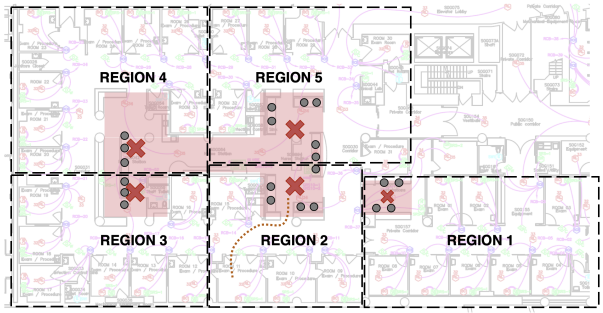
Appendix. Additional Tables & Analyses

A. Core ED Rooms: Room Distances and Fixed Effects

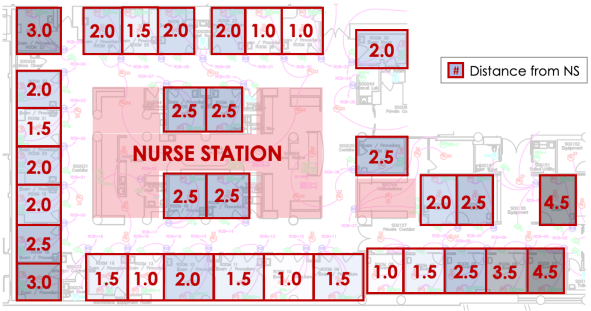
To identify the effect of patient room location on nurse work behavior, we code the distance of each patient room from the nurses' station based on actual travel distance. Since the nurses' station spans such a large space, in practice, nurses sit in the "region" of the station closest to the patient rooms for which they are responsible during that shift (see Figure 5a). We then measure the walking distance from the middle of these regions (marked by a red X on Figure 5a with a sample walking path marked on the figure with an orange dotted line on "Region 2") to the patient bedside in each of the rooms within the region. This approximates the most realistic measure of actual walking distance to patient rooms, based on normal seating arrangements in the ED. The farthest patient room is approximately 45 meters away, whereas the closest room is 10 meters away. These measured room distances are shown by room in units of 10-meters in Figure 5b. Differences in healthcare provider staffing levels across rooms are shown in Figure 5c and differences in physical room size are shown in Figure 5d.

Figure 5 Fixed Effects & Room Distance Measurement Across ED Rooms

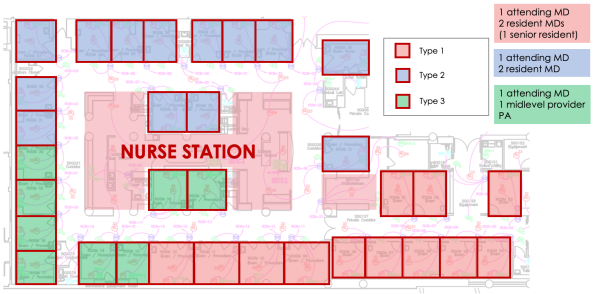
(a) Measuring Room Distance



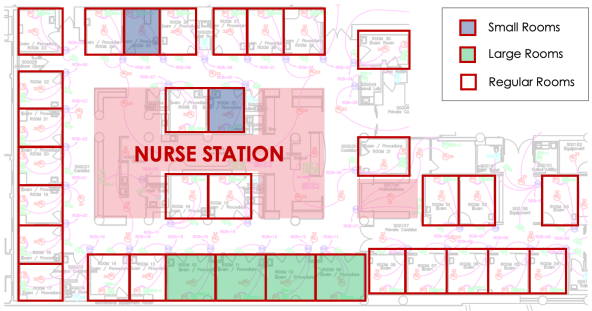
(b) Room Distance from Nurses' Station (10m)



(c) Room Provider Staffing Level



(d) Room Size



B. Core ED Rooms: Room Distances and Fixed Effects

We observe that nurses visit a single patient on a trip from the nurses' station 83.26% of the time (see Figure 6, where we plot the number of unique patients visited by nurses for each trip beginning and ending in the nurses' station staff area). Through discussions with ED nurses, we learned that this behavior is consistent with an ED policy created to minimize the risk of medical errors.

