Supplementary Method 1: Specification of the UWB tracking system

To provide a full description of the IPS implemented in this study, we used the evaluation framework proposed by Wichmann et al., based on the following key criteria [1]: (1) accuracy, expressed in meters; (2) availability of the signals on common devices; (3) low cost, if no additional hardware is required; (4) energy efficiency, considering device batteries; (5) latency/delay should be less than 1 second; (6) precision and consistency of the system; (7) reception range should be greater than 10 meters; (8) robust and remains functional even if a localization point fails; (9) and scalability.

In this study, we implemented an IPS based on Ultra-Wide Band (UWB) using multiple anchors and 27 tags (i.e., sensors) in the emergency department of Le Corbusier Hospital in Firminy, France. Radio frequency signals can be divided into continuous waves (e.g., Wi-Fi, radio frequency identification (RFID)) and pulse ultrawide band (UWB). In terms of (1) accuracy, (6) precision and (7) range, UWB IPSs have been shown to provide superior performance compared to continuous wave IPSs in terms of accuracy (i.e., up to one centimeter), precision and range (i.e., up to 200 meters) owing to its high temporal resolution [2,3,4,5]. Regarding (2) availability and (3) low cost, the UWB IPS implemented in this study is not compatible with common devices such as smartphones, and instead requires additional hardware (i.e., UWB tags). In terms of (4) energy efficiency, we used UWB tags with short-life batteries that can be easily recharged in between worker shifts. The data were collected in quasi-real time with almost no (5) latency/delay, as records were collected 5 times per second. The (8) robustness of the system was reinforced using a smoothing algorithm described in section 2, ensuring a correct interpretation even if a localization point failed. Lastly, in terms of (9) scalability, the system requires the acquisition of extra UWB tags and the installation of anchors in order to be extended to a broader population or buildings.

1. Wichmann, J., Paetow, T., Leyer, M., Aweno, B., & Sandkuhl, K. (2024). Determining design criteria for indoor positioning system projects in hospitals: A design science approach. Digital Health, 10. https://doi.org/10.1177/20552076241229148

2. Bregar, K. (2023). Indoor UWB Positioning and Position Tracking Data Set. Scientific Data, 10(1). https://doi.org/10.1038/s41597-023-02639-5

3. Ho, Y.-H., Hou, G.-H., Wu, M.-H., Chen, F.-H., Sung, P.-S., Chen, C.-H., & Lin, C.-L. (2019). High-Precision UWB Indoor Positioning System for Customer Pathway Tracking. 2019 IEEE 8th Global Conference on Consumer Electronics (GCCE), 466–467. https://doi.org/10.1109/GCCE46687.2019.9015284

4. Lou, P., Zhao, Q., Zhang, X., Li, D., & Hu, J. (2022). Indoor Positioning System with UWB Based on a Digital Twin. Sensors, 22(16). https://doi.org/10.3390/s22165936

