Katherine Roberts – engineer, environmental physics, Arup

Do single patient rooms reduce infection risks?

Government guidelines for new build hospitals in England and Wales currently state that 50% of patient bedrooms should be single rooms.

Hillingdon Hospital, in Uxbridge, Middlesex, is the first UK hospital to have 100% single rooms and there are other new builds in the UK following suit.

There is an ongoing debate among healthcare professionals regarding the benefits of single rooms. Some research has shown that patients received better care while housed in single rooms coupled with greater privacy and reduced noise which leads to lower stress levels. Other research states that nurse walking times are greater in single room accommodation which could affect patient care. Building costs are higher for single room accommodation compared with multi-bedded wards. There is also some supposition on various aspects of patient care in single rooms with regards to cleaning and reducing the spread of infection. Although some evidence exists, more research is needed to investigate patient safety in single rooms, particularly with regards to reducing the risk of cross-infection by other patients and staff. Ultimately, the aim is to create an optimally comfortable and safe environment for patients.

In an attempt to clarify some of these issues, a research study was undertaken to investigate the effect of hospital ward activity on microbiological load in multi-bedded wards and how the chain of infection might be broken.

Infection transmission in hospitals

Microorganisms follow certain paths of transmission which start with an infectious source (animate or inanimate) and transmit to a susceptible host. The transmission stage from source to host depends on various factors relating to the infecting microorganism, the environment to which the microorganism is exposed, and the effectiveness of the transmission route. Therefore, it is important to identify this transmission route at the onset of an outbreak as it is often the most effective way to break the chain of infection. The last link in this chain of infection is the host, which in a hospital environment will be human. The susceptibility of that host to infection is dependent on his or her immune responses which will be affected by age and immune system suppression.[1]

The main transmission routes of microorganisms in hospitals have been identified as contact, droplet, airborne, common vehicle, and vectorborne.[2] The World Health Organization (WHO) identifies that contact, droplet and airborne are the most important of these transmission routes in hospitals and that additional safety measures must be considered to prevent the transmission of infections in healthcare facilities.[3]

The main transmission routes associated with infection spread in hospitals can therefore be described as follows:

- Contact spread: there are two main types of contact spread – direct person-to-person contact and indirect contact.
- Direct contact spread involves the physical transfer of microorganisms between a susceptible host and an infected or colonised person via direct body surface to body surface contact.[2] This may involve transmission through an open wound or sore, or vulnerable body opening such as the mouth, nose or eyes.[4] Hospital activities that may be associated with this mode of transmission include patient washing, dressing and moving.
- Indirect contact spread occurs when a susceptible host comes into contact with a contaminated intermediate object or surface such as hospital equipment, beside tables, door handles or contaminated hands.[5]
- Droplet spread: droplets (typically larger than 10 microns in diameter) are generated from people coughing, sneezing or talking. These particles only travel short distances, usually 1 m or less. Transmission between source and recipient persons therefore requires close contact.[2]
- True airborne spread: this route includes droplet nuclei from evaporated droplets and dust particles which may harbour microorganisms (typically 1-5 microns in diameter) transmitted over long distances borne on convection currents.

> 'Microorganisms follow certain paths of transmission which start with an infectious source and transmit to a susceptible host.'

A recent document published by the Centers for Disease Control and Prevention has expanded the traditional transmission routes to further define the airborne transmission of infectious agents.[6] These guidelines describe the transmission of small particle aerosols over short distances which originate from patients during a specific activity, such as endotracheal intubation. A new term "aerial dissemination" is defined to describe this mode of transmission. The route involves particles entering the air for a short time (i.e. some minutes), and then falling onto exposed surfaces. Particles may become disturbed via various hospital ward activities such as floor polishing or bedmaking. When these particles land they can either infect patients directly or indirectly through the contamination of clinically important surfaces. The study undertaken here was

Katherine Roberts

Katherine Roberts is a graduate engineer working in Arup's environmental physics team, London. She obtained a Masters in the Built Environment from the University of Leeds and a Ph.D. doctorate (investigation of the aerial dissemination of *Clostridium difficile* in the clinical environment.

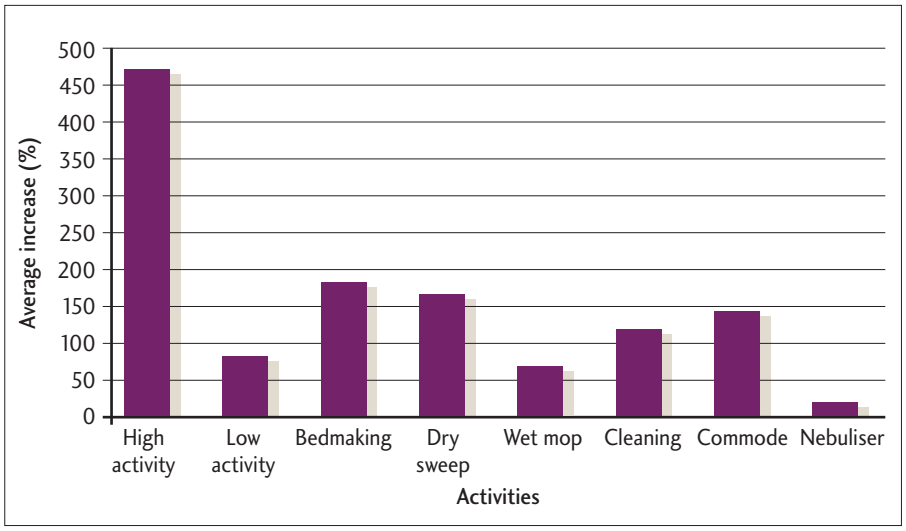

Figure 1: Average increase of particulate counts during ward activities.

particularly interested in the aerial dissemination route of microorganisms.

