Chapter 1
LITERATURE REVIEW

1.1 Introduction

In the *Mishnah Torah,* a collection of biblical and rabbinic customs, rules and practices, Moses Maimonides, a prominent physician of his time writes, "I dismount from my animal, wash my hands, [and] go forth with my patients…" This statement, written between 1170 and 1180 AD, may arguably be the first documented event of handwashing pertaining to patient care (Rosner, 2002).

In 1773, Charles White, a surgeon and obstetrician in England, published a paper stressing the importance of surgical cleanliness in order to prevent puerperal sepsis. Puerperal sepsis, also known as childbed and puerperal fever, is a streptococcal infection of the uterus and/or surrounding regions characterized by an acute fever. In 1795, and again in 1843, Drs. Alexander Gordon and Oliver Wendell Holmes published similar papers reiterating the importance of surgical hygiene to prevent this disease (Boyce and Pittet, 2001; HyGenius, 2004; Prescott *et al.*, 1999a).

In the late 1840's, Dr. Ignaz Semmelweis, an obstetrician, was distressed about the prevalence of puerperal sepsis killing new mothers in his hospital. The situation was so desperate that women would beg to give birth in the streets and be admitted to the hospital after delivery. It was initially unclear why giving birth followed by admission to the hospital caused fewer deaths.

A colleague of Semmelweis' finger was lacerated while performing an autopsy of a woman who had died from childbed fever. The cut became infected and shortly thereafter, the colleague died. This tragedy made Semmelweis realize that physicians were transferring something from sick and dead patients to healthy ones on their hands. Because of his position, he was able to immediately order every doctor, nurse, and student to wash their hands thoroughly with a calcium chloride solution before coming in contact with patients. The change in procedure quickly reduced the death rates in his hospital from 29% to less than 1%. Unfortunately, his ideas were ridiculed and severely criticized by other well-known obstetricians who had their own theories regarding the etiology, epidemiology and prophylaxis of childbed fever.

Semmelweis published his findings supported by years of data, but was unable to convince the majority of his colleagues. Exasperated, Semmelweis was eventually admitted to a psychiatric hospital where ironically he died, in 1865, due to an infection with the same organism that causes puerperal sepsis (HyGenius, 2004; Neville, 2003; Prescott *et al.*, 1999b; Project Creation, 2004).

In 1879, at a meeting addressing puerperal sepsis, a speaker was discrediting the idea that hands were one of the main vectors by which the disease was spread. An infuriated member of the audience stood and rebuffed the speaker proclaiming, "…it is you doctors that carry deadly microbes from sick women to healthy ones! (Case, 2004)". The member's name was Louis Pasteur, whose own ideas were the objects of parochial skepticism (Case, 2004).

While Semmelweis is credited with being the first person to acknowledge the existence of nosocomial infections, men such as Girolamo Fracastoro, Antony van Leeuwenhoek and Otto Müller also contributed greatly to the development of microbiology (Prescott *et al.*, 1999b).

1.2 Nosocomial Infections

A nosocomial or hospital-acquired infection is developed by a patient while in a healthcare facility due to the introduction of a pathogen whether or not the disease is expressed during the duration of the hospital stay (Johnson, 2002; Morley, 2002; Prescott *et al.*, 1999). Anything that facilitates the transmission of an infectious organism is termed a vector. Healthcare workers' (HCW) hands seem to be the most common vector of nosocomial infections, although food served in these facilities as well as medical equipment and instruments (fomites) have also been implicated (Boyce and Pittet, 2002; Goldrick *et al.*, 2002; Larson, 1995; McDonald, 2003; Muto *et al.*, 2000; Naikoba and Hayward, 2001).

Most nosocomial diseases are caused by bacteria and are frequently associated with infection of the blood, skin, surgical sites, the respiratory and urinary tracts and various other sites (Prescott, 1999c). Today, the idea of handwashing is inarguably accepted as an effective way to reduce the transmission of infectious agents. Despite this

knowledge, efforts to increase hand hygiene are still met with resistance. (Harbath, 2000; HyGenius, 2004; Naikoba and Hayward, 2001).

