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NOSOCOMIAL INFECTIONS IN DEVELOPING COUNTRIES: COST EFFECTIVE CONTROL AND PREVENTION
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NOSOCOMIAL INFECTIONS IN DEVELOPING COUNTRIES: COST EFFECTIVE CONTROL AND PREVENTION

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ABSTRACT

Objectives: **To review the efficient and cost-effective preventive, control and surveillance measures that could be employed against nosocomial infections in developing countries.**
Data sources: **Literature search on compact disk-read only memory (CD-ROM), Medline and Internet, using the key words: nosocomial infection, prevention and control, use of antibiotics and use of computers. Some articles were manually reviewed.**
Study selection: **Relevant studies or articles on nosocomial infections in developing and developed countries were included in the review.**
Data extraction: **From individual studies or articles.**
Data synthesis: **Information on nosocomial infections from developing and developed countries with some emphasis on Kenya is synchronized under the headings; introduction, historical background of nosocomial infections. Current situation of nosocomial infections and predisposing factors, nosocomial infections and antimicrobial resistance, consequences of nosocomial infections, hospital infection control programme and use of computers in nosocomial infection surveillance, and the cost benefit of infection prevention and control programme.**
Conclusion: **Nosocomial infections may be contained more effectively by having an infection prevention and control programme. Computer-assisted epidemiological surveillance appears to be the most important aspect of monitoring infection control programmes, and to identify changes in risk factors that can increase the infection rate. Even minimally, effective infection control programmes are cost-effective. For the war against nosocomial infections to be won, the whole exercise should be handled as a global project with significant inputs from developing countries.**

INTRODUCTION

Today's modern hospital is a large and complex institution offering a wide variety of diagnostic and therapeutic services to many patients. Inadvertently, the hospital environment has become heavily contaminated with different types of pathogens and acts as a reservoir of nosocomial pathogens that may infect patients during their stay in the hospital. The identification of the predisposing factors and patients at risk for acquiring an infection owing to a nosocomial pathogens is therefore vital in the development of a preventive strategy for nosocomial infections(1).

Historical background of nosocomial infections: The problem of nosocomial infections is very old and dates back to the pre-Listerian era, the 18th century, when many hospitals were considered unsafe. There were no antiseptics and disinfectants, no sterilization of instruments and dressing of wounds, no sterile gown for sterile surgeon, and no donning gloves. Infections were rampant, "Every wound becomes a sore and every sore is out to run into a gangrene" wrote John Bell(2). All wounds that were washed with a sponge that went from one patient to another became infected, and mortality after amputation was as high as 60%. Puerperal fever was common in the maternity wards and an epidemic in 1746 in one hospital in Paris, France, killed 19 out of 20 women(3). As bad as this may seem, it was argued that the only alternative, being out on the street, was worse(4).

On the whole, British hospitals seemed to fare better. They were cleaner, based on the requirements that every patient has clean sheets upon their admission, they have clean sheets at least once in three weeks and two patients not be admitted to the same bed except when there is no spare bed in the ward(5). This situation is still untenable in most developing countries, where even more than two patients may share a single bed. In Kenya for instance, during malaria outbreaks not only more than two patients share beds, but many also stay on floors of the congested wards using personal belongings such as blankets. This creates serious

sanitation problems, which predisposes individuals to nosocomial infections.

In the post-Listerian era, that is, after Lister described his antiseptic techniques in the year 1867, many physicians became aware that certain diseases such as smallpox could spread to hospitalized patients, and the practice of segregating certain patients was accepted. For instance, plague cases were confined, and segregation of smallpox and fever cases was formalised in England in the early 19th century when fever hospitals were established. However, the statistical evidence for the efficacy of isolation of the infected patients was fragmentary. By 1850, the demand for hospital beds had increased dramatically in European cities, until resources were stretched and could not provide acceptable hygienic practices. Hospital related mortality particularly on surgical and obstetric services increased dramatically(5). Mortality rates in the maternity units were notoriously high, so much that Lightfoot(4) writing in the London Medical Times in 1850 suggested that hospitals had become "the gates which lead (women) to death" from puerperal fever. Holmes(3) traced the evidence that puerperal fever was a contagious disease and Sammelwelis observed that Puerperal fever was a contagious disease spread by physicians and midwives when their hands were contaminated with necrotic material(5). Farr and Nightingale(6) also observed that most of the excess military mortality during wars was due to contagious diseases and crowding in the hospitals. Nightingale remarked that "the most unhealthy hospitals in England were those situated within the vast circuit of the metropolis" and made the stricking statement that "in all probability, a poor sufferer would have much better chances of recovery if treated at home"(7).

