The residual effectiveness of chlorhexidine gluconate 0.5% on vaccinating nurses hands during school vaccination programmes: A pilot study

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Abstract

In the well-health community setting of school based student mass vaccination programmes (MVPs) the risks of cross-infection are not clear, as hand cleansing is not always practised between each injection administered by public health nurses (PHNs). This study provides evidence of the microbial colony forming units (CFUs) gathered from Auckland District Health Board's PHNs hand flora (finger-tip press on agar plates) during MVPs. The purpose of the study was to describe the antimicrobial residual efficacy over time of chlorhexidine gluconate 0.5%, a component of the alcohol-based hand gel (Sterigel+) used as a hand hygiene product at MVPs by PHNs. A non-experimental survey (pilot) design gathered vaccinators' palmar finger-tip skin flora prior to hand cleansing. Sampling was conducted over an eight week period at 17 schools settings from participating vaccinators at each programme. Hand flora were collected on 77 occasions (N = 154 agar plate samples), from dominant and non-dominant hands and the CFUs reported by LabPlus.

No indications were found of a threshold to signify that chlorhexidine gluconate 0.5% was active up until a specific time and CFUs increased over the whole timeframe (5-90 minutes). A weak but significant correlation was found between the total CFUs and timeframe (r = 0.272, p = 0.001). Sixteen flora types were grown and formed into four microbial categories: skin flora (85% of all CFUs), Gram-negative flora (7%), environmental organisms (6%) and oral flora (2%). Potentially pathogenic flora were grown (*Staphylococcus aureus* occurring on 5% of samples and Gram-negative bacteria 17.5%). However, relatively few samples of highly pathogenic micro-organisms were culture positive and low CFU counts were identified. It was considered that, for healthy individuals, the cross infection risks presented were minimal. The vaccinators reasons to cleanse hands was strongly significant (p = 0.018) with non-convenience CFUs being on average 88% higher than convenience CFUs at any particular time point. Hand dominance was shown not to be significant. The results of this study indicate that Sterigel+ does not provide ongoing antimicrobial protection beyond the quantified effects of an alcohol-based hand gel. Therefore, PHNs need to take this information into account when considering hand hygiene practice decisions related to cross infection risks during MVPs.

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Chapter One: Introduction and Overview of the Study

1.1 Introduction

The study was conducted at school mass vaccination programmes (MVPs) within Auckland District Health Board's (ADHB's) catchment area. This chapter provides background information for the thesis by offering a historical perspective of ADHB's student MVPs. An outline of the key points from the New Zealand Ministry of Health's (MOH's) guideline for appropriate vaccination processes will be given (MOH, 2006) in relation to ADHB's public health nurse (PHN) vaccinator practices. The principal issues identified by PHNs during the development of a hand hygiene protocol for MVPs are documented. The rationale for the study, the research question and study aims are presented along with an overview of each of the five thesis chapters. Finally a summary of this introductory chapter is provided.

1.2 Background to the study

Somewhere in a New Zealand school this year a student will be vaccinated by a public health nurse. School based vaccination programmes may be part of the national childhood immunisation schedule or possibly organised in response to a MOH directive during a public health initiative such as the 2004-2005 Meningococcal B programme (see Appendix A). As authorised independent vaccinators PHNs are expected to follow the recommended New Zealand standards (MOH, 2006). The standards refer to vaccinators using aseptic techniques in the preparation and administration of vaccines along with knowing and observing standard safety guidelines, in order to minimise the risk of spread of infection (MOH, 2006). However, no recommendations or advice as to the frequency or type of hand cleansing regimes to be observed, at any vaccination occasion, are detailed in this handbook. Consequently, hand hygiene practices which are appropriate and feasible in community settings such as a school environment are not defined. This means that New Zealand PHNs do not have a specific evidence based guideline for best hand hygiene practice during MVPs.

School based vaccination programmes are organised and executed differently within each District Health Board area. Duffy (2002) conducted a mail survey of New Zealand District Health Boards PHNs hand cleansing practices at MVPs. Duffy found that hand hygiene protocols, products selection, and timeframes for product applications were not consistent between District Health Boards. The choice of cleansing methods was often left to the practitioner's discretion. Furthermore, via the survey comments section nurses requested information about suitable hand hygiene regimes for school MVPs (see Appendix B). Perhaps this request for appropriate cleansing methods was because school vaccination programmes differed markedly from vaccination processes that are followed within a doctor's surgery or a hospital setting. For instance, student MVPs performed in the school hall. So, to provide insight into ADHB's methods of organising MVPs an outline follows. The overview covers the relevant aspects (to this study) of PHN hand hygiene processes, vaccination practice and health status assessments for eligible students in a school setting.

1.3 Outline of school vaccination programmes

1.31 Health screening

Students are screened on several junctures to ensure the MOH's criteria for receiving vaccinations are met (MOH, 2006). Firstly, as part of the consenting process, parents complete a written health survey. This information is reviewed and health issues are assessed by a designated PHN (attached to the school) who determines if the student has met the MOH's guidelines for inclusion in the school programme. Secondly, prior to immunisation the assigned vaccinator completes another health screen face to face with each consenting student to confirm immunisation eligibility or to withdraw the student from the MVP. For these reasons pupils who qualify for vaccination are considered to be in good health, and the clinical venue is regarded as being within a healthy community setting.

1.32 Venues and programme routines

Mass vaccination programmes are normally held in school halls, libraries or classrooms. A team of up to 18 nurses are rostered for each MVP and each nurse is allocated to specific

areas of responsibility. Furniture from within the school setting is utilised and other equipment is collated and then conveyed to each setting by the PHNs. The clinical working area for the programme is set up by the entire team, often using trestle tables as vaccinators' stations. Vaccines are transported and stored in chilly bins which each have a digital temperature display unit attached to them. A nurse is assigned to monitor and maintain the cold chain temperatures within the optimal vaccine storage range of 2-8°C (MOH, 2006). Prior to the programme beginning approximately 20 vaccines (per vaccinator) are collated by the PHN team, and placed in trays for distribution to each vaccination station. During the MVP other designated nurses continue to draw-up vaccines (to meet the numbers required on an ongoing basis).

A healthcare worker (known as a *floater*) ushers each student to a vaccinator station and this floater is available to support any student (usually by holding their hand) whilst the injection process occurs (see Appendix A). Programme schedules are planned on the basis of each vaccinator completing 20-25 immunisations per hour. Nurses assigned to the post-immunisation recovery venue are responsible for overseeing students during the time period following vaccination (20 minutes minimum). Prior to a student leaving the recovery setting (to resume school activities) a nurse will visually review each injection site (MOH, 2006). Through these processes students are either confirmed as well, or identified as requiring further medical attention.

1.33 Hand hygiene

Before the commencement of the annual MVPs, an information session on hand hygiene methods is presented to PHNs by an infection control nurse or a medically accredited representative from the commercial company supplying the current hand cleansing agent. The update includes a practical demonstration of the recommended application regime for alcohol-based hand rubs followed by an update of product information. The next paragraph provides an outline of the MVP guideline's hand hygiene protocol which PHNs are expected to adhere to (see Appendix C).

On arrival at the venue PHNs cleanse their hands by either water based handwashing, or by

an antiseptic handrub with an alcohol-based hand gel. Nurses are required to cleanse their hands pre and post vaccine assembly, and the alcohol-based hand gel is reapplied prior to commencing vaccination. At the completion of the MVP either method of hand hygiene is repeated by all team members. However, PHN's may use their own discretion and decontaminate their hands at other times, as they consider necessary. Consequently, vaccinators' hands are not cleansed between each student's immunisation unless an occasion arises that each PHN individually determines necessitates decontamination. For example, if hands are coughed over then hand cleansing would be indicated (potential cross-infection risk). Vaccinators seldom have hand to hand contact with students, with direct contact limited to rolling up student's shirt sleeve to enable the vaccine to be injected correctly, for example into the deltoid muscle or subcutaneous tissue (see Appendix A). In fact, vaccinators frequently only have contact via their finger-tips during vaccine administration (syringe: dominant hand and student: non-dominant hand). Thus, it is only the injecting needle that is in contact with the vaccination site. If post-vaccination site bleeding occurs a cotton wool ball is directly applied to the area. The student will dispose of this item in a designated receptacle before leaving the recovery area.

1.4 Justification for the study

1.41 Background to the public health nurse hand hygiene guideline

School based vaccination programmes are frequently held in venues where access to handwashing facilities maybe difficult and the facilities themselves may be suboptimal for the MVP requirements. The timeframe available to PHN's for hand hygiene, in the context of a high work-load, is limited. The Immunisation Handbook's recommendation for using "...aseptic techniques in the preparation and administration of all vaccines..." (MOH, 2006, p. 403), have guided vaccinators' hand hygiene routines around the preparation of vaccines. However, both a PHN team leader and senior nurse commented from their MVP experience that PHNs have not performed hand hygiene routinely between vaccinating each student. Anecdotally no cross-infection issues have been identified by nurses or notified to ADHB from schools or parents following MVPs, even when water based handwashing was

the only method employed. Hence, it is not standard practise for vaccinators to cleanse hands between each student contact at MVPs because PHNs consider the risk of cross-infection to be low.

Prior to the introduction of a MVP hand hygiene guideline no formalised hand decontamination protocol had been adopted by PHNs for immunisation programmes. The routines and customs for managing student vaccinations and associated hand cleansing practices at MVPs were passed on orally within the nursing team. Benner (1984) maintains this handing down of knowledge from practice is embedded in nursing tradition. Regardless of these traditions, in 2001 PHNs voiced desires for an evidenced based cleansing strategy for MVPs that could be relied on to reduce the potential risk of cross-infection, to both student and vaccinator. In fact, the scope of practice for registered nurses requires the use professional nursing knowledge to provide skilled care, based on substantial scientific and well informed nursing judgement (Nursing Council of New Zealand, 2004).

1.42 Background of the choice of hand hygiene regimes

The potential for infection and cross-infection is an ever present concern in clinical healthcare. Evidence on how to reduce infection risk in hospitals is well documented for healthcare workers and for patients. Yet, in well-health non-acute community settings the risks are not clear. Besides there is a marked difference between community studies conducted for instance in long term residential situations, day care facilities or households compared to, community settings where nurses implement planned well-health initiatives.

Devising a suitable guideline for hand hygiene during MVPs (in the context of a busy vaccinating programme) was challenging for PHNs. Hospital infection control nurses were consulted and expertise sought from doctors within the University of Auckland's Medical School. Infection control nurses rely on the ADHB infection control manual which advocates hand cleansing between patients (ADHB, 2006). Remarks provided by two senior research doctors from the Auckland Medical School (with published hand hygiene studies) provided a different perspective. The risks of cross-infection at student vaccination programmes were considered minimal and more akin to a social handshake. This is because

students are regarded as well, only having brief contact with one vaccinator and slight direct skin-to-skin contact (see Appendix A). Thus, the hospital sourced recommendations (designed to prevent nosocomial infections) were regarded as neither transferable nor appropriate for the well-health community settings of school MVPs.

Nix (2000) recommends that the ideal hand hygiene regime should incorporate the latest scientific evidence and be based on intended users, the clinical aims and an understanding of ingredients. The idea that standard hospital hand hygiene recommendations apply in a situation more akin to social interactions caused much debate amongst PHNs during the creation of a suitable hand hygiene protocol for school MVPs. Regard was given to evidence gathered from the literature, university and hospital meetings and traditional ways of managing hand hygiene within the constraints of a school setting. Eventually a combination of practical and infection risk reducing solutions were agreed on. Subsequently, a draft MVP hand hygiene guideline (ADHB, 2002) was created to meet the PHNs aims of eliminating transient organisms and to reduce the level of contaminants acquired between hand hygiene episodes. The guideline employs standard handwashing (non-medicated liquid soap, water and paper drying method) and an alcohol-based hand gel 'Sterigel+'. Sterigel+ incorporates the antiseptic chlorhexidine gluconate (see Appendix D) for residual efficacy. It is the sustained broad spectrum anti-microbial activity of the chlorhexidine gluconate component that the hand hygiene guideline relies on to prevent the growth of bacteria thereby, providing ongoing protection against pathogenic colonisation and reducing the number of organisms acquired between hand cleansings.

During the literature search no reports of chlorhexidine gluconate's persistent or residual antimicrobial effects on hand flora within a community well-health clinical setting were located. Thus, safe nursing hand hygiene practice at MVPs could not be assumed. Denscombe (1998) advises potential researchers to consider what is already known about the research topic, the events to be studied, the range of people encompassed and what is likely to provide the best information. Therefore, after deliberation the most useful research vehicle was considered to be a descriptive survey to pilot tools and data collection methods, to provide PHNs with scientific evidence of chlorhexidine gluconate's antimicrobial action

from the community setting of a MVP.

1.5 Purpose of the study

This study proposes to provide descriptive evidence from microbial data gathered from ADHB vaccinators hand flora following an application of hand hygiene product, Sterigel+ during the 2006 student MVPs.

Research question:

- what is the residual effectiveness of chlorhexidine gluconate 0.5% on vaccinators hand flora?

Research aims:

- to provide evidence on the efficacy of chlorhexidine gluconate 0.5% in a community healthcare setting over time.
- to quantify the numbers of microbial colony forming units (CFUs) found in a community healthcare setting as pilot information for future studies.
- to provide information on factors that may affect bacterial counts in a community healthcare setting, such as the time elapsed since cleansing hands.

This descriptive survey records the effect of Sterigel+ on ADHB's PHN vaccinators' hand flora at MVPs over time. The microbial flora gathered to represent hand flora was from the palmar surfaces of the vaccinating nurses' distal phalanges (i.e., finger-tip press onto agar plates). The results were reported to the researcher as raw data (by microbial flora types and CFU counts), from ADHB's laboratory provider (LabPlus). The vaccinators' reasons for hand cleansing, incidence of hand hygiene were collated separately by the researcher. Then, the information obtained classified and statistically examined, with the results presented through descriptive statistics. The potential benefits of the study include a greater scientific understanding of the process of skin decontamination and the information gained may be incorporated into evidence based hand hygiene practice. Additionally, this study may fill a gap identified in the literature, by providing new evidence in this specific setting on hand flora and chlorhexidine gluconate's action. Hence, the study will provide a scientific basis

for risk management strategies that aim to curb the occurrence of undesirable bacteria on vaccinators' hands and thereby reducing the risks of cross-infection.

1.6 Structure of the thesis

The thesis is divided into five chapters: introduction, literature review, study design and methods, results and lastly discussion of findings and a recommendation.

Chapter One: Introduction

The introduction affords an overview of PHNs traditions, responsibilities and hand hygiene practices during New Zealand student school based MVPs. This chapter also presents the study's justification, purpose, aims and the research question formulated to provide descriptive evidence via a non-experimental survey.

Chapter Two: Literature Review

The literature review describes the processes taken to identify literature relevant to the risk of cross-infection, in the context of a MVP. This chapter provides and critiques a comprehensive range of literature related to the concept of microbial cross-infection, skin pathophysiology, skin infection, hand hygiene practices, hand cleansing products, the effects of hand hygiene practices (skin damage and skin moisture loss) and compliance to hand hygiene protocols.

Chapter Three: Research Design and Methods

The study design and methods chapter presents the theoretical framework and methodology and details the methods used to answer the research question. Included are ethical considerations and the study's approval pathways. Public health nurse participant recruitment, school contact approaches and the associated processes for consenting and consent withdrawal are detailed. The number of school settings where data gathering was performed and PHNs participation in the study are illustrated.

Chapter Four: Results

Summaries from the data gathered are provided through descriptive statistics tables and figures. These particularise the microbial hand flora reported on by LabPlus, and comment on the pathogenicity of organisms reported. The microbial CFU counts over time are presented. The results also include the vaccinators' reasons for choosing to decontaminate hands, the associated timeframes for hand hygiene and data related to hand dominance.

Chapter Five: Discussion and Conclusions

In this final chapter a discussion of the findings is presented and related to the research question and the aims of the study. The limitations and problems of the research process are acknowledged. Implications for nursing practice, education and research related to the study are commented on. A summary of the thesis is presented, then a concluding statement made, and lastly a recommendation for future research directions is offered.

1.7 Summary

In New Zealand PHNs are required to offer immunisation to students through MVPs. These programmes are executed within school venues where access to suitable water hand hygiene facilities maybe difficult and vaccinators' workload index is high. It is not standard practise for vaccinators to cleanse hands between each student contact because in this healthcare setting PHNs consider the risk of cross-infection to be low. The alcohol-based and chlorhexidine gluconate hand gel (Sterigel+) is relied on to provide both immediate and residual antimicrobial efficacy. However, this type of product has not been reported in the literature from a community well-health setting and therefore, information on the hand gel's effectiveness is limited.

The study's findings will describe CFUs found on vaccinators hand flora during 2006 ADHB school vaccination programmes and may reveal whether the current PHN hand hygiene guideline is adequate to reduce the risk of pathogenic infections for both vaccinators and students. Alternatively, the evidence presented may alert PHNs of the need to revise hand cleansing practices at MVP. So, whatever the data reveals will provide new

information which may be reflected in the PHN hand hygiene guideline for MVPs. Thus, justification for this study has been shown and the purpose, research question and aims clearly stated. The following chapter overviews and critiques literature related to hand hygiene, skin pathophysiology and cross-infection.

Chapter Two: Literature Review

2.1 Introduction

Chapter one has offered an overview of MVPs and the practices PHNs employ to perform school based vaccination initiatives. This chapter presents the published research literature relevant to student vaccination programmes. The literature was accessed through computerised searches of Medline, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Ovid, Web of Science and Google Scholar data-bases and articles published in English, between January 1990 and January 2008 were selected. Additional papers were obtained by searching reference lists within the retrieved papers. Academic texts were sought through Massey University and Auckland University's library catalogues, and further information related to vaccination processes was directly sourced from health organisations. The search focused on hand hygiene used in MVPs, plus current literature and topic reviews to 2008 pertinent to hand hygiene in a nursing environment. Where authors have based their findings on earlier research, the seminal articles have been accessed to provide original study references where possible. Keys search terms included 'compliance', 'injection practice', 'community', 'skin', 'infection', 'infection control', 'disinfection', 'disinfectants', 'antiseptics', 'chlorhexidine', 'chlorhexidine gluconate', 'persistence', 'residual', 'hygienic', 'hand cleansing', 'hand hygiene', 'handwashing', 'alcohol-based hand gels', 'alcohol-based hand rubs', 'alcoholic gels', 'immunisation', 'mass immunisation', 'vaccination', 'mass vaccination', 'protocols' and 'guidelines'.

The review provides information on hand hygiene from the perspective of reducing the risk of cross-infection at MVPs. The majority of studies located focused on nosocomial hand hygiene infection risk reduction and a minority of research addressed cross-infection risks in a community healthcare setting. No published literature was located on hand hygiene at MVPs or the use of an alcohol-based hand gel that incorporates an antiseptic (for residual efficacy) in a well-health clinical setting. As a consequence the researcher made direct contact with the manufacturer of Sterigel+ products who confirmed that no studies have been completed by SoluMed on the efficacy of Sterigel+ over time (S. Chartier, personal

communication, January 19, 2006). This review therefore encompasses hospital and laboratory studies, scientific texts and reports to gain an understanding and evidence relevant to vaccinator's hand hygiene at community based MVPs. An explanation supporting hand hygiene practice follows, along with an overview of skin pathophysiology and specific hand hygiene methods such as a standard handwash, alcohol-based hand gels and the use of gloves. Literature related to skin flora and the antiseptic chlorhexidine is examined and also the effects of hand hygiene practices and compliance with hand cleansing protocols are considered. These topics are covered to provide key background information from which the PHN hand hygiene guideline for MVPs was based and are relevant as the evidence found illuminates the hand hygiene dilemma for nurses in this setting. In this thesis the symbol *"N"* refers to the total number in the sample whereas the symbol *"n"* denotes the number in a subsample (American Psychological Association, 2001, p.142)

2.2 Hand hygiene rationale

2.21 Historical perspective

The term hygiene is derived from the Greek goddess of healing 'Hygeia' (Jumaa, 2005). Hygiene refers to cleanliness and encompasses the notion of reducing infectious organisms (Larson, 1999). Early medical writers such as Hippocrates (circa 460-370 BC) acknowledged the influence of infection in accounts of communicable diseases (Shulman, 2004). Block (2001) maintains that throughout history remaining healthy by reducing the risk to possible infection is recognised as being important. For example, during the plagues that swept through Europe during the Middle Ages, doctors sought to shield themselves from contagious agents by wearing protective attire (see Appendix E) (Block). But it was not until the 17th century that microbial organisms were first described. This was by the Dutch scientist Antoni van Leeuwenhoek in letters to the Royal Society of London (Postgate, 1999). The microbial concept of reducing infection risk was acknowledged during the 19th century when obstetrician, Ignas Semmelweis recognised the value of hand hygiene (Lowbury, Lilly, & Bull, 1964) in the prevention of puerperal fever (Gould, 2000;

Pittet & Boyce, 2001). Semmelweis's intervention of using chlorinated lime after hand cleansing (as a disinfectant) in 1847, represents the first evidence of reducing cross-infection between patients (Bjerke, 2004; Gould, 1996; Pittet & Boyce, 2001). Even so, until the 20th century wound infections were almost inevitable, and death by overwhelming sepsis was not uncommon (Miller, Rahimi, Scott, & Lee, 2005).

2.22 Overview of hand hygiene

Since Semmelweis many studies have shown that diseases are carried on the hands of healthcare workers (Girard, Amazian, & Fabry, 2001; Naikiba & Hayward, 2001; Paulson, Fendler, Dolan, & Williams, 1999). But, it is not possible to totally eliminate bacteria from hands by sterilisation products or processes (McGinley, Larson, & Leyden, 1988). Pittet, Dharan, Touveneau, Sauvan, and Perneger (1999a) maintain bacterial contamination of healthcare workers hands is a dynamic process, which results from many causes. Pittet et al. gathered microbiologic evidence of acquired contamination on hospital workers hands during routine patient care through 417 structured observations. Their study was the only research located that reports on timeframes related to bacterial contamination on healthcare workers hands in a clinical setting. Furthermore, Pittet et al. assert that no hand hygiene guidelines are based on the actual evidence of microbial flora gained during different types of patient care.

Larson (1988) declares that over the past century handwashing has been the cornerstone of infection risk reduction efforts. Gould (2005) emphasises that infection control risk reduction practices are the responsibility of every nurse and essential for safe clinical practice. King (1998) acknowledges that a patient has a right to be protected from preventable diseases in a clean and safe environment. From a review of hand hygiene literature (1980-2001) Aiello and Larson (2002) examined 53 studies and found a significant association between hand cleansing and the relative risk of illness (generally >20%) for situations where reduced hygiene practices were described. Jefferson et al. (2007) agree that the evidence to shows that personal and environmental hygiene reduces the spread of infection. This view is also supported by Guinan, McGuckin, and Ali's (2002) and Patrick, Findon and Miller (1997) research that documented microbial translocation

during contact with objects in the environment. Cross-transmission of micro-organisms may occur from healthcare workers hands to other patients, without the healthcare workers hands appearing soiled (Mackintosh & Hoffman, 1984). So, neither the healthcare workers nor patients may be aware of the cross-contamination process.

Several authors comment that hand hygiene measures have been universally accepted as a primary tool to reduce the risk of cross-infection (Barker, Stevens, & Bloomfield, 2001; Girou, Loyeau, Legrand, Oppein, & Brun-Buisson, 2002; Gould, 2000, Larson, Early, Cloonan, Sugrue, & Parides, 2000a; Pittet, 2001). Perhaps this view is overstated. Because in an endeavour to reduce healthcare associated infections, the World Health Organisation's (WHO) global patient safety challenge of 2005/2006 advocated raising the awareness of hand hygiene best practice and including hand hygiene as an integral part of clinical governance and risk management (WHO, 2005).

Nevertheless, much of the literature on hand hygiene examines the links between handwashing and transmission of infection (Cochrane, 2003). Hand hygiene is recommended between patients and during patient care if hands are visibly dirty or contaminated with body fluids (Boyce & Pittet, 2002; Department of Health and Aging, 2007; Trampuz & Widmer, 2004; WHO, 2004). The main cause of nosocomial (hospital acquired) infections is considered to be microbial cross-contamination via healthcare workers hands (Naikiba & Hayward, 2001; Pittet & Boyce, 2001). Numerous hospital studies confirm that pathogens are usually bacteria and the degree of hand contamination is associated with the duration of the nursing care episode and the amount of close contact with excreta, exudates, or patient's body fluids (Girard et al., 2001; Larson et al., 2000b; Naikiba & Hayward, 2001; Page, 2001; Paulson et al., 1999). Moreover, Sprunt, Redman, and Leidy, (1973) contend that healthcare workers hands may become permanently colonised by pathogenic flora from any clinical setting.

Microbial contamination can be linked to different activities or situations. Pittet et al. (1999a) reported on 372 agar plates samples gathered from hospital staff hands over time, and found that on average bacterial contamination progressively increased during the length

of time patient care was provided. Healthcare workers gained 16 colony forming units (CFUs) per minute of patient contact, with the peak rates acquired recorded from rehabilitation wards (following respiratory tract care) and with the handling of body fluids. Thus, higher CFU counts on healthcare workers hands may be related to a clinical setting. However, the types of microbial colonising organisms found on hands may also be allied to the patients underlying disease with higher organisms counts reported from specific settings. For example, higher numbers of yeasts in oncology units, and higher counts of *Staphylococci aureus* recovered in dermatology wards (Ayliffe, Babb, Davies, & Lilly, 1988; Horn, Larson, McGinley & Leyden, 1988). Yet another cause of higher microbial hand counts is linked to nurses who wear jewellery or artificial nails (Larson, 1995; Page, 2001; Trick et al., 2003). Possibly this is because the subungual space of the hand is a significant bacterial niche and is difficult to de-germ (McGinley et al., 1988). This view is also supported by McNeil, Foster, Hedderwick & Kauffman (2001) who report that significantly more artificial nail wearers had pathogens remaining after hand cleansing than nurses with native nails. Furthermore, McNeil et al. suggest the subungual areas of the hand may act as a reservoir of pathogenic organisms.

Hospitals are distinctive environments because of the movements of caregivers and visitors, the number of patients and assemblage of infectious patients. All these factors increase the likelihood of exposure to pathogens (Madigan, Martinko, & Parker, 1997). Nonetheless, the human skin has adapted to protect healthy individuals from pathogenic assault (Noble, 1993). Murray, Rosenthal, and Pfaller (2005) consider that a variety of factors such as age, diet, hormonal state, health and personal hygiene influence the microbial flora found on, and in, the human body. Several authors contend that the vulnerability of contracting an infection is significantly linked to the immune status of the individual at the time (Barker et al., 2001; Paulson et al., 1999). Consequently, patients in poor health are more susceptible because of their diminished wellbeing. Age may also influence the immune response, with infants and elderly persons more susceptible to potential pathogens (Byrd & Powledge, 2006). Hospital hand hygiene guidelines are, therefore, developed to cover quite different circumstances than those found in the well-health setting of school MVPs. Hence, utilising hand hygiene protocols designed to lessen nosocomial infections are contestable in a

student MVP setting because "...micro-organisms that colonise the hand surfaces pose little threat of infectious disease transmission from healthcare personnel to patients who are not immuno-compromised" (Paulson et al., 1999, p. 332).

Bacteria are not the only pathogens that may cause ill-health. Barker et al. (2001) examined the dispersal, persistence and control of viruses in home and community settings in 130 studies (1967-2000). They found growing evidence that person-to-person transmission via hands and fomites was instrumental in the spread of viral pathogens. So, cross-infection is not limited to hospital settings, nor is it only due only bacterial microbes (Barker et al., 2001; Guinan et al., 2002; Gould, 2000; Patrick et al., 1997). Interestingly, most hand hygiene protocols are from healthcare institutions in developed countries (Jumaa, 2005). But, within these countries few studies have reported on healthcare worker's hand hygiene practices in community settings (Gould et al., 2000; Larson, 1995).

Hand hygiene practices such as soap and water washing or the use of alcohol-based hand gels, are recommended as ways to reduce the risk of cross-infection (Gibson, Rose, Hass, Gerba & Rusin, 2002; Gustafson et al., 2000; Hugonnet & Pittet, 2000). Antimicrobial products such as antiseptics, or alcohol-based hand gels are bacterostatic (inhibiting) or bactericidal (deadly) to micro-organisms on skin surfaces (Bjerke, 2004; Gould, 2004a; Murray, Rosenthal, Kobayashi, & Pfaller, 2002). Although, inadequate removal of micro-organisms can occur if healthcare workers fail to adequately cleanse hands due to poor cleansing technique (Larson, 1995). Lowbury et al. (1964) suggest that the residual actions of antiseptics such as, chlorhexidine are useful because of their dual action of preventing immediate, and subsequent, contamination of hands. Widmer (2000) suggests that the residual attribute of an antiseptic may be reflected in the delayed the regrowth of bacteria. Nevertheless, bacterial counts vary from person to person (Evans, Smith, Johnston, and Giblett, 1950; Pelczar, Chan, & Krieg, 1993; Tannock, 1995). Consequently, no scientific studies have established the extent to which CFU counts on healthcare worker's hands need to be reduced to minimise transmission of pathogens (Boyce & Pittet, 2002; Jumaa, 2005).

2.3 Skin pathophysiology

Skin provides a tough yet pliable covering as the boundary between the outer environment and inner tissues, and is the largest organ system of the body (Hall, 2000; Priestly, 1993; Wycoski, 1999). It has many protective roles and functions (Lappe, 1996). Skin is an organ that contains sensory receptors, it is involved in immunologic surveillance, it functions as a permeable barrier to the environment, decreases water loss and has a role in temperature regulation (Boyce & Pittet, 2002; Kownatzki, 2003; Noble, 1993). Epidermal appendages include eccrine glands which produce sweat, apocrine glands that produce scent, pilosebaceous structures which contain hair and sebaceous glands producing oil, and nails.

Skin is composed of two layers, the outer layer (epidermis) and inner layer (dermis). Beneath the dermis is a subcutaneous layer consisting of adipocytes (fat cells) separated by blood vessels and fibrous walls of collagen (McCance & Huether, 2006). The palmar surface of the hand has more cell layers than in most other parts of the body; yet the surface remains permeable to water (Larson, 2001). The thickness of skin does change with aging, gradually increasing in thickness from birth to adulthood (Seidenari, Giusti, Bertoni, Magnoni, & Pellacani, 2000).

2.31 Epidermis

The epidermis is 50-100 micrometres [μm] thick and contains several types of cells including keratinocytes, dendritic cells, Merkel cells and Langerhan's cells (Boyce & Pittet, 2002; Franz & Lehman, 2000). Although Langerhan's cells are involved with immune response it is the nature of the antigen that may, or may not trigger an immune response (Bos, 1997). This layer has no blood vessels and depends on the dermal layer for nourishment (Kowalak, 2003). The epidermis has a defensive role preventing micro-organisms and foreign substances from penetrating the surface of the body by several means (Kownatzki, 2003).

The epidermis consists of five layers of which the stratum corneum, accounts for 75% of the epidermal thickness (Priestly, 1993). Although the stratum corneum is a thin layer of tissue (10-20 μm thick), it provides some protection against damage from mechanical

pressures and is remarkably resilient (Boyce & Pittet, 2002; Priestly). The cornified outermost layer is made up of stratified layers of dead keratinised cells (squames or corneocytes) (Hall, 2000). The physical action of these dead corneocytes constantly desquamating from the stratum corneum has a defensive function, by causing surface bacteria and other pathogens to be shed daily (Hall, 2000; Lappe, 1996; Martini, 1992).

