Infection control in the neonatal intensive care unit


Summary
Healthcare-associated infection (HCAI), also known as nosocomial infection, is one of the main causes of adverse events in the neonate. Despite current infection control policies and practices and ongoing education programmes for healthcare workers, HCAI infection rates within the neonatal intensive care unit (NICU) continue to increase, often with devastating results. This review of the literature aims to increase awareness of some of the many issues that contribute to high HCAI rates in the NICU, thereby highlighting many more interventions that can be carried out by the healthcare worker to reduce these rates. This literature review is limited because it considers only the contribution that healthcare workers make to HCAI rates.

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IMMATURE IMMUNOCOMPROMISED patients in the neonatal intensive care unit (NICU) are one patient group most at risk of acquiring healthcare-associated infections (HCAIs) (Urrea et al 2003, Schelonka et al 2006). In these patients HCAIs are defined as, ‘those which occur beyond 48 hours of birth and are caused by pathogens that are not maternally derived’ (Polin and Saiman 2003), or if infection occurs 72 hours after admission to the NICU (Urrea et al 2003). While one study by the UK Neonatal Staffing Study Group found wide variations in HCAI rates in NICUs in the UK, it concluded that UK levels were similar to those of other developed countries (Parry et al 2005).

HCAI is one of the leading causes of adverse events in the neonate, increasing the severity of illness, length of hospital stay and healthcare cost, and negatively affecting the infant’s neurodevelopment and growth (Parry et al 2005). The control and prevention of HCAI in the NICU is a major challenge for healthcare workers. Although many invasive procedures carried out in the NICU are carefully monitored, and strict aseptic techniques and programmes are meticulously followed, HCAI rates in this patient group are increasing and are five times higher in the neonatal population than in the older child (Adams-Chapman and Stoll 2002, Pessoa-Silva et al 2004). This increase in HCAI rates is partly explained by the improved survival rates in neonates, increases in invasive monitoring and care, exposure to broad-spectrum antibiotic therapies and the resulting longer stays in the NICU (Adams-Chapman and Stoll 2002, Pessoa-Silva et al 2004). Mokabel et al (1998) have also reported that despite the acknowledged and recognised issues with HCAI, infection control practices have not had any impact on reducing HCAI rates.

The literature search strategy used selected databases: Google, PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Academic Search Premier. Primary search words and phrases such as neonatal, NICU, neonatal unit in various combinations with infection risks, rates, control, nurse, link nurse, handwashing and environmental risks were used. International literature published in English, research reports...
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and organisational recommendations were included. Priority was given to, but not restricted to, literature published within the last ten years.

Causes of colonisation, contamination and cross-infection

Colonisation is the term used to describe the process where a group of micro-organisms grow and multiply on or in the body without invading the surrounding tissues and causing damage (Horton and Parker 2002). This process is usually a stable defensive mechanism that begins at birth and continues as contact is made with people and the environment.

The effective natural first-line defence barrier of the skin and mucous membranes of the stratum corneum are thin in the premature infant, allowing excess water loss and easy entry for micro-organisms (Palmer et al 1996). A patient’s normal skin flora is also altered by antibiotic therapy or from contact and cross-infection and colonisation by hospital micro-organisms from the hands of healthcare workers or contaminants in the surrounding environment. Invasive monitoring, central and peripheral intravascular catheters and insertion of nasogastric tubes are routine practices in the NICU, but all carry a high risk of contamination from the hands of healthcare workers. Total parenteral nutrition and mechanical ventilation are also associated with HCAI in the neonate (Kawagoe et al 2001).

Equipment

Equipment in the NICU can easily become colonised with bacteria and micro-organisms. Incubators are warm humid environments nurturing the growth of infant and micro-organisms. Incubator colonisation and contamination with bacteria also occur from the hands of healthcare workers or contaminants in the surrounding environment. Invasive monitoring, central and peripheral intravascular catheters and insertion of nasogastric tubes are routine practices in the NICU, but all carry a high risk of contamination from the hands of healthcare workers. Total parenteral nutrition and mechanical ventilation are also associated with HCAI in the neonate (Kawagoe et al 2001).

