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Demographics and training factors associated with hand hygiene among nursing students in Solwezi, Zambia: a cross-sectional study

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Abstract

Background: The low compliance to effective hand hygiene has continued to fuel the high prevalence of Hospital Acquired Infections (HAI) in Africa. The large number of nursing students has a potentially high impact at reducing the HAI public health problem in Zambia. **Objective**: To determine the demographic/training factors associated with nursing student's hand hygiene knowledge in Solwezi, Zambia thus provide information for action necessary to reduce HAI. **Methods:** A quantitative cross-sectional survey using primary data collected via a WHO validated self-administered questionnaire distributed to student nurses≥ 18 years at Solwezi College of Nursing. 167/206 (81.1%) participants were recruited via stratified random sampling. Descriptive statistics and inferential statistics (Fisher's exact test and multinomial logistic regression) were calculated using SPSS version 25.0.**Results:** Most (60.5%) nursing students had moderate hand hygiene knowledge. Using Fisher's exact test, hand hygiene knowledge was significantly associated with three training factors: year of study (p=0.018), program of study (p=0.003), routine use of alcohol-based hand rub (p=0.017), and one perception factor: average percentage of hospitalised patients who develop HAI (p=0.015). Regression analysis showed that only program of study was significantly associated with hand hygiene knowledge; general nursing students were 24 times more likely to have a moderate knowledge score compared to public health nursing students, adjusted odds ratio =24.859, p = 0.029.**Conclusion:**Public health nursing students posed the highest risk of spreading HAI owing to inadequate hand hygiene knowledge; tailor made interventions should consider the different program specific attributes as guided by this study.

Keywords: Hand hygiene, Hospital Acquired Infection, Infection prevention, Nurse, Primary prevention, Zambia

Introduction

World Health Organisation (WHO) defines Hospital Acquired Infections (HAI) as infections that occur during the care of a patient in the hospital/healthcare facility which was absent or in the incubating period at admission [1]. Because most (84.4%, 124/147) developing countries (Zambia inclusive) don't have a functional national surveillance system in place, the prevalence of HAI is either unknown or underestimated because of the intricacies of making such a diagnosis[2,3].

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Nonetheless, HAI is a major public health problem with the prevalence ranging from 5.7% - 19.1% and upto 37% for those admitted in intensive care units in developing countries [1, 4, 3]

The transmission of HAI is based on the epidemiologic triad where a disease agent can potentially cause HAI in a susceptible host present in the hospital environment [5]. Despite various factors such as disease factors, host factors or environmental factors, this research focused on the Healthcare Worker (HCW) associated factors causing HAI with emphasis on hand hygiene. To prevent transmission of HAI, WHO recommends effective hand hygiene as the most effective measure [6]. However, prerequisite knowledge about the moments to perform hand hygiene is essential to all HCW's including nurses to reduce the HAI incidence (i.e. primary prevention) (see Figure 1).

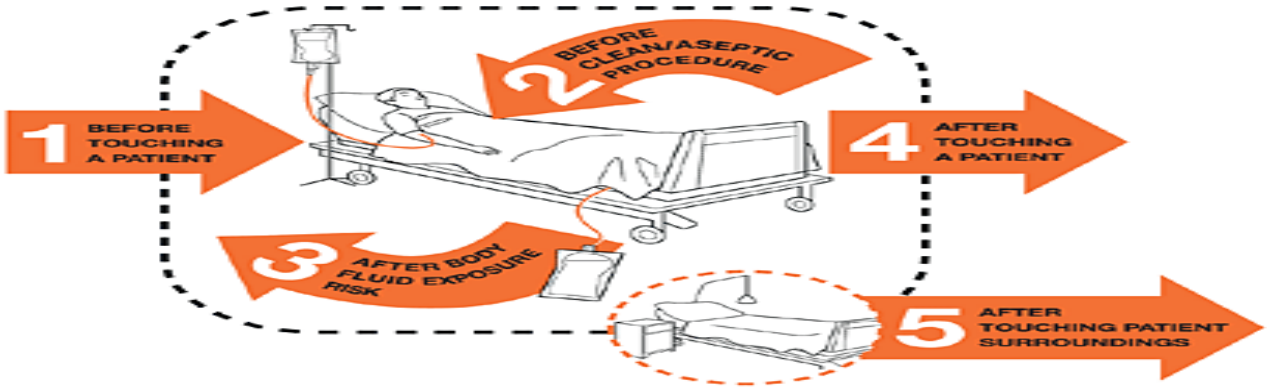

Fig 1: Five moments when to perform hand hygiene to reduce HAI's[1,7]

In a resource-limited setting like Zambia, treatment of HAI's (i.e. secondary prevention) is an economic burden due to costs related to prolonged hospital stay, patients out of pocket, increased chances of drug resistance, post-discharge complications, extra diagnostic and medical procedures [8]. Nurses can help to reduce HAI disease burden because they are the largest (47.2%) in number and most widely distributed among all HCW's according to Zambia's National Human Resources for Health Strategic Plan 2011-2015. Despite the inequitable distribution of nurses and other HCW's, strengthening measures to improve hand hygiene among nursing students would potentially have a positive impact on reducing HAI[9].This study examined the public health aspect of the problem of HAI by focusing on primary prevention using student nurses. This was achieved by exploring the demographic and training factors associated with nursing student's knowledge of hand hygiene in Solwezi, Zambia to ultimately provide information for action necessary to reduce HAI. Furthermore, this is consistent with primary prevention efforts being currently spearheaded by the Zambian Ministry of Health in line with the 2016 health reforms [10]. Hence the information generated from this research will inform policymakers at General Nursing Council of Zambia (GNC) and contribute to initiatives aimed at improving students hand hygiene techniques during clinical placements in hospitals to reduce the HAI public health problem. Globally, reduced HAI will compliment Sustainability Development Goal number 3 (SDG 3) to "ensure healthy lives and promote well-being for all at all ages" [11].

