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Exploring Effect Moderation In Our Understanding of Hand Hygiene Predictors

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Exploring Effect Moderation
In Our Understanding of Hand Hygiene Predictors

By:

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Exploring Effect Moderation

In Our Understanding of Hand Hygiene Predictors

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DECLARATION OF ORIGINALITY

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication.

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ABSTRACT

Although a multitude of factors affecting hand hygiene (HH) adherence have been investigated in the literature, limited research has specifically explored the moderating/ interaction effects among these factors. A secondary analysis of pooled self-reported HH adherence data, collected for two previous Canadian studies, was conducted to explore the presence of such interaction effects. Within a combined sample of 465 physician and nursing student participants, 67.1% were deemed adherent, with self-reported performance of HH before and after every patient contact at a minimum of 90% of the time.

Gender was found to moderate the relationship between forgetfulness and HH adherence within the merged dataset. Perceived forgetfulness significantly decreased HH adherence among male respondents only. In addition, perceived busyness was found to moderate the relationship between forgetfulness and HH adherence among nursing students. Forgetfulness decreased HH adherence, but only for those nursing students who did not perceive busyness as a factor impacting their HH adherence.

The study findings highlight the need to explore moderation/interaction effects to enrich our understanding of factors affecting HH, enabling more effective, targeted interventions to improve adherence.

DEDICATION

I dedicate my thesis to my children, Megan and Gavin. I hope my love for lifelong learning and graduate studies journey has inspired you to overcome any challenges life has in store. Never stop chasing your dreams! I am so very proud of both of you and hope I have also made you proud. I love you most.

I would also like to dedicate this thesis to my mother, Linda Patrick. You have always been my inspiration and fiercest supporter. You are an amazing example of a mother, nurse, educator, and researcher – which I continue to aspire to. Thank you for your unconditional love and support and for keeping me motivated through various challenges.

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INTRODUCTION

Seeking health care shouldn't make you sick, yet each year, hundreds of millions of people worldwide are affected by healthcare-associated infections (HAIs) with an increased burden experienced by low- and middle-income countries. HAIs result in deaths, prolonged hospital stays, disability, increased antimicrobial resistance (causing standard treatments to become ineffective), substantial financial burden for health systems, and increased costs for patients [World Health Organization (WHO), 2011]. In Canada, 220,000 patients are infected with HAIs each year, resulting in over 8,000 hospital deaths (Zoutman et al., 2003).

Proper hand hygiene (HH) is the most important practice for prevention of HAIs (Rosenthal et al., 2015; Whitby et al., 2007) and has a direct impact on patient safety [Public Health Agency of Canada (PHAC), 2012]. Despite provincial [Ontario Agency for Health Protection and Promotion (OAHPP), 2014], and international (Boyce & Pittet, 2002; WHO, 2009) recommendations for HH, and a national HH campaign (Canadian Patient Safety Institute, 2016), HH adherence remains suboptimal worldwide (Jang et al., 2010; PHAC, 2012). Reported HH adherence rates among acute-care healthcare workers in Ontario hospitals ranged from 88 to 91% (Health Quality Ontario, 2016), compared to rates of 20 to 84% among research studies internationally (Azim & McLaws, 2014; Erasmus et al., 2010; Huis et al., 2012; Korniewicz & El-Masri, 2010; Mayer et al., 2011; Midturi et al., 2015).

Theoretical Framework

The theory of ecological perspective (McLeroy, Bibeau, Steckler, & Glanz, 1988), also referred to as the social ecological model, offers a promising approach to

understanding and modifying HH behaviour (Pittet, 2004; WHO, 2009). Adapted from Bronfenbrenner's ecology of human development model (1977), the theory of ecological perspective (McLeroy et al., 1988) is based on two central tenets that behaviour affects and is affected by multiple levels of influence; and that behaviour influences and is influenced by the social environment (McLeroy et al., 1988; WHO, 2009). The theory views intended patterned behaviour as being determined by five levels of influence: (a) intrapersonal (individual) factors such as knowledge, attitudes, skills, and beliefs; (b) interpersonal factors, including informal and formal social support systems/networks; and groups that provide social identity and role definition (e.g., family, friends, and work group); (c) institutional factors that include formal and informal operating rules and regulations, and the availability and access to rules, policies, and procedures (Pittet, 2004); (d) community factors, which are the norms and social networks that exist between individuals, groups, and organizations, such as a unit or ward in a hospital (Pittet, 2004), and (e) public policy. This includes local, state (provincial), and national policies and laws and involves the support of the administration (within the hospital, for example), who must address infection prevention and control concerns and together develop strategies to resolve infection transmission, endorse these measures, and mobilize needed hospital resources (Pittet, 2004). These levels of analysis are highly interactive. Thus, in order to understand behaviour change, it is useful to examine not only each level, but the interactions between them (Simons-Morton, McLeroy, & Wendel, 2012). The theory of ecological perspective is thus ideally suited for examining moderating factors (interaction effects) affecting HH adherence.

The theory of ecological perspective (McLeroy et al., 1988) provides guidance in addressing and understanding various influences on health behaviour; which include not only individual beliefs and attitudes, but also interpersonal relationships, organizational and community affiliations, current politics, and cultural connections (Simons-Morton, McLeroy, and Wendel, 2012). While it has not been used to investigate or modify HH adherence specifically, Curry and Cole (2001) applied the theory to develop a multilevel, multidimensional intervention that successfully reduced vancomycin-resistant *enterococcus* (VRE) colonization rates among patients in intensive care units in a large hospital. According to the investigators, the problem required a multifaceted approach to change behaviour by shifting social norms at multiple levels. Their approach involved interventions directed at all five levels of influence, which the authors stated was crucial to their success. The results of this study suggest that changes in health behaviour, including HH, can be best understood and fostered through analyses of the influences at each societal level and their interactions, as is the purpose of the theory of ecological perspective (Simons-Morton, McLeroy, & Wendel, 2012).

LITERATURE REVIEW

The factors affecting HH adherence within this literature review are organized according to the five levels of the theory of ecological perspective (McLeroy et al., 1988). The factors in each of the levels are not assumed to be mutually exclusive, and can therefore belong to one or more levels. Pittet (2004) similarly organized factors associated with HH adherence according to the theory of ecological perspective. His classification scheme was used as a guide to organize the factors that were examined in this study (see Appendix A for the organizing scheme). Appendix A also provides an

overview of the results of previous studies that examined the potential predictors of HH adherence that were used in the current study.

Despite some inconsistent findings (Appendix A), the majority of studies support the conclusion that the following factors are independent predictors of HH adherence: self-protection; inherent versus elective indications for HH; self-efficacy; presence of HH auditing and feedback; availability of HH products; workload; forgetfulness; and skin irritation and dryness. However, there is significant disagreement among the findings of studies that examined age; gender; professional category; attitude toward HH; HH knowledge and education; role models, peer pressure, and social influence; type of hospital unit; and administrative support/institutional safety climate. Although years of experience and administrative sanctions and rewards have been studied within the literature, they have not been found to be independent predictors of HH (Appendix A).

To further our understanding of factors that influence HH adherence, it is important to explore the possible existence of moderating effects. A moderator variable is a second independent variable that influences the nature of the relationship between an independent and the dependent variable. Moderating variables are important to consider whenever a researcher has a reason to believe that the impact of an independent variable on the dependent variable may be different across different levels of a second independent variable (i.e., the moderating variable; MacKinnon, 2011). By studying effect moderators, we will have a better understanding of the true nature of relationships among variables, enabling the development of interventions that take into account differential effects across levels of independent variables.

Following a comprehensive review of the literature, only four studies were found that examined effect moderation as it relates to HH adherence (Allegranzi et al., 2013; Fuller et al., 2012; Luszczynska & Gunson, 2007; Yardley, Miller, Schlotz, & Little, 2011). Three of these studies explored moderators of the effect of interventions designed to improve HH adherence in hospitals (Allegranzi et al., 2013; Fuller et al., 2012) or in the home setting (Yardley, Miller, Schlotz, & Little, 2011), while the remaining study (Luszczynska & Gunson, 2007) explored moderators affecting predictors of patients asking medical personnel about HH. None of these studies addressed effect moderation among individual predictors of HH adherence among healthcare professionals (HCP).

If moderating effects are ignored, we may make misleading conclusions about study findings. For example, certain interventions may not be effective across the board in a given population, but may be effective for a subset (e.g., a specific gender, age group, or professional category) of the population. Exploring moderators is warranted to improve our understanding of factors affecting HH adherence, thereby enabling administrators to incorporate more effective, targeted interventions to improve adherence rates and decrease HAI rates. Thus, to address this gap in research and related knowledge, the purpose of this study was to explore the moderating/interaction effects that may exist among predictors of HH adherence. Specifically, a secondary analysis of pooled HH adherence data from two previous studies (Budimir-Hussey et al., 2013; Foote & El-Masri, 2016) was conducted to explore the presence of such interaction effects. The two datasets were combined to explore potential moderators across two different HCP positions. Testing for moderation was also explored within each of the datasets used in this study.

METHODOLOGY

Research Design

Upon clearance to conduct the study by the Research Ethics Board, a secondary analysis was conducted to explore potential effect moderators influencing HH adherence. Data for this study were obtained from two descriptive, cross-sectional self-report studies that investigated HH adherence (Budimir-Hussey et al., 2013; Foote & El-Masri, 2016). The purpose of the first study by Budimir-Hussey et al. (2013) was to explore self-reported HH practices and predictors of HH among physicians within a southwestern Ontario community. The purpose of the study by Foote and El-Masri (2016) was to investigate self-reported HH practices of undergraduate nursing students enrolled at a University in southwestern Ontario. Neither study explored effect moderation; which made them especially suitable for the conduct of this study.