2.32 Dermis

The dermis is 1-4 millimetres (mm) thick and consists of cellular elements, ground substance and connective tissue (Boyce & Pittet, 2002; McCance & Huether, 2006). The connective tissue component of the dermis provides support and elasticity via strong interwoven collagen fibres which can resist mechanical forces (without permanent damage to the fibres) (Noble, 1993). This capacity helps to maintain an intact skin barrier as the skin's surface is not abraded each time hands are used (Wycoski, 1999). The dermal layer has a rich nerve and blood supply and also contains, apocrine, eccrine and pilosebaceous structures (Lappe, 1996). Within this layer the epidermal cells co-operate with the vascular and immune system and mount an active response against any foreign substances or micro-organisms that breach the defences of the stratum corneum (Kownatzki, 2003). Secretions from the sweat and oil glands provide chemical barriers to infection because bacterial growth is inhibited by fatty acids (McPhee, Lingappa, Ganong & Lange, 2000). Thus, skin is well equipped to prevent microbial invasion.

2.33 Microbial flora

The human skin is constantly at risk of being colonised by micro-organisms. Colonisation commences shortly after an infant is born (McCance & Huether, 2006; Noble, 1993). Every square centimetre of skin is inhabited by bacterial CFUs ranging in density from 10^2-10^3 CFUs/cm^2 (centimetres), with the skin potentially hosting numerous parasites, arthropods and fungi (Burton & Engelkirk, 2004; Lappe, 1996; Widmer, 2000). Most of these species are commensal with their human host. Bacteria compose the major microbial population on the skin and although microbial flora may differ from person to person, it is relatively permanent to each individual (Boyce & Pittet, 2002; Pelczar et al., 1993; Tannock, 1995).

The air in populated places contains epithelial squames discarded from skin, and some squames carry micro-organisms originating from the surface flora of the host (Meers & Yeo, 1978). Ten percent of skin squames carry viable micro-organisms (Noble, 1975) and the average adult sheds around one million skin squames daily (Boyce & Pittet, 2002). Microbes move within the atmosphere as, next to the skin is a thin layer of air warmed by the body with an air flow of 1-2 cms around bare legs and 20 cm surrounding the head) (Andrews, 1976). Skin particles released through clothing are caught up in air flow and whisked upwards into the atmosphere (Wysocki, 1999), and may drift up (beyond 32 kilometres) and down from the biosphere (Postgate, 1999). Hence, the chance of cross-transmission of microbes is constant.

2.34 Bacteria

Bacteria are classified Gram-positive or Gram-negative (according to laboratory staining techniques) with Gram-positive species predominating in the skin ecosystem (Gould, 2000; Tannock, 1995). Gould (2004a) maintains that in general Gram-negative bacteria thrive in a damp environment and are vulnerable in dry conditions, whereas Gram-positive bacteria are more resistant to drying. However, to cause skin infections bacteria need an entry portal and invade. For example, entry into the host's tissue is gained through a break in skin's surface through skin abrasions, insect bites, wounds or via implementation of medical devices, or surgery (Gillespie & Bamford, 2003; Lappe, 1996; Murray, Baron, Jorgensen, Landry, & Pfaller, 2007). Consequently, microbes only thrive when the skin's surface is damaged, diseased, or hydrated (Priestly, 1993).

The normal bacterial flora in humans is composed of three major genera of Gram-positive bacteria; coryneform, micrococci and staphylococci, with a minor component of Gram-negative bacilli (Hugonnet & Pittet, 2000; Noble, 1998). The staphylococci are aerobic Gram-positive bacteria and they form the best speciated group of organisms found on human skin. These bacteria occasionally become pathogenic but even then infections tend to be superficial (Mancini, 2000; Noble, 1998; Page, 2001). Bacterial CFUs are known as either resident or transient flora (Bojar & Holland, 2002; McCance & Huether, 2006). Transient floras are not tightly attached to the skin surface and can be removed by washing

or are destroyed by antimicrobial agents. However, not all resident microbes will be removed by these methods some will endure (Larson, 1995; Porth, 1998). Pittet and Boyce (2001) and Madigan et al. (1997) maintain that the more difficult micro-organisms are to remove the less likely they are to cause cross-infection.

There are about 30 different types of resident microflora consisting primarily of bacteria and fungi (Burton & Englelkirk, 2004). Resident microbes are usually harmless and are found on all peoples although, at different CFU densities (Bojar & Holland, 2002). They are found on the skin's surface, deeper skin layers and in sweat glands, and rarely causes disease to the host (Gould et al., 2000; McPhee et al., 2000; Pittet, 2000; Porth, 1998; Rotter, 1999). Instead resident flora provides a protective mechanism (simply with its presence) by lessening transient microbial attachment opportunities, by microbial antagonism (such as competing for nutrients) and via the discharge of organic acids which help maintain the skin's acid mantle (Lappe, 1996; Page, 2001; Pelczar et al., 1993; Tortora, Funke, & Case, 2001). Hence, resident flora can retain a viable reproducing microbial population on the skin, whereas transient species cannot sustain growth in this environment (Bojar & Holland, 2002).

Transient organisms are not normal skin inhabitants and are gained by accidental contamination through contact with the environment (Priestly, 1993). They can be pathogenic or non-pathogenic, and include potential infection causing organisms such *Streptococcus pyogenes* and *Staphylococci aureus* (Mancini, 2000). Murray et al. (2005) maintain that most human infections are caused by opportunist pathogens which are typically members of the patient's normal flora. Transient bacteria are unlikely to cause an infection unless transferred to another susceptible site and then they need to survive in that site (Tortora et al., 2001). Virtually all transient microbes have a short term survival rate on the skin. This is related to the inhospitable physiochemical environment of the stratum corneum; where transient microbes are unable to multiply and will usually die (Hugonnet & Pittet, 2000; Noble, 1993). Even so, transient bacteria have a high pathogenic capability and are responsible for most nosocomial acquired infections (Pittet & Boyce, 2001).

Description of microbial organisms and the CFU numbers found on the hands of the general population is scant (Larson et al., 2002). However, the literature frequently reports on hospital healthcare workers' hand flora. In hospital wards, healthcare personnel may transfer or harbour Gram-negative microbes and cross-transmission commonly causes nosocomial infections. For example, in a burns unit where many patients were infected with *Pseudomonas aeruginosa* up to 50% of the sampled nurses' hands revealed this aerobic Gram-negative bacillus (Lowbury, 1969). Noble (1993) reports that not all hand carriage of Gram-negative bacteria are transient as some organisms have been observed to colonise hands at least temporarily within hospital settings. Larson (1981) found persistent carriage of Gram-negative bacteria over 35 days, on 21% of hospital healthcare personnel compared to controls. Bruun and Solberg (1973) report persistent carriage of Gram-negative bacilli was related to skin irritations or lesions in hospital staff. Larson et al. (2002) assert there is higher prevalence of Gram-negative bacilli within the community environment than amongst medical personnel. Larson et al. found that more than 75% of homemakers (N = 224) carried at least one Gram-negative organism prior to and post-handwashing. This finding is in keeping with Guenthner, Henley, and Wenzel (1987) who noted more Gram-negative bacilli on nurses' hands before starting patient care than later in their work shift.

Gram-negative bacteria (which include the *Proteus* spp.) are a major component of normal human flora, and can be found in the environment in water and soil (Collins, & Lyne, 2004; Gillespie & Bamford, 2003). Gram-negative bacilli can survive for long periods in a moist warm environment (Burton & Engelkirk, 2004; Larson 1981; Noble & Somerville, 1974). Occasionally Gram-negative rods may infect lesions such as ulcers, or if feet are frequently wet, toe webs may be infected (Gillespie & Bamford, 2003; Noble & Somerville, 1974). But Gram-negative bacilli rarely appear on exposed skin and will not survive long in this location (Lowbury, 1969; Marples, 1965). Thus, Gram-negative bacilli primarily present a pathogenic risk to human hosts with a compromised immune system or those exposed to continuing wet conditions (Lowbury).

Hall (2000) reports that 15 % of patients from the community population who see a general practitioner do so for care of some skin disease, or skin lesion. The literature confirms that

Staphylococcus aureus is the main pathogen responsible for pyogenic infections (Robinson & Roberton, 2003; Shriner, Schwartz, & Janniger, 1995; Sleigh & Timbury, 1998). Impetigo is the most common skin infection in children (Hogan, 1998; Leyden, 1992; Watkins, 2005). *Staphylococcus aureus* is a leading cause of both primary and secondary impetigo (Koning et al., 2007) and is disseminated by air and dust, and via the hands of heath care workers (Gillespie & Bamford, 2003). Asymptomatic carriage of *Staphylococcus aureus* is common and found in up to 40%-70% of healthy people (in the nose, on skin, and on less than 10% of hair) (Collins & Lyne, 2004; Noble, Valkenburg, & Wolter, 1967; Sleigh & Timbury, 1998). Damaged skin may harbour *Staphylococcus aureus*, and it is commonly recovered (<90%) from the skin of atopic children (Kownatzki, 2003).

In a prevalence study, Aiello, Cimiotti, Della-Latta and Larson (2003) compared bacteria found, and CFUs counted from non-medical individuals (from the community) and neonatal nurses' hands. These authors report significantly more *Staphylococcus aureus* was found within the community sample (32 versus 4). This finding is consistent with a study by Cespedes et al. (2002) who report higher counts of *Staphylococcus aureus* isolates from the hands of non-medical participants (18%) compared to hospital personnel (10%). Likewise, Larson et al. (2002) found that 18.5% of homemakers had *Staphylococcus aureus* on their hands, and Somerville (1969) reports its incidence on the skin of children to be high (43%). *Staphylococcus aureus* does not produce disease in its normal setting, but may establish disease when introduced into vulnerable sites, such as when skin is damaged and susceptibility to disease was increased when an individual's immune system was immature or compromised (Noble, 1993). Hence, the potential of transient organisms to cause disease, even through cross-transmission, is limited in healthy individuals.

2.35 Infection

Infection has been described as "...the invasion and multiplication of micro-organisms in or on body tissues that produce signs and symptoms as well as an immune response" (Kowalak, 2003, p. 48). Micro-organisms not only elicit irritative and allergic reactions, they also have capacity to multiply in the skin to cause infections (Kownatzki, 2003). The type of infection that occurs depends on the depth of the infiltration, the type and virulence

of the organism, and host defence (Bisno, Hacker, & Roaten, 1997). Potential pathogens may enter the body by various routes including respiratory, gastro-intestinal, urinary or genital tracts, or through a break in skin's integrity (Gould, 2005; Tortora et al., 2001). Moreover pathogenic organisms may exhibit a resistance to antibiotics such as methicillin-resistant *Staphylococcus aureus*. This particular bacterium has emerged as a community associated infection in recent years, with a reservoir of resistant organisms emerging (Pittet & Boyce, 2001; Trampuz & Widmer, 2004; Weber & Hughes, 2004).

Pathogens injure cells and tissues because they circumvent the defensive barriers firstly of an intact skin surface, secondly the host's inflammatory response and thirdly, the immune system. In response to infection or tissue damage macrophages, neutrophils, mast cells, endothelial cells, and plasma proteins activate the inflammatory response to protect the body from further injury, to prevent infection, and promote healing (McCance & Huether, 2006; Pirret, 2005). Then the immune system is able to target the invading pathogens with the purpose of destroying them. Younger children are more susceptible to pathogenic incursion as they have a less robust immune system as adult levels of immunoglobulin production are not reached until children are nine to twelve years of age (Robinson & Roberton, 2003; Watkins, 2005).

May (2000) contends that there are three sources of micro-organisms; endogenous (from the host), exogenous (other people), and environmental sources (contaminated surfaces). Pittet et al. (1999a) demonstrated that the duration and types of patient contact activity were significant in determining the level of hand contamination. For example, hospital workers having five minutes skin contact with a non-infectious patient displayed the same amount of hand contamination as shown from one minute of respiratory care. Lucet et al. (2002) report that hospital workers who had not had recent patient contact (involved in house-keeping duties) produced significantly higher CFU counts compared to other colleagues who had recently been involved in patient care.

Gillespie and Bamford (2003) assert that for an organism to be pathogenic it must have the ability to cause human disease (pathogenicity) by exhibiting transmissibility from one host

or reservoir to another human host. Several authors discuss the notion of a sequenced chain of infection where infection cannot develop if one of the links in the sequence is removed or controlled. That is, susceptible individuals, reservoir of pathogens, the method of transmission or points of pathogenic entry into the body (Bjerke, 2004; Kowalak, 2003; McCulloch 1999). Vaccination results in breakage of skin's integrity and hence there is a potential to cause infection because an entry point has been created. Nonetheless, skin disinfection (to reduce the risk of infection) before an injection is administered is not considered necessary, unless the area appears physically unclean (Chiodini, 2001; Dann, 1969; MOH, 2006; Vaccine Administration Taskforce, 2001; Workman, 1999). McCance and Huether (2006) and O'Dell (1998) maintain that most skin infections occur superficially and only occasionally systemic signs and symptoms develop even then, it is rare that these infections are life threatening. The New Zealand Medicines and Medical Devices Safety Authority (MEDSAFE) confirm that 30% of reports related to injection site reactions post-Meningococcal B vaccination in 2004, but no data was recorded, attributed to infection (MEDSAFE, 2004). Moreover, the statistical summary of almost three million doses of Meningococcal B vaccination administered to infants and young people up to 20 years of age (July 2004 to March 2006) from the Centre for Adverse Reaction Monitoring (CARM) did not incidentally mention any skin issues attributed to cross-infection (CARM, 2006) in any report.

2.4 Hand hygiene

2.41 Handwashing

Historically, handwashing was for dirt removal, and symbolically the procedure delivered people from physical and moral evils (Rotter, 1999; Wendt, 2001). In the medical literature the purpose of handwashing is to remove transient microbes, organic material, and dirt (Hugonnet & Pittet, 2000; Larson, 1995; May, 2000). A standard handwash is recognised as the most effective regime for removing organic matter, but is time consuming, can negatively affect skin integrity, and is the least effective hand cleansing method to remove bacteria (Boyce & Pittet, 2002; Gould, 2000; May, 2000; Teare, Cookson, & Stone, 2001).

Page (2001) maintains that a standard handwashing method of lathering with soap for 15 seconds then rinsing hands with water and drying appropriately will decrease more than 90% of transient flora. Yet cleansing hands by water based methods is frequently difficult for healthcare workers due to time constraints, and access to cleansing facilities (Gould, 1996; Larson, 1995; Voss & Widmer 1997). Schools in New Zealand are advised to encourage pupils to take responsibility for their own hand cleansing through water based methods (Ministry of Education, 2007b).

2.42 Soap

Plain soaps are found as bars or liquid products and contain esterified fatty acids, sodium or potassium hydroxide and may contain detergents (Boyce & Pittet, 2002; Jackson, 2003). Soaps have negligible antimicrobial activity and no bactericidal action as it is the friction caused by drying that is significant in removing transient bacteria (Ansari, Springthorpe, Sattar, Tostowaryk, & Wells, 1991; Trampuz & Widmer 2004). Rotter (1999) reports that washing may reduce bacterial counts on hands by a 0.6 $\log_{10}$-1.1 $\log_{10}$ in 15 seconds and 1.8 $\log_{10}$-2.8 $\log_{10}$ in 30 seconds but considers the finding of no statistical significance. Soap may contain an antiseptic agent (to reduce microbial flora) but there is little evidence to support antimicrobial soaps for routine use (Nix, 2000). Michaels et al. (2002) found during standard handwashing no statistically significant reduction in CFUs were found in the temperature test range (4.4-48.9°C) and considers that water temperature during hand washing has a minimal affect on flora counts.

Numerous studies report negative skin responses to frequent soap based hand cleansing regimes which resulted in healthcare workers impaired skin integrity (Boyce, Kelliher, & Vallande, 2000; Grove, Zerweck, Heilmand, & Pyrek, 2001; Larson, 2001). Many bar soaps are alkaline (pH 7-11) which negatively impact on the skin's acid mantle and subsequently, for skin to return to an optimal pH 5.5 (acidic environment) may take more than 25 minutes (Marples, 1965). Liquid soaps are preferable to bar soaps because following use of a bar soap, bacteria may survive on the soap for more than 24 hours (Larson, 2001). Therefore, liquid soaps with a pH 4-7 are recommended to discourage bacterial colonisation and to encourage epidermal moisture retention (Gould, 2000;

Marples, 1965; Nix, 2000).

2.43 Alcohol-based hand gels

Alcohol has been officially accepted as a skin antiseptic by the American Medical Association Council since 1935 (Boyce, 2000). Alcohol-based cleansers have been in general use for around 40 years and were first described in 1938 by Price as cited in Michaels, Gangar, Lin, & Doyle, 2003, p.71). Alcohol-based hand gels maintain hand skin health, are time efficient, cost effective and have excellent immediate bacterial efficacy (Larson, 1995; Voss & Widmer, 1997). Using an alcohol-based hand gel for degerming through a hand rubbing process (hand hygiene technique) has become increasingly acceptable in a wide variety of healthcare settings (Healthcare Infection Control Practices Advisory Committee (HICPAC) 2004; Jackson, 2003; Larson, 2001; May, 2000; Pittet, 2000). British, North American and European infection control policies recommend alcohol-based hand gels as an alternative to water based hand hygiene in circumstances where cleansing facilities are inadequate, inappropriate, or when time factors influence the ability to complete other methods of hand hygiene (Boyce & Pittet, 2002; Larson, 1995, Teare et al., 2001; Wendt, 2001). Although, the application of alcohol-based hand gels products have occasionally been rejected cultural or religious grounds (Jumaa, 2005).

Hand gels generally contain ethanol, isopropanol or n-propanol (Jackson, 2003). However, frequently the alcohol of choice is ethanol (Gould, 2000). Ethanol can dissolve membrane lipids and is most efficacious at a concentration of 70% in water (Teare et al., 2001; Tortora et al., 2001). Ayliffe et al. (1988) demonstrated alcohol-based gels and solutions were more effective than foamed alcohol-based products. Alcohol penetrates the cell walls and the bactericidal action is produced rapidly during evaporation by denaturing cell proteins and a dehydration process (Boyce, 2000; Galbraith, Bullock, & Manias, 1997; Gould, 1997; Larson, 1995). Alcohol-based solutions with concentrations between 60-95% (vol/vol) kill a very significant 3.4 $\log_{10}$-5.8 $\log_{10}$ CFU within 30 seconds (Rotter, 1999). Sterigel+ provides an organism colony count kill of more than 99% within 30 seconds though the ethyl alcohol (70% vol/vol) component of the formulation (SoluMed Incorporated, 2003; Trampuz & Widmer, 2004).

Alcohol-based hand gels versus soap handwashing

Pittet et al. (1999a) and Lucet et al. (2002) report that healthcare workers utilising a standard handwash during routine patient care, displayed higher bacterial counts than those using an alcohol-based hand gel. Other researchers have similar findings. For example, from a randomised clinical trial Zaragoza, Salles, Gomes, Bayas, and Trilla (1999) report a high of ($p = 0.0001$), in favour of an alcohol-based solution, versus soap for reducing CFUs during hand cleansing. Girou et al. (2002) compared the efficacy of an alcohol-based hand gel compared to standard handwash at 60 seconds post-hand hygiene. The percentage median reduction in the bacterial contamination was 26% lower for the alcohol-based hand gel ($p = 0.012$).

Nix (2000) suggests that any substance that touches skin and strips away its lipids will reduce normal skin's protective barrier. Many studies indicate that alcohol-based hand gels helps maintain hydration levels with less irritation from negative drying affects to hands than was evident than with soap use (Galbraith et al., 1997; Larson et al., 2001; Nix; Paulson et al., 1999). For example, healthcare workers confirmed (via self assessment) that the skin condition of hands significantly improved ($p = 0.046$) with an alcohol-based gel regime versus soap and water cleansing (Boyce et al., 2000).

Range of organisms effected

Despite the purported usefulness of alcohol-based gels, Jackson (2003) cautions that alcohol exhibit poor antimicrobial activity against protozoal oocysts, some non-enveloped viruses and bacterial spores. Rotter (2001) particularises that hydrophic non-enveloped viruses such as enteroviruses are more difficult to inactivate. Yet, Hugonnet and Pittet (2000) have a broader view contending alcohol-based gels are active against all bacteria and most clinically significant viruses, yeasts, and fungi. This view is supported by Trampuz and Widmer (2004) who assert that alcohol-based hand rubs are nearly 100 times more effective against viruses, than handwashing. Bacterial efficacy has also been demonstrated against multi-drug resistant organisms (Boyce, 2001). Several authors declare that alcohol-based hand gels decontaminate healthcare workers hands effectively for a wide range of pathogenic organisms and alcohol-based hand gels are significantly more effective

than a standard handwash in removing transient hand flora including rotavirus, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella spp.* (Barker et al., 2001; Crowley, 2001; Gould, 1997; Winnefeld, Richard, Drancourt, & Grob, 2000).

Reducing nosocomial infection

Results from a study conducted over 34 months, set in a 275-bed extended stay post-acute hospital by Fendler et al. (2002) confirms alcohol gels efficacy. The entire facility was part of the study with patient groups similar in age and gender, and wards were either control (using standard handwash) or used an alcohol-based hand gel. The infection rates for the areas using the alcohol-based hand gel achieved a significant nosocomial reduction rate of 30%, compared with the control group. Hilburn, Hammond, Fendler and Groziak (2003) describe similar findings with a 36.1% decrease in infection over a 10 month period that an alcohol-based hand gel was used (as the preferred hand cleansing method) in one unit of a 495 bed acute hospital setting. The authors consider that hospitals can achieve budget savings if an alcohol-based hand gel regime is primarily used because of the decreased hand cleansing time and by a reduction in the costs related to nosocomial infections.

Performance shortfalls and considerations

Nonetheless, alcohol-based hand gels are not flawless as hand cleansing agents. They do not contain detergents so are not suitable as a hand hygiene measure in the presence of heavy soiling (Goldrick, 2003: Gould, 2000). Moreover, Larson (1995) and Teare et al. (2001) advocate the use of a standard handwash for cleansing if hands are visibly soiled. Also, some alcohol-based gels do not meet international efficacy standards. Kramer, Rudolph, Kampf, & Pittet (2002b) tested 10 alcohol-based hand gels and 4 alcohol-based rinse products against the European Standards (EN 1500). Kramer et al. report that gel products were significantly less effective and did not meet the EN 1500 alcohol reference, within the required time period of 30 seconds. Thus, tested hand gels may not perform as effectively as anticipated to lessen the risk of pathogenic microbial transmission. Particularly as the average application time by nurses is reported as much less (8-15 seconds) than customary manufacturers' guidelines of 30 seconds (Boyce, 1999; Jackson, 2003; Pittet et al., 2000).

High alcohol concentrations are not recommended in alcohol-based hand hygiene products because in the absence of water, proteins are not denatured easily (Jackson, 2003). Pietsch (2001) suggests that the alcohol content (in hand gel products) should not exceed 60-75% of the product volume because the thickening system (gel) requires water to swell, to provide sufficient viscosity during application. Gould (2000) cautions this lack viscosity may allow evaporation to occur before contact is achieved with all hand skin surfaces. Several authors comment that inadequate hand decontamination may occur if less than the recommended amount of hand gel is applied (3-5ml, depending on product guidelines) (Gould, 2000; Boyce & Pittet, 2002; Sickbert-Bennett, Weber, Gergen-Teague, & Rutala, 2004; Trampuz & Widmer, 2004). Furthermore, Gould (2006) contends poor hand hygiene technique can affect the coverage and contact time of the alcohol-based gel being employed.

Consideration has to be given to the potential risk of fire, as alcohols are flammable products. Boyce and Pittet (2002) and Mimoz et al. (1999) maintain that alcohol-based hand gels have an excellent safety record but as a safety precaution should be stored away from high temperatures. The fire risk is dependent on the type of alcohol present, the alcohol concentration, and whether the design of the product container curtails evaporation (Rotter, 2001; Trampuz & Widmer, 2004). Alcohol-based gel products are available in a variety of containers such as pump bottles and wall mounted dispensers (Kohan, Ligi, Dumigan, & Boyce, 2002).

The bactericidal action produced during an alcohol-based hand gel's evaporation is not long lasting (Gould, 1997; Rotter, 1999). However, Gould (2000), Picheansathian (2004), and Rotter (1999) claim that the addition of antiseptics (such as chlorhexidine gluconate) can prolong an alcohol-based hand gel's residual action for intervals up to six hours. Mimoz et al. (1999) found that 0.5% chlorhexidine gluconate and alcohol solution was more effective than aqueous 10% povidone-iodine (as a skin antiseptic) in reducing contamination of blood cultures (1.4% versus 3.3%) during a large ($N = 2041$) randomised controlled trial, set in three intensive care units. So, there appears to be some agreement in the literature that chlorhexidine gluconate increases the efficacy of alcohol-based hand gels.

2.44 Chlorhexidine gluconate

Davies, Francis, Martin, Rose, and Swain (1954, p.192) described the excellent bacteriostatic properties of a cationic bisbiquanide compound that the authors refer to as "serial number 10,040". The product became known as chlorhexidine gluconate and has been in widespread use as an antiseptic since it was first synthesised by Imperial Chemical Industries (Hugo & Russell, 1998; Larson, 1995). Commonly used as an antimicrobial agent, chlorhexidine gluconate may be incorporated into surgical scrubs and healthcare workers hand cleansing products (Franklin & Snow, 1981; Kampf & Kramer, 2004).

Chlorhexidine's action

Chlorhexidine gluconate exhibits optimal antimicrobial activity in an environment where the pH ranges from 5.5 to 7.0 which correspond to the pH of body surfaces and tissues (Denton, 2001). The antimicrobial action is achieved by damaging the cytoplasmic membrane of bacteria and the subsequent loss of cytoplasmic moisture (Aly & Maibach, 1979; Rosenberg, Alatary, & Peterson, 1976). Chlorhexidine gluconate binds to the stratum corneum and this bestows a residual effect (by releasing a chemical activity over time which is bactericidal) and this characteristic is referred to as persistence or substantivity (Boyce, 2001; Davies et al., 1954; Larson & Laughon, 1987). A cumulative effect refers to a CFU reduction that increases after multiple applications of an antiseptic overtime (Rotter, 1999). An antiseptic with residual activity can prevent the multiplication of resident flora and may kill transient micro-organisms subsequently deposited on the hands after cleansing (Wade & Casewell, 1991).

In a review of antiseptic agents efficacy and safety results from recent studies (4 pivotal and 2 comparative antimicrobial clinical trials), Hibbard (2005) comments that combining two antiseptics, with different mechanisms of actions is more efficacious than using a product with one mode of action. Denton (2001, p. 328) agrees that there are advantages in using an antiseptic with residual efficacy stating, "Persistence of antibacterial action on the skin is considered desirable to help prevent colonisation with hospital pathogens and reduce the level of contaminant acquired between handwashes". The chemical activity of chlorhexidine has been shown to be affected by both strength and formulation base (Larson

& Laughon, 1987). Boyce and Pittet (2002) contend that concentrations of 2%-4% chlorhexidine gluconate have greater persistent antimicrobial activity than antiseptics hexachlorophene, triclosan and iodophors.

Laboratory volunteer studies

Kampf and Kramer (2004) comment in their review of decontamination agents that evidence of chlorhexidine gluconate's residual action is principally described from within laboratory settings where chlorhexidine gluconate (in detergent or an alcohol-based hand rinse) was tested in concentrations between 0.5%-4%, but with no exposure to environmental contaminates. Many of the clinical studies detailed the volunteers' base-line hand flora CFU counts studies and then, often trial bacterial marker contaminants were applied to hands. Later participants completed hand hygiene according to pre-assigned cleansing products and methods. Assessments of the activity of chlorhexidine gluconate were made by the difference in CFU counts (various time intervals) from the flora data examined.

Rosenberg et al. (1976), in an original study, found that 0.5% chlorhexidine gluconate (in several mediums) performed differently in a gloved hand test, reducing CFUs by 99.98% in alcohol, 98.77% in detergent and 96.84% in aqueous solution. Significantly, all formulations showed the bacterial levels still did not exceed the participant's baseline microbial counts six hours after application. Similarly Aly and Maibach (1979) cleansed hands (N = 81) and then the participant's hand was placed in a glove (to mimic a surgical setting). The chlorhexidine gluconate (4%) solution reduced CFUs, and microbial assessment revealed no significant growth of bacteria over a period of six hours when compared to baseline data. The authors concluded a persistent antimicrobial effect was found. Urlich (1982) agrees reporting that Hibistat (0.5% chlorhexidine gluconate in 70% isopropyl alcohol) produced significantly lower bacterial counts of the test organisms across all sampling times, compared to 'Betadine' (7.5% povidone-iodine). Urlich postulated that chlorhexidine gluconate would be effective in reducing future transient flora contamination by this substantive effect.

A study conducted over five days by Larson and Laughon (1987) confirms the previous findings comparing four hand hygiene products containing chlorhexidine gluconate (2-4%). Fifty participants washed their hands 15 times per day. Larson and Laughon report there was a significant reduction in log CFUs with all formulations compared to baseline microbial counts ($p = < 0.05$) between days one and five results. Over shorter time intervals Wade and Casewell (1991) maintain Hibisol (chlorhexidine gluconate 0.5% and 70% 2-propanol alcohol) showed an impressive decrease of bacterial counts of the artificially inoculated organism on hands. This effect was evident for all time intervals (5-30 minutes) post-application and for example, within one minute a significant reduction of 4 $\log_{10}$ in recoverable CFUs was recorded.

Further studies support chlorhexidine's efficacy. Ayliffe et al. (1990) applied test organisms volunteers hands ($N = 74$). Sampling was performed after five minutes and then this regime was repeated for a total of five cumulative treatments. The antiseptics tested included chlorhexidine gluconate at two strengths (2.5% and 4%). Results confirmed a significant mean $\log_{10}$ reduction of 1.0 greater, in the cumulative tests than the results obtained after one application of the test products. Mulberry, Snyder, Heilman, Pyrek, and Stahl (2001) performed similar trials to evaluate antimicrobial effectiveness of 1% chlorhexidine gluconate in 61% ethanol. The authors report significant microbial log reductions were found at all timeframes sampled when compared to a 4% chlorhexidine gluconate solution, and an alcohol-based vehicle control. Sickbert-Bennett et al. (2004) tested 14 hand hygiene agents over time against trial organisms with volunteers and reported the most efficacious agent was firstly chlorhexidine gluconate then, Triclosan, and next benzalkonium chloride. Yet, another study found the combination of alcohol and chlorhexidine gluconate 1% solution was the only product of the three of alcohol-based solutions tested that eradicated all marker organisms (Kjolen & Andersen, 1992).

Conversely, Ayliffe et al. (1988) demonstrated that the addition of 0.5% chlorhexidine gluconate did not improve the immediate efficacy of, or show significant, residual antimicrobial effects when added to the alcoholic hand rubs. Bartzokas, Gibson, Graham, and Pinder (1983) found that chlorhexidine gluconate in 70% alcohol solution had less residual activity than triclosan preparations for hand disinfection. Namura, Nishijima and,

Asada (1994) evaluated the residual activity of three hand cleansing products (soap, chlorbenzarconium (antiseptic) in 83% alcohol and 0.5% chlorhexidine gluconate in 77% alcohol. Volunteers were allowed to touch items in and out of the laboratory, and agar media plates were used for hand imprinting at varying time intervals (0, 10, 30 and 120 minutes). Namura et al., acknowledge that chlorhexidine gluconate exhibited a residual effect at 10 minutes post-application, but this effect was not evident after 30 minutes exposure to the surrounding environment. At longer intervals there were no significant differences between any of products and the authors' suspected that any residual activity depended on several factors, such as number and type of objects touched by participants.

