WORLD HEALTH & POPULATION

The Potential for Transmission of Hospital-Acquired Infections by Non-critical Medical Devices: The Role of Thermometers and Blood Pressure Cuffs

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Abstract

Healthcare-associated infection (HAI) is a major but often neglected public health problem. Most attention to HAI prevention is given to high-risk invasive diagnostic and therapeutic healthcare tools, while the importance of less critical tools tends to be underestimated. This study was designed to assess the potential contributory role played by thermometers and blood pressure cuffs in HAI transmission in a Nigerian teaching hospital. Analysis of swabs from thermometers and blood pressure cuffs used in the teaching hospital was conducted using standard microbiological techniques.

Results showed that 62.1% of thermometers and 82.1% of blood pressure cuffs examined were contaminated with *Staphylococcus aureus*, *Pseudomonas aeruginosa* or *Enterococcus faecalis*. *S. aureus* was the most common bacterial isolate, constituting 86.1% and 73.9% of the isolates from thermometers and blood pressure cuffs, respectively. Up to 80% and 100% of thermometers and pressure cuffs from the nursing unit and medical ward were contaminated. The bacterial isolates were resistant to the majority of the antibiotics tested, but all were susceptible to ciprofloxacin and streptomycin to varying degrees. This study emphasizes the urgent need to sanitize thermometers and blood pressure cuffs between patients to minimize transmission of resistant bacteria within hospitals by cross-colonization of non-critical medical devices used by healthcare staff.

Introduction

Healthcare-associated infection (HAI), or nosocomial infection, is a major but often neglected public health problem in both developed and developing countries (Pittet 2005). The World Health Organization (WHO) defines HAI as an infection acquired in a hospital or other healthcare facility by a patient in whom the infection was not present or incubating at time of admission. This includes infections acquired in the hospital but appearing after discharge, and occupational infections among staff of the facility (WHO 2002). Reports indicate that at any one time more than 1.4 million people worldwide are estimated to suffer from infections acquired in hospitals (Tikhomirov 1987; Vincent 2003). Schwegman (2008) noted that because of an increase in invasive procedures and a growing resistance to antibiotics, HAIs have increased by 36% in the last 20 years and are consuming more healthcare resources each year. He added that the burden these infections place on the healthcare system can be divided into three categories: the cost of quality (i.e., excellent standards of care), the cost in human lives and the financial impact. In most developing countries, particularly in resource-poor settings, the estimated rate of HAI ranges from 25% to 40% and exacts a tremendous toll on patients, families and systems of care, resulting in increased morbidity and mortality, and increasing the cost of healthcare (Pittet 2005; WHO 2000, 2011).

Most attention to HAI prevention is given to high-risk invasive diagnostic and therapeutic healthcare tools, while the importance of less critical tools tends to be underestimated (Schwegman 2008; Uneke and Ijeoma 2010). Recent studies have reported the potential nosocomial spread of microbial flora by means of non-critical healthcare tools including stethoscopes (Uneke et al. 2009; Schroeder et al. 2009), ultrasound transducers (Schabrun et al. 2006), gloves (Katherason et al. 2010), tourniquets (Ormerod et al. 2006), physicians' and nurses' pens (Wolfe et al. 2009), scissors (Cleal 2006), white coats (Treakle et al. 2009; Uneke and Ijeoma 2010), thermometers (Donkers et al. 2001) and blood pressure (BP) cuffs (Baruah et al. 2008; Davis 2009).

