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# Nosocomial Infections Transmitted Via Computers



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NOSOCOMIAL INFECTIONS TRANSMITTED VIA  
COMPUTERS: A LITERATURE REVIEW.

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Nosocomial Infection Transmitted via Computers: A Literature review.

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The purpose of this review was to discuss how current literature described nosocomial infections transmitted via computers in hospitals. It also described the various methods used to disinfect computers. The research questions in this study were; What are nosocomial infections? How do contaminated computer devices transmit nosocomial infections? and What infection control methods are applied to decontaminate computers within hospitals?

The aim of conducting this study was to create an awareness of the risk of nosocomial infection transmitted via computers and to establish a protocol for cleaning and disinfecting computers in order to minimize the spread of nosocomial infections. The method of data collection used was systematic literature review. The literature search was based on previously published studies, which included; current articles, journals and web searches. The data was selected from literature search by their relevance to the research task, and analyzed through inductive qualitative analysis.

The findings reported that, computers in hospitals act as reservoirs for nosocomial pathogens and the spread of nosocomial infection occurs through hand contact of health care workers moving from computers to patients without hand hygiene compliance. It also reported that there has not been any established protocol for cleaning and disinfecting of computers. However, it was found that regular cleaning and disinfection of computers minimizes the potential risk for cross-infection of nosocomial pathogens.

In order to reduce the risk of cross infection of nosocomial pathogens from contaminated surfaces to susceptible patients, the nurse's role in infection control should be emphasized. More research is required on the field of computers and other electrical devices commonly used in hospitals that may act as reservoirs for nosocomial pathogens. The establishment of evidence based cleaning and disinfecting protocol for computers should also be considered within hospitals in Finland, this would improve the quality of infection control and patient care.

Key words: Nosocomial Infection, Cross infection, Computer Keyboard, Disinfection, Infection control

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## 1 Introduction

In recent years, computerization of patient records has increased at a moderate pace and this trend is likely to continue particularly as technology improves, becomes more affordable and as the demand for health care information increases. With the introduction of computers in the hospital, there have been reports of computer hardware acting as potential reservoirs for infectious agents (Neely, Maley & Warden 1999,29). Studies have found links between nosocomial infections and computer contamination (Bures, Fishbain, Uyehara, Parker & Berg, 2000,28) caused by health care workers moving from computer to patient as part of their daily routine (Pittet 2001,40-46) and which may lead to transmission of nosocomial infections.

Nosocomial infections are diseases or infections acquired in the hospital. It has been found to be one of the causes of morbidity which is the prevalence of disease and mortality which is also death due to disease in modern medicine. The rapid increase of bacteria serves to worsen the problem as treatment of infections caused by these organisms acquired in the hospitals is complex and costly. To prevent cross-infection, it is necessary to identify the different sources that facilitate transmission of pathogens to patients. One of the major factors for cross-infection is the transfer of pathogens from the hands of healthcare workers to patients (Pittet 2001,40-46). There is a need for appropriate method of cleaning and disinfecting computer hardware in the hospitals if the number of microbes present on the surfaces is to be reduced. Guidelines for hand washing and disinfection among the health care workers should also be emphasized upon in order to improve the quality of patient care in hospitals.

The purpose of this literature review is to discuss how current literature describes nosocomial infections transmitted via computers in the hospital, and various methods used to disinfect these computers. The goal is to create awareness of the risk of nosocomial infections transmitted via computers and to establish a protocol for cleaning and disinfecting them in order to minimize the spread of nosocomial infections.

This thesis is directed to Cleanside Oy which is a part of Active Life Village. Cleanside Oy is a private company that provides computer cleaning services to the clients' premises including hospitals. The company aims to improve hygiene by lowering the risk of transmission of diseases and promoting a clean working environment.

## 2 Purpose of the study and research questions

The purpose of this review is to discuss how current literature describes nosocomial infections transmitted through contaminated computers in hospitals and the various methods used to disinfect computers.

The research questions are:

- 1) What are nosocomial infections?
- 2) How do contaminated computer devices transmit nosocomial infections?
- 3) What infection control methods are applied to decontaminate computers within the hospital?

## 3 Literature review as a method

According to Tranfield, Denyer & Smart (2003,207-222), "systematic literature review is a replica of scientific and transparent process that aims to minimize bias through exhaustive literature searches of published and unpublished studies and by providing an audit trail of the reviewer's decisions, procedures and conclusions". Systematic literature review has come out as a focus of interests for two main reasons. First, it has been suggested that many reviews of the literature tends to lack thoroughness and have reflected biases of the researcher also, adopting explicit procedures makes such biases less likely to surface. Second, in the field of healthcare, there has been an increasing movement towards evidence based solutions to illnesses and treatment. Systematic literature review is often perceived as complementary evidence based approach because the aim is to provide advice for clinicians and practitioners based on all available evidence (Tranfield et.al 2003,207-222).

Bryman (2008) states that "the purpose of the literature review is to convey to the reader what knowledge and ideas have been established on a topic, the strengths and weaknesses, and also, it allows the reader to be updated with regards to the state of research in the particular field as well as familiarize them with any contrasting perspectives and viewpoints of the topic". (Bryman, 2008) The reason why this method was chosen was to identify what was already known, the important concepts and theories; research methods and strategies that had been employed and identify significant controversies and unanswered research questions in this area of interest.

### 3.1 Data

The steps applied in the process of collecting data were literature search, screening, data extraction and data analysis.

#### 3.1.1 Literature search and Strategy

Literature search is the systematic search of published materials relevant to the study. The first stage of the literature search included identifying journals, articles, research reports that were related to transmission of pathogens via computer keyboards and disinfection techniques in the hospital. Electronic databases and internet search engines were used in identifying pertinent sources. Potential journals were identified using these sources with assistance from the school librarian as well as previous knowledge. Several search engines were used for the searches which are listed in the following table.

Table 1. Electronic Engine Searched

Electronic search engines	Potential Pertinent Sources	Non potential Sources	Sources not in English	Incomplete Sources	Sources Under-construction
Ovid Medline	X				
Pubmed	X				
Ebsco Cinahl	X				
Ebsco Academic Search Elite	X				
Elsevier Science Direct	X				
Springerlink	X				
BioMed Central via SCIRUS	X				
Sage		X		X	X
Linda		X	X		
Helka		X	X		

In table 1, An X is used to indicate the search engines that provided potential pertinent sources, non potential pertinent sources, sources not in English, sources that were incomplete and those that were under construction.

As the search proceeded, more specific means were applied in order to locate sound evidence on the research study, therefore creating a search strategy. Keywords which were derived from the research task were used as search words. MeSh browser which is an online vocabulary look up aid available for use with medical subject headings, was used to confirm appropriate keywords. Using only one keyword separately did not produce potential results

therefore; keyword list was redefined to include words that produced relevant results. Keywords were combined to narrow down results (see table 2) Moreover, the Boolean search method was applied to permit a more efficient search for instance, placing the word AND & OR between keywords, also, using inverted comma's to recognize combined keywords as one other than two separate words. For example, "Nosocomial infection" OR "Cross Infection" AND Computer? And Keyboard? The journals retrieved were saved in "Nelli" which is a folder on the school library's information portal. Internet search engines such as Google were also used to search for articles that could not be retrieved as full text in the databases. It was not possible to use the same search strategy for searching websites because the search engine facilities that permitted the developed strategy were not available. The literature review was retrieved mainly from search engines containing medical and scientific journals. The following table shows the search words used and the search results obtained.