Patient and healthcare workers volunteer studies

The *in vivo* studies describe similar findings of residual efficacy but are chiefly from surgical settings, where following glove removal, healthcare workers hand flora was assessed (Larson, et al. 2001; Wheelock & Lookinland, 1997). A combination of chlorhexidine gluconate and an alcohol-based hand rinse were tested but the participant's hand flora was not exposed to the environment over time. In a similar study Hibbard, Mulberry, and Brady (2002) reviewed the performance of 70% alcohol and 2% chlorhexidine gluconate (ChloraPrep) with 70% alcohol and 2% aqueous chlorhexidine gluconate on abdominal skin (beneath an occlusive dressing) through randomised parallel groups (N = 85). The trial findings declared no adverse events were recorded from any product. However, only the ChloraPrep product provided residual antimicrobial activity that was statistically significant when data was compared to baseline CFU counts at 24 hours. Mimoz et al. (1996) reviewed the incidence of central venous or arterial catheter colonisation and infection in intensive care patients over 16 months and found that the catheter related sepsis was significantly lower when the patient's skin was swabbed with alcohol and chlorhexidine gluconate 0.025 %, compared to benzalkonium chloride and alcohol-based solution. The authors concluded this effect appeared related to the more efficacious bactericidal activity of chlorhexidine gluconate 0.025 % against Gram-positive bacteria.

Community significance

Gould et al. (2000) tested the use of chlorhexidine gluconate 1% (within a hand cream) with community nurses in an endeavour to reduce levels of transient bacteria from hand flora. The results showed that the antiseptic cream did not reduce bacterial counts initially however, on review of the CFU counts at the beginning of the next visit demonstrated that bacterial carriage was reduced.

Nevertheless, the literature does not suggest using products that may exhibit persistent antimicrobial properties for infection risk reduction in for example, pandemic conditions. Water-based hand cleansing is suggested as an effective tool to lessen cross-infection risk in situations such as severe acute respiratory syndrome (SARS) because the incremental value of incorporating antiseptics is uncertain (Jefferson et al., 2007). Kampf and Kramer (2004, p. 873) when reviewing the residual efficacy of chlorhexidine state that "...the clinical benefit of such a residual effect has never been shown". Perhaps this is because no 'in use' studies of hand cleansers with residual properties have been reported from community settings.

2.5 Gloves

The wearing of gloves is the accepted practice in many clinical settings. However, donning gloves is considered unnecessary for vaccination procedures unless the healthcare worker could be in contact with potentially infectious material (Atkinson et al., 2002; Boyce & Pittet, 2002; WHO, 2004). Pittet (2003) considers wearing gloves may provide a false sense of security, as nurses workers may forget to change gloves during an episode of patient care. The material gloves are manufactured from, and how long gloves are worn can precipitate skin reactions in sensitive wearers (Boyce & Pittet, 2002; Kownatzki, 2003).

Larson et al. (1998) agrees that glove use is linked to skin conditions, such as a high prevalence of irritant contact dermatitis. Wearing of gloves causes the skin to sweat, resulting in more skin cells exfoliating and inducing higher bacterial counts during cell dispersal during glove removal and thereby increasing the risk of cross-infection (Gould,

1997; Mercier, 1997). Boyce and Pittet (2002) recommend the washing of hands following glove removal because of the negative effects of gloves on skin flora. Leighner (2001) and Tenorio et al. (2001) caution gloves may have unapparent defects or may develop holes during use and hands may become contaminated whilst gloves are being worn or during glove removal. The value of wearing gloves is thus dependent on the risk of cross-infection, the gloving technique and on the potential for harm to skin integrity and hand flora.

2.6 Skin damage

Damage to skin's integrity has been found to be a common and a potentially serious problem for nurse's hands. Skin damage was associated with hand hygiene practices rather than geographic or demographic factors, was not correlated with age, gender or skin type (Cimiotti, Marmur, Nesin, Hamlin-Cook, & Larson, 2003; Larson, Friedman, Cohran, Treston-Aurand, & Green, 1997; Sultana, Cimiotti, Aiello, Sloan, & Larson, 2003). Larson et al. (1998) report that damaged skin shows a change in micro flora and harbours increased numbers of pathogens. Kownatzki (2003) contends that the incursion and growth of transient micro-organisms further contributes to skin inflammation and initiates infection. Moreover, washing damaged skin is less effective and cross-infection risk increases because greater numbers of pathogenic microbes disperse whilst drying damaged skin (Gould, 2000; Larson 2001).

Hands that are cleansed frequently, washed quickly, and not dried effectively are likely to have increased bacterial translocation (Patrick et al., 1997). Drying factors need to be considered as impaired skin surfaces are more at risk of irritant and optimistic pathogenic entry (Larson et al., 1998). Hall (1999) suggests that hands which are soiled but dry, may well present less of a cross-infection risk than clean but damp hands. Patrick et al. (1997) report that when skin was touched by volunteers with dry fingers (contaminated by test organisms) 200 micro-organisms translocated, but after wetting the volunteers fingers, the microbial numbers transferred increased by up to 64,000 micro-organisms. So, wet surfaces allow microbes to translocate more easily than dry surfaces. But the translocation of bacteria can be reduced to more than 99% if hands are paper towel dried for 10 seconds,

and then hot air dried for 20 seconds (Gould, 2000; Patrick et al., 1997). If paper towels alone are used, then drying needs to be executed for at least 15 seconds to reduce the residual moisture left on hands to an efficacious level of less than 5% (Miller & Patrick, 2000).

Careful hand drying is the critical factor in determining the level of touch contact associated with bacterial transfer after handwashing (Patrick et al. (1997). Taylor, Brown, Toivenen, and Holah (2000) looked at drying efficacy. Fifteen volunteers washed and dried their hands then, hand flora was sampled. The participants used warm air hand driers, varying the drying times (10- 45 seconds on day one). On day two, hands were paper towel dried. Over 600 other samples were also microscopically assessed (from air ducts and washroom surfaces). Results showed drying hands by warm air driers was no more likely to produce airborne microbes than drying with paper towels, and the washroom surface levels of bacterial contamination were not significantly different to those in like facilities. Hand flora samples reflected the degree of dampness rather than the method of drying.

2.7 Skin moisture loss

Superficial skin layers contain water to keep skin pliable, and lipids to inhibit dehydration of the corneocytes (Pittet, 2000). In normal skin, water loss rates are very low but the loss rate increases if the barrier function of the stratum corneum is compromised by damage or disease (Grove et al., 2001). Nix (2000) argues that frequent cleansing with soap can reduce the lipid content of stratum corneum resulting in a trans-epidermal water loss. This is because as skin becomes drier, the barrier function declines and result in chapped dry hands with increased microbial shedding. Hand cleansing regimens that diminish skin damage also improve skin condition (Visscher, Canning, Said, Wickett, & Bondurant, 2006). Yet, no national standard for hand hygiene products exist (Larson et al., 2000b).

Physiologic procedures are available to assess skin condition, and the amount of moisture loss from hands can be measured by a variety of techniques, such as corneocyte shedding, electrical impedance and determining the amount of trans-epidermal water in skin (Grove et

al., 2001; Larson, et al., 2001). For example, Boyce et al., (2000) conducted an original prospective crossover trial and compared the frequency of skin irritation and dryness associated with hand cleansing (between soap and an alcoholic hand gel) through several measures. Electrical capacitance readings showed the epidermal water content levels decreased significantly with soap regimes but remained constant with alcohol-based hand gels. The other review measures of visual researcher and self assessment found soap to significantly increase skin dryness. In contrast the alcohol-based hand gels demonstrated cutaneous tolerance by retaining skins trans-epidermal moisture level and thereby helped sustain skins protective barrier function.

Nix (2000) avows that an emollient (humectant/moisturiser) is added to many cleansers to minimise the skin's lipid loss. Even so, Larson (2001) and Visscher et al. (2006) recommend the incorporation of a separate moisturising application into all hand hygiene regimes to reduce microbial dispersion, and to benefit skin health. Pittet and Boyce (2001) concur and suggest that emollients may even protect against cross-infection by keeping resident skin flora intact. Kramer, Bernig, and Kampf (2002a) in a double blinded trial of six alcohol-based hand gels found that emollients within the products helped prevent skin drying out, irrespective of the alcohol-based formulation. Kenny (2002) completed an audit of 21 Australian district nurses hand cleansing practice (standard handwash). Kenny noted that 38.1% of nurses' hands were cracked yet, 76% of nurses stated they did use a hand cream or lotion. It seems that in everyday nursing practice the recommendation to moisturise hands as part of hand hygiene practice may not be heeded.

The formulation of an emollient is important as the formula may inactivate the action of an antiseptic within susceptible hand hygiene products (Marino & Cohen, 2001). Consequently, care is needed in the selection of a hand moisturiser to ensure it will not inhibit the antiseptic hand hygiene product efficacy (Larson, et. al., 2001). For example, product information confirms that the hand moisturising lotion 'Revive' is compatible with the antiseptic chlorhexidine gluconate, found in Sterigel+ (Appendix D).

2.8 Hand hygiene compliance

Hospital healthcare workers in have failed to recognise the importance of hand hygiene and have been shown to underestimate by less than 50% the need for hand cleansing (Creedon, 2005; Girou & Oppein, 2001; Pittet, 2001). But perhaps this failure reported failure to recognise the need for hand cleansing is because health workers are in disagreement with the protocols. Disputing the need to frequently complete handwashing is reflected in a challenging letter to the British Medical Journal editor by a hospital specialist registrar. Weeks (1999, p. 518) asserts " If, ... there is such compelling evidence for the need to wash hands between each patient contact then why do I and the vast majority of my colleagues not do it?" Non-compliance is demonstrated by healthcare workers low compliance (48%-58%) with hand hygiene protocols (Cohen, Saiman, Cimiotti, & Larson, 2003; Girou & Oppein, 2001; Pittet, et al., 2000; Voss & Widmer, 1997).

Problems such as logistical barriers to hand hygiene products or facilities, lack of awareness for when hands need cleaning, and the influences organisational cultures have on hand cleansing practices are described (Boyce, 1999, Gould, 1996). Larson et al. (2000a) agree hand hygiene practices are persistently suboptimal amongst healthcare professionals. Several authors report that when the activity work index was highest then nurses hand hygiene compliance was lowest (Harris et al., 2000; Pittet, Mourouga, & Perneger, 1999b). Boyce reasons that the lesser time required for alcohol-based hand gel cleansing (compared to the time needed to access a sink and complete a standard handwash) may make it feasible for caregivers with high workloads to decontaminate their hands more frequently. The importance of time factors was highlighted from a controlled hospital trial which compared the efficacy of a standard handwash versus alcohol-based hand gel in reducing hand contamination following regular patient care (Girou et al., 2002). Twenty-three healthcare workers participated and the median time spent completing both hand hygiene regimes was found to be 30 seconds. This time duration was adequate to reduce bacterial contamination with an alcohol-based hand gel but wholly inadequate to complete both a standard handwash and hand dry (Girou et al.). Nevertheless, Widmer and Dangel (2004) found that 66% of the 60 healthcare workers using an alcohol-based hand gel still had detectable bacteria after hand cleansing. Consequently, correct hand hygiene techniques are

crucial for optimal decontamination regardless of the cleansing regime employed.

Strategies designed to improve compliance have been largely unsuccessful (Larson et al., 2000a; Naikiba & Hayward, 2001; Pittet et al., 2000). Boyce (2001) suggests that workers acceptance of hand cleansing products can influence the frequency of use and consequently compliance and overall effectiveness of infection control programmes. This view is endorsed by studies confirming increasing compliance by healthcare workers to hand hygiene protocols when alcohol-based hand gels are readily available (Girard et al., 2001; Gould, 2004b; Naikiba & Hayward, 2001; Pittet et al., 2000). On the other hand, Girou and Oppein (2001) maintain heath care workers remain reluctant to use alcohol-based hand gel and identify workers lack of knowledge about when to cleanse hands, lack of confidence in alcohol-based handrubs efficacy, and skin intolerance to products. Yet, healthcare workers acknowledge skin problems and being too busy as the principal factors that deter hand cleansing (Boyce, 1999). Harbarth et al. (2002) report from a survey of hospital workers (N = 62) that satisfaction with an alcohol-based hand gel was a modest 45%.

Wendt (2001) considers that until the *experts* can come to an agreement about hand hygiene indicators and standardise guidelines it is unrealistic to expect healthcare worker determine when hand cleansing is needed, as it is impossible to see or feel microbes. Burke (2003) identifies other obstacles such as understaffing, confusing and impractical guidelines, and disregarding behavioural change theory to support compliance. Harris et al. (2000) researched 199 healthcare workers attitudes to hand hygiene using a 74 question survey. The authors consider that participants recognised the value of hand hygiene but tended to overestimate their own compliance and suggest that interventions that make cleansing easier are preferred. But, Kenny (2002) asserts that ongoing educational programmes are needed so healthcare workers can update hand hygiene knowledge. From a quasi-experimental hospital study (N = 63), Creedon (2005) determined that healthcare workers did not recognise the need to cleanse hands (after handling urinary catheters). Compliance was recorded at 40% however, after the provision of hand hygiene information compliance rose to 85 %. Columbo et al. (2002) provided a three phased teaching intervention in five hospital wards and considered targeted teaching was successful and gains maintained. The

authors report the overall use of hand gels increased up to 30.9% per 1000 patient days with further increases over the following three months (1.2%). Another hospital survey reveals less favourable outcomes. Girou and Oppein (2001) report that when heath care workers (N = 271) were informed that over 50% of hand hygiene opportunities were being missed and encouraged to use an alcohol-based hand gel, they were still reluctant to use this process for hand cleansing.

Whitby, McLaws, and Ross (2006) examined the behavioural determinants of handwashing amongst nurses by linear regression of questionnaire responses (N = 745) and elucidated that compliance is not simply related to products or facilities. Rather it is highly dependent on behavioural perceptions. Creedon (2005) demonstrated increased hand cleansing compliance (p <0.001) by healthcare workers (N = 314) through a behavioural intervention study. Hence, behaviour modification programmes need to be incorporated into compliance initiatives across all healthcare disciplines. From the literature it seems that no one cleansing product is ideal, all have advantages and shortcoming. But easy access and rapid antimicrobial action appear key elements to improve compliance. Even so, non-compliance to hand hygiene protocols appears to be multifactorial and requires a multimodal and multi-disciplinary approach.

2.9 Summary

Background information encompassing hand cleansing rationales, practices, products and issues has been provided and evaluated. Much of the literature on hand hygiene examines the links between handwashing and transmission of infection predominately from within a hospital setting. International infection control guidelines continue to recommend that hands should be cleansed between patients. Bacteria were the predominate pathogens found to cause nosocomial infections and cross-contamination often occurs via healthcare workers' hands. Hand cleansing practices such as a soap and water handwash, or use of an alcohol-based hand rub seem universally accepted as hand hygiene methods that remove microbes and reduce the risk of cross-infection during patient care in the literature. However all products and methods have limitations, and damage to skin's integrity has

been found to be a common and a potentially serious problem for nurses' hands. Healthcare workers compliance to hand hygiene protocols was found to be challenging and multimodal approaches were suggested.

The cross-infection risks presented to non-immuno-suppressed individuals from CFUs found on skin (outside of a hospital setting) were found to be negligible. Because healthy individuals with an intact skin surface are well equipped to meet the everyday challenges microbes present. However, during school based MVPs it is important to reduce the risk of cross-infection for both students and vaccinating nurses. Evidence of the antiseptic chlorhexidine gluconate's residual persistence (within Sterigel+) was sought. The literature predominately describes results from laboratory trials where hand flora was not exposed to the environment over time. Overall these studies report chlorhexidine gluconate shows antimicrobial effects with a residual efficacy in restricted environments. Therefore the proof of ongoing antimicrobial persistence, relevant to PHNs school MVPs was not found. Nevertheless, through this descriptive survey the researcher will present original data describing the residual efficacy of Sterigel+ from flora gathered from vaccinating nurses' hands during MVPs. The following chapter focuses on the theoretical framework and methods for the study.

Chapter Three: Study Design and Method

3.1 Introduction

The previous two chapters provided an overview and discussed the evidence concerning hand hygiene, methods and products used and cross-infection issues. To help address the lack of data in the literature related to MVP hand hygiene practices this descriptive survey was designed. The study will principally reveal the efficacy over time of the hand hygiene product (Sterigel+) used by PHNs during ADHB's 2006 student vaccination programmes.

Chapter three encompasses the theoretical basis of the study, the study design, funding, ethical and cultural consultation processes and issues. Confidentiality and privacy concerns, the school settings, recruitment and participation (processes and outcomes) and methods for collecting, analysing and describing data are discussed. Supplementary information is provided to elucidate the study's setting and sampling arrangements. Reliability and validity issues are also considered.

3.2 Research process

3.21 Theoretical approach

Research is a way of gaining information about physical or social phenomena through rigorous methods of producing, recording and interpreting experiences relevant to a research question or hypothesis (Avis, 1995). A general perspective for guiding a line of inquiry is provided through a set of philosophical assumptions referred to as paradigms (Polit & Beck, 2006). Woods and Catanzaro (1988) maintain that paradigms are useful vehicles for directing thoughts, in order that lines of inquiry are guided quite specifically. Primarily, two paradigms influence modern nursing research; the positivist-empiricist and the naturalistic-inductive influence (Polit & Beck, 2006). These paradigms are commonly correlated to quantitative and qualitative methods (Gillis & Jackson, 2002; Mateo & Kirchoff, 1991). Still, in both qualitative and quantitative methods the goal is to expand

nursing knowledge and theory development (Cresswell, 1994). Qualitative research is a holistic approach that aims at exploring and understanding people's feelings and beliefs to describe an event (within its context) as experienced by the respondents (Fain, 1999; Sarantakos, 1998). On the other hand quantitative research is a formal, objective, systematic process using measurable data to obtain information. It is used to describe or examine relationships and may be employed to determine cause and effect (Burns & Grove, 2001; Cormack, 2000). However, the distinctions between qualitative and quantitative methods are governed more by the methodological framework of the study than the methods themselves (Blaxter, Hughes & Tight, 2000; Grant & Giddings, 2002).

Methodology refers to the research approach that underpins the study. It is the course of action or design that is the basis for specific methods and is related to the theoretical framework used to address the research question (Blaxter et al., 2000). The selection of methods depends on the nature of the research question (Polit & Beck, 2006). So, it is from the questions asked that the methods are chosen. The methods provide the specific answers about how the research will be achieved (Blaxter et al., 2000; Crotty, 1998). Hence, it is necessary to engage with the methodology which best fits the research aims. Qualitative research methods primarily collect narrative data (in a non-numerical form) and these processes do not relate to the aims of the present study. Whereas, quantitative methods collect information (in a numerical form) and this allows statistical analysis of data for review. Therefore, the two research approaches employ different methods in order to achieve different outcomes.

The methodology selected as the most fitting to address the study's research question of ***'what is the residual effectiveness of chlorhexidine gluconate 0.5% on vaccinators hand flora?'*** employs a positivist, non-experimental descriptive pilot study design as described by LoBiondo-Wood and Haber (2006). Nardi (2006) contends that descriptive research is the initial step in most research projects, and frequently the main purpose is to gather information through a survey. Quantitative descriptive survey designs are consistent with the methodology of a positivist framework because instruments are employed to collect data (Cresswell, 1994; Gillis & Jackson, 2002). An advantage of survey designs is that

information is able to be collected quickly from the chosen sample (Gillis & Jackson, 2002). Bouma (2000) and Polit and Beck (2006) consider that research information is provided within strictly determined contexts and based on exact methods of data collection and assessment. The methods utilised should focus on obtaining reliable and replicable data (Woods & Catanzaro, 1988).

3.22 Study design

Polit and Beck (2006) maintain that in non-experimental research data is collected without introducing changes to usual practices. Descriptive survey designs can be conducted in a natural setting and do not require the resources of an experimental study (which may involve a treatment or intervention) (Sproull, 1995). The data in this study was gathered without making any changes to the natural setting of a MVP and it was a vaccinator's practice decision when to cleanse hands (following Sterigel+ application). Thus, the researcher had no control over the time periods between hand hygiene episodes or the MVP organisation.

A descriptive design can answer questions that other methods may not afford, such as, what, how many of what (Blaxter, Hughes, & Tight, 2002; Cresswell, 1994; Gillis & Jackson, 2002; Guba, 1990). For example, in this study it would be unethical to randomise students into groups, where hand hygiene was limited or not performed. Hence, a descriptive survey is useful in generating knowledge in situations where it would be difficult to employ experimental methods as the researcher introduces no variables but numerical measures can be taken (Roberts & Ogden-Burke, 1989; Sproull, 1995) and the data obtained examined through descriptive statistics (Burns & Grove, 2001; Munro, 2005)

Employing a descriptive survey method can be of value to nursing practice. Non-experimental studies can be used to justify current practice, to identify problems or to make judgements and provide a rich source of data for researchers (Burns & Grove, 2001; Fain 1999; Polit & Beck, 2006). Nonetheless, Minichiello, Sullivan, Greenwood and Axford (2004) contend that evidence gathered must have value in every-day clinical practice and add to nursing's body of knowledge, if nurses are to fulfil their professional responsibility

to provide optimal client care. Accordingly, the data gained from this study is of value to PHNs as it provides original evidence on hand hygiene practice and the efficacy of a hand cleansing product relied on to reduce cross-infection risk at MVPs. LoBiondo-Wood and Haber (2006) recommend that when evidence is available, practice should be based on the evidence. Cochrane (2003, p. 37) supports "...informing praxis to assist in bridging the research-theory-practice gap". This study does fulfil these objectives, as PHNs will have microbial and statistical evidence from this study and may choose to review the MVP hand hygiene guidelines, in light of the data findings.

3.23 Pilot study

A pilot study was planned because a review of the literature did not reveal similar studies and thus the execution and worth of such research was unreported (Van Teijlingen, & Hundley, 2002). A pilot study can identify the best research process, may uncover problems, and provide an inkling of the likely outcomes which might occur in a comparable larger study (Peat, 2002; Polit & Beck, 2006; Taylor, 2005). For example, any barriers to participation may be identified, realistic resources and costs may be determined, data analysis techniques tested, and logistical and practical issues identified (Van Teijlingen & Hundley). Subsequently, evidence from this pilot study may be relevant to present to both ethical and funding bodies as data may be germane for other research studies (Mason & Zuercher, 1995; Peat, Mellis, Williams & Xuan, 2002). Peat (2002) contends that a pilot study cannot be used to test a hypothesis but may reveal whether a more definitive study to test a hypothesis is warranted and feasible. In this light the *p*-values (significance levels) obtained in the present study should perhaps be considered tentative and indicative of trends that a further study may confirm, rather than being conclusive.

3.24 Funding

The researcher was successful in obtaining a Ministry of Health Primary Healthcare Nursing Post Graduate Scholarship to assist with academic enrolment fees. The Child and Youth PHN Team Manager allowed data collection to be performed within the researcher's PHN role. A quote was obtained from LabPlus for identifying flora. The quote included the provision of blood agar plates, microbiological assessment and reporting costs (see

Appendix F). The researcher successfully submitted this quote to Massey University's Graduate Research fund and was reimbursed for laboratory costs (see Appendix G).

A smaller monetary grant was also received from Massey University to assist with costs associated with word processing, travel, mobile phone charges and the giving of koha (a gift). Koha is an important aspect of consultation and participation with Maori as it is recognises the contribution and time provided to korero (speak) with the researcher by an individual (Sporle & Koea, 2004). Travel included transport to the field and to the LabPlus. LabPlus is a secure facility and cannot be accessed by non-laboratory staff without appropriate approval. So, a mobile phone was necessary to make contact with a microbiologist to gain entry and deliver the agar plates. All other costs related to the research were covered by the researcher personally. No commercial business funding was sought or furnished, nor was sponsorship provided by the manufacturer of Sterigel+ (SoluMed Incorporated). Therefore, there were no commercial factors which could influence any research findings and therefore no conflict of interest with any party.

3. 3 Study locations and student population

3. 31 Study settings in schools

To inform schools of the prospective study, a letter (see Appendix H) was mailed to the Principals of 49 schools (ADHB catchment area) who had MVPs during July to October, 2006. One school did contact the researcher prior to their scheduled MVP as the school had questions around the data gathering process within the school venue. A meeting was arranged and the researcher provided detailed information about agar plate sampling to the Deputy Principal of this school. Afterwards, this school agreed to be included in the study.

When flora sampling was concluded (following consultation with the study's supervisors) all these school principals were advised by letter that data gathering was completed (see Appendix H). No contacts were received from any other school or people associated with a school community during the study.

3.32 School setting consent process

Schools could refuse to allow data collection to be performed at their school setting by contacting the researcher, the school's PHN or a research supervisor either verbally or in writing. Written consent was not required for the school setting by the ethics committees. Nevertheless, additional precautions were put in place to ensure schools were aware of the research study, and had an opportunity to discuss any aspects of the study, or decline consent. For example, if feedback was not received from any school by the researcher or supervisors then, two weeks prior to the MVP the PHN (allocated to the school) qualified the school's intention to confirm or decline inclusion in the study. If confirmation was still not received from either the school directly or the nominated PHN a week before the school's MVP then that school was considered ineligible as a study setting. Subsequently, all schools choose to be included as setting for the study.

3.33 Student population

The student population potentially eligible for vaccination ranged from 13-912 pupils. Parents or guardians choose to consent or not to consent to student vaccination at school. Therefore, the final school vaccination numbers were less than the student roll numbers. Schools with large student roll numbers to be potentially immunised were predominately selected as this afforded the greatest number of participant vaccinators on each occasion. After attending 17 school MVPs the data collection was determined to be completed by the researcher in consultation with Massey University Supervisors. The actual number of students consented and screened (as appropriate) to be vaccinated at any of the selected MVP varied considerably from 59 to 347 pupils. In total, at all 2006 MVPs provided by ADHB nurses a total of 5398 students were vaccinated and no reports related to infection were reported to PHNs or the PHN Manager (Child and Youth Team).

The sampled schools decile ratings ranged from one to ten (see, Figure 1) reflecting students from a widespread section of the population. Decile ratings indicate the criteria for school funding and the rating scales are based on socio-economic determinants as defined by the Ministry of Education (Ministry of Education, 2007a). Figure 1 depicts the selected schools (N = 17) and displays the number of schools in each decile band and the current

Ministry of Education decile rating as provided to the PHN team by each school. Seven schools were rated in the decile one to three band, no school was classified as decile four and the remaining schools (10) were rated in the decile bands five to ten.

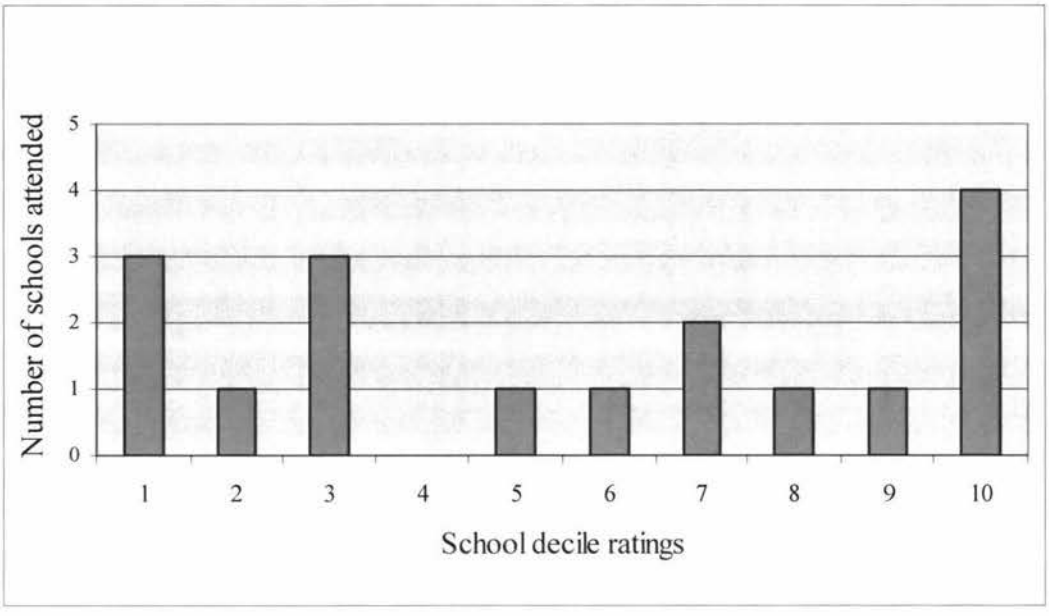

Figure 1 **Decile rating of school settings**

3.4 Participants

3.41 Sample size

Green (1991) provides a mathematical model on which to base sample size so that relationships and other measures can examined. Using this model, a sample size of 60 participant occasions (i.e., 120 agar plate collections) was selected as a feasible minimum number for this pilot study (B. McDonald, personal communication, April 10, 2006). Furthermore, because the number of potential participants (a PHN work force of less than 30) was limited it was agreed that vaccinating nurses could provide data on one to four occasions during the study. The sample size was chosen so that there would be sufficient data to detect moderate-sized differences in CFU counts between: dominant and non-dominant hands; convenience and non-convenience samples and shorter and longer time

spans between cleansing. For example, if hand dominance, or the reason for cleansing were important, then $n = 60$ (vaccinator gathering occasions) was considered sufficient to estimate the mean CFU to within 21 CFU with 95% confidence interval (CI) (B. Mc Donald, personal communication, April 10, 2006). A CI statistically quantifies the probable range which a population's parameter is expected to be situated (LoBiondo-Wood & Haber, 2006; Polit & Beck, 2006). Also, if chlorhexidine gluconate's effect wore off over time then statistical advice was that 120 agar plate samples was sufficient to detect a moderate trend by Spearman's rank correlation, with power exceeding 0.5 at the 10% significance level. For this study, a moderate trend was quantified as being that vaccinators whose hand hygiene interval was of a shorter time span (for example, 5 minutes), and have a mean CFU count one-fifth that of the vaccinators whose hand hygiene intervals were of a longer time span (90 minutes). Therefore, the chosen sample size reflects the pilot study budget, the MVP time schedule and the PHN population available.

3.42 Public health nurses

The participants were registered nurses working as PHNs and these people are likely to be representative of, or similar to, PHNs in other parts of New Zealand (G. Hinder, personal communication, April 10, 2006). The PHN workforce within ADHB is not constant, and not all nurses are able to vaccinate. Throughout the year PHN numbers fluctuate (due to resignations or illness), and not all positions are fulltime nor are all nurses accredited as independent vaccinators. So, the potential workforce able to consider participation in the study was uncertain until recruitment commenced.

The PHN workforce rostered to provide MVPs consisted of the Child and Youth Team nurses (allocated to primary, intermediate and secondary schools), and the Early Childhood Team nurses (assigned to children from birth to five years of age). But, working with school aged students is not part of the Early Childhood nurses contract. However, to maintain registration to practice at MVPs as an independent vaccinator, the Early Childhood nurses were required to participate in school based vaccination programmes annually. Accordingly, each year these nurses were rostered to attend two MVPs; one day to vaccinate and another day to assist in the post-vaccination recovery area.