Delivery of babies in hospitals is a relatively new phenomenon due to notoriously high mortality rates initially associated with the maternity units. In the United States for example, it was until 1940 that 50% births occurred in hospitals and it mostly involved the poor. The wealthy had their children at home until hospitals were shown to be safe.

During the 1950s, severe epidemics of nosocomial infections in surgical and paediatric units were being reported in Europe and America. This was the main impetus for the development of hospital epidemiology as a recognised discipline(8).

Current situation of nosocomial infections and predisposing factors: The problem of nosocomial infections appeared to have been solved during the antiseptic surgery and antibiotic era. Surgical sepsis was dramatically reduced by Lister's methods of antiseptic surgery. The invention of the autoclave paved way for the introduction of the methods of antiseptic surgery. In the surgical wards, the vast majority of wounds healed by first intervention and in maternity wards, the number of women who had a febrile puerperium declined drastically. The discovery of sulphonamides in 1935, and antibiotics in the 1940s seemed to be the dead knell to the problem of nosocomial infections. However, the expectations of eliminating nosocomial infections have not been realised. The old problem has re-appeared, but not exactly the same as in the pre- antibiotic era. The change in the pattern and spectrum of nosocomial pathogens is noteworthy. In the pre-antibiotic era, *Streptococcus pyogenes* dominated the scene. Today, *Staphylococcus aureus*(9,10), *Pseudomonas aeruginosa*(11) and enterobacteria in which *Klebsiella, Proteus, E. coli* and *Salmonella typhimurium* rank high, are in the forefront(1). *Candida* species have also emerged as important causes of nosocomial infections, accounting for more than 72% of fungal isolates causing nosocomial infections(12,13). *Candida tropicalis* is emerging as the second most frequent species after C. *abicans*(12).

A number of nosocomial viral infections have also been documented. For instance, Zuezem *et al.*(14) reported a high prevalence of hepatitis C virus (HCV) infection in haemodialysis patients, and they suspect the infection to be nosocomial within the dialytic environment. Elsewhere, rotavirus has been reported to be a frequent nosocomial infection and has become endemic within obstetric and hospital nurseries of the newborn(15).

The predisposing factors for nosocomial infections may be due to ordinary risks or peculiar to the environment of a hospital, and both intrinsic and extrinsic factors play an important role in the development of nosocomial infections. They include the duration of hospitalisation, type of ward, underlying disease, medical procedures and devices, antimicrobial therapy(1) and negligence of laid down hygienic and sanitary procedures. There is negligence of established methods of prevention of sepsis due to the unjustified faith in the efficacy of antimicrobials to take care of any sepsis that might develop. The widespread and indiscriminate use of antibiotics has a selective pressure which gradually replaces antibiotic sensitive strains with those resistant to multiple antibiotics and normal concentrations of disinfectants commonly used in the hospitals(1,16). The emergent antimicrobial resistant strains are commonly involved in the causation of nosocomial infections(17).

Patients on support machines in the intensive care unit (ICU) and those in surgical wards are more at risk of nosocomial infections compared to other wards. Invasive medical procedures such as catheterization and operations are also predisposing factors (18,19).

The susceptibility of many in-patients to nosocomial infections is another reason. Many patients who frequent hospitals today belong to an older age group than those admitted early in the antibiotic era. A large number of expectant mothers go to deliver in hospital maternity wards than early in the antibiotic era. Hospitalised patients with chronic infections and other debilitating diseases have weakened immunity and are more

susceptible to infections especially by nosocomial opportunistic micro-organisms. The population of immunosupressed patients as a result immunosuppressive therapy and immunodeficiency diseases like HIV/AIDS has greatly increased in hospitals(17,20). Prolonged hospital stay(18,19), overcrowding, and scarcity of drugs, apparatus and personnel also contribute to colonization and increased rate of nosocomial infections.

