Original Research Article

Epidemiological investigation into the source of water contamination at a tertiary care cancer hospital

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ABSTRACT

Background: Water quality impacts the performance of the hospitals and leads to drastic health service deterioration affecting infection control programs, along with safety of the patients and staff. Good quality water is an essential prerequisite to ensure optimal patient care, and the well-being of the staff and visitors in a hospital environment. Objectives was to study the current water supply and treatment system in the cancer hospital. Also, to carryout root cause analysis of the causes of episodes of diarrhoea amongst patients and staff and to identify the source of infection and suggest improvement in the existing system to prevent recurrence.
Methods: There were 25 reported cases of diarrhoea and other gastrointestinal symptoms between May 12 and June 2 2017, allegedly due to water contamination occurring in admitted patients and staff of a tertiary care cancer hospital in north India. This was reported to Hospital Administration, which prompted an epidemiological investigation.
Results: Formation of Biofilms on the plastic taps was found to be the main reason for contamination of water.
Conclusions: It was very clear that deposition of biofilm within the plastic taps was the main reason of diarrhea among the patients.

Keywords: Biofilm, Healthcare-associated infection, Infection control, Water safety plan, Waterborne pathogen

INTRODUCTION

One of the cardinal principles of hospital care is that it should cause no harm to the patient. However, for some patients the outcome of hospitalization is different as they acquire infections in hospital due to various reasons.[1]

Patients with immunocompromised states (e.g. solid organ transplantation, stem cell transplantation, malignancies) are at a high risk for severe gastrointestinal infections caused by viruses, bacteria and parasites. Compared with healthy hosts, these infectious diseases frequently run a more severe clinical course in immunocompromised patients and are associated with significant morbidity and mortality throughout the world. Moreover, severe diseases in immunosuppressed hosts may be caused by pathogens that rarely cause symptomatic infection in healthy individuals.[2]

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Problem statement

In total, 25 cases were associated with this outbreak with symptom onset dates between May 12 and June 2, 2017. Out of these 25 cases, 15 cases were identified among the admitted patients, who were admitted to the Medical

Oncology unit and Bone Marrow Transplant unit for more than 24 hours. Furthermore 04 cases occurred in visitors who stayed overnight with a relative in the same unit and 06 cases were reported among the staff posted in the cancer hospital. No cases were reported among patients with exposure to other parts of the cancer hospital.

METHODS

This was Descriptive, cross sectional, epidemiological study.

Study setting

The study was done in a tertiary care cancer hospital at New Delhi. The hospital is part of the apex tertiary care public hospital in India, has 182 in-patient beds; with a census of 40501 and 146688 in-patient and outpatient care during 2015-16 respectively.

Study period

This study was conducted within a period of 03 weeks after the cases were reported.

Procedure

The reported cases were investigated in the following sequence-

- Confirm existence of outbreak or epidemic,
- Verification of the diagnosis,
- Define the population at risk,
- Search for other cases and their characteristics,
- Data analysis,
- Hypothesis formulation,
- Testing the hypothesis,
- Evaluation of ecological factors,
- Further investigation of at risk population,
- Implement solution to reduce the outbreak,
- Test whether the proposed solution has yielded the appropriate result,
- Write report.

RESULTS

It was observed by the hospital administrators that multiple complaints of diarrhea were reported by staff and patients and it was also noted that the presentation of the disease was in a similar pattern in all the complaints.

This lead to the suspicion of the possible occurrence of outbreak/epidemic in the hospital. To confirm the existence of outbreak a survey was conducted among various cadres of staff to ascertain whether there was increase in cases, it was found that there was a sudden increase in reported cases, during this period whereas few cases were reported earlier. Hence the results of the survey confirmed the existence of epidemic/sudden increase in the cases of diarrhea.