Table 2. The literature search results

Search word	Ebsco Cinahl	Medic	Pubmed	Springerlink	Ebsco (Academic Search Elite)	Elsevier Science Direct	Ovid (Medline)	Helka	Linda
"Nosocomial infection" OR "Cross infection"	11441	390	39542	50076	4012	6674	39295	70	100
"Nosocomial infection" OR "Cross infection" AND Computer?	197	3	484	50076	527	650704	482	0	13
"Nosocomial infection" OR "Cross infection" AND Keyboard?	17	3	484	50076	18	650704	16	0	12
Disinfection AND "Computer keyboard"	1	0	1	20	12	6	1	0	0
Disinfection AND "Computer keyboard" AND "Infection Control"	0	0	0	0	7	5	0	0	0

Table 2 shows search words used and hits obtained from various search engines e.g. search-word "nosocomial infection OR cross infection" results showed, 11441 Ebsco-cinahl; 390 Medic; 19542 Pubmed; 50076 Springerlink; Ebsco search elite; 4012; Elsevier 6674; Ovid medline 39295; Helka 70 and Linda 100.



### 3.1.2 Screening of data

Screening is a criteria used to identify data that would be included or excluded. The results of each search were assessed in order to determine whether the articles retrieved were likely to meet the inclusion and exclusion criteria. Inclusion criteria are characteristics that the data retrieved must have in order to be included in the studies whereas exclusion criteria are characteristics that the data retrieved lacks in order to be excluded in the studies (Burns & Grove 2001:367) This criterion was derived from concepts that were an integral part of the research task. The criteria applied in including and excluding studies were as follows:

Table 3. Inclusion and Exclusion criteria

INCLUSION	EXCLUSION
Studies conducted after year 2000	Studies conducted before the year 2000
Studies written in English Language	Studies not written in English
Studies that drew on published research	Studies that drew on unpublished research
Studies that related to research task	Studies that did not relate to research task
Studies based on actual evidence and empirical research.	Studies not based on actual evidence and empirical research.

During the first screening, 26 articles were saved in "Nelli", the content of some of the articles that met the inclusion criteria covered a wider scope than that of the research task, therefore; a second screening was carried out of which part of the content were reconsidered as potentially more relevant. After the second screening, the number of articles retrieved reduced to 12. The potentially relevant parts were mostly found in the abstract, findings and discussions of those articles. Exceptions were made for older articles conducted before the year 2000 which contained significant evidence to our research task.

### 3.1.3 Data Extraction

This is the extraction of evidence that complies with the review after careful assessment of studies in accordance with the screening criteria. A technique was developed to provide a framework for extracting, assessing and analyzing data contained in the studies as described in Appendix 1. It was designed to support the process of analyzing, synthesizing and reporting review findings. It was used to decrease any bias from the processes that intervene between the research processes and findings. The data extraction method used was based on the research tasks that were, the purpose statement and the research questions. The area from which data were extracted was the abstract, findings and discussions of the selected articles. The research questions were designed to ensure that data was extracted consistently.

The articles considered as being relevant to the study was listed and described in depth on the appendices on page 31. It was organized alphabetically and included the author & year of publication, publication of the articles, purpose of the research, method of data gathering, central findings and the significance of findings to this thesis. Each data extraction was used to draw out key themes in the evidence as part of the synthesis stage of the review process.

### 3.2 Data Analysis

In this literature review, the main findings of the scientific research articles were analyzed using an inductive content analysis. Content analysis is a research technique which can be used for objective, systematic and qualitative description of documentary evidence. (Lo-Biondo-Wood & Haber, 2006.559-575). The main task in data analysis is to be fully knowledgeable with the data. The author has a task of familiarizing with the data precisely before forming data categorization. This helps in proper grouping of findings into suitable categories.

The process involved sorting, aggregating and synthesis of data. The first step began by reading through the 12 articles systematically several times and related the data to the research task. While reading through these articles, relevant information to the research study was color coded and short description of the articles were written on the margin which became the content areas. This process helped to realize what the phenomenon was related to. The second step was to collect similar content areas into one group then; a covering title that described similar findings of the content areas was allocated to the groups respectively. The final step involved further synthesis of the allocated titles into three main categorized themes. The three main categorized themes were titled as, nosocomial infection, chains of transmission and infection control method as these were relevant to the research task. "It is very important for the writer to read all the data collected carefully and categorize it into respective groups accordingly. The main goal in analysis of qualitative data is to organize the gathered information to attain a conclusion and data conveyed in a research report." (Polit, Tatano & Hungler, 2001).

To give an example of the analysis process, the concept of nosocomial infections and its subtitles were chosen in the following way. When a group of articles contained aspects of Methicillin-resistant staphylococcus (MRSA), Vancomycin-resistant enterococci (VRE) Acinetobacter baumannii (AB), this was combined as similar content area and described as Nosocomial pathogens. The same pattern was applied for articles containing high rates of morbidity & mortality, long stays in hospital and an increase in hospital costs and described as Impact of nosocomial infection. These similar content areas were further combined to form the main concept to the first categorized theme and titled as Nosocomial infections. This pattern was repeated and used to form the second category that is, chains of transmission

and the third category that is infection control methods. The following is a figure illustrating the process of creating the main themes.