1.3 Hand Hygiene

1.3.1 Handwashing

Handwashing and hand hygiene are terms that are often used interchangeably within the general public and among those who serve in healthcare arenas. However, as technology moves forward and continues to produce new products aimed at increasing the cleanliness of hands, it is important that these terms be more clearly defined.

Although not found in standard dictionaries the terms: handwashing, hand washing or hand-washing are widely accepted and have been used in numerous scientific journals. For the purpose of this text, handwashing will be defined as cleansing by the action of liquid, usually water, commonly but not always accompanied by soap, in order to remove soil or other contamination from the hands.

Plain soap, that is, soap without antimicrobial properties, is a cleansing agent composed mainly of fatty acids, sodium and/or potassium. Soap is currently available in the forms of a bar, liquid, tissue, leaflet, foam and powder preparations. Antibacterial soaps can contain solutions of chlorhexidine, chloroxylenol, hexachlorophene, quanternary ammonium and/or triclosan. Soaps can exhibit bactericidal or bacteriostatic properties depending on their exact composition (Boyce and Pittet, 2002).

Various recommendations for proper handwashing technique have been made in the literature. When attempting to properly wash one's hands with soap and water, one must first wet the hands with warm water. Secondly, the soap product must be applied to the hands and rubbed vigorously over all hand and wrist surfaces for 15 to 30 seconds. The hands should be rinsed and dried with a disposable towel. After drying, the disposable towel should be used to turn the faucet off so as not to contaminate the hands again (Boyce and Pittet, 2002; CDC, 2003; Larson, 1995; McDonald, 2003).

Handwashing is a form of hand hygiene. Hand hygiene will be defined in this text as procedures and practices such as handwashing and/or using a waterless antiseptic agent in order to maintain cleanliness of the hands (Boyce and Pittet, 2002; CDC, 2003; Larson, 1995; McDonald, 2003).

1.3.2 Alcohol-Based Waterless Hand Sanitizers

Alcohol, the main ingredient in most waterless antiseptic agents, has long been used as a disinfectant and antiseptic (Boyce and Pittet, 2002). It possesses bactericidal, fungicidal, and some viricidal properties, although it is not sporicidal. Alcohol is able to produce its disinfectant and antiseptic properties through the process of denaturing proteins and dissolving lipid membrane layers, which causes dehydration of the organism (Prescott *et al.*, 1999a). The manufacturers of alcohol-based waterless hand sanitizer (WHS) claim their products are capable of killing up to 99.9% of organisms within 15 seconds (GOJO, 2002). Alcohol is generally found at concentrations between 60 - 90% in these products. Waterless hand sanitizer does not possess residual activity (Boyce and Pittet, 2002). Most sources agree that WHS should not to be used in situations where the hands are visibly soiled or contaminated (Boyce and Pittet, 2002; CDC, 2003; GOJO, 2002, Dharan *et al.*, 2003; Fendler, 2002; Kramer *et al.*, 2002; Larson, 1995).

The above products were all developed in the hopes of increasing overall cleanliness and decreasing the transfer of infectious organisms. However, the burden of controlling infectious disease still rests on the shoulders of the medical workforce, epidemiologists, sanitarians, infection control personnel and the individual patient (Foley-Nolan *et al.*, 1998; Goldrick *et al.*, 2002; Johnson, 2002; Larson, 1995; Morley, 2002). The government is also actively involved through federal and public health programs and laboratories. These agencies in cooperation with private programs and laboratories compile their findings on infection control practices and share ideas with organizations such as the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) (Boyce and Pittet, 2002).