Thermometers and BP (sphygmomanometer) cuffs are among the most commonly used non-critical medical devices in hospital settings. Both have been associated with the spread of HAI in healthcare facilities (Baruah et al. 2008; Davis 2009). Thermometers in particular are linked to the outbreak of nosocomial infections in critical hospital units such as the intensive care unit (ICU) and neonatal and burns units (Donkers et al. 2001; Martínez-Pellús et al. 2002; v Dijk et al. 2002). In an earlier report, Livornese et al. (1993) found that an electronic thermometer was the vehicle that caused an outbreak of vancomycin-resistant *Enterococcus faecium* in a medical/surgical intensive care unit and ward of a university hospital. Similarly, a number of investigations including very recent studies have identified BP cuffs as potential vehicles for transmission of nosocomial infection in selected patient populations (Baruah et al. 2008; Base-Smith 1996; Davis 2009; Walker et al. 2006). BP cuffs have been associated with outbreaks of mupirocin-resistant *Staphylococcus aureus*, methicillin-resistant *S. aureus* (MRSA) and borderline methicillin-susceptible *S. aureus* (BMSSA) in various hospital settings (Boyce et al. 1997; Layton et al.1993; Webb 2002). An outbreak of this sort and linked to BP cuffs has also been observed in the ICU of a teaching hospital (De Gialluly et al. 2006).

Despite the increasing awareness of the association of non-critical medical devices with HAI, information is scarce on the contributory role of these devices to the burden of HAI in developing countries. A review of the literature shows that nearly all investigations on non-critical medical devices and transmission of HAI originate from developed countries. Our study was therefore designed to assess the potential contribution of thermometers and BP cuffs to HAI transmission in a Nigerian teaching hospital. Study objectives were to (1) assess the profile of microbial contamination of thermometers and BP cuffs used by health workers, (2) evaluate the relationship between thermometers and BP cuff contamination and their usage and handling practices by health workers, (3) assess the susceptibility of microbial isolates to various antibiotics commonly used in acute care practice, and (4) discuss the implication of the findings for the control and prevention of HAI in developing countries.

Materials and Methods

Sampling Technique

We conducted our study from September 2008 to February 2009 at the Ebonyi State University Teaching Hospital (EBSUTH) Abakaliki, southeastern Nigeria. The study was approved by the Infectious Diseases Research Division of the Department of Medical Microbiology of the Faculty of Clinical Medicine, Ebonyi State University Abakaliki. Thermometers and BP cuffs used in the various units of the hospital were sampled. The units included a nursing station, accident and emergency, orthopedic, the medical ward, outpatient, and the children's ward. All available thermometers and BP cuffs present in these units at the time of authors' visit were sampled. Sampling of the devices was done according to the methods described by Walker et al. (2006). Briefly, with the aid of sterile gloves, an estimated surface area of 100 cm^2 of BP cuff material coming into direct contact with patients' skin during BP measurement was swabbed using a sterile swab stick moistened with physiological saline. Likewise, thermometers were swabbed using swab sticks moistened with physiological saline as described by Baruah et al. (2008). Swabs were labelled appropriately and transferred to the Medical Microbiology Laboratory of Ebonyi State University Abakaliki for analysis. All laboratory analyses were done within one hour of sample collection.

Laboratory Investigation

The swabs were directly inoculated on blood agar and nutrient agar. The pairs of inoculated media were incubated aerobically at 37°C for 24 hours and then examined for bacterial growth according to standard protocol (Cheesbrough 2000). The authors isolated bacteria by assessing colony characteristics and Gram reaction and performed the following five tests: (1) catalase and coagulase, (2) hemolysis, sugar fermentation and other biochemical tests including indole production, citrate utilization and urase activity, (3) triple sugar iron (TSI) agar test (for glucose, sucrose and lactose fermentation), (4) gas and hydrogen sulphide production tests, and (5) oxidase tests, according to previously described protocols (Cheesbrough 2000). Three or more colony forming units (CFUs) were considered before assigning species as a contaminant (Uneke et al. 2009). Bacterial isolates were subjected to antibiotic sensitivity analysis using the Kirby Bauer disc diffusion method (Cheesbrough 2000; WHO 2003). The disc used was commercially available (Optun Laboratories Nig Ltd., Lagos, Nigeria) and contained a number of antibiotics: ciprofloxacin, nofloxacin, gentamicin, lincomycin, streptomycin, rifampicin, flucloxacillin, erythromycin, chloramphenicol, ampicillin-cloxacillin, ofloxacin, pefloxacin, amoxicillin-clavulanic acid, cefalexin, nalidixic acid, trimethoprim and ampicillin.

