

Introduction of New Theory for Hand Hygiene Surveillance: Healthcare Environment Theory

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Background and Purpose: The purpose of this article is to introduce a theoretical foundation, the healthcare environment theory (HET), tested in a quantitative, cross-sectional, overt observational study measuring the association of demographic variables with consistent hand hygiene compliance of the ICU nurse. **Methods:** Six environments found in a hospital ICU setting (family, church, work, administration, community, and culture) work bi-directionally to influence and be influenced by the nurse, simultaneously influencing each of the other environments in a multidirectional manner. The HET was used as the theoretical foundation for a study, which included a convenience sample of registered nurses (RNs) from five ICUs (64 participating RNs) in four hospitals in Texas who were observed for a total of 18 days (144 hours). The desired sample size of 613 hand hygiene opportunities for each ICU was obtained in 3 days of observation at 3 ICUs, 4 days in one ICU, and 5 days in one ICU. The six environments were used to support the results observed. **Results:** Through the variables of age and having children, hand hygiene rates were influenced by the family environment. Community environment was associated with a change in hand hygiene behavior in hospital hand hygiene rates in regards to age of the nurse. Younger nurses had higher hand hygiene compliance rates than older nurses. **Implications for Practice:** The different hospital environments surrounding the nurse can be used to explain hand hygiene compliance rates in association with demographic variables.

Keywords: theory; environments; theoretical foundation; hand hygiene; hospital settings

The healthcare environment theory (HET) was developed because currently there are no theories available specifically for hand hygiene studies or for the infection control practitioner to use in infection control studies. Consisting of six environments found in an ICU setting (family, church, work, administration, community, and culture), each environment influences and is influenced by the ICU nurse. Simultaneously, each of the environments influences all of the other environments multidirectionally.

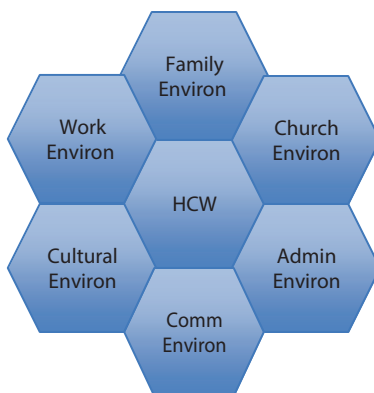


Figure 1. Proposed healthcare environment theory. *Note:* HCW = health care worker; Family Environment = personal family, hospital unit family; Church Environment = personal beliefs, church affiliation of hospital, religious influence, ethics, spiritual affiliation; Administrative Environment = policies, guidelines; Community Environment = friends, extended family, school, public health; Cultural Environment = culture of health care worker, diversity of culture at work, work culture (beliefs, attitudes, perceptions) of unit and of hospital, patient safety culture; Work Environment = lifetime experiences, workload, attitudes.

During the search for a foundational theory for a dissertation study, an article by Pittet (2004) advocated the ecological systems theory for explaining behavioral modifications in healthcare settings. Since changing hand hygiene behavior was the ultimate goal of the study, further investigation was pursued. The ecological systems theory was developed in the 1970s by Urie Bronfenbrenner as a theoretical foundation to explain behavior among children (Bronfenbrenner, 1994; Lang, 2015). After reviewing Bronfenbrenner's work, his five environments were slightly modified to fit the ICU setting in a hospital. During this conceptualization time, teachings of a college professor, Dusty Troyer, were again remembered. Predating Bronfenbrenner's work, Troyer used four environments (family, church, work, and government) in a square with the person placed in the center influencing and being influenced by the other environments and with each of the four environments influencing each other. What began as a transformation of Bronfenbrenner's five environments to fit the hospital setting, began to merge with Troyer's work, and from the combination of these two works, a metamorphosis produced the HET. The HET became the theoretical foundation for the dissertation study involving the association of 15 demographic variables in the hand hygiene adherence among the ICU nurses (See Figure 1, Kurtz, 2017a). Because this was a newly developed theory and untested, the systems thinking theory developed in the 1940s by Karl Ludwig von Bertalanffy (Mitchell, 2015; Zborowsky & Kreitzer, 2009) was used as a supportive theory.

Researchers exploring hand hygiene behavior have frequently looked for guidance in the health belief model (Ghanbari, Farzi, Shamsi, Khorsandi, & Esharti, 2014), the theory of planned behavior (Al-Tawfiq & Pittet, 2013; White et al., 2015), and

theoretical domains theory (Debono et al., 2017). While these theories are commonly used, it was felt these theories had certain deficiencies making them not useful in the proposed dissertation study. In the theory of planned behavior, Skinner and Champion suggest that the correlation between desired behavior and an immediate reward is sufficient to generate a repeated change in behavior and that a person must feel susceptible to a risk (e.g., self-infection) in order to modify their behavior (Champion & Skinner, 2008). However, there is no immediate reward for the healthcare worker (HCW) with regard to changing their hand hygiene behavior. Participating in hand hygiene does not give the nurse an opportunity *to see* whether the patient remains uninfected because of hand hygiene adherence or that the patient does get an infection because of non-adherence. Usually, there is no consequence, personally or professionally, for not participating in handwashing in the HCW (Rodak, 2013). Indeed, through countless episodes of non-hand hygiene compliance, the HCW often remains healthy and uninfected. With multiple personnel caring for a patient each day, if an infection does occur, the HCW responsible for the transmission remains unknown, so personal responsibility is diluted or avoided.

Since only aggregated hand hygiene rates are usually reported, individual hand hygiene rates are lost. With low hand hygiene compliance rates reported in studies, it would appear that HCWs either have no fear of self-infection or simply ignore the risk. This is somewhat evident in that high-risk procedures usually have lower rates of adherence (Pittet, 2001; Sharma, Sharma, Puri, & Whig, 2011). Further, the difference between self-perceived and self-reported rates is measured either through objective direct or through covert second-party observation. When they believe that their own rates of compliance are high, HCWs see no justification for altering their behavior.