1.4 Infection Control and Healthcare Worker Compliance

In 1970, the CDC along with participating hospitals collaborated in an effort to "describe the epidemiology of nosocomial infections, to describe antimicrobial resistance trends and to produce nosocomial infection rates to use for comparison purposes". As part of an earlier effort in 1985, the CDC released the findings of the “Study on the

Efficacy of Nosocomial Infection Control" (O'Boyle *et al.*, 2002). The study showed that staffing one infection control professional (ICP) for every 250 occupied beds in a human acute care facility was most advantageous in preventing nosocomial infections (O'Boyle *et al.*, 2002). The duty of ICPs varies from one facility to another. Generally, they are responsible for implementing procedures and protocols that would prevent the spread of infectious agents in their institution (Currin *et al.*, 2003; Goldrick *et al.*, 2002; Morley, 2002). Their plight in some cases seems as bleak as that of their predecessor, Dr. Semmelweis.

Educational and motivational techniques to improve hand hygiene have been cited as being effective for short periods of time, but they appear to have little long-term impact (Boyce and Pittet, 2002; Voss and Widmer, 1997). Compliance with hand hygiene procedures among HCW is still generally low averaging 40% (range 5-81%) (McDonald, 2003; Naikoba and Hayward, 2001; Rao *et al.*, 2002; Voss and Widmer, 1997).

Healthcare workers site may reasons for their non-adherence to outlined hand hygiene protocols. These include but are not limited to: skin irritation, inconvenience, lack of or shortage of sinks, lack of soap and/or paper towels, high-case loads, understaffing, insufficient time, low risk of acquiring infection, forgetfulness and lack of modeling by colleagues or superiors (Boyce and Pittet, 2002; Jarvis, 1994; Voss and Widmer, 1997). Poor adherence to protocol has been associated with the following factors: 1) being a physician, nurse assistant or intensive care unit employee, 2) being male, 3) working a weekday schedule (as opposed to a weekend schedule), 4) having the availability of an automated sink and 5) having to put on gloves and/or gowns (Boyce and Pittet, 2002).

Even in situations where HCW are found to act in accordance with the outlined handwashing protocols, they rarely spend more than 15 seconds doing so. Most soaps and waterless antiseptic agents are evaluated using wash/contact times between 30 to 60 seconds (Boyce and Pittet, 2002; Dharan *et al.*, 2003; Fendler, 2002; Kampf *et al.*, 2002; Larson *et al.*, 1986). Little data exists evaluating the efficacy of hand hygiene agents under the realistic conditions in which HCW use them (Dharan *et al.*, 2003). One would expect hand hygiene compliance rates to increase with the introduction of WHS and other

agents that require less usage time. However, lack of adherence to protocols is prevalent in all healthcare settings including veterinary medicine (Foley-Nolan *et al.*, 1998; Morley, 2002).

1.5 Biosecurity

The term biosecurity may be defined as organized hygienic efforts aimed at preventing the spread of infectious disease. This can include actions such as the barring of infectious disease into a facility, preventing the spread of infectious disease through isolation, increased awareness of personnel and the implementation of protocols aimed at hand hygiene and facility disinfection (Johnson, 2002; Morley, 2002).

Although the idea of preventing the spread of disease for the sole sake of patients' health is noble, it cannot be overlooked that economic well-being has a role in biosecurity. When biosecurity practices fail in either human or veterinary healthcare facilities drastic changes to normal institutional operations, decreased overall client trust and a damaged reputation in the community can occur. These things can result in decreased revenue for the facility. Litigation may even compound losses further.

In response to a survey conducted in 1997, approximately 70% (12/18) of veterinary teaching hospitals reported nosocomial outbreaks in their institutions. Associated costs ranged from $10,000 to $550,000. Six hospitals were forced to close their facilities in order to prevent further spread of the infectious agent. At the time of the survey, the majority of hospitals did not have anyone responsible for biosecurity at their institutions (Johnson, 2002; Morley, 2002).