Statistical Analysis

Differences between proportions were assessed by Chi-square analysis. Statistical significance was set at < .05.

Results

Of the 58 thermometers screened, 36 (62.1%) were contaminated by bacteria, whereas of the 28 BP cuffs screened, 23 (82.1%) were contaminated. Table 1 shows the spectrum of bacterial isolates from the devices. *S. aureus* was the most common bacterial isolate, constituting 86.1% and 73.9% of the isolates from the thermometers and BP cuffs, respectively. *Escherichia coli* was not isolated from any thermometers but constituted 8.7% of isolates from BP cuffs. *Pseudomonas aeruginosa* constituted 8.3% of isolates from thermometers and 4.4% from BP cuffs. *Enterococcus faecalis* constituted 5.6% of isolates from thermometers and 13.0% from BP cuffs.

All thermometers sampled from the nursing station and the children's ward were contaminated with bacteria. Of thermometers sampled at the medical ward, 80% were contaminated (Table 2). The lowest rate of thermometer contamination (33.3%) was observed at the outpatient unit. Statistical analysis indicated a significant difference in the trend ($\chi^2 = 15.85$, df = 5, $p < .05$). This implies a strong association between bacterial contamination of thermometers and their use in the various units. All BP cuffs sampled at the nursing station, medical ward and outpatient unit were contaminated, while the lowest rate of BP cuff contamination (63.6%) was observed at the accident and emergency unit. Statistically, however, there was no significant difference in the trend ($\chi^2 = 5.71$, df = 4, $p > .05$) (Table 3). This implies that there is no strong association between bacterial contamination of BP cuffs with any specific unit of the hospital; that is, no unit in the hospital necessarily has a higher risk of BP cuff contamination. However, the observed outcome might have occurred purely by chance.

Table 1. Bacterial isolates from thermometers and blood pressure cuffs in Ebonyi State University Teaching Hospital Abakaliki, Nigeria

Bacterial isolates	Thermometers (N = 58)		Blood pressure cuffs (N = 28)		Overall total
	No. (%) of isolates	95% confidence interval	No. (%) of isolates	95% confidence interval	No. (%) of isolates
Staphylococcus aureus	31 (86.1)	85.0–97.4	17 (73.9)	54.9–91.1	48 (81.4)
Escherichia coli	–	–	2 (8.7)	2.8–20.2	2 (3.4)
Pseudomonas aeruginosa	3 (8.3)	0.7–17.3	1 (4.4)	4.0–12.8	4 (6.8)
Enterococcus faecalis	2 (5.6)	1.9–13.1	3 (13.0)	0.7–26.7	5 (8.5)
Total	**36 (62.1)**	**48.6–73.4**	**23 (82.1)**	**26.6–51.4**	**59**

Table 2. Bacterial contamination of thermometers used in various units of Ebonyi State University Teaching Hospital Abakaliki, Nigeria

Hospital units	No. of thermometers examined	No. (%) of thermometers contaminated	95% confidence interval
Nursing station	6	6 (100)	100.0–100.0
Accident and emergency	12	5 (41.7)	38.9–44.5
Orthopedic	11	6 (54.5)	25.1–83.9
Medical ward	10	8 (80.0)	55.2–100.0
Outpatient	12	4 (33.3)	6.6–60.0
Children's ward	7	7 (100)	100.0–100.0
Total	**58**	**36 (62.1)**	

Table 3. Bacterial contamination of Blood pressure cuffs used in various units of Ebonyi State University Teaching Hospital Abakaliki Nigeria

