ORGANIC BUILDUP AND RESIDUAL BLOOD ON CLEAN INFANT STETHOSCOPES USED IN MATERNAL-INFANT AREAS

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN THE GRADUATE SCHOOL OF

TEXAS WOMAN'S UNIVERSITY

COLLEGE OF NURSING

BY

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AUGUST 1997

TEXAS WOMAN'S UNIVERSITY

DENTON, TEXAS

April 25, 1997

To the Associate Vice President for Research and Dean of the Graduate School:

I am submitting herewith a dissertation written by Jan Marie Nick entitled *"Organic Buildup and Residual Blood on Clean Infant Stethoscopes used in Maternal-Infant Areas."* I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Nursing.

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DEDICATION

This dissertation is dedicated to our mother, Lois LaDean Wilder Gross who fell asleep in Jesus during my doctoral studies. She instilled in me a zest for life, and a strong determination to complete whatever task lay ahead. During each of my educational endeavors, she would give me a big hug and say how proud she was of me—her faith in me never faltered. She has left a big hole in all of our hearts. Mom, we miss you--we'll meet you in heaven.

Jan & Kevin

Dad, Grandma

Carlene, Steve, & Tracy

Cynthia, Claude, Phillip, & Andrew

Ben, Flo, Chad & Todd

Joanne, Scott, Matthew, Mark & Timmy

ACKNOWLEDGEMENTS

There are many people I would like to thank publicly for their time, energy, and support through this long and arduous academic achievement. First, I would like to thank Dr. Joanette McGadney, for her guidance, expertise, and boundless supply of energy and enthusiasm on this dissertation committee. She has the knack for instilling confidence in anyone, and demonstrates an excitement about nursing research and the future of nursing that is not equaled by many. Dr. McGadney, it was a pleasure working with you. I hope our paths meet again in the future.

I would also like to thank Dr. Margaret Beard, for her gentle yet constant guidance in producing quality, theory based research. From her persistence in theory driven nursing research, my pragmatic mind can now appreciate the importance for and need for theory in clinical research. Throughout, your words of encouragement have endeared me to you. I look forward to continuing our professional relationship. Thanks Dr. Beard for showing that collegiality between professor and student is possible and desirable!

I would also like to thank Dr. Patsy Keyser for her support and generation of ideas on this project. Her strengths lay in creativity coupled with logic; these strengths were demonstrated numerous times during my student tenure. I think this research is stronger

because of it. Thanks Dr. Keyser, you are one of the most pleasant and compassionate persons I have met. God bless you.

Finally, I would like to thank my long time mentor and husband, Dr. Kevin Nick. Kevin, you have provided me with more spiritual, emotional, and physical energy than words can do justice to. Thanks, sweetie. I promise I won't go on to any more academic degrees if you won't!

ABSTRACT

ORGANIC BUILDUP AND RESIDUAL BLOOD ON CLEAN INFANT STETHOSCOPES USED IN MATERNAL-INFANT AREAS

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August, 1997

Since the mid 1980s, health care workers have attempted to eliminate contact with blood and other body via primary or secondary exposure. At delivery, stethoscopes used on newly born infants come in direct contact with blood and body fluids from the skin of the infant. If contaminants such as blood and body fluids still remain on stethoscopes despite cleaning, an environmental risk may exist.

Using a naturalistic setting, a non-experimental, two group post-test design was implemented to investigate the occurrence of organic buildup and residual blood on clean stethoscopes used on infants in the delivery and/or nursery areas. Eleven hospitals were chosen as data collection sites from a non-probability sampling technique.

Results showed that of 97 clean stethoscopes used on newly born infants, 41 of 51 L&D stethoscopes (80%) and 33 of 46 stethoscopes found in nursery areas (72%) had

organic buildup on the diaphragm of the stethoscope. There were no differences in the rates of organic buildup between L&D and nursery areas ($\chi^2_{(1, N=97)} = 1.00, p = .317$). Seventy six percent of stethoscopes used in L&D areas were positive for blood, as compared to 46% of Nursery stethoscopes testing positive. Nursery areas did have significantly lower rates of residual blood than stethoscopes from L&D areas ($\chi^2_{(1, N=97} = 9.89, p = .002$). The odds ratio indicated that stethoscopes used in L&D areas are four times as likely to have residual blood on them than stethoscopes used in nursery areas.

A significant association was found between organic buildup and residual blood ($\chi^2_{(1, N=97} = 6.60, p = .010$) . The odds ratio indicated that a stethoscopes is 3 ½ times more likely to have blood on the stethoscope if buildup is also present. When hospital sites were compared for organic buildup, the majority of proportions ranged from .666 to .857. All had similar confidence intervals. Two hospitals had better rates of blood contamination than the other nine hospitals. It can be concluded that traditional methods for cleaning stethoscopes in maternal-infant areas are ineffective in removing blood and other body fluids.

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CHAPTER 1

INTRODUCTION

Since the 1980s, health care personnel have become particularly aware of the inherent risk of transmission of dangerous diseases caused by blood borne pathogens. In response to this threat of transmission, the Centers for Disease Control and Prevention (CDC) issued a mandate that all health care personnel take precautions from direct contact with blood and body fluids. All body fluids are now considered potentially contaminated with blood born pathogens, and universal precautions are observed on all patients, regardless of their health status. Health care workers must now reevaluate direct skin and equipment contact, and seek to eliminate any and all exposures to blood and body fluids. Special procedures exist for the handling and cleaning of equipment contaminated with blood and body fluids. Stethoscopes used on newly born infants come in direct contact with blood, and other body fluids on a daily basis. Yet to date, no changes in stethoscope hygiene have been documented.

Upon delivery, the infant is often covered with a mixture of vernix caseosa, amniotic fluid, meconium (fetal feces), and maternal blood. Vernix is a thick tenacious substance that serves to protect the epidermal layer of the fetus in utero, and is difficult to remove from the skin and equipment. Immediately following the birth, the infant's cardiac and pulmonary status is assessed using a stethoscope. During this short

assessment period, the blood and body fluids can be transferred from the skin to the stethoscope via direct skin-to-equipment contact. Because of the tenacious nature of this admixture (primarily due to the vernix), routine cleaning of the stethoscope may prove ineffective in the removal blood and other organic matter. If this admixture remains on the stethoscope despite cleaning, a special environmental problem could exist. A combination of factors may contribute to this environmental hazard. These factors include the type and nature of the body fluid, the frequency of contact with blood and body fluids, and the design of the stethoscope.

Statement of the Problem

Due to the design of the stethoscope and the nature of the contaminant seen in the Labor & Delivery area, a natural buildup of organic material may occur on the diaphragm of the stethoscope. Superficial cleansing of the stethoscope may prove ineffective since there are many cracks and crevasses in the stethoscope where organic material such as the admixture of vernix, blood, amniotic fluid, and meconium can lodge and remain, thus proving an environmental risk for health care workers and patients. Therefore, the problem statement was: What is the effect of routine cleaning methods on the removal of blood and body fluids from stethoscopes used in the maternal-infant areas?

Purpose of the Study

The purpose of this non-experimental, exploratory study was to assess and describe the presence and incidence of environmental contaminants on a commonly used

piece of equipment found in hospital maternal-infant areas. The investigation was conducted at multiple study sites. The variables of interest include: 1) residual blood, 2) organic buildup of vernix and amniotic fluid, 3) and two units--Labor and Delivery, and Newborn nursery. Furthermore, field notes taken during data collection that visually described the stethoscope was analyzed using content analysis to see if new research variables emerge.

Rationale

Because of the threat of HIV, Hepatitis B and C, and other blood borne diseases, health care workers must reevaluate equipment that is exposed to blood and other body fluids. Many studies have shown that stethoscopes can transmit bacteria, and can be a significant source in the spread of methicillin resistant strains of staphylococcus. Those same studies have also shown the efficacy of routine cleaning in decreasing the bacterial load found on stethoscopes.

Yet there is no documented literature that has sought to study blood and organic matter contamination on stethoscopes. Stethoscopes used on newborn infants commonly come in contact with body fluids that are potentially contaminated with blood borne pathogens. If blood and body fluids are now considered contaminated, and if these fluids are found on stethoscopes used on newborn infants, then an environmental hazard could exist.

Significance of the Study

The significance of this study is threefold. First, this study sought to emphasize the importance of nursing's role in identifying potentially hazardous environmental influences on the health of individuals. Nursing has a rich history of developing principles of cleanliness in regards to patient care, starting with Florence Nightingale during the Crimean War.

Secondly, biomedical ethics has dictated that in the course of health care treatment for the patient, health care workers must strive to do no harm. Because of the principle of non-malficience, health care workers have the responsibility to seek out noxious stimuli and eliminate them. Current literature indicates that many viruses such as HIV, Hepatitis B and C, and Herpes are transported via blood and other body fluids. The Centers for Disease Control (CDC) now mandates precautions be taken when handling equipment contaminated with blood and body fluids (1989).

Thirdly, although the focus of this study is narrow, the potential impact for changing nursing practice is broad, and may affect health policy nationally and internationally. Once the problem is described in detail, interventions can be developed, tested, and implemented in order to provide a safe environment for patients, families and health care workers.

Theoretical Framework

In this study, the theory of germ transference was used to underscore the importance of the environment on the spread of infection. The link between equipment contamination, the subsequent cleaning methods used for disinfection of contaminated equipment, and the current concern over blood and other body fluids will be used to demonstrate the need to re-evaluate contamination of stethoscopes in maternal-infant areas of the hospital.

The nursing framework used to guide and give meaning to this study is nursing's meta-paradigm which includes four domains as recommended by the National League for Nursing. These four domains are: 1) person, 2) health, 3) environment, and 4) nursing. This nursing study seeks to investigate and identify potential noxious stimuli in the environment which may affect the health of the individual, defined as either patient or health care worker.

Historically, nursing has exerted a strong influence on the manipulation of the environment as a method of improving the health of the individual. This influence was first exerted by Florence Nightingale in the mid-1800s when portions of the germ theory were first postulated. Nightingale believed that many infectious diseases were spread by a general state of filth--by an unhealthy and unclean environment (Larson, 1989). To this end, Nightingale instituted a program of cleanliness of patients, environment, and hospital staff and effected dramatic improvements. It is anticipated that this study will

demonstrate the need for manipulation of the environment in order to continue exerting protective influences on clients. This model recognizes the impact nursing can have on the client's health by intervening in the environment.

Assumptions

For the purposes of this study, the following assumptions were made:

1. All body fluids and exudates are potentially contaminated with blood born diseases.
2. Different clinical areas of the hospital may carry different risks for cross-contamination from contaminated equipment.
3. Emerging blood born viruses and environmental bacteria that are currently unknown/unidentified can pose a health hazard to humans.
4. Health care workers and newborns who may come in contact with contaminated stethoscopes do not always have intact skin integrity.
5. Stethoscopes have been handled in a normal fashion.
6. Stethoscopes have been cleaned by wiping with an 70% isopropyl alcohol pad or by spraying with a germicidal and wiping with a cloth.

Study Questions

The following research questions were addressed by the proposed study:

1. What is the incidence of organic buildup seen on the diaphragm of stethoscopes used on newly born infants?

2. What is the incidence of residual blood on the diaphragm of stethoscopes used on newly born infants?
3. What is the relation between organic buildup on the stethoscope and the incidence of residual blood?
4. What are the differences in rates and proportions of organic buildup and residual blood between L&D and nursery areas.
5. What are the differences in rates and proportions of organic buildup and residual blood between the hospital sites?

Definition of Terms

The following terms were operationally defined for the purpose of this study as:

1. Organic Buildup. Organic buildup is theoretically defined as an admixture of vernix caseosa, amniotic fluid, and/or fetal meconium seen on the stethoscope ring or diaphragm, and has a positive reaction (bubbling) when hydrogen peroxide (H_2O_2) is applied. It is operationally defined as a yellowish-white collection of organic material seen in the crevasses of the diaphragm ring, or on the diaphragm disc.
2. Residual Blood. Theoretically defined as blood that cannot be seen but is still present on the stethoscope even after cleaning. For the purposes of this study, the presence of residual blood is operationally defined as a positive result from

a chemical test. The chemical test used is the Phenolphthalein occult blood test. The test is positive for blood if pink color appears on the cotton swab within 45 seconds after applying a Phenolphthalein indicator, and a hydrogen peroxide catalyst.

3. Clean Stethoscope. Clean stethoscopes are theoretically defined as stethoscopes that have been wiped off either with an alcohol pledgett containing a 70% solution of isopropyl alcohol, or had a germicidal spray applied, then wiped off with a cloth, removing all previous body fluids. Clean stethoscope is operationally defined as "ready for the next patient use".
4. Stethoscope Contamination. The theoretical definition includes the presence of pathogenic bacteria or viruses that can cause disease. For the purposes of this study, stethoscope contamination is operationally defined as visible organic buildup either with a 10X hand-held lens, or with the unaided eye; and/or positive for residual blood.

Limitations

There are three limitations identified for this study which could have affected the external, internal, construct, or statistical conclusion validity of the study. Methodological controls were built into the study to minimize these limiting effects. The limitations and controls are discussed below.

During the pilot study, the possibility of the Hawthorne effect became all too clear, thus possibly limiting the generalizability of the study. Prior to my coming, one nurse manager, took apart and thoroughly cleaned all the infant stethoscopes in the nursery area. If other L&D and nursery units knew I was coming to study stethoscope contamination, nurses might clean the stethoscopes more thoroughly than they normally did. To control for the Hawthorn effect, when permission from the nurse manager and research committee was sought, a statement was written, asking that the units continue with routine cleaning procedures and to not inform the staff nurses of the exact nature of this study. The nurses were told I was doing research on stethoscope contamination—they all assumed it was bacterial contamination.

Since the researcher had to mix up a phenolphthalein solution to test for occult blood, instrumentation was a possible threat to internal validity. To control for this threat, validity and reliability performance was assessed on this new solution. Positive and negative control solutions were tested with the reagent before each day's testing. No false negative or positives were obtained with this solution. Sensitivity results indicated that the solution was sensitive to blood dilutions of 1:1 000 for dried blood and 1:10 000 for wet blood dilutions.

The Phenolphthalein test is considered a presumptive test for the identification of residual blood. Other substances besides blood can provide false negatives and false positives. Therefore, construct validity might be questioned.

The catalytic reaction of the test is based on the peroxidase-like activity, and any substance with a peroxidase-like activity will provide a false positive. Some vegetables, a few germicidals, and certain heavy metals have a peroxidase-like activity. When tested with a Phenolphthalein reagent, these substances may indicate a positive reading for blood. To control for this effect, specificity testing was conducted on blood, vegetables, cleaning agents from each institution, the metal on the stethoscope, and other materials that the cotton swab came in contact with during the testing of each stethoscope. By demonstrating high specificity, construct validity is supported. The results of the specificity test indicated that no false negatives or false positive results were obtained with this mixture of Phenolphthalein.

Delimitations

The study was delimited by the following:

1. Any size of stethoscope used on newly born infants on a routine basis were included.
2. Stethoscopes used in delivery room suites or in the nursery units were included.
3. All stethoscopes found on the units on the day of data collection were included.

Summary

The potential contamination of stethoscopes used on newly born infants was studied in depth. Due to the special admixture of vernix, amniotic fluid, meconium, and blood, and to the design of the stethoscope, the effect of routine cleaning procedures was examined for residual blood and organic buildup. All stethoscopes used for newborn assessment, that were found on the day of data collection were included in this multi-site study.

CHAPTER 2

REVIEW OF THE LITERATURE

Research presented in this dissertation is related to the larger scheme of an environmental framework brought about by the influence the theory of Germ Transference has had on the development of nursing as a profession. The link between the initial development of the theory of germ transference and the influence this development has had on nursing is presented. Applicable literature is reviewed on the immuno-compromised state of the infant, and the widespread contamination of medical equipment in health care facilities by bacterial and blood borne pathogens. Proper methods for disinfection of contaminated medical equipment is then discussed.

Impact of Germ Theory

Not until the mid nineteenth century did scientists begin to make the connection between environmental influences of germs on the health of an individual. Previously, contagion was thought to be spread via the air, and no connection was made between hand-to-hand contact and subsequent spread of infection until the mid 1850s. The connection between transference of germs from hand-to-hand contact and puerperal fever was finally made when practitioners began to question and probe reasons why seemingly young healthy women were dying from infections after giving birth. Larson (1989)

recounts that this paradigm shift revolutionized health care in the late nineteenth and early twentieth centuries.

Prior to the development and acceptance of the germ theory, the mortality rate from puerperal fever was as high as 9% (Tauszky, 1882). Currently, the pregnancy related mortality ratio (PRMP) from puerperal infections in developed countries such as the U. S. is approximately 1 per 100,000 women (Berg, Atrash, Koonin, & Tucker, 1996). In developing countries, the ratio is closer to 125 per 100,000 women who die from puerperal infection, and accounts for approximately one fourth of all maternal deaths (Ruiz-Moreno, 1995; Spies, et al., 1995). The difference in pregnancy related mortality ratios between developed and developing countries can be largely accounted for the understanding and practice of antisepsis which is directly related to the germ theory.

Although slow to mature into the germ theory of today, several health practitioners were instrumental in the development of concepts such as asepsis, germ contamination, sanitation, and environmental control. Most notably, health practitioners such as Ignaz Semmelweis, Carl Mayrhofer, Joseph Lister, Oliver Wendell Holmes, and Florence Nightingale, were instrumental in promulgating the theory of germ transference. Surprisingly, elements of the germ theory were being developed concurrently but apparently independently from countries as diverse as Austria, Germany, England, and America (Carter, 1985; Larson, 1989; Macqueen, 1995).

Even though dramatic decreases in the mortality and morbidity rates of hospitalized patients have occurred since the acceptance and widespread use of antisepsis, the spread of contagious and infectious diseases by direct contact with contaminated equipment, or hands continues at an astounding rate. Macqueen (1995) attributes nosocomial outbreaks strictly to the carelessness and lack of attention health care workers pay to the theory of germ transference. In a conference held in Oklahoma City in September of 1996, Stroud (1996) summarized succinctly the impact nosocomial infections have on the personal health of the patient and the fiscal health of the health care provider.

> Each year there are over 2 million reported cases of nosocomial infections. These infections result in 8 million extra hospital days and cost an additional 4 billion dollars. More unfortunately, nosocomial infections (NI) account for 80,000 deaths every year. Deaths from infections ranks fourth behind heart disease, cancer, and stroke.

However, the impact of these cost estimates has not been fully realized and they are probably much higher than currently indicated. Wakefield (1993) states that due to limitations in the reporting of nosocomial infections, we have gained only a partial understanding of and appreciation for their total economic consequences. Wakefield recommends including not only direct care costs, but prevention costs, and indirect/future costs in calculating annual NI costs.

Yet even with our current knowledge of germ transference, infection control and antisepsis, health care workers remain illogical in their practice of infection control. In a qualitative study using ethnographic techniques for collecting data, and phenomenology as the analytic method, Macqueen (1995) found that anthropologic influences dictate how fastidiously health care workers enforce principles of antisepsis. Macqueen discovered that health care workers act differently towards body fluids from infants than from older children. She found that people, including health care workers, consider body fluids from a baby as less polluting than body fluids from other individuals. From personal experience in the clinical area, I can attest to this phenomenon—nurses still handle unwashed infants without gloved hands, whilst they would never touch the mother's perineum unless they had gloves on.