Sample and Setting

The Budimir-Hussey et al. (2013) study sampled 159 physicians from a regional medical association in southwestern Ontario who had medical practice privileges in local area hospitals. The study by Foote and El-Masri (2016) included 306 undergraduate nursing students registered in years two, three, and four of a nursing program in southwestern Ontario (year one students were excluded due to lack of clinical experience). G*power 3.1.9.2 (Faul, Erdfelder, Buchner, & Lang, 2009) was used to calculate the statistical power of this study. Given that both original studies reported odds ratios (*OR*) of greater than 2.0 for all independent predictors of HH, power analysis was calculated based on a conservative effect size (*OR* = 2.0). Using an *OR* of 2.0, the minimum required sample size of 148 participants would provide a study power of .95,

based on a two-tailed alpha of .05 (Faul et al., 2009). Thus, with the available sample of 465 participants, statistical power was not an issue.

Definition of HH Adherence

Since this was a secondary data analysis, the study variables were predetermined by the investigators of the original studies. Budimir-Hussey et al. (2013) and Foote and El-Masri (2016) defined HH adherence in terms of the proportion of respondents who reported that they performed HH before and after every patient contact at least 90% of the time. For consistency, the same operational definition of HH was used in this study; which is within the commonly reported rate. This rate is higher than the 80% adherence rate considered by Sax et al. (2007) to indicate good hand hygiene, but more lenient than the WHO (2009) recommended improvement goal of greater than 95% adherence.

Data Analysis

The SPSS statistical software package (Version 24.0) was used to analyze the data. Each of the initial databases was subject to screening for statistical assumptions and completeness of the data by the original investigators. Prior to data analysis, the combined database was subjected to further screening for violations of bivariate and multivariate assumptions and to ensure that data merging did not distort the data. All independent variables within the multivariate analysis were screened for multicollinearity by examining the standard error (*SE*) values for the unstandardized coefficients (*B*), as recommended by Field (2005). None of the variables in the logistic regression analyses had a standard error larger than 2.0, excluding the possibility of multicollinearity.

Data analysis of the merged database consisted of four discrete steps:

1. Descriptive statistics (chi-square analyses) were performed to describe the sample and to compare HH adherers and non-adherers across the study variables.
2. Forward stepwise logistic regression analysis was performed to identify independent predictors associated with HH adherence by entering all variables with a significance level of $p \leq 0.25$ from the univariate analysis (Hosmer & Lemeshow, 2000). Statistical significance for the logistic regression was determined based on a 2-tailed α of 0.05 or 95% confidence interval. This step examined main effects only, ignoring possible interaction.
3. Interaction terms consisting of pairs of variables with a significance level of $p \leq 0.25$ (in the initial [χ^2] analysis) were created to explore for possible moderating effects. Using separate hierarchical logistic regression analyses for each pair of variables, the main effects were entered in the first block and the interaction terms were entered in the second block.
4. All significant interactions ($p \leq 0.05$) were then added to the main effects models (step 2), one interaction term at a time, using forward stepwise logistic regression.

Steps 2 through 4 above were repeated to explore for potential interactions within the physician and nursing student databases, using variables with a significance level of $p \leq 0.25$ after univariate analysis, as identified within the original studies (Budimir-Hussey et al., 2013; Foote & El-Masri, 2016).

RESULTS

Within the original studies, 159 physicians (Budimir-Hussey et al., 2013) and 306 nursing students (Foote & El-Masri, 2016) completed questionnaires, resulting in a combined sample of 465 participants. The average age of participants was 32.9 (SD ± 15.5; range 19 to 81) years, and the majority of respondents were female (63.9%; *n*

=297). Overall, 67.1% (n = 312) of participants were deemed adherent with HH, with self-reported performance of HH before and after every patient contact at least 90% of the time. Table 1 shows the demographic characteristics of the combined sample, as well as the unadjusted chi-square comparisons of HH adherent versus non-adherent participants for all study variables.

Table 1.

Step 1: Chi-square Comparisons of Self-perceived HH Adherence and Non-adherence.

	HH Adherence n (%)				
Variable	**No (< 90%)**	**Yes (≥ 90%)**	**Row Total**	χ^2	***p***
Gender				25.80	< 0.001*
Male	80 (17.2)	88 (18.9)	168 (36.1)		
Female	73 (15.7)	224 (48.2)	297 (63.9)		
Age				31.20	< 0.001*
Age ≤ 32 years	68 (14.6)	222 (47.7)	290 (62.4)		
Age > 32 years	85 (18.3)	90 (19.4)	175 (37.6)		
HCP Position				46.25	< 0.001*
Physician	85 (18.3)	74 (15.9)	159 (34.2)		
Nursing Student	68 (14.6)	238 (51.2)	306 (65.8)		
Formal HH Education				26.88	< 0.001*
No	47 (10.1)	35 (7.5)	82 (17.6)		
Yes	106 (22.8)	277 (59.6)	383 (82.4)		
Reasons for non-adherence					
Too busy for HH				25.63	< 0.001*
No	72 (15.5)	222 (47.7)	294 (63.2)		
Yes	81 (17.4)	90 (19.4)	171 (36.8)		
Forgetfulness				7.35	0.008*
No	59 (12.7)	162 (34.8)	221 (47.5)		
Yes	94 (20.2)	150 (32.3)	244 (52.5)		
Unsure of Need				5.13	0.023*
No	133 (28.6)	291 (62.6)	424 (91.2)		
Yes	20 (4.3)	21 (4.5)	41 (8.8)		
Product not in convenient location				0.02	0.892
No	103 (22.2)	212 (45.6)	315 (67.7)		
Yes	50 (10.8)	100 (21.5)	150 (32.3)		
Products damage skin				21.21	< 0.001*
No	115 (24.7)	284 (61.1)	399 (85.8)		
Yes	38 (8.2)	28 (6.0)	66 (14.2)		
Other				0.48	0.490
No	145 (31.2)	300 (64.5)	445 (95.7)		
Yes	8 (1.7)	12 (2.6)	20 (4.3)		

Table 1. Continued

Motivation for Hand Hygiene					
Protection of patient				7.07	0.008*
No	26 (5.6)	27 (5.8)	53 (11.4)		
Yes	127 (27.3)	285 (61.3)	412 (88.6)		
Protection of self				0.76	0.384
No	8 (1.7)	23 (4.9)	31 (6.7)		
Yes	145 (31.2)	289 (62.2)	434 (93.3)		
System-related (following protocol or concern about reprimand/discipline)				6.45	0.011*
No	144 (31.0)	269 (57.8)	413 (88.8)		
Yes	9 (1.9)	43 (9.2)	52 (11.2)		
Self-satisfaction with HH practices				3.49	0.062*
No	10 (2.2)	9 (1.9)	19 (4.1)		
Yes	143 (30.8)	303 (65.2)	446 (95.9)		
Patients have the right to remind HCP to perform HH				3.49	0.062*
No	10 (2.2)	9 (1.9)	19 (4.1)		
Yes	143 (30.8)	303 (65.2)	446 (95.9)		

* = $p \leq 0.25$ and included within multivariate analysis.
HH = hand hygiene; HCP = healthcare professional

Table 2 displays the results of the multivariate stepwise logistic regression analysis. These results suggest that the following seven variables were independent predictors of participant HH adherence: female gender (*OR*, 1.78; 95% CI, 1.04–3.05), HCP position: nursing student (*OR*, 3.50; 95% CI, 2.02–6.05), too busy to perform HH reported as a reason for non-adherence (*OR*, 0.34; 95% CI, 0.21–0.53), forgetfulness reported as a reason for non-adherence (*OR*, 0.43; 95% CI, 0.27-0.69), the perception that HH products are damaging to skin (*OR*, 0.26; 95% CI, 0.14-0.49), patient protection as motivation for HH (*OR*, 3.12; 95% CI, 1.61–6.06) and system-related motivation (concern about reprimand/discipline if HH guidelines not followed/following protocol) (*OR*, 2.73; 95% CI, 1.12-6.64). The Cox and Snell R^2 and Nagelkerke R^2 indicate that the six independent predictors in the model explain 22.4 to 31.2% of the variance in HH adherence within this sample.

Table 2.
Step 2: Stepwise Logistic Regression Depicting Independent Predictors of HH Adherence Within Merged Dataset – Main Effects Only

Variable	*B*	*SE*	*OR*	*p*	95% CI
Gender (Reference = Male)	0.58	0.27	1.78	0.035	1.04 – 3.05
HCP Position (Reference = Physician)	1.25	0.28	3.50	<0.001	2.02 – 6.05
Busyness	-1.09	0.23	0.34	<0.001	0.21 – 0.53
Forgetfulness	-0.84	0.24	0.43	<0.001	0.27 - 0.69
Damage to skin	-1.35	0.33	0.26	<0.001	0.14 - 0.49
Motivation: patient protection	1.14	0.34	3.12	0.001	1.61 – 6.06
Motivation: system-related	1.00	0.45	2.73	0.027	1.12 – 6.64

B = unstandardized regression coefficient; *SE* = standard error; *OR* = odds ratio; *p* = probability of accepting the null hypothesis at $\alpha = 0.05$; CI = confidence interval.

Refer to the original studies for the results of their univariate and multivariate analyses (Budimir-Hussey et al., 2013; Foote & El-Masri, 2016).