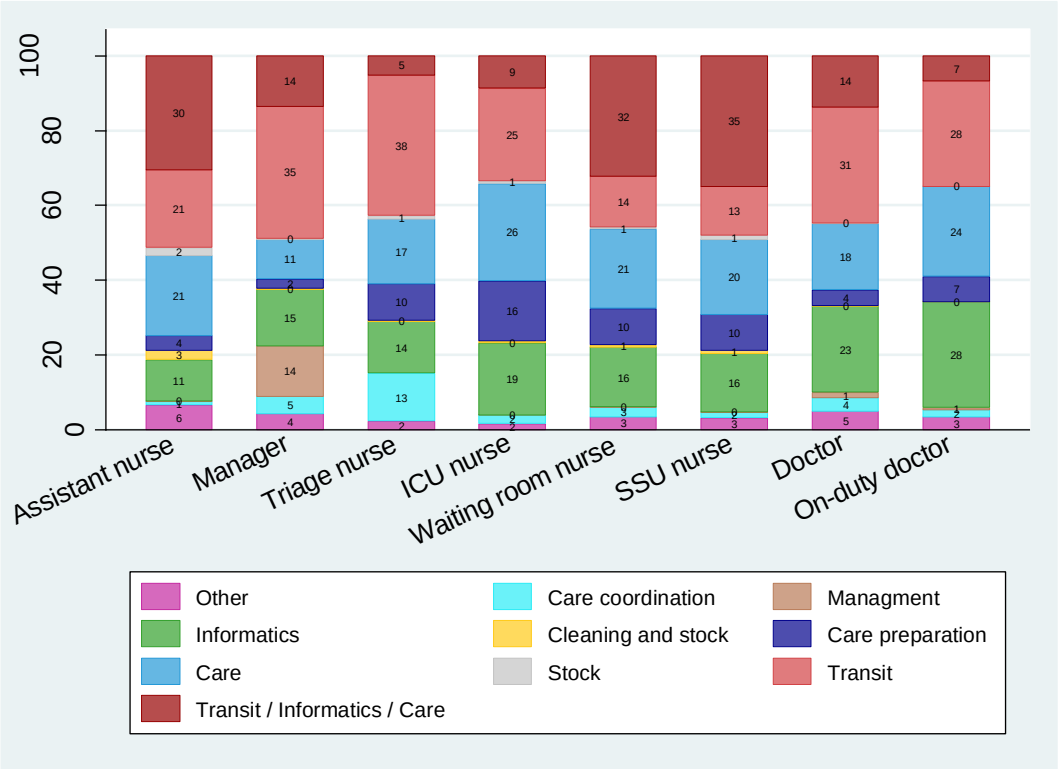
5. Qian, L., Chan, A., Cai, J., Lewicke, J., Gregson, G., Lipsett, M., & Rios Rincón, A. (2024). Evaluation of the accuracy of a UWB tracker for in-home positioning for older adults. Medical Engineering & Physics, 126, 104155. https://doi.org/10.1016/j.medengphy.2024.104155

Supplementary Method 2: Description of healthcare professional categories and of the cleaning procedure.

Assistant nurses work under the supervision of a nurse and assist in the performance of nursing duties. After patient registration, the triage nurse is the first point of contact in the ED, and performs an early-assessment to determine their level of need. ICU nurses are in charge of patients who are recovering from life-threatening illnesses or injuries in the ICU. The role of a waiting room nurse is to expedite care by assessing and managing patients waiting for hospitalization. SSU nurses care for patients admitted for surgery and medical procedures in the SSU. Managers include the head of the ED, as well as the health executive staff. Finally, doctors assess and treat patients in the ED, and on-duty doctors operate on a 24-hour basis to ensure continuity of service.