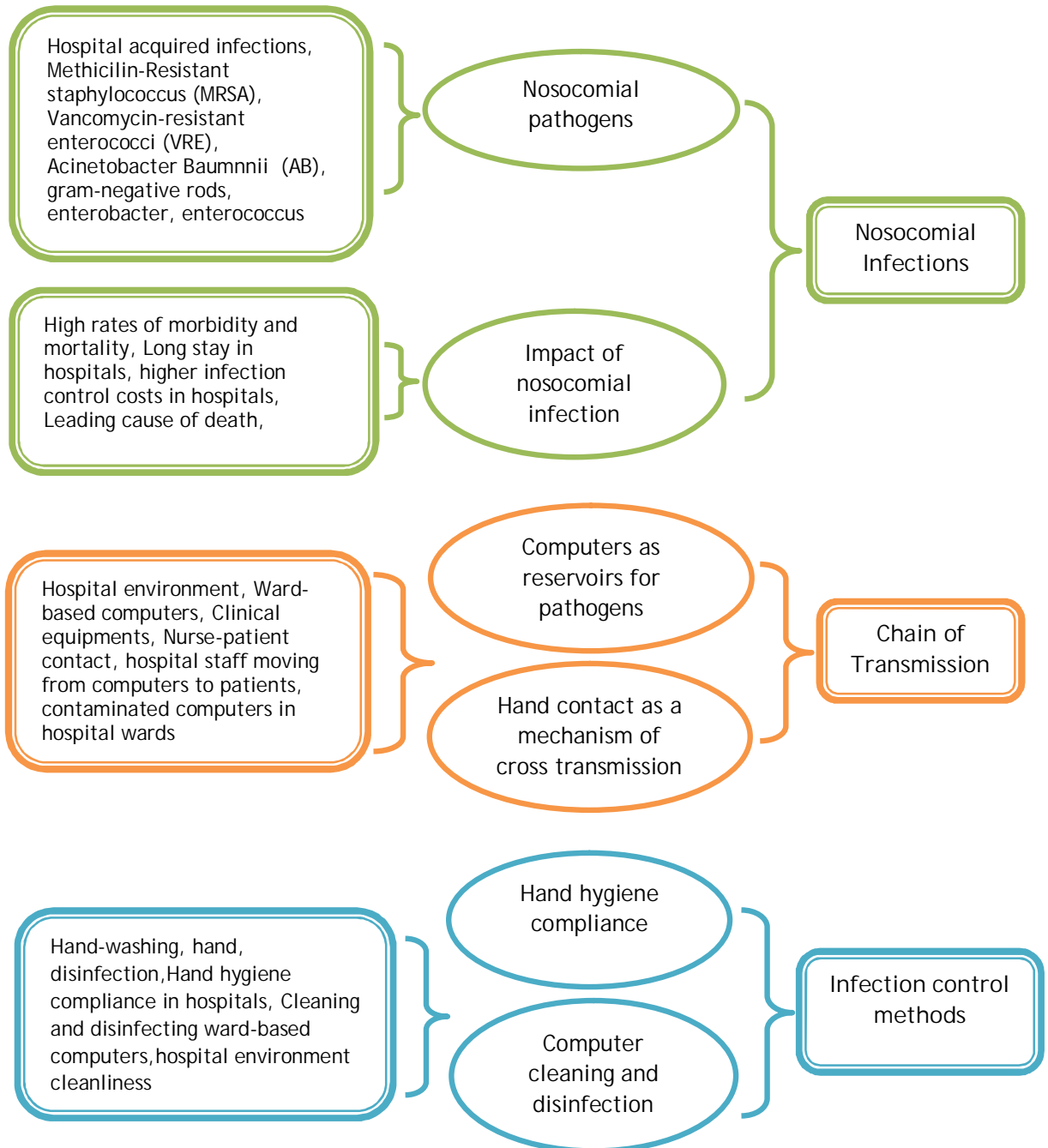


Figure 1. An illustration of the data analysis process

#### 4 Findings

On this section, the body of evidence that emerged from the literature review related to the main research task was examined. Three themes were identified: Nosocomial infections, Chain of transmission and Infection control methods applied to maintain clean computers in the hospitals. On the basis of the data analyzed these were the findings used as evidence to answer the research task.

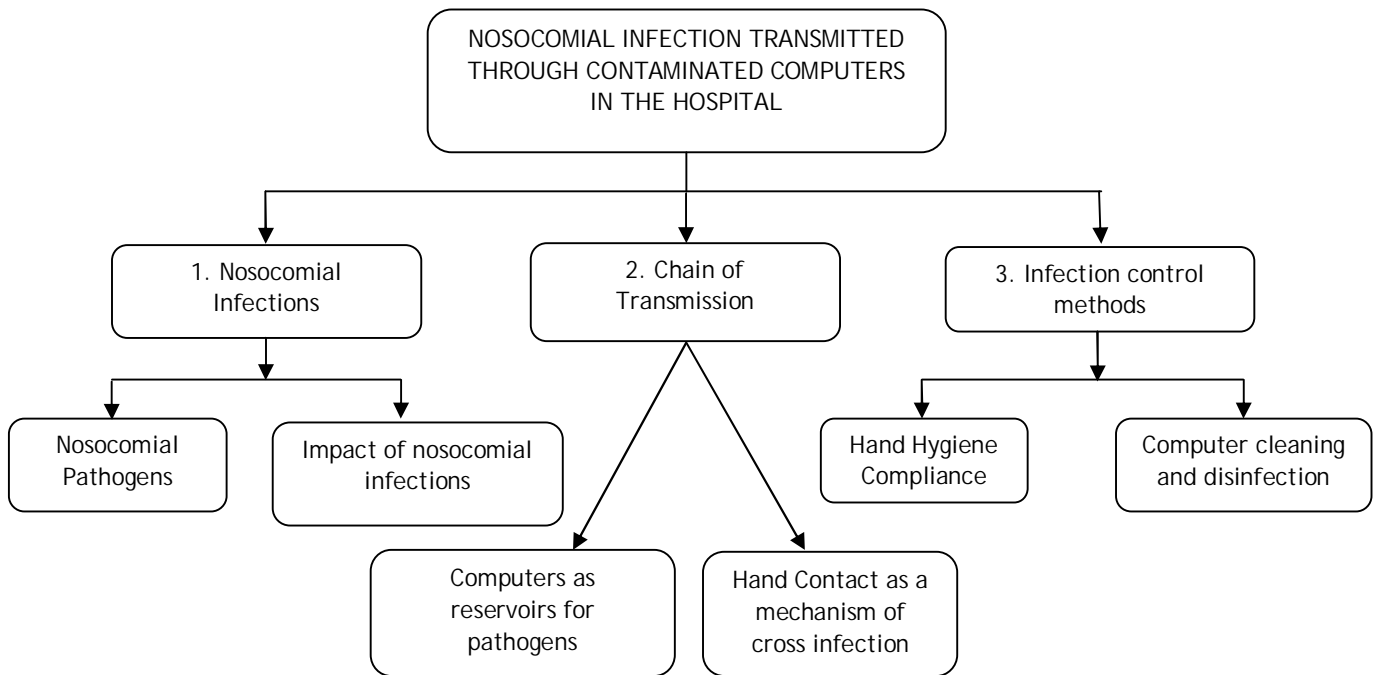


Figure 2 An illustration of outcome of the main categorized themes and subtitles.

##### 4.1 Nosocomial infection

Hospital acquired infections commonly known as nosocomial infections, is defined as medical related issues that are not associated with the patient's original diagnosis on admission into the hospital, they typically surface 72 hours after the patient has been admitted in the hospital for treatment. These infections are usually bacteria but may also be viruses, fungi or parasites. Patients in hospitals have been found to be more susceptible to infections and may even die as a consequence of nosocomial infections. Cross transmission of microorganisms by the hands of healthcare personnel from ward-based computers at the patients' bedside, might introduce an additional risk for critically ill patients, considering the frequent contact with nurses and other healthcare workers.

#### 4.1.1 Nosocomial Pathogens

Pathogen is a term that is most commonly used to refer to infectious organisms that cause diseases. Increasing attention has been drawn to the role of the hospital environment as a reservoir of potential pathogens. Pathogens associated with nosocomial infections have been found to persist on dry inanimate surfaces for several months as well as serve as vectors for cross contamination. Factors influencing the duration of their persistence on the surfaces are; low temperatures between 4-6 degrees centigrade, high humidity, type of surface material and the type of suspension medium. Several reports have also demonstrated contamination of a wide variety of environmental sites including stethoscopes, blood-pressure cuffs, thermometers, bedrails, doors, furniture surfaces and other medical equipment with the potential to spread nosocomial infections.

The most common pathogens implicated in nosocomial infections are gram-negative rods, mainly *Escherichia coli*, *pseudomonas*, *enterobacter* and gram-positive cocci such as *enterococcus* and *staphylococcus aureus*. MRSA and vancomycin-resistant enterococcus that are multidrug-resistant organisms are increasing in frequency and more difficult to treat. A study suggested that ward-based computers pose a low risk for cross-infection problems. Two other investigations conducted within a burns unit and an intensive care unit respectively described the presence of *acinetobacter baumannii* and methicillin-resistant *staphylococcus aureus* (MRSA) on computer keyboards.

*Methicillin-resistant staphylococcus aureus* (MRSA) is a type of bacteria often found in half of a country's population. It is commonly found on people's skin, noses or throat and may be responsible for common ailments such as rashes and spots. Most strains of these bacteria are sensitive to numerous antibiotics and infections can be treated. The MRSA strain is more resistant and less easily treated, this means that it does not react to certain antibiotics and will normally cause skin infections and other infections including pneumonia. In the year 2004, MRSA accounted for 63% of the total amount of *staphylococcus* infections in the United States of America. It occurs mostly among people in hospitals who have weakened immune systems and it has the potential to be fatal.

Studies reported that MRSA infections have grown from fewer than 2,000 in 1993 to an unprecedented 250,000 in the year 2005. All indicators point to MRSA infections multiplying to over a million a year within the next few years. MRSA infections represent only 8% of hospital infections. Nosocomial infections problems have become alarming because a broad number of bacterial infections such as *acinetobacter*, *pseudomonas aeruginosa* *klebsiella* have been found to cause headaches, skin infections, lethargy, and in some cases, pneumonia, toxic shock or even death.

MRSA resists extreme dry conditions and can survive in hospital dust for up to a year, it is found throughout the hospital environment particularly around patients known to be infected with the bacterium. MRSA can be found on general surfaces such as floors, radiators, furniture, and clinical equipment. The prevalence of MRSA on ward-based computers has been the most identified. Evidence from a study suggested that contaminated computer keyboards and tap handles acted as reservoir for nosocomial spread of MRSA strain on an intensive care unit and caused clinical infection in two patients. It also reported the results and the individual prevalence of different pathogens as illustrated on the following table and MRSA was the most common pathogen identified.