Pittet (2004) felt that the rationale for using the ecological systems theory was the importance of using multidimensional interventions to increase hand hygiene. Many current studies advocate using multimodal interventions to improve the hand hygiene rates of HCWs (Allegranzi, 2017; Watson, 2016). Looking at the interplay of the six environments in the ICU setting and how each affects the ICU nurse gives clarification as to why simultaneous multidimensional interventions are needed to engage the full attention of the nurse and to affect permanent hand hygiene behavioral change.

To understand the benefits of simultaneous multiple interventions, it will be necessary to formulate an associated theory that can explain all of the components that affect the HCW. Since the environments examined here already exist as an integral part of the hand hygiene behavior of the nurse, it is possible to create new interventions that work within existing environments.

The systems thinking theory was focused on relationships (the nurses) and arrangements of the parts (environments) that bind them into a whole and how the different parts relate to each other. Using support from Troyer's model, the environments are bound by the multidirectional influence that connects the ICU nurse and all six of the environments of the HET.

In considering the association of age on hand hygiene rates, it is important to look back into the 1970s and what was transpiring in the healthcare industry at

that time. The reason for this influence of age is felt to be an association with the community environment. During the 1970s, hospitals were beginning to feel the financial pressure placed on them by the medical malpractice insurance crisis. To reduce mounting costs, risk management programs (American Society for Healthcare Risk Management, n.d) were established. Coinciding with this was the growing emphasis by The Joint Commission on the reduction of healthcare-associated infections by increasing hand hygiene compliance rates (The Joint Commission, 2007). Infection prevention guidelines were published by the Centers for Disease Control and Prevention (CDC, 1986; Williams, 1983). In 1988, the CDC published two articles concerning nosocomial infections and criteria for surveillance purposes (Kouchak & Askarian, 2012). The Association for Professionals in Infection Control and Epidemiology, Inc. issued guidelines for handwashing and hand antisepsis in healthcare settings in 1995 (Larson, 1995). Now known as the National Healthcare Safety Network, the National Nosocomial Infection Surveillance (NNIS) database was established in 1970 and nosocomial infection rates were first published beginning in 1992 (CDC, 1986). HIV was also emerging and the rise in multidrug-resistant organisms was becoming a concern. Nursing schools and medical schools responded with increased emphasis on hand hygiene, wearing gloves for certain procedures, and the prevention of infections. Not only was there greater emphasis on hand hygiene in the hospitals but also in the community at large. During these years, children in their formative years of 1–10 were receiving more instructions from their moms to participate in hand hygiene (Niffenegger, 1997; Whitby, McLaws, & Ross, 2006).

EXPLANATION OF THE SIX ENVIRONMENTS OF THE HET

Bronfenbrenner's five environments of microsystem, mesosystem, exosystem, macrosystem, and chronosystem, along with Troyer's four environments of family, church, government, and work, evolved into the six environments of the HET. It seems more appropriate to use environment names that actually are representative of the environment. Bronfenbrenner's microsystem evolved into the family environment, while the mesosystem evolved into the work environment. Troyer also advocated the use of these two environments but the HET moves these two environments into the hospital setting and while the two are exerting influence along with the other environments, they are two separate environments.

The family environment not only represents the RN's own personal family but also the work family. The marital status of the nurse and whether or not they are a parent are influencing factors stemming from the personal family. A supportive spouse at home eases the stress and heavy workloads found in the ICUs. ICU nurses work under very intense and stressful conditions, forming a bond enabling support and cooperation between nurses to flow freely. A close-knit unit will generate a high level of teamwork with a strong sense of teamwork lending support to each nurse during times of a heavy workload and high-stress situations such as code blues. Certain situations in the hospital, such as a code blue or a

patient at risk of fall attempting to get out of bed, make it difficult to achieve hand hygiene rates of 100%. It is during these times that saving the patient from dying or falling becomes the rewarded behavior while there is no consequence for not participating in hand hygiene. The patient safety culture of the hospital, especially if there is a tolerance of low hand hygiene rates, has been related to the emphasis the chief executive and administrative department place on hand hygiene and its importance, all of which influences the work culture as well (McLaws & Sax, 2017; Whitby et al., 2007).

The work environment is the actual ICU setting itself but is enlarged with the addition of all of the departments the nurses interact with on a daily basis in order to care for patients. Work environment affects the family culture through the number of shifts worked, shift hours, working weekdays or weekends, stress carried between the ICU and the home, and the need for childcare while the parent is at work. The work culture also interacts with the cultural environment of the unit. Service systems, network linkages (the infamous *grapevine*), political forces and the policies of the hospital, the unit worked, cultural forces, the unit work culture, the culture of patient safety at the hospital, social forces, social work values, roles played by the nurses, and professional issues such as position held (e.g., staff nurse, charge nurse, or supervisor) all play interacting roles in hand hygiene habits. The work environment also involves interactions between the nurse, the physician, and other HCWs when developing the patient's care plan. Peer attitude also influences the work environment and the hand hygiene rates (Jimmieson et al., 2016; Pittet, Boyce, & Allegranzi, 2017; Whitby et al., 2007). The work environment directly affects the hand hygiene rates of nurses. Literature reports that an increased workload leads to decreased hand hygiene rates (Dai, Milkman, Hofmann, & Staats, 2015; Pittet, 2001, 2004).

The community environment of the HET is not found in either Bronfenbrenner's work or in Troyer's model. While it may be argued that the community environment is not a part of the hospital setting, there is strong literature support that the community culture is closely intertwined with hospital culture and vice versa. The hand hygiene rates in one environment will influence the hand hygiene rates in the other (McLaws & Sax, 2017; Whitby et al., 2006). Whitby et al. (2007) showed hand hygiene behavior differs on different hospital units and among different groups of HCWs, suggesting that the individual and the community each influence hand hygiene. Behaviors are transferred between the ICU and the community (McLaws & Sax, 2017; Whitby et al., 2007). Friends, extended family, school (including higher education in nursing and medical schools), public health, and outbreaks both in the community and in hospitals are all factors affecting the community environment, which is related to the hand hygiene behavior of the nurse (Whitby et al., 2007).