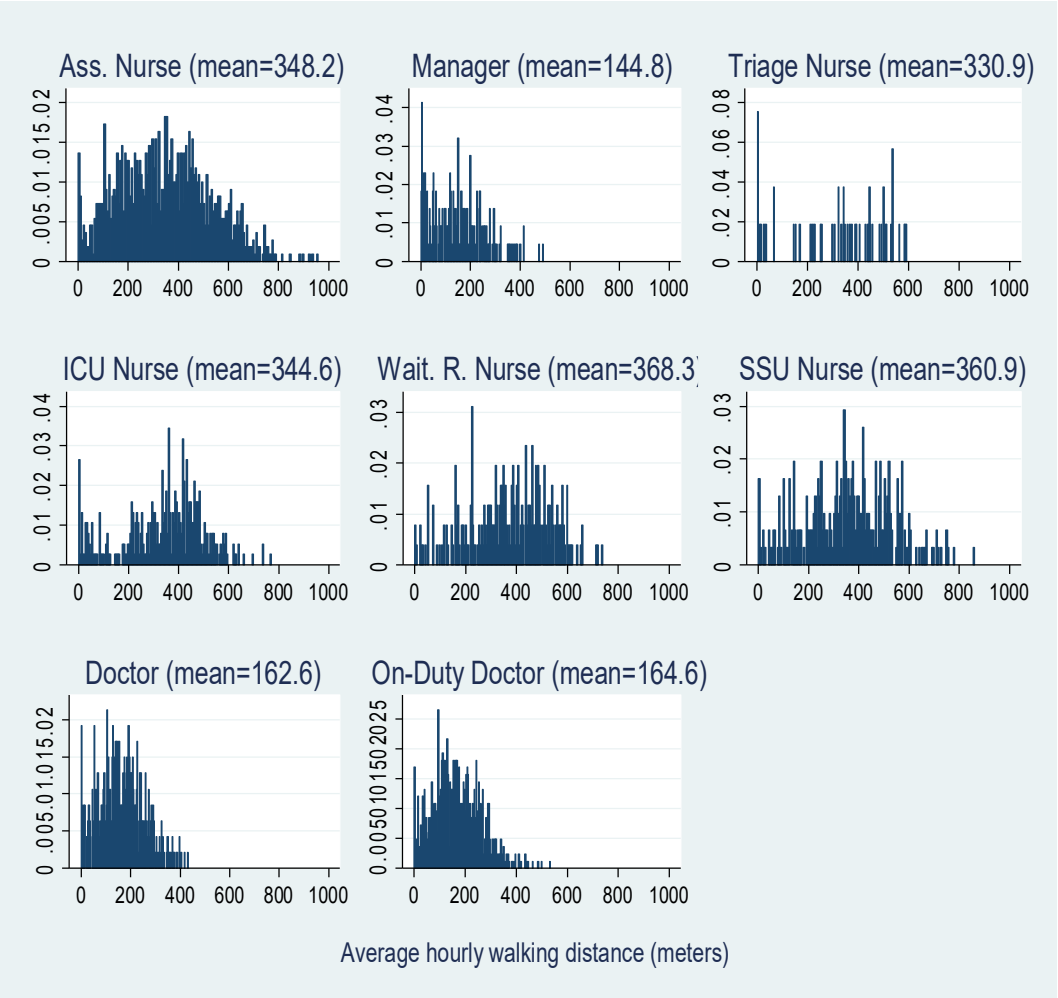
While IPS based on radio frequency signals benefits from a high accuracy, noise is often observed in locations due to the complexity of the indoor environment [8,20]. Exploiting the large amount of data recorded in quasi-real time, we employed a smoothing algorithm to reduce noise in the data. The principle is to group timestamped locations into 10-second time windows for each tag separately. Then, observations within each time window are aggregated. To aggregate the data, we first identify the most frequent room in which the tag is located in every time window. Then, a single record is retained per time window by randomly selecting one observation in the most frequent room of each time window. This type of algorithm has been shown to be an effective way to reduce noise in data generated by IPS [15]. Additionally, we applied a cleaning procedure for a few observations when the coordinates were within a wall or outside the building. In these situations, the coordinates were replaced by the coordinates of the previous observation, if it was from the same tag and within 10 seconds.

Supplementary Figure 1: Average time allocation of healthcare professionals.