Table 3 presents the logistic regression results depicting effect moderation (interaction effects) identified within all three datasets: merged; physicians; and nursing students. Scatterplots depicting interaction effects for the merged data set are displayed in Figure 1, while the interaction effects in the physician and nursing student databases are displayed in Figures 2 and 3, respectively. Please note that within each scatterplot, the lines of best fit are non-parallel, signifying an interaction effect.

Within the merged dataset, two interaction effects were identified: (a) forgetfulness (as a reason for non-adherence) with gender (*OR*, 2.74; 95% CI, 1.19–6.28); and (b) forgetfulness with received formal HH education (*OR*, 4.54; 95% CI, 1.55–13.29). Two interactions were identified in the physician dataset: (a) gender with hours worked per week (*OR*, 0.16; 95% CI, 0.03-0.97) and (b) self-reported reasons for non-adherence: forgetfulness with unsure of need (*OR*, 11.28; 95% CI, 1.19–107.39). As shown in Table

3 (and Figure 3), there were six significant interactions in the nursing students dataset: (a) forgetfulness with too busy (reasons for non-adherence) (*OR*, 11.28; 95% CI, 1.19-107.39); (b) ABHR damages skin with skin on hands is dry, cracked and/or irritated (*OR*, 5.44; 95% CI, 1.01–29.23); (c) ABHR damages my skin with motivation: concern about reprimand/discipline (*OR*, 0.09; 95% CI, 0.01–0.81); (d) age with nursing program level: year 3 (*OR*, 4.30; 95% CI, 1.05–17.61); (e) age with self-satisfaction with HH practice (*OR*, 11.00; 95% CI, 1.81–66.91); (f) age with total number of clinical placements (*OR*, 0.68; 95% CI, 0.48–0.97).

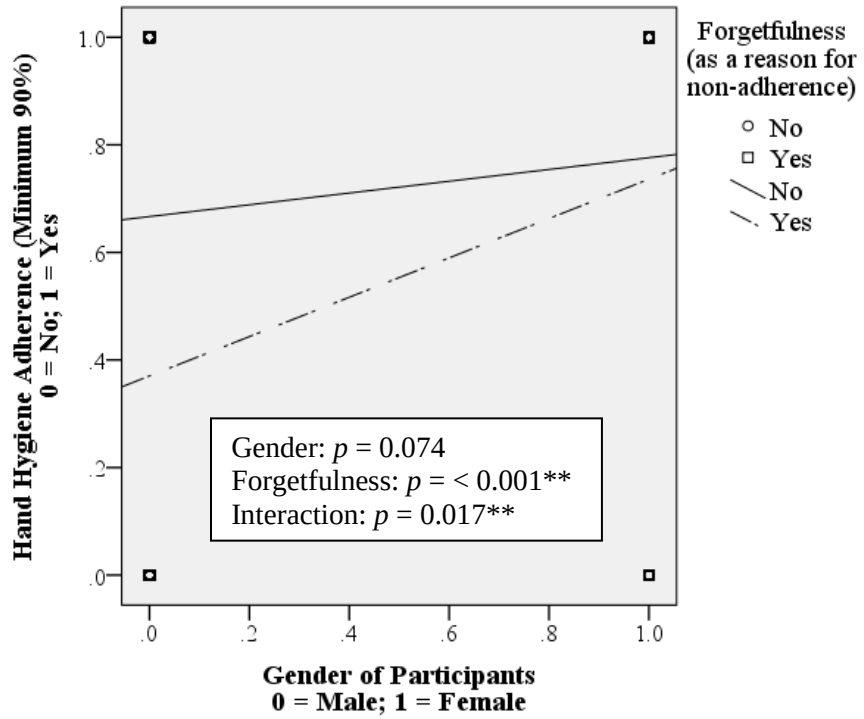
Table 3.
Step 3: Logistic Regression Results Depicting Interaction Effects Among All Datasets

Dataset	Variables	*B*	*SE*	*OR*	*p*	95% CI
Merged	Gender * Forgetfulness	1.01	0.42	2.74	0.017	1.19 – 6.28
	Formal HH Education *Forgetfulness	1.51	0.55	4.54	0.006	1.55 – 13.29
Physicians (Budimir-Hussey et al., 2013)	Gender * Hours worked per week	-1.85	0.93	0.16	0.046	0.03 – 0.97
	Forgetfulness * Unsure of need (reasons for non-adherence)	2.42	1.15	11.28	0.035	1.19 – 107.39
Nursing Students (Foote & El-Masri, 2016)	Forgetfulness * Too Busy (reasons for non-adherence)	1.40	0.65	4.05	0.030	1.14 – 14.37
	ABHR damages skin * Skin on hands is dry, cracked and/or irritated	1.69	0.86	5.44	0.048	1.01 – 29.23
	ABHR damages my skin *Motivation: concern about reprimand/ discipline	-2.38	1.11	0.09	0.032	0.01 – 0.81
	Age * Nursing Program Level: 3 Reference Group: Level 4	1.46	0.72	4.30	0.042	1.05 – 17.61
	Age * Self-Satisfaction with HH Practice	2.53	1.24	12.56	0.041	1.11 – 142.84
	Age * Number of clinical placements	-0.38	0.18	0.68	0.033	0.48 – 0.97

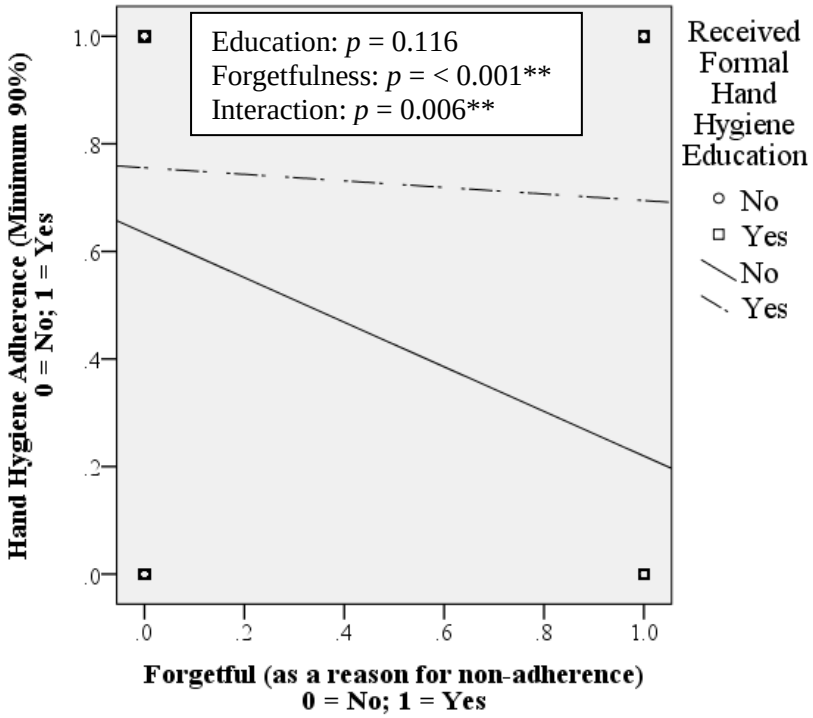
B = unstandardized regression coefficient; *SE* = standard error; *OR* = odds ratio; *p* = probability of accepting the null hypothesis at $\alpha = 0.05$; CI = confidence interval.
Outcome Variable (D.V.) = Hand Hygiene Adherence Before and After Patient Contact ≥ 90%

Figure 1.