Table 4. Bacterial isolates from patients and surfaces

Organisms	Patient Isolates n (%)	Surface Isolates n (%)
Total	14	33
MRSA	6 (43)	16 (49)
Other gram-negative rods	5 (36)	7 (21)
<i>Enterobacter</i>	3 (21)	4 (12)
<i>Enterococcus</i>	0 (0)	6 (18)

*Acinetobacter baumannii* was another form of nosocomial pathogen associated with contaminated computers in the hospital environment. It accounted for about 80% of reported infections in the hospitals. *Acinetobacter baumannii* can live on the skin and may survive in the environment for several days, growing in wet and dry conditions. It is resistant to many antibiotics and when not treated results to death.

A recent study was conducted to find out the role of cleaning in the control of nosocomial infections, it examined the levels of environmental contamination with *acinetobacter* in a neurosurgical ICU during a prolonged outbreak. The results reported that as with MRSA and *Clostridium difficile*, areas that were near to the patients and sites that had hand contact yielded the epidemic strain. The researcher also described what happened following the introduction of bedside computers in a pediatric burns ward during an outbreak. The results reported a sudden increase in the number of patients acquiring *acinetobacter* and screening of the environment demonstrated the presence of pathogens on various surfaces in the patients' rooms as well as plastic covers over the bedside computer keyboards. Up until the occurrence of the outbreak computer keyboards were never included in a routine cleaning

specification. It was during a period of high epidemicity of the *acinetobacter* pathogen in other burns unit that the endemic strain was identified from surfaces close to the patient.

*Vancomycin-resistant enterococci (VRE)* is a bacteria normally found in the hospital environment and once it has affected a patient, its presence is in the human intestines and in the female genital tract. It can sometimes cause infections and in some instances, become resistant to *vancomycin* (an antibiotic often used to treat infections caused by enterococci) and therefore referred to as vancomycin-resistant enterococci.

VRE pathogen is not associated with the same degree of pathogenicity as MRSA, but may still cause infections in immune-suppressed patients causing outbreaks that are difficult to control. In addition, this pathogen has been shown to transfer MRSA, making the latter even more difficult to treat. Part of the problem of controlling VRE in hospitals is due to their ability to persist in the hospital environment for a long period of time and their resistance to routine cleaning.

#### 4.1.2 Impact of nosocomial infection.

As mentioned previously, Nosocomial infections are an increasingly important cause of morbidity and mortality in modern medicine. Studies conducted by World Health Organization and others have found that the highest prevalence of nosocomial infections occurred in intensive care units, acute care surgical and orthopedic wards. Infection rates were higher among patients with increased susceptibility because of old age and the severity of the underlying disease.

Nosocomial infections have been found to add functional disability, emotional stress and in some cases, have led to disabling conditions that reduced the quality of life. It has contributed to the rise in cost of healthcare especially in countries least able to afford them through increased length of stay, use of other services such as laboratory tests, x-rays, transfusions and treatment with expensive medications such as antibiotics. Nosocomial infections were also reported to have been one of the leading causes of death in hospitals.

Two case studies were conducted, one was to measure the effect of enhanced cleaning in a hospital located in United Kingdom with the aim of evaluating the potential impact of one additional cleaner by using microbiological standards based on aerobic colony counts and the presence of MRSA. An additional cleaner was introduced into two matched wards from Monday to Friday, with each ward receiving enhanced cleaning for six months and patients were monitored for MRSA. A simple cost analysis was performed and the average cost of one hospital acquired surgical site infection caused by MRSA was estimated as £9,000. The cleaner earned £12,320 and consumables were £1,100. The results assumed that five to nine patients

were potentially spared MRSA and the hospital saved £45,000 to £81,000 minus the cost of the cleaner and consumables for one year. The overall cost savings was £31,600 to £67,600.

The second study was conducted to evaluate the impact of nosocomial infection on cost of illness and length of stay in intensive care unit. Estimates of the cost and length of stay for patients who acquired a nosocomial infection were computed using statistical analysis and results showed that nosocomial infection increased the total costs by \$3,306 per patient and increased the length of stay by 18.2 days per patient. Each additional day spent in the ICU increased cost per patient by \$353. Nosocomial infections were associated with increased cost of illness and length of stay in hospital. Improvement in the quality of care and prevention of nosocomial infection may thus reduce direct cost and decrease the length of stay for patients in hospitals.

## 4.2 Chain of transmission

Chain of transmission is the movement of pathogens from individual to individual through various routes. Here, the chain of transmission refers to the movement of nosocomial pathogens from health care workers to patients and vice versa through contaminated computer devices.

### 4.2.1 Computers as reservoirs for pathogens

Computers have become more prevalent in the hospital setting. What was initially a glorified typewriter in medical offices has evolved to include computer-based medical records available at bedsides, computerized reminders for preventive care of hospitalized patients, computerized physician decision making software in Intensive care unit (ICUs) or accessible from remote locations including via handheld devices. Hospital staff move from computer to patient and back as part of their daily routine creating the potential for hospital computer devices to act as reservoirs in nosocomial pathogenic transmission.

The introduction of computer devices into the patient care setting has brought reports of computer hardware as potential reservoirs for infectious agents with studies linking nosocomial infections with computer contamination. To find out whether computer keyboards may harbor nosocomial pathogens and act as potential reservoirs for nosocomial spread, various studies have been conducted in this area. A study reports that out of 48 computers in the theater that were swabbed, 4% were colonized with recognized bacterial pathogens and 96% of computers sampled harbored pathogens which in certain circumstances may have potential to cause nosocomial infection. Further studies revealed a 17.4% contamination rate of computer devices by MRSA, *acinetobacter*. The contamination rate of ward-based computers was 1.1% and 4.3% respectively. Another study reports that 95% of computer



keyboards were colonized by skin flora and 5% showed likely nosocomial pathogens such as MRSA and VRE.

Studies conducted in ICU indicated a more important role of computers there as reservoirs for pathogens than computers of non-ICU wards. Two previous studies have shown that computer interface surfaces in an ICU were contaminated with potentially nosocomial pathogenic microorganisms at a higher rate (6.3%) than the other surfaces. In the first study, a contamination rate was found to be 5.9% on keyboards and their mouse attachments that were significantly higher than other pieces of clinical equipment found within a surgical ICU. In the other study, the colonization rate for keyboards was 24% for all rooms and 26% for occupied rooms within the ICU. The environmental isolates and their prevalence were: MRSA, 49% *enterococcus*, 18% *enterobacter*, and other gram negative rods of which 21% subsequently caused nosocomial infection in 2 patients.

A study was conducted to define the extent of microbial contamination of ward-based computer equipments in a hospital and the potential for these computers to transmit microorganisms. The results indicated that, 40/85 keyboards, 36/80 mice and 15/44 mouse pads yielded multiple bacterial species. MRSA strains were obtained from a keyboard and a mouse.

#### 4.2.2 Hand contact as a mechanism of cross infection

Concerns have been raised over contact with contaminated computer keyboards serving as a mechanism for hand contamination of health care workers with potential pathogens, thereby leading to cross infection of bacteria to patients. Given the frequency with which user interfaces such as keyboards in various hospital units have been shown to serve as reservoirs for nosocomial pathogens and survives from days to months on clinical surfaces, it is likely that nosocomial pathogens can be transferred from hands of health care workers using contaminated computer keyboards and mice to non-infected patients. Such potential transmission is of particular concern within the ICUs of which health care workers caring for severely ill patients may not be able to maintain optimal hand hygiene.