Equipment are cleaned adequately (Malik et al 2003), but there is little evidence in the literature as to what constitutes an adequate cleaning regimen for patient equipment in the NICU.

Some studies highlight that the cleaning of patient equipment in the NICU is often inadequate and fails to eliminate micro-organisms, and may even cause further contamination because ward staff are not appropriately trained in equipment cleaning or in the safe use of detergents (Penna et al 2001, Golan et al 2005). There is an absence of studies in the literature about the effects of detergents on the immature infant, who is at risk of exposure to them if any area of the incubator, such as port handles, is cleaned on a daily basis. However, where units have a designated person trained and educated in equipment cleaning they have reported significant reductions in HCAI (Zafar et al 2002).

Stethoscopes have long been identified as contaminants that contribute to HCAI rates (Horton and Parker 2002, Kennedy et al 2003), and it has been demonstrated that it is not sufficient for each patient just to have individual stethoscopes. Individual stethoscopes require cleaning with alcohol before each use or alternatively more units should introduce the use of antimicrobial impregnated stethoscope diaphragms which have been shown to reduce bacterial contamination (Kleiner and Bozeman 2003). Stethoscopes should always be individual to the patient and never shared, and the use of healthcare workers’ own stethoscopes between patients should not be permitted unless it can be demonstrated that meticulous cleaning between patients is being performed.

Environment

Suboptimal environments also pose a risk to the infant, particularly overcrowding and insufficient handwashing facilities. It is recommended that there should be at least six feet between incubators and open warmers and also that there should be at least one sink for every two patients (Brady 2005). In 2002 the American Institute of Architects produced guidelines for sinks in NICUs advocating not only that they should be within 20 feet of each bed, but also that they need to be deep enough to minimise splashing, as well as having knee or foot-operated taps (Joint Commission Resources 2005). The British Association of Perinatal Medicine (BAPM) recommends that it is best to allocate a minimum of 20 to 24 square metres of space to each intensive care cot with at least one large sink with knee or elbow-operated taps for every three beds on the NICU, never more than six metres from the incubator (Laing et al 2004).
Tap water and sinks have been identified as areas of colonisation that have led to outbreaks of infection within neonatal units (Wenger et al 1998, Orenstein et al 2006). Water taps are fitted with ‘aerators’, devices that come in several forms to control the flow of water at hand basins. Healthcare workers should be aware of when and how often these aerators have been changed since their initial installation as Verweij et al (1998) and Orenstein et al (2006) identified that large amounts of caked mineral deposits on the aerators increase the risk of colonisation by micro-organisms. Therefore, water used for handwashing, bathing and cleaning has the potential to become contaminated.

Carpets are generally discouraged in the NICU, but those in the less clinical areas should be able to withstand heavy duty cleaning and regular steaming (Joint Commission Resources 2005). Carpets should have impermeable backings and antistatic properties as well as chemically sealed seams. Medical grade vinyl sheet flooring, vinyl furniture, countertops with minimal seams and sealed corners, as well as splash backs that are sealed or integrated with sinks are all further recommendations for the environmental safety of the NICU (Joint Commission Resources 2005).

Housekeeping staff who are adequately trained and experienced in unit cleaning practices also play a vital role in infection control (Joint Commission on Accreditation of Healthcare Organizations [JCAHO] 2003, Unison 2005). However, there are concerns that cost cutting and chronic problems with recruitment and retention of contractual cleaning staff are contributing factors in the apparent decline in standards of hospital cleanliness (Unison 2005). Malik et al (2003) have also identified the need for comprehensible unit cleaning regimens.

The JCAHO (2003) stress the importance of the facility manager’s role in the reduction of HCAI rates. The BAPM also recommend the involvement of a variety of healthcare professionals, ancillary, maintenance and building staff when planning and designing NICUs (Laing et al 2004). Just as important is the continued involvement and communication between medical and nursing staff and the housekeeping, medical maintenance and building facilities departments in the ongoing monitoring and maintenance of NICU environmental standards.

Staffing levels and patient numbers and acuity in the NICU can also contribute to HCAI levels. Frequent moving of infants around the unit, sharing of equipment and higher patient to nurse ratios are all contributing factors that increase infection rates (Garcia 2005). Palmer et al (1996) suggest that the number of healthcare workers allocated to care for patients is more important than a well-designed, spacious unit. Inadequate staffing numbers result in healthcare workers rushing from one infant to another with little time to consider effective infection control measures. This is one of the main reasons for the lack of adequate handwashing between patients.