Patients are also brought into the hospital from the community and discharged back into the community, sometimes discharged with infections increasing the risk of cross contamination among community members which includes nurses (CDC, 2016; Donker, Wallinga, Slack, & Grundmann, 2012). During a disease outbreak in the community, patients may be hospitalized. Likewise, a nosocomial outbreak in

the hospital may generate patients who are discharged back into the community colonized or still with active infection.

Bronfenbrenner's exosystem and Troyer's government environment became the administrative environment of the HET. The government and administrative environments involve the person being influenced but that person is usually not a part of the decision-making process. A person (nurse in the community) is influenced by local, state, and federal regulations. Although each person has the right to vote, their one individual vote seldom is the deciding factor for a given law or regulation. Likewise in the hospital, the administrative department sets policy and regulations but the nurse does not usually have a say in this. There is no choice given to the nurse whether or not he or she wants to participate in hand hygiene. The policy will call for 100% compliance of hand hygiene behavior 100% of the time by 100% of all HCWs. The administrative leaders in the hospital will include the unit managerial staff, the vice president in charge of patient care, the chief nursing officer responsible for the oversight of all nursing personal, and the chief executive officer of the hospital.

In the HET, the culture environment replaces the macrosystem of Bronfenbrenner. There are many cultures represented in the ICU setting. Each nurse has his/her own individual culture or ancestry. The cultural environment of the unit will be influenced by the ethnicities of all of the HCWs on that unit, their religious beliefs, the teamwork practices of the unit, and by the blending of all of these individual cultures into a unit culture. Added to this is a hospital culture, which is set by the CEO and administrative offices. The hospital culture affects the hand hygiene behavior of all HCWs because the hand hygiene compliance and infection rates are what a CEO and the administrative will tolerate (Jimmieson et al., 2016).

All of the unit cultures and the influence of the administrative environment combine to form the hospital patient safety culture (Pellegrini, 2017; Sammer & James, 2011). The cultural environment is also influenced by whether or not the hospital is church or faith affiliated, whether or not the hospital is for profit, and whether it is a private hospital or a community hospital supported by community funds. Also involved with the cultural environment are the invisible and unconscious aspects of culture, such as attitudes, values, beliefs, peer pressure, and norms of behavior or the inherent hand hygiene habits of the HCW (Kaufman & McCaughan, 2013; Whitby et al., 2007).

Under Bronfenbrenner's macrosystem and Troyer's church environment, a nurse's religious beliefs and practices as well as the church affiliation of the hospital will resonate in the church environment of the HET. The church environment combines with the unit and hospital culture environment to also influence the nurses' values and attitudes toward teamwork and patient safety, the overall hospital culture, organizational goals, and the mission statement. Depending on if the hospital is church affiliated or for profit will contribute an important component in determining the hospital culture and the unit culture concerning organizational values and practices, the patient population served, hospital policies, and the hospital's position on abortion. The family, church, and community environments will all impart an influence on the decisions of the Ethics Committee.

The chronosystem of Bronfenbrenner fits under the work environment of the HET. Nurses' behavior toward patients and their personal culture will transition as years of experience are gained. A patient response elicited from a nurse during the first year after graduation should be different from that of a seasoned nurse. A seasoned nurse will have greater observational powers, better decision-making skills, and greater management skills.

Please see Appendix A for a list of the definitions used for each of the 15 independent variables and the dependent variable of hand hygiene compliance. Although Bronfenbrenner's theory of ecological systems theory has been tested many times, this is the first time this conceptualization of his theory in the healthcare setting has been used. The HET was born because once the environments were changed and the community environment was added, it had evolved into a unique theory that could now be utilized as a theory for the hospital setting and for hand hygiene surveillance studies. Troyer's model of his four environments has not been identified in print. Because of the lack of an existing theory for hand hygiene studies, it was deemed important to present the HET as a unique theory that could be utilized by the infection control practitioner with a goal of better understanding the motivational drivers for modifying hand hygiene behavior among HCWs. The goal of the infection control practitioner has always been to increase hand hygiene rates in order to reduce the incidence of healthcare-associated infections. For example, understanding how age affects the rates of hand hygiene, it becomes clearer as to which age groups should be targeted for use as champions and which groups should be targeted for interventions.

In viewing all of the interactions and interplay between all of the environments that influence the nurse and those which the nurse influences, it is easy to understand why multidimensional interventions are required in order to affect hand hygiene rates. HET is presented for hand hygiene and other infection prevention compliance studies in hospital settings to provide infection control practitioners with a theory useful for explaining the hand hygiene behavior of the HCW.

METHODOLOGY FOR STUDY IN WHICH HET WAS UTILIZED

Institutional review board approval number: Walden University 03-09-16-0327877 and Aspire IRB, Inc. 0.29.NUR.2015C.

HET was used as the theoretical foundation for the dissertation study, *Demographic Factors Associated with Consistent Hand Hygiene Adherence Among ICU Nurses* (Kurtz, 2017a). The study design was a quantitative, cross-sectional, prospective, overt observational study by a single observer, who was an infection control practitioner, Certified in Infection Control (CIC), and trained in hand hygiene observation. Agreements were signed with four hospitals in Texas to be used as data collection sites with one hospital contributing two ICUs. Bed capacity ranged from less than 175 beds to two hospitals each having over 500 beds. ICU beds ranged from 20 beds to 36 beds. A convenience sample of 64 ICU registered nurses (RNs) participated in

the study with an average of 13 RNs participating at each ICU (range 11–15 RNs). A total of 3,620 hand hygiene opportunities were collected from the five ICUs (range of 551–891 hand hygiene opportunities at each ICU). In order for each ICU to qualify as a stand-alone study, an individual sample size of 613 (sample size of 556 plus a 10% margin for missing data) hand hygiene opportunities was sought from each ICU. This sample size was based on a priori analysis using alpha as 0.05, effect size as 0.10 (small effect), and a power of 95%. G*Power, v. 3.1.9.2 for MacOSX, March 28, 2014, downloaded from the Heinrich Universität Düsseldorf website was used for the calculation (Faul, Erdfelder, Lang, & Buchner, 2007, 2009; G*Power, 2013). Length of observation was calculated on 20 hand hygiene opportunities per hour, yielding 160 opportunities for 8 hours (20×8), and 640 opportunities in 4 days of observation (160×4 days). Opportunities varied greatly, from a low of 6 per hour to 71 per hour, average of 25 hand hygiene opportunities per hour.