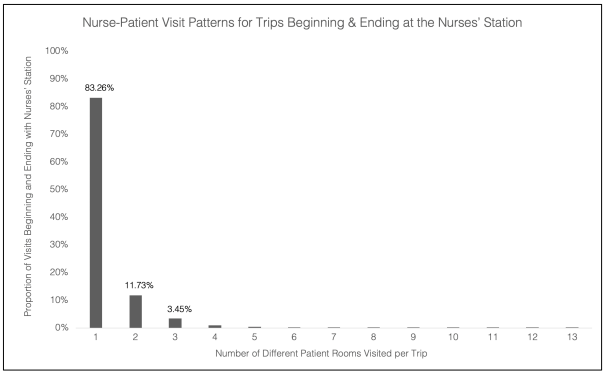


Figure 6 Nurse-Patient Visit Patterns for Trips Beginning and Ending at the Nurses' Station

C. Robustness Analysis

To ensure the robustness of our estimates, we repeat our analysis using robust regression (Ripley 2002). This method uses Huber's M-estimator and is appropriate for situations in which there exist outliers in the outcome variables (Huber et al. 1964, Huber 2011). The distribution of our response variables are right-skewed with several outliers. While many of these outliers seem to be representative of normal ED operations, we conduct robust regression on the data to ensure our findings are consistent, even when using a much more conservative estimator that is robust to outliers. Using this more conservative method, our results are qualitatively identical. The number of visits made to patient rooms per hour decreases by 0.275 visits for every additional 10 meters of distance. Similar to our OLS findings, there appears to be no significant difference in the total nurse-patient interaction minutes per hour across room distances. As the distance between a patient's room and the nurses' station increases by 10 meters, the duration of each visit by a nurse increases by about 0.277 minutes. When using robust regression to understand the impact of this behavior on the patient experience, we find that patients experience 2.75 additional minutes of wait time between visits for every 10 meters of distance between their room and the nurses' station, and these patients make an average of 0.016 more calls for the nurse during their visit. The length of stay of patients across rooms of varying distances remains unchanged. We choose to use OLS and robust regression to avoid log-transforming the data just to satisfy OLS assumptions, thereby preserving the linear relationship between distance and our response variables. We conduct the main analyses using the log-transformed dependent variables as an additional robustness check and find qualitatively identical results; more information and tables are available from the authors if needed.

We repeat our analysis with the inclusion of the ED LOS as a control variable. We find qualitatively identical results, suggesting our estimates hold across different ED lengths of stay: for every 10-meter increase in patient room distance, patients receive fewer visits per hour ($\beta_p = -0.390, p < 0.001$), but each visit is longer ($\beta_p = 0.303, p < 0.001$). We find no statistical difference in the total duration per hour providers spend with patients across room distances ($\beta_p = -0.044, p > 0.05$). Lastly, controlling for the ED LOS, patients farther away similarly make more calls per hour ($\beta_p = 0.015, p < 0.001$).

D. Robustness: Main Results Using Full Dataset

To compare our findings estimated from the subset of data against the full dataset that includes instances where there were multiple patient beds available when a patient was assigned to a bed, we repeat the OLS regression analysis using all of the data and the same models. The coefficient estimates are qualitatively identical (Table 10). The number of visits made to patient rooms per hour decreases by 0.393 visits for every additional 10 meters of distance. This translates to 1.37 fewer visits for the patients in the rooms farthest away from the nurses' station. Similar to our findings on the truncated dataset, there appears to be no significant difference in the total nurse-patient interaction minutes per hour across room distances. This suggests that nurses are reducing visits, but not reducing the total time spent; we find support for the hypothesis that they are batching tasks. As a patient's room distance increases by 10 meters, the duration spent per visit by a nurse increases by about 0.271 minutes. The rooms farthest away from the nurses' station receive visits that are, on average, 0.95 minutes longer compared to the rooms closest to the nurses' station.