Patients generally acquire nosocomial infection through hand contact, and it is possible that healthcare workers transmit nosocomial infections via hands after touching these computer devices that may be susceptible reservoirs of nosocomial pathogens. Hospital surfaces are often contaminated with nosocomial pathogens and may serve as vectors for cross contamination. When healthcare workers touch these contaminated computers, they can touch other surfaces close to the patients such as curtains, tables, beds without hand washing hence leading to cross infection. It is common for health care workers to frequently touch keyboards immediately after patient related procedures without first performing hand hygiene and then touch other keyboards without hand disinfection possibly passing bacteria

including MRSA to patients. Therefore, contaminated hands can also be the source of re-contaminating a surface.

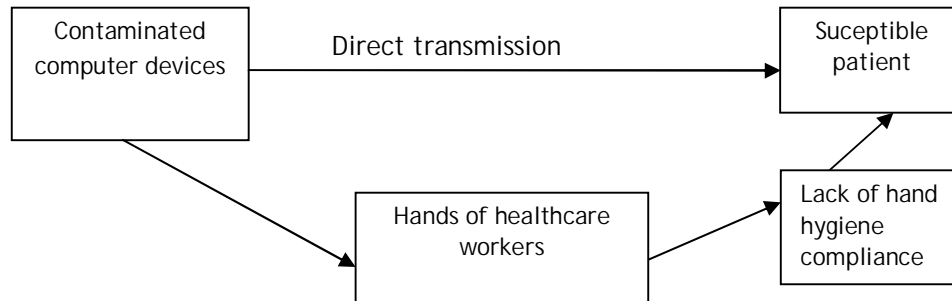


Figure 3. A flow chart illustrating transmission through hand contact

Contaminated computer devices when directly touched by susceptible patients results to direct transmission of nosocomial pathogens. Another transmission occurs when contaminated computer devices are touched by hands of health care workers and non-compliance to hand hygiene in turn touches the patient.

A single hand contact with a contaminated surface results in a variable degree of pathogen transfer. Previous studies have reported that hand transmission was 100% successful with *escherichia coli*, *salmonella spp.*, MRSA and *candida albicans* 90 %. Also, observation revealed that gloved health care staff moved back and forth between patients and keyboard while ungloved support staff that had no direct patient contact then touched the computer keyboards to enter and retrieve data before moving to another patient.

#### 4.3 Infection control methods

Nosocomial Infections continues to be a barrier to patient safety therefore; infection control is a significant component of safe, quality health care and is concerned with preventing the spread of nosocomial infections. According to medical dictionary, infection control refers to policies and procedures used to minimize the risk of spreading infections, especially in hospitals. The content of infection control methods is described through literature in the following topics: Hand hygiene, Computer cleaning & disinfection and Nurse's role.

##### 4.3.1 Hand hygiene compliance

Good hand hygiene has been considered to be the most significant measure that can be applied to prevent the spread of nosocomial infections. Continuous emphasis on this has lead to the general opinion that nosocomial infection rates can be enormously decreased by increased hand hygiene compliance. Several studies have frequently documented that health care workers do not adequately recognize importance of hand hygiene when it comes to moving between patients and computers. Therefore, adherence with recommended practices is unacceptably low. Average compliance with hand hygiene recommendations is usually

estimated as below 50%; it varies from ward to ward, amongst different health care workers and according to working conditions.

A study reported that as hand hygiene compliance increased, the number of high-risk events such as a nosocomial outbreak dramatically decreased. When hand hygiene compliance is very low, say 10%, high-risk events occur frequently with the results that transmission between patients is likely to occur. However, as the compliance of hand hygiene increases, so does the rate at which the occurrence of high-risk events rapidly decreases, until a point is reached beyond which further hand hygiene is unlikely to yield any greater benefit.

Reasons reported by healthcare workers as to why adherence to hand hygiene is unacceptably low were; skin irritation by hand hygiene agents, inaccessibility of hand hygiene supplies, interference with health care worker-patient relationship, patient needs perceived as a priority, wearing of gloves, forgetfulness, the lack of knowledge of guidelines, insufficient time for hand hygiene, high work load, understaffing and the lack of scientific information showing a definitive impact of improved hand hygiene on nosocomial infection rates. It was also reported that hand hygiene compliance was 48% and non-compliance was lowest among nurses compared with other health care workers and during weekends. It was higher in critical care units during procedures which carried a high risk of bacterial contamination and when intensity of patient care was high. Similarly, the lowest compliance rate (36%) was found in intensive care unit where indication for hand hygiene was typically more frequent. The highest compliance rate (59%) was observed in the pediatrics where the average activity index was lower than elsewhere.

Hand hygiene is required whether gloves have been used or changed. Failure to remove gloves between dirty and clean body sites and after patient's contact or care, on the same patient must be regarded as non-compliance with hand hygiene recommendations. Health care workers tend to be more compliant with hand hygiene after than before patient care. Hand disinfectant has also been found to be significantly more efficient than standard hand washing with soap and water or water alone, particularly when contamination is high. Alcohol based formula for hand disinfection is less irritable than any antiseptic or non-antiseptic detergent.

#### 4.3.2 Computer cleaning and disinfection

Cleaning can be defined as an act of removing dirt or impurities from a surface whereas disinfection is the process of killing pathogens while cleaning the surface. It has been reported that cleaning is yet to be regarded as an evidence-based science and consequently receives little attention from the scientific community. Since there haven't been reports of scientific standards to measure the effect of an individual cleaner or assess environmental cleanliness, finding evidence to benefit the control of infection has been held back. There has been plenty of evidence to support the role of cleaning in hospitals as a significant

intervention in the control of nosocomial infection. Unfortunately, it often forms part of an overall infection control package in response to an infection outbreak. Its importance, as a stand-alone activity remains controversial therefore, this does not encourage a continuous managerial support for cleaning services in the hospital, particularly if resources are limited.

Computers represent yet another item in the hospitals that needs to be considered as a possible source of nosocomial infection. Computer devices require continuous disinfecting and cleaning, especially in clinical areas exposed to splatter and fluid contamination because germs may enter the keyboard and remain trapped under the keys. Since standard keyboards and mice have open gaps, cracks and seams around the keys where fluid and dirt can collect and accumulate over time, they cannot be completely cleaned and disinfected with liquid cleaner or reached with a scrubbing tool. There has been no routine cleaning policy for computers in the majority of hospital and it is questionable whether such a policy exists, no evidence could be found of a specific cleaning regime for computers or their attachments in the medical literature. Manufacturer's recommendations seem limited to cleaning the keyboards with a 'damp cloth'.

As a result the lack of effective cleaning regime, some hospitals have installed plastic keyboard covers with daily cleaning policies, the need for hand washing after all environmental and patient contact has also been reinforced. Studies have suggested flat keyboard with an alarm as being easy to clean and related this to better cleaning compliance. Although the need to clean the computer interface surfaces as a routine practice is generally accepted and keyboards can be safely and successfully disinfected, no specific cleaning and disinfection frequency and procedure for computer accessories has been defined, domestic cleaning has been reported useful to control the spread of MRSA.

## 5 Discussion

This chapter describes the ethical awareness considered while carrying out the research and the credibility and reliability of the findings. It also includes an in depth discussion of findings, the strengths and limitations of the review and finally, the conclusion and recommendations of the research.

### 5.1 Ethical Considerations

Fry & Johnstone (2002) refer to ethics as a form of philosophic inquiry used to investigate morality and helps in resolution of moral dilemmas. Collecting data from people during research obviously leads to issues that can be resolved and challenged in ethical parameter.

This thesis is directed to Cleanside Oy that is part of active life village. Cleanside Oy is a Finnish Company that provides computer cleaning services. The company personnel provided

the thesis idea and sufficient information about what the study should entail. The consent for the researchers' participation was voluntary and no financial support was offered to carry out the thesis project.