Nosocomial infections and antimicrobial resistance: Antimicrobial resistance is a temporary or permanent capacity of a micro-organism to remain viable and/or multiply in the presence of the antimicrobial, for instance a drug, which otherwise would inhibit or inactivate the micro-organism(21). This is a major factor limiting long-term successful use of an antimicrobial agent, with infections that were at one time easy to treat now proving difficult to manage(22). The areas hit hardest by antimicrobial resistance are hospital settings where it has become common and often goes unnoticed until it assumes epidemic proportion, and from where the resistant strains can spread to communities(1).

Antimicrobial resistant nosocomial infections are on the increase globally, causing considerable concern among physicians and others in the medical community. Methicilin resistant *Staphylococcus aureus* (MRSA) has set up a permanent residence in various hospital environments such as floors, benches, bed frames, furniture handles and linen. Colonized or infected patients and staff who are carriers of the MRSA in their nares are also reservoirs of infection(9,10). Dissemination of MRSA from large hospitals to smaller units has occurred since 1970s and some of the strains involved have been found to be resistant to virtually all available antimicrobial agents. MRSA is a great problem both as community and nosocomial infection, especially in the immunosuppressed patients(23). Intra-and inter-hospital transfer of patients and staff has been documented to spread multidrug resistant strains of MRSA and coagulase-negative staphylococci(24).

Outbreaks of nosocomial multidrug-resistant tuberculosis (MDRTB) have been reported(25). MDRTB is defined as tuberculosis resistant to isoniazid and rifampicin, the two most effective antimycobacterials available for the treatment of tuberculosis. However, resistance to other antimycobacterials has been reported. The nosocomial transmission of MDRTB to health care workers and among human immunodeficiency virus (HIV)- infected patients, both in hospitals and outpatient clinics, is well documented and associated with extraordinarily high case-fatality in the range of 72-89%(26). The HIV infection has greatly altered the epidemiological and clinical profile of TB worldwide(27). With an increase of MDRTB, treatment will become more complicated than today's short-course chemotherapy (25).

Pseudomonas aeruginosa is an important nosocomial pathogen having been isolated from a variety of aqueous solutions including disinfectants, ointments, soaps, irrigation fluids, eyedrops, and dialysis fluids(11). It is frequently found in aerators, and traps of sinks, baby and hydrotherapy baths, and respiratory equipment. *Nosocomial P. aeruginosa* displays resistance to multiple classes of antimicrobial agents and is particularly troublesome in wounds and burns patients(28).

The emergence and spread of nosocomial multi-drug resistant gram-negative bacilli (MRGN) is a worrying major side effect of broad-spectrum antibiotic usage and advanced invasive medical techniques. These organisms usually carry antimicrobial resistance plasmids, which can spread within the same and to other species, and are the major cause of cystitis (29). *Proteus* species are increasingly being demonstrated to be multi-drug resistant, including gentamicin, which is considered to be the most potent antibiotic against them(1). *Nosocomial S. aureus, P. aeruginosa* and *P. Proteus spp.* seem to compete in causing wound and burns infections and resistance to various antimicrobials.

The continous selection of resistant flora together with the identification of new pathogens calls for a reconsideration of hospital policies regarding the dispensation of antibiotics.

Consequences of nosocomial infections: In the current climate of cost containment and quality control, nosocomial infections are worrisome adverse events in hospital care(16). They constitute an important health problem with high morbidity and mortality, prolongation of hospital stay, and increased costs of direct patient care(30).

Nosocomial infections may spread from hospitals to communities, for instance the transmission of staphylococci (by newborns) and measles to members of the household, which are common occurrences. The excess duration of hospitilisation secondary to nosocomial infections in the US has been estimated to be 1 to 4 days for urinary tract infections, 7 to 8 days for surgical site infections, 7 to 21 days for blood stream infections, and 6 to 30 days for pneumonia(32). In Kenya, this duration may be up to 70 weeks for burns patients infected with MRSA(25). This excess duration of hospitalisation not only disrupts the patients families programmes, but also means occupation of beds which should otherwise he used to admit other needy cases. Infection with nosocomial pathogens also means high treatment costs, particularly the multi-drug resistant ones, as this may encourage the use of more expensive drugs which may be more toxic(31).