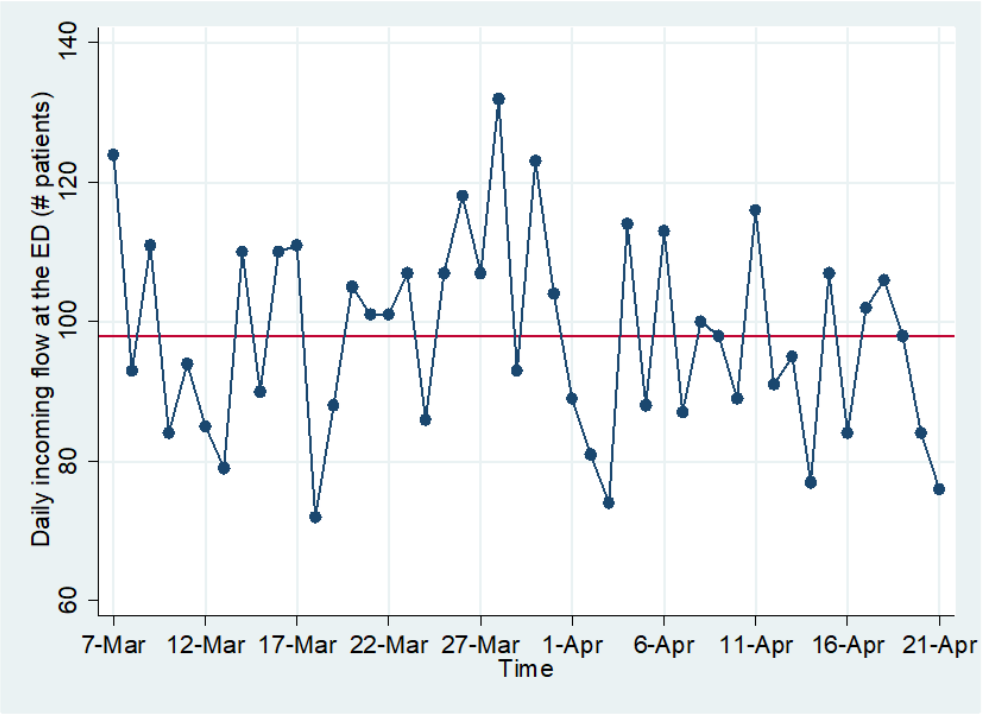
Caption: Types of medical staff are classified into assistant nurses, triage nurses, intensive care unit (ICU) nurses, waiting room nurses, short-stay unit (SSU) nurses, managers, doctors and on duty doctors.

Supplementary Figure 2: Distributions of hourly walking distances.

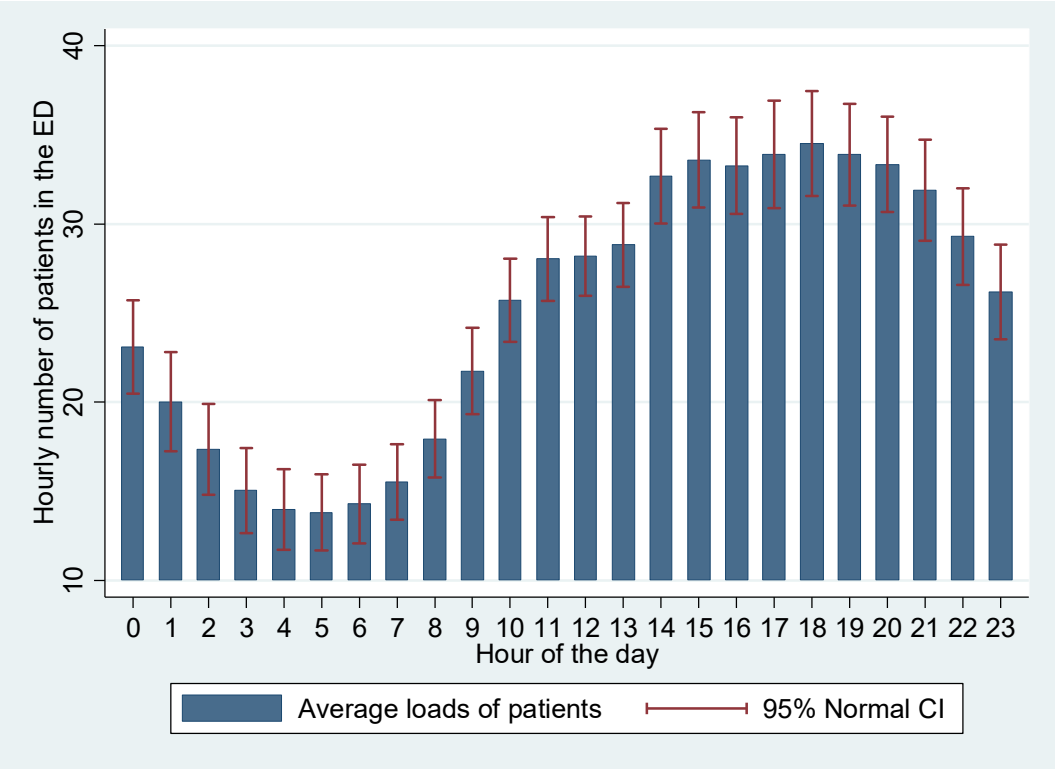


Caption: Types of medical staff are classified into assistant nurses, triage nurses, intensive care unit (ICU) nurses, waiting room nurses, short-stay unit (SSU) nurses, managers, doctors and on duty doctors.