Toys and personalised bedding, and dressing the infant within the incubator are essential aspects of care in the NICU, softening the harsh clinical environment and encouraging parental involvement. However, toys become contaminated by the hands of healthcare workers and parents, as well as by blood and body fluids (Davies et al 2000, Horton and Parker 2002). Hanrahan and Lofgren (2004) demonstrated that HCAI rates decreased when toys were removed from the NICU. Toys in incubators become part of the infant’s immediate environment and steps should be taken to reduce their infection risk. Toys on the NICU should be individualised and made of heat-resistant materials that will allow them to be washed at high temperatures, or chemically disinfected on a regular basis (Davies et al 2000). Neely (2000) has also demonstrated that it is possible for a variety of Gram-negative bacteria to survive for up to eight days on the fabrics and plastics found in hospitals.

Many neonatal units have local laundering facilities, washing individualised bedding and clothes worn by the infants in the NICU. These items should be able to be washed at high temperatures, or disinfected without being damaged. Washing machines used by neonatal units in the UK need to meet the disinfection standards set out in Hospital Laundry Arrangements for Used and Infected Linen by the NHS Executive (1995).

**Hand hygiene**

Micro-organisms that cause HCAI are most likely to be transmitted from the hands of healthcare workers (Lam et al 2004). Pratt et al (2007) confirmed that the cross-transmission of micro-organisms, either directly from hands or indirectly from environmental sources, via hands, ‘... is a major contributing factor in the current infection threats to hospital inpatients’. HCAI rates in NICUs are also linked directly to the hand hygiene practices of staff (Parry et al 2005). Handwashing is a simple, low-cost, low-technology intervention and is considered to be the single most important factor in the prevention of HCAI (Brady 2003, Darmstadt et al 2005). However, some studies indicate that handwashing is suboptimal in the NICU high-risk setting (Cohen et al 2003, Liniment and Fleming 2002).
Thibeau et al. (2005), and that hands ‘...become progressively contaminated with commensal flora and potential pathogens during routine neonatal care’ (Pessoa-Silva et al. 2004). Horton and Parker (2002) state that handwashing ‘...is universally considered to be the most basic but vital infection control measure, but it is also one of the most neglected of practices’.

Resistance to handwashing is multifactorial, with the most common reasons given being lack of time, heavy workload and poor access to sinks, as well as skin dryness and irritation (Fendler et al. 2002).

The hands of healthcare workers are major transmitters of infection and even after only minor contact with the patient or equipment, pathogens have been recovered from the hands of healthcare workers as long as two and a half hours after the initial contact (Teare et al. 2001, Nagata et al. 2002). Pessoa-Silva et al. (2004) also demonstrated significant increases in bacterial counts on the hands of healthcare workers after just two minutes of contact with an infant’s skin during routine care, and even higher counts during respiratory care.

Several studies have identified that artificial and long nails are more likely to be colonised with bacteria than short natural nails (Foca et al. 2000, Moolenaar et al. 2000). These studies recommend that artificial nails should be banned from all healthcare settings and short, natural nails should be encouraged, because long, natural nails can compromise the integrity of protective gloves. However, none of these studies link the use of nail polish or chipped nail polish on natural nails to increases in colonisation of micro-organisms (Saiman et al. 2002). Nevertheless, Pratt et al. (2007) recommended that ‘...fingernails should be kept short, clean and free from nail polish’.

The use of gloves is recommended for the protection of the healthcare worker, and to reduce the cross-transfer of micro-organisms between patients. While gloves can protect staff from contamination, commensal and pathogenic bacteria accumulate on gloves during care episodes, facilitating the transmission of pathogens (Pessoa-Silva et al. 2004). The use of gloves does not replace handwashing. Gloves become easily contaminated and hands are then contaminated during the removal of gloves (Pratt et al. 2007). Boyce et al. (1997) and Bhalla et al. (2004) found that the gloves of healthcare workers can easily be contaminated without direct contact with a colonised patient; they only require contact with the patient’s bedrails and tables. Hence, in the NICU there is the risk of contamination from a colonised patient’s incubator. Horton and Parker (2002) stated that washing gloves rather than changing them is not safe. Pratt et al. (2007) also cautioned that gloves may leak while appearing undamaged. Therefore, it is recommended that gloves are changed and hands washed after each activity, especially between patient body sites.