The main aim of the study was to investigate the relationship between ward activity and bioaerosol production. Regular microbiological and particulate (0.3 – 5 microns) sampling of the ward air was undertaken, together with an observational study of ward activity. Results for microbiological sampling have been published elsewhere[7,8] and are not presented here.

Observational survey

Throughout the study a number of ward activities were observed. It was decided that during times when several activities occurred at the same time, analysis of individual activities would not be possible. These periods would therefore be defined as high activity periods, defined specifically as times when four or more people (excluding patients and researcher) are undertaking two or more activities in the bay area. Activities undertaken during these high activity periods could include bedmaking, ward rounds, cleaning, serving of food and drink, drug rounds, opening and closing of bed curtains and helping patients to wash and dress. There are also numerous occasions when activities occur in the wards at times of low activity. These periods of low activity are defined as times during the day when three or fewer people are in the bay area undertaking only one activity at a time. Other activities which are identified include bedmaking, floor sweeping, floor mopping, general cleaning, commode use and nebuliser use. At these times no other activity was being undertaken in the bay area. General cleaning could involve the wiping of surfaces, cleaning the toilet or dusting of surfaces.

Particulate air sampling

Airborne particulate data collected throughout the study suggest that the greater than five microns (>5 µm) particulate data correlates very strongly to ward activity. Data for this particle range were therefore analysed to establish if a significant relationship exists between ward activity and peaks in particulate counts. All ward activities observed during the study were defined according to their onset and duration in relation to peaks in particulate counts. Particulate count data were measured over five minute time periods correlated to events occurring within this time. A total of 316 ward activity events were observed during the study. The amount of particulate increase occurring during an activity was calculated by taking the difference between the lowest value recorded at the start of the activity and the highest value recorded during the activity.

Figure 1 shows the average percentage increase of particulate counts >5 µm for all ward activity. Particulate counts that decreased during an activity were treated as zero increase. The greatest increase in particulate counts was seen during periods of high activity where particles were found to increase up to 471%. The activities most often undertaken during these times included stripping beds of dirty linen and helping patients to wash and dress, which often involves curtain movement. During times when bedmaking occurred independently from other activities, particulate counts for the >5 µm data had an average increase of 181%. Cleaning was also shown to significantly increase particle counts. Dry sweeping had an average increase of 165%. Floor mopping in comparison was relatively low with only a 69% increase although it still had an impact. Commode use showed a large average increase of 142%.

> ‘Aerosol particles are frequently liberated within the clinical environment as a result of specific ward activities.’

> ‘More research is needed to investigate patient safety in single rooms.’

Conclusions

This study found that aerosol particles (including bioaerosol particles) are frequently liberated within the clinical environment as a result of specific ward activities. Ward activity was found to increase particulate counts significantly, especially during high activity periods, bedmaking, dry sweeping and commode use. The aerial dissemination of infectious particles could have detrimental effects on the health of susceptible patients through particles being redistributed into the patients' immediate environment. This will therefore increase the risk of infection to susceptible patients via hand contact of contaminated surfaces. The contact route of transmission for many hospital infections may still be the most important transmission route but it is supplemented by the aerial dissemination route as aerosolised infectious particles will land on surfaces and be transmitted to susceptible patients. Ward activity in single rooms will likely be reduced assuming only low activity events occur due to a reduced number of people present compared with the high activity events which occur daily in multi-bedded rooms.

These findings highlight the importance of using single rooms by creating physical and psychological barriers to reduce the transmission of hospital-acquired infections. Staff and visitors are more likely to wash their hands when patients are housed in single rooms as these create physical barriers which serve as reminders. This hand washing, of course, relies on the location of basins in single rooms and would ideally benefit from basins being easily accessed near the door so staff and visitors can wash their hands before having contact with the patient.

Acknowledgements

This work was completed as part of my doctorate undertaken at the University of Leeds alongside the Pathogen Control Engineering Institute (PACE – www.engineering.leeds.ac.uk/pace) and the Bradford Infection Group. The hospital study was undertaken at Harrogate District Hospital and supervised by the Infection Control Team.

References

1 Mims C. *et al*. Chapter 13: Entry, Exit and Transmission, in *Medical Microbiology*. 2004, Elsevier Limited: London. p. 123-142.
2 Garner J. S., Guideline for isolation precautions in hospitals. Part II. Recommendations for isolation precautions in hospitals. *American Journal of Infection Control*, 1997. 24 (1): p. 32-52.
3 World Health Organization, *Practical guidelines for infection control in health care facilities* 2004. p. 1-103.
4 ASHRAE, Chapter 4: Overview of health care HVAC, *in HVAC Design Manual for Hospitals and Clinics*, Geshwiler M. Editor. 2003. W. Stephen Comstock p. 27-45.
5 Garner J. S. Guideline for isolation precautions in hospitals. Part II. Recommendations for isolation precautions in hospitals. *American Journal of Infection Control*, 1997. 24 (1): p. 32-52.
6 Centers for disease Control and Prevention, *Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings 2007*. 2007, CDC: Atlanta, GA.
7 Roberts K. *et al*. Aerial Dissemination of *Clostridium difficile* spores. *BMC Infectious Diseases*, 2008. 8: p. 1-7.
8 Roberts K. *et al*. Bioaerosol production on a respiratory ward. *Indoor and Built Environment, 2006*. 15: p. 35-40.

'Staff and visitors are more likely to wash their hands when patients are housed in single rooms as these create physical barriers which serve as reminders.'