Health care workers must not become complacent about the low but still existent infection rate caused by poor hygienic principles. They must not lose sight of the goal to identify and eliminate environmental stimuli that could prove noxious to a person's health. As Larson (1989) reasons, "it seems reasonable to speculate that further reductions in nosocomial infection rates are possible by a more careful application among individual practitioners of the basic principles of antisepsis."

Relationship Between Nursing Theory and the Study

Nursing as a profession continues to evolve. Many nursing theories are in existence today and these theories encompass four domains. These include: (a) person,

(b) environment, (c) health, and (d) nursing. Using these four domains, this nursing study seeks to identify potential noxious stimuli in the environment which may ultimately affect the health of the individual. The individual may be identified as the client, or the health care worker.

Nursing has long held an influence in promoting health by eradicating noxious stimuli in the environment. For example, Florence Nightingale, the first nurse researcher and theorist kept copious records and statistics regarding patient outcomes during the Crimean War, cut the death rate of hospitalized and wounded soldiers from 42% down to 2% in four short months. Her secret? Sanitary reforms which included fresh air, and absolute cleanliness of the environment, the staff, and the patients (Larson, 1989). Nightingale believed that general environmental and personal cleanliness affected the outcome of health for the patient. Nightingale did much to elevate the status of nursing from a job in which low classed, poorly educated women entered to the status of a profession. Because of her foresight and use of theory in nursing, environmental influences have played a large part in nursing theory.

Immuno-compromised State of the Newborn

Three factors contribute to the infant's increased risk of acquiring a nosocomial infection from direct contact with contaminated equipment or hands. These factors include (a) interrupted/broken skin integument, (b) poorly functioning immune system, and (c) increased skin permeability to exogenous antigens.

The skin of the newborn infant is not always intact. At birth, the near term or post term infant can have dry, cracked, and peeling skin. Cracks in the skin integument are seen mainly over the chest and abdominal areas, and at the wrists and ankles where moveable joints exists. This loss of skin integrity provides a possible port of entry for exogenous bacteria and viruses.

At birth, the infant's immune system is not fully functional. Several phases comprise the complexity of phagocytotic activity. In newborns, leukocytes have a decreased ability for migration and ingestion of foreign substances (Donowitz, 1993). Another factor which decreases the functional status of the infant's immune system is the inability to produce normal amounts of certain immunoglobins until months later. Immunoglobin M (IgM) production does not reach maturity until well after one year of life (Donowitz, 1993). Immunoglobin G (IgG) is transferred via the placenta to the fetus during the third trimester of pregnancy. However, once delivered, the serum levels of IgG begin to drop off and the infant does not begin producing IgG until months later. During this time, the infant is referred to as hypogammaglobulinemic (Donowitz, 1993). In the first year of life, the infant is constantly bombarded with environmental factors that challenge the immune system. The infant must rely on others to reduce exposure to bacteria and viruses until the immune system is fully functional.

In addition to the lost skin integrity, and immature immune system, a newborn's skin is more permeable, thus allowing a very real source of bacterial and/or viral entry

into the newborn (Donowitz, 1993). The infant is considered to have an immature skin barrier. The skin is the first line defense against bacteria and viruses, by acting as an efficient barrier by providing a protective layer. However, researchers have recently discovered that the skin of newborns less than 37 weeks gestation is thin and poorly keratinized, thus making this barrier more permeable to exogenous antigens than those of with well developed corneum stratum layers (Donowitz, 1993).

Equipment Contamination

Since the evolution of Germ Theory, scientists now understand the role of fomite transfer, and have taken aggressive steps towards decontamination of equipment. Current review of the literature regarding equipment contamination in this study involves information on the presence of bacteria, the presence of blood borne viruses, and the appropriate methods for cleaning equipment contaminated with bacteria and viruses.

In 1989, the Centers for Disease Control and Prevention (CDC) published guidelines handling of materials contaminated with blood and body fluids. These guidelines, which have been updated frequently include precautions for health care workers when exposure to blood and body fluids is anticipated. As the regulatory agency working in cohort with the CDC, the Occupational Safety and Health Administration, more commonly known as OSHA enforces those guidelines. In 1991, OSHA published a government document entitled "Occupational Exposure to Bloodborne Pathogens." Among other recommendations, this publication states that all equipment, environmental

and working surfaces be cleaned and decontaminated with an appropriate disinfectant after contact with blood or other potentially infectious materials (Rutala & Weber, 1995). Stethoscopes used in maternal-infant areas have germicidals applied to them, however, they may not have been cleaned properly (i.e., removal of organic material). The removal of organic material prior to application of a germicidal is paramount, since the presence of organic material can inactivate the effect of the germicidal (Hoffman, 1987; Rutala, 1993; Simmons, 1983).

Historically, health care professionals have known that contaminated equipment is one source of transmission of infection. Fereres (1988) states that hospital equipment remains a common cause of infection.

Bacterial Pathogens

Bacterial Contamination of Stethoscopes

The stethoscope was invented as an auscultatory assessment tool in 1816 by a French physician, René Laënnec (Weinberg, 1993). Currently, the stethoscope is one of the most common pieces of diagnostic equipment used by health care personnel. Because stethoscopes are not used for invasive assessments, and are generally used over intact skin, health care personnel have not considered the stethoscope to be a significant transmitter of bacteria and viruses. However, stethoscopes may not be as innocuous as we are led to believe. Microbiologic studies clearly document that pathogenic bacteria are easily cultured from stethoscopes and from a variety of settings (Boo, Wong, & Khoo,

1989; Breathnach, Jenkins, & Pedler, 1992; Garner & Rimland, 1982; Gerken, Cavanagh, & Winner, 1972; Wright, Orr & Porter, 1995). These authors all conclude that stethoscopes can act as a transmitter of pathogens, and recommend cleaning with isopropyl alcohol or other cleaning agent since a significant reduction in positive growth cultures was found after swabbing the stethoscope with a cleaning agent.

In the classic study by Gerken, Cavanagh, and Winner (1972), 100 stethoscopes were studied to determine the infection hazard in the hospital setting. These authors found that 21% of the stethoscopes tested were positive for coagulase-positive staphylococci. Of the 21% that tested positive for pathogenic strains of staphylococci, almost half of those (43%) were resistant strains to penicillin, tetracycline, and methicillin. Gerken, et al., cleaned ten of the contaminated stethoscopes with a mixture of 5% chlorhexidrine and 70% isopropyl alcohol solution and found that three of the ten stethoscopes showed no growth, while the remaining seven showed only one or two colonies. They concluded that cleaning is effective in killing pathogenic bacteria from stethoscopes.

In the same year, Mangi and Andriole (1972) sampled ten stethoscopes from five different units at Yale-New Haven Hospital. Of the 50 stethoscopes included in the study, 26% were contaminated with at least one potential pathogen (*S. aureas* and gram-negative bacilli). Ten stethoscopes were swabbed with 70% alcohol and then re-cultured for organisms. These ten yielded only three different organisms, had a significantly

lower colony count, and contained no pathogenic bacteria. Mangi and Andriole concluded that stethoscopes can be a method of bacterial transfer, but that proper cleaning is effective in killing pathogenic bacteria from stethoscopes,

In 1983, Arroyo, Harrison, and Birgenheier published their results on stethoscope contamination. These researchers found that of 67 stethoscopes cultured, 63 (94%) were positive for Staphylococci (mostly *S. epidermidis*). Of the 94% contaminated with bacteria, only one stethoscope was found to be a resistant strain of *S. aureus*. Even though the majority of the bacteria cultured was *S. epidermidis*, and is considered normal flora, it has been shown that this strain can produce serious infections in hospitalized patients (Christensen, et al., 1982). Additionally, even normal flora such as *S. epidermidis* can also act as a reservoir for antibiotic resistant *S. aureus* (Weinstein, et al., 1982). *S. aureus* is always considered pathogenic, and resistant strains of *S. aureas* are of particular concern, since many first line antibiotics are ineffective in killing this bacteria.

Boo, Wong, and Khoo (1989) cultured 26 stethoscope diaphragms from a normal newborn nursery, and found positive bacterial growth on 21 (81%) of the stethoscopes. After disinfection with 70% isopropyl alcohol, Boo, et al. (1989) saw an 85% reduction in positive growth cultures of organisms. Unfortunately, these authors did not identify the type of bacteria found on the stethoscope.

Breathnach, Jenkins, and Pedler (1992) cultured the diaphragms of 29 stethoscopes used by junior doctors at their institution. These authors found that 90% of

the stethoscopes cultured positive for *Staphylococcus*. Of those positive for *Staphylococcus*, almost one fifth (19%) were positive for *S. aureus* which is a potentially dangerous organism and is not considered normal flora. Upon cleaning the stethoscopes with a 70% isopropyl alcohol, the authors found on the average a 97% reduction in the bacterial count. These results demonstrate that stethoscopes harbor pathogenic organisms, but with proper cleaning, bacterial counts can be greatly reduced.

Discomforted by the results obtained by Breathnach, Jenkins, and Pedler (1992), Wright, Orr, and Porter (1995) decided to study the presence of bacterial contamination of stethoscopes in the NICU. Of a total 24 stethoscopes cultured prior to cleaning with alcohol, Wright, Orr, and Porter were able to isolate coagulase-negative Staphylococci in 16 (67%) of the neonatal stethoscopes; one stethoscope also grew gram-negative bacilli. Gram-negative Bacilli are most often implicated in iatrogenic urinary tract infections and pneumonias. Wright, et al. (1995) conclude that regular cleaning of stethoscopes should be a part of NICU practice in the same way that hand washing is implemented. They also demonstrated that regular swabbing with alcohol significantly reduced the bacterial load on the stethoscopes ($p = 0.005$, Fisher's exact test).

Jones, Hoerle, and Riekse (1995) surveyed 150 emergency care providers about their stethoscope-cleaning practices, and then correlated these practices with the prevalence of Staphylococcus carriage present on each care provider's stethoscope.

Jones, Hoerle, and Riekse found that 133 (89%) of stethoscopes grew *staphylococci*, and of that number, 19% (n=25) were *S. aureus*.

And finally, the most recent publication found regarding bacterial contamination of stethoscopes was reported by Smith, Mathewson, Ulert, Scerpella, and Ericsson (1996). Smith, et al., obtained cultures from 200 stethoscopes from four area hospitals in Houston. Results showed 159 (80%) were contaminated with microorganisms. The majority of the organisms were primarily *Staphylococcus* species, however, *Micrococcus*, *Bacillus*, *Listeria*, *Acinetobacter*, and *Candida* species were also isolated. Fifty-eight percent of the Staphylococcus species were resistant to methicillin. This is a very high incidence of resistant strains. In a later section, the clinical significance of resistant bacterial strains is discussed.

Table 1 provides a summary of the studies done on stethoscope contamination, and the bacterial found. From the summary table, the reader can see that the majority of organisms cultured were coagulase-negative Staphylococci. These organisms accounted for almost 72-74% of all contaminated stethoscopes. Coagulase-negative Staphylococci, even though considered to be normal flora for many, are the leading cause of nosocomial infection in the acute care setting for patients considered at risk for infection. Patients at risk for infection include pre term, term, and post term infants, immuno-compromised and immunosuppressed individuals, and patients with open wounds such as tracheostomies, surgical incisions or bedsores. Staphylococci infections have been

implicated as the second most common organism responsible for nosocomial infections in the U.S. (Jay, 1983). In fact, Russell, Smyth, and Cooke (1992) report that coagulase-negative Staphylococci are responsible for up to 70% of nosocomial infections in the Neonatal Intensive Care Unit (NICU).

The second most prevalent organism found on contaminated stethoscopes was *Staphylococcus aureus*. This organism is always considered pathogenic and is difficult to eradicate. The incidence of *S. aureus* contamination accounted for 10-20% of all contaminated stethoscopes tested in the studies. Due to the insidious nature of *S. aureus*, resistant strains develop which are very difficult to eradicate. Subsequently, many persons infected with resistant strains of *S. aureus* succumb to the infection and morbidity and mortality result.

Table 1. Summary of Microbiologic Studies Performed on Stethoscopes

Year	Author(s)	Sample Size	Bacteria Cultured and no. positive for growth	Method of collection and culture medium used
1972	Gerken, Cavanagh, & Winner	N=100	[1]coagulase-negative Staphylococci and Micrococci n=100 (100%) [2]coagulase-positive Staphylococci n=21 (21%)	Direct impression on blood-agar plates
1972	Mangi & Andriole	N=50	[1]coagulase-negative Staphylococci n=49 (98%) [3]coagulase-positive Staphylococci n=6 (12%)	Direct impression on blood-agar plates
1983	Arroyo, Harrison, & Birgenheier	N=67	[1]coagulase-negative Staphylococci n=62 (92.5%) [2]coagulase-positive Staphylococci n=1 (1.5%)	Dry swabbed then streaked onto Columbia Nutrient Agar (BBL) Swabs
1989	Boo, Wong, & Khoo	N=26	[4]NI n=21 (81%)	
1992	Breathnach, Jenkins, & Pedler	N=29	coagulase-negative Staphylococci n=21 (72%) coagulase-positive Staphylococci n=5 (17%)	Moistened swab with saline, then streaked onto blood-agar plates
1995	Wright, Orr, & Porter	N=24	coagulase-negative Staphylococci n=16 (67%) gram-negative bacteria n=1 (4%)	Moistened swab, then inoculated onto blood-agar plates
1995	Jones, Hoerle, & Riekse	N=150	coagulase-negative Staphylococci n=108 (72%) coagulase-positive Staphylococci n=25 (17%)	Direct impression on mannitol agar plates
1996	Smith, Mathewson, Ulert, Scerpella, & Ericsson	N=200 N=159	coagulase-negative Staphylococci n=195 (74%) coagulase-positive Staphylococci n=24 (9%) [5]All other microorganisms n=44 (17%)	Moistened swab, then vortexed in sterile saline, then inoculated onto various culture plates

[1] Other Staphylococcus species [2] Staphylococcus aureus

[3] Other pathogens cultured included *E. coli, Erwinia, Serratia, Klebsiella, Proteus vulgaris*, Enterobacter A and B, and *Pseudomonas aeruginosa*

[4]Did not identify organisms [5]Including Micrococci, Bacilli, Listeria, Acinetobacter, Candida, and Streptococci organisms

Resistant Bacterial Strains

Resistant bacterial strains are particularly bothersome due to the difficulty in killing the bacteria once it has established itself in a host. The advent of antibiotics during the first half of the century greatly improved the mortality rate due to bacterial infections. However, new strains have evolved that are resistant to traditional first line antibiotic defense. The most common resistant bacterial strain, Methicillin-resistant *Staphylococcus aureus* (MRSA) became an important nosocomial pathogen in the late 1970s in the United States (Pittet, 1993). Since then, the incidence of MRSA has steadily increased, and now resistance has developed to several antibiotics, not just Methicillin. Two studies recently published indicate that as much as 15% of all *Staphylococcus aureus* isolates are now resistant to one or more antibiotics (Boyce, 1991; Jones, Barry, Gardiner, & Packer, 1989).

Although most agree that MRSA is spread primarily via hands of health care workers (Pittet, 1993), there seems to be conflicting viewpoints in the literature as to the culpability of equipment as primary causes of nosocomial infections from resistant strains of bacteria. Garner and Rimland (1982) reported that of the 32 stethoscopes cultured, only one culture grew the multiresistant *S. aureus* (MRSA), and concluded that the role of stethoscopes in the transmission of MRSA was minimal at their institution. Yet as early as 1972, both Gerken, Cavanagh, and Winner (1972) and Mangi and Andriole

(1972) found the incidence of resistant strains on stethoscopes to be 43% and 25% respectively.

Additionally, Berman, Schaefler, Simberkoff, and Rahal (1986) reported that 45% of all *S. aureus* isolates in their study were methicillin resistant strains. In a study on tourniquet contamination, Berman, et al., found that 12 of 24 reusable tourniquets had Methicillin resistant *S. aureus*. The tourniquets had been used from three weeks to six months, on approximately 15 to 20 patients a day. This study suggests that reusable equipment may be an significant transmission of resistant strains of hospital pathogens, or equipment that has residual blood may have a higher MRSA isolates .

Scientists have impressively demonstrated the presence of pathogenic organisms on stethoscopes which can prove problematic to susceptible individuals. Susceptible individuals are those mentioned previously which include immuno-compromised or immuno-suppressed individuals, infants, and patients with open wounds. Table 2 summarizes the studies of resistant strains of bacteria found on stethoscopes.

Table 2. Summary of Resistant Strains found on Stethoscopes

Year	Author(s)	Sample size	No. resistant strains	Culture Medium Used
1972	Gerken, Cavanagh, & Winner	N=100	n=9 (43%)	Disk diffusion method
1982	Garner & Rimland	N=32	n=1 (11%)	Disk diffusion method
1991	Widmer, Pfaller, & Wenzel	N=109	n=0 (0%)	Moistened swab applied to trypticase soy broth with methicillin
1996	Smith, Mathewson, Ulert, Scerpella, & Ericsson	N=200	n=4 (17%)[1] n=44 (46%)[2] n=67 (84%)[3]	Disk diffusion method with Oxicillin and Methicillin

*N/A = did not report—only looked for MRSA

[1] S. aureus [2] S. epidermidis [3] Other Staphylococcus species

Stethoscope Cleaning

Many of the studies cited above support swabbing the stethoscope with alcohol as an effective means of killing bacteria on the stethoscope diaphragm. However, these

studies also document that health care personnel do not clean their stethoscopes on a routine basis.

Arroyo, Harrison, and Birgenheir (1983) queried a group of 53 physicians regarding stethoscope cleaning practices. Of the 53 physicians, 35% had never cleaned their stethoscope, 64% reported cleaning their stethoscope about once a month to as infrequently as once every six months. Out of that group, only two of the 53 physicians cleaned their stethoscopes everyday. In another study on stethoscope cleaning practices, Breathnach, Jenkins, and Pedler (1992) reported that 26 out of 29 physicians (90%) had never cleaned their stethoscope.

Unfortunately, physicians are not the only health care professionals that do not practice stethoscope cleaning on a routine basis. Nurses also fall short in this area. Wright, Orr, and Porter (1995) studied stethoscope contamination in the Neonatal Intensive Care Unit (NICU). Results showed that of the 22 nurses polled, 55% of nurses reported never cleaning or very occasionally cleaning the stethoscope used for intensive care infant assessment. Of the nine doctors queried, 89% stated that they had never or only very occasionally cleaned the stethoscope. Martin (1994) queried 29 staff nurses and found that 75% cleaned their stethoscope at least once a week, but the other 25% had never cleaned their stethoscope. Similarly, Garner and Rimland (1982) informally surveyed a variety of health care personnel and found that stethoscopes were cleaned on a random basis only.

Apparently, the lack of cleaning in regards to stethoscopes has been a problem for at least 35 years. In 1972, Mangi and Andriole studied stethoscope contamination and found that of the 60 physicians and nurses who participated in the study, only three had ever cleaned their stethoscope.

These six reports demonstrate that a large percentage of stethoscope used on a daily basis are not routinely cleaned before each patient use, even though pathogenic bacteria are found on stethoscopes.

Bacterial Contamination of Other Medical Equipment

Many common pieces of health related equipment have been identified as potential sources of pathogenic strains of bacteria. Equipment studied includes tourniquets (Berman, Schaefler, Simberkoff, & Rahal, 1986), blood pressure cuffs (Cormican, Lowe, Keane, Flynn, & O'Toole, 1991; Myers, 1978), bath hoists (Murdoch, 1990), shaving brushes (Whitby, Blair, & Rampling, 1972) and most recently, tongue depressors used in Neonatal Intensive Care Units (NICU) as limb splints (Mitchell, et al., 1996).