Patients suffering from infections such as viral haemorrhagic fevers and MRSA infection, typhoid, *E. coli* gastroenteritis (in babies), and tuberculosis may require isolation(25). Extreme measures like ward closures are expensive exercises considering that many hospitals have limited resources(33).

In the United States, the more than two million nosocomial infections that occur annually(32,34), result

in substantial morbidity, mortality, and financial cost. The estimated mortalities associated with nosocomial bloodstream infections and pneumonia are 23.8% to 50% and 14.8% to 71% (overall), or 16.3% to 35% and 6.8% to 30% (attributable), respectively(32). Girou *et al.* (33) in the United States have conducted a case-control study to determine the contributions of severity of illness, therapeutic activity and nosocomial infections to patients outcomes. Forty-one cases of patients who developed nosocomial infections during a 1-year period were paired with 41 controls without nosocomial infections. Mortality attributable to nosocomial infections was 44%. A similar study has been conducted by Asensio *et al*(34) in Spain to determine the proportion of mortality caused by severe nosocomially infected 702 open-heart surgery patients. They have observed that severe nosocomial infections is a principal factor in-hospital mortality, and one third of all deaths are caused by infections. They have recommended major efforts to be devoted to the prevention and control of severe nosocomial infections in open-heart surgery patients to prevent mortality.

Hospital infection control programme (ICP) and use of computers in nosocomial infection surveillance: Control and prevention of nosocomial infections should not be merely a spasmodic exercise to be employed when an outbreak occurs, but rather a permanent on-going activity in any large hospital. Therefore, every major hospital should have an infection prevention and control committee(10) consisting at least of a Medical Officer, Nursing Officer, Public Health Officer, Microbiologist, Epidemiologist, Pharmacist, Laboratory Technologist, Hospital Administrator, Hospital Health Information System Scientist, Central Sterile Unit Supplies Manager and Hospital Engineer. Besides investigating and controlling outbreaks, its functions should also include formulating appropriate. guidelines for admission, nursing, and treatment of infectious patients, surveillance on sterilization and disinfection practices, determining antibiotic policies and immunization schedules, and educating patients on personal hygiene and hospital personnel on infection prevention and control. Such measures may greatly help in reducing the incidence of hospital infections, even if they do not eliminate them altogether(35).

Manangan(36) has reported the development by the Investigation and Prevention Branch, Hospital Infection Programme, Centers for Disease Control and Prevention (CDC), of the Hospital Infections Program infection control information system (HIP ICIS) to respond more efficiently to public enquiries (telephone or written) that HIP receives daily. The HIP ICIS allows awas assess d using micro II strips. Setting: Outpatient diabe ic clinic at Kenyatta National Hospital, Nairobi. Sub ects: Patients who were newly diagnosed or had had type diabetes for two years or less. Main outcome m asures: Microalbuminuria, lipids, glycated haemoglo in, fasting blood glucose an blood pressure. Results: One hundred and thirty n ne patients who had type 2 diabetes mellitus for ≤ yrs were seen, but only 100 patients were include in the study over a six month period. Their mean (S) agcomial infections. This has been achieved by the creation of Co-ordination Committees at the regional level and one central National Committee in charge of defining policies and priorities on hygiene. From early 1990 several epidemiological surveys have been set up, both at the national and regional levels, displaying nosocomial infections prevalence rates of approximately 6 to 16%. High risk groups for nosocomial infections had been targeted as a priority in the different survey programs; wounds, bacteremias, surgery wards and intensive care units. The epipidemiologic situation of France, as in south Europe, is characterized by a high rate of multi-drug resistant strains. The methicillin resistance rate of *S. aureus* was over 40%. A specific programme to prevent *S. aureus* transmission had led to a significant decrease of this prevalence rate to 32%. French Health Authorities and health care providers now consider prevention of nosocomial infections as a public health priority given their frequency, morbidity and mortality rates, and financial costs. He suggests that optimization of the prevention of nosocomial infections be considered as a significant marker for quality of care and safety of hospitalised patients, as this might play a significant role in budgeting for hospitals.