Table 10 OLS Results Using All Patient Encounters - Nurse Visit Models

	Dependent variable:		
	(14)	(15)	(16)
	Vis/Hr	Dur/Hr	Dur/Vis
Distance (10m)	-0.393^{***} (0.027)	-0.126 (0.072)	0.271^{***} (0.016)
Room-Specific Controls **W**	✓	✓	✓
Encounter-Specific Controls **X**	✓	✓	✓
Time-Related Controls **Z**	✓	✓	✓
Constant	3.902^{***} (0.325)	6.281^{***} (0.872)	1.375^{***} (0.193)
Observations	15,500	15,500	15,500
Adjusted R^2	0.223	0.186	0.112

*p<0.05; **p<0.01; ***p<0.001

Note: *model controls include room-specific controls **W**: room size and room staffing level, encounter-specific controls **X**: patient ESI, age, gender, race, whether patient required labs, radiological imaging, diagnostics, or medications, the physician assigned to the patient, the nurse assigned to the patient, the chief complaint of the patient, whether the patient was admitted to the hospital, the ED bed census and waiting room census upon patient arrival, and time-specific controls **Z**: the month, hour of day, whether the day was a weekend, and nursing shift during which the patient was placed into a room in the ED.*

Similarly, when using the full dataset to understand the impact of this behavior on care quality (Table 11), we find that patients in rooms every 10 meters farther away experience a 3.25 minute increase in their inter-visit wait time, and make on average 0.016 more calls per hour for the nurse. In the rooms farthest away

this translates to 11.4 minutes of additional waiting time between visits and 0.05 more calls per hour. The length of stay of patients across rooms of varying distances remains unchanged.

Table 11 OLS Results Using All Patient Encounters - Call Frequency and LOS Models

	Dependent variable:		
	(17)	(18)	(19)
	Time btw. Visits (Mins)	Calls/Hr	LOS (Hrs)
Distance (10m)	3.252^{***} (0.287)	0.016^{***} (0.003)	-0.016 (0.033)
Room-Specific Controls **W**	✓	✓	✓
Encounter-Specific Controls **X**	✓	✓	✓
Time-Related Controls **Z**	✓	✓	✓
Constant	29.439^{***} (4.109)	0.004 (0.044)	0.523 (0.398)
Observations	15,500	15,500	15,500
Adjusted R^2	0.083	0.246	0.335

*p<0.05; **p<0.01; ***p<0.001

Note: *model controls include room-specific controls **W**: room size and room staffing level, encounter-specific controls **X**: patient LOS (hrs, for model 17 only), patient ESI, age, gender, race, whether patient required labs, radiological imaging, diagnostics, or medications, the physician assigned to the patient, the nurse assigned to the patient, the chief complaint of the patient, whether the patient was admitted to the hospital, the ED bed census and waiting room census upon patient arrival, and time-specific controls **Z**: the month, hour of day, whether the day was a weekend, and nursing shift during which the patient was placed into a room in the ED.*

E. Robustness: Main Results Using Excluded Dataset Only

To compare our findings estimated from the subset of the data against the excluded subset of the data, we present in this Section the results from our main models using *only* the excluded subset of data. The coefficient estimates are qualitatively similar (Table 12). The number of visits made to patient rooms per hour decreases by 0.410 visits for every additional 10 meters of distance. This translates to 1.4 fewer visits for the patients in the rooms farthest away from the nurses' station. Unlike our main results using the selected subset, here there appears to be a reduction in the total nurse-patient interaction minutes per hour across room distances; the minutes patients spend with the nurse decreases by 0.284 minutes for every 10 meters of distance. This translates to approximately 0.9 minutes less time with the nurse for patients in the rooms farthest away from the nurses' station. We similarly find support for the hypothesis that nurses are batching their tasks. As a patient's room distance increases by 10 meters, the duration spent per visit by a nurse increases by about 0.211 minutes. The rooms farthest away from the nurses' station receive visits that are, on average, 0.74 minutes longer compared to the rooms closest to the nurses' station.