Observation began at each ICU on Monday at 7:00 am and continued for 8 continuous hours per day until the sample size of 613 was obtained. The sample size was collected at three ICUs in 3 days, one ICU in 4 days, and one ICU in 5 days. At one ICU, 551 hand hygiene opportunities were recorded rather than the full sample size sought ($556 + 10\% \text{ margin} = 613$). Total observation period was 18 days or 144 hours. Data were collected from March 21, 2016 to August 4, 2016. Multiple nurses were observed each day, with usually 5–7 nurses being observed simultaneously. It was not possible to observe more because of the hall structure. Usually sitting in the middle of the hallway across from the middle room being observed, it was possible to observe only 2 or 3 rooms to the right and to the left. During the observation period, the observer was very visible to all of the participant nurses.

During observation, hand hygiene opportunities were recorded for each nurse participant during each room entry/room exit. Did the nurse participate in hand hygiene, yes or no? Quality of hand hygiene practice was not collected during this study. Rate was calculated as the number of positive hand hygiene opportunities over the total number of opportunities. Rates were calculated for each nurse per hour and per each day of observation. Each ICU received a report of their individual aggregated hand hygiene compliance rates. Data were then aggregated.

Individual nurses or groups of one and two were approached each morning between 6:30 am and 7:00 am and asked if they would be willing to participate in the study. Explanation of the study with opportunity to ask questions was given before verbal agreement to participate was accepted. The nurses were asked to participate, given a 15 demographic questionnaire to complete by 3:30 pm, and they were told their hand hygiene opportunities would be observed and recorded by a single observer who would be sitting in the hallway across from the entrances to their assigned rooms. Please see Appendix B for questionnaire. Nurses were provided a letter of consent for their records, but their signatures were not required since completing the 15-question demographic questionnaire signified their willingness to participate. No information other than demographic information was sought and participating nurses received no compensation. Five nurses declined the invitation to participate with one of the five self-volunteering

2 days later for a participation rate of 94%. A total of 11 missing answers on the questionnaires out of a possible 960 answers generated a missing data rate of 1.15%. Nursing demographics have been reported in other manuscripts (Kurtz, 2017b, 2017c).

Data from each questionnaire were linked to the individual RN's hand hygiene rate before aggregation of data took place. Each nurse was requested to wear a research badge with a number matching the number on the questionnaire he or she had filled out. This number was used to record each nurse's hand hygiene opportunities. Each of the demographic variables were assigned to one of the six environments in order to help understand how these six environments influence the hand hygiene compliance of the ICU nurse.

The variables related directly to the family environment were *age, gender, marital status, and number of children*. Church environment was represented by the variable *spiritual affiliation*. *Total gross family income* and whether the RN was an *agency nurse or a hospital employee* was related to the administrative environment. Community environment was represented by the *country in which the nurse was born, the county in which the nurse graduated from nursing school, and the number of years the nurse had lived in the United States*. *Ancestry* was associated to the cultural environment. The work environment was associated with the *year of graduation from nursing school, number of years of active nursing practice, areas of previous nursing practice, and nursing degree* (e.g., bachelor of science in nursing or associate degree).

Descriptive and paired-sample *t*-tests were used for analysis, with all the data stored and analyzed using the Statistical Package for Social Sciences (SPSS) for Macintosh (IBM SPSS Statistics version 22.0, Armonk, NY, released in 2013).

RESULTS

The descriptive and inferential analyses of this study with the demographic variables and the hand hygiene rates have been reported elsewhere (Kurtz, 2017a, 2017b, 2017c). In this section, only how the variables and the environments interacted will be discussed.

Using a paired-sample *t*-test and the dependent variable of hand hygiene measured in percentage ranges, it was found that the influence of the *number of children, number of years living in the United States, and age* of the nurse had a statistically significant ($p < .001$) effect on hand hygiene rates. When the dependent variable was associated with $<50\%$ or $>50\%$ adherence, *number of years of active nursing practice, number of years of living in the United States, and age* of the nurse became significant ($p < .001$). Using the dependent variable of the actual hand hygiene rate of each nurse, *gender, marital status, ancestry, spiritual affiliation, areas of previous nursing practice, gross family income, degree program* (bachelor of science in nursing or associate degree), *country in which nurse was born, and country from which the nurse graduated* were each statistically significant ($p < .001$). The variable, *year of graduation from nursing school*, was dropped from final analysis because of the high degree of collinearity with the variable of *number of years of nursing practice*.

TABLE 1. Confidence Intervals for Independent Variables Using a Paired-Sample *t*-Test

	Test Value = 0					
	<i>t</i>	<i>df</i>	Sig. (two- tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Age of nurse	29.307	59	<.001	35.933	33.48	38.39
Number of children	7.012	63	<.001	1.000	0.72	1.28
Number of years of living in United States	5.688	63	<.001	3.578	2.32	4.84
Number of years of active nursing Practice	8.228	63	<.001	6.688	5.06	8.31
Female/male marital status	4.965	63	<.001	.281	0.17	0.39
Ancestry of nurse	14.793	63	<.001	2.813	2.43	3.19
Spiritual affiliation	13.834	61	<.001	16.661	14.25	19.07
Areas of previous nursing practice	10.837	62	<.001	15.333	12.50	18.16
Gross household income	5.602	62	<.001	3.556	2.29	4.82
Degree program	13.892	63	<.001	7.391	6.33	8.45
Country in which nurse born	17.845	61	<.001	2.226	1.98	2.48
Country from which nurse graduated nursing school	4.667	63	<.001	3.156	1.80	4.51
	10.558	63	<.001	1.203	0.98	1.43

The variable of *hospital employee or agency nurse* was dropped because of the small percentage of nurses who were represented in the agency nurse population (4.7%).