Scatterplots Illustrating Effect Moderation Among Merged Dataset Variables



a.) Gender * Forgetfulness

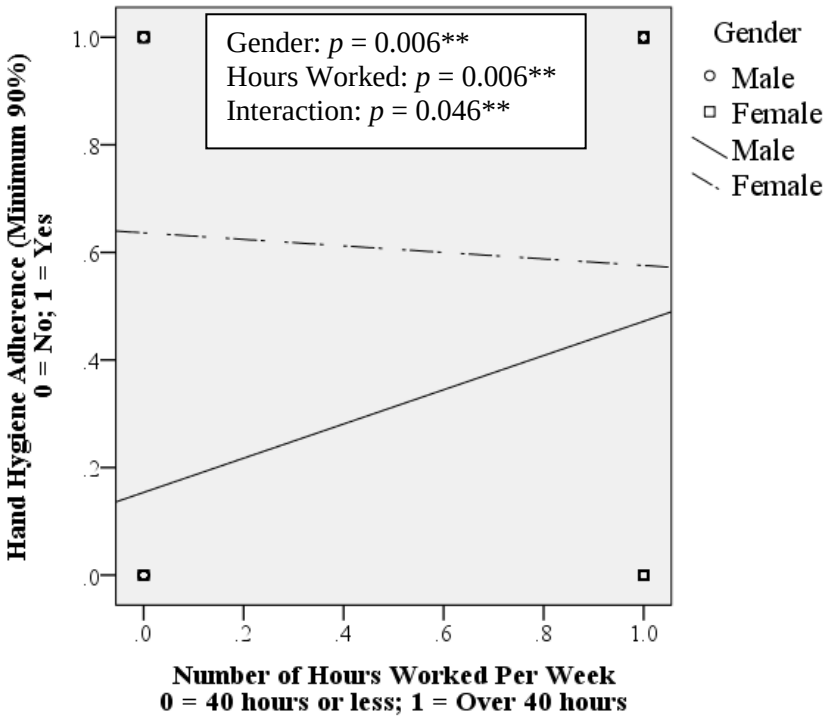


b.) Forgetfulness * Formal HH Education

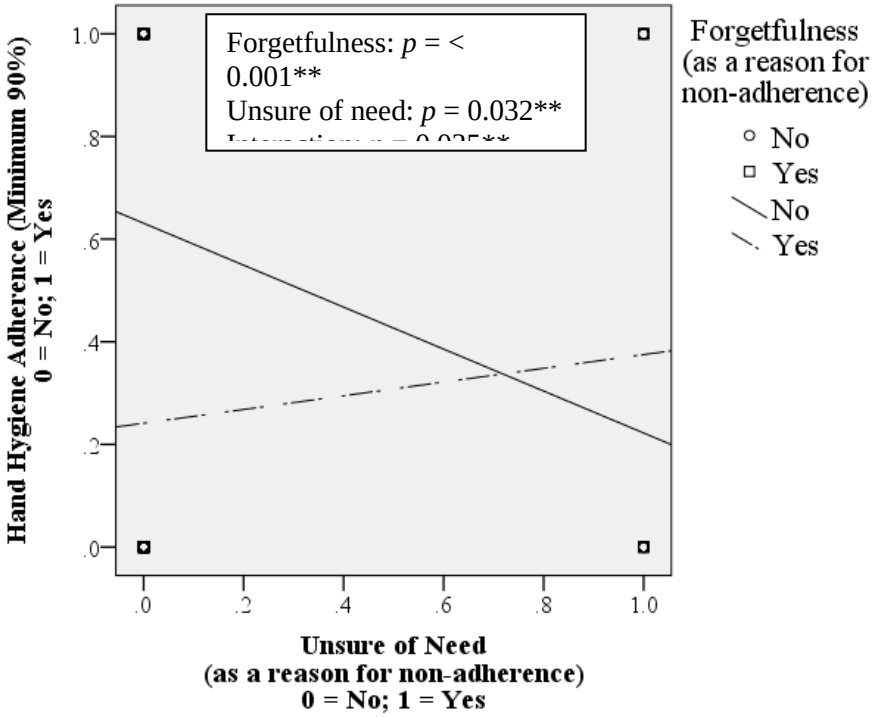
* denotes interaction; ** indicates $p < 0.05$

Figure 2.

Scatterplots Depicting Effect Moderation Among the Physicians Dataset Variables (Budimir-Hussey et al., 2013)



a.) Gender * Hours worked per week

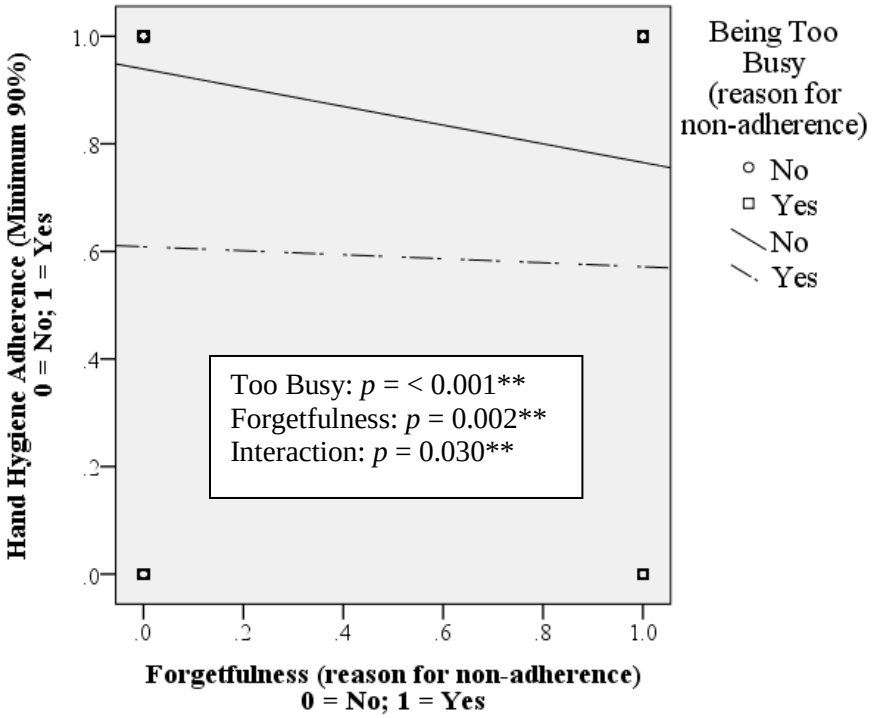


b.) Forgetfulness * Unsure of need (reasons for non-adherence)

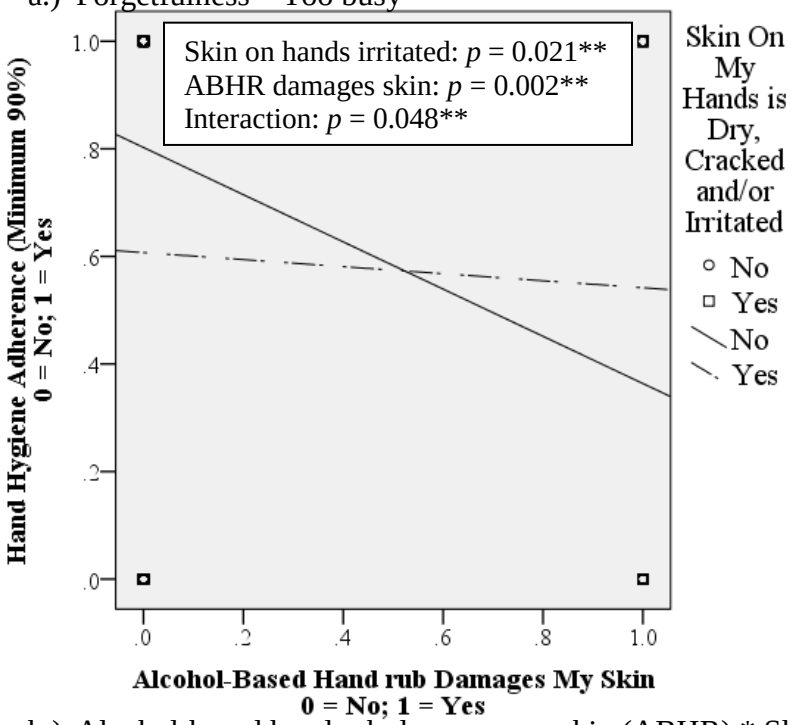
* denotes interaction; ** indicates $p < 0.05$

Figure 3.

Scatterplots Depicting Effect Moderation Among the Nursing Students Dataset Variables (Foote & El-Masri, 2016)



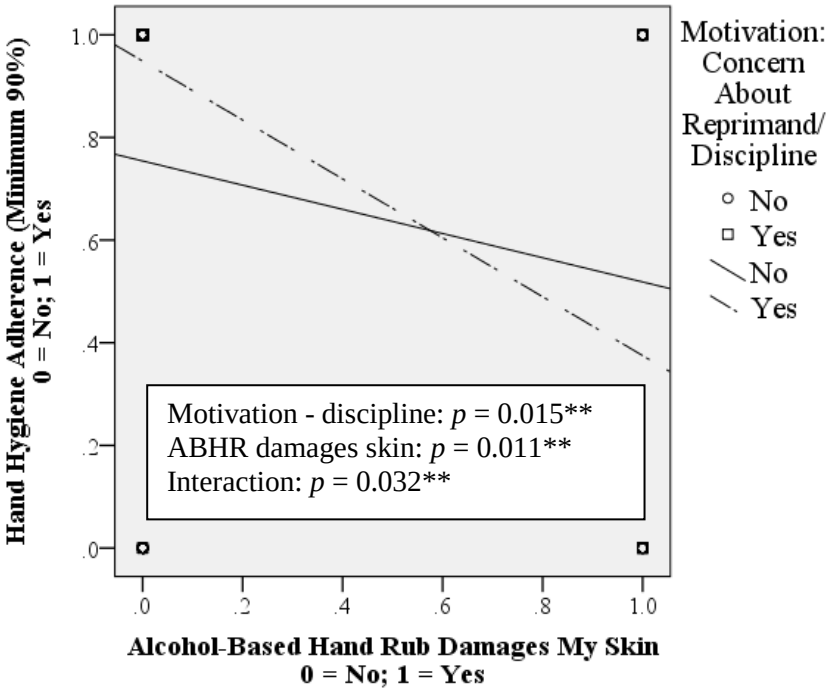
a.) Forgetfulness * Too busy



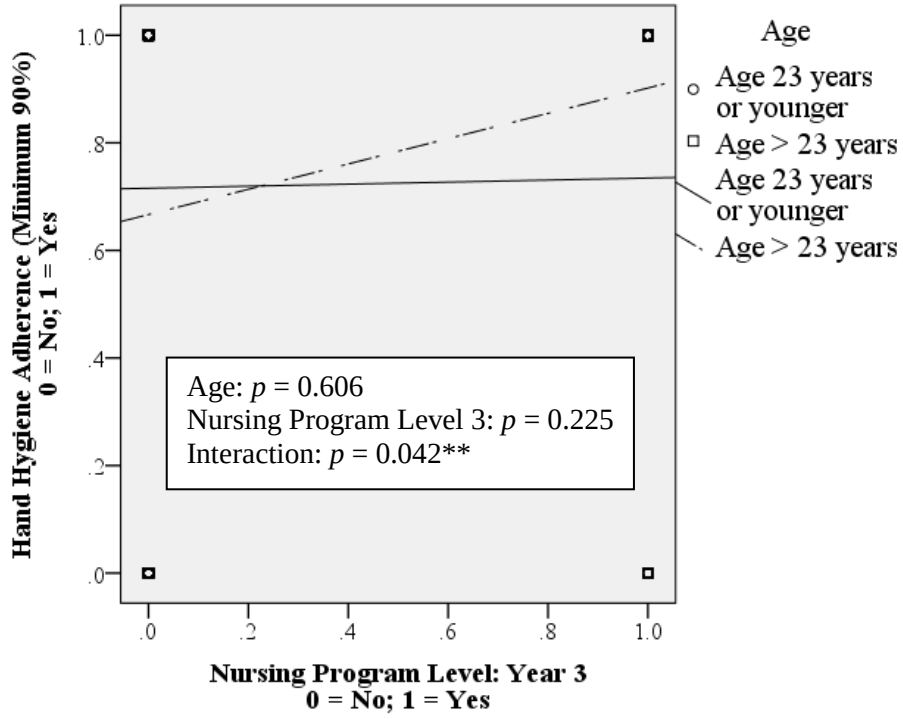
b.) Alcohol-based hand rub damages my skin (ABHR) * Skin on hands is dry, cracked/irritated