Hayanga *et al.*(11) have reported MRSA among both in-and outpatients at the Nairobi Hospital in mid 1996. However, the hospital's Infection Control Committee quickly identified the source and the disinfectant methods were modified, which led to the eradication of the infection by the end of the year. They attribute this timely success to the hospital's active and on-going infection control programme.

Unfortunately in many hospitals, particularly in developing countries, infection control is attempted by resorting to more and more usage of broad-spectrum antibiotics. This is not only futile, but may even be positively harmful by encouraging selective colonization by multi-drug resistant pathogens. In the final analysis, prevention and control of nosocomial infections rests on a proper understanding of aseptic practices and meticulous attention to hygienic principles. Sir William Osier's aphorism that "soap, water and common sense are the best disinfectants" applies even today in the context of nosocomial infection(s).

The infection Prevention and Control (IPC) manual may be a useful tool for ward-laboratory-central sterile unit-and kitchen level training and education of all staff, medical and non-medical. It may also provide uniformity and standardization of patient care and staff practice(9). The IPC manual should be approved by the hospital executive board, and be revised and updated regularly, preferably after every two years. This may greatly help in reducing the number of nosocomial infections and their associated morbidity,

mortality and financial cost, which are the primary goals for infection control.

Many systems have been developed by Infection Control Programmes, which allow for surveillance of nosocomial infections and organization of the resuting surveillance data. However, much of the effort expended in the name of infection control is usually directed at repetitious data gathering. There is need to lessen the time and other resources spent merely in data collection while increasing the time used to question, analyze and intervene. Computer-directed surveillance is likely to become a time-saving reality for many health institutions(38). This is because computer-based systems excel at performing repetitive tasks rapidly, and can facilitate many of the repetitive tasks associated with infection control(33).

Advances in both computer hardware and software have also greatly increased the contribution of computers infection-control programmes in many other ways. Access to literature on infection control is facilitated by computerized data base services, particularly MEDLINE(39). Computer surveillance provides the raw material from which problems can be identified and the effects of interventions scrutinized. A review chart of every hospital patient every hour or after suitable interval(s) is gold standard surveillance method. Computers may help select patients with increased risk of having developed a nosocomial infection, therefore allowing chart review to be more efficient(40). Computer data analysis helps identify problems and allows testing of hypotheses about causation before design of interventions(41). Complex statistical tests may be performed routinely and results displayed graphically by using computer support. Other important tasks facilitated by computers include various word processing tasks(42), communication functions(41) and surveillance of antibiotics use practices(43).

The initial cost of computer hard- and softwares and system maintenance and the possibility of catastrophic data loss in poorly maintained systems may seem prohibitive. However, careful consideration of the hard and softwares before purchase and proper training of personnel can minimise these problems to make the benefits of computelization of surveillance to outweigh these disadvantages (33).

The cost benefit of nosocomial infections prevention and control programme: Infection control programmes (ICPs) in the developed countries have successfully reduced patient mortality and morbidity while limiting excess hospital costs. Haley *et al*(44) have conducted a study in the United States of America (USA) on the efficiency of the Nosocomial Infection Surveillance (SENIC). They have observed that nosocomial infection rates call be reduced by 32% through effective infection control. In the United Kingdom (UK), the North Middlesex Hospital's infection control policy over a 10-year period (1980-1990) has shown a cost saving of 24.4% (9). Yalcin *et al*(30) have conducted a study in one hospital in Turkey to determine the cost of nosocomial infections and length of hospitilisation by matching infected patients with uninfected controls. Data collected from 102 individuals with nosocomial infection (group A) and 102 controls without nosocomial infection (group B) were recorded by using a computer programme (dbase IV). Urinary tract infections, surgical wound infections and bacteremias were the most common nosocomial infections. The average hospital cost was US $2280 for group A, and US $698 for group B ($p<0.001$). They concluded that the high economic expense which nosocomial infections represents measures to control this entity.