3.43 Public health nurses' recruitment process

It was accepted by Northern X Regional Ethics Committee that all participant documents would be in English and not translated into other languages (see Appendix I). This dispensation was granted by the Northern X Regional Ethics Committee because nurses needed to have achieved a high level of English language competency to gain nursing registration in New Zealand (Nursing Council of New Zealand, 2003).

Recruitment for participants began with the researcher gaining an 'agenda item slot' to explain the study to PHNs at scheduled nurses' meetings with the Child and Youth and Early Childhood teams. Enrolment was open to all fulltime and part-time PHNs who were accredited independent vaccinators on an equal basis. Bearing in mind that the MVP hand hygiene guideline (see Appendix C) provides direction as to whether a PHN can, or cannot vaccinate on any occasion (due to skin problems or other infection risks) and this was a self-regulatory practice. At the meeting nurses were fully informed of the study's aims, purpose, format, participation and consenting processes, as well as confidentiality aspects of the study. Questions were invited from the PHNs and all queries were answered. It was explained that it was not possible to access to a vaccinator's individual laboratory results, due to participant anonymity pathways embedded in the study methods. Confirmation was provided that the study's findings were to be presented at a PHN team meeting by the researcher (post-thesis completion).

Additional processes were in place to safeguard participants' wellbeing. For example, if a participating nurse determined that immediate decontamination of hands was necessary (prior to data collection) then that nurse was released from involvement in that day's data collection and was able to attend to the hand hygiene issue without delay or consultation with the researcher. If any health concerns arose connected to the study then volunteers were advised they could contact ADHB Occupational Health Services, Accident Compensation Corporation and access the Health and Disability Advocate Service (see Appendix J). Finally, individual participant information and consent documents were left for nurses to peruse (see Appendix J).

3.44 Public health nurse consent

To be included in the study written consent by PHNs was necessary and this included confirmation that the information had been read and study guidelines understood. The time interval for PHNs to provide consent was requested to be within two weeks of the initial briefing but participants could be accepted until the study was completed. Completed consent forms were placed in an attached ADHB internal mail envelope, addressed to the researcher. On receipt of a consent form, the document was checked by the researcher to ensure all aspects were completed correctly. Participants received a copy of their consent form. The original consent documents were stored in a locked secure filing cabinet. At the end of the study these consents were handed to the researcher's first supervisor and subsequently placed in secure storage as per Massey University guidelines (Massey University, 2004).

3.45 Public health nurse consent withdrawal

Participant consent could be withdrawn by contacting the researcher or the research supervisors (in writing or verbally). No participant chose to withdraw consent at anytime during the study period.

3.46 Public health nurse participation

All PHNs who were eligible to participate volunteered to be part of the study and provided written consent. This meant that during three months of recruitment (July - September) 20 nurses from the Child & Youth team were able to participate, on one to four vaccinating occasions. The five consenting nurses from the Early Childhood team could only participate on one vaccinating occasion due to the stipulations of the ADHB vaccinator update programme. Hence, the maximum number of data collection points was potentially 85 occasions (both hands sampled = 170 agar plate specimens) if all participant opportunities were realised from the 25 PHN participants. The sample numbers were large enough to meet the guidelines for statistical analysis which was selected for this pilot study (B. McDonald, personal communication, April 10, 2006).

3.5 School vaccination programmes

3.51 Sampling process

A maximum of five participant nurses were sampled at each of the selected MVPs. Not all eligible vaccinators were included at any one programme either because of the time constraints to complete the immunisation programme or for the researcher to collect data. The researcher was provided with a team plan (roster) for nurses' allocation for each MVP by the immunisation team leader from which participants were initially selected for each school programme. From this MVP roster (see Appendix K) the eligible vaccinators' names were selected for sampling during that MVP. However, if fewer than five participants were available then a lesser number (two to four) were sampled. No participant was sampled more than once on any day.

A confidential list of consenting nurses was compiled by the researcher beside a four column spreadsheet (see Appendix K). This format allowed the date each participant was sampled to be recorded. Thus, when an eligible nurse provided the maximum of four flora samples collections this was readily apparent and the participant was informed that the maximum number of data collections was reached.

3.52 Participants' sampling occasions

In each of the selected school settings ($N = 17$) the number of participants varied according to the numbers of eligible vaccinators. The number of vaccinators participating at each selected MVPs are illustrated in Figure 2. At 76% of venues (13 MVPs) the maximum of five participants were able to be sampled. Four participants sampled at one MVP (6%). Three participants were sampled at two MVPs (12%), and two participants sampled at one MVP (6%). The study's data collection was completed over an eight week timeframe.

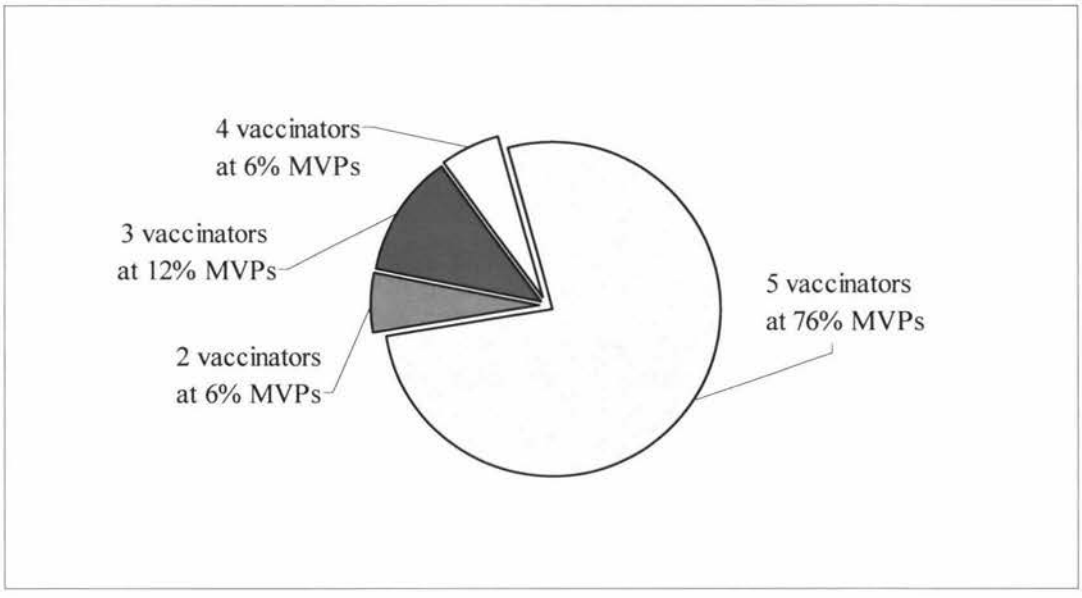

Figure 2 **Participants' sampled at each school setting**

Table 1 demonstrates how all PHN participants (N = 25) are accounted for during the 77 data occasions in which the study's 154 agar plate samples were gathered. The Child and Youth Team (n = 20 consenting) provided 148 agar plate samples from 74 collection occasions. The early Childhood Team (n = 5 consenting) provided six samples from three collection occasions.

Table 1

Summary of Consenting Nurses' Participation

Consenting PHNs Teams	One occasion	Two occasions	Three occasions	Four occasions	Flora samples collected both hands
Child and Youth	-	2 PHNs	2 PHNs	16 PHNs	74 occasions = 148 samples
Early Childhood	3 PHNs	-	-	-	3 occasions = 6 samples
Total PHNs	3	4	6	64	77 occasions = 154 samples

All of the Child and Youth Team PHNs (n = 20) were sampled however, two of the Early Childhood Team nurses (n = 5) were not sampled because data collection had ended (one nurse was on sick leave and one nurse had been rostered to a vaccinator role at a future MVP). Accordingly, 23 nurses were sampled and no PHNs chose to withdraw from the study thus, all participants were accounted for.

3.53 Transporting equipment

Agar blood plates were collected from specified storage facilities (LabPlus or Child and Youth Team) and the time was noted on the microbial data collection tracking form (see Appendix L). Extra plates were included in case any agar plates were inadvertently contaminated or damaged. The expiry date on the back of the agar plates was checked to ensure currency. A review of the agar plate surface and plate container was completed to confirm plates met microbiological collection standards. All plates were placed within secured plastic containers for transportation to and from each venue. The Technical Head of Microbiology (LabPlus) verified the transporting and collection methods met New Zealand laboratory standards for samples and unused media. The necessary stationery was assembled and placed in a lockable file for carriage and security. Privacy screens were collected from the PHNs resource room. Other items such as a mobile phone and a timing watch were packed. All equipment was then transported to the venue in the researcher's vehicle.

The researcher's work station (table) was sited within the vaccination venue. This was to allow easy data collection from the participants by being in close proximity to the vaccinators'. Arrival time at the schools was designed to be at least 40 minutes before vaccination commenced. This time period allowed sufficient time for locating the venue, setting up the researcher's station, making contact with participants and accounting for any traffic delays.

3.54 Setting up at the school venue

On arrival at the venue contact was made with the designated PHN co-ordinator for the school programme to confirm data collection was still permitted in that school setting. The

researcher's station was setup and portable screens assembled to provide privacy for both the participants and the researcher. The data collection table was covered to provide a clean surface with clinical paper sheets (disposable) and paperwork was arranged. Agar plates were rechecked for any damage in transit and if acceptable, the agar plates were numbered on their bases. Dominant hand agar plates were allocated uneven digits, and non-dominant hands an even number and noted on a sheet of paper in two columns (uneven and even numerals). Then the 'use by date' printed onto the Sterigel+ containers (150ml size) to be used by the vaccinators was checked to ensure currency and then placed at the vaccinators stations. To limit the likelihood of unintentional reapplication of Sterigel+ the researcher moved this container to the nearby equipment tables (once student immunisation commenced). If rapid hand decontamination was needed by a vaccinator then any nurse could still access the Sterigel+ promptly.

3.55 Participants' site briefing

Participants' met with the researcher individually prior to student vaccination commencing. Queries were answered and participants' collected a coloured folder containing data collection information (see Appendix M). Participants' also selected code numbers for their agar plate samples. PHN identification was protected as the plate numbers selected were not required to be sequential and thus afforded participant anonymity. To provide a temporary link from the agar plate's number to a participant and the folder colour (for example, pink) was recorded against the selected agar plate numbers by a 'post-it strip' (see Appendix N). The linking coloured 'post it' code was discarded at data collection.

3.56 At the vaccinator's station

When seated at their vaccination station the participants applied Sterigel+ to their hands and recorded the application time on the data collection sheet. The coloured folder and data sheet remained with the vaccinator and was brought to the researcher's station when data collection occurred. The occasion of microbial flora gathering was determined by each participant decision and the timing for hand hygiene was related to several factors. For example, the vaccinator's scheduled breaks, the duration of each programme and the vaccinator's judgment regarding potential hand contamination.

3.57 Sampling procedure

Each participant was seen separately behind privacy screens during agar plate sampling. This procedure promoted a relaxed environment and afforded privacy. The process for microbial collection was reviewed to ensure a consistent format was followed by all participants. The colour of the folder (brought by each participant) alerted the researcher to which agar plates had been pre-selected by that vaccinator. A large faced watch was placed near the agar plates to assist participants' to gauge the correct length of time for imprinting the agar media.

The dominant hand was always sampled first. This was accomplished by the participant gently pressing down onto the surface of the sterile blood agar plate for five seconds with all four finger-tips (palmar surfaces of the distal phalanges) and then placing their thumb on the same agar plate and gently pressing down (on a non-imprinted space for a five second period). Hence each hand was imprinted separately as the dominant or non-dominant hand, by a consistent method. It is acknowledged that the entire hand surface may carry bacteria of medical significance but this method (finger-tip press) was considered suitable for sampling nurses hands as it did not intrude into client care, was not time consuming or costly for this pilot study. Other authors have also chosen the finger-tip press sampling method (for collecting bacterial flora for similar reasons (Ayliffe et al., 1990; Gould et al., 2000; Kjolen & Andersen, 1992; Lucet et al., 2002; Widmer & Dangel, 2004).

The researcher noted the finger-tip press imprint time and time interval since Sterigel+ was last applied. The vaccinator's data sheet was checked and any unfinished sections completed before the participant departed to perform a standard hand wash. The researcher recorded the information onto the microbial data tracking form. To lessen the risk of inadvertently transcribing details on to an incorrect hand preference, the stationery was coloured. Green paper was provided for dominant data and yellow paper for non-dominant data. The date was written on the four column spreadsheet beside the participants' name (see Appendix K) to indicate which vaccinators were eligible for sampling at future MVPs and this information was confidential to the researcher.

3.58 Departing the venue

Following completion of data gathering at each MVP the PHN team leader was notified of this fact. The microbial data tracking forms were photocopied (as backup in case of loss or damage). The microbial data tracking forms and all other paper forms from that day were placed into an envelope and on the agar plate numbers range and the MVP date was written on the front of the envelope. Next the agar plate samples were transported to LabPlus accompanied by the original microbial data tracking forms. Contact was made via mobile phone with an assigned microbiologist who accepted the specimens at the laboratory door and then recorded this handover time on the microbial data tracking form (see Appendix L).

3.6 Microbial analysis processes

3.61 Pre-testing

A small pre-test (20 agar plates) was performed. This trial was a rehearsal for laboratory staff, the researcher and statistician on the data gathering process and to gain information on the numbers and species of CFUs that may be grown. LabPlus requested that all identification labelling be written on the plastic base of the agar media with a permanent marker pen. Identifying the plates in this way ensured that when the lids were off the plates (during microbial assessment) the plates remained identifiable.

The degree of laboratory assessment was principally determined by LabPlus microbiologists in consultation with the researcher. The organisms were grouped to typical habitat, pathogenicity and microbial CFU counts were performed. Several other studies truncated counting CFUs once counts exceeded 300 CFUs (Callaghan, 1998; Pittet et al., 1999a). However, following a review of the numbers of CFUs identified from the trial (with the statistical advisor and LabPlus staff) it was decided not to truncate as the results would be more meaningful if they could be accurately described. It was agreed following a discussion with a microbiologist that only aerobic cultures would be performed as it was unlikely that anaerobic flora would be found. Furthermore, anaerobic tests were costly and may have been beyond the fiscal resources of this study. This meant that the microbiologic

reviewing processes were in keeping with similar studies that have reported on bacterial contamination in clinical areas (Callaghan; Lucet et al., 2002; Palmer, 1999; Pittet et al.).

3.62 Agar plate media and sample incubation

The media used to propagate and grow the microbial flora gathered was tryptic soy agar plates with 5% sheep blood. An ADHB microbiology registrar confirmed this was the standard sterile blood agar plate culture medium employed by LabPlus. Blood agar grows a wide range of bacterial CFUs and consequently allows more accurate identification and enumerating of any microbial flora present (Alexander & Strete, 2001; Callaghan, 1998). The agar plates were incubated at 37°C under aerobic conditions for 48 hours, and then standard laboratory assessments were performed. Bacteria from the human body require a temperature range of 20-40°C for growth, and most human pathogens are incubated at around 37°C for approximately 48 hours (Alexander & Strete, 2001; Kjolen & Andersen, 1992; Murray et al., 2005; Tannock, 1995). Confirmation was provided by LabPlus that all agar plates used in the study would be disposed as per LabPlus protocols.

3.63 LabPlus reports

Bacteria were described by kingdom, family, genus and species or group and CFU counts were completed where possible. All LabPlus reporting information was recorded beside each agar plate's number on the accompanying microbial data tracking forms. This reporting process meant duplication of forms was not necessary and so errors in transcription were curbed prior to computer input. The microbiological results were handed to the researcher fortnightly. The envelope containing forms from each MVP and the microbial tracking forms with LabPlus reporting information were held in a locked file and later stored as per Massey University guidelines.

3.7 Statistical analysis

3.71 Initial data entry

The researcher entered all raw data into computer configuration by utilising Microsoft

Word and Microsoft Excel computer programmes (Microsoft Corporation, 2003). To ensure accuracy of data recorded, cross-checking was performed by the researcher. When data entry correctness was confirmed data were transferred to a statistical analysis programme by a Massey University senior statistician. Statistical analysis was conducted using MINITAB Release 14 computer software (MINITAB Incorporated, 2003). Statistical computations provide additional insight into the meaning of the data collected (Denscombe, 1998; McPherson, 2001).

Once these numerals were in the MINITAB programme, data cleaning was undertaken and this process resulted in identifying any data with missing or questionable values. Then decisions were made by the researcher (in consultation with the statistician and microbiologist) about how to handle this information. The only situations where 'missing' data occurred were when the number of CFUs could not be ascertained because the microbiologist deemed the colonies to be 'overgrown' or 'smudged'. These terms are defined section 4.41. Where overgrowth or smudge occurred but the microbial type could be identified, then this information was included in data on the numbers of times flora occurred. However, since the colonies could not be accurately counted the corresponding CFU number was recorded as missing and excluded from statistical modelling. Next data were formatted to allow for initial statistical analysis.

3.72 Data analysis

Data analysis commences with organising or summarising the data to look for pattern and order (Couchmann & Dawson, 1995) and accordingly this study followed that format when reviewing the data from the 77 vaccinator sampling occasions. Initially, the CFUs total counts and proportions of bacteria were described using standard descriptive statistics. The supervising statistician provided assistance to perform the statistical analyses and to summarise the data. The level of significance for statistical tests was set at a 5% probability of error ($p = <0.05$). Comparisons of CFU counts from dominant and non-dominant hands were made using Wilcoxon's Signed Ranked Test. Comparisons of CFU counts from convenience and non-convenience samples were made using the Kruskal-Wallis test. A

hypothesis test for whether there was a significant relationship between timeframe and CFU count was performed using the Spearman Rank Correlation.

Each of the above non-parametric hypothesis tests can be used whether or not the data are normally distributed, and since the CFU counts were not normal, these were deemed the most reliable tests. The methods are all based on the ranks of the CFU counts, for example the lowest-ranking (smallest) CFU count is given rank 0, the next smallest CUF count rank 1, and so on up to the largest CFU count being given rank equal to the number of data points. So a trend for, say, the non-convenience sample to have higher CFU counts than the convenience sample, leads to the non-convenience group having higher mean ranks. The Wilcoxon, Kruskal-Wallis and Spearman tests all look for whether the mean rank is significantly different to what one would expect by chance (Jackson, 2006).

In addition, regression analysis was used to quantify the trend for CFUs to increase with time, and the effects of convenience versus non-convenience samples. Regression analysis requires the random errors from the line to be normally distributed, and so to accommodate this $\log_2$ (CFU count) was analysed instead of the ordinary count. A log scale is frequently used by statisticians to analyse data relating to concentrations or exponential growth of micro-organisms (Rosner, 1990). Using the $\log_2$ scale means that if one agar plate has twice the CFUs of another plate, then that plate scores one unit higher on the $\log_2$ scale, a fourfold difference is two points higher and so on, a fact that aids visual interpretation of the resulting scatter plot. Statistical review of the results and confirmation that data was displayed authentically was provided by senior statistician Dr B. McDonald from Massey University's (Auckland), Institute of Information and Mathematical Sciences.

3.8 Ethical considerations

3.81 Ethics approval

A pilot study requires the same robust research and ethical processes as a larger study (Granger & Chulay, 1999; Grant & Giddings, 2002; Van Teijlingen & Hundley, 2002).

Ethical approval was sought and granted in 2006 from the Northern X Regional Ethics Committee, Auckland District Health Board's Ethics Committee and Massey University Ethics Committee: Northern (see Appendix I). The study was under the auspices of three supervisors based at Massey University (Auckland) with the principal supervisor having responsibility for overseeing the study. The Team PHN Manager (Child and Youth Team) confirmed that the study had the endorsement of nurses within PHN teams and formal consent was granted to access the PHNs the MVP school setting by approval gained though an ADHB locality agreement. This locality agreement was submitted as part of the ethics application to Northern X Regional Ethics Committee. Written letters of support were provided from ADHB Service Manager Medical Services and Community Services (Child Health), Child and Youth Teams Medical Officers, Immunisation Advisory Centre Regional Co-ordinator and Waitemata District Health Board's PHN Professional Nurse Leader (see Appendix O). No participant recruitment was commenced prior to ethical approval being granted by all three ethics committees and approved by Massey University Supervisors (July, 2006). The researcher was not a participant in the study.

On completion of the study all original participant consents, associated study documents and laboratory reports were handed over to the researcher's principal supervisor to be stored by Massey University for 10 years. This material will then be destroyed as per Massey University protocols. Confirmation of the field study's completion was provided in a report submitted to Ethics committees at Northern X Regional Ethics Committee, ADHB and Massey University with (additional reports sent to Maori and Pacific Advisors consulted (as a courtesy). All ethical bodies accepted this report.

3.82 Cultural consultation

One of the fundamental responsibilities in clinical research in New Zealand is to maintain the principles of the Treaty of Waitangi, that is, partnership, participation and protection with tangata whenua (Maori) (Wood & Schwass, 1993). To meet these obligations, and prior to seeking ethical approval, the study was discussed initially with the Child Health Team's Kaiwhakahaere (Maori Advisor in Health Promotion) and later with ADHB's Chief Advisor, Tikanga.

Human tissue and fluids are regarded by Maori as taonga (cared for as a treasure) or are tapu (treated with caution) (Sporle & Koea, 2004). However, "The process of consent to the taking of tissue and body fluids (as part of a research protocol) amounts to entrusting the researcher with this taonga" (Sprole & Koea, p. 5). The collection of hand flora and the potential collection of tissue (skin cells) were acknowledged as taonga and through discussion assurances were given that all material gathered would be treated respectfully and disposed of properly by the researcher and LabPlus. Subsequently, no areas were identified (within the study) that could cause unnecessary harm to Maori and no adjustments to the study were needed to meet cultural needs as required by Massey University's code of ethical conduct for research (Massey University, 2004). Also, on an informal basis the study was discussed with Pacific nurses from both the Early Childhood and Child and Youth PHN teams to identify any cultural issues related to the data gathering process. Then consultation with Auckland Regional Public Health Service's Pacific Health Development Manager was arranged, and again no areas of concern were identified. Formal letters of support were received for the study from the Chief Advisor, Tikanga and the Pacific Health Development Manager (see Appendix P).

3.83 Anonymity and confidentiality

Privacy issues relating to the New Zealand Privacy Act, Massey University policy and the Health and Disability ethical guidelines were considered in the handling, description and storing of participants and research data (Massey University, 2004; New Zealand Office of the Privacy Commissioner, 1993).

Abbott and Sapsford (1998) maintain that challenges, both personal and ethical may occur when the researcher is known to the participants. It was recognised that the researcher was a PHN team member and this relationship could result in difficulties for the PHNs and researcher. A process was established so that any participant issue could be taken to the team leaders, Massey Supervisors or directly to the researcher to be addressed. The researcher was to contact a Massey Supervisor initially if an issue arose related to the study. No personal or ethical issues emerged (from either participants' or the researcher) so the process pathway was not implemented.

Participant and data confidentiality, and the provision of anonymity, were important ethical responsibilities. The literature suggests considering how to provide such safeguards for the participant and encourages researchers to be accountable, to explain clearly what they wish to achieve, and how this will be accomplished (Alderson & Goodey, 1998; Gillis & Jackson, 2002; LoBiondo-Wood & Haber, 2006). Accordingly, sensitivity to possible identification through data reporting was carefully addressed. Assurance was reiterated that the identity of nurses choosing to participate or not to participate was confidential to the researcher. Therefore, the decision to be part of the study was to be made freely by each nurse on the basis of informed personal choice and would not reflect on professional standing, or influence employment within the team.

Participating vaccinators were not the only people that may have been concerned about protecting their identity as the study was conducted within school settings, and the data results could potentially reflect negatively on students attending the school. For example, if highly pathogenic organisms were found and linked to a particular setting this may be detrimental to members of the school community. The recording process did not link any participant's or school settings by name to a microbial result. Thus school, student, and nurse identity was protected and privacy and respect for the groups involved in the study shown.

3.84 Reliability and validity

This study is pilot research and is an original study in this area of health practice. Consequently, the reliability and validity measures are not readily enumerated as few similar studies are comparable, and therefore prior evidence was limited. Brink and Wood (2001) contend external validity refers to the extent research findings are generalisable whereas, internal validity is the extent to which the findings can be ascribed to the action of the variable described. Hence, via descriptive statistical analyses the residual microbial effects of chlorhexidine gluconate 0.5% (within Sterigel+) on vaccinators hand flora will be shown over time. The population has been clearly defined and generalisability may be limited to similar areas of nursing practice in comparable settings.

LoBiondo-Wood and Haber (2006) argue that content validity requires considerable rigour from both the researcher and an expert panel. Whereas face validity (an unsophisticated subtype of content validity), essentially reflects the idea the researcher intends to measure. Face validity is a valuable tool in tool development (LoBiondo-Wood & Haber). As pilot research, the study simply sought face validity. Face validity was determined primarily through PHN peer review of the survey tool. Then the completed proposal was submitted to Massey University supervisors (overseeing the study) for comment and later to ethical bodies for suitability and ethical soundness (as part of the process for gaining ethical consent) for the study to proceed.

Nieswiadomy (2008) maintains that reliability and validity are closely connected and need to be considered when choosing a research instrument. Polit and Beck (2006) contend that instrument reliability can be considered as 'accuracy' that is the regularity with which a tool measures the characteristic. Nevertheless, a tool cannot be valid unless it is reliable, but it can have reliability and low validity (Nieswiadomy, 2008). Several authors (Fain, 1999; LoBiondo-Wood & Haber, 2006; Sapsford, 2007) emphasise validity is reviewed firstly from the viewpoint that the data constitutes an accurate measurement of what was supposed to be measured. For example, in this study numerical values to reflect the properties of the data gathered. Even so, validity is not an all or nothing concept but rather supported by an accumulation of evidence (Fain; Polit & Beck). Secondly, all participants and participant occasions were accounted for. Thirdly, the methods utilised to complete this descriptive survey were appropriate to gain data and to provide evidence pertinent to the specific clinical setting.

As a measure of reliability the researcher strived to provide accurate and trustworthy data (LoBiondo-Wood & Harber, 2006; Sapsford, 2007). All data were meticulously collected by the researcher with uniformity of data gathering procedures to minimise chance errors occurring. For example, all scores recorded in the field to the convenience or non-convenience (yes or no) questions were double checked once by a numerical count and later by calculator addition to eliminate the possibility of tallying errors. The original data forms used to record agar plate numbers and other field information were handed to the laboratory

and all assessment results were entered onto these documents. The agar plate samples gathered on any day were low (8-16) hence, data checking was not an arduous task

The methods used for agar media storage, transport, checking and gathering participants hand flora were consistent and attention was paid to the appropriate handling and delivery of data to LabPlus microbiology staff. As earlier mentioned, the agar plate collection and assessment processes were pre-tested, to identify and resolve any systems problems. The examination of flora was standardised and performed by qualified microbiologists using equipment that met laboratory accreditation standards. However, with laboratory assessment the tool becomes more than a microscope and method; it encompasses the assessment skills of the microbiologist reviewing the flora. Hence the study relies on the professional competence of the laboratory personnel. Because of this and the fact that repeated measurements or independent review on the same data was not performed, reliability of assessment is accepted as standard laboratory practice and not otherwise quantified. Nevertheless, the support provided by a statistician (utilising academically recognised statistical computer analyses programmes) to look for error and to substantiate results contributes to the reliability of results presented. Accordingly, the acknowledged reliability achieved from the descriptive results therefore enhances the study's validity claim for this pilot study.

3.9 Summary

Chapter three has described the theoretical rationale which underpins the study and found that the research methodology selected was appropriate for the research question. Employing a non-experimental descriptive survey design permitted the prevalence of the microbial flora in its natural setting to be described, and measured. Choosing to limit the enquiry size to a pilot study enabled the study to be realistic time wise, be financially feasible and provided sufficient data to support reliability and validity of the instruments utilised. The processes involved in recruitment were fully discussed and all school settings and PHNs participants were accounted for. Ethical considerations and cultural consultations were shown to be considered and no issues were identified. Autonomy and respect have

been demonstrated by confirmation that participants and schools were fully informed. The researcher has endeavoured to ensure no harm to volunteers or school communities thus beneficence has been shown. Microbiological processes met New Zealand standards. The researcher collated the data with statistical review provided through Massey University.

This chapter has provided enough information to allow replication of the study. In the following chapter the study results are presented. The findings encompass the participants' reasons for hand hygiene, timeframes between hand cleansing episodes, a description of organisms cultured from agar plate samples and statistical examination of data related to the study's aims and research question.

Chapter Four: Results

4.1 Introduction

The previous chapter has detailed the research approach, methodology and methods selected for this study. This chapter presents the microbial evidence gathered during the study with data collection details and laboratory assessment findings presented through descriptive statistics. Ancillary data gathered relates to vaccinators reasons for hand cleansing and the timeframes between hand hygiene episodes. Regression analysis was used to reveal the effect of time, and reason (convenience or non-convenience) on CFU counts by the action Sterigel+. Any suspected effects were quantified using nonparametric or normal-based statistical methods.

Participants' convenience and non-convenience reasons for hand hygiene are depicted in section 4.2 and the time intervals for hand hygiene episodes shown in section 4.3. In sections 4.4-4.43, the laboratory reports on flora cultured from participants samples are described by standard descriptive statistics, and the findings are displayed through tables and figures, to illustrate the key points. The pathogenicity of the flora cultured and the rate organisms were gained over time on vaccinators' hands are described in section 4.44-4.45. In section 4.46 the effect of chlorhexidine gluconate 0.5% was revealed from data showing an increase in CFUs over time. This data is illustrated through scatter plots identifying hand dominance, and delineated by, vaccinators' reasons for hand cleansing. Lastly, a summary of the findings are given in section 4.5.

4.2 Participants' reasons for hand hygiene

Eighty-four percent (n = 65) of participants provided convenience samples (that is, elected to perform hand hygiene at a suitable time such as, a morning tea break or the end of the MVP). Non-convenience samples were provided on 16% occasions (n = 12) (that is, PHNs identified a possible cross infection risk (see Figure 3).

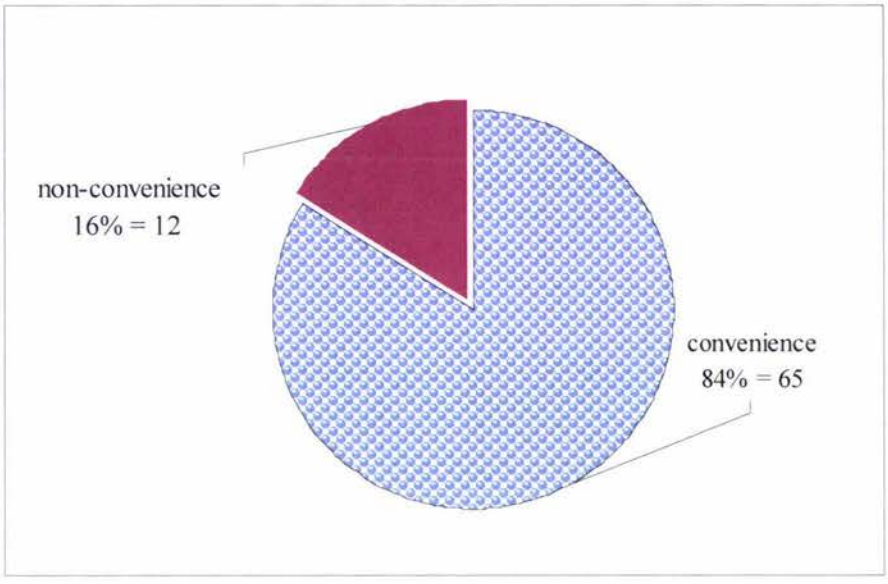

Figure 3 **Convenience versus non-convenience responses (*N* = 77)**

4.3 Participants timeframes for hand hygiene

The timeframe from the application of Sterigel+ and the next episode of hand hygiene ranged from 7-90 minutes for 65 convenience samples while the 12 non-convenience samples ranged from 5-46 minutes (see Figure 4).