* denotes interaction; ** indicates $p < 0.05$

Figure 3. Continued



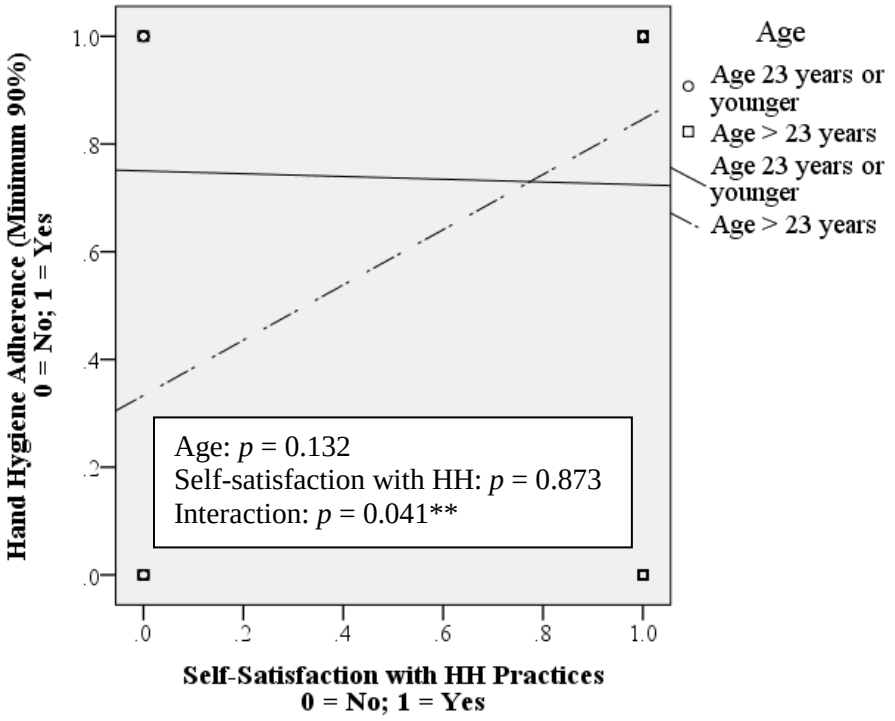
c.) ABHR damages my skin * Motivation: concern about reprimand/discipline



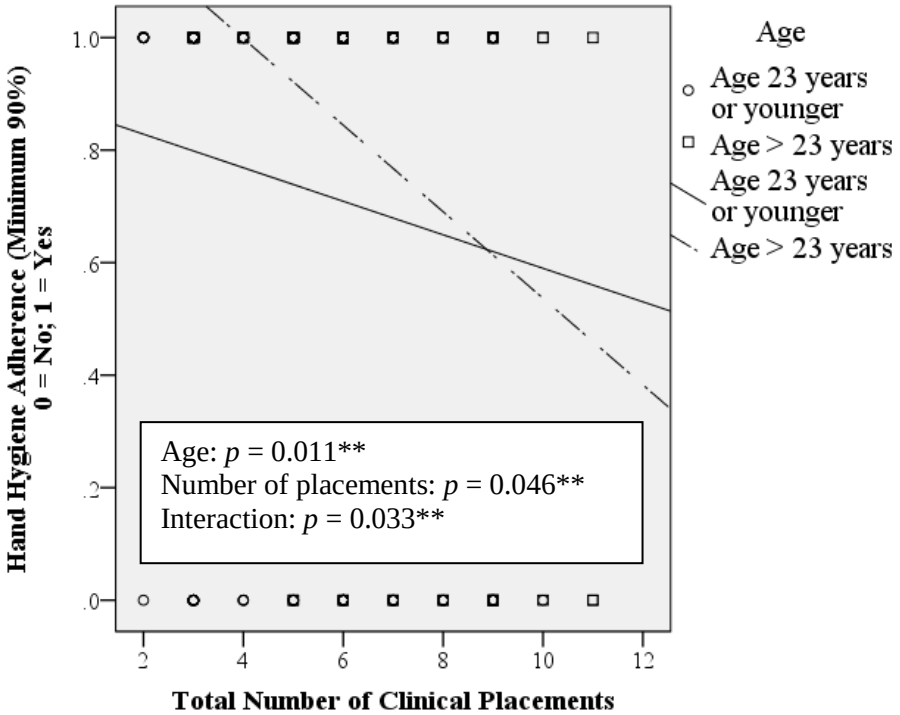
d.) Age * Nursing Program Level: Year 3

* denotes interaction; ** indicates $p < 0.05$

Figure 3. Continued



e.) Age * Self-Satisfaction with HH Practices



f.) Age * Number of clinical placements

Table 4 displays the results of the separate hierarchical logistic regression analyses performed for each pair of variables, with the main effects entered in the first block and the interaction terms entered in the second block.

Table 4.
Hierarchical Logistic Regression - Significance of Variables: Main Effects then Interaction Term

Dataset	Variables	*p* Block 1 (Main Effects Only)	*p* Block 2 (Interaction Added)
Merged	Gender	< 0.001**	0.074
	Forgetfulness	0.002**	< 0.001**
	Gender *Forgetfulness	----------	0.017**
	Formal HH Education	< 0.001**	0.116
	Forgetfulness	0.004**	< 0.001**
	Formal HH education * Forgetfulness	----------	0.006**
Physicians	Gender	0.026**	0.006**
	Hours worked per week	0.026**	0.006**
	Gender * Hours worked per week	----------	0.046**
	Forgetfulness	< 0.001**	< 0.001**
	Unsure of need	0.196	0.032**
	Forgetfulness * Unsure of need	----------	0.035**
Nursing Students	Forgetfulness	0.011**	0.002**
	Too busy	< 0.001**	< 0.001**
	Forgetfulness * Too busy	----------	0.030**

Table 4. Continued

ABHR damages skin	0.016**	0.002**
Skin on hands is dry, cracked/ irritated	0.154	0.021**
ABHR damages skin * Skin on hands is dry, cracked/irritated	----------	0.048**
ABHR damages skin	< 0.001**	0.011**
Motivation: concern about reprimand/ discipline	0.041**	0.015**
ABHR damages skin * Motivation: concern about reprimand/ discipline	----------	0.032**
Age	0.059	0.606
Nursing Program Level: 2	0.008**	0.122
Nursing Program Level: 3	0.005**	0.225
Age * Nursing Program Level: 2	----------	0.999
Age * Nursing Program Level: 3	----------	0.042**
Age	0.103	0.132
Self-satisfaction with HH practice	0.096	0.873
Age * Self-satisfaction with HH practice	----------	0.041**
Age	0.129	0.011**
Number of clinical placements	0.002**	0.046**
Age * Number of clinical placements	----------	0.033**

p = probability of accepting the null hypothesis at $\alpha = 0.05$; ** indicates $p < 0.05$

For each dataset (merged, physicians, and nursing students), logistic regression analyses were repeated with the interaction terms included in the original main effect

models. The results of these analyses are presented in Tables 5 (merged dataset), 6 (physician dataset), and 7 (nursing student database).

Table 5.
Step 4: Stepwise Logistic Regression Depicting Independent Predictors of HH Adherence Within Merged Dataset – Final Model After Adding Interaction Terms to Main Effects.

Variable	*B*	*SE*	*OR*	*p*	95% CI
HCP Position (0 = Physician)	1.30	0.26	3.67	<0.001	2.21 – 6.12
Busyness (0 = No)	-1.04	0.23	0.35	<0.001	0.22 – 0.56
Forgetfulness (0 = No)	-1.37	0.31	0.25	<0.001	0.14 – 0.47
Motivation: Patient-protection (0 = No)	1.13	0.34	3.08	0.001	1.60 – 5.96
Motivation: System-related (0 = No)	0.97	0.45	2.64	0.032	1.09 – 6.40
Damage to skin (0 = No)	-1.32	0.32	0.27	<0.001	0.14 – 0.50
Interaction: Gender * Forgetfulness	0.89	0.35	2.44	0.011	1.23 – 4.84

B = unstandardized regression coefficient; *SE* = standard error; *OR* = odds ratio; *p* = probability of accepting the null hypothesis at $\alpha = 0.05$; CI = confidence interval.

Table 6.
Stepwise Logistic Regression Depicting Independent Predictors of HH Adherence Within Physician Dataset (Budimir-Hussey et al., 2013) – Final Model After Adding Interaction Terms to Main Effects.

Variable	*B*	*SE*	*OR*	*p*	95% CI
HH Auditing (0 = No)	1.21	0.42	3.37	0.004	1.48 – 7.68
Too busy (0 = No)	-0.90	0.39	0.41	0.021	0.19 – 0.87
Forgetfulness (0 = No)	-1.49	0.41	0.23	< 0.001	0.10 – 0.50
Damages skin (0 = No)	-1.32	0.56	0.27	0.018	0.09 – 0.80

B = unstandardized regression coefficient; *SE* = standard error; *OR* = odds ratio; *p* = probability of accepting the null hypothesis at $\alpha = 0.05$; CI = confidence interval.