This thesis was conducted through systematic literature review; no interviews, questionnaires or observations were applied as part of methodology. Therefore human subjects were not directly included in the data collection process and thus the need for privacy and confidentiality of their names and identities were not taken into consideration. The risk of harm was also not an issue to be taken into consideration. Ethical considerations were taken into account while collecting and analyzing data, articles used were accurately reported to avoid any bias. Direct quotations were accurately noted and accounted for by using correct referencing according to Laurea's thesis guidelines.

The results of the thesis are beneficial to all health care workers and patients in hospitals. It is also specifically beneficial to Cleanside Oy, which aims at improving hygiene by lowering the risk of transmission of diseases and promoting a clean working environment.

## 5.2 Trustworthiness

The aim of trustworthiness in a qualitative analysis is to support the argument that the research findings are "worth paying attention to" Lincoln & Guba, 1985, p.290. This literature review provided sound evidence based on the link between nosocomial infections to computer devices in the hospital, various ways of infection control, its impact in healthcare and the nurses' role. Since data used in this thesis was collected through a literature review, to the best of the authors' knowledge, the findings and associated discussion can be trusted because the primary data is assumed to be valid having been critiqued, reviewed and published in medical journals. The following section considers the strength and limitations, the lessons learnt during the literature review process together with the overall effect of the applied criteria.

### 5.2.1 Strengths of the review

The principles and the key concept used were adapted from the literature review. The rigorous monitoring and recording of all data selected and screened were essential to the process. Despite the time consumption and intense labour involved in the review methodology, it provided a sound framework for undertaking a comprehensive, unbiased and transparent assessment of available research. All sources and data used for this study were thoroughly screened online before being exported to link in the school library portal "Nelli". This proved to be a valuable part of the process since it saved the links to the search method process, the results of the number of hits, records and databases from which articles were retrieved. (See table 2)

The literature review method is designed to reduce any unintended bias, which may occur if other methods were used as literature review is systematic and each step of the research is noted and accounted for (Tranfield et. al 2003). Applying a clear defined search strategy for instance, using Mesh search string to identify correct keywords. This contributed to a continuous consistent search with the same understanding and allowed the capability of narrowing down the search results. Developing and applying the exclusion and inclusion criteria in this way ensured that the search results were objective and unbiased. The search strategy also ensured that studies selected and included in the review addressed the research task. Also, the process assisted with the identification of potential gaps in the existing study and areas for future reviews. Throughout the review, the author's have been part and parcel of the process by exercising professional judgments, and in discussion amongst each other and the supervisors as to what should be included, together with what is considered as factors linking nosocomial infection to computer devices in the hospital. The review methodology has been followed critically.

However, it is important to note that the literature review has successfully identified 12 studies on nosocomial infection linking it to computer devices, transmission and infection control techniques, which will hopefully be useful in the future, study of this field. Evidence gaps have also been identified, with the potential that existing knowledge could be extended in a way that deepens understanding and creates awareness as stated in the recommendations for further studies.

#### 5.2.2 Limitations of the review

Some limitations experienced during the review process were accuracy, technical difficulties, unobtainable full text articles, language barrier and time frame restrictions: As the review process made every effort to include all data potentially relevant to the research task, some studies may not have been identified due to poor key wording imposed by the editorial process in the databases. (The Boolean search method had to be applied).

Databases, of which technical difficulties were experienced, were not further searched, as it would have been time consuming. For instance several texts were identified in Sage, Linda and Medline database but chances to access meant that those identified texts could not be obtained for screening process. Despite all the attempts made to obtain all materials considered to be potentially relevant to the research question, some texts were not included because of changes in access to the database or lack of availability. For instance, not all of the data was available electronically and it was time consuming trying to obtain these texts, especially when working with a restricted time frame.

The literature review was limited to some extent as a result of the confined time frame, language barrier, a selected number of databases and websites were searched. All the

selected databases were extensively searched and just a few, if any, relevant reference would have been identified if search had continued.

### 5.3 Discussion of findings

This review focused on the link between contaminated computer devices to nosocomial infections and the various methods used to disinfect computers. Nowadays, computers are forming a major part of hospital equipment for the use of recording and retrieving data. Little attention has been paid to computer surfaces as having the potential to harbor nosocomial pathogens that could contribute to cross infection within the hospital; this literature review is therefore intended to create an awareness of these potential risks.

The findings support the concern that computer devices used in the hospitals may have the capacity to act as reservoirs of cross infection. The most common pathogens identified in patients, on hospital surfaces and with nosocomial infections is the MRSA (Bures et al 2000, 465-471). The MRSA contamination rate reported in the various studies conducted differed in the sense that some contamination rates were higher while others were relatively low. This difference might be related to differences in hospital size, hand hygiene compliance, extent of computer use and proximity to patient rooms. One study identified that out of 48 computers in the theatre, 4% were colonized with recognized pathogens while 96% were harbored pathogens. This indicated that all computers tested grew some kind of organisms, though only 4% were contaminated with recognized pathogens; the total level of contamination shows that computers used in the hospital environment have the capacity to act as reservoirs (Waghorn et al,2005) Two other studies have shown similar results supporting the view that computers used in hospital environment have the capacity to act as reservoirs (Hartman et al 2004,7-12 and Schultz et al 2003,302).

There are differences in the contamination level of ward-based computers within various hospitals; this could mean that computers may play different roles as reservoirs of nosocomial pathogens. Studies conducted in intensive care units have shown a more significant role of computers as potential reservoirs for nosocomial pathogens than those of non intensive care - units (Hartmann, Benson, Junger, Quincio, Rohrig & Fengler 2004, 7-12 & Bures et al, 2000. 465-471). This could be because computers in the ICU are in close proximity to the patients, the frequency of computer use is much higher compared to other wards and there is regular contact between the healthcare worker and the patient.

Nosocomial infections have been reported to have a financial impact in the healthcare system by increasing the total cost of healthcare services and length of stay. The longer the infected patient stays in the hospital, the more likely the infection is cross transmitted to other susceptible patients and also additional financial costs to treating the infection. It was reported that the length of stay in hospitals increased by 18.2 days per patient and additional

cost incurred was \$353 per day. A hospital in United Kingdom saved cost from £31,600 to £67,600 per annum and *MRSA* infection was also prevented in 5 to 9 patients by introducing an additional cleaner.

A single hand contact with contaminated surface results in a degree of pathogen transfer. Health care workers frequently touch keyboards after performing patient related procedures without compliance to hand hygiene and then touch other surfaces possibly passing bacteria including *MRSA* to patients. Although contamination of computers by nosocomial pathogens has been recognized, the transfer of these pathogens through contaminated computers has not been evident. We suppose that hand contact with the contaminated computers instigates the transmission.

Figure 4 is an illustration of the transmission chain by Kelly M Pyrek, 2002, it was modified from "breaking the chain of infection" article. It shows the links involved in the transmission chain. The transmission starts from nosocomial pathogen, which is the infectious agent. The pathogen dwells on the computers, gets it contaminated and makes it a reservoir for these pathogens. The pathogens depart from the computers via portal of exit. The portal of exit is the mechanism of touch i.e. when the healthcare worker has touched the contaminated computers in-turn contaminating his/her hands. Modes of transmission are the contacts made by the contaminated hands of the healthcare worker with patients, other health care workers and hospital surfaces. Through the portal of entry, the nosocomial pathogen enters the susceptible host. The portal of entry could be eyes, nose, and broken skin. The susceptible host refers to the immune-suppressed patients in the hospital environment.