In response to the article by Martin (1994), which recommended cleaning the stethoscope with alcohol between every patient, Kirkis (1995) stated that Staphylococcus is a normal flora, and considered routine swabbing to be busy work. Kirkis recommended that the stethoscope be swabbed only if it touches anything wet during a physical assessment. Kirkis is partially correct in stating that Staphylococcus is

considered normal flora. Many organisms in the Staphylococcus family are normal flora and are ubiquitous. She is also correct in recommending cleaning equipment that comes in contact with body fluids. However, it appears that Kirkis is negating factors such as immuno-compromised patients, new and evolving resistant strains, and epithelial sloughing onto equipment when contact with patients is made. Even equipment with normal flora can transmit infection in the right circumstances.

As early as the 1970s, researchers have made the connection between contaminated equipment and outbreaks of infections. Whitby, Blair and Rampling (1972) identified the cause for two outbreaks of *Serratia marcescens* infections in an Intensive Care Unit. After the second outbreak, the authors cultured environmental surfaces and discovered that two shaving-brushes were the only surfaces which grew the same strain of Serratia as the patients did. The second outbreaks of S. marcescens occurred eleven months later. After environmental sampling, they discovered that a ventilator was the culprit for spreading the gram-negative bacilli. Both the shaving brushes and the ventilator had been cleansed with standard disinfection procedures which included soaking the equipment in disinfectant. The authors concluded that the inability of the disinfectant to penetrate shaving brushes was the cause of the outbreak. They felt that no disinfectant would be able to penetrate and thoroughly cleanse the brushes.

In 1991, Cormican, Lowe, Keane, Flynn, and O'Toole reported on a study of blood pressure cuffs. In this study, seven new stethoscopes were introduced into the operating room environment. The blood pressure cuffs were sampled prior to use, then at the beginning and end of each day's use for five days. Of the 42 cultures taken, eighty-six microorganisms were isolated. Staphylococci species represented 71% of all the bacteria isolated. Of those 71%, 65% were coagulase-negative, and 6% of the Staphylococci species was S. aureus. One of the *S. aureus* isolates was also identified as MRSA. The remaining 29% of organisms found were a mixture of *Streptococci*, *Escherichia, Pseudomonas* species, and *Cornyforms non J. K.* These authors were particularly interested in finding a MRSA strain since none of the patients who used the blood pressure cuffs during the five days of testing were known to have methicillin resistant S. aureus. Cormican, et al., concluded that health care personnel need to be aware of the potentially harmful consequences of seemingly innocuous pieces of hospital equipment.

Myers (1978) studied longitudinally the effect of environmental exposure to nosocomial infections and found that a single blood pressure cuff, which was used on all infants in the nursery was associated with an increased rate of infection. Since that time, disposable blood pressure cuffs have become accepted practice in many areas of a hospital, especially in newborn units.

Understanding the relationship between a moist environment, and bacterial growth, Murdoch (1990) investigated the bacterial contamination of bath hoists and concluded that they are a potential source of cross-contamination. The investigator found that after only two weeks of use, gram-negative organisms were grown from the samples of new chair hoists. Four months later, swabs showed heavy growth of *Flavobacterium, Pseudomonas, Acinetobacter* species, and *Clostridium welchii.* Cultures were taken prior to cleaning with a germicidal, and also after the cleaning procedure. All cleaning methods were found to be effective in reducing the numbers and types of bacteria growing, but phenolics and hypochlorites were most effective. Murdoch concluded that acknowledging the problems of cleaning and raising the staff's awareness was an important factor in decreasing the contamination of bath hoists.

Most recently, Mitchell, et al. (1996) reported on the culpability of wooden tongue depressors as the causative agent in nosocomial fungal infections in preterm infants. The tongue depressors were used in the nursery as splints for intravenous and arterial cannulation sites. However, staff began noticing localized infections – necrotic lesions were noted on the limb with the splints. Intensive environmental culturing occurred, paying particular attention to equipment that touched the skin. The tongue depressors were the only environmental surface that were found to harbor the same species of fungus as the necrotic wounds. Of the four infants infected, three preterm infants succumbed to a progressive systemic fungal infection, and one preterm infant lost

the limb due to amputation. The authors noted that since the tongue depressors have been removed, no outbreaks of fungal infection have occurred since that time.

Viral Pathogens

Blood Contamination on Equipment

From past research, health care professionals understand the link between bacterial contamination of equipment and iatrogenic infections. Until recently, little attention has been given to possible identification of blood contamination of medical equipment. Researchers have just begun to evaluate the potential contamination of blood and other body fluids on equipment that is exposed to these fluids on a daily basis. Hoffman (1987) indicates that equipment coming in direct contact with blood and body fluids should be classified as intermediate risk of transmissibility and precautions must be taken.

In 1987, the CDC issued recommendations to prevent HIV transmission in the health care setting (Centers for Disease Control and Prevention). Prior to that point, health care workers wore protective clothing only when blood and body fluid exposure was anticipated during a procedure with a known infected individual or an high risk individual. Once these guidelines were issued, a new term "universal precautions" was coined and the practice of universal precautions was implemented. Implementation of universal precautions includes wearing protective gear when contact with blood and body fluids from *any* individual is anticipated, not just hi risk individuals. Currently, no matter

what the socio-economic status, education, or background of the individual, all health care workers have been mandated to where protective gear when coming in contact with any blood or body fluid.

The relationship between bacteria and equipment has been shown to cause nosocomial infections. Once researchers began to understand the dangers of blood contamination in the mid 1980s, a renewed interest in studying equipment contamination began. There is evidence now to suggest that residual blood potentially remains on equipment that once was considered non-problematic.

To date, there are only three published studies that investigate the presence of blood remaining on equipment following routine procedures. These studies focused on the identification of residual blood on equipment either from primary contact (and were subsequently cleaned), or on secondary contact (gloved hands transferred blood to other surfaces).

The first study to appear in the literature evaluating environmental surfaces contaminated with blood was in 1987. Beaumont (1987) sampled nonporous surfaces of an autopsy suite and found the presence of blood on a variety of environmental surfaces that typically did not come in direct contact with cadavers or tissues. Surfaces tested positive for blood included faucet handles, disinfectant bottle, refrigerator door handle, desk top and drawer handles and other common surfaces. The method used for residual blood detection was the HEMASTIX® reagent strips., using Benzidine as the indicator.

This author concluded that the contaminated gloves of persons performing or assisting the postmortem were the predominant vehicle by which blood was spread in the autopsy suite. Parallels can also be drawn in the maternal-infant areas. Delivery room nurses and nursery nurses also touch a variety of surfaces after handling a newly born infant whose skin still has blood, amniotic fluid, fetal meconium, and vernix on it. Implications for further study in the L&D area include sampling of environmental surfaces nurses commonly come in contact with while they still have on latex gloves.

A year later, Kennedy and Gwaltney (1988) published a report regarding residual blood contamination on gloved hands of central sterile personnel. To detect residual blood, these authors used the HEMOCCULT® Slide, a chemical test for fecal occult blood based on the guaiacum reagent. Kennedy and Gwaltney reported that 59% of the instruments still contained traces of blood even though they had been rinsed off and soaked in a germicidal, and were considered "clean but not sterile." After handling and processing the "clean but not sterile" instruments, the gloved hands of the workers were then tested; 15% of the gloves tested positive for blood.

Two years after the study by Kennedy and Gwaltney (1988) was published, a third study appeared, documenting the incidence of blood contamination of tourniquets used in routine phlebotomy. Forseter, Joline, and Wormser (1990) sampled 102 tourniquets for the presence of blood. Of the total sampled, 30% of the tourniquets tested positive for blood even though the tourniquet had no visible blood on it. When the staff were queried

about their reuse, 86% of personnel stated they reused tourniquets. These researchers used the leucomalachite method for residual blood detection on the tourniquets.

The incidence of residual blood contamination reported in the three studies above is surprising and disturbing since all the surfaces tested were assumed clean and without blood. Yet, one has to surmise that the incidence of residual blood found on these surfaces could be higher still taking in to account two additional factors.

First, all three methods used to detect residual blood provide very localized testing of an area—possibly providing incomplete coverage. Therefore, it can be concluded *that of the spots tested*, the incidence reported is true and accurate, but what about the areas not tested?

The second factor to take into account is that in each of the three studies, they used different reagents to indicate residual blood. In two of the studies (Beaumont, 1987; Kennedy & Gwaltney, 1988) used commercially packaged reagents that have only been approved as indicators for testing blood in the urine (HEMASTIX®) and blood in the feces (HEMOCCULT®). Validity and reliability studies have not been done for use on environmental sampling. The third study used Leucomalachite as the reagent, which is an acceptable environmental testing agent—however it has been found to have lower sensitivity and specificity than some of the other methods (Cox, 1991; Gaensslen, 1983). When the suspect area is large, or for pattern distribution, the luminol test might be a better indicator for the detection of residual blood.

In summary, the results of the above mentioned research studies on poor cleaning habits, positive growth of potentially serious flora, coupled with the ubiquitous presence of occult blood provide the message that stethoscopes that come in contact with blood and body fluids may pose a significant threat of cross-contamination. Health care workers have succeeded in identifying the risk of exposure to blood from direct patient contact. However, as these studies indicate, exposure to equipment that is contaminated with blood also provides a risk that must be realized.

Viruses Found in Blood

HIV. Acquired Immune Deficiency Syndrome (AIDS) was first described in the United States in homosexual males and IV drug abusers in 1981 (Lott & Kenner, 1994b). By 1983, the human immunodeficiency virus (HIV) was identified (Stone, Lonergan, Reed, Lemaitre, & Scala, 1996). Shortly after first being recognized as a disease, the AIDS virus was recognized in recipients of infected blood products, heterosexual partners of infected patients, and infants and children (Lott & Kenner, 1994b). Just seven years ago, the fastest growing number of new AIDS cases were in heterosexual childbearing women (Allen, 1990). It is estimated that there are currently 900,000 HIV positive individuals in the United States (Stone, et al., 1996).

Hepatitis B and C. The seriousness of the HIV virus realized in the mid 1980s. Prior to that time, the main concern for exposure and subsequent seroconversion of a blood borne disease was Hepatitis B virus (HBV). Hepatitis C (HCV)has also been

associated with increased mortality and causes hepatocellular changes similar to that of HBV. The mortality from HBV arises from acute fulminant hepatitis (uncommon) and chronic infection leading to chronic active hepatitis, cirrhosis, liver failure, or hepatocellular carcinoma (Zuckerman, 1995). Hepatitis infections can be insidious—the infection may be mild, many people are carriers and do not know it.

Herpes Simplex. Although several investigators have demonstrated that herpes simplex virus (HSV) can survive on wet cloth, or dry plastic surfaces for several hours up to days later (Larson & Bryson, 1982; Nerurkar, West, May, Madden, & Sever, 1983), transmission of genital HSV via fomites has not been proven (Mead, 1993). However, Mead (1993) did mention that there was litigation involving this very issue of fomite transfer at another institution.

Larson and Bryson (1982) tested various surfaces to examine the ability of the HSV to remain viable at room temperature. Materials used for sampling included dry cotton gauze pressed directly on to the lesion, plastic gloves and speculums after gynecologic exams, fingerprints from gloves pressed on to petri dishes, and cotton swabs from lesions. Samples were cultured initially and at various time intervals post-collection (0 to 90 hours). Results included detection of HSV on the dry gauze 88 hours after inoculation, on speculums 18 hours post inoculation, and fingerprints of contaminated gloves after 1 hour. HSV was also cultured from the toilet seat 1 ½ hours after direct patient contact, and after swiping with dry gauze. Larson and Bryson (1982) concluded

that non-venereal transmission of HSV is possible in the clinic setting to susceptible patients.

In another classic study on non-venereal transfer of Herpes Simplex Virus (HSV), Nerurkar, et al. (1983) investigated the survival capability of HSV in water specimens from Public hot tubs in Spa facilities. The factors investigated included: 1) presence of HSV in the hot tub water, 2) amount of bromine (Br_2) and chlorine (Cl_2), and ability of HSV to survive in the spa hot tub water. Findings indicated that typical hot tub water had high levels of Br_2 and Cl_2, and that spa water was effective in killing the virus. However, the researchers did find that HSV was able to survive up to 4 ½ hours on plastic-coated benches in a simulated spa environment. Nerurkar, et al. (1983) suggest that non-venereal fomite transfer is possible.

The incidence of HSV in women of child-bearing age varies from 3.6% up to 13.2% (Augenbraun et al., 1995). In their study comparing viral shedding of the HSV virus between HIV-seropositive and HIV -seronegative women, Augenbraun, et al. (1995) discovered that among other things, most of the shedding was asymptomatic, and that HIV-seropositive women were four times more likely to be infected and actively shed the HSV virus than seronegative women. Mothers who shed HSV at the time of birth may shed the virus onto the infants wet skin as it comes out the birth canal.

In summary, at least 4 out of every 100 (and may be as high as 13 out of every 100) women of childbearing age is infected with the HSV virus. If these women deliver vaginally, the virus may be found on the infant's wet skin, which then may be transferred to the stethoscope when the infant is assessed shortly after birth. The virus can survive for several hours—maybe longer when mixed with moisture retaining vernix.

Other Sexually Transmitted Diseases. In 1995, the CDC added Chlamydia to the National Notifiable Diseases Surveillance System (NNDSS). The NNDSS is a national reporting system to document the prevalence of infectious diseases. During 1995, sexually transmitted diseases (STDs) predominated the top ten infectious diseases list and were reported among all age groups (Centers for Disease Control and Prevention, 1996). Sexually transmitted diseases include the five types of hepatitis viruses (HAV, HBV, HCV, HDV, and HEV), human papilloma virus (HPV), chlamydia, gonnorrhea, syphilis, chancroid, lymphogranuloma venereum, herpes, and AIDS (Killion, 1994; Lott & Kenner, 1994).

Chlamydia was the most common infectious disease reported in the NNDSS for 1995, followed by gonorrhea and AIDS, then salmonellosis, hepatitis A, shigellosis, tuberculosis, primary and secondary syphilis, Lyme disease, and lastly, hepatitis B (Centers for Disease Control and Prevention, 1996). It is interesting to note that six of the ten listed above were STDs. The CDC reported that those six STDs accounted for 87% of cases reported for the top ten diseases (1996). Apparently, the vast majority of

reportable diseases are sexually transmitted and are transmitted through contaminated secretions of blood and other body fluids.

To summarize, STDs are very prevalent, the body fluids are contaminated with these bacteria and viruses, and that same body fluid is transferred to the stethoscope head when the newly born infant is assessed.

Inactivation of Pathogens

There are several methods available for inactivating virulent organisms from equipment. However, in the hospital setting, there are primarily three methods used to decontaminate equipment. These methods include cleaning, disaffection, and sterilization.

Cleaning is defined as the physical removal of organic material or soil from objects, and is usually done by using water, friction, and possibly detergents (Rutala, 1993; Rutala & Weber, 1995; Simmons, 1983). Cleaning is intended to physically remove matter and virulence rather than to kill them as in the case of disaffection and sterilization. Cleaning, therefore is an essential first step in either the disinfection and/or sterilization procedures since organic material has been shown to provide a barrier for bacterial and viral organisms which cause the germicidal to be useless (Rutala, 1993; Simmons, 1983).

Disinfection is defined as the elimination of many or all pathogenic microorganisms on inanimate objects with the exception of bacterial endospores (Rutala, 1993; Rutala & Weber, 1995). Disinfection only renders an object non-infectious (Hoffman, 1987). Spores are highly resistant to destruction but are not usually infectious.

The efficacy of disinfection is affected by several factors which include: (a) prior cleaning of the object, (b) the organic load present, (c) the type and level of microbial contamination, (d) the concentration and exposure time to the germicide, (e) the nature of the object (e.g., crevasses, hinges, and/or lumens), and finally (f) the temperature and pH of the disinfection process (Rutala, 1993). Objects potentially contaminated with virulent organisms such as hepatitis viruses, *Shigella*, or multiply-resistant gram-negative bacilli may require disinfection procedures even if their use would normally dictate cleaning procedures (Simmons, 1983). Cleaning must precede disinfection and sterilization procedures and often times are very effective in reducing the number of microorganisms present on contaminated equipment (Rutala & Weber, 1995).

Equipment can be either disinfected either by heat (wet or dry) or by chemicals. Hoffman (1987) reports that heat disinfection is more efficacious and reliable than chemical disinfection, however, extra equipment is required for application of either wet or dry heat to the affected equipment. Application of wet heat is commonly called autoclaving. Chemical disinfection is commonly done to equipment that has come in contact with intact skin.

Sterilization is defined as the complete elimination or destruction of all forms of microbial life (Hoffman, 1987; Rutala, 1993). Several methods can be employed to sterilize: (a) steam under pressure, (b) dry heat, (c) ethylene oxide gas, and (d) liquid chemicals. When liquid chemicals are applied to the equipment for long periods of time (such as soaking for hours), sterilization results. When liquid chemicals are applied for shorter periods of time, disinfection results. Although sterilization kills virtually everything, and is therefore a more effective cleaning procedure, several factors make this method less desirable. Sterilization of equipment is more time consuming, is not necessary, nor is it feasible (i.e., large objects such as beds). For these reasons, disinfection has become the method of choice for cleaning most medical equipment, unless the equipment will be used in a sterile environment.

Chemical Disinfection

Chemical disinfectants can be categorized broadly as fitting in to one of six categories. These include alcohols, hypochlorites, gluteraldehydes, phenolics, iodophors, and quaternary ammonium compounds (Rutala, 1993). Of the above, iodophors are only used on skin; hypochlorites, gluteraldehydes, phenolics and quaternary ammonium compounds are used only on equipment. The alcohols, either ethyl or isopropyl alcohols can be used either on equipment or skin.

Alcohols. Alcohols are one of the most commonly used disinfectants in the hospital today, since isopropyl alcohol pledgetts (pads) are readily available. In the maternal-newborn area, alcohol pads are used to clean stethoscopes prior to and after a delivery, and often, between each newborn in the nursery. The strength of the solution is 70% isopropyl alcohol. Alcohols provide germicidal activity by the denaturation of proteins (Rutala, 1993). Unfortunately, in order for alcohol to be an effective disinfectant, prolonged exposure is required--a rapid swipe with an alcohol pad does not provide much disinfectant efficacy (Hoffman, 1987).

Hypochlorites. The use of hypochlorites in the clinical setting has risen dramatically since the 1980s, as they are very effective in killing viruses commonly found in blood and body fluids. The most common way of using hypochlorites is to mix up a solution of sodium hypochlorite and water, and use it in a spray bottle. The equipment (or blood spill) is sprayed with the hypochlorite solution, then wiped up. Scientists are unsure of the mode of action—possibly inhibition of some enzymatic reaction, protein denaturation, and inactivation of nucleic acids (Dychdala, 1991). One problem with hypochlorites is that they are easily inactivated by organic matter (Hoffman, 1987; Rutala, 1993). This study sought to determine the prevalence of organic matter still remaining on the stethoscope after use in maternal-infant areas since germicidals would be ineffective in disinfecting stethoscopes contaminated with bacteria, viruses, blood, and other body fluids.

Gluteraldehydes. Gluteraldehydes have gained wide acceptance recently as a high-level chemical disinfectant (and sterilant for longer periods of time) for equipment (Rutala, 1993). These disinfectants are potent, and actually have the capability of killing bacterial spores when activated (made alkaline) (Rutala, 1993). Hypochlorites and alcohols do not have a sporicidal capability. Gluteraldehydes work by the alkylation of microorganisms, thus affecting the RNA and DNA syntheses (Rutala, 1993). However, gluteraldehydes have a noxious odor and precautions should be taken to decrease the risk of contact with the liquid or the vapor.