Hospital units	No. of blood pressure cuffs examined	No. (%) of blood pressure cuffs contaminated	95% confidence interval
Nursing station	4	4 (100)	100.0–100.0
Accident and emergency	11	7 (63.6)	35.2–92.0
Orthopedic	3	2 (66.7)	38.8–94.6
Medical ward	5	5 (100)	100.0–100.0
Outpatient	5	5 (100)	100.0–100.0
Total	**28**	**23 (82.1)**	**67.9–96.3**

Findings from the antibiotic sensitivity test are presented in Table 4. The bacterial isolates exhibited resistance to a majority of the antibiotics tested, with *E. coli* exhibiting the highest level of resistance. All bacterial isolates were susceptible to ciprofloxacin and streptomycin. *S. aureus* was susceptible in varying degrees to many of the antibiotics tested, including ciprofloxacin, nofloxacin, gentamicin, lincomycin, streptomycin, rifampicin and pefloxacin, but was resistant to the beta-lactam antibiotics such as flucloxacillin, ampicillin-cloxacillin, amoxicillin–clavulanic acid and ampicillin (Table 4).

Table 4. Antimicrobial susceptibility test of bacterial isolates from the thermometers and blood pressure cuffs

		Bacterial isolates			
Antibiotic	**Concentration**	***S. aureus***	***P. aeruginosa***	***E. Faecalis***	***E. coli***
Ciprofloxacin	10 mcg	100.0	33.3	66.7	33.3
Nofloxacin	30 mcg	33.3	R	R	R
Gentamicin	10 mcg	33.3	R	R	R
Lincomycin	30 mcg	33.3	33.3	R	R
Streptomycin	30 mcg	66.7	66.7	33.3	66.7
Rifampicin	10 mcg	R	R	R	R
Flucloxacillin	30 mcg	R	R	R	R
Erythromycin	30 mcg	R	R	R	R
Chloramphenicol	20 mcg	R	R	R	R
Ampicillin–cloxacillin	30 mcg	R	R	R	R
Ofloxacin	10 mcg	33.3	R	R	R
Pefloxacin	10 mcg	33.3	R	33.3	R
Amoxicillin–clavulanic acid	30 mcg	R	R	R	R
Cefalexin	10 mcg	R	R	R	R
Nalidixic acid	30 mcg	R	R	R	R
Trimethoprim	30 mcg	R	R	R	R
Ampicillin	30 mcg	R	R	R	R

R = resistant.

Discussion

Evidence remains scant on the importance of non-critical medical devices in HAI transmission in healthcare settings in developing countries. Underestimating the contributory role of non-critical medical devices in transmitting HAI has resulted in the neglect of basic decontamination guidelines for these devices. Findings from our investigation clearly showed that thermometers and BP cuffs have the potential to harbour and transmit antibiotic-resistant bacteria in hospital settings.

We were concerned to observe that 62.1% of thermometers screened in this study had bacterial contamination, and it was even more worrisome to note that all thermometers screened at the children's ward were contaminated. Moreover, the difference in the trend was statistically significant

($p < .05$). Other studies have reported similar findings. Donkers et al. (2001) observed a nosocomial outbreak of multi-resistant *Enterobacter cloacae* in the neonatal ICU at a medical centre in Amsterdam due to the use of contaminated thermometers. Furthermore, in another study at a university medical centre in Philadelphia, Livornese et al. (1992) reported a nosocomial outbreak of infection due to a highly vancomycin-resistant strain of *Enterococcus* (VRE) in which an electronic thermometer was implicated as the vehicle of transmission. In an earlier study, Brooks et al. (1992) had noted that replacing electronic thermometers with single-use disposables significantly reduced the incidence of *Clostridium difficile*–associated diarrhea in both acute care and skilled nursing care facilities. In another investigation, Brooks et al. (1998) reported 60% and 40% risk reductions for nosocomial VRE and *C. difficile* infections, respectively, after switching to tympanic thermometers following a 20-month observation.