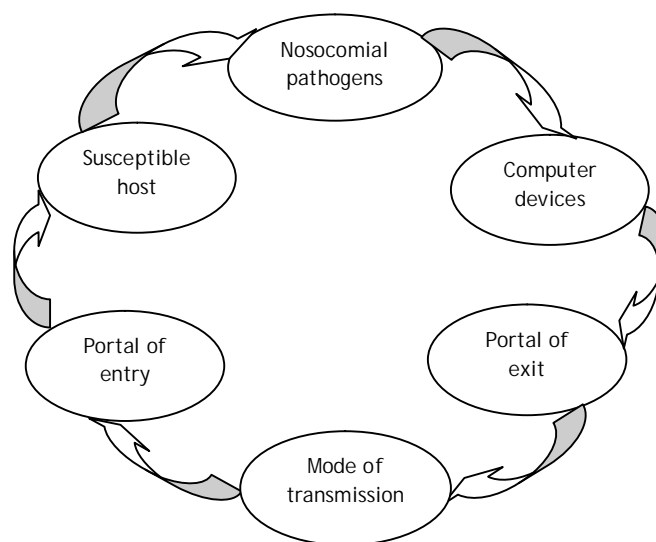


Figure 4 a flow chart illustrating chains of transmission

The transmission chain indicates that nosocomial infection is transmitted through the mechanism of touch (hand contact), therefore, contaminated computer devices are potential reservoirs for nosocomial pathogens but do not cross-transmit infection unless when there is



hand contact between health care workers and the contaminated computer device. As a result of high rate of hand contamination, hand hygiene compliance is highly recommended.

A report showed that hand hygiene compliance was 48% and non-compliance was lowest among nurses when compared with other health care workers and during the weekends. Compliance was low in intensive care unit, higher in critical care units and highest in pediatric unit, which the average activity index was lower than elsewhere (Pittet 2001,40-46.) This indicates that compliance varied by type of health care worker and within the different unit. Non-compliance to hand-hygiene with nurses was the lowest and this could be as a result of nurses being the main contact to the patient, emphasis has been placed for nurses to adhere to hand hygiene compliance that is part of aseptic measures. Targeted educational programs could be useful and provision of easy access to hand hygiene could help to improve hand hygiene compliance. In high demand situations such as in the critical care units and in high stress working conditions, availability of hand rub containing alcohol solution could be an alternative to possibly uphold and facilitate reasonable hand hygiene compliance.

Hand disinfectant is significantly more efficient than standard hand washing with soap and water or water alone. Alcohol hand rubs have excellent germicidal activity against *MRSA*, *Escherichia coli*, gram negative and gram-positive bacteria. Unfortunately, with bacteria spores such as *colistridium difficile* and *enteroviruses* that cause diarrheal illnesses, alcohol is not effective but appropriate hand washing with soap is effective (Boyce & Pittet 2002,3-10). Based on the above study, alcohol-based hand rubs are effective against a wide range of bacteria and compared with the traditional hand washing with soap and water, it may be superior because it acts quicker, irritates the hands less and requires less time. The use of alcohol hand rubs alone is insufficient with diarrheal causing bacteria, therefore to attain the maximum efficacy; it should be used together with compliance to hand washing.

One of the reasons reported as to why adherence to hand hygiene compliance is unacceptably low was that the regular use of soaps might be damaging on the skin. Alcohol based formula for hand disinfection is less irritable than any antiseptic or non-antiseptic detergent and that alcohols with the addition of appropriate emollients are as well tolerated and efficacious as soaps. It is important that health care workers are informed on the possible effects of these hand hygiene agents. Easy access to hand lotions should be made available to help protect the skin. Also lack of knowledge and education on this could be a key barrier in motivating health care workers to adhere to hand hygiene compliance. The results of a study conducted on ward computers in the hospital environment with improved hand hygiene compliance showed low rates of *MRSA* as 1.1%. (Po-liang Lu, Siu, Tun-chieh, Ling, Weng-gin, Yen-hsu, Sheng-fung & Tyen-pop 2009,164). We suppose that the relatively good hand hygiene amongst health care workers contributed to lower contamination rate because the other previous studies used did not provide hand hygiene compliance data. When the compliance of hand

hygiene increases, so does the rate at which high-risk event occurrence rapidly decreases until a point is reached whereby further hand hygiene is unlikely to yield greater benefits (Beggs, Shepherd & Kerr 2009,114). Although hand hygiene remains the basis for good infection control practice, achieving 100% compliance may not yield the expected benefits that such high level of compliance is intended to produce, therefore, not completely eliminate cross infection but minimizing the spread as well as the impact on healthcare and quality of life.

Cleaning and disinfecting the hospital environment has so far been the most fundamental method applied in infection control, however it is yet to be regarded as an evidence-based science and consequently receives little attention from the scientific community (Dancer 2004,10-15). We suppose that this could be due to the fact that most hospitals have their own cleaning protocols of which there are different variations to quantity or quality of the cleaning agent used, and there is also no proof to what can be achieved from using them. Therefore, there is no established model or specifications to cleaning. Although there is no evidence-based science to cleaning and disinfecting, cleaning of computers and its devices should not be overlooked.

Computer keyboards and mice require continuous disinfecting and cleaning, especially in clinical areas exposed to splatter and fluid contamination. We assume that these clinical areas are mostly subjected to infectious pathogens due to the splatter and fluid contamination; these could be collected in between open gaps of the keyboards and could remain trapped under the keys making it impossible to reach, in the effort to clean and disinfect the computer keyboard. Attempting to use liquid disinfectant may kill some surface germs but may also destroy the host keyboard. As a result of the inability to reach the open gaps of the computer keyboard when cleaning, some hospitals have installed plastic keyboard covers with daily cleaning policies. Flat keyboard with an alarm as have been suggested as easy to clean and associated with better cleaning compliance (Po-liang et al 2009,164). This could suggest that the alarm is activated whenever the computer requires cleaning. The plastic keyboard covers are designed in a way that the surface is flat, covering the open gaps in between the keys making cleaning possible and easier.

All healthcare workers must understand that computers represent yet another item within the hospital that should be considered as a possible source of nosocomial infection. Nurses have first hand contact with the patients; therefore, they have a major role to play in infection control. It is important to understand the infection process and prevention techniques. Nurses are responsible in assessment of nosocomial infection rate with the help of continuing scrutiny of all aspects of occurrence and spread of disease that are pertinent to effective control. It is questionable whether patients are routinely screened for infections when they are admitted to hospitals, they might be carrying MRSA but it is not known what proportion of

patients carrying MRSA will then go on to be infected. When nosocomial infection is suspected on a patient, it is the nurses' role to ensure that swabs are taken and sent to the laboratory for diagnosis. If the results are positive, isolation measures to limit the spread of the infection should be implemented, part of this measure would include putting patients into isolation wards; physically segregating infected patients in one part of the ward, using barrier precautions such as gowns, gloves, masks and hand hygiene before and after contact with patients as physical barrier to transmission. A recent systematic review of all studies assessing the effectiveness of isolation measures against MRSA found major methodological weaknesses in published research (Cooper BS et al 2004,329,533). It concluded that no study has been able to give evidence to the effectiveness of isolation measures alone for dealing with the spread of MRSA infection.

The responsibility for ensuring that hand-touched sites are thoroughly cleaned usually rests with the ward nurses, who are often busy and almost permanently understaffed in many hospitals. Two recent studies in ICU'S have demonstrated an increased risk of infection following periods of inadequate nurse staffing, or conversely, excess workload (Dancer, Coyne, Speeken, Brink, Sama, Vidam, Kennedy & Wallace 2006,10-17). Nurses provide advice and support related to the environment of care and management of outbreaks of diseases. This support and advice is provided through education and training initiatives, development of guidance and protocol, participation surveillance and monitoring, research and outbreak management and on-going advice to service providers. It is also their responsibility to maintain appropriate knowledge and skills on infection control and to participate in implementing appropriate guidance.

#### 5.4 Conclusion and Recommendation

This thesis amongst other studies firstly, agrees that computers act as reservoirs for nosocomial pathogens and as the transfer of these pathogens through contaminated computer devices has not been evident, we suppose that hand contact with the contaminated computer devices instigates the transmission. Secondly, it supports cleaning and disinfection recommendations of computers in the hospitals, regular cleaning guidelines should not only be implemented but also actively carried out as a daily domestic cleaning routine within the hospitals. Thirdly, it emphasizes the nurses' role in infection control which should be taken seriously and strongly implemented in order to reduce the risk of cross infection of nosocomial pathogens from potential surfaces to susceptible patients.