Depicted in Table 2 are the participant convenience and non-convenience responses between participants hand hygiene episodes (post Sterigel application) at the 77 data gathering occasions. The mean time to decontamination was 37.35 minutes (standard deviation of 19.62 minutes) for convenience responses which was longer than the non-convenience responses mean time of 26.08 (standard deviation of 12.06 minutes). This difference in time range had to be taken in to account when comparing the convenience and non-convenience CFU data. This is discussed further in section 5.22.

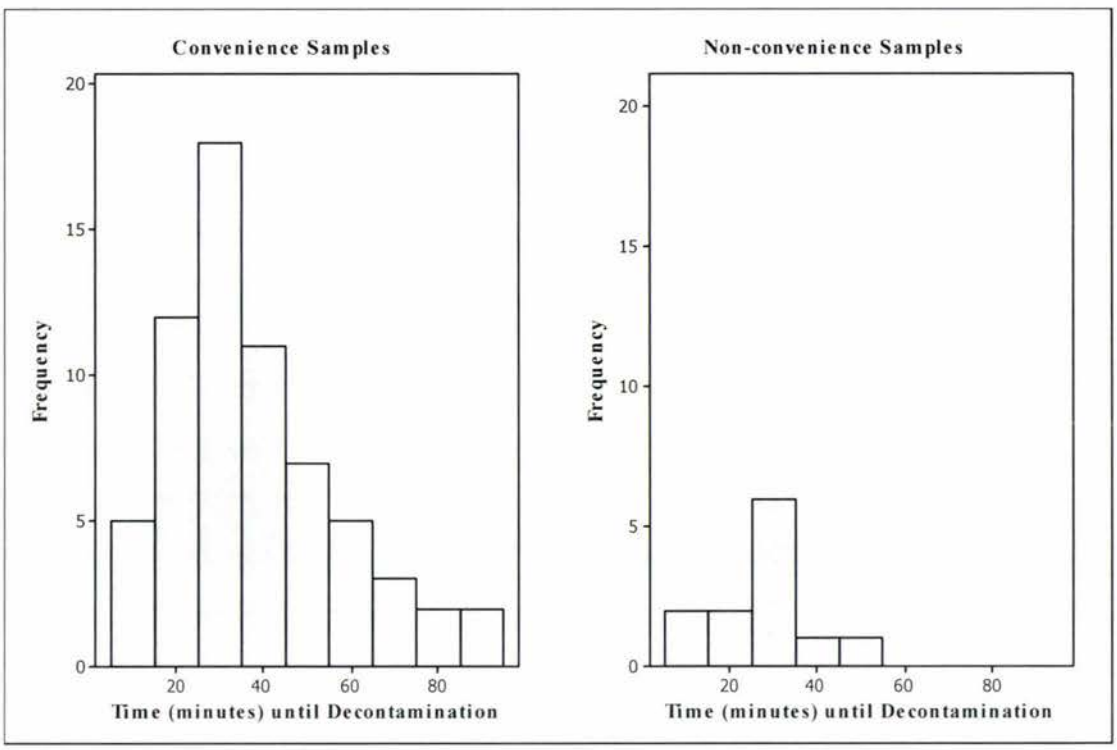

Figure 4 **Timeframes for hand hygiene following Sterigel+ application**

Table 2

Participant Responses Showing Hand Hygiene Timeframes in Minutes **($N = 77$)**

Sample	Minimum time	Mean	Standard deviation	Quartile 1	Quartile 2 Median	Quartile 3	Maximum time
Convenience	7	37.35	19.62	22.50	33.00	49.50	90
Non-convenience	5	26.08	12.06	22.00	25.00	32.50	46

4.4 Microbial flora

4.41 Agar plate colony counts

Following 48 hours incubation at 37°C at LabPlus, agar plates were reviewed for CFUs. A total of 150 of the 154 agar plate samples were culture positive. The remaining four agar plate samples recorded zero organism growth. Two of the four plates with a zero count were from dominant hands, with collection times of seven and eight minutes. The collections from the two non-dominant hands with zero counts were at five minutes and 34 minutes, respectively.

The samples with undetermined CFU counts (n = 14) were identified as 'smudge' or 'overgrown'. The organisms reported from these 14 plates were identified and the flora was not different to flora cultured on other samples. Smudge was described as unable to be counted as the colonies were not discrete, and was reported on eight agar plates (two dominant and six non-dominant hands). Overgrown was defined as unable to be counted accurately because some flora had overrun other flora on the agar plate and was reported from six agar plates (four dominant hands and two non-dominant hands). On one sampling occasion however, a participant had both their hand samples identified as smudge/overgrown.

Examination of the flora resulted in 16 microbial entities being culture positive from the agar plates. Detailed in Table 3 are the computer microbial database abbreviation, the name of each organism and taxonomic categorisation (kingdom, family, genus, species or group). Different levels of specificity were accomplished as determined appropriate by LabPlus. For example, fungi were considered of low pathogenicity and classified to kingdom, whereas identification down to species was made to identify *Staphylococcus aureus,* as this bacterium is associated with cross infection.

Table 3

Microbiology Database Abbreviations and Terms

Abbreviation	*Nomenclature*	*Kingdom/Family/Genus/Species/Group*
ACI Spp	*Acinetobacter* spp.	Genus
AHS	Alpha haemolytic streptococcus	Genus
ASB	Aerobic sporing bacillus	Genus
CNS	Coagulase negative staphylococci	Family
CORSP	*Corynebacterium* spp.	Genus
Fungi	Fungi	Kingdom
GNB	Gram-negative bacillus	Family
GPB	Gram-positive bacteria	Family
Micrococcus	*Micrococcus* spp.	Genus
Neisseria	*Neisseria* spp.	Genus
NFNB	Non-fermative Gram-negative bacillus	Group
Proteus spp	*Proteus* spp.	Genus
S. aureus	*Staphylococcus aureus*	Species
Staph spp	*Staphylococcus* spp.	Genus
Strep spp	*Streptococcus* spp.	Genus
Yeast	Yeast (not *Candida albicans*)	Group

In Table 4 a synopsis of the microbial data from all samples (N = 154) is provided. Also shown are the number of zero (0) CFU count occasions for each specified organism. The percentages of CFU counts from each agar plate are provided to illustrate the count range of flora in the samples. For example, 50% $\leq$ 20 means that 50% of the plates had no more than 20 CFUs and 95% 0 means that 95% of the plates had none of these organisms present. Detailed microbial information from each agar plate is offered through a laboratory summary spread sheet report (see Appendix Q).

Table 4

Summary of Combined Hands CFU Counts on Agar Plates (N = 154)

Organisms	Number of plates without the specified organisms	Percentage of CFUs	Maximum CFUs	Overgrown agar plates	Smudge agar plates
Any CFUs	4	50% ≤ 20 75% ≤ 35	215	6	8
Overgrown	148	-	no count	6	-
Smudge	146	-	no count	-	8
ACISP	139	95% ≤ 3	6	-	1
AHS	128	95% ≤ 3	8	-	1
ASB	81	95% ≤ 3	68	3	4
CNS	20	50% ≤ 7 75% ≤ 20 95% ≤ 69	210	2	8
Corny spp	121	95% ≤ 4	11	1	-
Fungi	153	95%0	1	-	-
GNB	127	95% ≤ 2	13	-	2
GPB	145	95% ≤ 1	16	-	-
Micrococcus	65	50%≤ 1 75%≤ 6 95% ≤ 16	56	1	5
Neisseria	147	95% 0	3	-	-
NFNB	139	95% ≤1	106	-	-
Proteus spp	153	95% 0	0	1	-
S.aureus	146	95% ≤1	10	-	-
Staph spp	150	95% 0	10	-	-
Strep spp	150	95% 0	3	-	-
Yeast	150	95% 0	2	-	-

Note. Percentage of CFUs column illustrates the range of CFU counts from each agar plate.

4.42 Flora Categories

The microbial CFUs shown in Table 4 are now presented in Table 5 within four categories related to their typical habitat as determined by LabPlus.

- A = Skin flora (Gram-positive)
- B = Environmental organisms
- C = Oral (oropharyngeal) flora
- D = Gram-negative bacilli

Table 5

Flora Category Types

Type	*Category*	*Flora Abbreviation/database term*
A	Skin flora	CNS, Corny spp, GPB, Micrococcus, S.aureus, Staph spp, Strep spp, Yeast
B	Environmental organisms	ASB, Fungi
C	Oral flora	AHS, Neisseria
D	Gram-negative bacilli	GNB, NFNB, ACI spp, Proteus spp.

Participants sample data ($N = 77$) from the 154 agar plates (dominant and non-dominant hands) were examined and any samples with missing values were excluded. This resulted in 128 agar plates remaining which comprise the 'paired samples' ($n = 64$). Colony forming units of the paired hands are illustrated by percentage from each flora category type, in Figure 5. From this paired hand data skin flora predominates (85%), then Gram-negative flora (7%), followed by environmental organisms (6%) and the smallest category identified, oral flora (2%).

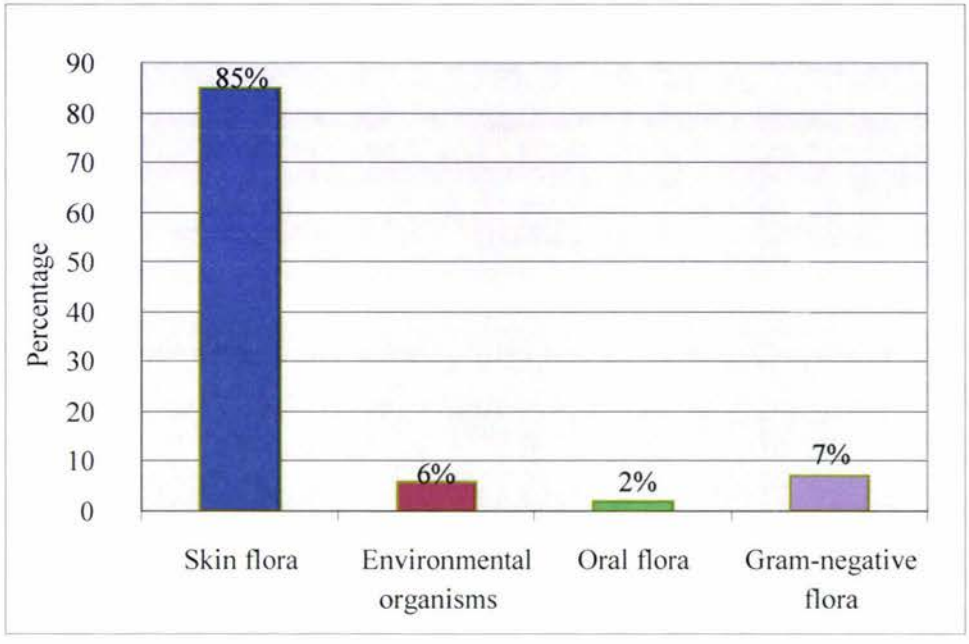

Figure 5 **Flora categories from paired hands by percentage of CFUs**

The proportion of times that each of the individual CFU organisms appeared on the total number of agar plate samples reviewed (N = 154) from dominant and non-dominant hands are categorised and further delineated in Figure 6. Coagulase negative staphylococci account for the highest percentage of CFUs at 86% of dominant hands and 88% of non-dominant hands. *Micrococcus* spp., is next at 57% of dominant hands and 58% of non-dominant hands. Both of these bacteria are from the skin flora category and percentages revealed negligible differences in CFU counts related to hand dominance. However, aerobic sporing bacillus (environmental organism) shows 52% CFUs from dominant hand compared to 42% from non dominant hand. All other organisms show minimal dissimilarity related to hand dominance. At 1% each, fungi and *Proteus* spp., had the lowest proportion of CFUs.

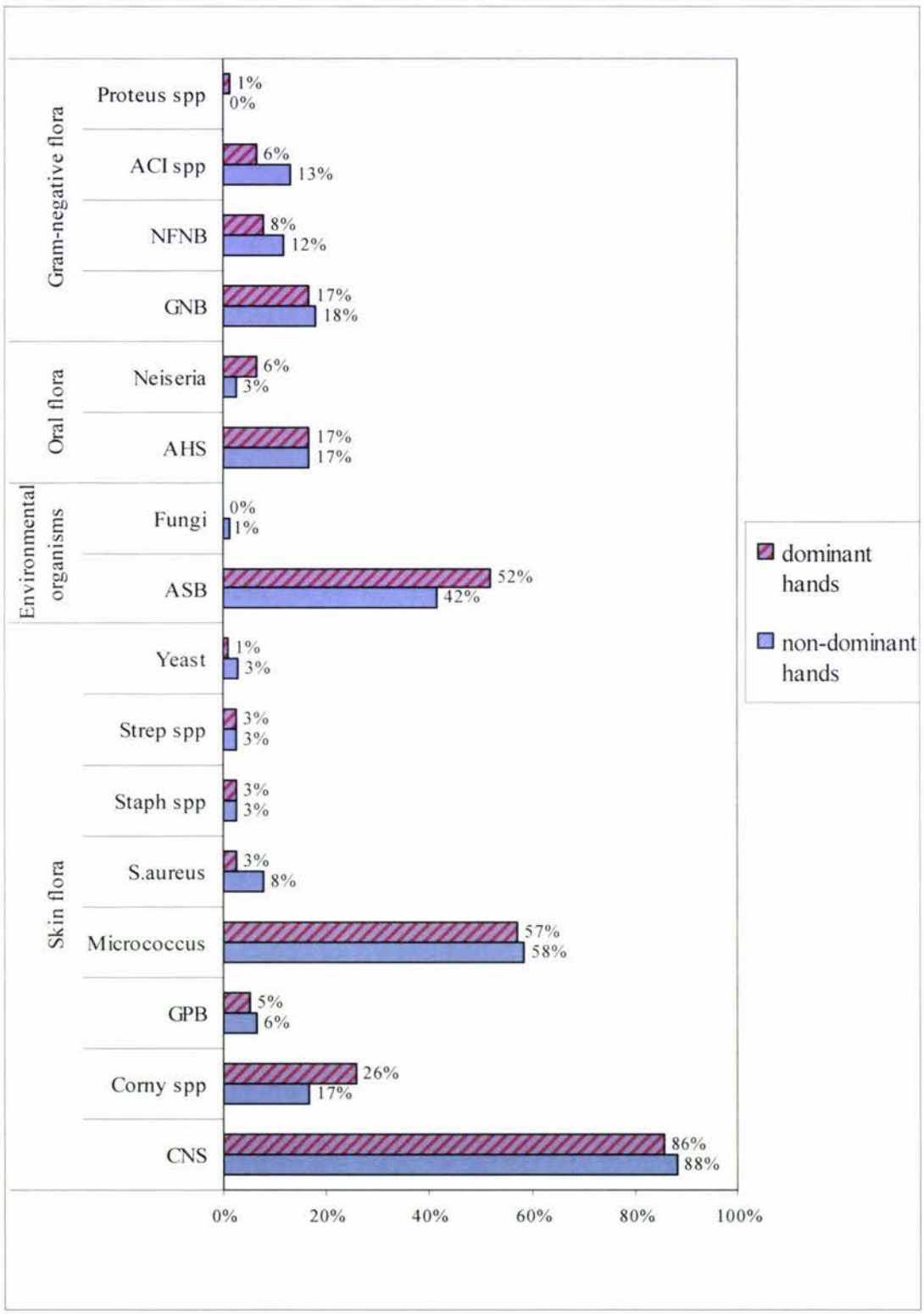

Figure 6 **Percentage of agar plates samples with organism present ($N = 154$)**

Until now there has not been any published data on micro-organisms cultured from the hands of PHNs during mass vaccination programmes. The actual number of times and the proportion of samples organisms that were culture positive was identified by hand dominance. Table 6 shows the distribution of flora CFUs from all nurses where complete data (both hands) was available (n = 64). This permits a comparison between dominant and non-dominant hands to be shown. Data are presented within the flora categories of skin flora, environmental organisms, oral flora and Gram-negative bacilli. The results showed little difference between dominant and non-dominant hands in terms the relative frequency of culture-positive agar plates for the various organisms.

Table 6

Identifying by type and proportion organisms from paired hand samples (n = 64)

Flora category and organism	Number of dominant CFU plates	Proportion of dominant CFU plates	Number of non-dominant CFU plates	Proportion of non-dominant CFU plates	Totals of paired hands CFU plates	Proportion of paired hands CFU plates
Skin flora						
CNS	66	0.86	68	0.88	134	0.87
Corny spp	19	0.25	13	0.17	32	0.21
GPB	4	0.05	5	0.06	9	0.06
Micrococcus	44	0.57	45	0.58	89	0.58
S.aureus	2	0.03	6	0.08	8	0.05
Staph spp	2	0.03	2	0.03	4	0.03
Strep spp	2	0.03	2	0.03	4	0.03
Yeast	1	0.01	3	0.04	4	0.03

Table 6 (continued)

Identifying by type and proportion organisms from paired hand samples (n = 64)

Flora category and organism	Number of dominant CFU plates	Proportion of dominant CFU plates	Number of non-dominant CFU plates	Proportion of non-dominant CFU plates	Totals of paired hands CFU plates	Proportion of paired hands CFU plates
Environmental organism						
ASB	41	0.53	32	0.42	73	0.47
Fungi	0	0	1	0.01	1	0.01
Oral flora						
AHS	13	0.17	13	0.17	26	0.17
Neisseria	5	0.06	2	0.03	7	0.05
Gram-negative bacilli						
GNB	12	0.16	14	0.18	26	0.17
NFNB	6	0.08	9	0.12	15	0.1
ACI spp	5	0.06	10	0.13	15	0.1
Proteus spp	1	0.01	0	0	1	0.01

Figures 7 and 8 summarise the CFU data from dominant and non-dominant paired hands. Skin flora predominates in dominant (83%) and non-dominant (87%) samples gathered from paired hands (n = 64). Environmental organisms were similar, dominant hand 5% and non-dominant hand 6%. Oral flora at 2% was the same for both hands. However, Gram-negative flora was higher (10%) in the dominant hand samples than the non-dominant samples (5%). Overall, there were 23% more CFUs on the non-dominant hands (1678 CFUs) than on dominant hands (1294 CFUs). Gram-negative flora made up a larger proportion of the flora found on dominant hands compared to non-dominant hands but no other striking difference in distributions is apparent.

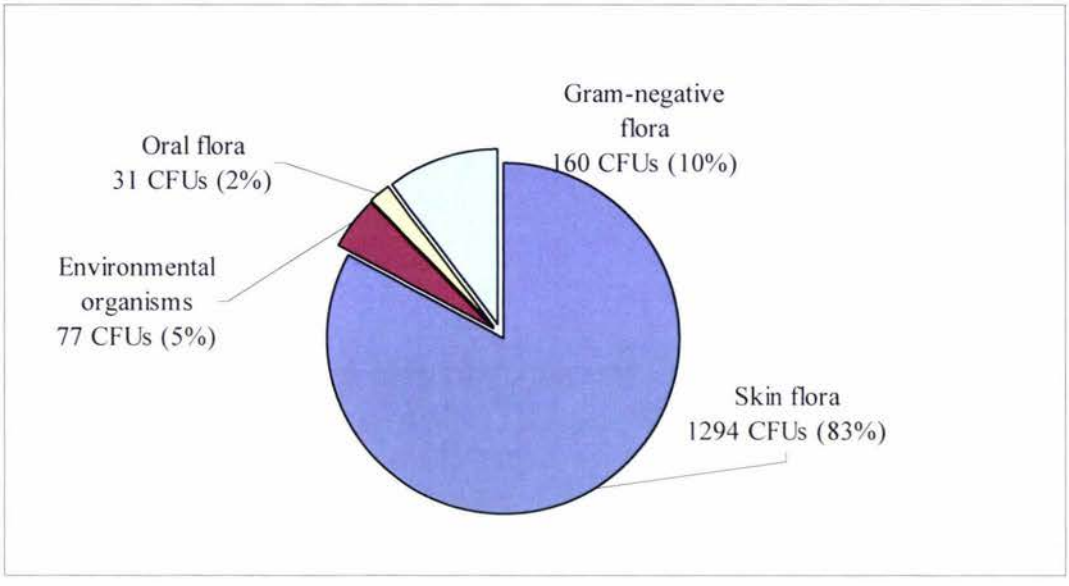

Figure 7 **Dominant hands flora categories**

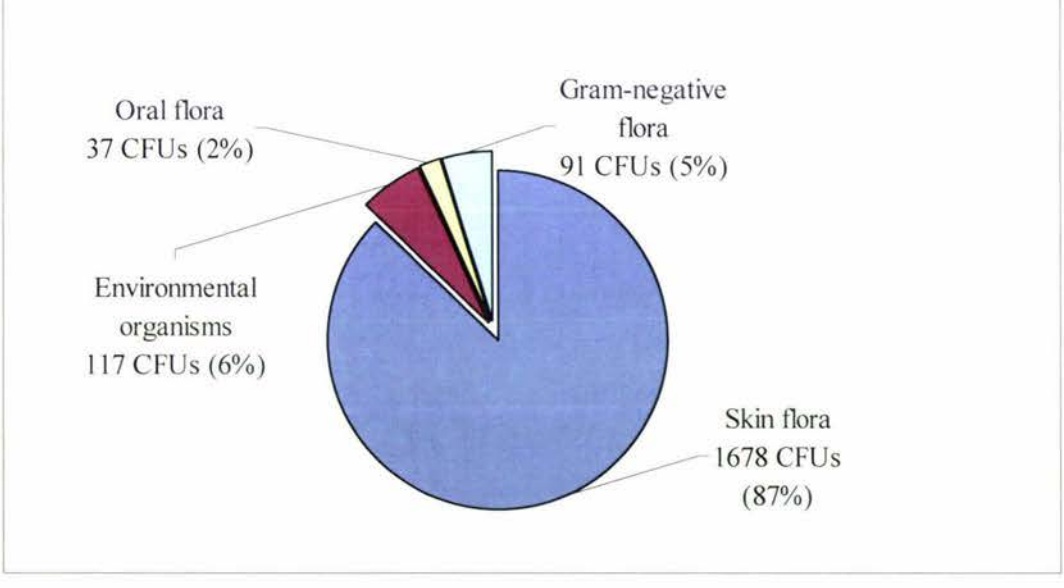

Figure 8 **Non-dominant hands flora categories**

4.43 Frequency of organisms

The frequency that each organism appears on agar plate samples ($N = 154$) are shown in Tables 7A and 7B and are displayed for dominant and non dominant hands respectively, excluding data from overgrown and smudge agar plates. The organism found most frequently was ranked first and accordingly the organisms that were identified less

frequently have a lower ranking. The first six organism's types (coagulase negative staphylococci, *Micrococcus* spp., aerobic sporing bacillus, *Corynebacterium* spp, alpha haemolytic streptococcus and Gram-negative bacillus) are similarly ranked (see Tables 7A and Table 7B). For example, first ranked coagulase negative staphylococci were on 63 dominant agar plates and 61 non-dominant agar plates. Second ranked *Micrococcus* spp., were on 41 dominant agar plates and 42 non-dominant agar plates. The proportion of flora occurring on agar plates samples for all other organism types was less prevalent being reported on fewer than 10 agar plates in both dominant and non dominant samples.

Table 7A ***Frequency of Organisms on Dominant Hands (n = 71)***

Placed	Types	Flora	Number of agar plates
1	A	Coagulase negative staphylococci	63
2	A	*Micrococcus* spp.	41
3	B	Aerobic sporing bacillus	39
4	A	*Corynebacterium* spp.	19
5 =	C	Alpha haemolytic streptococcus	12
5 =	D	Gram-negative bacillus	12
7	D	Non-fermative Gram-negative bacillus	6
8 =	D	*Acinetobacter* spp.	5
8 =	C	*Neisseria* spp.	5
10	A	Gram-positive bacteria	4
11 =	A	*Staphylococcus aureus*	2
11 =	A	*Staphylococcus* spp.	2
11 =	A	*Streptococcus* spp.	2
14	A	Yeast (not *Candida albicans*)	1
15 =	B	Fungi	0
15 =	D	*Proteus* spp.	0

Note. Order of organism frequency on agar plates (excludes overgrown and smudge agar plates)

Table 7B ***Frequency of Organisms on Non-dominant Hands*** **(*n* = 69)**

Placed	Types	Flora	Number of agar plates
1	A	Coagulase negative staphylococci	61
2	A	*Micrococcus* spp.	42
3	B	Aerobic sporing bacillus	27
4 =	C	Alpha haemolytic streptococcus	13
4 =	A	*Corynebacterium* spp.	13
4 =	D	Gram-negative bacillus	13
7 =	D	Non-fermative Gram-negative bacillus	9
7 =	D	*Acinetobacter* spp.	9
9	A	*Staphylococcus aureus*	6
10	A	Gram-positive bacteria	5
11	A	Yeast (not *Candida albicans*)	3
12 =	C	*Neisseria* spp.	2
12 =	A	*Staphylococcus* spp.	2
12 =	A	*Streptococcus* spp.	2
15	B	Fungi	1
16	D	*Proteus* spp.	0

Note. Order of organism frequency on agar plates (excludes overgrown and smudge agar plates)

For smudge and overgrown plates the first three organisms were similarly ranked from dominant and non-dominant hands (coagulase negative staphylococci, *Micrococcus* spp., and aerobic sporing bacillus). Next on dominant hands, alpha haemolytic streptococcus and *Proteus* spp., were reported each on one occasion and likewise on one occasion *Acinetobacter* spp., and Gram-negative bacillus each were reported from non-dominant hands. No other organisms were culture positive on smudge or overgrown agar plates.

4.44 Pathogenicity of flora

Consultation was held with LabPlus regarding the microbial results and some organisms were termed as 'low pathogenicity' and others as 'high pathogenicity', bearing in mind that all organisms given the 'right' circumstances, can cause invasive disease (M. Bilkey, personal communication, October 26, 2006). The organisms gathered from vaccinators' hand flora considered as being of low pathogenicity were *Acinetobacter* spp., alpha haemolytic streptococcus, aerobic sporing bacillus, Coagulase negative staphylococci, *Corynebacterium* spp., fungi, Gram-positive bacteria, *Micrococcus* spp., *Neisseria* spp., non-fermative Gram-negative bacillus, *Staphylococcus* spp., *Streptococcus* spp., and yeast (not *Candida albicans*). However, *Staphylococcus aureus* and Gram-negative bacteria including *Proteus* spp., (excluding *Acinetobacter* spp., and non-fermative Gram-negative bacillus) were identified of high pathogenicity. Table 8 provides details of the times (post-hand hygiene) when these highly pathogenic organisms were collected, and whether the vaccinators' reason for cleansing hands was convenience or not. On three 'data gathering occasions' (33, 63 and 75 minutes) both *Staphylococcus* spp., and Gram-negative bacilli were culture positive on either or both of a participant's hand samples.

Table 8

Organisms of High Pathogenicity

Organism	Timeframe minutes	Convenience (yes/no)	Dominant hand CFUs	Non-dominant hand CFUs
Staphylococcus aureus	22	no	-	3
	30	yes	-	2
	33*	no	6	10
	33	yes	5	8
	63*	yes	-	1
	75*	yes	-	1
Proteus spp.	33	yes	overgrown	1

Note. * indicates both S.aureus and GNB were reported on the agar plate of this timeframe

Table 8 (continued)

Organisms of High Pathogenicity

Organism	Timeframe minutes	Convenience (yes/no)	Dominant hand CFUs	Non-dominant hand CFUs
Gram-negative bacillus	15	yes	1	-
	16	yes	1	2
	22	yes	1	-
	25	yes	1	-
	25	no	10	13
	27	yes	-	4
	27	no	2	1
	27	yes	smudge	-
	31	yes	-	1
	31	no	-	1
	32	yes	-	2
	33*	no	2	1
	37	yes	1	-
	40	yes	-	smudge
	42	yes	-	1
	43	yes	2	-
	45	yes	5	-
	49	yes	-	1
	63*	yes	-	3
	65	yes	4	10
	75*	yes	1	1

Note. * indicates both S.aureus and GNB were reported on the agar plate of this timeframe

Table 9 provides a synopsis of CFU counts from the combined hands agar plate results presented in Table 5 (p.73), and illustrates how many occasions each particular potentially pathogenic organism was recorded. Further consultation with a LabPlus microbiology registrar confirmed that the overgrown *Proteus* spp., plate should be regarded as belonging in the Gram-negative category. Eight agar plates from the sample (N = 154) were reported as culture positive for *Staphylococcus aureus* however, the CFU counts were low with 95% of these plates recording one or less CFU. The highest count was 10 CFUs of *Staphylococcus aureus* and the overall proportion from the sample was 5.5%. Gram-negative bacilli were reported on 28 agar plates and the microbial count was considered low being two or less CFUs on 95% of plates. The maximum CFU count for Gram-negative bacilli was 13 and the overall sample proportion was 17.5%.

Table 9

Summary of Highly Pathogenic Organisms' from Samples

Organism	*Staphylococcus aureus*	Gram-negative bacilli
Number of positive samples	8	28
Percentage of samples and counts	95% ≤1	95% ≤2
Maximum CFUs	10	13
Overgrown agar plates	-	1
Smudge agar plates	-	2
Overall proportion of sample	5.5%	17.5%

4.45 Rate flora gained on vaccinators' hands

Following the application of Sterigel+ the CFU counts over time are illustrated by hand dominance in Figure 9 (dominant hand $n = 71$) and Figure 10 (non-dominant hand $n = 69$). The number of CFUs increases over time and the rate of increase on the $\log_2$ scale are about the same for both dominant and non-dominant hands. For dominant hands the number of CFUs for non-convenience samples was about 2.5 times greater than for convenience samples at the same point in time, as evidenced by the fact the lines are about 1.4 units of the $\log_2$ scale apart. This was a significant difference ($p = 0.010$). For the non-dominant hands the non-convenience samples tended to have a higher CFU count but the difference was not significant. There was no evidence that Sterigel+ had any ability to provide ongoing antimicrobial residual efficacy.