Phenolics. Phenolics were probably the first disinfectant used—Lister employed their use in surgical antisepsis. They work by disrupting the cell wall and precipitating proteins from the cell (Rutala, 1993). A common problem seen with the indiscriminate use of phenolics is tissue irritation (Kahn, 1970).

Chemical disinfectants are widely used in the hospital setting for their ease of use, and bactericidal action. However, their usage is not without problems. Chemical disinfectants can be corrosive to equipment, the bactericidal qualities are inactivated by the presence of organic matter, there is variability in susceptibility of different microbes, instability of the solution, and different rates of bactericidal action, and also can have an unpleasant odor and/or be hazardous for the user or receiver (Hoffman, 1987). Nevertheless, chemical disinfectants are often the first-line defense used against bacteria in the hospital setting.

Because of these problematic considerations, Hoffman (1987) recommends using chemical disinfectants only as a last resort, and to soak instruments for a minimum of 10 minutes *provided they are scrupulously clean.* Unfortunately, soaking stethoscopes is an impossible task due to the high usage of the equipment, the time factor, and the corrosive nature of the chemical on metal and plastic. Stethoscopes are commonly sprayed with a disinfectant such as gluteraldehydes or hypochlorites, then wiped with a washcloth, or are swiped clean with an alcohol pad.

Methods of Sterilization

Disinfection and to a greater extent, sterilization, can be achieved using either dry or moist heat under pressure, or ethylene oxide gas under pressure. The application of moist heat under pressure (a.k.a. autoclaving) is preferred over dry heat, as dry heat requires much higher temperatures to achieve the same effect (Rutala, 1993). Dry and moist heat works by coagulation of and denaturation of enzymes and structural proteins (Rutala, 1993). None of these methods are employed to disinfect or sterilize stethoscopes.

Conceptual Model of the Relation between Germ Theory and Nursing

Based on the information presented in the review of the literature, a conceptual model was developed which depicts the relationship between the theory of germ transference and the four domains of nursing. As presented earlier, portions of the germ theory were initially developed and supported by Florence Nightingale, nursing's first

professional nurse. Because of the belief that germs and bacteria can directly affect the health of the individual, nursing continues to strive to eliminate environmental toxins. Due to the information learned about the environment and cleanliness, nursing has attempted to manipulate the environment in an attempt to improve the health of the individual. In this model, nursing's actions and interventions are influenced by the development and acceptance of the theory of germ transference. Nursing takes the knowledge gained from this basic theory, and attempts to manipulates the environment. Nursing believes that removal of noxious stimuli can directly impact and influence the health of the individual.

Applied directly to this study, the researcher has attempted to identify potential noxious stimuli which may negatively impact the health of the individual. The noxious stimuli is identified as medical equipment contaminated with blood and body fluids. Figure 1 provides a conceptual model of the interaction between germ theory, and the four domains of nursing (nursing, environment, health, and person).

Summary

In the maternal-newborn area, stethoscopes used on newly born infants are routinely subjected to gross amounts of maternal blood, amniotic fluid, vernix on the newborn's skin, meconium, maternal feces, and fetal blood from the cutting of the umbilical cord. This admixture of body fluids may be difficult to remove from the surface of the stethoscope due to the tenacious nature of the admixture. This author

found no studies which investigated the incidence of blood and other body fluid contamination on stethoscopes. As Forseter, Joline, and Wormser (1990) state, it is time to re-evaluate equipment that is contaminated with blood to minimize the risk of infection to hospital workers and to patients.

Current literature now indicates that all blood and body fluids should be considered contaminated with potentially lethal viruses. Germicidals are an effective means of decontamination if no organic matter remains. Unfortunately, if a significant amount of organic material remains on the stethoscope even after cleaning, any beneficial effect of the germicidals are nullified.

The results of many research studies demonstrate poor cleaning habits towards stethoscopes, positive microbial growth of potentially serious flora, coupled with the ubiquitous presence of occult blood on environmental surfaces all indicate that stethoscopes that come in contact with blood and body fluids may pose a significant threat of cross contamination to certain groups of individuals. Although to date no cases have been directly linked with fomite transference, exposure to equipment that is contaminated with blood provides a theoretical risk that must be realized.

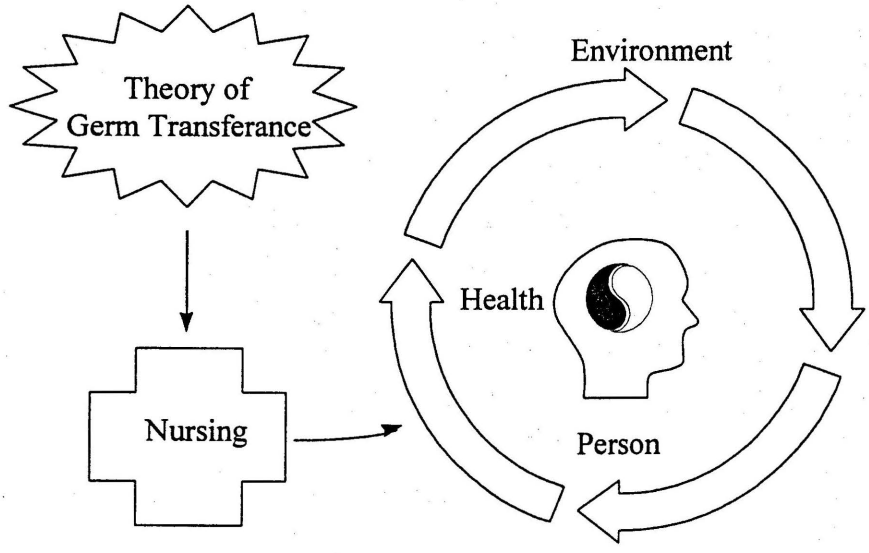

Figure 1. Conceptual Model of the relation between Germ Theory and the Meta-paradigm of Nursing. Using the knowledge gained by germ theory, nursing attempts to manipulate the environment in order to positively impact the health of the person

CHAPTER 3

METHODOLOGY

Since there was no evidence in the literature demonstrating research on the investigation of organic material and detection of residual blood on stethoscopes, an exploratory study was warranted. The purpose was to explore and describe the problem in detail prior to manipulation or randomization is incorporated. Therefore, the design chosen for this project was a non-experimental, two-group, post-test with an ex post facto time frame. The subjects chosen for the study, the methods for measuring the variables and the procedures undertaken for data collection are reviewed.

Setting and Population

The setting for this study was hospital maternal-infant areas in acute care hospital based units. The geographic area sampled included three states in the southwestern portion of the United States. The population identified in this study was all stethoscopes found in maternal-infant areas. The accessible population in each hospital varied from 3 to 17 stethoscopes. Since the accessible population in each unit was small, a multi-site study was undertaken.

Unit managers were initially contacted by phone, followed by a cover letter (Appendix A) and the research proposal. After permission was granted, the agencies completed and signed three copies of the "Agency Permission for Conducting Study"

form developed by the College of Nursing (Appendix B). Each agency retained one copy, and sent two copies back. One copy was kept by the principle investigator, and the other copy was kept on file at the College of Nursing.

The maternal-infant areas in each hospital consisted of either Labor, Delivery, and Recovery (LDR), Labor, Delivery, Recovery, and Postpartum (LDRP), and/or separate Newborn Nurseries. Usually, LDRP units have a separate nursery, though not always. When an LDRP unit was encountered in the hospital during data collection, it was classified with L&D units since stethoscopes were used during delivery and had the highest probability of coming in contact with blood, vernix, and amniotic fluid. When a separate Newborn Nursery was present, stethoscopes from that area were coded as being used primarily in the nursery.

Subjects

Sample

The sampling procedure chosen for this study included a non-probability convenience method. This method was considered adequate for the present study since the variables measured would be categorical and hence distribution free. Since probability sampling does not insure representativeness of the sample, only that the sample is unbiased (Kerlinger, 1986, p. 110), steps were taken to decrease the chance of bias selection.

One method employed to decrease bias was to include a diverse setting and enlarge the area from which samples were drawn. The geographical area sampled included a three state area in the southwest portion of the United States. Several hospitals were large enough to be considered a Standardized Metropolitan Statistical Area (SMSA) while other hospitals were considered urban. With the geographical and metro/urban differences, the chance of bias selection was decreased.

The target sample size was 90 stethoscopes; the final sample size obtained was 97 stethoscopes. The target sample size of 90 was based on Cohen's (1988) sample size tables for chi-square analyses. For *a priori* levels of power = 0.80, $\underline{p} = .05$, and a calculated effect size (ω) = 0.30, the minimum sample size required was 87. The effect size calculated for this study is considered medium in magnitude, as defined by Cohen (1988, section 7.2.3, p. 227). Appendix C demonstrates how the effect size for Chi-square Tests for Goodness of Fit was calculated using Cohen's formula and the data from a pilot study. Since attrition was not anticipated with this population, oversampling was not planned. All subjects initially entered into the study were retained.

Instrumentation

Several instruments were used to validate and/or measure organic buildup and residual blood. Organic buildup was measured with two instruments—one was a hydrogen peroxide test used to document the presence of organic buildup, and the other was used to quantify the amount of organic buildup. These two tools were tested during a

pilot and found to be acceptable.

Two instruments used to indicate the presence of residual blood were piloted. Both are accepted forensic methods currently used in the field by investigators in the United States. One method, the phenolphthalein test demonstrated high specificity and sensitivity. The second method, which uses chemoluminescence to indicate the distribution of bloodstains is called the luminol test. During a pilot, it was determined that the luminol was not specific enough and caused false positives with the iron in the metal of the stethoscopes. Because of the false positive results, the luminol test was not used for the study.

Organic Buildup

Two methods were used to measure organic buildup. One method was used to verify the presence of organic matter, while the second method was used to quantify the amount of organic matter.

During the course of an infant's assessment, the stethoscope comes in contact with gross amounts of vernix and amniotic fluid (whitish to yellowish in color). The material found on the stethoscopes was also whitish to yellowish. When hydrogen peroxide (H_2O_2) was applied to the material, oxidation occurred, producing bubbles of carbon dioxide. Although not every stethoscope was tested with H_2O_2 the ones that were tested were positive for organic material (n=5). The stethoscopes tested with H_2O_2 were similar in appearance to those not tested. Two photographs are supplied in Figure 2 that

demonstrate the bubbling effect on two of the stethoscopes when hydrogen peroxide (H_2O_2) was applied. The microscope photographs in Figure 2 were taken with a Nikon FX-35A 35 mm camera attached to a Nikon UFX-II Microscope. The film was Kodak Royal Gold ASA 25. Lumination was provided by two fiberoptic point sources.

The second instrument was used to quantify the amount of buildup seen on the stethoscope. A classification scheme was developed for rank ordering the amount of buildup. The categories can be seen in Table 3. There were three possible categories for organic buildup--principally, none, mild, and gross amount. In the original computer coding, these three categories were retained. However, for most of the analyses, the categories mild and gross were collapsed into one and classified as simply "buildup present." This was done because in the clinical area, sometimes it is more important to determine the existence of a problem than to measure the degree of existence. The rank ordering of the amount of organic matter present on the stethoscope was measured by visually inspecting the diaphragm disc with a Bausch & Lomb Hastings triplet 10× hand held lens. This hand lens increased the visual image ten times greater than with the eye.

During the development phase of this classification scheme, several stethoscopes were inspected. It was noted that many of the diaphragm discs had a reddish discoloration in the middle of the diaphragm disc itself; consequently the characteristic discoloration was added as another factor when quantifying the amount of buildup present.

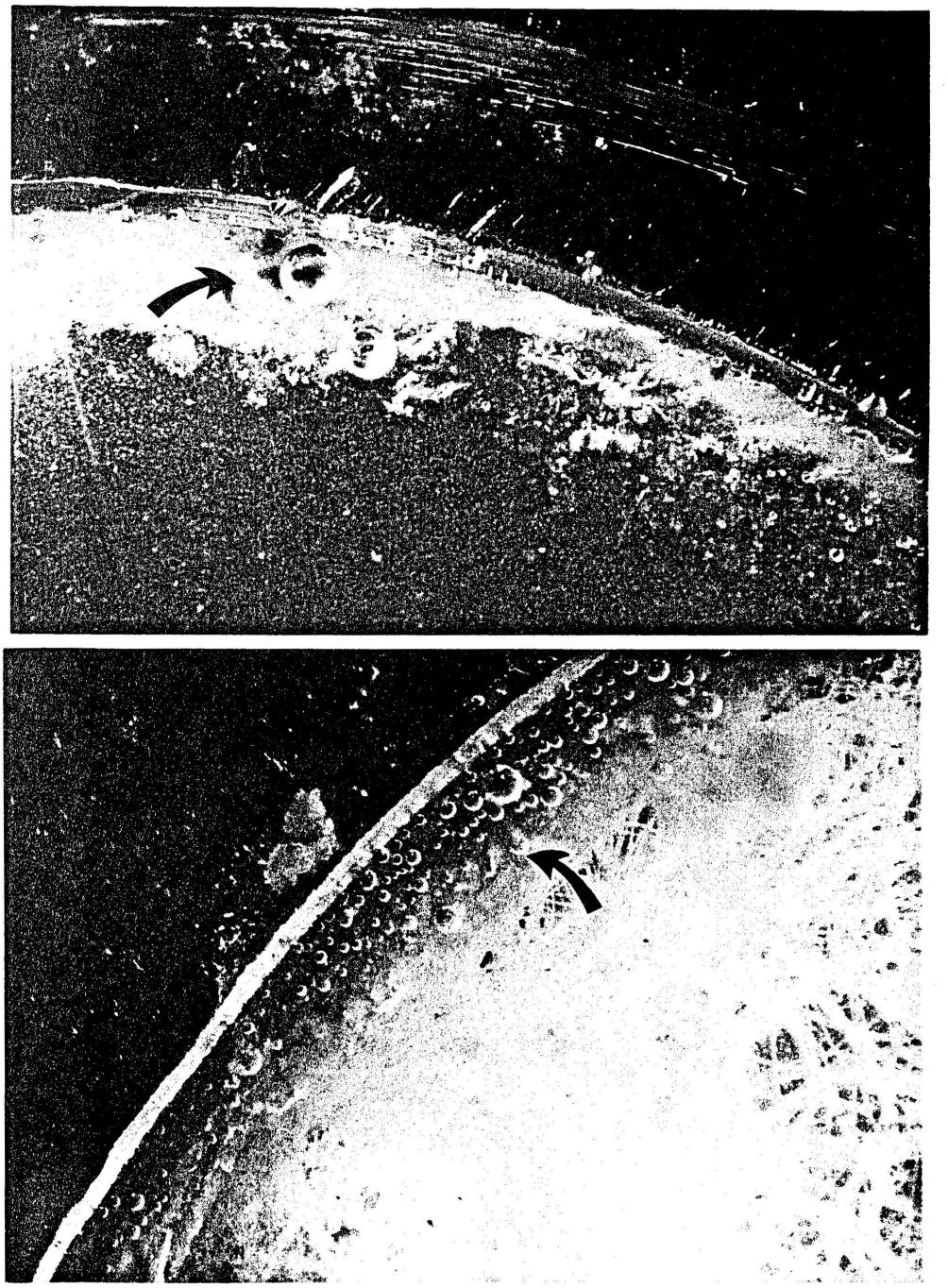

Figure 2. Production of bubbles from the reaction of H_2O_2 with organic material on two of the stethoscopes included in this study. Bubbles are indicated by the arrow. The diaphragms of both stethoscopes are approximately 7/8 inch in diameter

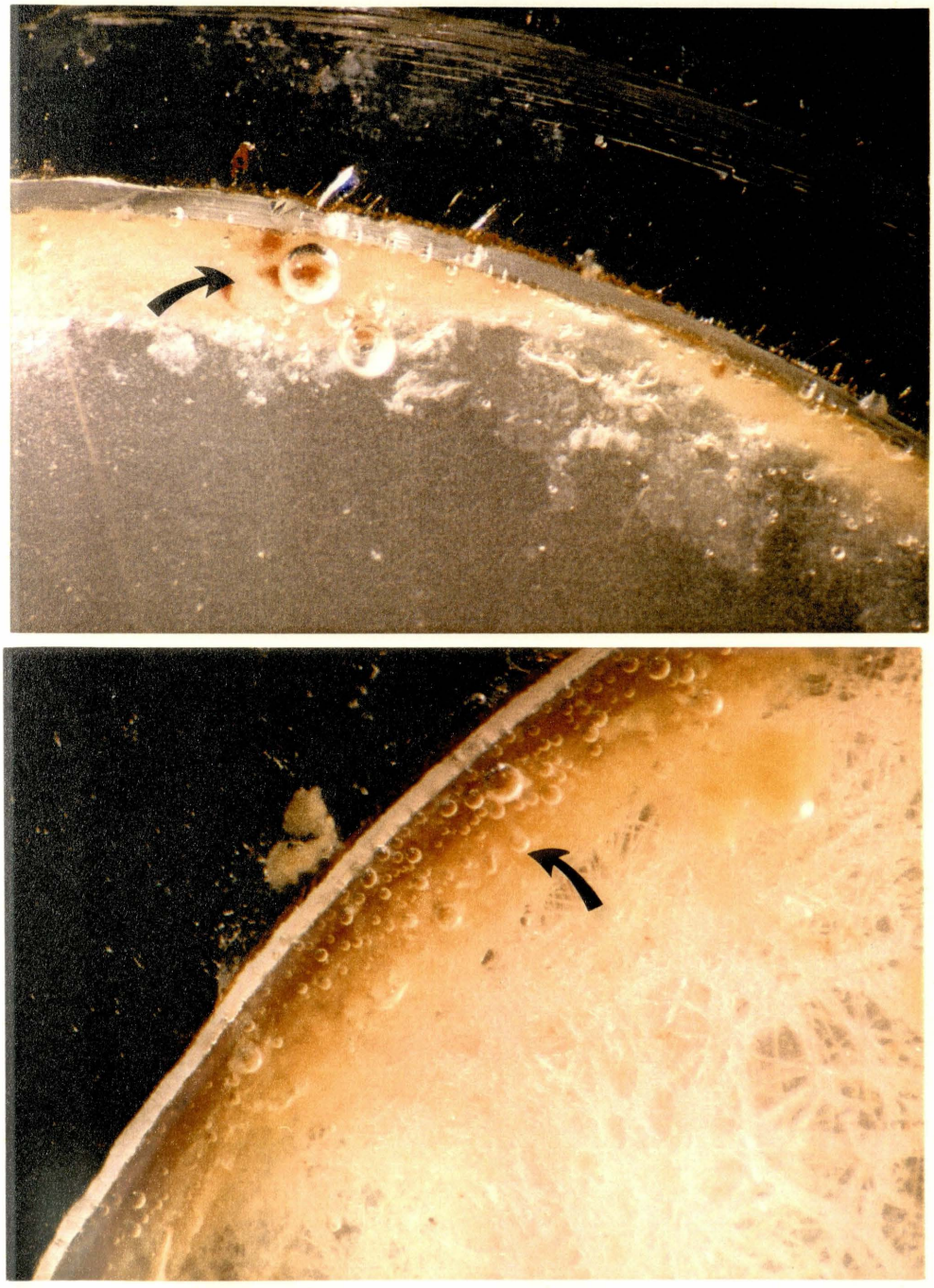

Figure 2. Production of bubbles from the reaction of H_2O_2 with organic material on two of the stethoscopes included in this study. Bubbles are indicated by the arrow. The diaphragms of both stethoscopes are approximately 7/8 inch in diameter

Table 3. Classification of Amount of Organic Buildup seen on Stethoscopes

No buildup seen (1)	Mild amount seen (2)	Gross amount seen (3)
No discoloration seen on diaphragm disc with aid of 10X hand lens and no organic buildup seen in cracks or edges of diaphragm with aid of 10X hand lens.	Discoloration seen on diaphragm with aid of 10X hand lens and/or organic buildup seen in cracks or edges of diaphragm with aid of 10X hand lens.	Discoloration and/or organic buildup seen on diaphragm disc without the aid of the 10X hand lens (seen with the human eye).