The reported cases were emphatically treated and followed up to study the characteristics of the disease. It was found that all the cases had bacterial infection which led to diarrhea. A root cause analysis was done to identify all the possible causes of epidemic. It is depicted in the chart below (Figure 1).
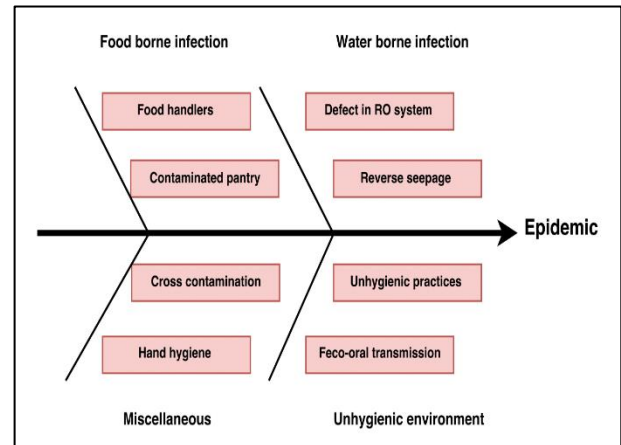

Figure 1: Root cause analysis of possible causes of epidemic.

To localize the source of contamination the areas from where the cases were reported was noted It was observed that the cases were reported from various areas in different floors of the hospital. Hence, it was hypothesized that the cause of spread of the disease is water borne. To test this hypothesis, the infection control teams were asked to test water samples from various areas of the hospital. The infection control team collected water samples from the affected wards on 23rd May 2017, and the microbiological reports were found positive for non-faecal enterococci. Based on the microbiology report as an empirical measure a notice was issued to clean the overhead water tank immediately, which was the main source of water for various purposes including drinking.

Once the tank got cleaned thoroughly, fresh samples were collected from the taps of the same ward(s) and were found positive yet again. To understand the extent of the problem, water samples from all locations in different floors were collected through the taps, among these samples few turned out to be positive and few negative. There was no clear pattern to point out the cause or source of contamination. As the building has concealed water pipes, it was difficult to fathom how water samples were getting contaminated in same areas even after cleaning of the overhead tank.

Thereafter, water samples were taken directly from the overhead tank which turned out to be negative. Considering the above finding the possibility of reverse

seepage through the pipeline was explored and it was found that entire pipeline was made using Poly Propylene random Copolymer (PPR) and it was also found that the entire network of pipeline was intact with no possible source of contamination or reverse seepage.

It was speculated that the taps could be a possible source of contamination and on examination of taps after removal, it was observed that a black slime layer was found around the lumen of the taps. This finding was further investigated by consulting a microbiologist and the microbiologist determined that the black slime layer is a biofilm deposited around the lumen of taps. It was found that in spite of having an entirely RO based system of drinking water there is a possibility of water contamination by formation of Biofilms on the inner surface of taps. This biofilm was the root cause of dwelling non-fecal bacteria which was causing contamination of drinking water.
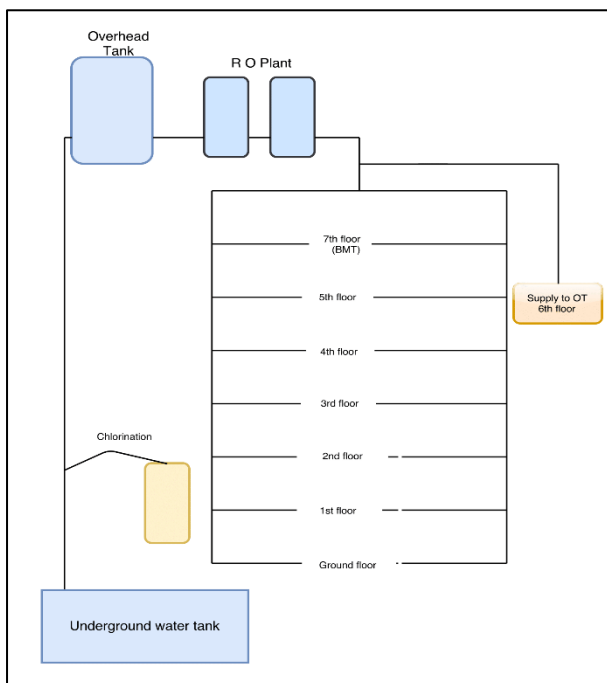

Figure 2: Schematic diagram of the water distribution system at the cancer hospital.