The more than 2 million nosocomial infections that occur annually in the USA(31) have estimated average costs of US$558 to US$593 for each urinary tract infection, US$2,734 for each surgical site infection, US$3,061 to US$40,000 for each bloodstream infection, and US$4,947 for each pneumonia. In countries with prospective payment systems based on diagnosis-related groups, hospitals lose from US$583 to US$4,886 for each nosocomial infection. As administrators focus on cost containment, increased support should be given to infection control programmes so that preventable nosocomial infections and their associated expenditures can be averted. However, participation from developing countries must be increased until infection control becomes a global project(45).

The implementation of infection control policies in developing countries can also result in considerable cost saving(35). The benefits of ICP can best be shown by a baseline assessment of infection rates, procedures and practices for six months prior to introduction of all ICP programmes and identical monitoring for the first six months of the programme, and a further six months for monitoring once the ICP is established and institutionalised. However, the average cost of nosocomial infections in developing countries will vary from country to country, depending on the type of infections prevalent in a country's hospitals, the infections rate and the cost of health care in a country. In Asian and African countries, nosocomial infections rates have been estimated to vary from 3% to 12%(11) with high rates of blood stream(39), respiratory, urinary tract, surgical and burns, gastro-intestinal and newborn infections(45). Assuming an average infection rate of 8% in the developing countries of Asia and Africa, and a cost per infection from US$50 to US$500, Western *et al*(45) have estimated that a 32% reduction in nosocomial infections could result in savings of US$230 million to US$2.3 trillion annually.

CONCLUSIONS

The spectrum of nosocomial infections is rapidly widening due to among others, HIV/AIDS, deteriorating sanitary conditions, immunosupressive therapy and over use of antibiotics. The costs of nosocomial

infections in most developing countries have not been documented. There is generally inadequate government budgetary allocation for health care in most the developing countries, which also translates into inadequate allocation of funds for essential activities such as control and surveillance of nosocomial infections. Therefore, the costs of nosocomial infections are probably much higher in morbidity and mortality, and lower in financial costs in developing compared to developed countries.

There is general lack of sound footing in hospital epidemiology and health information system in most developing countries, which is a pre-requisite for successful prevention and control of nosocomial infections in a modern hospital. Most hospitals in developing countries do not have or have weak hospital infection control programmes (ICPs), which are crucial for the surveillance of nosocomial infections. The prevention of hospital infections requires a multi-faceted approach. Concentration of efforts in a single direction, for instance the massive use of antibiotics, which will never be a substitute for asepsis, hygiene and sanitation cannot yield desired results. Computer-assisted epidemiological surveillance is the most appropriate and important aspect of monitoring infection control programmes and to identify changes in risk factors that can increase the nosocomial infection rate.

Nosocomial infection rates may be used as indicators of the quality of hospital care.

RECOMMENDATIONS

There is need for governments in developing countries to increase budgetary allocations to health care, to enable hospitals administration to allocate adequate resources to nosocomial infections control. All major health care facilities such as provincial and district hospitals should establish effective hospital infection prevention and control committees. The committee should among others, develop infection control manuals, characterise all clinical and hospital environment pathogens and computerise the resulting information into a pathogen databank, and formulate antibiotic policies. This will assist in the establishment of surveillance mechanisms on various microbiological procedures and quality control at the hospitals, and improve the management of patients.

Collaborations and linkages between national health institutions and other major health facilities in developing countries in the areas of nosocomial infections prevention, control and surveillance should be established. For instance, in Kenya, provincial and district hospitals would gain immensely in terms of technical support and staff training by collaborating with national institutions like University of Nairobi Medical School, Kenyatta National Hospital (KNH), and The Kenya Medical Research Institute (KEMRI), and international non-governmental organisations (NGOs) such as African Medical Research Foundation (AMREF), and World Health Organisation (WHO).

Since it is well understood that preventive medicine is superior to curative medicine, health personnel have no excuse of allowing hospitals to be health hazard areas by habouring pathogens. However, in the event that an outbreak occurs, the source(s) of infection such as hospital personnel, patients or inanimate objects, such as water, air, beddings, surfaces and food should be identified and the pathogen eliminated.

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