Reliability Studies. Demonstration of intra-rater reliability for quantification of buildup was accomplished by rating the amount of buildup found on stethoscopes at the same institution on two separate occasions, then comparing the results to see if they were similar. The comparisons were done at site #1 . Similar results were obtained on the second visit. There was agreement of coding on all five stethoscopes. Qualitative field notes were also reviewed on five stethoscopes from site #4. From the descriptions written during the first episode of data collection, and using the classification scheme in Table 3, re-scoring was done and results were compared with the first set of scores. The coding was the same on the five stethoscopes (five of five). Since similar results of

scoring for buildup were obtained from the same hospital on two episodes and similar scores were obtained on the same stethoscopes when field notes were used, intra-rater reliability was deemed acceptable.

Figures 3 and 4 provide examples of typical stethoscopes seen in the field. Figure 3 shows two types of stethoscopes that have mild amounts of buildup on them (required a hand lens to see the buildup). Two more stethoscopes with gross amounts of buildup are featured in Figure 4. The buildup on the two stethoscopes in Figure 4 could easily be seen with the unaided eye. The microscope photographs in Figures 3 and 4 were taken with a Nikon FX-35A 35 mm camera attached to a Nikon UFX-II Microscope. The film was Kodak Royal Gold ASA 25. Lumination was provided by two fiberoptic point sources.

Residual Blood

Two instruments used to measure residual blood were piloted. They included the phenolphthalein test and the luminol test. The OSBI manual (1989) states that the luminol test is not a replacement for the phenolphthalein test which is the primary blood identification test (p. 2-6). There is some controversy in the literature as to the effect luminol has on subsequent testing with other presumptive and confirmatory tests (i.e., phenolphthalein test). The OSBI manual states that luminol is a destructive reagent which may adversely affect subsequent analysis of blood enzymes (p. 2-6). However, in a recent study published in the Journal of Forensic Sciences, Laux (1991) found that

spraying the area in question with luminol prior to testing with a phenolphthalein reagent did not adversely affect the outcome of the phenolphthalein test. Laux allowed the sprayed samples to dry completely (one-half hour) prior to testing with additional tests. The procedure for the preparation and use of the phenolphthalein test and the luminol used during the pilot are found in Appendices E and F.

The Phenolphthalein test is classified as a catalytic test for residual blood, and is considered a presumptive test. Catalytic tests for blood are based on the premise that hemoglobin exhibits a peroxidase like activity (Gaensslen, 1983). Hemoglobin catalyzes or "speeds up" oxidation when peroxide is added and causes a color change in the compound almost immediately. If hemoglobin in not present, oxidation will still take place but at a much slower rate. All catalytic tests have windows of time wherein the reagent must change to the expected color—if no color change is apparent, then the results are considered negative for the presence of blood. The phenolphthalein reagent turns a pink color when residual blood is present.

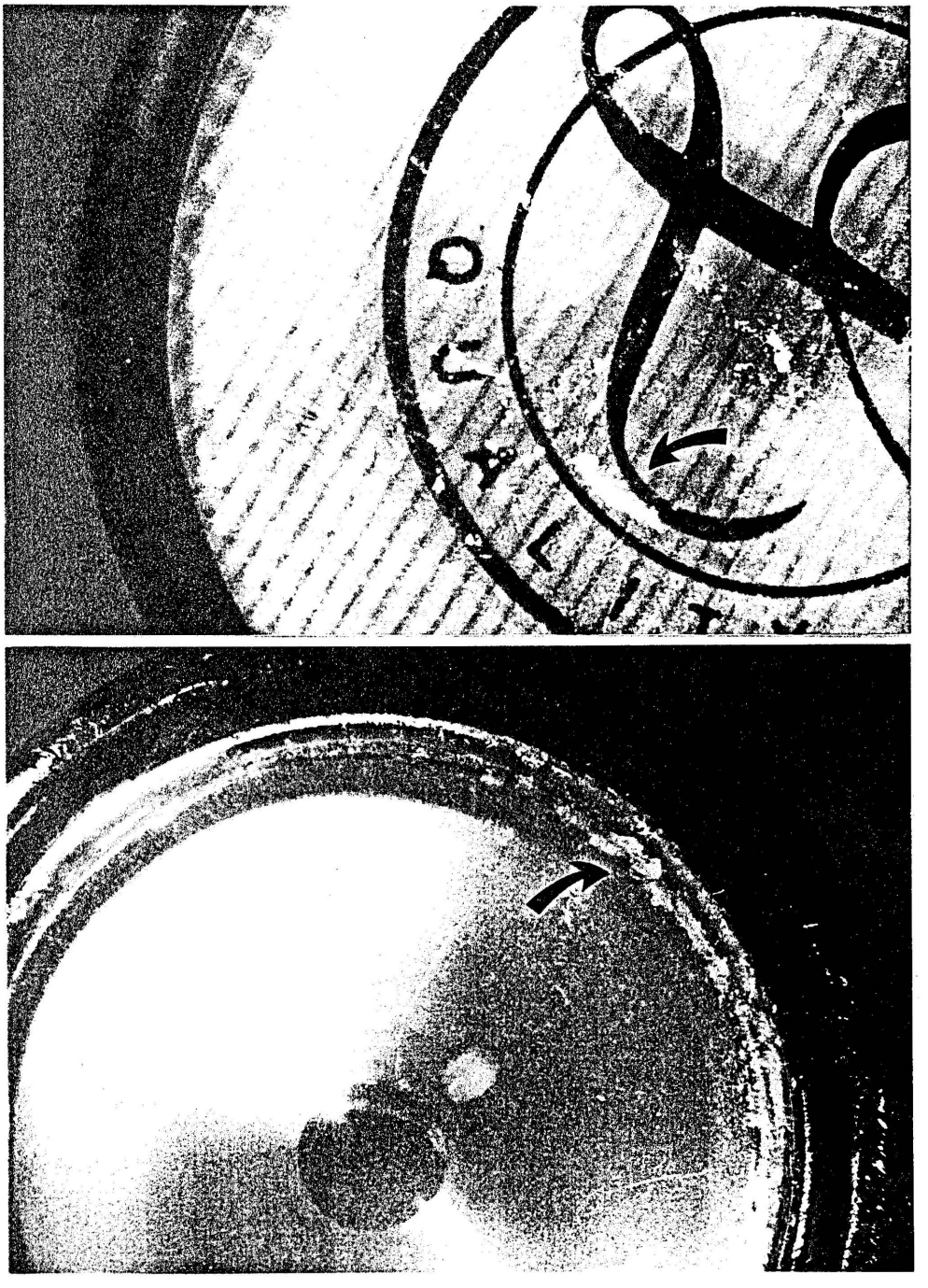

Figure 3. Examples of stethoscopes categorized as mildly contaminated. This amount of contamination is difficult to see without magnification. Note the whitish to yellowish material as indicated by the arrows. Both stethoscope diaphragms are approximately 7/8 inch in diameter.

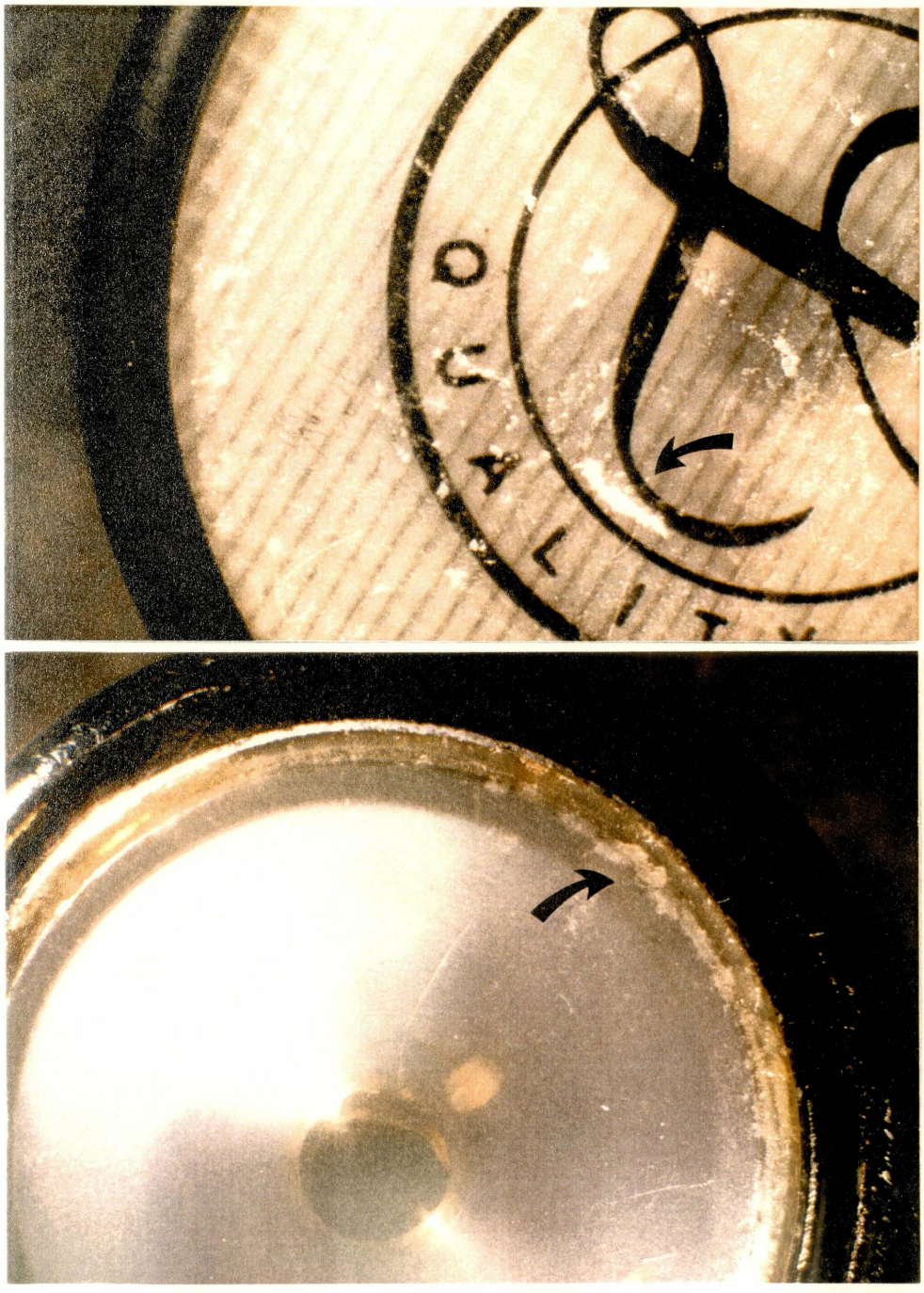

Figure 3. Examples of stethoscopes categorized as mildly contaminated. This amount of contamination is difficult to see without magnification. Note the whitish to yellowish material as indicated by the arrows. Both stethoscope diaphragms are approximately 7/8 inch in diameter.

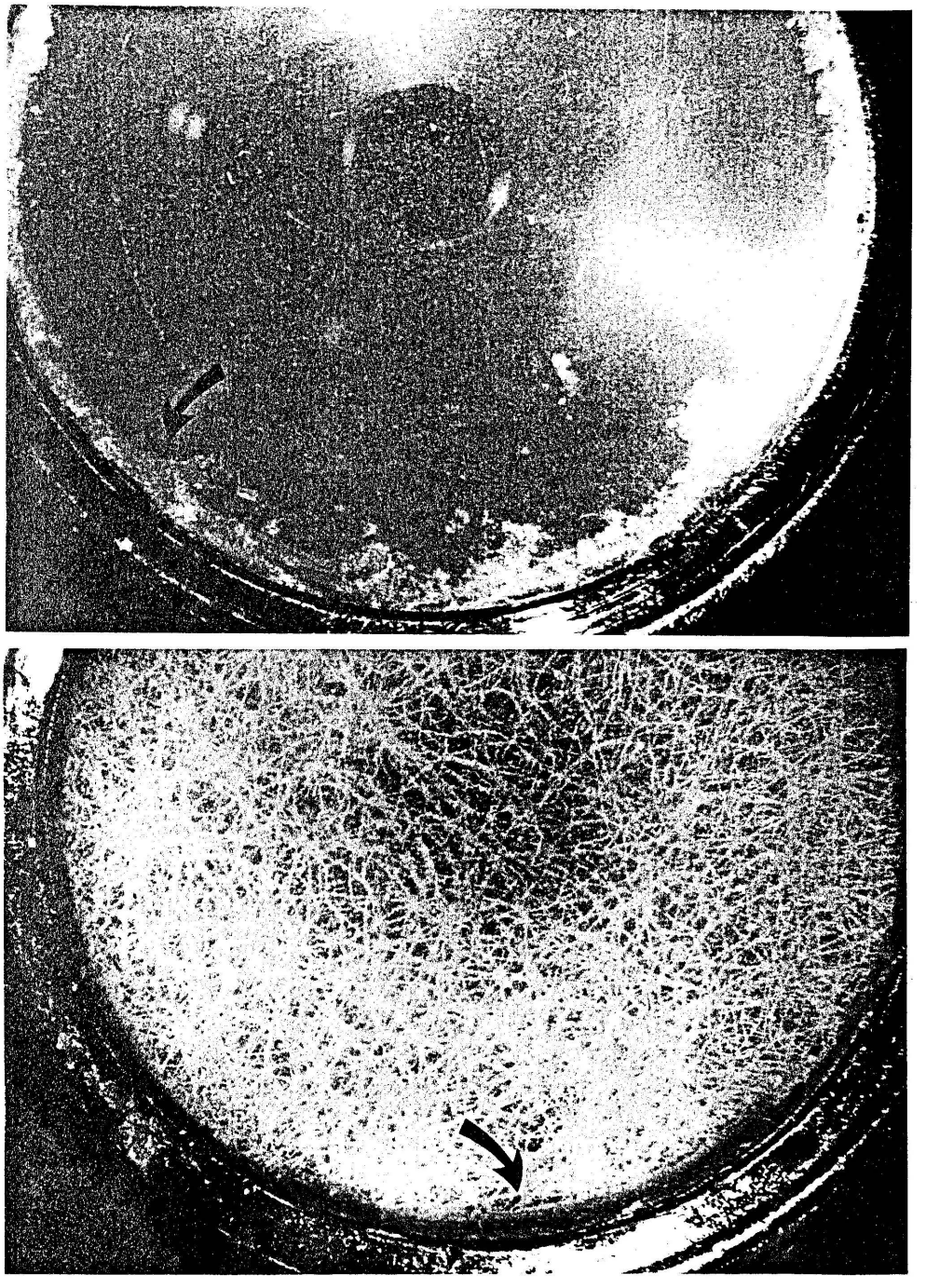

Figure 4. Examples of stethoscopes showing gross amount of buildup. This level of buildup is visible with the unaided eye. Note the white and orange color of material around the rings as indicated by the arrows. The diaphragms are approximately 7/8 inch in diameter.

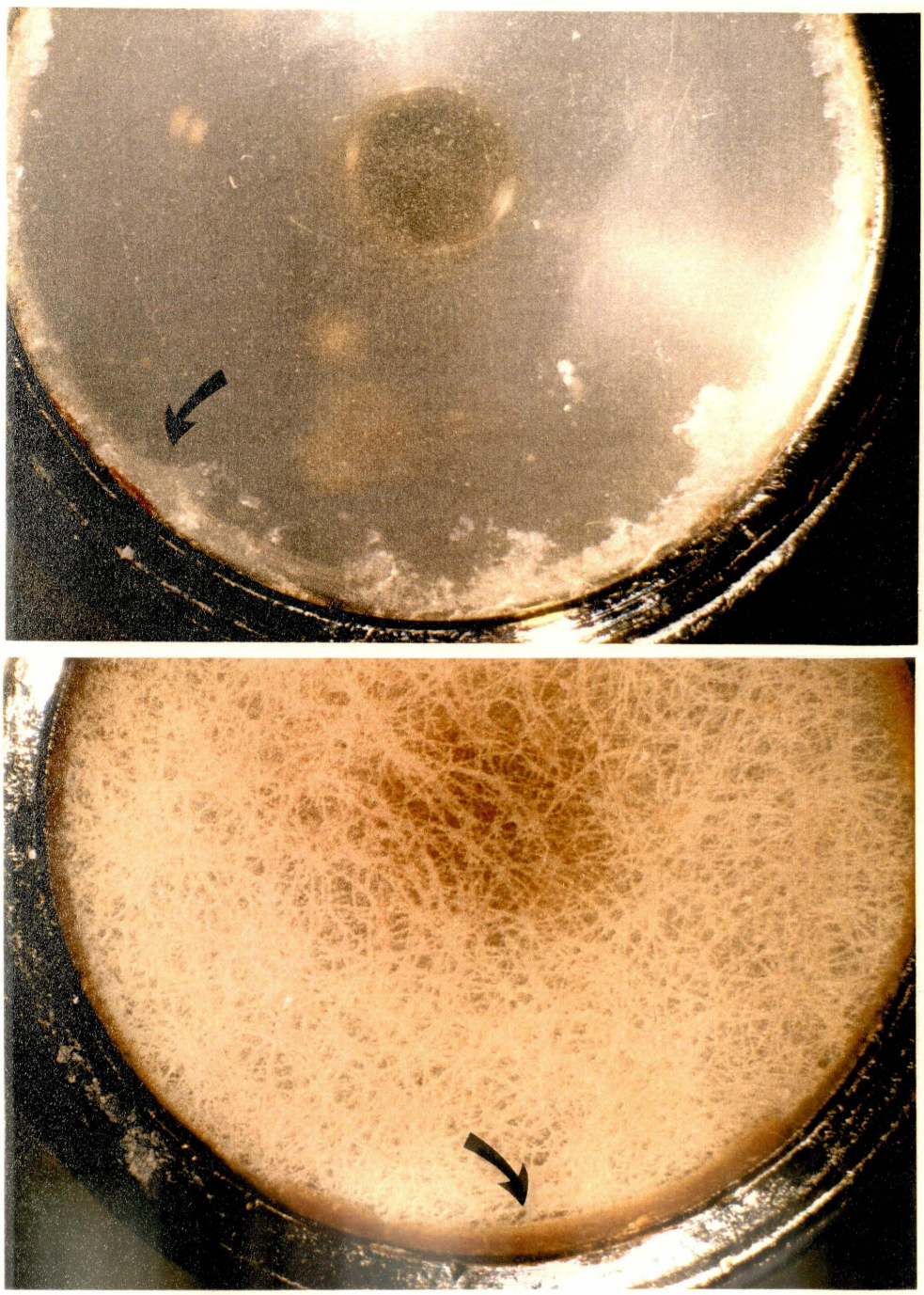

Figure 4. Examples of stethoscopes showing gross amount of buildup. This level of buildup is visible with the unaided eye. Note the white and orange color of material around the rings as indicated by the arrows. The diaphragms are approximately 7/8 inch in diameter.