Table 12 OLS Results on Excluded Dataset

	Dependent variable:		
	Vis/Hr (20)	Dur/Hr (21)	Dur/Vis (22)
Distance (10m)	-0.410^{***} (0.050)	-0.284^{*} (0.135)	0.211^{***} (0.028)
Room-Specific Controls **W**	✓	✓	✓
Encounter-Specific Controls **X**	✓	✓	✓
Time-Related Controls **Z**	✓	✓	✓
Constant	3.793^{***} (0.634)	6.485^{***} (1.721)	1.816^{***} (0.359)
Observations	5,715	5,715	5,715
Adjusted R^2	0.210	0.173	0.105

*p<0.05; **p<0.01; ***p<0.001

Note: *model controls include room-specific controls **W**: room size and room staffing level, encounter-specific controls **X**: patient ESI, age, gender, race, whether patient required labs, radiological imaging, diagnostics, or medications, the physician assigned to the patient, the nurse assigned to the patient, the chief complaint of the patient, whether the patient was admitted to the hospital, the ED bed census and waiting room census upon patient arrival, and time-specific controls **Z**: the month, hour of day, whether the day was a weekend, and nursing shift during which the patient was placed into a room in the ED.*

Similarly, when using the excluded dataset to understand the impact of this behavior on care quality (Table 13), we find that patients in rooms every 10 meters farther away experience a 3.0 minute increase in their inter-visit wait time, and make on average 0.019 more calls per hour for the nurse. In the rooms

farthest away this translates to 10.4 minutes of additional waiting time between visits and 0.06 more calls per hour. The length of stay of patients across rooms of varying distances remains unchanged.

Table 13 OLS Results on Excluded Dataset

	Dependent variable:		
	Time btw. Visits (Mins) (23)	Calls/Hr (24)	LOS (Hrs) (25)
Distance (10m)	2.998^{***} (0.483)	0.019^{**} (0.006)	-0.003 (0.044)
Room-Specific Controls **W**	✓	✓	✓
Encounter-Specific Controls **X**	✓	✓	✓
Time-Related Controls **Z**	✓	✓	✓
Constant	27.727^{***} (7.041)	0.055 (0.088)	1.988^{***} (0.557)
Observations	5,715	5,715	5,715
Adjusted R^2	0.098	0.257	0.385

*p<0.05; **p<0.01; ***p<0.001

Note: *model controls include room-specific controls **W**: room size and room staffing level, encounter-specific controls **X**: patient ESI, age, gender, race, whether patient required labs, radiological imaging, diagnostics, or medications, the physician assigned to the patient, the nurse assigned to the patient, the chief complaint of the patient, whether the patient was admitted to the hospital, the ED bed census and waiting room census upon patient arrival, and time-specific controls **Z**: the month, hour of day, whether the day was a weekend, and nursing shift during which the patient was placed into a room in the ED.*

F. Calls by Type

Figure 7 shows the breakdown of the "type" of each of the calls made by patients in our dataset. We estimate a models to assess the impact of patient room distance on the frequency of "Normal Calls" in Table 14. Our results remain qualitatively consistent, a 10 meter increase in the patient room distance results in a 0.048 normal calls made by the patient ($\beta_p = 0.048$, $p < 0.05$) as shown in Table 14.

TYPE OF CALL	FREQUENCY (n)
Bath Call	74
Bed Disconnect Call	25
Bed Offline	40
Call Cord Disconnect	147
Code Blue Call	16
Normal Call	17320
Pillow Speaker Disconnect Call	922
Staff Call	159
Staff Emergency Call	38

Figure 7 Breakdown of Patient Calls by Type and Frequency

Table 14 OLS Models for Normal Calls

	(26)
	Normal Calls
Distance (10m)	0.048* (0.022)
Room-Specific Controls **W**	✓
Encounter-Specific Controls **X**	✓
Time-Related Controls **Z**	✓
Observations	9,785
Adjusted R^2	0.344

*p<0.05; **p<0.01; ***p<0.001

Note: *model controls include room-specific controls **W**: room size and room staffing level, encounter-specific controls **X**: patient LOS (hrs), patient ESI, age, gender, race, whether patient required labs, radiological imaging, diagnostics, or medications, the physician assigned to the patient, the nurse assigned to the patient, the chief complaint of the patient, whether the patient was admitted to the hospital, the ED bed census and waiting room census upon patient arrival, and time-specific controls **Z**: the month, hour of day, whether the day was a weekend, and nursing shift during which the patient was placed into a room in the ED.*