Despite all the information, studies and education demonstrating the importance of handwashing in infection control, healthcare workers frequently do not wash their hands adequately (Widmer 2000, Fendler et al. 2002). Alcohol-based hand rubs are now recommended as an effective means to reduce many micro-organisms on the hands of healthcare workers. The use of alcohol hand rubs has overcome many obstacles to handwashing such as lack of time and lack of access to sinks, and apart from causing some dryness they are less of an irritant to the skin than soap and water. Therefore, there is a higher compliance rate (Teare et al. 2001, Horton and Parker 2002).

The introduction of alcohol-based hand rubs may have had a positive effect on reducing colonisation and HCAI rates and their use is highly recommended (Teare et al. 2001, Fendler et al. 2002). However, one trial in an NICU found no statistical differences in infection rates during trials between hand washing and alcohol hand rubs (Pratt et al. 2007).

The effectiveness of the alcohol-based hand rub is dependent on the concentration of ethanol and the volume used (Centers for Disease Control and Prevention (CDC) 2002, Kampf and Ostermeyer 2003), and some alcohol-based handrubs lose efficacy after ten consecutive uses (Pratt et al. 2007).

Many alcohol-based hand rubs are also ineffective against bacterial spores and Noroviruses (CDC 2007), or some micro-organisms such as Clostridium difficile (Pratt et al. 2007). Also, alcohol hand rubs are not effective as cleaning agents and hands that are visibly soiled or that have been contaminated by body fluids need to be washed with soap and water (Horton and Parker 2002, Pratt et al. 2007).

**Education**

In many organisations healthcare professionals attend educational sessions on infection control practices on initial employment, and then every year thereafter (Horton and Parker 2002). The Royal College of Nursing (2005) stated that all healthcare staff should undergo mandatory infection control training as part of their induction and on an annual basis. However,
techniques reduced the levels of HCAI in the unit. Also, the importance of good handwashing demonstrated that increasing knowledge of contamination and cross-infection, and especially on the importance of good hand hygiene practices. Polin and Saiman (2003) demonstrated that increasing knowledge of infection rates and the type of micro-organisms, as well as the importance of good handwashing techniques reduced the levels of HCAI in the unit.

Adams-Chapman and Stoll (2002) and Schelonka et al. (2006) found that where units had educated staff about their specific infection rates, micro-organisms and prevention, this empowered the entire staff on the unit to enforce maximum compliance with infection control practices. Educational programmes about infection rates, types and patterns in individual units have had a positive effect on reducing HCAI rates.

The responsibility for implementing and monitoring infection control practices, infection rates and the effectiveness of educational programmes currently lies with the infection control team (Horton and Parker 2002). This team usually includes at least one designated and identifiable full-time infection control nurse or nurse consultant and at least one infection control doctor, whose areas of responsibility encompass the entire hospital or NHS trust. However, there are no government guidelines on acceptable numbers of infection control nurses or beds. Consequently the National Audit Office (NAO 2000) considered the current ratio of patients to infection control nurses in many NHS trusts in England to be ‘unacceptably high’.

It is not financially viable for many NICUs to employ a full-time infection control nurse for a single unit, as the benchmark from a number of American studies for the ratio of infection control nurses to beds is one to every 250 beds (NAO 2000). A sharing option should perhaps be considered by NHS trusts or even the new regional neonatal networks that have been established throughout England, allowing one neonatal infection control nurse to cover several units. With the limited staffing and financial resources facing many NICUs one possible way to address this problem is through the development of the infection control link nurse.