After confirmation of the presence of biofilm inside the plastic taps, all taps at the user end got changed except one. Fresh samples were taken from these new taps and the reports came out negative this time. Now another sample taken from the unchanged tap was also sent to the lab and this sample was found positive. Hence, it was very clear that deposition of biofilm within the plastic taps was the main reason of diarrhea among the patients (Figure 2).

DISCUSSION

This study was conducted with an objective to identify the source of infection. Hospital tap water is also not expected to be free of pathogens; waterborne infections can occur from proximal (central pipes) or distal (points of use) ends of hospital water supply. Contamination of hospital water usually occurs within the infrastructure of the healthcare facility. Contaminated water supply severely affects immuno-compromised patients in healthcare settings. Bacteria that may not cause illness in most users of potable water in the community can infect hospitalized patients due to immunosuppression, and the presence of invasive devices.

Importance of clean water in cancer hospital

Patients with hematological malignancies or after autologous or allogeneic hematopoietic stem cell transplantation rank among immunosuppressed individuals. Prolonged and deep neutropenia is considered a potential and key risk factor of the occurrence of an exogenous infection.[3]

The number of patients with immuno-compromised status is prone to any type of infection; waterborne infections incur significant morbidity and mortality. Hospital water safety is a major priority and constant challenge for healthcare provider, engineers, and administrators. Occurrence of nosocomial waterborne infections erodes public confidence in healthcare facilities.

Biofilm

A biofilm is a surface deposit of bacteria, other microorganisms, organic and inorganic materials that accumulate within a slime layer. Biofilms can form on solid and liquid surfaces when nutrients and water are present. Much like the plaque that forms on teeth, biofilms also form inside drinking water distribution systems and can sometimes cause several problems.4 Biofilms of water distribution systems and points of use have long been recognized as a rich environment for growth of various microorganisms (e.g. Legionella, mycobacteria, Pseudomonas, and other waterborne organisms).

Biofilm formation

Water distribution systems are complex environments that can provide many opportunities for biofilm development. This development may occur rapidly or slowly, sometimes over a period of years. However, clean pipes, especially metal pipes, are not initially attractive surfaces for bacteria. Once enough organic material adheres to the pipe surface-a process referred to as "conditioning"-bacteria can begin to attach. Once the bacteria reach a critical density, they begin to produce a gelatinous substance that gives biofilms their characteristic slimy nature. This slime layer makes up the majority of the weight and volume of the biofilm. After the slime layer forms, a veritable micro-ecology can flourish. The slime layer helps trap additional organic particles that many bacteria can use for food and energy.

Other microorganisms including viruses, protozoa, algae, fungi, and helminthes may become associated with or entrained within the biofilm (Figure 3).[5]
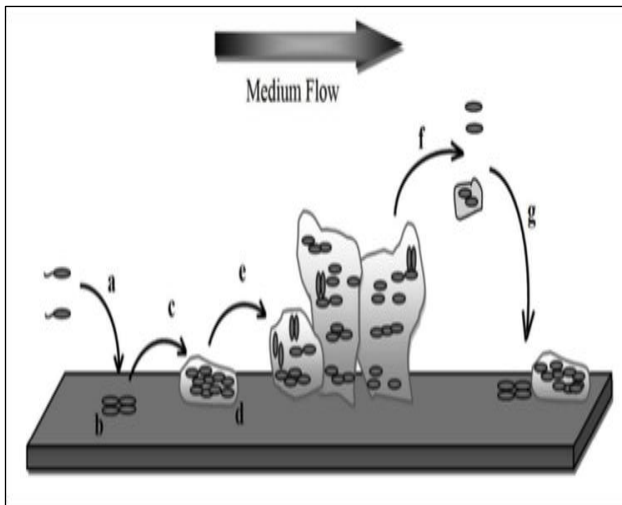

