

Spatial Data Mapping

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Spatial data maps use points, lines, color, shades, or hatches overlaid on an architectural floor plan to reveal how a space is used. For instance, you might be interested in mapping a snapshot of where patients and health-care providers are located over a given period of time, such as a 12, 24 or 48 hours. Or, you might be interested in mapping the daily interactions between nurses and patients or patients and doctors. Tagged data can be assembled into spatial maps, both static and animated, using GIS or a graphics software package. Spatial maps paired with bar graphs, line graphs, or pie charts can deepen the interpretation of the data.

You can map the daily interactions between people and the hospital environment using a floor plan and data generated through occupancy surveys and environmental monitoring. Data can be collected using paper-based or tablet-based occupant survey methods (see *Creating Occupant Surveys*). Data is tagged on architectural floor plans with essential information, such as where the data is collected from, when it is collected, and what type it is.

Architectural floor plans are the base layer for spatial maps. They provide a complete layout of the area being studied, and they show adjacencies between rooms, corridors, and zones. Before collecting data, familiarize yourself with architectural floor plans and the symbols used to represent doors, windows, and walls. Locate corridors, paths of travel, and various rooms types, such as exam, waiting, MRI, or equipment rooms. Try layering information into your floor plan that might be relevant to the scope of your study, such as furniture and equipment. A solid understanding of architectural graphics will inform your approach to mapping the hospital environment.

After planning, designing, and implementing an occupant survey, you will have an abundant data set to play with and parse in a myriad of ways. Convene a workshop to review the data set, brainstorm study questions, and test different ways to visualize data with maps (see *Design Workshop*). Don't limit yourself to one question. An open mindset will allow you to examine other relationships, test alternate theories, or tell new stories.



COLLECTING DATA To create a post occupancy study (POE) of the emergency department (ED) at Thomas Jefferson University Hospital, architectural researchers from KieranTimberlake and Jefferson medical faculty distributed tablets to medical interns loaded with a floor plan and GIS-based survey application. The interns collected data on the movement of nurses, doctors, and patients, noting behaviors such as conversations, breaks, dedicated tasks, and phone calls. They also collected data on environmental conditions such as light, sound, and temperature. The data was georeferenced and time-stamped, priming it for exploration using spatial mapping techniques.

How does occupancy in the emergency department change over time?

In a post occupancy study (POE) conducted at Thomas Jefferson University Hospital, the research team implemented an occupant survey to explore how space is used over time in the emergency department (ED). Using a snapshot approach to collecting data, medical interns mapped the location of occupants every hour over a 48-hour period. They color-coded the data to distinguish between providers, patients, nurses, other staff, and family and friends.

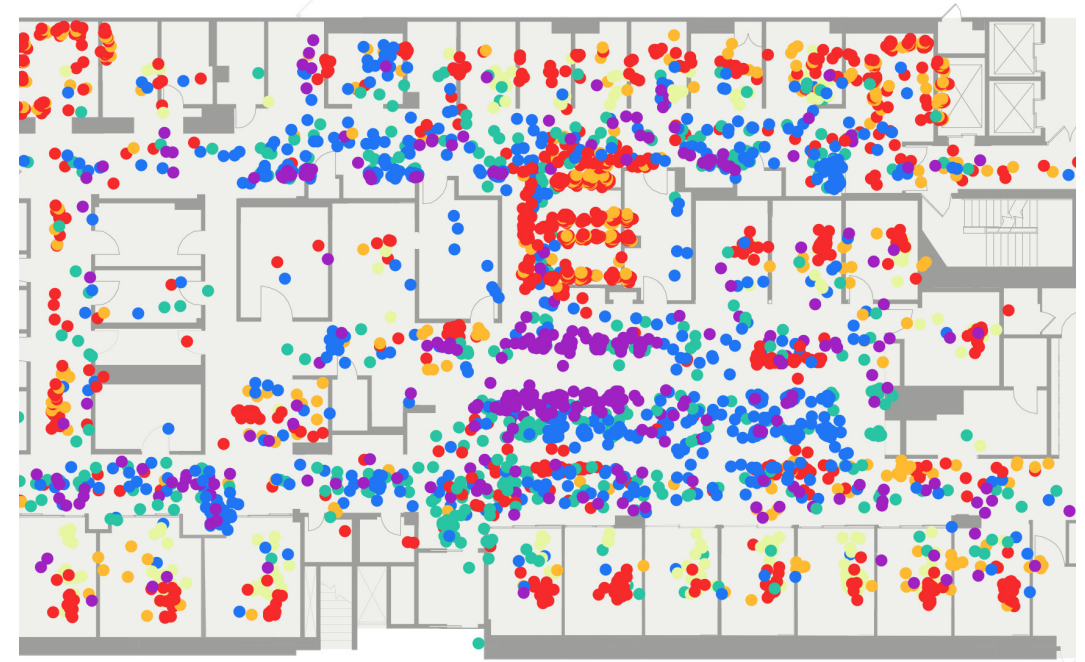
The final map is paired with a bar chart showing the hourly fluctuation of the ED's population. During the study period the number of individuals peaked early in the evening, having steadily doubled over a fourteen hour period. By mapping this trend, hospital staff gained a

more holistic understanding of the ED, confirmed areas of congestion and identified opportunities for increased efficiency. The snapshot of the ED revealed an area of high population density and congestion around the patient waiting area, adjacent nurses station and hallway. By visualizing their experience, staff could illustrate for hospital administrators how patients and providers competed for specific spaces on a daily basis in the ED. The ED staff reimagined the placement of the waiting room to reduce congestion and patient wait times. The study further demonstrated the potential for spatial mapping to supplement routine metrics, such as wait time and length of stay, which are statistics reported by the hospital staff regularly.