Please see Table 1 for the confidence intervals associated with the independent variables. The post hoc power analysis with an alpha of 0.05 yielded a power of 0.9999780 with an effect size of 0.100003. Being a parent was associated with increased hand hygiene but marital status was not.

In the literature, the hand hygiene rates for nurses between 21–30 years old and 31–40 years old were 41.5% and 41.1%, respectively (Sharma et al., 2011). Younger nurses today in the 20–29 years old range were born between 1987 and 1996 (in this study, this age group had hand hygiene rates of 85% when looking at hand hygiene compliance rates >50%). Nurses who are now 30–39 years old were born between 1977 and 1986 (in this study this age group were 78% compliance in hand hygiene compliance rates >50%). Nurses in the 40–49 year range now were born between 1967 and 1976 (hand hygiene rate >50% was 67%). In this study, when looking at hand hygiene compliance rates of >50%, nurses in the 50- to 69-year-old range were between 50% and 80% compliant, but no rates were recorded above 80%.

The results of this study also showed that both younger age and a shorter length of nursing practice were factors associated with higher rates of hand hygiene. Shorter lengths of time of active nursing practice can be correlated with both older and younger nurses as many individuals are now entering nursing as a second career at a later stage of their lives. One of the nurses in this study, age 61, was a recent graduate (less than 6 months) and had been working in the ICU for only a couple of months.

The community environment is also encompassed by the variables of *country in which the nurse was born*. In a comparison of nurses born in the United States and born in countries other than the United States, in looking at hand hygiene rates, 75% of the nurses born in the United States had a hand hygiene rate >50% and 10% had a rate >90%, while 83% of the foreign born nurses had a hand hygiene rate >50% and 25% had a rate >90%.

Because of the small sample size for each spiritual affiliation category and for the categories of ancestry, it was not possible to draw an association between the church environment, the culture environment, and hand hygiene compliance.

Pertaining to country of graduation, 94% of participants were from nursing schools within the United States and 6% were from Canada, India, and the Philippines. The small percentage of nurses graduating from other countries made it mathematically unsound to draw conclusions regarding the association of country in which nurse graduated from with hand hygiene rates.

The variables of *number of years of active nursing practice*, *areas of previous nursing practice*, and *degree program* are all reflected in the work environment. While additional years of practice constitute work experience (not only in terms of clinical expertise but also in terms of social and management skills), this variable was not shown to generate a higher hand hygiene rate.

DISCUSSION

The family environment variable involves not only the nurse's private family but also his or her work family. The extended work family includes all of the various departments with which nurses interact daily. Network linkages established by the nurse political forces, hospital policies, unit worked, the cultural forces of the unit (both the unit culture and the cultures of the individual nurses), the culture of patient safety set by the administration, and position held (e.g., staff nurse, charge nurse, or management staff), all interact to assert influence on the nurse's hand hygiene behavior. In this study, age was shown to be a significant variable associated with hand hygiene compliance. These results are believed to be the results of the influences of hand hygiene during the 1970s and 1980s with greater emphasis on hand hygiene not only in the community but also through increased emphasis of hand hygiene by nursing schools and medical schools as a way to decrease infections.

Age and number of years of nursing practice can be considered important factors in the family environment as it gives the nurse a position in the family hierarchy and also a position on the unit. Nurses with longer years of nursing practice are

used as mentors for nurses with less experience. However, today it can no longer be assumed that an older nurse has the greater years of practice. A nurse today who is 50 years of age may have been in practice for 30 years or may have been in practice only for the past couple of months. So it was deemed important to investigate if higher hand hygiene rates were associated with the age of the nurse or with the number of years of active practice. This study confirmed that the nurse younger in chronological age and those nurses with less years of practice had higher rates of hand hygiene compliance even though some of these nurses were in the older age brackets. As a result of the inherent training (from 1 to 10 years of age) and the increased emphasis of hand hygiene in nursing and medical school, the younger nurses of today are exhibiting higher hand hygiene compliance rates. Children born earlier, who are now the older nurses of today, did not receive this additional training and today are exhibiting lower hand hygiene rates (unless they are recent graduates).

It will be interesting to see if the increased rates that are being reported today among the younger nurse population will continue as these younger nurses age and the older nurses retire. What is being seen may be a slow cultural change. If this trend continues as the current nursing population ages, it may be that the best way to teach nurses to become 100% adherent with hand hygiene is to teach children the importance of hand hygiene.

It was also deemed important to know if the influence of being a parent would influence hand hygiene behavior. It was shown that those nurses who were parents did have higher compliance rates. This might be contributed to the increased teaching of the child, setting the example by their own increased rates, and increased awareness of the necessity of hand hygiene in the community setting.

In the administration environment, the nurse does not play an active role but experiences the influence of administrative decisions. Although nurses are, for the most part, not a part of the policy process, they are bound to comply with policies that call for 100% compliance with hand hygiene. In this study, the ICU with the highest overall hand hygiene rate had the strongest administrative and management support.

Culture is a complex issue because many different cultures coexist in a hospital setting. The culture of each individual nurse, the diversity of all of the nurses working in the ICU, and the work culture itself are all reflections of the attitudes, beliefs, and perceptions of the unit staff. Categorizing the ages of the nurses into groupings such as 20–29, 30–39, and so forth, also forms a culture, as different values and attitudes are held by different age groups, each exerting its own influence on hand hygiene behavior.

Lifetime experience, workload, individual attitudes, and support from management and team members multidirectionally affect and are affected by the work environment. Also influential is whether the nurse works the day or night shift, weekdays, or weekends. The work environment includes, as well, how the nurse interacts with other HCWs from other departments, with residents and physicians, with family members, with visitors, and with the community. A nurse coexists within the

hospital and the community life. This is evidenced by the higher hand hygiene rate seen in nurses who are parents. In a work environment where there is a great deal of teamwork, nurses experience less stress. When sharing the workload, each nurse feels that there is more time to follow policy and to participate in hand hygiene.

The higher hand hygiene rates of some of the variables (age, number of children) dealing with the family environment shows influencing factors of some but not all variables found within the family environment. The administrative environment has been shown to be influential in affecting hand hygiene rates. The work environment and the community environment also were shown to influence hand hygiene. This study has also shown how each of the environments are influenced by all of the other environments and how each environment is composed of multiple subenvironments.