G. Rounding Simulation Results

We conduct a simulation to test the impact of nurse rounding at different frequencies. Using the the empirical data on the time to the first call, and the empirical data on the time between a nurse visit and the patient's next call, we draw times for each of 33 simulated patients in the ED over the duration of several hours. The fastest rounding frequency we test is a nurse visit every 15 minutes (0.25 hours) and the longest rounding frequency is a nurse visit every 180 minutes (3 hours). Figure 8 shows the number of calls per hour and the hourly walking distance under various rounding frequencies (from a simulation with 10,000 iterations). The number of calls per hour is the number of calls across all 33 patient rooms on average each hour, and the total walking distance is the average walking distance each hour across all 33 patient rooms, taking only return trips between the nurses' station and patient rooms into account. We assume here that a trip is made during rounding and each time a patient presses the call button.

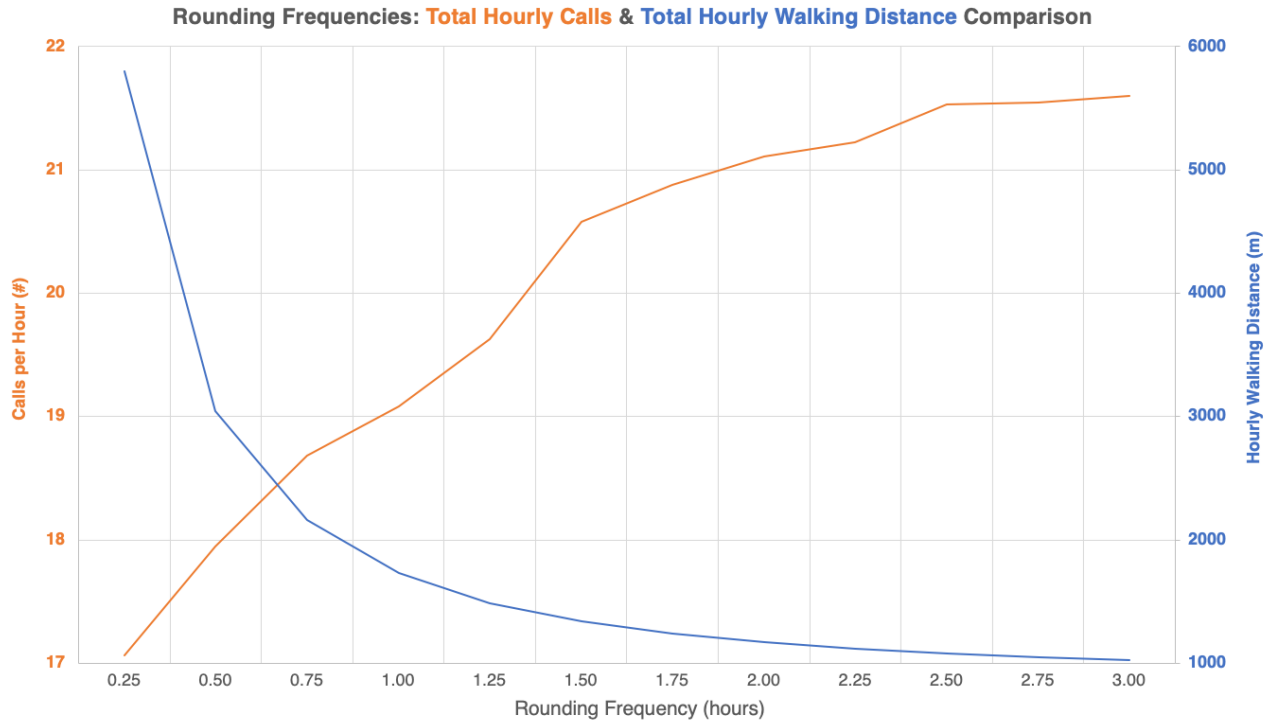


Figure 8 **Rounding Frequencies: Comparison of Total Hourly Calls and Rounding Frequencies**