There are several catalytic chemistry tests currently used to determine the presence of residual blood. Each test uses a different reagent and each indicator turns a specific color when positive for blood. The tests include: (1) Guaiacum, (2) Aloin, (3) Phenolphthalein, (4) Benzidine, (5) Orthotolidine, and (6) Leucomalachite green. Another indicator, luminol, is also used for testing residual blood, but is not classified as a catalytic test. Luminol works from a different principle in chemistry and uses a luminescent agent which glows in the presence of blood. Whereas the six catalytic tests are dependent on local swabbing and are useful for indicating the presence/absence of residual blood in very localized areas, luminol can provide information on patterns of blood splattering and/or patterns of bloodstain distribution. Catalytic tests are portable, relatively stable in solution, and require sufficient lighting to ascertain color changes of the material being tested. On the other hand, Luminol requires elimination of all ambient light, making it somewhat difficult to use in the field, and even more difficult to photograph the glow produced by the chemical.

Current literature indicates that the Phenolphthalein test is the preferred catalytic test used today in forensic science (Cox, 1991, Gaensslen, 1983; OSBI Manual, 1989). It is reported to be the most specific and most sensitive (Cox, 1991). In addition, the solution is very stable, and easy to administer in the field. For these reasons, the Phenolphthalein test was chosen for this study.

For the Phenolphthalein test, the OSBI procedure manual (1989) recommends a cut-off time of 60 seconds, since auto-oxidation can occur in the presence of light and air (p. 2-3 and 2-4). A more conservative cut-off time of 45 seconds was used for this study. Table 4 was developed and used for a guide during interpretation of the presence/absence of blood.

Table 4. Description and coding of the Phenolphthalein Residual Blood Test

Negative (0)	Positive (1)
No pink shading on the cotton swab within 45 seconds after the application of H_2O_2.	Any shade of pink color on the cotton swab obtained less than 45 seconds after the application of H_2O_2.

Reliability Studies. In Chapter 1, three limitations were identified which could compromise the results if they were not controlled for. They included instrumentation, the Hawthorne effect, and threats to construct validity. Controls for two of the three limitations involved specificity and sensitivity testing. The results of these tests are discussed below.

Sensitivity and specificity testing was conducted on the phenolphthalein test and was found to have high sensitivity and 100% specificity. No false negatives or false

positives were obtained on known materials tested. The luminol test was also tested in a pilot study but yielded unreliable and hence invalid results. False positive reactions were obtained with the luminol test, therefore this method of documenting the presence of residual blood was dropped from the pilot.

Results of Specificity and Sensitivity Testing

Specificity. Since the phenolphthalein test is classified as a presumptive test, not a confirmatory test, determination of false positive and false negative results were done by completing specificity testing. As the name implies, specificity testing demonstrates the *validity* of using the Phenolphthalein residual blood test by testing known positive blood sources and known negative blood sources. Testing for false negatives and false positives prior to each use is recommended (OSBI Manual, 1989, p. 2-6).

Known negative blood sources included all materials the stethoscope is likely to come in contact with. These included germicidals, gloves, cotton swabs, the distilled water used to moisten the cotton swab, and the metal of the stethoscope. Since certain metals can react with the phenolphthalein and give false positive results, metal parts of new stethoscopes were tested to see if any false positives occurred.

In the literature, certain vegetables and germicidals which also have a peroxidase-like activity have been identified as giving false positive results. Vegetables which have a peroxidase-like activity include horseradish, potato, and carrot. These vegetables were tested and no false positives were found. These vegetables do not come in contact with

tested and no false positives were found. These vegetables do not come in contact with stethoscopes, and hence do not pose a threat to the outcomes of the test. However, they were tested and no false positives were obtained with the vegetable sources. Germicidals/disinfectants pose a much more serious threat since some germicidals have been known to give false positive results and they come in contact with stethoscopes on a daily basis.

There are numerous types of chemical disinfectants used in the hospital setting. These include (1) alcohols, (2) hypochlorites, (3) gluteraldehydes, (4) phenolics, (5) and iodophors to name a few. Of the various chemical disinfectants, hypochlorites are the only germicidal identified in the literature as having peroxidase-like activity (Cox, 1991). Because of the possibility of germicidals affecting the outcome, testing of all chemical disinfectants used to clean stethoscopes was done. No false positives were obtained.

Specificity and sensitivity testing were done prior to data collection at each institution. Results were recorded at 20 seconds and at 45 seconds which was the cutoff point used for the Phenolphthalein test. If two institutions were visited within a seven day period, then specificity and sensitivity testing were completed only once, prior to the first visitation. Specificity results are displayed in Table 5. No false negatives or false positives were obtained on any of the sources, thus validating the use of the Phenolphthalein test for the detection of residual blood on stethoscopes.

Table 5. Specificity Results for the Phenolphthalein Residual Blood Test

Medium Tested	20 sec	45 sec
Blood	+	+
Saliva	-	-
Perspiration	-	-
Horseradish	-	-
Potato, fresh	-	-
Carrot, fresh	-	-
Germicidals		
Hypochlorite	-	-
Sparquart	-	-
Wexcide	-	-
Alcohol	-	-
Septisol	-	-
Lysol	-	-
TOR	-	-
Diaphragm disc		
clear	-	-
opaque	-	-
Metal ring	-	-
Powdered Latex glove	-	-
Cotton swab w/o water	-	-
Cotton swab w/ Distilled water	-	-

Key to abbreviations:

20 sec = within 20 seconds. 45 sec = within 45 seconds.

- = negative result indicated by no color change

+ = positive result indicated by a pink color change.

Sensitivity. It was also necessary to determine how sensitive the solution is to different dilutions of blood. Sensitivity testing demonstrates how dilute or weak a blood stain can be and still have a positive reaction to the blood in the solution. The phenolphthalein test has a reported sensitivity of 1:1 000 strength historically. Recently, Cox (1991) reported sensitivity findings of 1:10 000 on dried filter paper and cotton cloth, and dilutions of 1:1 000 000 for direct blood solution.

The results of the sensitivity testing are displayed in Table 6. Wet and dried dilutions were tested. Testing of the wet solutions included dipping dry sterile cotton swabs into the solutions, followed by application of a drop of phenolphthalein reagent and hydrogen peroxide. For testing of the dry dilutions, two types of diaphragm discs were dipped into the different blood concentrations and allowed to dry. Once dry, a moistened cotton swab wiped the surface of the discs, followed by application of phenolphthalein reagent and hydrogen peroxide on the cotton swab.

Results showed that all three of the wet dilutions tested positive, indicating the phenolphthalein solution used in this study was highly sensitive to minuscule amounts of blood in fluid. However, the diaphragm discs that were dipped in the blood dilutions then dried were positive for blood only at the most concentrated level (1:1 000). Whether all the stethoscopes that tested positive had a dilution of 1:1 000 or stronger is difficult to say. Covariables may affect sensitivity results. One covariate which may have affected the results of the sensitivity testing is that the discs used for dried dilutions were new.

The surface of a new disc may be smooth and impervious to certain substances like blood--age and amount of use may change the smoothness. A second covariate which may have affected the sensitivity results include the effect of other body fluids on the disc. The presence of vernix and/or amniotic fluid may increase the likelihood of finding residual blood on the stethoscope diaphragm. The results of the sensitivity testing are displayed in Table 6.

Table 6. Sensitivity Results for the Phenolphthalein Residual Blood Test, showing time required for a result or no reaction

Blood Dilution	Specimen tested	Results, in seconds
1:1 000	Diaphragm disc (clear)	+, 02
	Diaphragm disc (opaque)	+, 03
	Wet solution*	+, 02
1:5 000	Diaphragm disc (clear)	-, 60
	Diaphragm disc (opaque)	-, 60
	Wet solution	+, 03
1:10 000	Diaphragm disc (clear)	-, 60
	Diaphragm disc (opaque)	-, 60
	Wet solution	+, 05

Note: *solutions made with distilled water

Key to abbreviations: - = negative + = positive

Qualitative field notes were written during sensitivity and specificity testing, and during data collection. When blood is present, phenolphthalein indicates its presence by turning a pink color on the cotton swab (the testing material in this study). The more concentrated the blood, the more intense was the pink shade, while weaker solutions provided progressively lighter shades of pink. Confirmation of the color shades was verified by Winn Horman , a forensic serologist at the Oklahoma State Bureau of Investigations, Lawton, OK.

Procedures for Data Collection

At each site, permission was obtained from the nurse manager of the unit and from nursing administration. Once permission was obtained, data collection began. All stethoscopes found on the L&D/LDRP and/or nursery units on that day of data collection was tested. The steps for data collection include:

1. Each stethoscope was visually inspected and rank ordered (see Table 3) for the amount of organic buildup on the diaphragm, using a 10× hand-held lens.

2. If buildup was present, a small amount was taken and placed on a slide. Two drops of H_2O_2 were applied to the sample to determine if bubbling activity was noted, indicating the presence of organic material. Not all stethoscopes were tested with H_2O_2.

3. The stethoscope diaphragm was then tested for residual blood. One drop of distilled water was applied to a sterile cotton swab. The stethoscope was swabbed around the ring of the diaphragm twice. A single drop of phenolphthalein indicator was then

applied to the cotton swab, followed by a single drop of hydrogen peroxide. Once the hydrogen peroxide was applied, a timer was started to determine how many seconds it took for a pink color to appear—or until 45 seconds had passed—whichever came first. The results of the phenolphthalein test were then recorded on the data collection sheet. Table 4 provides the guidelines for interpretation of the phenolphthalein test for residual blood. Specificity testing was done on the phenolphthalein indicator test prior to each day's data collection period.

4. Anecdotal notes were also recorded regarding observations, results of the first two treatments such as the intensity of the pink color, how the organic buildup looked, or the pattern of bloodstain distribution. The purpose of the notes was to describe the appearance of the stethoscope tested and the outcomes of the testing.

5. A demographic questionnaire was also completed on each institution. This questionnaire was developed by the researcher, and was constructed in order to profile the setting where data collection took place. In addition, information was obtained that may provide possible explanations to alternate hypotheses. One demographic questionnaire was completed for each institution. The group analysis of the demographic questionnaire is found in Tables 7 and 8 in Chapter 4. The sample demographic questionnaire can be found in Appendix F.

Treatment of the Data

Descriptive statistics were used to portray the characteristics of the hospital sites sampled. Additionally, frequency tables and histograms were utilized. Since the level of measurement for most of the variables studied was primarily categorical in nature, contingency table analyses were completed. These analyses included Chi-square test for independence, and Chi-square test of differences. When significant relationships were found, then measures of association were computed to determine the strength of the association.. The measure of association chosen was the odds ratio.

Additionally, qualitative research consisting of photographs and field notes were used to present, explain results, or allow new patterns to emerge. Representative photographs included stethoscopes with mild and gross amounts of organic buildup on them, and the bubbles produced when hydrogen peroxide is applied to organic material.

CHAPTER 4

ANALYSIS OF DATA

Eleven hospitals from three states in the southwest portion of the U.S. were visited. Ninety seven stethoscopes from maternal-infant areas were tested for body fluid contamination. Body fluid contamination was defined as the presence of organic material and/or residual blood on the diaphragm of stethoscopes. Stethoscopes from both areas were tested since stethoscopes in the nursery came in contact with a newborn's skin prior to the initial bath. The findings discussed in this chapter pertain to the following research questions posed in Chapter 1. The initial study questions included:

1. What is the incidence of organic buildup seen on the diaphragm of stethoscopes used on newly born infants?
2. What is the incidence of residual blood on the diaphragm of stethoscopes used on newly born infants?
3. What is the relation between organic buildup on the stethoscope and the incidence of residual blood?
4. What are the difference in rates and proportions of organic buildup and residual blood between L&D and newborn nursery areas?
5. What are the differences in rates and proportions of organic buildup and residual blood between the hospital sites?

A description of the sample is presented, then findings of each study question is reviewed. Photographs of representative stethoscopes with mild and gross amounts of buildup were provided in the previous Chapter. Qualitative field notes taken during data collection are reviewed, and summarized.

Description of the Sample

The sample consisted of 97 "clean" stethoscopes used in L&D or newborn nursery areas. A variety of stethoscope sizes were used on infants in the eleven hospitals. Stethoscope sizes included 32 neonatal stethoscopes (about 7/8 inch diameter); 40 Littman® brand stethoscopes; 12 pediatric, and 13 adult size stethoscopes. Stethoscope brands included Abco®, BMS®, Littman®, Hewlett-Packard®, Sprague-Rappaport®, and others unable to be identified by brand name.

Characteristics of the Setting

Stethoscopes were collected from both urban and metropolitan areas. Five hospitals were in urban areas and six hospitals were from what is classified as a Standard Metropolitan Statistical Area (SMSA). Haupt and Kane (1989) define urban areas as areas with a population greater than 2 500 but less than 100 000; and define SMSA's as areas with populations in excess of 100 000.

The median number of deliveries at each institution was 850 per year with a range of 150 deliveries per year at the smallest hospital to 1850 deliveries per year at the largest

hospital. The majority of the hospitals cleaned the stethoscopes by wiping with alcohol pads (n = 9, p = .82). Two institutions sprayed a germicidal on to the stethoscope then wiped with a washcloth (n = 2, p = .18). About half of the sites were set up as a LDRP unit (n = 6) and the other half consisted of a LDR unit (n = 5). The LDR/LDRP concept in nursing care emerged in the early 1980s. LDRP is an acronym for labor, delivery, recovery and postpartum periods which occur in the same room. A variance of this concept is LDR where the gravid patient labors, delivers, and recovers, but is moved to another unit for the postpartum stay.

Nine of the eleven hospitals had a functional nursery. Of the two that did not have a nursery (sites #4 and #8), initial and on-going infant care was provided in the mother's room. If the infant required level II or level III nursing care, he/she was transferred to a Neonatal Intensive Care Unit (NICU). The number of stethoscopes found at each institution ranged from 3 to 17.

Tables 7 and 8 summarize the demographic characteristics of the participating hospitals. For purposes of analyses, LDRP and LDR units were grouped together and labeled as L&D. On LDR/LDRP units which also had a nursery, if stethoscopes were not interchanged between the newborn nursery and deliveries, stethoscopes were analyzed separately.

Table 7. Summary Characteristics of Participating Institutions

Site	Area	Number of deliveries per year	Method of cleaning stethoscopes	Type of cleaning agent
1	Urban	500	Spray/washcloth	Gluteraldehyde
2	Metropolitan[1]	1200	Alcohol pads	Isopropyl alcohol
3	Metropolitan[2]	1850	Spray/washcloth	Gluteraldehyde
4	Metropolitan[2]	1400	Alcohol pads	Isopropyl alcohol
5	Metropolitan[1]	550	Alcohol pads	Isopropyl alcohol
6	Urban	1200	Alcohol pads	Isopropyl alcohol
7	Urban	1200	Alcohol pads	Isopropyl alcohol
8	Urban	150	Alcohol pads	Isopropyl alcohol
9	Metropolitan[2]	850	Alcohol pads	Isopropyl alcohol
10	Metropolitan[3]	500	Alcohol pads	Isopropyl alcohol
11	Urban	720	Alcohol pads	Isopropyl alcohol

Note: [1] = from same SMSA [2] = from a second SMSA [3] = from a third SMSA

Table 8. Type of Service and Number of Stethoscopes found at Participating Institutions

Site	Type of unit	No. stethoscopes in L&D (n = 51)	No. stethoscopes in Newborn Nursery (n = 46)	Total number stethoscopes/site (N = 97)
1	LDR	n = 4	n = 1	n = 5
2	LDR	n = 7	n = 7	n = 14
3	LDRP	n = 5	n = 12	n = 17
4	LDRP	n = 13	*	n = 13
5	LDR	n = 3	n = 4	n = 7
6	LDRP	n = 2	n = 7	n = 9
7	LDRP	n = 1	n = 5	n = 6
8	LDRP	n = 3	*	n = 3
9	LDRP	n = 7	n = 4[1]	n = 11
10	LDR	n = 2	n = 4	n = 6
11	LDR	n = 4	n = 2	n = 6

* = No Nursery in existence [1] = Level II NSY only (no level I NSY)

LDR = Labor, Delivery, and Recovery only

LDRP = Labor, Delivery, Recovery, and Postpartum

Findings

Analysis of Study Questions #1

Of the 97 stethoscopes tested, 51 were from L&D/LDRP and 46 were from Nursery areas where stethoscopes were kept solely in the nursery. Twenty three stethoscopes (24%) had no visual organic buildup on the diaphragm disc, while 52 (54%) had mild amounts of organic buildup, and 22 (23%) had gross amount of buildup on them. These results are shown in Figure 5. Note the normal distribution for the combined group, and for L&D and Nursery areas.

Once normality of the distribution was apparent, the two categories "mild amount" and "gross amount" were collapsed into one category and the variable organic buildup was dichotomized. This was done because clinically it is unacceptable to have even a mild amount of body excrement from patients on equipment that is considered to be clean. All subsequent analyses with organic buildup were done with two categories—"buildup present" and "buildup absent."

Re-analysis revealed that 80% of L&D stethoscopes had buildup on them ($\underline{n} = 41$) while 72% of stethoscopes from newborn nursery had buildup on them ($\underline{n} = 33$). A frequency distribution of these findings is displayed in Figure 6. Both L&D and nursery areas as well as the combined total are depicted.

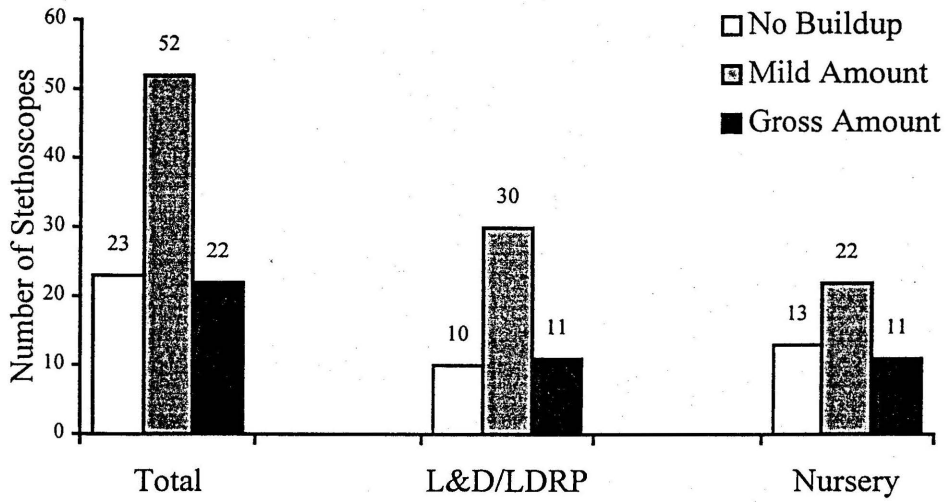

Figure 5. Frequency distribution of stethoscopes examined for organic buildup and classified as either none, mild or gross amounts. Two areas were examined (L&D/LDRP and Newborn nursery).