An opportunity is now presented to use a theory specifically designed for studying the hand hygiene behavior of the HCW. The act of hand hygiene is a simple but highly complex behavioral function influenced by multiple factors simultaneously. Understanding hand hygiene behavior through the HET environments and the bi-directional influence that each has on the others can benefit and broaden our understanding of hand hygiene behaviors and the HCW.

LIMITATIONS

Limitations in this article mostly apply to the results obtained for the hand hygiene surveillance portion of the study reported elsewhere, but are listed here for a clearer understanding of the HET application.

1. The 64 nurses who did volunteer may have had higher or lower hand hygiene compliance rates than nurses who did not volunteer. Likewise, their answers to the demographic questions could have differed from non-participants. Thus, the HET environments may have influenced this group of participants differently than other potential groups of participants.
2. Only ICU RNs were studied. It may be that different HCWs react differently to the six environments presented. It might also be that the six environments may influence other hospital units differently than the ICU.
3. Missed hand hygiene opportunities may have altered the rates thus affecting how the different environments influenced the rates. Approximately 20% of the nurses working in these five ICUs were participants. Thus, there are missed opportunities from all nurses working in these ICUs and missed opportunities from those participating. These missed opportunities may have affected the rates, which could have altered the interpretation of the influence of the six environments.
4. Since only one observer was used, there is the possibility of observer bias.
5. The observation period itself could be considered a limitation in that surveillance was conducted only Monday to Friday, 7:00 am to 3:30 pm. No night shifts or weekends were observed.
6. Since only hospitals in Texas were observed, this brings about two limitations. First is that since this was a convenience sampling, it might be speculated that the participating nurses might not be representative of the nurses in other

hospitals in Texas or in the United States. Second is the difficulty to generalize the influence of the six environments to a world population.

7. A limitation also exists in that this is the first time the HET has been used in a study. Although there is supporting evidence from the ecological systems theory and the systems thinking theory, with this being a newly developed theory, there are no studies available for comparison or to lend support.

OPPORTUNITIES FOR FUTURE RESEARCH

Designed specifically for healthcare, the hospital setting, infection prevention, and hand hygiene surveillance, the HET can be used to understand the hand hygiene behavior in the ICU nurse.

With many articles advocating the use of a multidisciplinary approach to interventions to increase hand hygiene, there is a need for a theory that examines multiple environments to explain all of the interventional multidirectional influences. Nurses do not live and work in isolated environments. Their family lives are brought into the ICU and, likewise, their ICU experiences are carried back into the community. Their work family affects their hand hygiene through teamwork, peer relationships, and management influences. The church environment, the administration environment, and the community environment all influence the hand hygiene rates of nurses, with the nurse affecting each of these environments in turn. The individual culture of the nurse, the cultures of coworkers, the culture of the nursing unit, and the hospital culture of patient safety bidirectionally assert influence on the hand hygiene of the ICU nurse. Therefore, the HET model is proposed for consideration as a new theory to help explain the hand hygiene behavior of the ICU nurses. Until testing is done on an international basis, it will be unclear as to whether or not these six environments will be influential in hand hygiene compliance studies in other countries.

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APPENDIX A

DEFINITION OF 15 INDEPENDENT VARIABLES AND 1 DEPENDENT VARIABLE

1. Date of birth (used to calculate age): The date upon which a person was born.
2. Gender: The state of being male or female (Merriam-Webster dictionary, 2015).
3. Marital status: A person's state of being single, cohabitating, married, married by common law, separated, divorced, or widowed (Oxford dictionaries, 2015).
4. How many children living in your household: The number of children living in the nurse's household at the time of this survey. No age limit is placed on the age of the children. This information will help determine if there is a difference in hand hygiene rates between parents and non-parents based on a theory that because they should be involved in teaching their children hand hygiene habits, they will be more aware of their own habits in the hospital thus increasing their own rates. It will also be observed if the number of children a nurse has is an associate factor in hand hygiene.
5. What was your total gross household income in U.S. dollars for 2015: The total of all revenue (before taxes and other deductions) in U.S. dollars that the nurse's family made in 2015 (Merriam-Webster dictionary, 2015).
6. Year of graduation from nursing school: The year a nurse graduated from nursing school. This information helped determine the possible number of years of nursing practice. This information was used to help determine if HHA rates were associated with age or with the number of years of active nursing practice.
7. Number of years of active nursing practice: The number of years of actively working as a nurse. This information was used in conjunction with the year of graduation from nursing school and age to help determine if hand hygiene rates were associated with age alone or with the actual number of years of practice.
8. Are you a hospital employed nurse or an agency nurse: The nurse was employed either as a permanent hospital employee or was employed by a nursing agency and working for the hospital on a temporary basis.
9. Areas of previous nursing practice where you have actually worked on a nursing unit dedicated to this specialty: The identification of all nursing units that the nurse has worked other than ICU.
10. What is your degree program: Degree program (associated nursing degree, diploma degree, bachelor of science in nursing, masters of nursing or masters in another field, PhD, DNP): The number of years of nursing education this person has received. There is a question as to whether an inverse ratio of HHA in regard to educational level exists among nurses as it appears to with doctors.
11. In what country were you born: The country in which a person's birth is recorded. This helped to establish ethnicity and racial origin of the nurse.
12. From what country did you graduate nursing school: The country where the nurse attended nursing school. This provided information on where the nurse received the bulk of his or her training in HHA.
13. How would you classify your ancestry: A group of people with whom a person would classify himself or herself; a group of people in your family who preceded you and with whom you are genetically linked; a person from whom you are

- descended (Merriam-Webster dictionary, 2015). The term *ancestry* was used in place of *race/ethnicity*.
14. What is your spiritual affiliation: The religious or non-religious preference of the nurse. Into what religion or non-religion does this particular nurse classify himself or herself. The term *spiritual affiliation* was used in place of *religious preference*.
 15. How many years have you been living in the United States: The number of years a person has been living in the United States. This question will help to distinguish native-born Americans from persons born in another country. The longer a person has been in the United States, the more influence should have occurred in the areas of personal hygiene and hand hygiene in particular.