Figure 3: Biofilm formation steps. (A) Transport of planktonic cell from the bulk liquid to the surface; (B) Adsorption of cells at the surface; (C) Starting of Extracellular Polymeric Substances (EPS) formation; (D) Irreversible adsorption of cells; (E) Biofilm maturation; (F) Detachments of biofilm; (G) Biofilm recolonization.

Steps (a) to (d) correspond to the different steps involved in bacterial adhesion. Based on Simões and Qureshi et al.[6,7] Eliminating biofilms and their pathogenic residents is a major challenge, as organisms dwelling in these environments may be especially impervious to disinfectants. Pathogens such as *Legionella*, *Pseudomonas* and non-tuberculous mycobacteria can colonize the deep infrastructure or outlets of hospital water distribution systems, while other Gram-negative bacteria tend to adhere to biofilms at or near the distal points of use.

Mode of transmission to patients

Increased water demand during summer increases flow through stagnant pipelines, dislodging organisms from biofilms and releasing them into the water supply. Patient exposure to waterborne microorganisms in the hospital occurs while showering, bathing, and drinking and through contact with contaminated medical equipment (e.g. tube feed bags, endoscopes, and respiratory equipment) rinsed with tap water. The sources of organisms include hospital water tanks, faucet tap water, and showers.[8]

Prevention of waterborne infections and water safety plans in other countries

Only a few European countries (United Kingdom, France and Germany) and the US Centers for Disease Hospital Control and Prevention (CDC) have drawn up guidelines for water quality in healthcare facilities. The CDC recommendations include strategies to minimize the growth and persistence of gram-negative waterborne bacteria, such as the recommendation that cold water in healthcare facilities should be stored and distributed at temperatures below 20°C and that hot water should be stored above 60°C and circulated with a minimum return temperature of 51°C in 2011.[9]

WHO issued guidelines on the quality of water for human consumption, including hospital water supplies. These guidelines recommend the adoption of a Water Safety Plan (WSP) for water-risk management. The aims of the plan are to implement active surveillance of infections, prevent contamination during storage and distribution, monitor the quality of water sampled at the most significant points of the water system in the healthcare facility and adopt procedures for sanitation (to eliminate or reduce contamination) and for the maintenance of plumbing systems.[10]

The data obtained from a study conducted by Casini et al, suggest that no disinfection method is completely safe and free from side effects, and that the risk related to the water supply in hospitals and other healthcare facilities should be periodically assessed. Only WSPs based on locally adapted interventions and continuous surveillance can effectively prevent such nosocomial infections. By providing safe water, proper implementation of the water safety plan ensures patient safety and reduces costs, in that waterborne infections increase morbidity, mortality, treatment costs and compensation claims, and prolong hospitalization.[11]

CONCLUSION

It was very clear that deposition of biofilm within the plastic taps was the main reason of diarrhea among the patients. Discussions were made regarding how to permanently resolve the problem of Biofilm. Suggestions were made to replace plastic taps with copper or brass because they embrace antibacterial properties, but this solution was accompanied by some major concerns discussed below.

Metals taps would incur an extra cost burden, as they are costlier. Metals taps accompany a higher risk of being stolen as they provide a good resale value. Plastic taps are cheaper and do not carry a risk of theft.

It concluded that, Areas with negligible public access would have copper or brass taps. Premises which were under constant surveillance through recently installed CCTV system would have steel taps. Places with continuous public access would have plastic taps but these would be changed at regular intervals before any deposition of biofilm could take place. Periodically to check for fecal contamination. Tank cleaning is mandatory with in scheduled time frame.

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