The high rate of BP cuff contamination (82.1%) observed in this study was not a surprise, as no other piece of hospital equipment was in more common use without adequate disinfection than this device. Base-Smith (1996) noted that in the hurried milieu of operating rooms, emergency departments and ICUs, contaminated BP cuffs may not be routinely sanitized or replaced with clean cuffs between patient use. Recent studies have revealed high rates of bacterial contamination of pressure cuffs, ranging from 45% to 97% (Baruah et al. 2008; Davis 2009; De Gialluly et al. 2006; Walker et al. 2006). The findings of the present study revealed 100% bacterial contamination of all BP cuffs screened at the nursing station, medical ward and outpatient unit. In other studies, De Gialluly et al. (2006) and Baruah et al. (2008) observed that the highest rates of contamination with potentially pathogenic micro-organisms were observed on cuffs used in ICUs and those kept on nurses' trolleys. The implication of the findings from the present and similar studies is that BP cuffs represent a source of bacterial contamination that is yet to be fully realized and that may play significant part in a hospital's nosocomial infection rate. This is further substantiated by the fact that bacteria have been shown to survive for up to five days on BP cuffs (Cormican et al. 1994). Against this backdrop, therefore, Cormican et al. (1994) had suggested a need for awareness of the potential cross-contamination to patients and healthcare workers from seemingly innocuous items of general use hospital equipment, specifically BP cuffs.

In this study, bacterial isolates from the screened devices exhibited a high level of antibiotic resistance. This finding is of enormous public health significance because it has been proven that some of the bacterial agents isolated in this study, particularly antibiotic-resistant *S. aureus* and *E. faecalis*, are capable of initiating severe nosocomiasis in a hospital environment and often require contact isolation and aggressive treatment to prevent their spread (Nester et al. 2004; Struelens 1998; WHO 2000, 2003). Nearly all of the *S. aureus* showed resistance to the beta-lactam antibiotics such as flucloxacillin, ampicillin-cloxacillin, amoxicillin–clavulanic acid and ampicillin, and can therefore be classified as methicillin-resistant *S. aureus* (MRSA). This finding confirms a previous report of a nationwide survey that revealed that 78% of community-acquired pathogens in Nigeria produced beta-lactamases, while more than 50% of most community-isolated pathogens showed in vitro resistance to most commonly prescribed antibiotics (Oyelese and Oyewo 1995). In a study of the prevalence of methicillin-resistant *S. aureus* in eight African hospitals, Kesah et al. (2003) indicated that the rate of MRSA was relatively high in Nigeria. Furthermore, recent studies in Nigeria have shown that a high rate of multiple-drug-resistant *S. aureus* could be isolated from non-critical medical materials such as stethoscopes and white coats (Uneke et al. 2009; Uneke and Ijeoma 2010). Antibiotic resistance increases the morbidity and mortality associated with infections and contributes substantially to rising costs of care resulting from prolonged hospital stays and the need for more expensive drugs (Struelens 1998). This situation is worrisome and of serious public health concern in developing countries including Nigeria, where dysfunctional health services, inadequate drug supplies, non-adherence to treatment strategies, self-medication and dubious drug quality all favour the emergence and sustenance of microbial resistance (WHO 2000).

Conclusion

The findings of this study have clearly demonstrated that non-critical medical devices such as thermometers and BP cuffs can harbour potential infectious pathogens including antibiotic-resistant bacteria. The implication is that these devices are potential vehicles for the transmission of HAI in healthcare facilities. However, it is imperative to state that we have not been able to unequivocally demonstrate that the thermometers and BP cuffs could actually transmit pathogenic micro-organism. Future studies with a more complex design would be required to accomplish this. Nevertheless, because antibiotic resistance can be caused by transmission of resistant bacteria within hospitals by cross-colonization of non-critical medical devices used by healthcare staff, this study emphasizes the urgent need for sanitizing thermometers and BP cuffs between patient use. Furthermore, to minimize the risk of cross-contamination from thermometers, we advocate the use of disposable thermometers.

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