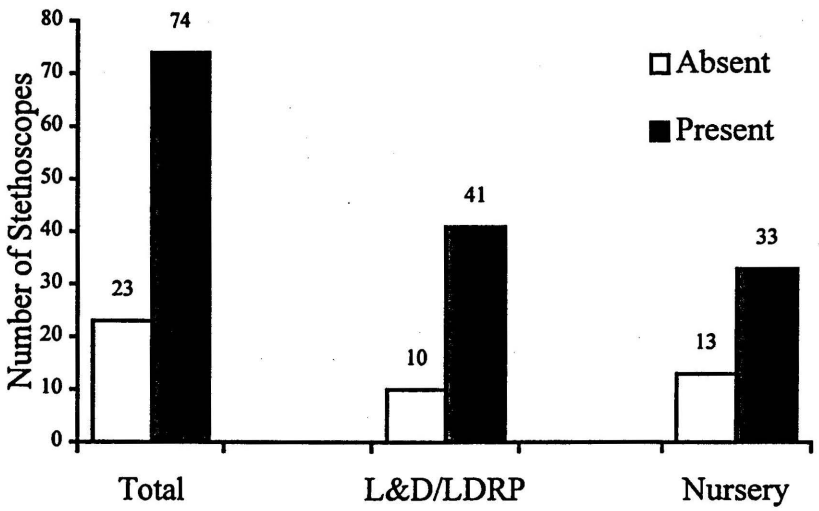

Figure 6. Frequency distribution of stethoscopes examined for organic buildup after collapsing the categories of buildup to either absent or present. L&D and Newborn nursery are analyzed separately.

Analysis of Study Question #2

Of the 97 stethoscopes tested for residual blood, 62% (n = 60) were positive. Of the 60 stethoscopes positive for residual blood, two-thirds came from L&D areas and one-third came from Nursery areas. Nursery areas had similar numbers of clean (n = 25)

and bloody (n = 21) stethoscopes.

Residual blood contamination was evaluated by area and revealed that 39 of 51 L&D stethoscopes had residual blood still on them which resulted in a residual blood contamination rate of 76%. In Newborn nursery areas, 21 of 46 stethoscopes were positive for residual blood which resulted in a residual blood contamination rate of 46% in that area. A histogram providing this information is found in Figure 7 below.

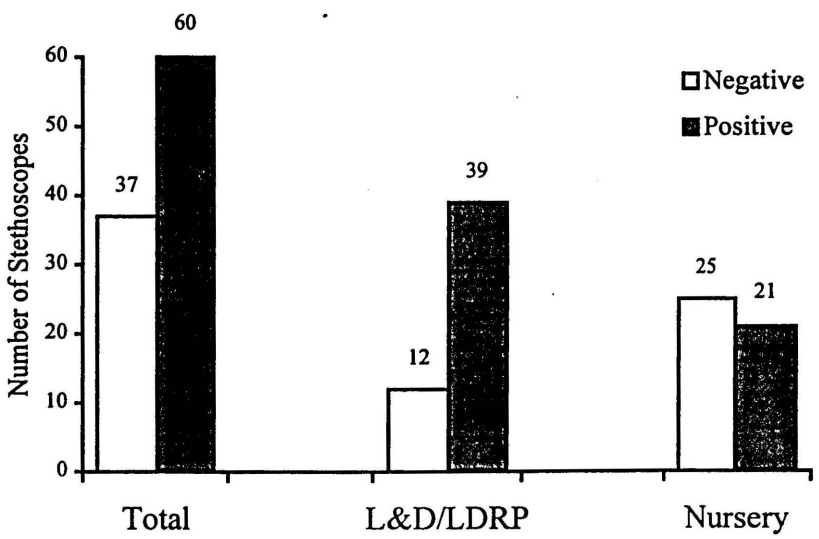

Figure 7. Frequency distribution of stethoscopes examined for residual blood in L&D and Newborn nursery areas.

Analysis of Study Question # 3

To determine if an association, or dependency exists between organic buildup and residual blood, the Chi-square test for independence was computed on the categorical data. As Table 9 shows, there was a significant association between organic buildup and residual blood. The odds ratio was chosen to indicate the strength of the significant chi-square since the odds ratio is not a function of χ^2, and the association can be studied when one of the factors is antecedent to the other (Fleiss, 1981, p. 61).. The odds ratio of 3.64 indicates that a stethoscope is 3 ½ times more likely to have blood on the stethoscope if buildup is present than if no buildup was present.

Table 9. Association between Residual Blood and Organic Buildup

	Tested for Residual Blood		
Buildup	Negative	Positive	Total
Absent	14 (p = .144)	9 (p = .09)	23
Present	23 (p = .237)	51 (p = .525)	74
Total	37	60	97

χ^2 (df = 1, N = 97) = 6.5989, p = 0.010 Odds ratio = 3.64

Much attention has been given to number of stethoscopes that were either contaminated with organic buildup or with residual blood. A closer inspection of the relationship between buildup and blood shows that of the 23 stethoscopes that "looked" clean (no organic buildup seen), nine (39%) stethoscopes tested positive for residual blood. Investigation into other factors might be instructive in future studies.

Analysis of Study Question #4

To determine whether one area is more at risk for having contaminated stethoscopes than the other, rates of contamination were compared between L&D/LDRP areas and Newborn Nursery areas. Intuitively, one might suspect that stethoscopes used in L&D would have higher rates of residual blood and organic buildup than stethoscopes used in the Newborn Nursery. The reason is, shortly after delivery, the infant is vigorously dried with warm towels to stimulate breathing efforts, and to minimize the effects of evaporation. Much of the fluid is wiped off prior to the infant going to the nursery to be admitted.

Contingency tables were constructed and the cells were analyzed using the Chi-square test for differences. Tables 10 and 11 provide the results. No significant difference in rates of organic buildup was found between the two areas. The nonsignificant Chi square indicates that nursery areas are just as likely to have organic buildup on their stethoscopes as L&D/LDRP areas. Although no statistical differences

were found, L&D stethoscopes did have a higher percentage of stethoscopes with organic buildup (80%) stethoscopes from Newborn Nursery (72%). The differences in percentages would seem reasonable.

Table 10. Differences between Two Maternal-Infant Areas and Organic Buildup

	Where primarily used		
Buildup	L&D	Nursery	Total
Absent	10	13	23
Present	41	33	74
Total	51	46	97

χ^2 (df = 1, N = 97) = 1.001, p = 0.3170

If stethoscopes from Nursery areas have similar rates and amounts of buildup as L&D/LDRP areas, are they also as likely to have similar rates of residual blood on the diaphragms? The results of the 2 × 2 contingency table are displayed in Table 11. This

table compares the rates of blood contamination between L&D/LDRP and Nursery areas. The results demonstrate that there is a significant association between the area in which the stethoscope is used and the rate of blood contamination. By examining the odds ratio (o = 3.97), it is estimated that stethoscopes used in the L&D area are four times as likely to have residual blood on them than stethoscopes used in nursery areas.

Table 11. Differences between Two Maternal-Infant areas and Residual Blood

	Where Used		
Residual Blood	L&D/LDRP	Nursery	Total
Negative	12 (p =.123)	25 (p =.257)	37
Positive	39 (p = .402)	21 (p =.216)	60
Total	51	46	97

χ^2 (df = 1, N = 97) = 9.892, p = 0.0018 Odds ratio (o) = 3.97 s.e.(o) = 1.76

Analysis of Study Question #5

Study question #5 asked: What are the differences in rates and proportions of organic buildup and residual blood between hospital sites? Chi-square analyses for differences between hospitals was not feasible since a large majority of the cells in the $m \times p$ contingency table had frequencies less than five. Chi-square analysis allows less than 20% of the cells to have frequencies less than five. Therefore, proportions of the stethoscopes with organic buildup and residual blood are displayed, and 95% confidence intervals were computed. As Table 12 shows, the majority of proportions ranged from .666 to .857. Most of the confidence intervals overlap, indicating the hospital sites had similar rates of organic buildup on their infant stethoscopes. Since the proportions and confidence intervals are similar, there is no reason to believe differences exist.

Table 13 shows the rates and proportions of stethoscopes found to still have residual blood on them after cleaning. When rates and proportions of stethoscopes contaminated with blood were compared between hospitals, a significant difference was found. Two hospitals had lower rates of blood contamination on their stethoscopes than nine other hospitals (sites #6 and #7).

A possible explanation for this difference is that in site #6, often times the stethoscope would not be used at delivery if the newborn infant had spontaneous respirations and demonstrated a lusty cry. Therefore stethoscopes at that site did not

come in contact with blood, amniotic fluid, and vernix as often.

The stethoscopes from site #7 were possible outliers. None of the stethoscopes from site #7 tested positive for blood, and only an occasional fleck of vernix was found on them. One of the limitations identified at the beginning of the study was the Hawthorne effect. The Hawthorne effect may have occurred at site #7. Extra cleaning efforts may have caused a lower rate of blood contamination.

Table 12.
Proportions of Organic Buildup on Infant Stethoscopes among Eleven Hospitals

Site	Number of Stethoscopes		Number with Buildup	Proportion with Buildup (P)		95% Conf. Int. $P_L \leq P \leq P_U$
1	5	$(= n_1)$	5	1.00	$(= p_1)$	$.549 \leq P \leq 1.00$
2	14	$(= n_2)$	11	.785	$(= p_2)$	$.492 \leq P \leq .953$
3	17	$(= n_3)$	12	.705	$(= p_3)$	$.440 \leq P \leq .897$
4	13	$(= n_4)$	7	.538	$(= p_4)$	$.251 \leq P \leq .808$
5	7	$(= n_5)$	6	.857	$(= p_5)$	$.421 \leq P \leq .996$
6	9	$(= n_6)$	6	.666	$(= p_6)$	$.299 \leq P \leq .925$
7	6	$(= n_7)$	5	.833	$(= p_7)$	$.359 \leq P \leq .996$
8	3	$(= n_8)$	3	1.00	$(= p_8)$	$.368 \leq P \leq 1.00$
9	11	$(= n_9)$	10	.909	$(= p_9)$	$.587 \leq P \leq .998$
10	6	$(= n_{10})$	4	.666	$(= p_{10})$	$.223 \leq P \leq .957$
11	6	$(= n_{11})$	5	.833	$(= p_{11})$	$.359 \leq P \leq .996$
	97	$(= \underline{N})$	74	.762	$(= p)$	

Table 13.
Proportions of Residual Blood on Infant Stethoscopes among Eleven Hospitals

Site	Number of Stethoscopes		Number with Blood	Proportion Positive		95% Conf. Int. $P_L \leq P \leq P_U$
1	5	$(= n_1)$	3	.600	$(= p_1)$	$.147 \leq P \leq .947$
2	14	$(= n_2)$	11	.786	$(= p_2)$	$.492 \leq P \leq .953$
3	17	$(= n_3)$	8	.470	$(= p_3)$	$.230 \leq P \leq .722$
4	13	$(= n_4)$	11	.846	$(= p_4)$	$.545 \leq P \leq .981$
5	7	$(= n_5)$	6	.857	$(= p_5)$	$.421 \leq P \leq .996$
6	9	$(= n_6)$	3	.333	$(= p_6)$	$.075 \leq P \leq .700$
7	6	$(= n_7)$	0	0.00	$(= p_7)$	$.000 \leq P \leq .459$
8	3	$(= n_8)$	3	1.00	$(= p_8)$	$.292 \leq P \leq 1.00$
9	11	$(= n_9)$	9	.818	$(= p_9)$	$.482 \leq P \leq .977$
10	6	$(= n_{10})$	2	.333	$(= p_{10})$	$.043 \leq P \leq .777$
11	6	$(= n_{11})$	4	.666	$(= p_{11})$	$.223 \leq P \leq .957$
	97	$(= \underline{N})$	60	.618 $(= p)$		

Additional Findings

Analysis of Field Notes

Qualitative, descriptive and explanatory comments were recorded about each stethoscope. Comments were recorded on general appearance, brand name (if determinable), type of disc on the diaphragm, description and placement of discoloration and amount of buildup seen on stethoscope (i.e., < ½ of ring has buildup, etc.), if the stethoscope came from an operating room used for cesarean deliveries, and shade of pink color seen on the swab. The addition of anecdotal notes validated the rating of categories, assisted with assessment of intra-rater reliability, facilitated the development of new questions for future study, and organized phenomena that were not captured from the quantitative albeit categorical portion of the study. From these notes, it was determined that:

1. When the phenolphthalein test was positive, the pink color usually appeared within 1-5 seconds. Sometimes a lighter shade of pink would take longer to appear but for the most part, when it was positive it was positive right away. The cutoff time of 45 seconds was a long time to wait to classify the stethoscope as negative for residual blood!
2. There were three basic diaphragm disc types. Namely a fibrous, cross-hatched disc seen mainly on a 7/8 inch diameter stethoscope; a clear smooth disc seen

mainly on a second type of 7/8 inch diameter stethoscope; and an opaque/translucent smooth disc used on Littman™ Infant stethoscopes which has a slightly larger diameter. The fibrous disc absorbed the fluid and one could generally see fibers that were discolored a dark red/brown.

3. At one hospital, which carried predominately Littman™ Infant stethoscopes , it was noted that several of the diaphragm discs moved when swabbed. Many stethoscopes of this brand had organic and inorganic material under the disc. Review of the company's literature on that stethoscope revealed that Littman had purposely designed a "patented movable diaphragm."
4. It was also noted that the majority of stethoscopes with exudate on the underside of the disc were the Littman™ Infant Stethoscope (with the patented movable diaphragm). This raises the question that this design feature might actually be a design flaw!
5. There were three main types of stethoscopes seen in the hospitals. Over 95% of the smaller 7/8 inch stethoscopes had organic buildup around the ring. Further investigation is needed on the role stethoscope design has on the presence of organic buildup and residual blood.
6. When the diaphragm was swabbed, the organic matter would often times come off onto the swab.

7. The organic matter on the stethoscopes varied in color from red/brown to yellow to white. Sometimes the two ends of the color spectrum were seen on the same stethoscope (i.e., the second stethoscope from site #5). The red/brown may indicate frank blood, while the yellow color may indicate old dried vernix, and the white may indicate fresh vernix.
8. The higher the concentration of blood, the brighter the pink seen on the swab. This phenomenon was first noted with repeated Sensitivity testing. The consultant forensic serologist was contacted and he verified these findings.
9. The quickest time a swab turned positive was one second and gave a bright pink color. The longest time a swab turned positive was 30 seconds with a light pink color. Further examination of the data revealed that the bright pink spots appeared quickly within one to two seconds. Swabs with a light pink color took longer to appear. The average time for a pink color to appear was six seconds, with a median of three seconds, and a mode of two seconds.
10. Further examination of the data revealed that stethoscopes used in operating rooms for cesarean births ($\underline{n} = 9$) had a very high proportion positive for residual blood (8 / 9). Similar rates and proportions were noted for the presence of organic matter (8 / 9). More data is needed however to analyze this phenomenon effectively.

Summary of Findings

Using a two group post hoc non-experimental design, the incidence of body fluid contamination on stethoscopes used in maternal-infant areas was investigated, and determined to be a problem despite relative differences in urban and metropolitan settings. Over three-quarters of all stethoscopes tested were positive for organic buildup. Almost two thirds of all stethoscopes were positive for residual blood. A dependent association was found between the presence of organic buildup and the presence of residual blood on the stethoscopes . Nursery areas are just as likely to have similar rates and proportions of organic buildup on their stethoscopes, but are less likely to have residual blood on their stethoscopes. No difference in rates and proportions of organic buildup was found between the eleven hospital sites. However, two of the eleven hospitals did have significantly less residual blood found on their stethoscopes. Patterns of bloodstain distribution were not determined since the luminol reacted with the metal on the stethoscope. Of the three basic types of stethoscopes consistently seen in maternal-infant areas, two types may have design flaws. From the qualitative field notes taken during all phases of the testing, several interesting patterns emerged which have either provided possible explanations for results or posed new questions for further research.

CHAPTER 5

Summary of the Study

Stethoscopes used in Labor and Delivery, and Nursery areas were studied to determine the prevalence of blood and body fluid contamination on what were generally believed to be clean stethoscopes. Stethoscopes from these two areas come in direct contact with body fluids frequently. Using a non-probability sampling technique, eleven hospitals from three states in the southwest served as data collection sites. Due to the nature of the phenomenon studied, and to the instruments chosen to measure the construct, three possible limitations were identified for this study. They included the Hawthorne effect, instrumentation, and construct validity. Controls to minimize these effects were built into the study, however one hospital possibly had a Hawthorne effect. Stethoscopes from this hospital did not have any residual blood on the diaphragm than the other ten sites. This phenomenon and the effect it had on the outcomes of the study are reviewed in the discussion section below.

The incidence of organic buildup and residual blood on infant stethoscopes was documented. Additionally, relationships were examined between organic buildup, residual blood, and the primary area of usage. Differences in rates and proportions of stethoscope contamination between the two areas and between hospital sites were also investigated. An attempt at identification of patterns of bloodstain distribution on

stethoscopes was done using a chemoluminescent agent. However during a pilot, false positive results pointed to problems with construct validity, and this part of the study was suspended.

A discussion of the findings and conclusions based on the discussion are presented. As with any study, *a priori* questions are answered, *a posteriori* questions also surfaced. In light of these new questions, recommendations for further study of the phenomenon are supplied.

Discussion of Findings

Although there were numerous studies in the literature investigating bacterial contamination of stethoscopes, no previous studies related to blood and body fluid contamination of stethoscopes was found. Studies on bacterial contamination of stethoscopes provide similar findings. The majority of studies reviewed in Chapter 2 documented the ability of stethoscopes to harbor and transmit pathogenic bacteria. However, the studies also demonstrated that simple cleaning with alcohol or other appropriate germicidal significantly reduces the bacterial load of the stethoscopes.

Because of the contribution the theory of germ transference has made to the understanding of fomite transfer, health care professionals now know that pathogenic organisms are spread via direct contact with contaminated vessels. This study has documented that between 72% to 80% of stethoscopes used in maternal-infant areas are contaminated with blood and other body fluids. Therefore, stethoscopes can become

potential hosts to body fluid once thought to be harmless but now is known to carry lethal pathogens.

The findings also suggest that stethoscope contamination in maternal-infant areas may be widespread. All of the hospitals tested had similar rates of organic buildup and most of the hospitals had similar rates of residual blood.

It seems cogent to discuss the results in view of a possible Hawthorne effect in one hospital. At the onset of the study, this limitation was identified as a possible threat, and steps were taken to control for this. However, the results of hospital site #7 suggest this phenomenon may still have occurred at that site despite valiant efforts to control for it. None of the six stethoscopes from site #7 tested positive for blood. At other sites included in this study, observed frequencies of stethoscopes positive for blood ranged from one third to four-fifths of all stethoscopes. Expected frequencies for blood contamination at site #7 should have been at least two of the six stethoscopes positive for blood.

Additionally, all six stethoscopes from site #7 had very little to no organic matter seen on the diaphragm disc. When questioned about cleaning methods, site #7 used similar methods as compared to other hospitals. They wiped the stethoscopes off with alcohol swabs. If methods for cleaning are similar, and the type and amount of blood and body fluids on newborns is a constant variable, then they may have cleaned to stethoscopes well prior to my coming. The inclusion of these outliers did not

significantly change the percentage of stethoscopes contaminated with vernix and amniotic fluid. However, it did significantly change the rates of residual blood found on the stethoscopes. By including this site, the overall residual blood rate dropped from 66% down to 62% . Now that observed frequencies and proportions are documented, results of future studies will allow comparison of expected frequencies against obtained frequencies to determine if the Hawthorne effect has occurred.