The operational definition of the dependent variable is as follows:

1. Hand hygiene: The act of cleaning of the hands either with the alcohol hand sanitizer or by washing the hands with soap and water.
2. Hand hygiene adherence: The act of cleaning of the hands upon entry or exit of the patient's room.

Each entry into a patient's room was considered one hand hygiene opportunity and each exit from the patient's room was considered a separate hand hygiene opportunity. A nurse's entry and subsequent exit from a patient's room would be considered two hand hygiene opportunities.

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

Demographic Questionnaire

1. What is your month, day, and year of birth? (MM/DD/YYYY)

_____/_____/_____

(Statistical Package for the Social Sciences)

2. What is your gender?

- Female
 Male

Code for SPSS

0
1

3. What is your marital status?

- Single
 Single but cohabitating
 Currently married
 Common law marriage
 Separated
 Divorced
 Widowed
 Prefer not to answer

Code for SPSS

1
2
3
4
5
6
7
8

4. How many children are living in your household at the time of this survey? This will include your own children, grandchildren, or someone else's children who are living with you.

- None
 1
 2
 3
 4
 5
 6
 7
 if more than 7, please give number _____
 Prefer not to answer

Code for SPSS

0
1
2
3
4
5
6
7
8
25

5. What was your total gross household income in U.S. dollars for 2015 (the total of all revenue (before taxes and other deductions) in U.S. dollars? (Please indicate total income of family, not just yours).

- < \$39,000
 \$40,000 - \$49,000
 \$50,000 - \$59,000
 \$60,000 - \$69,000
 \$70,000 - \$79,000
 \$80,000 - \$89,000
 \$90,000 - \$99,000

Code for SPSS

1
2
3
4
5
6
7

<input type="checkbox"/>	\$100,000 - \$109,000	8
<input type="checkbox"/>	\$110,000 - \$119,000	9
<input type="checkbox"/>	\$120,000 - \$129,000	10
<input type="checkbox"/>	\$130,000 - \$139,000	11
<input type="checkbox"/>	\$140,000 - \$149,000	12
<input type="checkbox"/>	\$150,000 - \$159,000	13
<input type="checkbox"/>	\$160,000 - \$169,000	14
<input type="checkbox"/>	\$170,000 - \$179,000	15
<input type="checkbox"/>	\$180,000 - \$199,000	16
<input type="checkbox"/>	\$200,000 - \$224,000	17
<input type="checkbox"/>	\$225,000 - \$249,000	18
<input type="checkbox"/>	> \$250,000	19
<input type="checkbox"/>	Prefer not to answer	20

6. Year of graduation from nursing school? _____

7. Number of years of active nursing practice? (Number of years actually worked as a nurse, not number of years you have been an RN) _____

8. Are you an agency nurse or a hospital employed nurse?	Code for SPSS
<input type="checkbox"/> Agency nurse	1
<input type="checkbox"/> Hospital employed nurse	2
<input type="checkbox"/> Prefer not to answer	3

9. Area of previous nursing practice where you have actually worked on a nursing unit dedicated to this specialty? (Please check all that apply).	Code for SPSS
<input type="checkbox"/> Only worked in ICUs	1
<input type="checkbox"/> Burn unit	2
<input type="checkbox"/> Cath lab	3
<input type="checkbox"/> Diabetic unit	4
<input type="checkbox"/> Emergency room	5
<input type="checkbox"/> L & D	6
<input type="checkbox"/> Medical unit	7
<input type="checkbox"/> Medical/Surgical unit	8
<input type="checkbox"/> Neurology unit	9
<input type="checkbox"/> Nurse Educator	10
<input type="checkbox"/> OB unit	11
<input type="checkbox"/> Oncology unit	12
<input type="checkbox"/> Operating room	13
<input type="checkbox"/> Orthopedic unit	14
<input type="checkbox"/> Pediatric unit	15
<input type="checkbox"/> Psych unit	16
<input type="checkbox"/> Radiology	17
<input type="checkbox"/> Recovery room	18
<input type="checkbox"/> Surgical Unit	19
<input type="checkbox"/> Telemetry unit	20

- | | | |
|--------------------------|----------------------|----|
| <input type="checkbox"/> | Transplant unit | 21 |
| <input type="checkbox"/> | Urology unit | 22 |
| <input type="checkbox"/> | Other _____ | 23 |
| | _____ | 24 |
| <input type="checkbox"/> | Prefer not to answer | 25 |

- | | |
|---|---------------|
| 10. What is your degree program? (Please check all that apply) | Code for SPSS |
| <input type="checkbox"/> Associate degree | 1 |
| <input type="checkbox"/> Diploma degree | 2 |
| <input type="checkbox"/> Bachelor of Nursing | 3 |
| <input type="checkbox"/> Bachelor in field other than nursing (Please indicate field) | |
| _____ | 4 |
| <input type="checkbox"/> Masters in Nursing | 5 |
| <input type="checkbox"/> Masters in field other than nursing (Please specify field) | |
| _____ | 6 |
| <input type="checkbox"/> PhD (Please specify field) | |
| _____ | 7 |
| <input type="checkbox"/> DNP | 8 |
| <input type="checkbox"/> Prefer not to answer | 9 |

- | | |
|--|---------------|
| 11. In what country where were you born? | Code for SPSS |
| <input type="checkbox"/> United States | 1 |
| <input type="checkbox"/> Canada | 2 |
| <input type="checkbox"/> England | 3 |
| <input type="checkbox"/> India | 4 |
| <input type="checkbox"/> Korea | 5 |
| <input type="checkbox"/> Mexico | 6 |
| <input type="checkbox"/> Philippines | 7 |
| <input type="checkbox"/> Africa (Please specify which country) | |
| _____ | 8 |
| <input type="checkbox"/> Asia (Please specify which country) | |
| _____ | 9 |
| <input type="checkbox"/> Europe (Please specify which country) | |
| _____ | 1.1 |
| <input type="checkbox"/> Middle East (Please specify which country) | |
| _____ | 10 |
| <input type="checkbox"/> South A merica (Please specify which country) | |
| _____ | 12 |
| <input type="checkbox"/> Other country (Please specify which country) | |
| _____ | 13 |
| <input type="checkbox"/> Prefer not to answer | 14 |