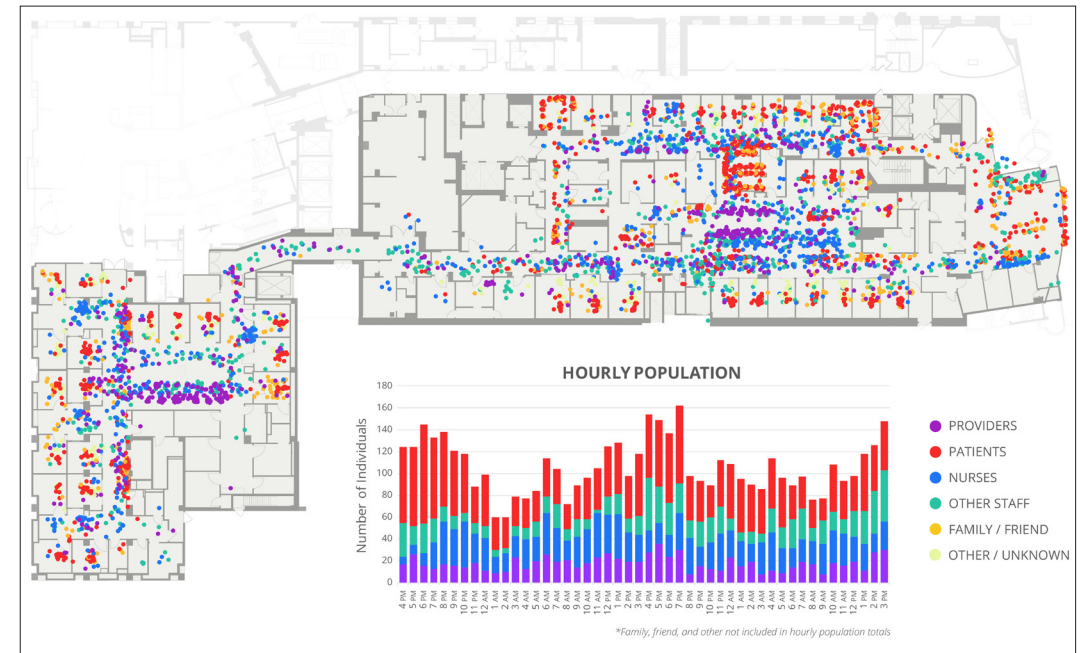


EARLY PROTOTYPES show the location of occupants in the ED. The numbers refer to patient rooms. The team used this instrument to test if the research interns were able to capture data answering the questions, "Who is in the ED?" "Where are they?" and "What are they doing?"

Early paper prototypes like this one led to the creation of the final digital workflow, which uses geographic information systems (GIS) mapping software.



COMPLETED GRAPHIC (DETAIL)



COMPLETED GRAPHIC (FULL VIEW)

What is the relationship between environmental conditions and patient experience?

To answer this question, medical interns used a shadow approach—they tracked individual patients through the ED. This method helped them understand a patient’s experience over time. They simultaneously measured temperature, humidity, and light and sound levels. Each patient’s path across the department is accompanied by a graph of the variation in environmental conditions per space type over time.

Because patients often have treatment-specific environmental requirements, variation in environmental conditions from place to place in the ED is not inherently problematic. The team understood, for example, that trauma patients

benefit from quiet environments during healing. The mapping exercise revealed spaces in the ED that were quieter or warmer than others, suggesting potential design improvements for better patient placement.

The map below reveals that a particular patient interacted with various areas of the ED, interacted with several providers, made phone calls, watched TV, and used the restroom. The companion graph suggests that from the intake area to patient room, this patient encountered some unevenness in ambient temperatures, especially during the first third of their experience in the ED.



How is communication affected by different spatial arrangements?

Empowered by the results of the survey workflow and spatial mapping technique, the team initiated an additional study to target a unique spatial feature of the ED. The department is divided into two wings: the A-side and B-side. Thus, the ED provided an ideal backdrop for understanding how different spatial layouts can affect communication.

The A-side’s centralized layout concentrates a cluster of nurses and doctors in a workstation surrounded by patient rooms, whereas the B-side’s decentralized layout and individual nurse stations distances the nurses from other hospital staff in order to situate them closer to patient rooms. Many nurses and doctors voiced strong opinions about which layout they preferred and how it affected their movement and communication with team members. Perhaps counterintuitively, the research team’s mapping paired with statistical analysis revealed that on average, the B-side’s decentralized layout led to increased

communication and contact time between doctors and nurses despite the greater distance between their workstations. While this comparative study focused on existing spatial layouts in the ED, a similar method could be used to study the effects of design interventions before and after renovations.

Mapping the hospital environment allows healthcare providers to gain a deeper understanding of the variables that affect movement and experiences in different parts of a facility. Mapping techniques can be used to better understand, for example, the composition of a nurse’s team. Quantitative analysis visualized in spatial maps do not tell the full story. The process of mapping can help designers and users of complex environments, like a hospital’s ED, unearth patterns and possibilities to foster more comfortable, productive and empathetic spaces.