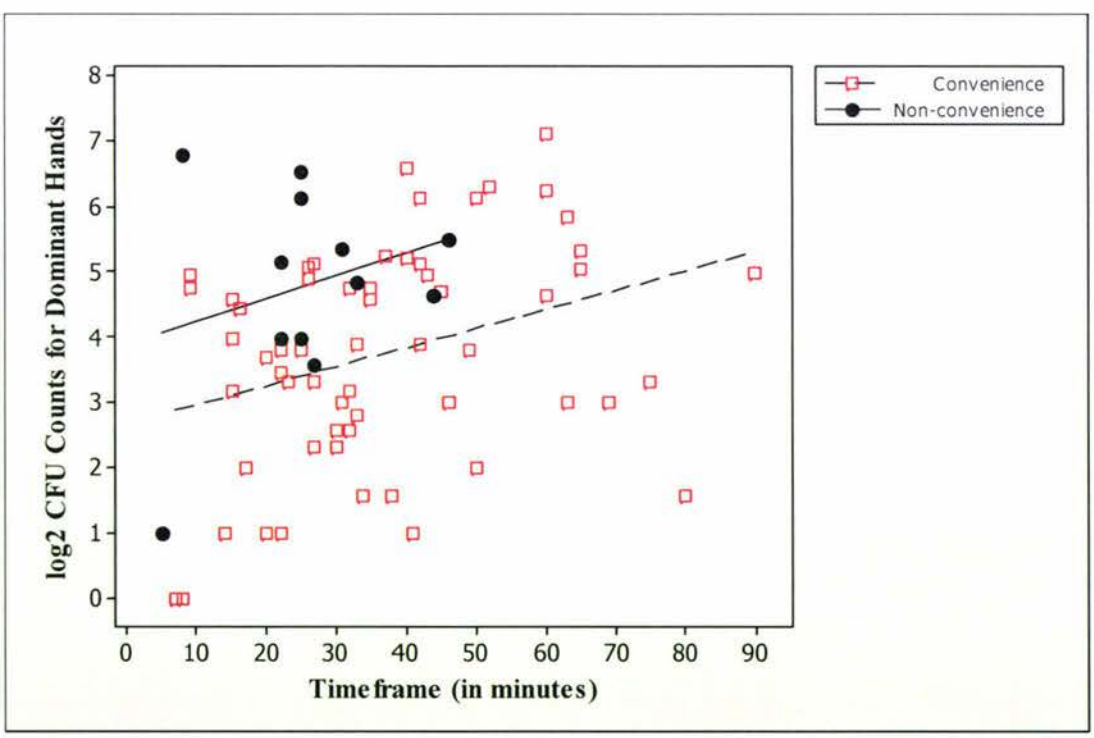

Figure 9 **Antimicrobial effect of Sterigel+ on dominant hand flora over time**

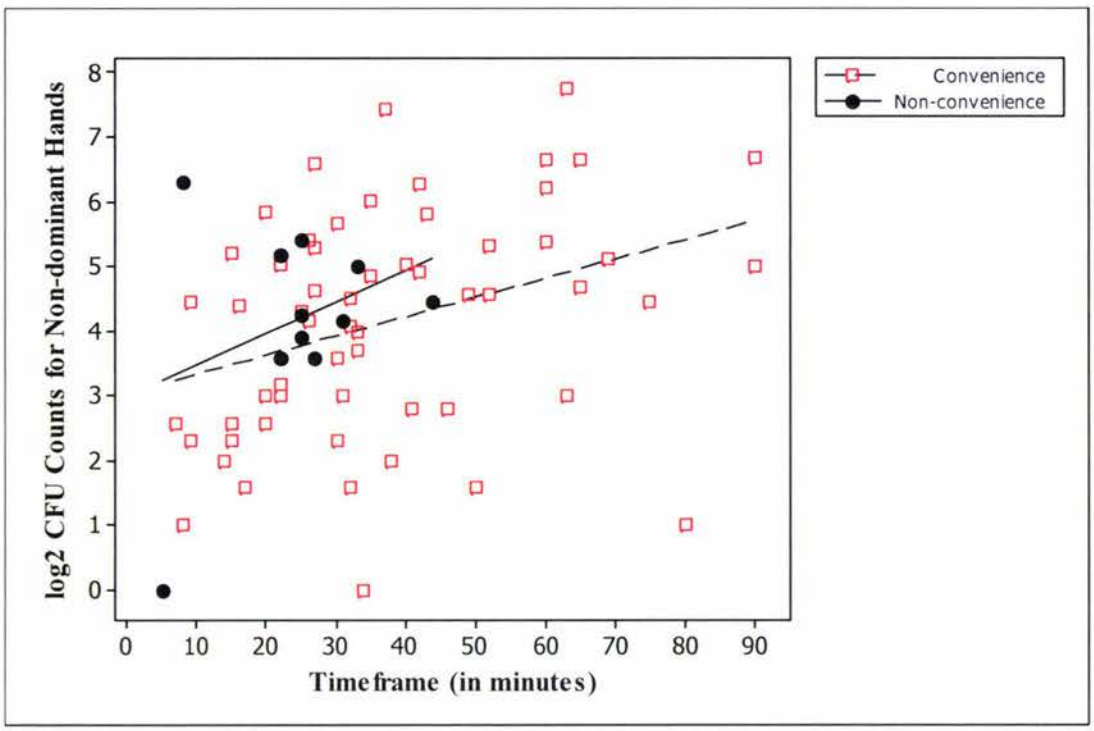

Figure 10 **Antimicrobial effect of Sterigel+ on non-dominant hand flora over time**

4.46 Effect of time and reason for hand hygiene on organism counts

The effect of time and reason for hand hygiene on CFU counts was calculated using a Kruskal-Wallis test, which revealed there was no significant difference in the median CFU counts between dominant and non-dominant hands (p = 0.958). Further statistical analyses (paired t test) compared CFU differences between dominant and non-dominant hands (95% CI for mean difference) and generated a non-significant t value of 0.27. The regression of $\log_2$ CFUs against time for dominant hands, showed a significant positive relationship (p = 0.032), with an estimated doubling of the number of CFUs every 43 minutes. For non-dominant hands a positive relationship was also significant (p = 0.006), with an estimated doubling of CFUs every 35 minutes. Spearman's correlation of total CFUs and timeframe was = 0.307 which was very significant (p-value = 0.001).

However, on further investigation it was noted that all non-convenience occasions were less than one hour. When restricting attention to all data collected under one hour

(excluding smudge and overgrown) the difference was statistically significant with the convenience median of 14.5 CFUs versus, the non-convenience median of 25 CFUs (p = 0.025). After adjusting for timeframe, the difference between convenience and non-convenience $\log_2$ CFU count was statistically significant (p = 0.018). The difference corresponded to non-convenience CFUs being on average 88% higher than convenience CFUs at any particular time point.

4.5 Summary

The participants' reasons for electing to decontaminate hands in this study were primarily for reasons of convenience (65) versus non-convenience (12). The mean time interval between hand hygiene episodes for a convenience response was longer at 37.35 minutes than the non-convenience mean of 26.08 minutes. The CFU counts for dominant hands revealed higher CFUs for non-convenience responses and this was a significant difference (p = 0.010) when compared to convenience responses. The difference corresponded to non-convenience CFUs being on average 88% higher than convenience CFUs at any particular time point.

LabPlus identified all organisms grown from the 154 samples but 14 samples (CFUs) were unable to be counted as flora were described as overgrown or smudged. Sixteen organisms groups were documented and then categorised to four types according to normal microbial habitat. The flora predominately cultured was normal skin flora which was regarded as of low pathogenicity. *Staphylococcus aureus* and Gram-negative bacilli were described and these bacteria were considered highly pathogenic organisms. However, the numbers of culture positive highly pathogenic plates in the sample was low and 95% of these plates recorded two (or less) CFUs.

To describe the effects of Sterigel+ on vaccinators hand flora, data were statistically compared and reviewed over time by convenience and non-convenience CFUs shown by $\log_2$ transformed bacterial counts in scatter plots to seek evidence of the ongoing antimicrobial efficacy of chlorhexidine 0.5%. There was no evidence that Sterigel+ had any ability to provide ongoing antimicrobial residual efficacy.

Chapter Five: Discussion and Conclusions

5.1 Introduction

In this final chapter the results of the study are discussed in relationship to the literature. Implications for both nursing practice and nursing education are commented on. Problems encountered during the study, along with limitations and delimitations of the study are acknowledged. A summary of the thesis is presented and a concluding statement made. Lastly, a recommendation for future research into the area of hand hygiene at MVPs is offered.

The intention of this study was to provide descriptive information relevant to hand hygiene at MVPs, by measuring the effect of the Sterigel+ on PHN's hand flora, over time. This addressed the study's research question of '*what is the residual effectiveness of chlorhexidine gluconate 0.5% on vaccinators' hand flora?*'

The results are commented on in relation to the research question in section 5.21. The results are also discussed (within the context) to the wider literature and linked to the study's aims of:

- providing original evidence on the efficacy of chlorhexidine gluconate 0.5%, in a community healthcare setting over time (discussed in section 5.21: residual efficacy of chlorhexidine gluconate 0.5%).
- providing pilot information on factors that may affect bacterial counts in a community healthcare setting, such as the time elapsed since cleansing hand (discussed in section 5.22: vaccinators hand hygiene timeframes and reasons for cleansing).
- quantifying the numbers of microbial CFUs found in a community healthcare setting as pilot information for future studies (discussed in section 5.23: vaccinators hand flora).

5.2 Discussion of study results

5.21 Residual efficacy of chlorhexidine gluconate 0.5%

No evidence has been found in the literature that conveys realistic data for comparing chlorhexidine gluconate 0.5% residual antimicrobial activity (as reported from laboratory trials) to the well-health MVP setting. Sterigel+ was anticipated to provide ongoing infection risk reduction by providing an immediate, and then subsequently a persistent bactericidal action that prevented contamination of vaccinators' hand flora at MVPs. There was no evidence detected in the statistical data of any residual antimicrobial efficacy following the application of Sterigel+. The number of CFUs increased over time and doubled approximately every 35-43 minutes. Spearman's correlation of total CFUs and timeframe (p = <0.001) confirmed that CFUs have a weak positive correlation with time. Therefore, the answer to the study's research question 'what is the residual effectiveness of chlorhexidine gluconate 0.5% on vaccinators' hand flora?' is that no residual antimicrobial action of 0.5% chlorhexidine gluconate was found in the data described in this study.

These results are at variance with the majority of other studies that found an ongoing persistence of the antimicrobial effect of chlorhexidine could be demonstrated in laboratory trials on volunteers' hands or with participants in hospital settings when tested under occlusive dressings or surgeons gloves (Aly & Maibach, 1979; Ayliffe et al., 1990; Hibbard et al., 2002; Kjolen & Andersen, 1992; Larson & Laughon, 1987; Lowbury et al., 1964; Mulberry et al., 2001; Rosenberg et al., 1976; Urlich, 1982; Wade & Casewell, 1991). However, the findings from this study are in accord with an older study by Ayliffe et al. (1988). Ayliffe et al. reported no antimicrobial residual effect on the viability of transient organisms after 10 applications 0.5% chlorhexidine in 70% isopropanol (Hibisol) over a six-hour sampling period.

There was no indication of a threshold of residual activity that would indicate that chlorhexidine was active (as an antimicrobial agent) up to any particular time. Any suggestion of a threshold for chlorhexidine's action would be demonstrated by a flat, then an increasing upwards slope in the trend line, and this is not evident in Figure 9 (see p. 83)

and Figure 10 (see p. 84). Whereas, Namura et al. (1994) found that 0.5% chlorhexidine gluconate in 77% alcohol demonstrated peak antimicrobial effect for less than 10 minutes, and then decreasing residual antiseptic effects were evident, with no persistence found beyond 30 minutes. However, a substantive antimicrobial effect was reported by Larson and Laughon (1987) after 15 applications of chlorhexidine gluconate and, by Mulberry et al. (2001) after repeated chlorhexidine gluconate treatments with sampling over one to five days. A similar cumulative finding was shown by Gould et al. (2000) from a community based nursing study. Gould et al. reported that initially a chlorhexidine (1%) hand cream did not reduce CFUs on nurses hand flora (prior to patient care) but hands re sampled later in the work shift showed reduced CFUs. During the present study the vaccinators' previous Sterigel+ usages (on that day or on any other day) was not elicited and participants were not re-sampled on the same day. Therefore, it is unknown whether over time the effect of using Sterigel+ did reduce CFUs, or if a cumulative effect would have occurred.

5.22 Effect of hand dominance, vaccinators' cleansing reasons and timeframes

Does hand dominance affect the bacterial carriage or CFUs on vaccinators' hands? The findings from this study showed that microbial data examined hand sample groups revealed no significant difference between the flora counts from either dominant, or non-dominant hands ($p = 0.79$). No recent studies were found that agreed with this result, however studies by Aly and Mailach (1979) and Urlich (1982) reported no significant differences related to hand dominance, during baseline measurements of CFUs.

In other studies, the decision to sample both hands appears simply related to sampling numbers or to the selected data collection method rather than exploring the question of hand dominance (Bartzokas et al., 1983; Gould et al., 2000; Kjolen & Andersen, 1992). This impression was surmised, because results from each hand were not reported separately and no data comparisons were made between hands. Several authors acknowledged sampling from the dominant hand only (Aiello et al., 2003; Cespedes et al., 2002; Girou et al., 2002; Pittet et al., 1999a; Lucet et al., 2002), but these results were frequently reported broadly as CFU log reductions, with a general description of the flora. Other studies reported choosing either hand (Gustafson et al., 2000; Larson et al., 2002; Trick et al.,

2003). Accordingly, no studies were found to compare the detailed microbial results of this study in relation to hand dominance.

The rationale behind a nurse's decision to perform hand hygiene appears to be an area of research that has as yet not been quantified. Predominately the literature concentrates on reasons why hand hygiene was not performed according to customary protocols of the healthcare provider (Burke, 2003; Creedon, 2005; Girou & Oppein, 2001; Gould, 2004b; Larson et al., 2000b; Pittet, 2001) rather than asking why it was performed. Hence, eliciting the response to clarify what prompted the decision to cleanse hands on each occasion contributes evidence of nurses' 'decision making' in practice.

However, unpredicted data emerged from this study regarding convenience and non-convenience responses. The participant's reasons for hand cleansing are illustrated in Figure 3 (see p. 67). Predominately the response was convenience (84%), with few non-convenience replies (16%). However, when the convenience versus non-convenience data were reviewed (over an equal time period) a statistical significance ($p = 0.018$) was found with a non-convenience response corresponding to an average of 88% greater number of CFUs than a convenience response at any point in time. This finding appears to support PHNs professional practice skills (of recognising when it is prudent to decontaminate hands) by choosing the non-convenience response. Bearing in mind that the participant's response selection (convenience or non-convenience), was a rather general measure for indicating the reason for hand cleansing.

The time intervals between hand cleansing varied considerably in the current study (5-91 minutes). Pittet et al. (1999a) was the sole study found that reported the timeframes of healthcare workers hand hygiene episodes (1-17 minutes). Although the microbial hand CFU counts were higher when the time period between hand cleansing increased (Pittet et al.). Pittet et al. confirm that over time bacterial contamination of hospital healthcare increased linearly during patient care, with the duration and type of care affecting contamination. But perhaps the shorter time durations observed by Pittet et al. reflected the commonly accepted hospital hand hygiene recommendations for hand cleansing such as,

prior to direct contact with each patient (ADHB, 2006; Boyce & Pittet, 2002; Department of Health and Aging, 2007; Trampuz & Widmer, 2004; WHO, 2004). The mean for this study's convenience responses was 37.35 minutes (standard deviation 19.62 minutes). The non-convenience responses were not considered significant as this response indicating a response to a possible cross-infection risk, and as such the timeframes could vary considerably according to the risks presented

The longer timeframe between hand hygiene episodes (recorded by vaccinators) reflected the MVP hand hygiene guideline which allows PHNs a degree of autonomy to decide when it is judicious to decontaminate hands. At MVPs standard vaccination techniques were practised so differences related to a variety of patient care practices could not be examined and only the difference between convenience and non-convenience recorded responses (as previously mentioned). Here the non-convenience responses revealed higher CFUs. Overall there were 23% more CFUs on the non-dominant hands than on dominant hands.

Nonetheless four agar plate samples recorded zero organism growth in this study. Microbial data gathered (post-Sterigel+ application) with zero CFU counts were at time periods of seven and eight minutes (dominant hands), and at five and 34 minutes (non-dominant hands). Hand dominance and time intervals documented for zero counts were different and no pattern was deduced from these results. Moreover, no literature was located that incorporated zero CFU counts in study results, therefore no comparisons were possible

5.23 Vaccinators hand flora

The sample yielded a total of the 154 agar plates of which flora on 140 plates were fully assessed as 16 organism types. Fourteen agar plates had missing flora counts, but the CFUs were identified. It is unknown if other studies encountered microbiological reviewing issues. Many studies comment on the number of plates reviewed by statistical analyses but no comments were reported of limited microbial analyses due to the inability to enumerate flora numbers. Furthermore, during this study no upper threshold limit for CFU counts was made and so the numerical range of CFUs on agar plates has been accurately described. This is in contrast to other studies that comment CFU counts have been truncated to 300

CFU (Callanghan, 1998, Pittet et al., 1999a). For example, Callanghan states some agar plate CFUs as greater than 300 colonies and Pittet et al (1999a) gives the CFU range without stating the organisms. Accordingly, this study provided an accurate view of the microbial population on vaccinators' hands at MVPs but similarly detailed data was not found to enable comparison with other studies.

Figure 5 (see p. 73) described the organisms found on vaccinators' paired hands data and revealed 85% as skin flora, 7% as Gram-negative flora, 6% as environmental organisms and 2% oral flora of all CFUs. This was an expected finding because skin flora is the predominant flora, normally resident on hands and arms. Likewise, both Pittet et al. (1999a) and Lucet (2002) report that normal skin flora were the principal microbial culture recovered from hospital healthcare workers hands'. Within the literature there does not seem to be a standard method for presenting microbial findings, so it was difficult to find comparable data as CFUs were presented in broad classifications, with full details of pathogenic species, yet CFU counts were seldom provided.

The organism that returned the highest CFU agar plate count in this study was coagulase negative staphylococci at 210 CFUs, this bacterium was identified on 134 of the 154 agar plates of the study's sample. Coagulase negative staphylococci are considered to be normal skin flora, commensal with the host (Hugonnet & Pittet, 2000; Mancini, 2000; Noble, 1998: Page, 2001). Accordingly, skin flora is not considered a cross-infection risk in healthy individuals. A true comparison with other studies is difficult as the study was not controlled and the microbial challenge varied in the periods studied (as different students presented). Other authors report less detailed information on specific flora (Aiello et al., 2004; Larson et al., 2002; Lucet et. al 2001; McNeil et al., 2001; Mulberry et. al., 2001).

Of more interest to this study were the organisms cultured from the samples and considered to be of high pathogenicity that is *Staphylococcus aureus* and Gram-negative bacilli including *Proteus* spp., but excluding non-fermative Gram-negative bacillus and *Acinetobacter* spp., as they indicate a potential for cross-infection. Asymptomatic carriage of *Staphylococcus aureus* is common but to cause an infection in a healthy individual the

bacterium needs a portal of entry into the skin. The 5.5% incidence rate of *Staphylococcus aureus* from this study was less than the 10.5% *Staphylococcus aureus* reported from hospital workers' hands by Pittet et al. (1999a) and substantially less than the 18.5% *Staphylococcus aureus* described by Larson et al. (2002) from homemakers' hands.

The literature agrees that higher counts of *Staphylococcus aureus* isolates are generally recovered from the hands of non-medical participants compared to hospital healthcare workers (Aiello et al., 2003; Cespedes, et al., 2002). The low numbers of *Staphylococcus aureus* isolates found in this study may therefore be considered unusual as the nurses were not in a hospital setting and were in contact with students from the community. Perhaps the lower CFU numbers can be explained by Ayliffe et al. (1988) who claim that the survival of an organism on the skin may be influenced by the residual activity of antiseptics. Studies by Kjolen and Andersen (1992) and Namura et al. (1994) confirm that a solution containing alcohol and chlorhexidine showed an antimicrobial effect and was bactericidal to *Staphylococcus aureus,* but report its persistence was for less than 30 minutes. So, maybe chlorhexidine gluconate 0.5% has provided a residual antimicrobial effect on vaccinators' hand flora that has not been found due to the data gathering format employed in this study.

Pittet et al. (1999a) report the incidence of Gram-negative bacilli was 14.5% from hand flora (prior to hand cleansing) whereas this study revealed 17.5% Gram-negative bacilli from samples. Guenthner et al. (1987) and Larson et al. (2002) found a similar higher prevalence of Gram-negative bacilli within the community environment when compared to medical personnel. In the current study, results revealed Gram-negative flora made up a larger proportion of the flora found on vaccinators' dominant hands compared to non-dominant hands, but no other striking difference in distributions was apparent. This is interesting because the non-dominant hand may be placed on the student's skin/attire whereas the syringe is held in the dominant hand during vaccination (see Appendix A), and thus the non-dominant hand has more direct skin contact with the student than the vaccinator's dominant hand. But the risk of infection in the well health setting of a MVP is questionable as the relative dryness of most skin surfaces is a functional factor that limits

colonisation and thought to be a major cause for the poor survival rate of Gram-negative bacilli (Aly & Maibach, 1977; Gould, 2004a; Lowbury, 1969; Noble & Somerville, 1974).

The cross-infection risks associated with *Staphylococcus aureus* and Gram-negative bacilli were reviewed with LabPlus (microbiologist and a laboratory scientist). It was considered that the highly pathogenic organisms identified (see Table 8, p.80) would present only a minimal infection risk to healthy individuals. This is because relatively few samples were culture positive and the colony counts were low for both *Staphylococcus* aureus and Gram-negative bacillus. Nonetheless, all pathogenic organisms have the potential to cause human disease given the right circumstances and a vulnerable host.

5.3 Issues: participants, school settings and data management

5.31 Participants

No issues were evident in the process of gaining volunteers' as all PHNs eligible to participate consented to inclusion in the study. All of PHN participants were accounted for during the study and no one choose to withdraw consent for any reason. Nevertheless, the reduced involvement of Early Childhood PHNs due to the constraint of being able to vaccinate on one occasion, coupled with PHNs that were unable to participate, because authorisation to vaccinate as an independent vaccinator was not current or yet granted, was a limitation. This restriction on the number of potential participants, and the flow-on effect for the number of data collection occasions was not a factor taken into account prior to the study commencing. Even so, the outcome was acceptable as the level of participation met the suggested data collection numbers for statistical analysis.

5.32 School settings

No issues arose from the process of gaining access to the MVP school setting, and no school communities withdrew from potential inclusion in the study. This may have been facilitated by the personal endorsement offered by the PHN of each school and the researcher (as an experienced PHN) being familiar with MVP processes. During the data

gathering processes no problems became evident nor were any concerns brought to the attention of the researcher, Massey University Supervisors or PHNs team members.

Setting up at some of the locations required more time than was planned for because furniture required for the researcher's data collection station was unsuitable or nonexistent in the venue. Hence, data collection was minimally delayed on a few occasions as the necessary items were sourced. The actual processes of data collection had a negligible time impact on MVPs and had no effect on the time allocated for each school. This was because each data gathering occasion was completed in 5 minutes or less per vaccinator. It was most helpful that equipment (used to transport agar plate samples) and portable privacy screens (for researcher's station) were available to the researcher from within the PHN team.

5.33 Data management

All data were managed according to ethical guidelines. Storage of the agar plates, and travel to and from LabPlus was uneventful. The laboratory reporting format chosen meant that all results were handwritten onto the original data collection sheets to limit transcription errors and to be cost effective. On several occasions the microbial results received needed clarification (to ensure the correct interpretation of numerals and organisms for data entry) as the handwriting and abbreviations used varied with the reporting microbiologists. When ambiguities arose then contact was made with LabPlus by telephone or email and all queries were answered promptly. No other problems arose during the entering of data. The final cost of the laboratory services was within the fiscal limits of the study's budget. The assistance of the Massey University supervising statistician enabled discussion of the findings and provided confidence that data were accurately described and presented.

5.4 Implications for nursing

5.41 Education

The researcher construed from casual comments made by participants, that some PHNs

were unsure of the methods of microbial transmission. For example, the potential relationship between the carriage of bacteria under their rings or artificial nails, and the related cross-infection risks or the over-reliance on the efficacy of chlorhexidine-based hand gels for any length of time for ongoing antimicrobial activity. Continuing annual in-service education programmes are important to heighten and sustain awareness for infection risk reduction. Such sessions can highlight the importance of hand hygiene techniques and should not be simply on hand cleansing products.

5.42 Practice

The results of this study indicate that Sterigel+ does not provide ongoing antimicrobial protection beyond the quantified effects of an alcohol-based hand gel. Therefore PHNs need to take this information into account when considering hand hygiene practice decisions related to cross infection risks during MVPs.

Additionally, through the research process an anomaly was identified by the researcher regarding the information provided by the manufacturer of Sterigel+ which could result in a misinterpretation of a graph illustrating the efficacy of antiseptics. SoluMed reformatted a graph from Rotter (1996) to highlight their products efficacy and in the process renamed both axes. By renaming the axis lines, the evidence is open to a different interpretation than the original graph presented. On reviewing the graph "Figure 79.1" (Rotter, 1996, p.1062) the *y* axis line is labelled the "reduction of release of skin bacteria" and the *x* axis "after disinfection". Whereas, on the SoluMed graph the *y* axis is labelled "reduction of skin bacteria" and the *x* axis "time after disinfection" (see Appendix D). The SoluMed flyer therefore does not limit the action of their product to simply the release of skin bacteria; rather it suggests that there is a scientifically proven ongoing effect without limitations, not inferred in the original graph (Rotter). Revealing this anomaly has highlighted the importance of reviewing evidence critically and not merely accepting a commercial manufacturer's brochures without confirming the evidence on which such data is based. Otherwise, practice decisions may be based on mistaken interpretation.

The potential benefits of the study include a greater scientific understanding of the process

of skin decontamination. Subsequently, the information gained may be incorporated into evidence-based hand hygiene practices and may be of interest to other researchers in this area of health practice. The study adopted a methodology intent on informing praxis to assist in bridging the research-practice gap as the researcher will present back to the PHN teams post-thesis completion. Unpredicted outcomes for participants (anecdotally) are raised PHN awareness of the value of complying with hand cleaning protocols to reduce cross-infection risk, and to maintain skin integrity by moisturising hands regularly.

5.43 Research evidence

Gaps were found in the published literature as no data was located outside of a laboratory or hospital setting on the antimicrobial persistence of chlorhexidine gluconate's ascribed ongoing residual efficacy (when incorporated into alcoholic solutions) for hand cleansing. Also, there is a lack of evidence related to hand hygiene in a well-health community clinical settings, timeframes for hand cleansing episodes and reasons that prompt hand hygiene by healthcare workers. This study adds to nursing's body of knowledge and could provide the impetus for related future research. The original evidence described affords valuable insights for community health professionals on microbial flora, nursing practice and supplies information for possible future academic enquiry.

5.5 Limitations and delimitations of the study

All methodologies are fallible and have limitations (Hek, Judd, & Moule, 2002). This study has several limitations. Firstly, studies not published in English were excluded by the researcher from the literature review. Another delimitation was the selection of a purposive sample. This choice was made because the PHN population was small, and hence the findings potentially biased. Nevertheless, the entire eligible workforce did volunteer and the study did provide an accurate account of the specific MVP situation where PHNs practice. Therefore, this study may be generalisable to similar MVPs, in like settings, in those that utilise a comparable hand hygiene protocol.

The survey method allowed for the collection of information quickly from the chosen

sample however it merely provided point in time data which could only be displayed through descriptive statistics. It is acknowledged that a descriptive survey does not provide such robust evidence as an experimental study but the level of confidence attached to this study's findings was supported by the utilisation of trustworthy data collection methods and by consistency in sampling processes and documentation by the researcher. Validity is also demonstrated by microbial review processes that met New Zealand laboratory standards.

Although there was no active intervention on any occasion by the researcher in a vaccinators' practice, nurses could have been aware that other participants were choosing to decontaminate hands and this may have influenced the time period for their usual hand hygiene practices. But, the busyness of each vaccinator at MVPs may have lessened this possible effect as each nurse was focused on the immunisation processes that need to be attended to with each student and generally appeared unaware of other nurses' practices. Hence, the researcher recognised that a 'Hawthorne effect' may have occurred during the data collection process (Taylor, 2005).

The study design did not incorporate baseline flora sampling from participants and hence it is unknown whether some organisms cultured are natural to that volunteer. There was a more definitive method of collecting flora (glove juice method) which may have been more effective in recovering the whole bacterial burden on hands when compared to the blood agar plates. This technique was not chosen as it would have been time consuming to perform in a MVP setting and also more costly to employ. Additional more detailed microbial examinations (such as, anaerobic review) were not performed as considerable resources beyond the fiscal constraints of this pilot study would have been required.

5.6 Summary

School based MVPs are far from an ideal clinical health setting nevertheless, students and their families/whanau trust PHNs to employ adequate infection control methods at MVPs. From micro-organisms gathered from vaccinators' finger-tip press samples the bacterial flora revealed was predominately normal skin flora considered of low pathogenicity.

Nonetheless, bacteria regarded as highly pathogenetic was culture positive, although the risk of cross-infection at MVPs was regarded as minimal in this healthy population. This view was supported by comments from PHNs confirming no incidence of cross-infection from MVPs has been reported by nurses, schools, families and whanau, or identified in New Zealand government agencies reports.

No obvious residual antimicrobial persistence from chlorhexidine gluconate 0.5% has been revealed from this study but no evidence of cross-infection has also been identified. Because this pilot study did not incorporate baseline flora data it is unknown what flora were intrinsic to each vaccinator nor is any cumulative effect from Sterigel+ known as no nurse was sampled more than once daily. Public health nurses appeared to make prudent hand cleansing practice judgements regarding potential contamination exposure by the non-convenience CFU data revealed previously. Thus, self regulating cross-infection risk reduction strategies were in place.

The literature search has highlighted a practice dilemmas faced by PHNs during student MVPs as no literature was located on hand hygiene protocols for this setting. Comparison with other studies was difficult because the pilot study provided limited data because this descriptive study was in a specialised setting. The findings from this study are original and will fill gaps identified in the literature by providing new scientific evidence in this setting.

5.7 Conclusion

Although, the results presented do not quantify the ongoing microbial efficacy of Sterigel+, the current MVP hand hygiene guideline appears adequate until further evidence becomes available. Therefore, more stringent hand hygiene protocols are not suggested for MVPs.

5.8 Recommendation It is recommended that a larger study is carried out which incorporates vaccinators' baseline flora CFU data and sampling over an extended time period with links to participants.

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Appendix A

ADHB nurses assist with massive meningococcal contract (2004, September). *Nova Magazine*, p. 1.

ADHB nurses assist with massive meningococcal contract

The child and youth health team, Community Child Health and Disability Services, is assisting Counties Manukau District Health Board with the school-based meningococcal B vaccinations in the Eastern Corridor, reports child and youth health team leader Grace Hinder.

For more than a decade, New Zealand, and in particular the Auckland region, has been in the grip of a persistent epidemic of meningococcal disease. The government's $200 million campaign to vaccinate all those under 20 against this killer disease is now underway.

The meningococcal vaccine strategy is expected to prevent at least 4,000 cases and up to 200 deaths over ten years. The programme is being funded as a public health emergency, which means that its cost is not part of the Ministry of Health's district health board funding allocations.

A total of 150,000 children at 228 schools in high risk areas in Counties Manukau and in parts of Auckland's Eastern Corridor are being vaccinated first.

ADHB's child and youth health team is assisting Counties Manukau District Health Board with this huge task. This first stage of the vaccination roll out is expected to take until the end of the year to complete.

To help with the Eastern Corridor vaccinations, there is a 15-member team comprising six FTE nurses from Auckland DHB, four FTE nurses from Waitemata DHB and three nurses from Counties Manukau DHB, plus support and administrative people. The team is based on the fourth floor of Building 13 at the Greenlane Clinical Centre.