**Infection control link nurses**

The infection control link nurse is not a new concept and was suggested as a solution to UK healthcare workers’ limited knowledge of infection control nearly 20 years ago (Horton 1988). Infection control link nurses are ward-based staff with sufficient clinical experience in their areas of expertise (Horton and Parker 2002). The NAO (2000) also found that to be successful these nurses needed to have sufficient clinical experience and standing to have authority with managers and colleagues. These nurses are the link between their units and the infection control team, increasing awareness of infection control issues and motivating the staff to improve infection control practices (Dawson 2003). Infection control link nurses receive extra training and education in infection control and form close liaisons with the hospital’s infection control team.

Parry et al. (2005) established that the presence of an infection control or link nurse decreased the risk of an infant acquiring probable nosocomial bacteraemia. This confirmed the findings of Wright et al. (2002) who found that the implementation of an infection control liaison position within their NICU resulted in decreased HCAIs, despite the continuing increase in low birth weight admissions.

Horton and Parker (2002) cite the work of Teare and Peacock (1996) to support and suggest that a link/liaison system has been successful in raising the infection control profile and changing practice in clinical areas. However, a study by the NAO in 2000 found that only 59% of NHS trusts in England were using the infection control link nurse system. Eighteen per cent of these trusts reported that the system had been unsuccessful, while a further 7% had abandoned the system as a result of high turnover of staff, or because nominated staff had lacked the required authority. Also, some difficulties with the role have been reported, especially where there is a shortage of nurses, overworked and demoralised staff and restricted healthcare budgets (Horton and Parker 2002).

Despite these failings, however, at least half of the NHS trusts in England that had implemented the infection control link nurse system reported that they considered the system to be successful in improving infection control practices as a direct result of increasing the awareness of such issues among staff (NAO 2000). Therefore, while some operational difficulties with this role have been reported, the infection control link nurse can succeed in contributing to improving infection control practices and reducing HCAI rates (Wright et al. 2002, Dawson 2003).
Conclusion

There is ample information and evidence about the many causative factors of HCAI in the NICU. There are many factors that compromise the health of the NICU patient, but complacency should not be one of them. Handwashing is the simplest, most cost-effective and ultimate means to reduce HCAI rates (Brady 2005, Darmstadt et al 2005). However, despite all of the studies and the evidence presented, handwashing compliance rates are still considered to be suboptimal in many units (Cohen et al 2003, Thibeau et al 2005). In neonatal care handwashing and the use of alcohol-based hand rubs, and even the changing of gloves between body sites, particularly between nappy care and respiratory care should be routine, monitored and enforced. NICU staff should not become mistakenly confident in the sole abilities of alcohol-based hand rubs to prevent cross-contamination.

Education has also been highlighted as a major contributing factor in the reduction of HCAI. However, as this article has identified, despite this evidence and the established protocols and practices in NICUs, HCAI rates continue to rise with devastating consequences to the infant and healthcare budgets (Polin and Saiman 2003, Parry et al 2005).

While HCAI rates in NICUs remain high, current educational programmes continue to fail to address this issue. All healthcare staff should have an increased awareness of the many issues previously identified for there to be a positive effect in reducing HCAI rates in the NICU.

Developing the role of the neonatal infection control nurse or the infection control link nurse will increase awareness of infection control practices and reduce HCAI rates in the NICU.

There is a need for healthcare workers in NICUs to examine cleaning regimens.

References


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particularly unit equipment. More studies are required to assess what constitutes an effective and safe cleaning regimen in the NICU, and if unit staff continue to clean the equipment, more education and training are required (Wenger et al. 1997; Malik et al. 2003), and equipment cleaning and changing regimens should be researched and developed.

There is a lack of nursing and medical input into the development and maintenance of an optimum environment in the NICU, as well as a lack of liaison with hospital cleaning, maintenance and building facilities departments. The role of the neonatal infection control nurse or infection control link nurse should be developed further to encompass these areas, raising awareness among healthcare workers in the NICU and other departments of the many environmental issues that influence HCAI rates.

Despite the financial and staffing constraints that many NICUs experience, serious consideration should be given to establishing a infection control link nurse post in the NICU, and even the employment of a neonatal infection control nurse who could work across various NHS trusts or the currently established regional neonatal networks in England. Hospital trusts should consider these roles as a sound financial investment, for the return on their investment would be the resultant reduction in neonatal HCAI, reduced lengths of stay and, ultimately, reduction in the cost of neonatal care


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