Table 7.
Stepwise Logistic Regression Depicting Independent Predictors of HH Adherence Within Nursing Students Dataset (Foote & El-Masri, 2016) – Final Model After Adding Interaction Terms to Main Effects.

Variable	*B*	*SE*	*OR*	*p*	95% CI
Motivation: concern about discipline if HH guidelines are not followed	1.37	0.54	3.95	0.010	1.38 – 11.32
Number of clinical placements	-0.26	0.07	0.77	<0.001	0.67 – 0.89
Barrier: busyness	-2.80	0.62	0.06	<0.001	0.02 – 0.21
Barrier: forgetfulness	-2.19	0.57	0.11	<0.001	0.04 – 0.34
Barrier: alcohol-based hand rub damages skin	-1.85	0.46	0.16	<0.001	0.06 – 0.39
Interaction: Busyness * Forgetfulness	2.04	0.72	7.70	0.005	1.86 – 31.80

B = unstandardized regression coefficient; *SE* = standard error; *OR* = odds ratio; *p* = probability of accepting the null hypothesis at $\alpha = 0.05$; CI = confidence interval.

Of the 10 interaction terms originally identified in the three datasets, two interactions remained significant: forgetfulness and gender within the merged dataset (*OR*, 2.44; 95% CI, 1.23-4.84) and forgetfulness and busyness within the nursing students dataset (*OR*, 7.70; 95% CI, 1.86–31.80). See Tables 8 and 9 for cross-tabulations comparing the percentages of HH adherent participants for each of these significant moderator variables.

Table 8.
Percentage of Hand Hygiene Adherent Participants (a minimum of 90% before and after patient contact) (Merged Dataset)

		GENDER	
FORGETFULNESS as a reason for non-adherence		Male	Female
	Yes	37	74
	No	67	78

Table 9.
Percentage of Hand Hygiene Adherent Nursing Students (a minimum of 90% before and after patient contact)

		BUSYNESS as a reason for non-adherence	
FORGETFULNESS as a reason for non-adherence		Yes	No
	Yes	57	77
	No	61	94

After controlling for interaction effects in the merged dataset, gender was no longer an independent predictor of HH adherence. The new model, with six independent predictors explains 23% to 32% of the variance in HH adherence within the combined sample. Within the physicians dataset (Table 6), the original model remained the same, with four independent predictors. However, when controlling for interaction effects, this model explains 22% to 30% of the variance in HH adherence, compared to the original 18% to 24% (Budimir-Hussey et al., 2013). Within the new nursing student model, six predictors (including the interaction between busyness and forgetfulness) explain 22% to 32% of the variance compared to the original 20% to 30% (Foote & El-Masri, 2016).

DISCUSSION

This study used a secondary analysis of existing data to explore effect moderation in the study of HH adherence. Due to the exploratory nature of this study that explored the existence of many possible main and moderating effects, only significant findings are discussed. Implications for practice, education, policy, and future research, including research methodology issues are also discussed.

Moderation

Without hypothesizing potential moderators a priori, pairs of variables were explored for moderation effects within the original and merged datasets. Prior to adjusting for potential confounding effects, a total of 10 possible interaction effects were identified in the three datasets. However, when the interaction effects were added into their respective (i.e., merged, physician, nursing student) regression models, only two interactions remained significant: (a) gender moderated the relationship between forgetfulness and HH adherence among physicians and nursing student participants (within the merged dataset); and (b) the perception of busyness as a reason for non-adherence moderated the relationship between perception of forgetfulness as a reason for non-adherence and HH adherence among nursing students.

Male participants who perceived forgetfulness as a reason for non-adherence had the lowest self-reported percentage of adherers (37%). This number increased to 67% for males who did not perceive forgetfulness as a reason for non-adherence. However, virtually no difference was noted between the proportion of female adherers who perceived forgetfulness as a reason for non-adherence (74%) versus those who did not perceive forgetfulness as such (78%).

In the nursing students dataset, among students who did not perceive forgetfulness as a reason for non-adherence, self reported HH adherers was a modest 61% in the subset of students who perceived busyness as a reason for non-adherence, as opposed to an impressive 94% in the subset of students who did not perceive busyness as a reason for non-adherence. Not surprisingly, the lowest percentage of adherers (57%) occurred when students perceived both busyness and forgetfulness as reasons for non-adherence, and was highest (94%) when neither busyness nor forgetfulness were perceived as such. This finding indicates that busyness and forgetfulness create a synergistic effect with regard to their impact on HH adherence. While previous studies have examined the influence of gender, busyness, and forgetfulness as main effects, this is believed to be the first study to find interactions between gender and forgetfulness, and between busyness and forgetfulness. These findings are therefore difficult to discuss within the context of previous literature. It is interesting to note however, that the interaction between busyness and forgetfulness was present only in the student database, but disappeared when the data were combined with the physician database. It is difficult to explain the reason for this, but it is possible that the merging of databases diluted the interaction effect, rendering it non-significant. That is, the interaction effect between these two variables may not have been in the same direction between the two databases.

Main Effects

When comparing the results in the physician database with those reported by Budimir-Hussey et al. (2013), the same four variables (busyness, forgetfulness, the perception that HH products damage the skin, and the existence of HH auditing at the workplace) remained as independent predictors of HH adherence when potential

interactions were examined. Other researchers have similarly found forgetfulness (Squires et al., 2014), busyness (Barrett & Randle, 2008; De Wandel, Maes, Labeau, Vereecken, & Blot, 2010; Erasmus et al., 2010; Knoll, Lautenschlaeger, & Borneff-Lipp, 2010), and concerns about skin damage (Al-Hussami, Darawad, & Almhairat, 2011; Barrett & Randle, 2008; Darawad, Al-Hussami, Almhairat, & Al-Sutari, 2012; Jang et al., 2010) to have negative effects on HH adherence; while auditing has previously been shown to be associated with increased HH adherence (Fuller et al., 2012; Jang et al., 2010).

Examination of interaction effects in the nursing student database resulted in a reduction in the number of main effects in comparison to those reported by Foote and El-Masri (2016). While busyness, forgetfulness, concerns about being disciplined if found not practising HH, number of clinical placements, and concerns about skin damage remained as predictors; patient protection as a motivating factor and role modelling by the clinical instructor were no longer significant. The presence of an interaction effect in the model could have resulted in a change in the nature of the main effects within the model.

Forgetfulness, busyness, and concerns about skin damage, all significant predictors in the original physician and nursing student studies, were similarly related to HH in the merged database. HH for patient-protection and system-related motivations (following protocol or concern about discipline/reprimand) both emerged as independent predictors of adherence in the merged database. These variables were also originally reported by Foote and El-Masri (2016) as independent predictors within the nursing students study (Foote & El-Masri, 2016), but not within the physicians study (Budimir-

Hussey et al., 2013). However, previous researchers have reported self-protection as motivation for HH (Al-Hussami, Darawad, & Almhairat, 2011; Allegranzi et al., 2013; Budimir-Hussey et al., 2010; Erasmus et al., 2010; Jang et al., 2010; Korniewicz & El-Masri, 2010; Mertz et al. 2011). However, when comparing reported HH adherence rates before physical contact with patients, 70% of participants perceived they were adherent before contact with patients, while 87% of participants reported they were adherent after patient contact. These rates suggest motivation to perform HH was actually based on self-perceived risk, rather than for patient protection; a finding more congruent with current literature.

Professional category emerged as an independent predictor of adherence (specifically, nursing students were more likely to adhere to HH protocols than were physicians). Researchers have also demonstrated a positive association between the nursing profession (compared to other professional groups, including physicians) and HH adherence (Azim & McLaws, 2014; Erasmus et al., 2010; Mertz et al., 2011; Rosenthal et al., 2013). However, these studies compared nurses with physicians (and other professional groups), not nursing students. Caution must also be taken in interpreting these results as Cole (2009) reported nursing students tend to overestimate their HH adherence.

Conventional wisdom dictates that we should ensure both main effects are included within the model when testing an interaction effect. However, due to the exploratory nature of this study, forward stepwise logistic regression was used to test for the presence of interaction effects. In doing so, gender no longer remained significant in the merged dataset, and was therefore removed from the model. However, the interaction

gender with forgetfulness remains in the final model and tells us more clinically, than the main effects alone.

Implications

The perception of busyness was an independent predictor of reduced HH adherence in all three databases, and interacted with forgetfulness to further reduce adherence in the nursing student database. These findings point to a need to address the issue of busyness (workload and time constraints) in health care settings, particularly among nursing students.

One possible implication for management includes ensuring that non-professional duties unrelated to patient care are eliminated from nurses' workloads (Knoll et al., 2010). In addition, education to nursing students should include reinforcing the relationship between busyness and decreased adherence and the importance of HH in reducing the transmission of HAIs (Foote & El-Masri, 2016). Education should also reinforce that the use of alcohol-based hand rub takes less time to use than soap and water (OAHPP, 2014). This might help mitigate the beliefs of some healthcare professionals that it's acceptable to knowingly skip HH during emergency situations and when workloads are especially heavy (Jang et al., 2010). Education of students should also review and reinforce all five moments for HH (WHO, 2006), regardless of personal motivations for performing HH (Whitby et al., 2006).

