.

following: (1) step counts tended to increase or stay about the same over the course of a hospitalization; and (2) for the medicine service line, step counts in the final 24 hours prior to discharge for patients with longer lengths of stay (72 or 96 hours) did not appear to be substantially different from patients with shorter lengths of stay. The data for the surgical patients are either too sparse or erratic to make any firm conclusions. Patients accrued steps throughout the day with the highest percentage of steps logged at approximately 6 AM and 6 PM; these data are based on time stamps from the device, not the time of data transfer or documentation in the EMR (Figure 3).

More frequent documentation of step counts in the EMR (proxy for step count data retrieval and review from the vendor web site) by the care team was associated with higher total step counts after adjustments for relevant covariates ($P \leq 0.001$); 3 or more documentations over a 24-hour period appears to be a minimal frequency to achieving approximately 200 steps more than the median value (Table 4).

DISCUSSION

We found that ambulatory medical-surgical patients accrued a median of 1158 total steps in the 24 hours prior to their discharge home, which translates to walking approximately 500 meters; older patients accrued fewer steps compared to younger patients. In patients with longer length of stay, the level of ambulation at discharge was similar to patients with shorter stays, suggesting there may be an ambulation threshold (~1100 steps) that patients achieve regardless of the length of stay before they are discharged home. In addition, patients whose care team reviewed and documented step counts at least 3 times over a 24-hour period accrued significantly more steps than patients whose care team made fewer documentations.

The median step counts accrued by surgical patients in our study are similar to that found in Cook and

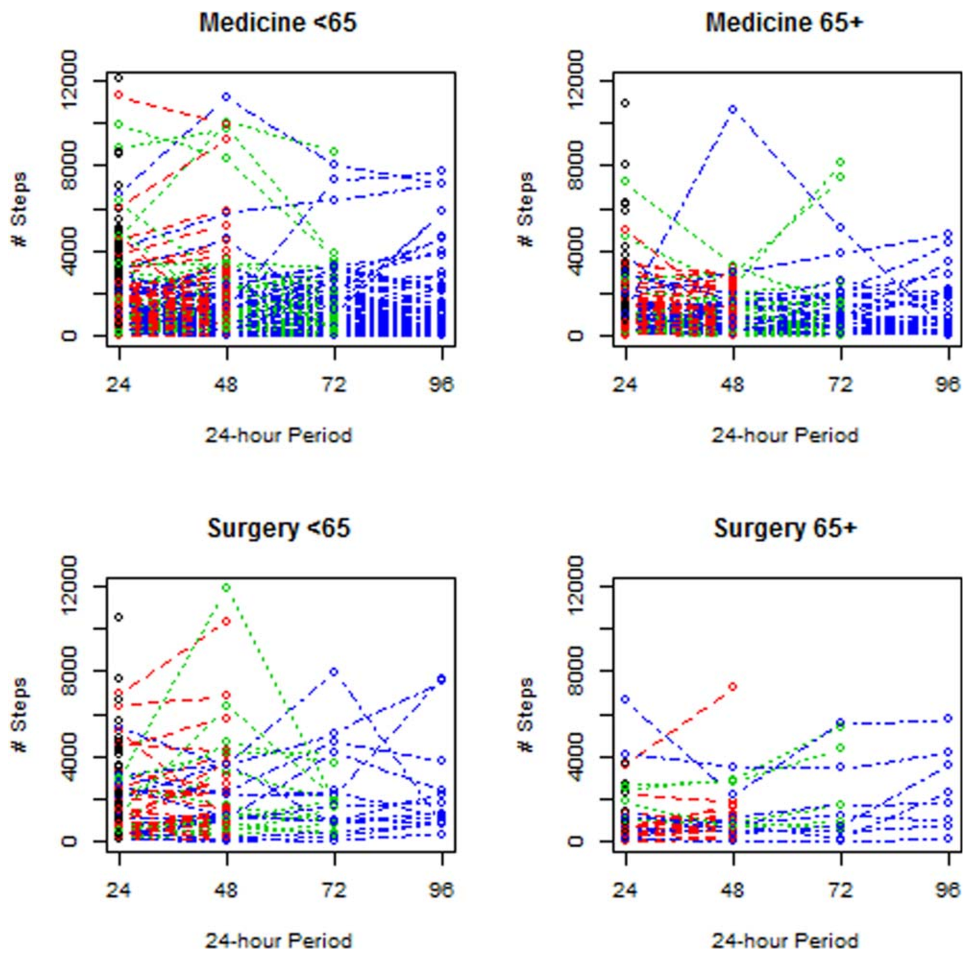

FIG. 2. Spaghetti plots of total step counts for each 24-hour monitoring period by age (<65 and ≥65 years) and service line (medical or surgical). Sample sizes are as follows: 24 hours (black dots, n = 399), 48 hours (red lines, n = 190), 72 hours (green lines, n = 80), 96 hours (blue lines, n = 108).