Conclusions and Implications for Nursing

Based on the findings of this study, it can be concluded that stethoscope contamination with blood and other body fluids was a problem in the eleven hospitals visited. Over three-quarters of the stethoscopes tested had visible organic buildup and almost two-thirds of the stethoscopes had detectable amounts of blood left on them from previous deliveries. Many maternal-infant nurses realize that stethoscopes are exposed to blood and body fluids on a daily basis. However, they also believe that simple wiping with an alcohol pad, or spraying with a germicidal and wiping with a cloth are effective methods of cleaning the stethoscopes. These findings indicate that maternal-infant nurses are not effectively cleaning the stethoscopes and cleaning methods may need to be changed.

It was also determined that organic matter increases the likelihood of finding residual blood on the stethoscope. However, the influence is not as strong as was suspected—there were several stethoscopes that looked perfectly clean (no buildup on

them) and yet they were positive for blood. Apparently visual inspection of the stethoscope for organic material is not sufficient grounds for determining if blood is present on the stethoscope or not.

It can also be concluded that nursery areas have similar problems with stethoscope contamination as Labor & Delivery areas. The rates of organic buildup between the two areas was similar. Nursery areas did have lower rates of residual blood found on their stethoscopes. Drying of the newborn infant at delivery appears to be effective in removing some of the blood found on the infant however it does not effectively remove the vernix from the skin. Since the late 1980s, it has been recommended practice to wear protective gloves when handling all newborns until they have had the initial bath. The results of this study underscore the importance of wearing gloves while handling unbathed newborns. If vernix and blood could rub off on to stethoscopes, then it is possible that blood and vernix can rub off on to hands of health care workers.

In light of the above conclusions, implications for nursing practice include detailed and meticulous attention to cleaning of the surface and the crevasses of the stethoscope in order to decrease the amount of exudate that remains on the stethoscope. They must also realize that all blood and body fluids are potentially contaminated and must treat any piece of equipment with residual blood and organic material as contaminated.

In a broader scope, these findings imply the need for exercise of care for nurses and health care workers in other areas where stethoscopes also may become contaminated with blood and body fluids. Implications for nursing education include incorporating information and principles gained from this study and enlarge the scope to include other areas. All stethoscopes that come in direct contact should be investigated for residual material.

Implications for nursing research are discussed in detail below. Many of the questions and areas of research posed in the next section would be best answered using a multidisciplinary approach. Nurses in consultation with other scientists could answer some very important questions. As funding becomes more difficult to obtain, and research proposals become more sophisticated, nurses need to look for opportunities for teamwork and team building.

Recommendations for Future Study

Due to the evolving and revolving nature of research, using an inductive approach such this has led to the generation of more ideas for research in which a deductive or retroductive approach would better serve to answer new questions. Since a large percentage of stethoscopes appear to be contaminated with blood, vernix and other organic matter in the crevasses of them, one important question that needs to be answered is what effect does this admixture of organic material have on the life of an HIV virus outside the host. Does the presence of several enriched mediums (amniotic fluid, blood,

meconium) plus a moisture retaining medium (vernix caseosa) allow viruses to survive for longer periods outside the host? Researchers now know that certain viruses such as HIV virus, and sexually transmitted organisms are inactivated when dried. Hepatitis viruses can survive for weeks on fomites. Does the moisturizing and nutrient rich medium allow these potential lethal viruses and other organisms to survive even longer? This research would best be served by a multidisciplinary team of expert nurses, microbiologists, pathologists, virologists, and physicians.

Although the findings of this study are believable, replication is needed prior to recommending a change in practice on a national level. Since the sampling was non-probability, replication should include probability sampling techniques. This sample may have been biased—although the widespread geographical area, and the mix of hospitals coming from differing urban and metropolitan areas decreased the possibility attempted to decrease the possibility. A change in practice is needed, however one study is not sufficient evidence to support that change, nor provide interventions to eliminate organic buildup and residual blood from stethoscopes.

The addition of field notes was extremely helpful. New themes and future research questions emerged. Firstly, two of the three main types of stethoscopes seen in maternal-infant areas possibly have design flaws. Investigation of stethoscope design type would add another dimension to the knowledge base on stethoscope contamination. Which stethoscope design had the least amount of buildup and blood found on the

stethoscopes? What are the main design features of each stethoscope? What features contribute to stethoscope contamination and which features inhibit the buildup and subsequent residual blood from occurring? Which type of diaphragm disc is better for use in areas with frequent exposure to blood and body fluids? After multiple uses, does one disc type increase the chances of buildup adhering to the disc than another? With one particular disc, discoloration (a brown/reddish color) in the middle of the disc was often noted. This raises the question of permeability potential of discs—do they change over time? Are worn out discs more permeable or absorb more body fluids than new ones? How often should discs be changed?

It is very important to determine the potential presence of blood on stethoscopes. The instrument chosen to measure residual blood would probably not be a viable option for ongoing quality control efforts in a hospital. The phenolphthalein indicator was chosen to measure residual blood for it's reported sensitivity in detecting blood on surfaces, and it's reported specificity—false positives and false negatives are rare with this test. The phenolphthalein solution was also chosen because of it's stability once it is mixed up. The solution is able to be stored for one to two years in a refrigerated place. However, there are several steps required with the phenolphthalein test, and hospitals may not want to use this method for quality control management. A simpler method such as using commercially prepared urine dipsticks could be tested against the criterion (phenolphthalein) to compare performances in both measures. A commercially prepared

urine dipstick would be much easier to implement for monitoring purposes. However, they do not currently recommend the dipstick for use on anything but blood detection in urine (even though many forensic serologists use these dipsticks in the field). Criterion-related validity could be established with this possible measure.

Replication of this study in other areas of the hospital might also provide clues in to contamination of stethoscopes with blood and other body fluids. Do emergency rooms, burn units, and ambulance providers also have problems with this type of contamination? Information regarding these areas would be an important addition to the growing body of literature on stethoscope contamination.

Now that stethoscope contamination is suspected, and cleaning methods are not effective, future studies can also concentrate on interventions to ameliorate this phenomenon. One possible intervention is to use disposable stethoscope coverlets when exposure to gross amounts of blood and body fluids (such as we have in delivery of an infant) is anticipated. However, if the coverlet attenuates the sound transmissal capability, and decreases the signal reaching the auditory canal, then the coverlet would fix one problem and create another. Experiments using different designs and materials for the coverlet are needed before this intervention can be used in the clinical setting. The principle investigator began working on a prototype coverlet and is in the planning stages of a new research project utilizing this intervention.

Replication of the construct of stethoscope contamination is needed while enlarging the sphere of variables studied. As usual, investigation of a particular phenomenon cannot be completed in one study. Several more projects are necessary to complete the picture emerging on this canvass.

Conclusions

From these results, it appears that routine cleaning methods are not an effective means of cleaning for stethoscopes habitually exposed to gross amounts of blood, amniotic fluid, vernix, and other body fluids associated with delivery of an infant. Re-evaluation of equipment commonly contaminated with blood and body fluids is a necessary function in today's society where universal precautions are observed on all patients. Nurses must be aware of the potential cross contamination of an infected infant to another since the infant stethoscopes come into contact with newly born infants covered with this special admixture. All of these body fluids can transmit lethal organisms given the right circumstances. Ineffective cleaning techniques, coupled with an increase in pathogenic organisms that survive for weeks on non-organic material may present a potentially serious problem in the health care field.

The findings of this study indicate attention must be re-directed to environmental pathogens and the potential spread of disease. Nurses have played a pivotal role in the identification and eradication of environmental diseases. This study sheds light on to one more aspect of the ongoing problem of the contamination of the environment.

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Appendix A
Letter of Access to Institutions

Date

Nurse Manager, Maternal-Infant Areas
Hospital

Dear Nurse Manager:

Thank you for taking my call the other day. As I explained over the phone, I am a doctoral student in the College of Nursing, Texas Woman's University. I am following up our conversation with this introductory letter and the proposal. I am writing to request permission to collect data at your institution that will be used in my dissertation. The study is entitled *"Residual Blood and Organic Build-up on Infant Stethoscopes used in Maternal-infant Areas."*

Generally, the data collection on the nursery and L&D units usually lasts a couple of hours, depending on the number and accessibility of the stethoscopes in the two areas. I will not need nursing personnel to assist me other than point to where the stethoscopes are kept. I would hope that you continue cleaning the stethoscopes in your usual fashion—that no special treatment is given them in anticipation of my coming.

As you can see by the proposal, *no human subjects will be used for this study*. The study focuses on possible contamination of blood born pathogens on a common piece of diagnostic equipment. I will be very happy to present my findings of this study at the conclusion of the data collection phase. I will be conducting the study at several locations, and can tailor the findings to your specific institution and compare them with other institutions if the committee wishes.

Below is the name, and business phone of the faculty sponsor. If you have any questions, you may reach her during daytime hours at the phone number below. You may also contact me by telephone at (405) 255-7127, or by writing at: 4550 Odom Dr, Duncan, OK 73533. Thank you for considering this proposal.

Sincerely,

Jan M. Nick

Jan M. Nick, M. S., R.N.C.
Doctoral student, TWU

Joanette McGadney, Ph.D., R.N.
Faculty Sponsor
Texas Woman's University--Dallas
College of Nursing
(214) 689-6512

Appendix B
Agency Permission for Conducting Study

TEXAS WOMAN'S UNIVERSITY
COLLEGE OF NURSING

AGENCY PERMISSION FOR CONDUCTING STUDY*

THE _____

GRANTS TO _____

a student enrolled in a program of nursing leading to a Doctoral Degree at Texas Woman's University, the privilege of its facilities in order to study the following problem:

The conditions mutually agreed upon are as follows:

1. The agency (may) (may not) be identified in the final report.
2. The names of consultative or administrative personnel in the agency (may) (may not) be identified in the final report.
3. The agency (wants) (does not want) a conference with the student when the report is completed.
4. The agency is (willing) (unwilling) to allow the completed report to be circulated through interlibrary loan.
5. Other _____

_____

_____

Date: _____

_____
Signature of Agency Personnel

_____
Signature of Student

_____
Signature of Faculty Advisor

**Fill out and sign three copies to be distributed as follows: Original—Student; First copy—Agency; Second copy—TWU College of Nursing.*

Appendix C
Determination of Effect Size Index

Determination of Effect Size Index

When alpha (α), power (1- β), and effect size (ES) are known, the minimum sample size can be determined *a priori*. Determination of the minimum sample size *a priori* is important in order to provide the proper level of power to the statistical test used for analysis. Power is defined as the ability to detect a significance when a true association exists, or the ability to correctly reject or correctly fail to reject. Computationally, power is written as 1 - beta (β). Convention usually calls for beta (β) to be set at .20 (Cohen, 1965, pp. 98, 99). The four parameters, α, power, ES, and N are so interrelated that any one of them is a function of the other three parameters (Cohen, 1988, p. 14). In other words, if any three parameters are known, the fourth can be determined by completing a few simple calculations.

For this study, alpha (α) was set at .05; beta (β) was set at .20 in order to provide power at .80, and the calculated effect size (ω) was .30 . The effect size was calculated based on the results from the unpublished pilot study completed in the Fall of 1995. Table 14 shows the frequencies of organic buildup and residual blood from the pilot study from which the effect size was calculated. Once α, β, and ω are known, sample size tables were used to determine the minimum sample size needed a priori that would provide a power of .80.

Table 14.

Association between Residual Blood and Organic Buildup from Pilot Study

Buildup	Positive	Negative	Total
Present	22	7	29
Absent	5	7	12
Total	27	14	41

χ^2 (df = 1, N = 41) = 4.29, p = 0.038

From these results, proportions P_1 and P_0 can be computed and used in the formula and examples of computation of the ES index provided by Cohen (1988) on pages 216-227. The proportions used in calculation of effect size, based on the frequencies in Table 14, are found in Tables 15 and 16.

Table 15. P_1 (Association exists) Values in a Joint Distribution of Buildup and Residual Blood on Stethoscopes used in Maternal-infant Areas

Buildup	Positive	Negative	Buildup marginal
Present	.54	.17	.71
Absent	.12	.17	.29
Residual Blood marginal	.66	.34	1.00

Table 16.

P_0 (No Association) Values in a Joint Distribution of Buildup and Residual Blood on Stethoscopes used in Maternal-infant Areas

Buildup	Positive	Negative	Buildup marginal
Present	.47	.24	.71
Absent	.19	.10	.29
Residual Blood marginal	.66	.34	1.00

Note: P_0 values for each cell are determined by multiplying row marginals by column marginals of Table 15, then adding up new cells to determine new marginals.

Cohen's formula for calculating effect size index (ω) for Chi-square Tests is:

$$\omega = \sqrt{\sum_{i=1}^{m} \frac{(P_{1i} - P_{0i})^2}{P_{0i}}}$$

$$\omega = \sqrt{\frac{(.54-.47)^2}{.47} + \frac{(.17-.24)^2}{.24} + \frac{(.12-.19)^2}{.19} + \frac{(.17-.10)^2}{.10}}$$

$$\omega = \sqrt{.0104+.0204+.0257+.049}$$

$$\omega = \sqrt{.1055}$$

$$\omega = .325$$

Appendix D
Phenolphthalein Test

Preparation and Use of Phenolphthalein Presumptive Test Reagent

This oxidative test for the presumptive identification of blood is based on the catalytic activity of the heme group of hemoglobin.

Materials:

1. Phenolphthalein granules
2. Sodium or Potassium Hydroxide
3. Zinc granules
4. Distilled water
5. Glass boiling beads
6. Ethanol, 95% solution
7. 3% Hydrogen peroxide
8. Cotton applicator swabs
9. Three dark glass bottles with droppers, to use in the field

Reagent Preparation:

1. Place 2 gm phenolphthalein, 20 gm NaOH or KOH, 20 gm zinc granules and 100 ml distilled water in a 500 ml round bottomed flask. Secure to reflux apparatus. This solution is 2% phenolphthalin.
2. Reflux solution 2-4 hours or until resulting solution is colorless. This reduces phenolphthalein to phenolphthalin.
3. Store stock solution refrigerated in an amber container. Add some zinc granules.
4. Prepare a working solution of 5 ml phenolphthalin solution plus 20 ml ethanol for a ratio of 1:5.
5. Store working solution in the refrigerator in an amber container with zinc granules when not in use.

Procedure:

1. Sample the questioned area by lightly rubbing with a cotton swab moistened with a single drop of distilled water.
2. Add a single drop of the phenolphthalin working solution to the swab. Observe to detect any oxidative contaminants which may be present.
3. Add a single drop of 3% hydrogen peroxide (H_2O_2) and observe carefully for any pink color which usually develops within 10 to 15 seconds. Any pink color after the application of H_2O_2 indicates the presence of the blood.

Interpretation:

1. Appearance of the distinct pink color on the swab is indicative of, but not

proof positive of the presence of blood. A pink color forming after one minute should not be considered as a positive result, as auto-oxidation can occur in air and light.

2. The test as set forth will routinely detect whole blood diluted 1:1000.
3. Prior to use on questioned stains in casework, the working solution should be tested against both positive and negative controls.
4. A personal determination of the specificity of the reagent is recommended, using such materials as blood, semen, saliva, perspiration and a variety of vegetable materials, including horseradish.

This procedure was taken from the Procedure Manual of the Oklahoma State Bureau of Investigations, Lawton, OK. The procedure is a modification of that given in Camps, F. E. (Ed.). (1968). Gradwohl's Legal Medicine. Baltimore: Williams and Wilkins Company.

Specificity Test of the Phenolphthalein Test for Residual Blood

	20 seconds		45 seconds	
Blood	Neg	Pos	Neg	Pos
Saliva	Neg	Pos	Neg	Pos
Perspiration	Neg	Pos	Neg	Pos
Horseradish	Neg	Pos	Neg	Pos
Potato	Neg	Pos	Neg	Pos
Carrot	Neg	Pos	Neg	Pos
Germicidals:				
Alcohol	Neg	Pos	Neg	Pos
Sparquart	Neg	Pos	Neg	Pos
Wexcide	Neg	Pos	Neg	Pos
Hypochlorite	Neg	Pos	Neg	Pos
Septisol	Neg	Pos	Neg	Pos
Lysol	Neg	Pos	Neg	Pos
TOR	Neg	Pos	Neg	Pos
Controls:				
Disc (clear)	Neg	Pos	Neg	Pos
Disc (Opaque)	Neg	Pos	Neg	Pos
Metal ring	Neg	Pos	Neg	Pos
Latex glove	Neg	Pos	Neg	Pos
Cotton swab w/o water	Neg	Pos	Neg	Pos
Swab w/ distilled water	Neg	Pos	Neg	Pos

Appendix E
Luminol Test

Preparation and Use of Luminol Presumptive Test Reagent

Principle: Hemoglobin enhancement of luminol luminescence subsequent to its alkaline oxidation provides a procedure for the presumptive identification of blood.

Materials:

1. Luminol, 5-amino-2, 3-Dihydro-1, 4-Phthalazinedione
2. Sodium Perborate
3. Sodium Carbonate
4. Distilled water
5. 3% Hydrogen peroxide

Note: Luminol is also referred to as 3-aminophthalhydrazide.

Reagent Preparation:

1. In a glass or plastic (non-metallic) container, dissolve 0.1 gm luminol and 5.0 gm sodium carbonate in 100 ml of distilled water. (This solution is 0.1% luminol).
2. Immediately prior to use, add 0.7 gm sodium perborate to the above solution.
3. An alternative reagent which has proven effective may be prepared as follows: Dissolve 0.1 gm luminol and 5.0 gm sodium carbonate in 90 ml distilled water and add 10 ml 3% hyrdogen peroxide immediately prior to use.

Procedure:

1. Using a spray bottle, mist the above mixture over areas where blood is suspected. Since optimum visibility of the reaction requires total darkness, the area should be darkened immediately after misting. In situations where luminescence is short-lived, re-spraying may be helpful.
2. The use of a copper penny and a swabbing of a known bloodstain as positive controls are recommended.
3. As soon as the luminescence is observed, the area should be photographed and marked to facilitate later observations and or sample collection.
4. One of the most common applications of the reagent is by spraying or misting areas where blood is suspected but not seen. An alternative procedure would employ swabbing a suspected area with a moistened cotton swab and misting the swab with the reagent or testing with a single drop of the reagent applied from a dropper bottle.

Interpretation:

1. This is not a replacement for the phenolphthalein test which is the primary blood identification test.

2. Use of luminol is recommended where blood is suspected but not visible. When stains are visible, alternative sampling/screening methods should be employed. Application of luminol to a stain will adversely affect subsequent analysis of blood enzymes (in-house study) although serum proteins may be detected. It is a destructive reagent.
3. Luminescence (blue-white) indicates as positive result and should be observed almost immediately (within three to five seconds), provided that the area is darkened immediately after reagent application. Ambient lighting makes this observation impossible. Duration of luminescence will depend on the quantity of blood present and may last as long as one to two minutes.
4. Metallic contaminants such as iron (rust) and copper or copper alloys will give false positive reactions.
5. Luminol is classified as a moderately toxic reagent (Class III). While the concentration and frequency of application may not suggest drastic safeguards, the reagent should be used in a well ventilated area and frequent breaks for fresh air should be routine.

Appendix F
Demographic Survey of Institutions

Demographic Survey of the Institutions

Hospital Site: _____ Number assigned: _____

(1) Public (2) Private

Type of cleaning solution used
(1) Hypochlorites (2) Alcohols (3) Gluteraldehydes (4) Phenolics (5) Soaps

Does the unit have a written policy about how to clean stethoscopes? Yes No

#babies born per year in L&D _____

#stethoscopes on L&D/LDRP unit _____

stethoscopes on Nursery unit _____

Who is responsible for cleaning the stethoscopes after delivery?
(1) licensed (2) unlicensed (3) both