Interventions to strengthen prioritization and time management skills among nursing students may help to reduce their sense of busyness, and consequently help improve their HH adherence. Clinical instructors should also monitor their students' perceptions of busyness, and consider modifying their students' workloads as

appropriate. Students should be encouraged to honestly communicate to their instructors if they are feeling too busy to manage their assigned workloads. Nursing students commonly need help to properly structure their time and manage the work demands of clinical settings (Cleary & Horsfall, 2011). Further, clinical instructors and nurses need to model prioritization and ensure that hand hygiene is consistently identified as a high priority.

In recognition of the importance of remembering or thinking about HH, reminders in the workplace have been widely included as part of bundled approaches to improving HH (Akpaka, 2014; Ellingson et al., 2014; Huis et al., 2013; Rosenthal et al., 2013; Schweizer, et al., 2014), and are considered one of five essential elements of the WHO multimodal strategy for improvement of HH adherence (2009). Budimir-Hussey et al. (2010) also reinforced the continued need for visual cues and periodic HH campaigns as reminders; it is important that efforts such as this continue. To address the issue of forgetfulness among nursing students, instructors should provide consistent reminders to their nursing students, and model proper hand hygiene performance (Foote & El-Masri, 2016).

Previous research has demonstrated that performing HH audits can serve as a reminder to perform HH (Jang et al., 2010) and provide a form of social and professional pressure to adhere (Budimir-Hussey et al., 2010). Fuller et al. (2012) specifically recommended the use of audits combined with immediate feedback, including goal-setting and action planning, as an effective technique for improving HH practices. In recognition of the interaction identified in this study within the merged database between

gender and forgetfulness, a conscious effort should be made to ensure male healthcare professionals are included within HH audits.

Lastly, easy and sufficient access to skin-friendly products (De Wandel et al., 2010), including hand moisturizing products and emollient-containing alcohol-based hand rubs (OAHPP, 2014), and communication to healthcare professionals about these products (Budimir-Hussey et al., 2010) are recommended to address skin damage concerns.

The findings of this study have significant implications for research methodology as it pertains to the study of HH adherence. As discussed previously, the search for moderating effects among the predictors of HH adherence is scarce, at best. To deepen our understanding of how one variable affects another, we need to understand what limits or enhances an existing relationship, including the circumstances in which the effect exists (Hayes & Matthes, 2009). It is therefore important to explore moderating variables whenever there is reason to believe that such moderation exists, and that the impact of an independent variable on a given outcome will be different across different levels of a second independent variable. In the case that perfect moderation exists (i.e., an interaction with no main effect) but is not examined, one may erroneously report that an independent variable is not associated with an outcome, when in fact it might have had an association that was moderated by a second independent variable. Without investigating such effects, important relationships will be missed and our understanding of the true relationship between the independent variable and the outcome will be concealed (MacKinnon, 2011). Consequently, testing for moderation effects is of fundamental importance when studying human behaviour (Hayes & Matthes, 2009). Therefore,

whenever a researcher theoretically suspects a possible moderator, it must be included within the analysis as part of the main effects model.

The results of this study also highlight the fact that moderating effects can be confounded and that, as more variables are added to the analysis, some moderating effects may cease to exist. In this study, 10 interaction effects were originally identified based on models built with only two main variables. However, after adjusting for confounding via logistic regression by adding the interactions effects and their respective main effects back into larger models that include other independent variables, these interactions were no longer significant. Had the analysis not included this additional step, we would have erroneously concluded that all identified moderators were significant, when in fact most were not. This methodological approach provided a final model that is more likely to be representative of the true nature of relationships.

More research is needed to guide more targeted interventions to improve and sustain HH adherence among healthcare workers, including nurses, within acute care. Improvements in adherence may reduce the transmission of HAIs, thereby reducing associated morbidity, mortality, and health care costs. Although only two significant interaction effects were identified within this study, they highlight the importance of realizing the presence of a third variable isn't always a confounding effect for which we should control. A third variable may in fact be a moderator that provides important information about the subject matter. This is relevant clinically, in understanding that interventions to improve behaviour may not work the same for everyone. Whenever a moderator conceptually makes sense, we must consider the possibility of such a relationship and include moderation analysis within the research design.

Limitations

The inability to verify the accuracy of the data is an inherent limitation of secondary analysis studies (Johnston, 2014). Further, the self-report nature of the data carries the possibility of social desirability (Johnson & Fendrich, 2005) and response bias (Budimir-Hussey et al., 2010), although the assurance of anonymity in both surveys likely mitigated these effects. Also, this study was limited to the investigation of the variables in the original databases, and to those that were similar across both databases (i.e., variables not included in both original databases were excluded from analyses). It is not clear what other interaction effects may have existed if all conceptually relevant variables were subject to investigation.

Two separate datasets were pooled to increase the sample size and power of the current study, while simultaneously exploring professional group as a potential moderator. However, this merging of data from two relatively unrelated professional groups may have inadvertently neutralized some interaction effects. This may explain why the busyness/forgetfulness interaction was not present in the merged database. In addition, it would have been more appropriate to compare registered nurses to physicians; however, the researcher was unable to obtain data on HH adherence among registered nurses. Thus, it is important that future research directly explore moderating effects among nurses. Regardless, the results of this study (with different interactions identified within each of the datasets) highlight the importance of studying individual healthcare professional groups.

In consideration of the limitations of this study, future research using larger sample sizes and prospective designs should explore more complex relationships among

factors affecting HH adherence. Researchers should always pay attention to possible interaction effects, rather than run the risk of drawing misleading conclusions from incomplete analyses. As this was an exploratory study, potential moderator effects were not hypothesized prior to analysis. Future studies should use a conceptual framework and past research to hypothesize and test for possible moderators. According to Bennett (2000), this is especially warranted when the associations between the independent variables and outcomes are inconsistent across studies; the levels of a hypothesized moderator may explain what circumstances strengthen or weaken such a relationship. This may help clarify the overall lack of concensus among factors affecting hand hygiene, as reported within the review of the literature. Moving forward, the author hopes this study helps highlight the importance of exploring more complex statistical relationships, specifically within HH adherence research. Researchers should further explore moderators affecting HH to strengthen these preliminary findings and provide recommendations for future practice, education, and policy.

Conclusion

Exploration of moderation effects may provide a deeper understanding of certain relationships than studying direct effects alone. Without considering moderator effects in the data, a researcher may miss more exact explanations of the study phenomenon (Bennett, 2000). This study was the first to explore potential moderating factors affecting hand hygiene adherence and highlighted a promising area for future research.

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APPENDICES

Appendix A

Factors associated with hand hygiene adherence classified by study according to level of influence from the Theory of Ecological Perspective (McLeroy, Bibeau, Steckler, and Glanz, 1988) using Pittet (2004) as a guideline.

Factors associated with hand hygiene compliance/adherence (observed and self-report)				
Level of Influence	*Factor*	*References*		
Intrapersonal/Individual knowledge, attitudes, beliefs, personality traits (Curry & Cole, 2001; Pittet, 2004).				
		Positive Association	*Negative Association*	*No Relationship*
	Age	Al-Hussami, Darawad, & Almhairat, 2011 (univariate only)		Allegranzi et al., 2013 Darawad, Al-Hussami, Almhairat, & Al-Sutari 2012 Korniewicz & El-Masri, 2010 Sax, Uçkay, Richet, Allegranzi, & Pittet, 2007 Sharma, Sharma, Puri, & Whig, 2011
		Positive Association	*Negative Association*	*No Relationship*
	Years of experience	Al-Hussami, Darawad, & Almhairat, 2011 (univariate only)		Darawad Almhairat, & Al-Sutari, 2012 Korniewicz & El-Masri, 2010 Sax, Uçkay, Richet, Allegranzi, & Pittet, 2007

	Positive Association	*Negative Association*	*No Relationship*
Female gender	Rosenthal et al., 2013 Sax, Uçkay, Richet, Allegranzi, & Pittet, 2007	Korniewicz & El-Masri, 2010	Al-Hussami, Darawad, & Almhairat, 2011 Budimir-Hussey et al., 2010 Mertz et al., 2011

	Positive Association	*Negative Association*	*No Relationship*
Professional category (Nurse)	Azim & McLaws, 2014 (univariate only) Erasmus et al., 2010 (systematic review) Mertz et al. 2011 Rosenthal et al., 2013	Sharma, Sharma, Puri, & Whig, 2011 (reported lower HH rates for nurses; unsure if further analysis performed)	Al-Hussami, Darawad, & Almhairat, 2011 Allegranzi et al., 2013 Darawad, Al-Hussami, Almhairat, & Al-Sutari (2012) Korniewicz and El-Masri, 2010

	Positive Association	*Negative Association*	*No Relationship*
Self-protection and high-risk procedures	Al-Hussami, Darawad, & Almhairat, 2011 Allegranzi et al., 2013 Budimir-Hussey et al., 2010 Erasmus et al., 2010 (systematic review) Jang et al., 2010 (Qualitative study) Korniewicz & El-Masri, 2010 Mertz et al. 2011	Sharma, Sharma, Puri, & Whig, 2011 (defined high-risk to include high-risk of cross-transmission to patients)	

	Positive Association	*Negative Association*	*No Relationship*
Inherent versus elective	Barrett & Randle, 2008 (Qualitative study) Jang et al., 2010 (Qualitative study) McLaws, Maharlouei, Yousefi, & Askarian, 2012 Whitby, McLaws, & Ross, 2006		