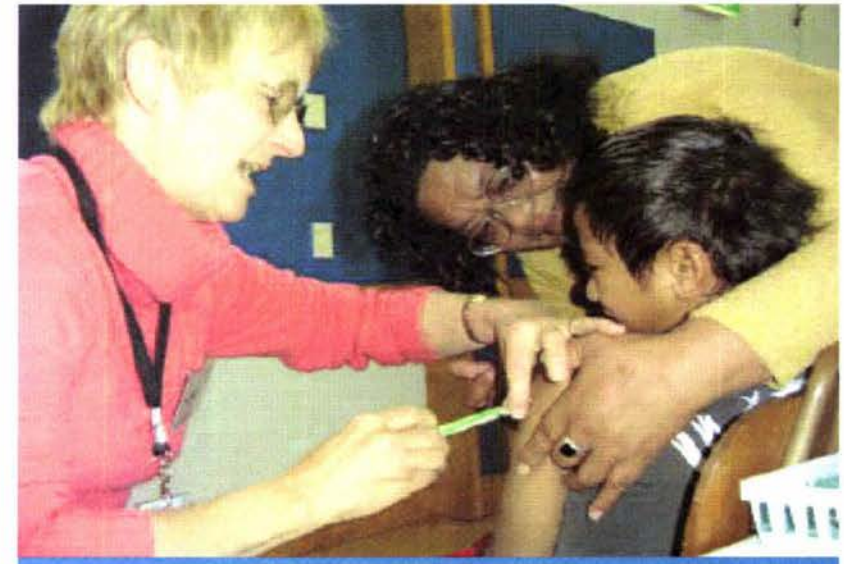
In July the team began the consent and education process in Otahuhu, Mt Wellington, Panmure, and Glen Innes. At schools the nurses gave presentations to teachers and students and handed out resource packs and consent letters.

On August 2 they initiated the vaccination programme starting with Otahuhu Primary School. The programme represents a formidable logistical exercise, since each child will need to have three doses of vaccine six weeks apart.

Vaccination by primary care of children aged between six months and five years and those children not in school will begin in central Auckland in November 2004. In early 2005 the vaccination programme will roll out to schools in central Auckland, as well as Waitemata and Northland.

In order to be able to offer assistance with the Counties Manukau DHB programme, ADHB's child and youth health team has had to reprioritise its already pressing public health work.

"We've had a lot of good will from our schools in central Auckland, even though they are experiencing reduced access to public health nursing while the child and youth health team is engaged in the meningococcal B vaccinations," explains team leader Grace Hinder. "Everyone has been very supportive and flexible, because we all recognise the importance of the meningococcal campaign."



ADHB public health nurse Rhonda Maloy vaccinates a five-year-old at Otahuhu Primary School against meningococcal disease, with Maori community health worker Hoki Apanhama assisting as a support worker. "The three DHB school-based teams are truly working together in a collaborative and effective way on this programme," says ADHB child and youth health team leader Grace Hinder.

Appendices B

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Summary

To elicit what was happening in New Zealand 17 clinical leaders of public health nurses (nationally) were requested by letter to complete and return a questionnaire on products and protocols/guidelines their District Health Boards (DHBs) relied on for hand hygiene during school based student mass vaccination programmes.

The respondent's information was collated.

- Thirteen questionnaires were returned from eight DHBs.
- Protocol – hand washing Year 7 programmes (yes - five) and (no - eight).
- All respondents are guided by the Ministry of Health's *Immunisation Handbook.*
- Six respondents confirm PHN's often cleanse hands between each student contact.
- No one product or hand hygiene method is exclusively adopted.
- Eleven PHN's commented alcohol-based sanitizer is available at each vaccinator station.

Public health nurse comments included, inadequate hand-washing at venues, and requested from the writer recommended best practice guidelines for hand hygiene at mass vaccination programmes if guidelines were later formulated.

Appendix C

Hand hygiene: recommended best practice guideline for public health nurses at school based student vaccination programmes (Auckland District Health Board, 2002).

Summary

Alcohol-based hand gel must be readily available to all nurses at vaccination programme

Liquid soap formulation should be with pH 4-7 range.

Hand cream or lotion compatible with alcohol hand gel to be available.

Gloves may be worn for drawing up vaccines but should be removed prior to vaccinating. After wearing gloves a standard handwash must be completed.

The wearing of jewellery/artificial nails is discouraged during direct client contact.

A standard handwash is recommended if hands are visibly soiled or sticky.

Inform co-ordinator if skin problems or possible reactions to hand hygiene products

Hand cleansing

- (S) standard handwash
- (A) alcohol-based hand gel
- (A/S) alcohol-based gel or standard handwash

Compulsory

(A/S)	Before drawing up vaccines
(A)	Prior to vaccination programme commencing
(S)	After removal of gloves
(A/S)	At the end of student vaccination programme

As required

(S)	Soiled hand e.g. blood vaccines or body fluids
(A/S)	After contact with any skin that may be compromised
(A/S)	After touching any surface that may be contaminated
(A/S)	After drawing up vaccines

Appendix D (1/2)

SoluMed product information

STERIGEL+
ÉVOLUTION SoluMed

STÉRIGEL+ is a broad-spectrum antiseptic gel for surgical prepping of hands and forearms. ***STÉRIGEL+***, with active ingredients 0.5% W/V Chlorhexidine Gluconate and 70% V/V Ethyl Alcohol, requires no rinsing and reduces colonization. In accordance with the objectives of surgical hand and forearm disinfection[1], ***STÉRIGEL+*** achieves a high level of microbial decontamination of hands and forearms for the duration of surgical procedures. ***STÉRIGEL+*** is an antiseptic gel with the following characteristics:

- **acts in 30 seconds and provides persistent antimicrobial protection for 6 hours;**
- **effective against: Gram-positive bacteriá, Gram-negative bacteria, fungi, viruses;**
- **hypoallergenic;**
- **not absorbed through skin;**
- **dries quickly, leaving skin feeling soft;**
- **discreet, pleasant fragrance;**
- **helps improve skin condition.**

Product # 104.04 DIN 02240800
Available in 780 mL bags-in-boxes
18 bags-in-boxes/case

Product # 104.05
Automatic *STÉRIGEL+* Dispenser
with proximity sensor
Available individually and in cases of 12

REVIVE
ÉVOLUTION SoluMed

REVIVE is a moisturizing lotion which is compatible with Chlorhexidine Gluconate and delivers superior moisturization by nourishing the skin. ***REVIVE*** leaves skin feeling softer, and is non-greasy. ***REVIVE*** contains no added fragrance, nor coloring or irritating agents. Applied at least four times daily, ***REVIVE*** protects and relieves even the driest skin for hours.

Product # 105.02
Available in 500 mL bottles
12 bottles/case

Product # 104.03
Wall unit for *REVIVE* bottle
Available individually

The ÉVOLUTION concept respects recommendations in the most recent "Guideline for Hand Hygiene in Health-Care Settings"[2] published in October 2002 by the Centers for Disease Control and Prevention.

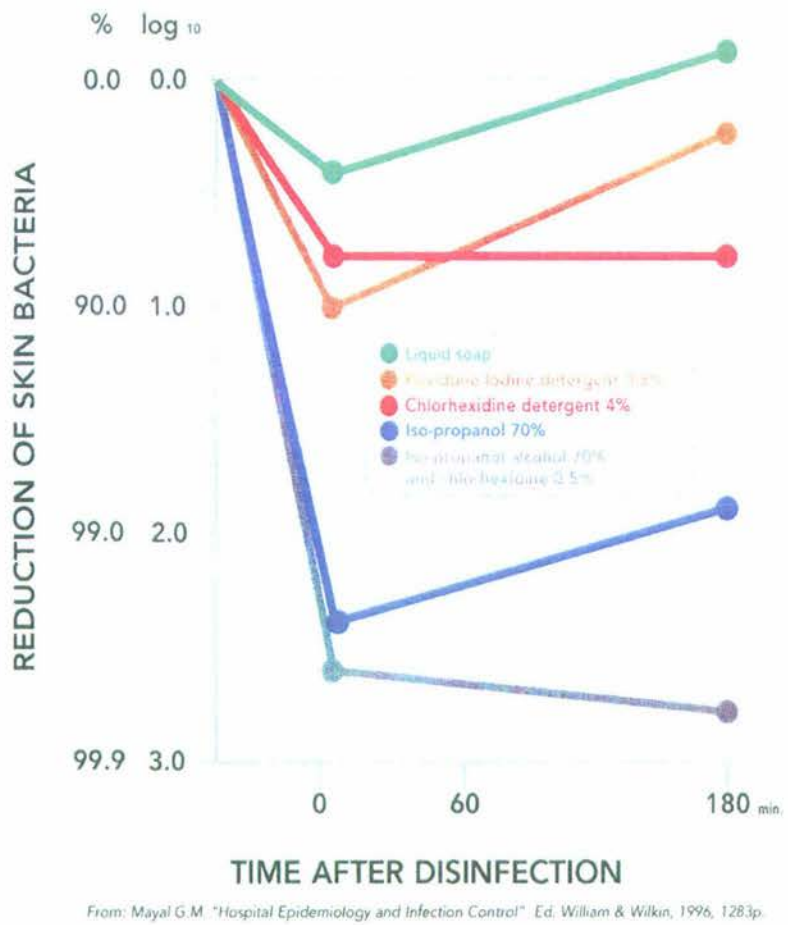
[1] Rotter, M.L. Hand washing and hand disinfection. In: Mayall, C.G., editor. Hospital epidemiology and infection control. 2nd ed. Philadelphia: Lippincott, Williams & Wilkins; 1999, p. 1339-55.

[2] Guideline for Hand Hygiene in Health-Care Settings. Morbidity and Mortality Weekly Report. October 25, 2002, Vol. 51, No. RR-16.

Appendix D (2/2)

SoluMed product information

EFFICACY OF ANTISEPTICS



From: Mayal G.M. "Hospital Epidemiology and Infection Control" Ed. William & Wilkin, 1996, 1283p.

SoluMed **Les Entreprises SoluMed Inc.** (Quebec) Canada page 1

Appendix E

Plague physicians were careful to protect themselves by wearing a mask, hat, long coat and gloves. The beak contained perfumes to counteract the foul odours which may fortuitously have contained volatile oils that had disinfectant properties (Block, 2001).

Plague physician's protective clothing

Aesculape. (1932). *Plague doctors: habit des medecins, et autres personnes qui visitent les pestiferes Il est de marroquin lenant, le masque a les yeux de cristal, et un long nex rempli de parfums.* Volume 22, Figure 6, L0025219. Retrieved November, 23, 2007 from http://images.wellcome.ac.uk/indexplus/page /Terms+of+Use.html

Courtesy of Wellcome Library, London

Appendix F

LabPlus quote

Microbiology
LabPlus
Auckland Hospital

(09) 307 - 4949
6086

9th May 2006

Robyn Duffy
Public Health Nurse
Community Child & Disability Service
ADHB

Dear Robyn

Thankyou for the opportunity to quote for providing the Microbiology input to your research project.

LabPlus will provide blood agar plates to you.
Staff in the vaccination clinics will imprint the plates with finger tips and thumb prints as demonstrated to you.
Plates will be returned following Clinics on Tuesday and Thursday by you to LabPlus for incubation and interpretation.

Plates will be read at 48hrs and we will provide colony counts and a breakdown of the various types of organisms to the species level. Colony counts will have a cut off point at >300cols (where possible). This information will be provided to you in a spreadsheet at the end of the study.

Prices

1. Agar plates @ 50c each

2. Read and report on 48hr cultures @ $3.50ea

Total of $4 per plate based on an estimated 120 plates

On completion of the study we will invoice you for the total amount on one account.

(this quote is valid for 6 months)

Please contact Maree Gillies two weeks prior to the actual commencement of the study.

Kind regards

Maree Gillies
Technical Head
Microbiology

Appendix G

Graduate Research Fund Application (subsequently reimbursed $1117.30)

Head of School Secretary 13 December 2006

School of Health Sciences

Massey University

Private Box 756

Wellington

Re: Robyn Duffy [redacted] Graduate Research Fund Application

Dear Caroline

Please see below a breakdown of approved costs and claimed costs and I would like to retrospectively claim for telephone costs not envisaged prior to my research commencing. I needed to contact the microbiologist on arrival at the site to gain entry to the laboratory to collect and deposit agar flora data plates. Also, it was necessary to make contact with the Public Health Nurse teams to clarify data collection times and venues and this was only possible by cell phone. Therefore, after discussion with my supervisor (Dr Stephen Neville) I enclose Vodafone prepay receipts of $80 to cover some of this unforseen cost for consideration.

	$ approved	cost	claimed
Lab+ agar plates and results	880.00	738.00	738.00
Stationary for on the day etc	20.00	13.77	13.77
Containers for transporting (no claim as able to use chillybins already owned by researcher)	40.00	Nil	-------
Koha/gifts for consultation Maori Tikanga manager and team; Pacific Island team manager and Pacific Island nurses; Maori team members in community health teams; Maori Justice of the Peace and Microbiologists	140.00	85.43	85.43
Transporting agar plates to and from Lab+	200.00	227.72	200.00
Mobile Vodafone – pre paid vouchers		80.00	80
Approved	**$1280.00**		**$1117.30 receipted**

Please find attached photocopied receipts and ethic approval letter (StudyNTX/06/06/065).

Sincerely

Robyn Duffy

Appendix H (1/2)

Letter to school principals/Board of Trustees re data collection

Massey University
COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF HEALTH SCIENCES
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 441 8186
F 64 9 441 8165
www.massey.ac.nz

July 3rd 2006

Dear Principal

Research project: the effectiveness of an antiseptic on vaccinators' hands

During the Year 7 and Year 8 school based vaccination programme this year I will be undertaking a hand hygiene research project with public health nurses within Auckland District Health Board's area (ADHB). This research is to fulfil my Master's of Philosophy thesis and the project will be supervised through Massey University, Auckland. This study has received ethical approval from the Northern X Regional Ethics Committee and has the support of ADHB.

The project would only involve public health nurses who are allocated to the role of vaccinator on your school's immunisation day and does not involve students or any members of your staff. I will be reviewing the effectiveness of a product used by vaccinator nurses to cleanse their hands. This type of research is normal quality control for healthcare practices and standard hand hygiene practices will be maintained. The data collection will occur behind a screen. Vaccinators will place their fingertips on a sterile medium (agar plate) for a few seconds. This study should not impact on your school's vaccination programme timeframe as the data collection process is brief and vaccinators only provide flora on one occasion per day.

No information collected will refer to your school or its pupils (e.g. address, decile rating or ethnicities. No school will be identified in the data or subsequent reports. It is anticipated that this project will not affect your staff, pupils or the school in any way. I request that you notify the Board of Trustees (BOT) that this research may be conducted on the premises. If you, or any member of the BOT have questions or concerns please contact me (Robyn Duffy) or my supervisors at Massey University.

Sincerely

Researcher Robyn Duffy 307-4949 ext 27488#
CCH&DS Level 6, Cornwall Complex, Greenlane, Clinical Centre, Auckland.

Massey University Supervisors

Doctor Stephen Neville	414-0800 ext. 9065	email: S.J.Neville@massey.ac.nz
Doctor Denise Wilson	414-0800 ext. 9070	email: D.L.Wilson@massey.ac.nz
Doctor Barry McDonald	414-0800 ext. 41039	email: B.McDonald @massey.ac.nz

Appendix H (2/2)

Letter to school principals/Board of Trustees re data completion

Massey University
COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF HEALTH SCIENCES
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 441 8186
F 64 9 441 8185
www.massey.ac.nz

11 November 2006

Dear Principal

Research project: the effectiveness of an antiseptic on vaccinators' hands

In July this year I wrote to you explaining a hand hygiene research project I proposed to undertake within Auckland District Health Board's (ADHB) school based Year 7 and Year 8 vaccination programme. The research was part of my thesis towards a Master's of Philosophy (Nursing) degree. The study received ethical approval from the Northern X Regional Ethics Committee, was supported by ADHB and was supervised through Massey University, Auckland.

The audit involved up to five public health nurses who were allocated to the role of vaccinator at approximately 25% of school immunisation programmes and did not involve students or any members of school staff. I am currently reviewing the effectiveness of a product used by vaccinator nurses to cleanse their hands and the information gained will be reflected in the hand hygiene guideline for ADHB public health nurses at the completion of the project. This type of research is normal quality control for healthcare practices and standard hand hygiene practices were maintained.

Thank you for allowing your school to potentially be part of this research and you may wish to notify the Board of Trustees (BOT) that data collection for this project is completed. If you or any members of the BOT have questions, please contact me (Robyn Duffy) or my supervisors at Massey University.

Sincerely

Researcher Robyn Duffy 307-4949 ext 27488#
CCH&DS Level 6, Cornwall Complex, Greenlane, Clinical Centre, Auckland.

Massey University Supervisors

Doctor Stephen Neville	414-0800 ext. 9065	email: S.J.Neville@massey.ac.nz
Doctor Denise Wilson	414-0800 ext. 9070	email: D.L.Wilson@massey.ac.nz
Doctor Barry McDonald	414-0800 ext. 41039	email: B.McDonald @massey.ac.nz

Appendix I (1/7)

Initial Correspondence from Northern X Regional Ethics Committee (1 of 2)

-----Original Message-----
From: Sally_Cook@moh.govt.nz [mailto:Sally_Cook@moh.govt.nz]
Sent: Thursday, 15 June 2006 19:00
To: Robyn Duffy (ADHB)
Subject: Ethics application NTX/06/06/065 - original letter in the mail
15 June 2006

Ms Robyn Duffy
[redacted]

Dear Robyn

NTX/06/06/065 Pilot study of the residual effectiveness of chlorhexidine gluconate 0.5% on public health nurses hand flora during student mass vaccination programmes
Principal Investigator: Ms Robyn Duffy, Massey University Auckland
Supervisor: Dr Stephen Neville

The Northern X Regional Ethics Committee thanks you for attending its meeting on 7 June 2006 and Dr Neville for being available by teleconference when the above study was considered.

The Committee noted
- that the study was an audit of current practice and recommendations would be made regarding changes to current practice if needed.
- That the researcher has just received a research grant of up to $800.

The Committee has requested that you provide/amend :

Application Form:
- ADHB MRRC letter of support to be received.
- The Boards of Trustees of the schools should be aware the research is being conducted on the premises either by the researcher writing to them directly or requesting the Principal to notify them. Please provide revised letter/s.

Information Sheet for Public Health Nurses.
- Insert 'If you have any queries or concerns regarding your rights as a participant in this study, you may wish to contact your professional organisation'.
- Insert the correct approval statement, 'This study has received ethical approval from the Northern X Regional Ethics Committee' in the information sheet and also in all letters.

The Committee forwards the following suggestions that do not affect the application's ethical approval status.
- As nurses need high competency in English, the interpreter box is not required
- Consent form – set out with bullet points to separate each sentence beginning 'I' for ease of reading

Appendix I (2/7)

Initial Correspondence from Northern X Regional Ethics Committee (2 of 2)

Please forward your response in letter format with an amended information sheet/consent form or other required forms to the Committee administrator.

Please highlight all changes for clarity and speed and include an updated version no. and date as a footer on the information sheet/consent form.

Your response will be reviewed by the chairperson and final ethical approval will be given by her under delegated authority if the above points have been satisfactorily addressed.

You may not proceed with the study until you have received the formal letter or approval.

Yours sincerely,

Laura Neal
Assistant Administrator

Cc: ADHB Research Office A+3491

Sally Cook
National Co-ordinator - Ethics Committees
Strategic Policy on Ethics & Innovation
Sector Policy Directorate
Ministry of Health
DDI: 04 496 2053
Fax: 04 496 2191

http://www.newhealth.govt.nz/ethicscommittees
mailto:Sally_Cook@moh.govt.nz

Appendix I (3/7)

Ethical consent documents: Northern X Regional Ethics Committee (1 of 2)

Health and Disability Ethics Committees

e-mail: pat_chainey@moh.govt.nz

Northern X Regional Ethics Committee
Ministry of Health
3rd Floor, Unisys Building
550 Great South Road, Penrose
Private Bag 92 522
Wellesley Street, Auckland
Phone (09) 580 9105
Fax (09) 580 9001

29 June 2006

Ms Robyn Duffy
[redacted]

Dear Robyn

NTX/06/06/065 **Pilot study of the residual effectiveness of chlorhexidine gluconate 0.5% on public health nurses hand flora during student mass vaccination programmes**

Principal Investigator: Ms Robyn Duffy, Massey University Auckland
Supervisor: Dr Stephen Neville

Thank you for your amendments, received 26 June 2006

The above study has been given ethical approval by Northern X Ethics Committee for the Northern Region. A list of members of this Committee is attached.

Approved Documents:

- Principals letter V#3. 19/06/06
- Information Sheet/Consent Form for Public Health Nurses V#3. 19/06/06
- Participant 'on the day' Information Sheet, V#1, 14/05/06
- Vaccinator participant data form V#1, 14/05/06

Certification
The Committee is satisfied that this study is not being conducted principally for the benefit of the manufacturer or distributor and may be considered for coverage under ACC.

Accreditation
This Committee involved in the approval of this study is approved by the Health Research Council and is constituted and operates in accordance with the Operational Standard for Ethics Committees, March 2002.

Progress Reports
The study is approved until 29 June 2007. A progress report is required for this study by that date.

..../2

Appendix I (4/7)

Ethical consent documents: Northern X Regional Ethics Committee (2 of 2)

A form should come off our database requesting this information two months prior to the review date but if a form is not received, it is still your responsibility to provide a progress report and this may be obtained from the website below. Please note that failure to complete and return this form may result in the withdrawal of ethical approval.

Please advise the Committee when the study is completed and under the ethical approval process, a final report is also required at the conclusion of the study.

Requirements for SAE Reporting
Please advise the Committee as soon as possible on the SAE form to be found on the website below, should there be any serious adverse events that may relate to this study.

Amendments:
All amendments to the study must be advised to the Committee prior to their implementation, except in the case where immediate implementation is required for reasons of safety. In such cases the Committee must be notified as soon as possible of the change.

Please quote the above ethics committee reference number in all correspondence.

It should be noted that Ethics Committee approval does not imply any resource commitment or administrative facilitation by any healthcare provider, within whose facility the research is to be carried out. Where applicable, authority for this must be obtained separately from the appropriate manager within the organisation.

Yours sincerely,

Pat Chainey
Administrator, Northern X Committee

Cc: Auckland Research Office A+ 3491

Appendix I (5/7)

Ethical consent documents: Auckland District Health Board

Auckland District Health Board
Greenlane Clinical Centre, Green Lane West
Auckland 3, New Zealand
Telephone: 09 638 9909
Website: www.adhb.govt.nz

Service: ADHB Research Office
Office: Level 8, Bldg. 13, GCC
Phone: Postal: PB 92189 Auckland
Ext: 630-9943
Fax: 4085, 4077 and 3122
Email: 630 - 9796 or 4996
GaylH@adhb.govt.nz
Website: www.adhb.govt.nz/RDO

4 July 2006

Ms. Robyn Duffy
[redacted]

This is the ADHB Management Approval. Please keep in your Trial Master File.

Dear Ms. Duffy,

RE: Research project A+3491 (NTX/06/06/065) Pilot study: the residual effectiveness of chlorhexidine gluconate 0.5% on public health nurses hand flora during student mass vaccination programmes

We wish to advise you that the above research project has received ADHB management approval.

This approval is given based on the materials submitted for ADHB management approval. If there are any amendments or change in the research status, it is **essential** that you send a copy of the amendments to the Research Office as well as to the Ethics committee. Continued management approval is dependant on the Research Office receiving all documentation.

Please send a copy of your final report to the Research Office (Level 8, Bldg 13, Greenlane Clinical Centre, PB 92189, Auckland) on completion of the project.

If you have any questions please do not hesitate to contact the Research Office.

Yours sincerely

Gayl Humphrey
Manager, Research Office
Auckland DHB

c.c. Grace Hinder, Team Leader, Community Child Health & Disability Services
Elizabeth Wood, Service Manager, Community Child Health & Disability Services

Appendix I (6/7)

Ethical consent documents: Massey University

Massey University

OFFICE OF THE ASSISTANT
TO THE VICE-CHANCELLOR
(Ethics & Equity)
Private Bag 11 222
Palmerston North
New Zealand
T 64 6 350 5573/350 5575
F 64 6 350 5622
humanethics@massey.ac.nz
animalethics@massey.ac.nz
gtc@massey.ac.nz
www.massey.ac.nz

26 May 2006

Ms Robyn Duffy
[redacted]

Dear Robyn

Re: Pilot study of the residual effectiveness of chlorhexidine gluconate 0.5% on public health nurses hand flora during student mass vaccination programmes

Thank you for your HDEC Notification which was received on 26 May 2006.

Your project has been recorded on the database for applications referred to HDECs which is reported in the Annual Report of the Massey University Human Ethics Committees.

Please advise this office of any changes required by the approving HDEC. These will be placed on your file. Please also supply to the office a copy of the approval letter from the approving HDEC, when received.

Best wishes for your research.

Yours sincerely

Sylvia Rumball

Professor Sylvia Rumball, Chair
Massey University Human Ethics Chairs Committee

cc Dr Felix Ram
School of Health Sciences
ALBANY

Professor Carol McVeigh, HoS
School of Health Sciences
WELLINGTON

Appendix I (7/7)

Ethical documents: Northern X Regional Ethics Committee - completion letter

Health and Disability Ethics Committees

16 February 2007

Northern X Regional Ethics Committee
Ministry of Health
3rd Floor, Unisys Building
650 Great South Road, Penrose
Private Bag 92 522
Wellesley Street, Auckland
Phone (09) 580 9105
Fax (09) 580 9001

e-mail: pat_chainey@moh.govt.nz

Robyn Duffy
[redacted]

Dear Robyn,

NTX/06/06/065 **Pilot study of the residual effectiveness of chlorhexidine gluconate 0.5% on public health nurses hand flora during student mass vaccination programmes: PIS/Cons V#3, 19/06/06.**

We are in receipt of your letter dated 14 December 2006.

Northern X Committee considered your final report for this study at the meeting held on 13 February 2007.

The report is received. Thank you. This file will now be closed and archived.

Yours sincerely,

Laura Neal
Assistant Administrator

Cc: Auckland Research Office A+ 3491

Appendix J (1/3)

Participant: consent form

Massey University
COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF HEALTH SCIENCES
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 441 8166
F 64 9 441 8165
www.massey.ac.nz

June 30th 2006

Consent form for public health nurses

Research project: The effectiveness of an antiseptic on vaccinators' hands

The researcher, Robyn Duffy has given me an explanation of this study. The research will look for the antimicrobial effects of the antiseptic, chlorhexidine on vaccinators' hand flora during school based vaccination programmes. No material which could identify me or any place will be used in reports or publications.

- I have read and understand the information given to me on the information sheet dated 24.06.2006.
- I have had an opportunity to ask questions, am satisfied with the answers I have been given and have had time to consider whether to take part.
- I realize there will be no payment for participation and understand the compensation provisions for this study.
- I appreciate that taking part in this study is voluntary and I can withdraw my consent at anytime from the study.
- I will not have to give any reasons if I wish to withdraw consent and this will be not affect my employment as a public health nurse.
- I understand that confidential information, data and all consent forms will be securely stored at Massey University Auckland for a period of 10 years and then destroyed as per Massey University's guidelines.

☐ I consent to provide fingertip imprints for microbial flora collection via, agar contact plates.

☐ I understand I am unable to request the return of collected agar plates, as plate data is anonymous.

☐ I realize all agar plates collected will be destroyed after microbial assessment per Lab+ protocols.

I _____(full name)

hereby consent to take part in this study _____(date)

Project explained by Robyn Duffy _____ (date) _____ (signed)

Researcher: Robyn Duffy 307-4949 ext 27488#

CCH&DS Level 6, Cornwall Complex, Greenlane Clinical Centre, Auckland.

Massey University Supervisors:

Doctor Stephen Neville	414-0800 ext. 9065	email: S.J.Neville@massey.ac.nz
Doctor Denise Wilson	414-0800 ext. 9070	email: D.L.Wilson@massey.ac.nz
Doctor Barry McDonald	414-0800 ext. 41039	email: B.McDonald@massey.ac.nz

Appendix J (2/3)

Participant: information sheets (1 of 3)

Massey University
COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF HEALTH SCIENCES
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 441 8186
F 64 9 441 8165
www.massey.ac.nz

24 June 2006

Information sheet for public health nurses

Research project: The effectiveness of an antiseptic on vaccinators' hands

My name is Robyn Duffy and during the Year 7 and Year 8 school based student vaccination programmes (July - September, 2006) I will be undertaking a hand hygiene research project with public health nurses within Auckland District Health Board's area (ADHB). This research is to fulfil my Master's of Nursing thesis and the study will be supervised through Massey University, Auckland. The study has received ethical approval from the Northern X Regional Ethics Committee and has the support of ADHB.

I invite you to participate in this research, no exclusion criteria apply and your participation is entirely voluntary. The study will be conducted over 6-8 weeks on scheduled mass vaccination programme (MVP) days. No interventions are planned. The project will collect and describe flora recovered from vaccinators (public health nurses) hands, during MVPs. As a participant you will follow the ADHB hand hygiene guidelines specific to MVPs. It is proposed to collect 120 agar plate samples (i.e. 60 participant occasions – 2 plates per person). The research aims to measure the sustained antimicrobial efficacy of the alcohol handrub (AHR) sterigel +. The alcohol portion of sterigel+ cleanses hands promptly and the chlorhexidine component provides ongoing antimicrobial activity against bacteria, viruses and yeasts. The potential significance is that evidence of any residual antimicrobial efficacy will be obtained and will provide vaccinating public health nurses with data on which to base hand cleansing practice. There is no payment for participation.

Participation Processes

Written consent is necessary to become a potential participant in this research project (see consenting - page 3 and consent form). Participation is linked to your place as a vaccinator on the school's programme plan, as rostered by the team leader MVPs. Research participation is limited to a maximum of 5 vaccinators per MVP and therefore not all consenting nurses will be included at any one programme. You may be asked to participate up to 4 times during the project. If you do agree to take part you are free to withdraw from the study at any time, by verbal or written communication with the team leader of the MVP, or the researcher. No reason needs to be given to withdraw consent, and this action will not effect your employment.

Appendix J (3/3)

Participant: information sheets (2 of 3)

Participant's role

On arrival at the school venue, verify you are allocated to a vaccinator role with the MVP team leader and you will be advised whether you are a participant at this programme, or not. If you are a participant, you will be directed to the researcher's station to collect the "on the day information" and "vaccinator data sheet". Conversely, if you are not a participant at this programme you will work as a designated vaccinator as is customary.

As a participant vaccinator you cleanse hands with sterigel+ and proceed to work as per usual practice. Then, when you decide to next cleanse hands you will be requested to first, provide fingertip imprints from both hands for five seconds, onto commercial sterile agar plates. This data collection will be completed at the researcher's station behind a privacy screen, within the venue. All agar plates will be coded to numbers to provide anonymity for data information. As a research participant you choose your own agar plate numbers (from a series provided) to augment data privacy. There are 2 yes/no questions asking what prompted you (on this occasion) to cleanse hands. Was this for convenience e.g. scheduled break or, because of a concern e.g. touched a possibly contaminated surface? This data collection process is expected to be completed within three minutes on each occasion. Then you will leave the researcher's station and perform a standard hand wash as per MVP guidelines. No further participation in that day's programme will be required as only one microbial data collection per day, is scheduled per vaccinator.