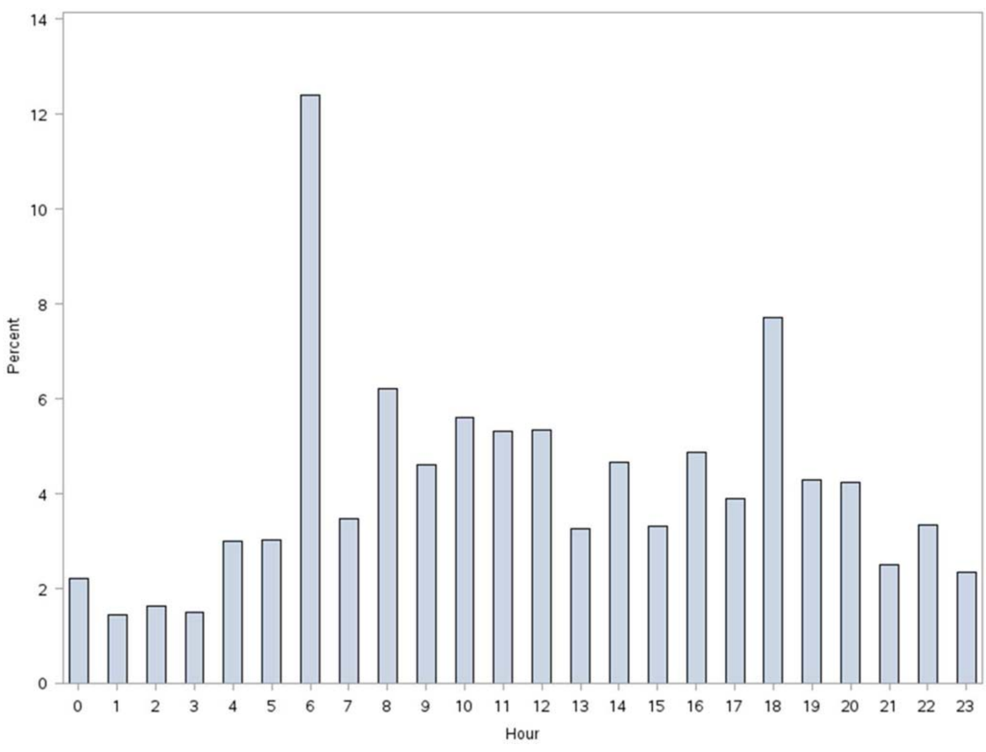

FIG. 3. Distribution of step counts by percentage of accrued steps over 24 hours prior to discharge.

TABLE 4. Association Between Frequency of Step Count Documentation in the EMR and Total Step Counts in the Last 24 Hours Prior to Discharge to Home for Those With at Least 24 Hours of Observation

Service		Frequency of Documentation of Step Counts in EMR Over 24 Hours					*P* Value Trend*	Adjusted *P* Value†
		0	1	2	3	≥4		
Medicine								
<65 years old (n = 321)	Mean ± SD	1,405 ± 1,414	2,415 ± 2,037	2,010 ± 1,929	1,981 ± 1,907	2,741 ± 2,876		
	Median	1,056	1,514	1284	1,196	1,702	0.004	0.003
	N (%)	83 (26%)	109 (34%)	71 (22%)	25 (8%)	33 (10%)		
≥65 years old (n = 287)	Mean ± SD	1,348 ± 1,711	1,199 ± 1428	1,290 ± 951	1,529 ± 1,180	1,878 ± 1,214		
	Median	850	773	999	1,278	1,498	0.07	0.10
	N (%)	85 (30%)	82 (28%)	66 (23%)	20 (7%)	34 (12%)		
Surgical								
<65 years old (n = 118)	Mean ± SD	2,077 ± 2,001	1,859 ± 1,598	2,618 ± 2,536	2,312 ± 2,031	3,802 ± 2,979		
	Median	1,361	1,250	1,181	1,719	3,149	0.06	0.05
	N (%)	42 (35%)	36 (31%)	18 (15%)	14 (12%)	8 (7%)		
≥65 years old (n = 51)	Mean ± SD	2,003 ± 2,254	1,478 ± 1,603	1,165 ± 1,246	478	1,219 ± 469		
	Median	1,028	820	672	478	1,426	0.20	0.15
	N (%)	13 (26%)	19 (37%)	15 (29%)	1 (2%)	3 (6%)		
Total (n = 777)	Mean ± SD	1,544 ± 1,717	1,736 ± 1,799	1,720 ± 1,699	1,883 ± 1720	2,415 ± 2,304		
	Median	1,012	1,116	1,124	1,314	1,557	<0.001	<0.001
	N (%)	223 (29%)	246 (31%)	170 (22%)	60 (8%)	78 (10%)		

NOTE: **Abbreviations:** EMR, electronic medical record; SD, standard deviation.