	Positive Association	*Negative Association*	*No Relationship*
Positive attitude toward hand hygiene	Al-Hussami, Darawad, & Almhairat, 2011 Darawad, Al-Hussami, Almhairat, & Al-Sutari, 2012 De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 (negative attitude toward time-related barriers independently associated with poor adherence) Eiamsitrakoon, Apisarnthanarak, Nuallaong, Khawcharoenporn, & Mundy, 2013 Jang et al., 2010 (qualitative study) McLaws et al., 2012		De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 (no relationship between moral attitude of HH and adherence)

	O'Boyle, Henly, & Larson, 2001 (associated with intent to perform HH only) Pittet et al., 2004 Sax et al., 2007 (univariate only) Whitby, McLaws, & Ross, 2006		
	Inconclusive results: Erasmus et al., 2010 (systematic review)		

	Positive Association	*Negative Association*	*No Relationship*
Skin irritation and dryness		Al-Hussami, Darawad, & Almhairat, 2011 Barrett & Randle, 2008 (qualitative study) Budimir-Hussey et al., 2010 Darawad, Al-Hussami, Almhairat, & Al-Sutari, 2012 Jang et al., 2010 (qualitative study)	

	Positive Association	*Negative Association*	*No Relationship*
Knowledge of HH guidelines/ educational interventions	Barrett & Randle, 2008 (qualitative study) Fuller et al., 2012 (qualitative study) Jang et al., 2010 (qualitative study) Sharma, Sharma, Puri, & Whig, 2011 (only frequencies reported) Squires et al., 2014 (qualitative study)		De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 Dunn-Navarra et al., 2011 Jeong & Kim, 2016
	Inconclusive results: Erasmus et al., 2010 (systematic review)		

	Positive Association	*Negative Association*	*No Relationship*
Forgetfulness		Budimir-Hussey et al., 2010 Squires et al., 2014 (qualitative study)	

	Positive Association	*Negative Association*	*No Relationship*
High self-efficacy	De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 Sax et al., 2007 Squires et al., 2014 (qualitative study)		

Interpersonal

peer groups, family, friends, etc. (Curry & Cole, 2001; Pittet, 2004).

	Positive Association	*Negative Association*	*No Relationship*
Understaffing/ overcrowding and workload (including the subjective perception of stress caused by external factors)		Barrett & Randle, 2008 (qualitative study) Budimir-Hussey et al., 2013 De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 Erasmus et al., 2010 (systematic review) Knoll, Lautenschlaeger, & Borneff-Lipp, 2010 O'Boyle, Henly, & Larson, 2001 Pittet et al., 2004	Sharma, Sharma, Puri, & Whig, 2011

	Positive Association	*Negative Association*	*No Relationship*
Role models and social influence	Barrett & Randle, 2008 (qualitative study) Jang et al., 2010 (qualitative study) Pittet et al., 2004 Sax et al., 2007 Squires et al., 2014 (qualitative study) Whitby, McLaws, & Ross, 2006		De Wandel, Maes, Labeau, Vereecken, & Blot, 2010

	(except peer pressure from nurses had no impact)		

	Positive Association	*Negative Association*	*No Relationship*
Audit and feedback	Budimir-Hussey et al., 2010 Fuller et al., 2012 Jang et al., 2010 (qualitative study)		

Institutional

organizational factors that include the availability and access to policies, rules, and structures that help facilitate recommended behaviours (Curry & Cole, 2001; Pittet, 2004)

	Positive Association	*Negative Association*	*No Relationship*
High activity index (included previously as a measure of workload at the interpersonal level)		Barrett & Randle, 2008 (qualitative study) Budimir-Hussey et al., 2013 De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 Erasmus et al., 2010 (systematic review) Knoll, Lautenschlaeger, & Borneff-Lipp, 2010 O'Boyle, Henly, & Larson, 2001 Pittet et al., 2004	Sharma, Sharma, Puri, & Whig, 2011

	Positive Association	*Negative Association*	*No Relationship*
Skin irritation and dryness (included previously within the intrapersonal level)		Al-Hussami, Darawad, & Almhairat, 2011 Barrett & Randle, 2008 (qualitative study) Budimir-Hussey et al., 2010 Darawad, Al-Hussami, Almhairat, & Al-Sutari, 2012 Jang et al., 2010 (qualitative study)	

	Positive Association	*Negative Association*	*No Relationship*
Type of hospital unit	Eiamsitrakoon, Apisarnthanarak, Nuallaong, Khawcharoenporn, & Mundy, 2013 Erasmus et al., 2010 (systematic review) Korniewicz and El-Masri, 2010		Mertz et al., 2011

	Positive Association	*Negative Association*	*No Relationship*
Availability of hand hygiene products	Jang et al., 2010 (qualitative study) Mertz et al. 2011 Pittet et al., 2004 Squires et al., 2014		

	Positive Association	*Negative Association*	*No Relationship*
Institutional priority for hand hygiene, institutional safety climate, and administrative support	Jang et al., 2010 (qualitative study) Rosenthal, McCormick, Guzman, Villamayor, & Orellano, 2003 Rosenthal et al., 2013 Sax et al., 2007		

	Positive Association	*Negative Association*	*No Relationship*
Role models (colleagues or superiors)	Barrett & Randle, 2008 (qualitative study) Jang et al., 2010 (qualitative study) Pittet et al., 2004 Sax et al., 2007 Squires et al., 2014 (qualitative study) Whitby, McLaws, & Ross, 2006 (except peer pressure from nurses had no impact)		De Wandel, Maes, Labeau, Vereecken, & Blot, 2010

	Positive Association	*Negative Association*	*No Relationship*
Audit and feedback (included previously at the interpersonal level)	Budimir-Hussey et al., 2010 Fuller et al., 2012 Jang et al., 2010 (qualitative study)		

Community

Social networks and norms that exist formally and/or informally between individuals, groups and organizations. Within the hospital, this is the ward (Curry & Cole, 2001; Pittet, 2004)

	Positive Association	*Negative Association*	*No Relationship*
Attitude toward hand hygiene (including community norms, such as overall skepticism about the value of HH; attitude toward HH previously discussed at the individual/ intrapersonal level)	Al-Hussami, Darawad, & Almhairat, 2011 Darawad, Al-Hussami, Almhairat, & Al-Sutari, 2012 De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 (negative attitude toward time-related barriers independently associated with poor adherence) Eiamsitrakoon, Apisarnthanarak, Nuallaong, Khawcharoenporn, & Mundy, 2013 Jang et al., 2010 (qualitative study) McLaws et al., 2012 O'Boyle, Henly, & Larson, 2001 (associated with intent to perform HH only) Pittet et al., 2004 Sax et al., 2007 (univariate only) Whitby, McLaws, & Ross, 2006		De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 (no relationship between moral attitude of HH and adherence)

	Inconclusive results: Erasmus et al., 2010 (systematic review)		

Administrative/Public Policy

Includes local policies that support and manage practices for disease prevention, control, and management (Pittet, 2004)

	Positive Association	*Negative Association*	*No Relationship*
Administrative sanctions and rewards	Chou et al., 2010 (part of a bundled intervention) Mayer et al., 2011 (part of a bundled intervention)		

	Positive Association	*Negative Association*	*No Relationship*
Availability of hand hygiene products (included previously at the institutional level)	Jang et al., 2010 (qualitative study) Mertz et al. 2011 Pittet et al., 2004 Squires et al., 2014		

	Positive Association	*Negative Association*	*No Relationship*
Understaffing/ overcrowding and workload (included previously at the interpersonal level)		Barrett & Randle, 2008 (qualitative study) Budimir-Hussey et al., 2013 De Wandel, Maes, Labeau, Vereecken, & Blot, 2010 Erasmus et al., 2010 (systematic review) Knoll, Lautenschlaeger,	Sharma, Sharma, Puri, & Whig, 2011

		& Borneff-Lipp, 2010 O'Boyle, Henly, & Larson, 2001 Pittet et al., 2004	
	Positive Association	*Negative Association*	*No Relationship*
Senior management (administrative support) (included previously at the institutional level)	Jang et al., 2010 (qualitative study) Rosenthal, McCormick, Guzman, Villamayor, & Orellano, 2003 Rosenthal et al., 2013 Sax et al., 2007		
	Positive Association	*Negative Association*	*No Relationship*
Audit and feedback (included previously at the interpersonal and institutional levels)	Budimir-Hussey et al., 2010 Fuller et al., 2012 Jang et al., 2010 (qualitative study)		

Appendix B

Request for permission to use original nursing student database. Email correspondence with Anne Foote (Principal Investigator for nursing students study – Foote & El-Masri, 2016)

Anne Foote
Sat 2016-12-24, 2:31 PM

Hi Amanda,
Nice to hear from you, yes you can evaluate my data set.
Not sure what you would need from me - my SPSS data set?
Hope you have a great holiday!
Anne

Professor Anne Foote, RN, MScN, CCNE.

From: Amanda Mcewen
Sent: December 23, 2016 12:06 PM
To: Anne Foote
Subject: Request for permission related to thesis

Hello Anne,

I'm currently finishing my latest edits on my first two chapters of my thesis and working on Chapter 3 (methodology). I'm hoping to defend my proposal late January/early February. My thesis is titled "Exploring Effect Moderation in our Understanding of Hand Hygiene Predictors". Dr. El-Masri and I would like to pool a few sets of previously collected HH data to investigate interaction effects in HH research. I would really appreciate it if I could use your collected data as one of those data sets, so I am emailing you today to ask permission to do so. (Just to clarify, we are not planning to replicate your study, but instead want to explore possible interaction effects within the pooled data set.)

Please let me know if you have any questions regarding details of my study.

I hope you and your family have a very Merry Christmas and Happy New Year!

Thank-you,

Amanda

Amanda McEwen, RN, BScN, BSc (Biology), MScN Student
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