1.6 Zoonotic Infectious Agents

Some diseases that occur in animal settings are of double concern because of the potential for zoonoses. Zoonotic organisms are agents capable of causing infection in both human and animal species. They may be transferred from animal to human or from human to animal. Approximately 80% of veterinary teaching hospitals in the previously

mentioned survey reported that their nosocomial outbreaks were due to *Salmonella*, an organism with zoonotic potential (Johnson, 2002; Morley, 2002).

The mode of transmission for *Salmonella* is typically fecal-oral and the source can often be traced to contaminated water or food, particularly meat, milk and eggs. Humans and animals, infected subclinically, can shed the bacteria and may only exhibit signs of illness in response to stress (Morley, 2002; Quinn and *et al.*, 1994). *Salmonella* possesses the ability to quickly develop resistance to antimicrobials and is somewhat susceptible to antiseptic and disinfectant agents. *Salmonella* has been known to cause illness in humans, rodents, birds, sheep, pigs, cattle and horses (Quinn *et al.*, 1994).

Humans, pigs, cattle, sheep, poultry, horses, and rabbits have also been known to become infected with members of the genus *Escherichia* (Quinn *et al.*, 1994). *Escherichia coli* naturally inhabits the lower small and large intestine of warm-blooded animals. It is excreted in the feces and can survive in the environment for months at a time (Prescott, 1999; Quinn *et al.*, 1994). Many strains of *E. coli* are considered non-pathogenic, but may occasionally cause opportunistic infections.

The family *Enterobacteriaceae* has earned the reputation of being home to some of the most commonly encountered, pathogenic bacteria in the world. Both *Salmonella* and *E. coli* have been repeatedly implicated in nosocomial, food-borne and other outbreaks (Johnson, 2002; Morley, 2002). Recently, a particularly deadly form of *Escherichia, E. coli* O157: H7 has been brought to public attention as a global health concern. It has caused numerous deaths and illness in over 30 different countries and 6 continents (Mead and Griffin, 1998). Fast food restaurants have also faced litigation due to allegedly contaminated food and during the last decade, beef processors within the United States have had to recall over 25 million pounds of beef out of fear that their products contained *E. coli* O157: H7 (Mead and Griffin, 1998).

Potential deadly organisms can exist not only on the infected individuals or animals, but also in surrounding environments for months at a time (Prescott, 1999; Quinn *et al.*, 1994). Their ability to do this makes hand hygiene even more important because one must assume that everything one touches in these environments has the possibility of being contaminated.

Numerous litigations against county fairs, local farms, petting zoos and similar venues, have involved children who became severely ill and in some cases died due to zoonotic infections (Christie, 2002; Christie, 2003). It is possible that many more less serious cases go unreported (CDC, 2001a; CDC, 2001b; CDC, 1999, Crump *et al.*, 2003; Crump *et al.*, 2002; Milne *et al.*, 1999; Sanchez *et al.*, 1995).

The CDC recommends that operators of animal facilities open to the public provide information about the risk of zoonoses. In addition, they recommend that food service and animal-contact locations should be separated. The CDC stresses the importance of proper handwashing immediately after animal contact and suggests that when an attraction does not have the proper facilities for handwashing, WHS should be used. However, this suggestion is followed by a disclaimer that scientific data is lacking regarding the efficacy of WHS in animal environments (CDC, 2001a).

1.7 Research Justification

Waterless hand sanitizer has already been shown to decrease hand bacterial contamination and increase hand hygiene compliance among human HCW (Fendler *et al.*, 2002; Kampf *et al.*, 2002; Marena *et al.*, 2002; Mody *et al.*, 2003). In October 2002, the CDC released recommendations for the usage of WHS in human healthcare settings; however, no recommendations were made for veterinary or animal agricultural settings (Boyce and Pittet, 2002). Therefore, it is of value to access the efficacy of WHS in such settings where nosocomial and zoonotic infections with agents like *Salmonella* and *E. coli* may take place.

1.8 References

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