**P* value for trend (quantile regression for median step counts).

†Adjusted for age, gender, LACE score (readmission risk score based on length of stay ("L"); acuity of the admission ("A"); comorbidity of the patient (measured with the Charlson comorbidity index score) ("C"); and emergency department use (measured as the number of visits in the six months before admission) ("E"), and service line (medicine/surgical) where relevant.

colleagues'[14] report of patients after elective cardiac surgery using another popular consumer-grade accelerometer. The providers in that study also had access to the data via a dashboard, but it was not clear how this information was used. Brown et al.[12] conducted the first study to objectively monitor mobility using 2 accelerometers in 45 older male veterans who had no prior mobility impairment, and found that patients spent 83% of their hospitalization lying in bed. The veterans spent about 3% of the time (~43 minutes per day) standing or walking over a mean length of stay of 5 days. In a similar study with 43 older Dutch patients who had an average length of stay of 7 days, Pedersen et al.[10] found that patients spent 71% of their time lying, 21% sitting, and 4% standing or walking. Unfortunately, neither the Brown et al. nor Pedersen et al. studies were able to distinguish between standing and ambulatory activities. In a more recent study of 47 patients on medical-surgical units at 2 hospitals that relied on time and motion observation methods, the mean duration for ambulation was <2 minutes during an 8-hour period.[13]

We took advantage of the variability in the nursing documentation of step counts in the EMR to determine if there was a dose-response relationship between the frequency of nursing documentation in a 24-hour period and number of steps patients accrued. We hypothesized that if nurses make an effort to retrieve data from the vendor website and manually key in the step counts in the EMR, they are more likely to incorporate this information in their nursing care, share the information with patients and other clinicians, and therefore create a positive feedback loop for greater ambulation. Although our findings suggest a positive association between more frequent documentation and increased step counts, we cannot exclude the possibility that nurses naturally modulate the frequency with which they review and document step counts based on their overall judgment of the patients' mobility status (ie, patients who are more functionally impaired are assumed to accrue fewer steps over a shift, and therefore, nurses are less inclined to retrieve and document the information frequently). Future studies could prospectively examine what the optimal frequency for review and feedback of step counts is during a typical 8- or 12-hour nursing shift for both patients and the nursing care team to promote ambulation.

A major strength of our study is the collection of objective ambulation data on a large inpatient sample by clinical staff as part of routine nursing care. This strength is balanced with several limitations. Due to the temporal pattern associated with ambulation, we were only able to analyze data for patients who had at least 24 hours of continuous monitoring. This could affect the generalizability of our findings, though we believe there is limited pragmatic value in closely tracking ambulation in patients who have such short stays. There was substantial variability in the step counts, reflecting the mix of medical versus surgical patients and their age, with very small samples available for meaningful subgroup analyses other than what we have presented. We were not able to measure other dimensions of mobility such as transfers or sitting in a chair, because the sensor is designed to only measure steps. In addition, we lost a large number of devices, mostly due to staff forgetting to remove the devices from patients' ankles at discharge. Finally, because we did not blind the nurses and patients to the step count data, the preliminary normative step counts that we present in this article may be higher than expected in patients cared for on medical-surgical units.

In summary, we found that it is possible to measure ambulation objectively and reliably in hospitalized patients, and have provided preliminary normative step counts for a representative but heterogeneous medical-surgical population. We also found that most patients who were discharged were ambulating at least 1100 steps over the 24 hours prior to leaving the hospital, regardless of their length of stay. This might suggest that step counts could be a useful parameter in determining readiness for hospital discharge. Our data also suggest that more frequent, objective monitoring of step counts by the nursing care team was associated with patients ambulating more. Both of these findings deserve further exploration. Future studies will need to be conducted on larger samples of medical and surgical hospitalized patients to adequately establish more refined step count norms for specific clinical populations, but especially for older patients, because this age group is at a particularly higher risk of poor functional outcomes with hospitalization. Having accurate and reliable information on ambulation is fundamental to any effort to improve ambulation in hospitalized patients. Moreover, knowing the normative range for step counts in the last 24 hours prior to discharge across specific clinical and age subgroups, could assist with discharge planning and provision of appropriate rehabilitative services in the home or community for safe transitions out of the hospital.[17]

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