- | | |
|--|---------------|
| 12. From what country did you graduate nursing school? | Code for SPSS |
| <input type="checkbox"/> United States | 1 |
| <input type="checkbox"/> Canada | 2 |
| <input type="checkbox"/> England | 3 |

<input type="checkbox"/>	India	4
<input type="checkbox"/>	Korea	5
<input type="checkbox"/>	Mexico	6
<input type="checkbox"/>	Philippines	7
<input type="checkbox"/>	Africa (Please specify which country)	
	_____	8
<input type="checkbox"/>	Asia (Please specify which country)	
	_____	9
<input type="checkbox"/>	Europe (Please specify which country)	
	_____	11
<input type="checkbox"/>	Middle East (Please specify which country)	
	_____	10
<input type="checkbox"/>	South America (Please specify which country)	
	_____	12
<input type="checkbox"/>	Other country (Please specify which country)	
	_____	13
<input type="checkbox"/>	Prefer not to answer	14

13. How would you classify your ancestry? (Please check only one). Code for SPSS

<input type="checkbox"/>	African	1
<input type="checkbox"/>	Alaskan Native	2
<input type="checkbox"/>	American Indian	3
<input type="checkbox"/>	Arabian	4
<input type="checkbox"/>	Asian	5
<input type="checkbox"/>	Austrian	6
<input type="checkbox"/>	Australian	7
<input type="checkbox"/>	Black (African African)	8
<input type="checkbox"/>	Black (African American)	9
<input type="checkbox"/>	British	10
<input type="checkbox"/>	Canadian	11
<input type="checkbox"/>	Caucasian (White) Non Hispanic	12
<input type="checkbox"/>	Caucasian (White) Hispanic	13
<input type="checkbox"/>	Chinese	14
<input type="checkbox"/>	European	15
<input type="checkbox"/>	Filipino	16
<input type="checkbox"/>	Germanic	17
<input type="checkbox"/>	Hispanic	18
<input type="checkbox"/>	Non Hispanic	19
<input type="checkbox"/>	Hungarian	20
<input type="checkbox"/>	Indigenous or Aboriginal	21
<input type="checkbox"/>	Indian (from India)	22
<input type="checkbox"/>	Irish	23
<input type="checkbox"/>	Italian	24
<input type="checkbox"/>	Japanese	25
<input type="checkbox"/>	Korean	26
<input type="checkbox"/>	Latino	27

<input type="checkbox"/>	Mexican	28
<input type="checkbox"/>	Middle Eastern	29
<input type="checkbox"/>	Mongolian	30
<input type="checkbox"/>	Multiracial	31
<input type="checkbox"/>	Native Hawaiian	32
<input type="checkbox"/>	Pacific Islander	33
<input type="checkbox"/>	Polish	34
<input type="checkbox"/>	Russian	35
<input type="checkbox"/>	Scandinavian	36
<input type="checkbox"/>	Scottish	37
<input type="checkbox"/>	Southeast Asia	38
<input type="checkbox"/>	Spain	39
<input type="checkbox"/>	Vietnamese	40
<input type="checkbox"/>	Other (Please specify) _____	41
<input type="checkbox"/>	Prefer not to answer	42

14. What is your spiritual affiliation?(Please check only one)	Code for SPSS	
<input type="checkbox"/>	None	1
<input type="checkbox"/>	Agnostic	2
<input type="checkbox"/>	Amish	3
<input type="checkbox"/>	Anglicanism	4
<input type="checkbox"/>	Assembly of God	5
<input type="checkbox"/>	Atheism	6
<input type="checkbox"/>	Baha'l	7
<input type="checkbox"/>	Baptist	8
<input type="checkbox"/>	Buddhism	9
<input type="checkbox"/>	Candomblé	10
<input type="checkbox"/>	Catholic (Roman Catholic)	11
<input type="checkbox"/>	Church of Christ	12
<input type="checkbox"/>	Church of God	13
<input type="checkbox"/>	Church of the Nazarene	14
<input type="checkbox"/>	Congregational/ United Church of Christ	15
<input type="checkbox"/>	Disciples of Christ	16
<input type="checkbox"/>	Eastern Orthodoxy (Orthodox Eastern)	17
<input type="checkbox"/>	Episcopalian	18
<input type="checkbox"/>	Evangelical	19
<input type="checkbox"/>	Hinduism	20
<input type="checkbox"/>	Holiness/Holy	21
<input type="checkbox"/>	Islam	22
<input type="checkbox"/>	Jainism	23
<input type="checkbox"/>	Jehovah's Witnesses	24
<input type="checkbox"/>	Judaism	25
<input type="checkbox"/>	Lutheran	26
<input type="checkbox"/>	Methodist	27
<input type="checkbox"/>	Mormon (Latter-Day Saint)	28
<input type="checkbox"/>	Nondenominational	29

15. How many years have you been living in the United States?

	Code for SPSS
<input type="checkbox"/> All my life. I was born here.	1
<input type="checkbox"/> less than 12 months	2
<input type="checkbox"/> 13 months to 23 months	3
<input type="checkbox"/> 2 years	4
<input type="checkbox"/> 3 years	5
<input type="checkbox"/> 4 years	6
<input type="checkbox"/> 5 years	7
<input type="checkbox"/> 6 years	8
<input type="checkbox"/> 7 years	9
<input type="checkbox"/> 8 years	10
<input type="checkbox"/> 9 years	11
<input type="checkbox"/> 10–14 years	12
<input type="checkbox"/> 15–19 years	13
<input type="checkbox"/> 20–24 years	14
<input type="checkbox"/> 25–29 years	15
<input type="checkbox"/> 30–34 years	16
<input type="checkbox"/> 35–39 years	17
<input type="checkbox"/> More than 40 years	18
<input type="checkbox"/> Prefer not to answer	19