Management of consent and data information

Confidential information, data and all consent forms will be securely stored at Massey University (Auckland) for a period of 10 years and then destroyed as per Massey University's research guidelines. No material which could personally identify you, any other person or venue will used in any data description, research report or publications on this study. Once microbial samples are collected you are unable to request their return because agar plates are not linked by identifiers (due the anonymity of numerical coding) to participants. Therefore the researcher cannot confirm which plates are yours. Lab+ (ADHB) will follow standard laboratory processes to handle, report and dispose of agar plate samples. At the completion of this project I will attend a public health nurses' team meeting and provide a summary of the data analysis.

Risks and safety

There are no known risks or side effects to taking part in this study. In the unlikely event of a health concern ADHB occupation health (ext. 3861) should be contacted. However in the unexpected event of a physical injury as a result of your participation in this study, you may be covered by the Accident Compensation Corporation (ACC) under the Injury Prevention, Rehabilitation and Compensation Act. ACC cover is not automatic and your case will need to be assessed by ACC according to the provisions of the 2002 Injury Prevention Rehabilitation and Compensation Act. If your claim is accepted by ACC, you still might not get any compensation.

Appendix J (3/3)

Participant: information sheets (3 of 3)

This depends on a number of factors such as whether you are an earner or non-earner. ACC usually provides only partial reimbursement of costs and expenses and there may be no lump sum compensation payable. There is no cover for mental injury unless it is a result of physical injury. If you have ACC cover, generally this will affect your right to sue the investigators. If you have any questions about ACC, contact your nearest ACC office or investigator (915 -9400). If you have any queries or concerns regarding your rights as a participant in this study, you may wish to contact your professional organization for further information.

Consenting

To be part of this research project complete the consent form. Please post the consent form to the researcher within 2 weeks (attached ADHB internal mail pre-addressed envelope). A photocopy of your consent form will be mailed back to you with researcher's note confirming your inclusion. If you have any questions or concerns regarding this project please contact me (Robyn Duffy) or my supervisors at Massey University.

Thank you for considering participation in this research

Robyn.

Researcher: Robyn Duffy: 307-4949 ext. 27488#
CCH&DS Level 6, Cornwall Complex, Greenlane Clinical Centre, Auckland.

Massey University Supervisors:

Doctor Stephen Neville	414-0800 ext. 9065	email: S.J.Neville@massey.ac.nz
Doctor Denise Wilson	414-0800 ext. 9070	email: D.L.Wilson@massey.ac.nz
Doctor Barry McDonald	414-0800 ext. 41039	email: B.McDonald @massey.ac.nz

This study has received ethical approval from the Northern X Regional Ethics Committee on 29 June 2006 Reference number: NTX/06/06/065

Appendix K (1/2)

Spread sheet showing nurses participation dates

2006 Vaccinating Public Health Nurses

✓	Child & Youth	Data 1	Data 2	Data 3	Data 4
1		10 August	22 August	31 August	5 September
2		20 July	25 July	27 July	24 August
3		3 August	15 August	29 August	31 August
4		18 July	20 July	8 August	10 August
5		18 July	27 July	Sick leave	Sick leave
6		20 July	8 August	22 August	31 August
7		1 August	3 August	17 August	24 August
8		18 July	27 July	22 August	24 August
9		20 July	27 July	5 September	-
10		25 July	27 July	17 August	5 September
11		27 July	3 August	15 August	29 August
12		18 July	27 July	1 August	29 August
13		1 August	3 August	15 August	31 August
14		31 August	5 September	-	-
15		27 July	1 August	8 August	22 August
16		18 July	10 August	15 August	31 August
17		8 August	10 August	17 August	24 August
18		20 July	25 July	1 August	24 August
19		10 August	15 August	17 August	-
20		3 August	22 August	29 August	31 August
	Early Childhood	Data 1			
1		Sick			
2		-			
3		17 August			
4		29 August			
5		8 August			
	data completed	-	(not needed)		

Appendix K (2/2)

Sample of team plan with fictitious names

IMMUNISATION TEAM – 2006

Date: *20th July*	*Day:* *Thursday*	*Arrival Time:* *0815*
School: *City Central Intermediate*		
Address: Mayoral Drive City		
School Phone: Ph: 123 - 4567	*Team Phone: 021 - 0000000*	
Venue: School Hall		
Parking: Equipment vehicles beside hall all others on the road		
PHN: Susan	*Number to be vaccinated: 312*	
Cold Chain: Su	*Floater: Heather*	
Vaccinators: *(1) Deborah*	*(2) Rhonda*	
(3) Ann	*(4) Sheryl*	
(5) Wanda	*(6) Liz*	
(7) Nancy	*(8) Margaret* *(9) Frances*	
Recovery: *(1) Kelly*	*(2 Heata*	
(3) Debbie	*(4) Jenny*	
Extras: Student Nurse - Bella		

ARE YOU VACCINATING? – TAKE A SHARPS CONTAINER

Appendix L

Microbial data collection tracking form: researcher/laboratory (sample)

Microbial data collection tracking form: researcher/laboratory page 1 /

Time into chilly bin_____ **Time received laboratory**_____

Date 2006	agar plate number *dominant*	time sterigel+ applied	time of collection	time since sterigel+ applied	convenience yes or no	microbiology	comments

Appendix M (1/2)

Vaccinator data sheet: recording research details

Massey University
COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF HEALTH SCIENCES
Private Bag 102 904
North Shore Mail Centre
Auckland
New Zealand
T 64 9 441 8166
F 64 9 441 8165
www.massey.ac.nz

Vaccinator participant data form

Research project: the effectiveness of an antiseptic on vaccinators' hands

- Vaccinator to document the application time of sterigel+ in a 24 hour clock format i.e., as 0910 rather than 9.10am or 1320 rather than 1.20pm.
- Researcher will complete remainder of form with the participant, post collection of fingertip agar imprints from both hands.

date	
sterigel+ **application time**	
agar plate **time of data collection**	
time period since sterigel + applied	
agar plate number: **dominant hand**	
agar plate number: **non dominant hand**	
answer: **yes or no** on this occasion hand cleansing initiated as e.g. end of programme or scheduled break (convenience)	
answer: **yes or no** on this occasion hand cleansing initiated as nurse identifies potential cross infection risk e.g. body fluids such as blood or contaminated surface touched (concern)	

Thank you for participating in this research project

Researcher: Robyn Duffy 307-4949 ext 27488#
CCH&DS Level 6, Cornwall Complex, Greenlane Clinical Centre, Auckland.

Appendix M (2/2)

Vaccinator 'on the day information': an outline of the process of data collection (reverse side of vaccinator participant data form)

Participant "on the day" information sheet

Research project: the effectiveness of an antiseptic on vaccinators' hands

Today, as a vaccinator you will follow your normal mode of practice and the only additional activity will be one microbial data collection. This is when your fingertips will be imprinted on an agar plate and information recorded (next sheet).

1. Following application of the AHR (sterigel +) record this treatment time on the data collection form and keep the sheet of paper with you until microbial flora has been collected.
2. When you decide it is necessary to cleanse your hands, come to the area where the researcher is stationed (behind the screen).
3. You will choose 2 agar plates (pre numbered) for fingertip imprints.
4. Then, imprints will be collected for five seconds onto the selected agar plates (researcher will direct this process). You will press gently down onto a new sterile agar plate for 5 seconds with all 4 fingertips and then the thumb from that hand will be placed on the same agar plate (on a non imprinted space for a 5 second period). Flora retrieved from a dominant hand will be identified on the agar plate base by "D" and an "N "will identify flora from a non-dominant hand.
5. The imprint time and elapsed time since sterigel+ was last applied will be noted on your participant's sheet and then written onto the base of each agar plate.
6. You will be asked to identify whether the reason for hand cleansing was for convenience (e.g. scheduled break or end of programme) or because you felt it was prudent to cleanse hands at this time (e.g. body fluids on hand or potentially contaminated surface contacted).
7. Next you complete a standard hand wash and you may apply a hand moisturizer (revive) that is chlorhexidine compatible i.e. does not inhibit the substantivity of sterigel+.
8. No further participation is required at this programme.

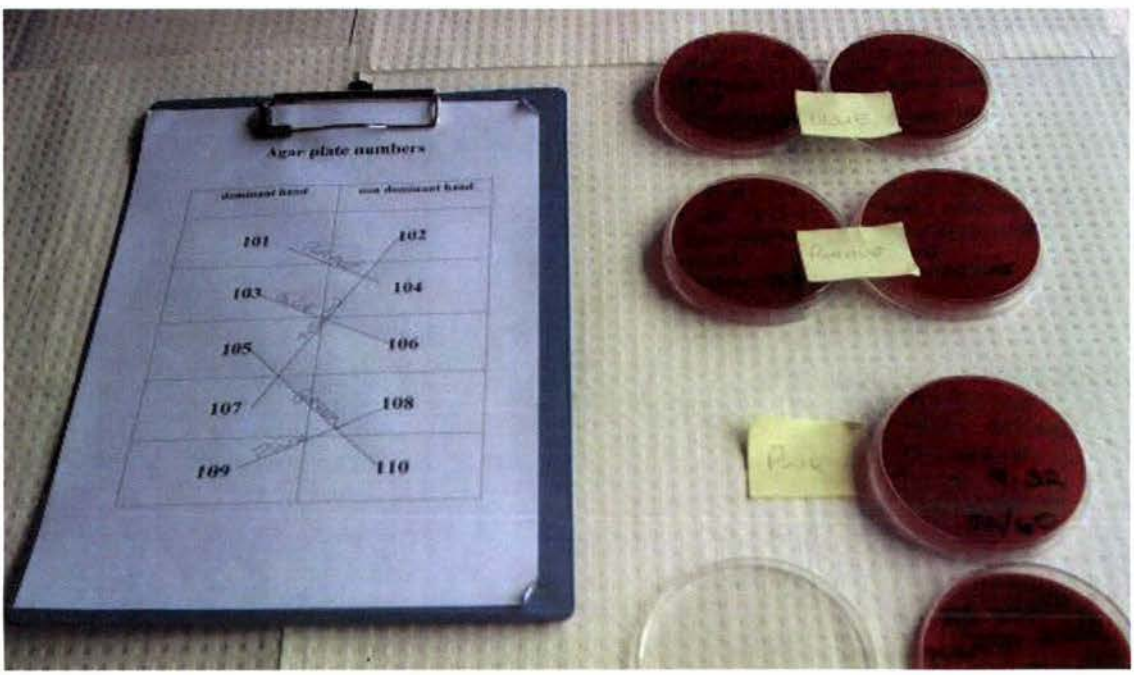
Thank you for participating in this research project

Researcher: Robyn Duffy 307-4949 ext 27488#
CCH&DS Level 6, Cornwall Complex, Greenlane Clinical Centre, Auckland.

Appendix N

Photographic examples showing how:

- agar plate numbers were initially linked to participants
- information was recorded on agar plates
- samples were temporarily linked by 'post it" stationary (identified by colour code to match participants coloured folder



Appendix O (1/4)

Support letter Service Manager: Medical Services and Community Services (Child Health) Auckland District Health Board

AUCKLAND DISTRICT HEALTH BOARD

Community Child Health & Disability Service

A division of Community Health Services

Phone 09 639 0216

Ext: 09 639 0238

Fax: Child & Youth Team

Email: Cornwall Complex

Address: Greenlane Clinical Centre
Building 15, Level 6
Private Bag 92189
Auckland Mail Centre

26 April 2006

To whom it may concern

I would like to formally acknowledge support for the research project being proposed by Robyn Duffy (senior public health nurse).

Robyn has had an association since 1997 with Auckland District Health Board's school based immunisation programmes and is very experienced in this setting. The hand hygiene research she is planning to conduct will be of benefit to public health nurses as there is little evidence currently available on this aspect of community nursing practice.

I am able to confirm that Robyn has approval to conduct the microbial data collection with consenting public health nurse participants at mass vaccination programmes once all ethical and school consents have been gained.

Sincerely

Elizabeth Wood
Service Manager
Medical Services and Community Services (Child Health)
Auckland District Health Board

Appendix O (2/4)

Support letter Service Manager Child and Youth Team Medical Officers (Community Child Health and Disability Service)

AUCKLAND DISTRICT HEALTH BOARD

Community Child Health & Disability Service

A division of Community Health Services

Phone: 09 639 0216

Ext:

Fax: 09 639 0238

Email:

Address: Child & Youth Team
Building 15, Level 6
Cornwall Complex
Greenlane Clinical Centre
Private Bag 92189
Auckland Mail Centre

27 April 2006

To whom it may concern

We would like to formally acknowledge support for the hand hygiene research project being proposed by Robyn Duffy (public health nurse).

Robyn has been involved as a team leader for Auckland District Health Board in several national mass vaccination programmes and is part of the public health nurses' immunisation working party.

The research she plans may provide valuable evidence on the efficacy of the hand hygiene practices currently in use by vaccinators at school based mass vaccination programmes. Information gained will be transferable to both, public and hospital environments for infection control such as, pandemic situations.

The study will present no harm to any volunteers (as standard hand hygiene practice will be followed) nor will pupils or school be exposed to any risk. Therefore, this project will be beneficial for the knowledge gained.

Sincerely

Lalith Goonaratne

Doctor Lalith Goonaratne

Doctor Caroline Schulze

Medical Officers
Community Child Health and Disability Service
Auckland District Health Board

Appendix O (3/4)

Support letter: Service Manager; Associate Director of Nursing (Child Health) Waitemata District Health Board

Waitemata
District Health Board
Te Wai Awhina

Associate Director of Nursing
Child, Maternal and Family Health
Waitemata District Health Board
Private Bag 93-503, Takapuna, North Shore 1309, Auckland
Ph 09 4861 491 / Fax 09 441 8957,
Marianne.cameron@waitematadhb.govt.nz

4th May 2006

To Whom It May Concern:

I would like to formally acknowledge support for the research project being proposed by Robyn Duffy (Level four Public Health Nurse).

Although there is information in the literature regarding hand hygiene practices within an acute setting there is a distinct lack of research to support hand hygiene nursing practice within a school immunisation setting.

Robyn's proposed research will assist with developing evidenced based policies and procedures based on contemporary research and will add to the body of nursing knowledge for public health nurses.

Yours sincerely

Marianne Cameron
Associate Director of Nursing (Child Health)
Waitemata District Health Board

Appendix O (4/ 4)

Support letter: Northern Regional Coordinator Immunisation Advisory Centre

Rebecca Chandra
PO Box 17,360
Greenlane, Auckland
Mobile (027) 4976971
Email: imacnth@ihug.co.nz

April 27th, 2006

To whom it may concern,

We as the Immunisation Advisory Centre would like to formally acknowledge support for the hand hygiene research project being proposed by Robyn Duffy (senior public health nurse).

Robyn has been involved as a team leader for Auckland District Health Board in several national mass vaccination programmes and is part of the public health nurse's immunisation working party.

The research she plans may provide valuable evidence on the efficacy of the hand hygiene practices currently in use by vaccinators at school based mass vaccination programme. Information gained will be transferable to both public and hospital staff environments for infection control such, as pandemic situations.

The study will present no harm to any volunteers (as standard hand hygiene practice will be followed) nor will pupils or school be exposed to any to any risk. Therefore, this project will be beneficial for the knowledge gained.

Kind regards

R. Chandra

Rebecca Chandra
Northern Regional Coordinator

Immunisation Advisory Centre
PO Box 17, 360
Greenlane,
Auckland.
Ph: 0274976971

Appendix P (1/2)

Support letter: Chief Advisor-Tikanga Auckland District Health Board

AUCKLAND DISTRICT HEALTH BOARD
Te Toka Tumai

Service: Maori Health
Private Bag 92184
Phone: GreenLane Clinical Centre
Ext: (09) 630 9943
Fax: 8081
Fax Internal: 4964
Email: vanessaw@adhb.govt.nz

1 May 2006

Re: How clean are Vaccinator's Hands?

To whom it may concern

I would like to formally acknowledge support for the Hand Hygiene Research Project proposed by student researcher Robyn Duffy (Master of Philosophy - Nursing, Massey University).

Robyn has been involved for nearly a decade as a Public Health Nurse Team Leader (Auckland District Health Board) and has wide experience with student school based mass vaccination programmes.

The research she plans may provide valuable evidence on the worth of the hand cleansing regimes currently in use by vaccinators at vaccination programmes. From the discussion we held I understand that no harm will come to any volunteers (as standard hand hygiene practice will be followed) nor will pupils or school be exposed to any to any risk. Additionally as anonymity for participants and schools is paramount no information will be recorded in the study, or reports that could identify a group, an individual or a school.

In my respectful opinion nothing that is being done in this research impinges or breaches any sensitivity around cultural or spiritual areas for Maori. Information on the hand hygiene product reviewed (sterigel+) may be transferable to Maori environments and this is important especially in light of any possible pandemic situation. Therefore, this project will be beneficial for the knowledge gained.

Naku na

R. Naida Glavish JP
Chief Advisor-Tikanga
Maori Health, ADHB

Appendix P (2/2)

Support letter: Pacific Health Service Development Manager Auckland Regional Public Heath Service

Auckland Regional Public Health Service
Rātonga Hauora ā Iwi o Tamaki Makaurau

Level 2
Building 15
Cornwall Complex
Greenlane Clinical Centre
Epsom, Auckland
Private Bag 92 605
Symonds Street
Auckland
Telephone: 09 623 4600
Facsimile: 09 623 4633
Website: www.arphs.govt.nz

27 April 2006

To Whom It May Concern

RE: How clean are vaccinators' hands?

I am writing in support of the above research proposal being submitted for ethical approval by Robyn Duffy, a master's student at Massey University Auckland and public health nurse Auckland District Health Board.

The evidence sought is around the efficacy of the antiseptic (chlorhexidine) (in the product sterigel+) within a community setting. This research may provide Pacific communities in the future with information to support and promote their well being and this aligns well with our cultural and health priorities. The findings of this project will be used to inform public health nurse and other health professionals about the use of sterigel+ to and may influence hand hygiene guidelines to continue to provide the highest standard of nursing practice for immunisation delivery for Pacific people.

I was pleased to find that Robyn has previously discussed her research with both Samoan and Tongan public health nurses to endeavour to plan a research project that was cultural sensitive and appropriate.

Please feel free to contact me if you need further assistance while the study is in progress.

I look forward to receiving a final report of the study.

Yours sincerely

Louisa Ryan
Pacific Health Service Development Manager
Auckland Regional Public Health Service

Appendix Q (1/2)

Excel worksheet: summary of dominant hands laboratory data

2006	Row	Time Applied	Time Collect	Time Frame	Convenience	Dominant	Total CFU	Overgrown	Smudge		CNS	Corny spp	GPB	Micrococcus	S aureus	Staph spp	Strep spp	Yeast		ASB	Fungus		AHS	Neisena		GNB	NFNB	ACI spp	Proteus
											A	A	A	A	A	A	A	A		B	B		C	C		D	D	D	D
18-Jul	1	9.05	9.25	20	Y	107	*	1												#									
18-Jul	2	9.05	9.27	22	N	101	15				14			1															
18-Jul	3	9.05	9.28	23	Y	103	9				7			1						1									
18-Jul	4	9.03	9.36	33	Y	105	*	1																					#
18-Jul	5	9.05	9.57	52	Y	109	79				64			13						2									
20-Jul	6	9	10.03	63	Y	117	7				6			1															
20-Jul	7	9	10.3	90	Y	111	*		1		#			#									#						
20-Jul	8	9.25	10.1	45	Y	119	25				16			4												5			
20-Jul	9	9.05	9.36	31	N	113	40				27			12						1									
20-Jul	10	9	9.42	42	Y	115	69				3	11		54						1									
25-Jul	11	8.45	10	75	Y	121	9				2						1			1						1	4		
25-Jul	12	9.1	10.02	52	Y	123	*	1												#									
25-Jul	13	8.4	9.24	44	N	125	24				7			15						2									
27-Jul	14	8.5	9.5	60	Y	127	138				8			16						2							106	6	
27-Jul	15	8.5	10.2	90	Y	129	31				12			16						1			2						
27-Jul	16	8.5	9.15	25	N	131	92				64	11		15						2									
27-Jul	17	8.4	9.4	60	Y	133	75				57	9		5						4									
27-Jul	18	8.45	10.05	80	Y	135	2					1								1									
27-Jul	19	11.4	11.49	9	Y	137	26				1									25									
27-Jul	20	11.32	11.37	5	N	139	1					1																	
27-Jul	21	11.15	11.48	33	Y	141	6				4									1			1						
1-Aug	22	8.3	8.38	8	N	143	111				110									1									
1-Aug	23	8.25	9.07	42	Y	145	34				23	1		7									3						
1-Aug	24	8.27	9.05	38	Y	147	2				2																		
1-Aug	25	8.3	9	30	Y	149	4				1			1						1			1						
1-Aug	26	8.55	9.02	7	Y	151	0																						
3-Aug	27	8.4	9.45	65	Y	153	39				29	6								1			3						
3-Aug	28	8.33	9	27	Y	155	4				1	1		1						1									
3-Aug	29	8.31	9.04	33	N	157	28				16	4			6											2			
3-Aug	30	8.32	9.06	34	Y	159	2					1											1						
3-Aug	31	8.34	9.07	33	Y	161	14				6				5		1			2									
8-Aug	32	8.45	9.17	32	Y	163	8				5	2								1									
8-Aug	33	8.57	9.34	37	Y	165	37				22			14												1			
8-Aug	34	9.16	9.3	14	Y	167	1				1																		
8-Aug	35	9	9.27	27	Y	169	9				3	2		1						1			2						
8-Aug	36	8.59	9.21	22	Y	171	13				5			6						1						1			
10-Aug	37	8.35	8.57	22	Y	173	1				1																		
10-Aug	38	8.32	9.12	40	Y	175	95				89			4						2									
10-Aug	39	8.3	8.55	25	Y	177	13				10									2						1			
10-Aug	40	8.3	9.05	35	Y	179	26				13			12						1									
10-Aug	41	8.41	9.08	27	Y	181	34				29			1						2			2						
15-Aug	42	8.48	9.38	50	Y	183	3							2		1													
15-Aug	43	8.46	9.32	46	Y	185	7				7																		
15-Aug	44	8.48	9.37	49	Y	187	13				5	2		4						1								1	
15-Aug	45	8.49	9.39	50	Y	189	70				63			6						1									
15-Aug	46	8.49	9.31	42	Y	191	14				8	1		3														2	
17-Aug	47	8.44	9.11	27	N	193	11				3															2		6	
17-Aug	48	8.44	9.16	32	Y	195	26				12			9						4			1						
17-Aug	49	8.42	9.28	46	N	197	44				20	5		18						1									
17-Aug	50	8.41	9.06	25	N	199	15				1	1						1								10	2		
17-Aug	51	9	10.05	65	Y	201	32				18	1	8	1												4			
22-Aug	52	8.25	8.52	27	Y	203	*		1		#			#												#			
22-Aug	53	8.25	8.51	26	Y	205	29				28		1																
22-Aug	54	8.3	8.38	8	Y	207	0																						
22-Aug	55	8.3	8.45	15	Y	209	15				7	1	2	2										2		1			
22-Aug	56	8.28	9.08	40	Y	211	36				35		1																
24-Aug	57	9	10	60	Y	213	24				14	1											6	3					
24-Aug	58	8.54	10.03	69	Y	215	7				3									3							1		
24-Aug	59	8.55	9.58	63	Y	217	57				53			3													1		
24-Aug	60	9.25	9.57	32	Y	219	5				3									2									
24-Aug	61	8.45	9.16	31	Y	221	7				6									1									
29-Aug	62	9.05	9.21	16	Y	223	21				5			12						1				2		1			
29-Aug	63	9.05	9.22	17	Y	225	3				1									2									
29-Aug	64	9.15	9.35	20	Y	227	1																1						
29-Aug	65	9.06	9.36	30	Y	229	5				4									1									
29-Aug	66	9.05	9.2	15	Y	231	23				3			17						1				2					
31-Aug	67	9.04	9.26	22	N	233	35				19			12						2								2	
31-Aug	68	8.54	9.19	25	N	235	70				66			3		1													
31-Aug	69	8.55	9.38	43	Y	237	30				13			12												2	3		
31-Aug	70	8.55	9.36	41	Y	239	1							1															
31-Aug	71	9	9.35	35	Y	241	23				20			3															
31-Aug	72	12.57	13.12	15	Y	243	8				5			2										1					
31-Aug	73	12.58	13.18	20	Y	245	12				11									1									
5-Sep	74	10.28	10.37	9	Y	247	30				14			14						2									
5-Sep	75	10.3	10.56	26	Y	249	33				23			10															
5-Sep	76	10.3	10.52	22	Y	251	10				5			4									1						
5-Sep	77	10.27	10.57	30	Y	253	*	1			#	#		#															
							1843	4	2	0	1133	62	12	338	11	2	2	1		83	0		24	10		31	117	17	0

Appendix Q (2/2)

Excel worksheet: summary of non-dominant hands laboratory data

2006	Row	Time Applied	Time Collect	Time Frame	Convenience	Non Dominant	Total CFU	Overgrown	Smudge		CNS	Corny spp	GPB	Micrococcus	S aureus	Staph spp	Strep spp	Yeast		ASB	Fungus		AHS	Neisseria		GNB	NFNB	ACI spp	Proteus
											A	A	A	A	A	A	A	A		B	B		C	C		D	D	D	D
18-Jul	1	9.05	9.25	20	Y	106	56				43			13																
18-Jul	2	9.05	9.27	22	N	104	11				9			1						1										
18-Jul	3	9.05	9.28	23	Y	102	*		1		#																			
18-Jul	4	9.03	9.36	33	Y	108	*		1		#			#						#										
18-Jul	5	9.05	9.57	52	Y	110	39				21			18																
20-Jul	6	9	10.03	63	Y	120	7				2				1					1						3				
20-Jul	7	9	10.3	90	Y	116	101				81			14						1			4				1			
20-Jul	8	9.25	10.1	45	Y	118	*	1												#										
20-Jul	9	9.05	9.36	31	N	114	17				13									3						1				
20-Jul	10	9	9.42	42	Y	112	76				14	5		56												1				
25-Jul	11	8.45	10	75	Y	122	21				5			8	1								5			1	1			
25-Jul	12	9.1	10.02	52	Y	124	23				20						3													
25-Jul	13	8.4	9.24	44	N	126	21				7			12						2										
27-Jul	14	8.5	9.5	60	Y	128	100				9									68							23			
27-Jul	15	8.5	10.2	90	Y	130	31				7	2		10		10											2			
27-Jul	16	8.5	9.15	25	N	132	42				21			21																
27-Jul	17	8.4	9.4	60	Y	134	41				23			13			3											2		
27-Jul	18	8.45	10.05	80	Y	136	1					1																		
27-Jul	19	11.4	11.49	9	Y	138	4				1												2				1			
27-Jul	20	11.32	11.37	5	N	140	0																							
27-Jul	21	11.15	11.48	33	Y	142	12				1	9								2										
1-Aug	22	8.3	8.38	8	N	144	79				69									9	1									
1-Aug	23	8.25	9.07	42	Y	146	*		1		#			#																
1-Aug	24	8.27	9.05	38	Y	148	3				2	1																		
1-Aug	25	8.3	9	30	Y	150	4				2				2															
1-Aug	26	8.55	9.02	7	Y	152	5				5																			
3-Aug	27	8.4	9.45	65	Y	154	99				92			2						2			3							
3-Aug	28	8.33	9	27	Y	156	*		1		#																			
3-Aug	29	8.31	9.04	33	N	160	31				13	2		3	10			2								1				
3-Aug	30	8.32	9.06	34	Y	158	0																							
3-Aug	31	8.34	9.07	33	Y	162	15				6				8					1										
8-Aug	32	8.45	9.17	32	Y	164	2							1									1							
8-Aug	33	8.57	9.34	37	Y	166	174				169			1				2		2										
8-Aug	34	9.16	9.3	14	Y	172	3				2												1							
8-Aug	35	9	9.27	27	Y	170	38				29			6						3										
8-Aug	36	8.59	9.21	22	Y	168	32				19			12						1										
10-Aug	37	8.35	8.57	22	Y	174	8				8																			
10-Aug	38	8.32	9.12	40	Y	176	*		1		#									#						#				
10-Aug	39	8.3	8.55	25	Y	178	19				10			9																
10-Aug	40	8.3	9.05	35	Y	180	64				46			14						2			2							
10-Aug	41	8.41	9.08	27	Y	182	95				91															4				
15-Aug	42	8.48	9.38	50	Y	184	2				1			1																
15-Aug	43	8.46	9.32	46	Y	186	6				1		2															3		
15-Aug	44	8.48	9.37	49	Y	188	23				16	2		2						1			1			1				
15-Aug	45	8.49	9.39	50	Y	190	*		1		#			#						#								#		
15-Aug	46	8.49	9.31	42	Y	192	29				26			3																
17-Aug	47	8.44	9.11	27	N	194	11				3	1		2												1		4		
17-Aug	48	8.44	9.16	32	Y	196	22				17		1	3														1		
17-Aug	49	8.42	9.28	46	N	198	*	1			#									#										
17-Aug	50	8.41	9.06	25	N	200	18				4			1												13				
17-Aug	51	9	10.05	65	Y	202	25				9			2						1						10		3		
22-Aug	52	8.25	8.52	27	Y	208	24				16			2													1	5		
22-Aug	53	8.25	8.51	26	Y	204	17				14	3																		
22-Aug	54	8.3	8.38	8	Y	210	1				1																			
22-Aug	55	8.3	8.45	15	Y	206	5				4									1										
22-Aug	56	8.28	9.08	40	Y	212	32				25	4	1											2						
24-Aug	57	9	10	60	Y	214	73				69			3													1			
24-Aug	58	8.54	10.03	69	Y	216	34				26	2		4						2										
24-Aug	59	8.55	9.58	63	Y	218	215				210			2						3										
24-Aug	60	9.25	9.57	32	Y	220	16				8			6												2				
24-Aug	61	8.45	9.16	31	Y	222	7				2			2									1	1		1				
29-Aug	62	9.05	9.21	16	Y	224	20				11			3												2		4		
29-Aug	63	9.05	9.22	17	Y	226	2																1				1			
29-Aug	64	9.15	9.35	20	Y	230	5				4									1										
29-Aug	65	9.06	9.36	30	Y	228	11					1	1					1					8							
29-Aug	66	9.05	9.2	15	Y	232	36				18			14						1			3							
31-Aug	67	9.04	9.26	22	N	234	35				15			17	3															
31-Aug	68	8.54	9.19	25	N	236	14				7			4													2	1		
31-Aug	69	8.55	9.38	43	Y	240	55				38		16							1										
31-Aug	70	8.55	9.36	41	Y	238	6							4		2														
31-Aug	71	9	9.35	35	Y	242	28				21	1		6																
31-Aug	72	12.57	13.12	15	Y	244	4				2			2																
31-Aug	73	12.58	13.18	20	Y	246	7				5									1								1		
5-Sep	74	10.28	10.37	9	Y	248	21				10			8						3										
5-Sep	75	10.3	10.56	26	Y	250	42				26			8						2			6							
5-Sep	76	10.3	10.52	22	Y	254	7							5						2										
5-Sep	77	10.27	10.57	30	Y	252	50				43			6						1										
							2177	2	6		1492	34	21	324	25	12	6	5		118	1		38	3		41	33	24	0	