Abstract

Human occupants have a profound influence on indoor environments, although there is limited information on means to cost-effectively assess occupant metrics in all types of buildings. Multiple measures of occupancy (i.e., the number of occupants and the duration of their presence) and occupant activity (i.e., the number of occupant movements through room doorways) were investigated in ten single-patient rooms in a new hospital in Chicago, Illinois as part of the Hospital Microbiome Project, with the overarching goal of determining occupant characteristics to inform an investigation of interactions between humans and microbial communities. Four relatively low-cost, non-invasive methods to estimate time-resolved occupancy and occupant activity were developed using data from (1) CO_2 concentration sensors installed in patient rooms and the supply air streams serving each room and (2) non-directional doorway beam-break sensors installed at each patient room doorway. A method that utilized data from both sensors produced the most accurate estimates and was used to characterize time-varying occupancy and occupant activity. Daily occupancy varied among rooms, with median values ranging from 0 to 3 persons per hour. Occupant activity exhibited less variation on average (approximately 8 doorway movements per hour), but reached high levels on certain days for some patient rooms. No consistent relationship was observed between estimated occupancy and occupant activity, indicating that one metric cannot be inferred from the other. This study shows that this dual-sensor methodology provides a relatively inexpensive, non-invasive, accurate approach to estimate occupancy and occupant activity in an environment with rigorous privacy and security limitations.

Main findings

- We estimated **occupancy** and **occupant activity** in 10 hospital patient rooms.
- Estimations are based on **carbon dioxide (CO_2)** and **doorway beam-break sensor** data.
- A combination of beam-break and CO_2 concentration data improves estimate accuracy.
- Occupancy exhibits more **variation** between rooms than occupant activity.
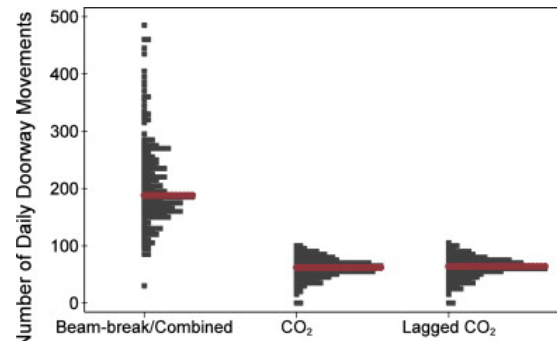- Occupancy and occupant activity alter **building operation** and **environmental quality**.

Figure 2. Sample occupant activity estimates for patient room 105 using each of the four methods (the Beam-break method and the Combined method are expressed by the same distribution).
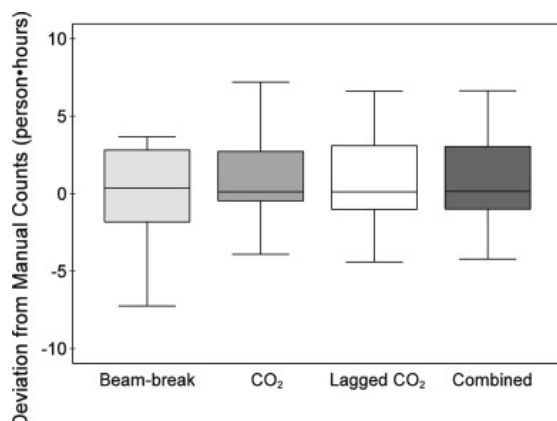

Figure 3. Cumulative deviation of occupancy estimates from the manual count value (represented by 0 on the *y*-axis) over 4-h periods for various patient rooms that were monitored at different times.