Supplementary Figure 3: Daily incoming flow at the ED.



Supplementary Figure 4: Hourly patient load in the ED.



Supplementary Table 1: Description of the sequences (frequencies).

	Train	Test	Total
- Assistant nurse	70	23	93
- Manager	21	7	28
- Triage nurse	4	1	5
- ICU nurse	22	7	29
- Waiting room nurse	15	5	20
- SSU nurse	19	7	26
- Doctor	48	16	64
- On-duty doctor	37	13	50
Total	236	79	315

Supplementary Table 2: Confusion matrix of the best-performing random forest classifier (SelectKBest_175).

		Predicted							
		Assist. Nurse	Manager	Triage nurse	ICU nurse	Wait. nurse	SSU nurse	Doctor	On-duty Doctor
Observed	- Assistant nurse	23	0	0	0	0	0	0	0
	- Manager	0	7	0	0	0	0	0	0
	- Triage nurse	0	0	0	1	0	0	0	0
	- ICU nurse	0	0	0	7	0	0	0	0
	- Waiting room nurse	0	0	0	0	5	0	0	0
	- SSU nurse	0	0	1	0	0	6	0	0
	- Doctor	0	0	0	0	0	0	15	1
	- On-duty doctor	0	0	0	0	0	0	0	13

Supplementary Table 3: Fractional multinomial logit model of the time allocation on loads of patients, and interactions terms with types of healthcare professional.

Variables	LB care-related	Transit	P-value	Informatics	P-value	Transit / Informatics / Care	P-value	Others	P-value
Intercept	Ref	-10.16	0.001	-0.26	0.194	-0.16	0.102	-0.62	0.001
Patients load	Ref	0.01	0.083	-0.01	0.056	0.01	0.489	0.01	0.915
Tags' label									
- Assistant nurse	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
- Manager	Ref	20.81	0.001	0.58	0.308	0.57	0.244	10.84	0.001
- Triage nurse	Ref	0.27	0.348	-10.16	0.097	-10.66	0.001	-10.64	0.004
- ICU nurse	Ref	-0.09	0.635	-0.31	0.181	-10.18	0.001	-0.20	0.418
- Waiting room nurse	Ref	-0.42	0.117	0.02	0.943	-0.14	0.411	-0.36	0.167
- SSU nurse	Ref	-0.78	0.004	-0.08	0.798	-0.09	0.527	-0.56	0.079
- Doctor	Ref	0.23	0.458	0.31	0.284	-10.06	0.001	0.03	0.938
- On-duty doctor	Ref	0.46	0.024	0.65	0.007	-10.72	0.001	0.25	0.462
Tags' label X Patients load									
- Assistant nurse	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
- Manager	Ref	-0.06	0.001	0.01	0.841	-0.05	0.001	-0.03	0.001
- Triage nurse	Ref	0.01	0.695	0.03	0.162	-0.02	0.316	0.01	0.222
- ICU nurse	Ref	-0.01	0.206	0.01	0.088	-0.03	0.006	-0.06	0.001
- Waiting room nurse	Ref	-0.01	0.513	0.01	0.673	0.01	0.507	-0.03	0.001
- SSU nurse	Ref	0.01	0.942	0.02	0.109	-0.01	0.247	-0.02	0.124
- Doctor	Ref	0.01	0.654	0.03	0.001	0.01	0.842	-0.02	0.140
- On-duty doctor	Ref	-0.01	0.149	0.02	0.034	0.01	0.522	-0.06	0.001
# observations	6669								
Log pseudo-likelihood	-9452.5								

Note: Modality in reference (Ref). Time is discretized in 30 minutes time windows. Standard errors are adjusted for 27 clusters, allowing intracluster error correlation.