To recommend future studies, more research is required on the field of computer devices acting as reservoirs for nosocomial pathogens and the actual risk of cross infection through the computers. Infection control methods applied to clean and decontaminate computers should also be researched as well as the establishment of evidence based cleaning and disinfecting protocol within hospitals in Finland. Furthermore, we recommend that these studies should go beyond computer devices and also include other electronic devices commonly used in the hospitals that have the potential to act as reservoirs for nosocomial infections such as phones, pagers, personal digital assistant (PDA).

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## Appendices

## Appendix 1 Data analysis articles

Author and the year of publication	Publication of the articles	Purpose	Method of data gathering	Central findings	Significant findings to this thesis
Beggs, C.B, Shepherd. S.J & Kerr, G.K (2008)	BioMed Central	To evaluate the impact of imperfect hand cleansing on the transmission of MRSA infection and to identify, whether there is a limit, above which further hand hygiene compliance is unlikely to be of benefit.	Quantitative analysis	If transmission of MRSA is only via the hands of healthcare workers, then prevention is possible by adhering to hand hygiene compliance even if it's as low as 50% and that, the relationship between hand cleansing efficacy and frequency is not linear - as efficacy decreases, so the hand cleansing frequency increases disproportionately.	Confirmation of other researchers and gives suggestion concerning hand hygiene compliance.
Bures S, Fishbain J.T, Uyehara F.T Catherine Parker J.M & Berg, B.W (2000)	American Journal of Infection Control (AJIC)	To postulate computer keyboards and faucet handles as significant reservoirs of nosocomial pathogens in the intensive care unit.	Taking sterile swab samples from 10 Keyboards and 8 pairs of faucets handles in an ICU unit.	A total of 144 samples were obtained (80 keyboards and 64 faucet handles), yielding 33 isolates.	Colonization rate for keyboards and faucet handles, is greater than that of other well-studied ICU surfaces in rooms with patients positive for MRSA.
Chen, Y., Chou ,Y.& Chou P. (2005)	Infection Control and Hospital Epidemiology	The study evaluated the impact of nosocomial infections on cost of illness and length of stay in intensive care units.	A stratified analysis and regression approach.	Nosocomial infection increased the total cost of length of stays of patients in the hospitals by a significant amount in terms of U.S \$ per day.	Prevention of nosocomial infections should reduce direct costs and decrease the length of stays of patients in the hospitals
Dance. S.J (2009)	Journal of Infection control	To examine the links between hospital environment and various pathogens such as MRSA and clostridium difficile.	A Literature Review	Evidence of the presence and survival of the mentioned pathogens.	Prevention of nosocomial infections by supporting cleaning as a valid infection control intervention for patients.
Dancer S, White L, Lamb J, Girvan .K & Robertson C (2009)	Article from BioMed Central .	To evaluate the potential impact of one additional cleaner.	Observation and Literature review	Enhanced cleaning in wards made 32.5% reduction in levels of microbial contamination in hand touch sites. Enhanced cleaning saved the hospital 30,000 to 70,000 pounds.	Practicing enhanced hygienic cleaning in the hospital wards is a measure towards control of nosocomial (MRSA) infection.

Author and the year of publication	Publication of the articles	Purpose	Method of data gathering	Central findings	Significant findings to this thesis
Devine J, Cooke R.P.D, Wright E.P (2001)	Journal of Hospital Infection	To investigate the extent of methicillin-resistant staphylococcus aureas (MRSA) contamination of ward-based computer terminals and Hand washing compliance.	Quantitative statistical Analysis	Identification of MRSA contamination in 6 of the 25 wards examined. No policy for cleaning the keyboards, mouse or mouse mats due to electrical safety concerns.	Ward-based computers are a low risk items for cross-infection in hospitals. Emphasis on hand washing before contacting patients in order to reduce the risk of contamination.
Neely N.A, Weber J.M, Daviau P, MacGregor A, Miranda C, Nell M, Bush P (2005)	American Journal of Infection Control (AJIC)	Creating recommendations that would help hospitals to provide computer cleaning and disinfection guidelines where needed in a manner that was safe for patients, health care workers, and the equipment.	A literature Review	No infection control methods were in place prior to a study being done, whereas, after the study, various means of disinfection and/or hand hygiene procedures were generally instituted or more strongly enforced.	Recommendations for cleaning and disinfection of computer hardware consistent with CDC guidelines and with APIC providing general guidelines and principles for environmental infection control.
Piteet D. (2001)	Journal of Hospital Infection	To review barriers appropriate to hand hygiene and to describe the results of the first successful experience of sustained hand hygiene Promotion and its effectiveness on hospital-acquired infection.	An Epimological survey	This study confirmed modest levels of compliance with hand hygiene in a teaching institution and showed compliance varied by hospital ward and by type of Health Care Workers, thus suggesting that targeted educational programmes may be useful.	Hand washing Liaison Group was created in the UK with the mission 'to modify the behavior of Health Care Workers to produce sustained improvement in hand hygiene Guidelines to avoid cross-infection.
Po-Liang. L, Siu L.K, Tun-chieh C, Ling M, Wen-Gin C, Yen-Hsu C, Sheng-Fung L, Tyen-Po C. (2009)	Article from Biomed Central	To investigate Methicillin Resistant Staphylococcus Aureas (MRSA) & Acinetobacter baumannii on computer surfaces of hospital wards.	Quantitative data analysis.	Results revealed significant varying degrees of contamination rate of the computer devices tested.	Computers devices vary in degree of contamination. Good hand hygiene among hospital staff reduces rate of contamination without spread of nosocomial infection.



Author and the year of publication	Publication of the articles	Purpose	Method of data gathering	Central findings	Significant findings to this thesis
Rutala .W, White .M, Gergen .M, Weber. D, (2006)	Society for Healthcare Epidemiology of America	To determine the degree of microbial contamination, the efficacy of different disinfectants, and the cosmetics and functional effects of the disinfectants on the computer keyboards.	The effectiveness of 6 different disinfectants was assessed against 3 test organism inoculated into study computer keyboards. Computer keyboards were also assessed for functional and cosmetic damage after disinfectant use.	Potential pathogens cultured from more than 50% of the computers included nosocomial pathogens (Vancomycin-susceptible enterococcus species 12%) All disinfectant was effective at removing more than 95%of the test bacteria. There were no functional or cosmetic damage was observed after 300 disinfection cycles.	Computer keyboards can harbor pathogens and disinfecting keyboards do not cause damage to them instead it effectively decontaminates them from pathogens.
Schultz, Gill, Zubairi (2003)	Article from hospital infection and epidemiology	To evaluate the extent of contamination of computer keyboards in acute care, ambulatory care and long term care.	A sample test of 100 keyboards in 29 clinical areas.	Out of 100computers tested, 95% had growth of microorganism,5%were positive for pathogens associated with nosocomial transmission.	Computers in the hospital environment can be contaminated by pathogens that could cause nosocomial infection.
Waghorn ,D.J, Wan, W.Y, Greaves, C., Whittome, N., Bosley, H.C, Cantrill, S. (2005)	British Journal of Infection Control	To ascertain whether computer keyboards may harbor organisms and act as potential reservoirs for nosocomial infections.	Taking swab samples from keyboards of 48 computers situated in a variety of clinical areas.	4% of the keyboards were colonized by bacterial pathogens while 96% harbored organisms, which in certain clinical circumstances may have potential to cause nosocomial infections.	All computer keyboards tested grew some kind of organisms of which may act as reservoirs of cross infection. Regular procedures should be in place for maintenance and cleaning of all equipments in the clinical areas.