Materials and methods

Study design

A cross-sectional epidemiological survey using a WHO validated self-administered questionnaire was employed[5].

Setting

The study occurred at SCN located in the urban suburbs in Solwezi city, of Solwezi district in North Western Province of Zambia. The public institution was established in 1988 and has been approved by the General Nursing Council (GNC) of Zambia to train general nurses, and recently in 2018 started training public health nurses and midwives for 3 years, students graduate with a Diploma [12].

Sampling

The sampling frame was a total of 446 nursing student attending SCN during the 2017/2018 academic year [13]. Using class lists, two stage stratified random sampling via both year of study and program of study was done in Microsoft Excel 2016. The inclusion criteria for participation in the study were: nursing students of any gender at SCN pursuing any program and were 18 years and above. The exclusion criteria were: students below 18 years. After accounting for a 10% non-response rate, the total sample size needed was 206 nursing students[14].

Ethics

Ethical clearance was obtained from Tropical Disease Research Center TRC/C4/04/2018 in Zambia and the University of Liverpool Research Ethics Committee in United Kingdom, while gatekeeper permission was granted by SCN. WHO granted permission (number 268378) to use the validated structured questionnaire titled 'Hand Hygiene Knowledge' and 'perception survey for healthcare workers' [15]. Confidentiality

and anonymity were also maintained, each participant provided written consent before inclusion in the study.

Recruitment and data collection methods

Primary data was collected for three weeks. The researcher notified management once on the nursing school premises before any data collection began. Potential participants selected via a stratified random list were approached, invited to participate in the study and asked to review the participant information sheet that the researcher discussed in class. Eligibility check was done by confirming that any student nurse was 18 years and above. Eligible students were then asked to pick up a questionnaire at their own time from a common centrally located place and were shown where to return the completed questionnaire with a signed consent form

Scoring of Hand hygiene knowledge related questions

Based on literature review, a 1 point score and 0 point score was allocated for each correct and wrong responses respectively available from WHO titled 'Data Summary Response framework'. [16,17]. Out of 20 maximum points, 'knowledge' (also dependent variable) was deemed 'good' if >75% of responses were correct, 'moderate' 50 – 74% and 'poor' if <50%.

Scoring of Hand hygiene perception related questions

The perception questions were not gauged as correct or wrong in the 'Data Summary Response framework' because they simply communicated how nursing students interpreted the hand hygiene topic.

Data analysis

Descriptive statistics

Categorical variables were reported with frequency and percentage. For normally distributed data (i.e., Shapiro Wilk Test,$p \geq 0.05$), continuous variables were reported using mean (standard deviation, SD). Median and interquartile range (IQR) were used for non-normal distribution[18].

Inferential statistics – Bivariate Analysis

Fisher's exact test was used for the null hypothesis that 'there was no association between nursing students hand hygiene knowledge and any demographic/training factor'. The null was rejected when the selected $\alpha < 0.05$[19]. The use of Chi-square test was not applicable because of assumption violation, i.e. in more than 20% of cells, the expected frequency was less than 5[18].

Inferential statistics – Multivariate Analysis

Multinomial logistic regression was used to determine the strength of the relationship between the demographics/training factors and student nurses hand hygiene knowledge. Initially, univariate multinomial logistic regression was used to determine which variables qualified to be included in the multivariate multinomial logistic regression analysis using p value cut off of 0.1 [20,21]. Ordinal regression was not used because the assumption of proportional odds was violated, the test of parallel lines was used to confirm[22].

Results

Demographic and training factors for nursing students

A total number of 167 nursing students participated thus giving a response rate of 81.1%, 71.3% were female. Most students (55.7%) home city was in North Western Province, and the median age was 22.00 with IQR of 4. Age was not normally distributed ($p< 0.001$) and was highly skewed to the right with more than half (57%) being in the age group 21 – 25 years, 29.1 % in the age group 16 – 20 years and a few (13.9%) ≥ 26 years. The majorities were pursuing general nursing (73.3%) and almost all (91.3%) students were straight from high school with the rest upgrading from certificate (enrolled nursing) to diploma (general nursing). Most students (23.3%) were doing their clinical placement from mixed medical/surgical wards such as Kabompo Female and Zambezi Male wards, 13.6% were under Internal Medicine in Kifubwa Female and Mutanda Male wards. Regarding education, 67.9% of student's fathers had attained tertiary education compared to 39.5% for mothers. About half (53.6%) of the households had members between 6 – 10 individuals. A larger proportion (73.5%) mentioned that they had received formal hand hygiene training in the last three years, however, only half (50.0%) of the students used alcohol-based hand rub on a routine basis.

Hand hygiene Knowledge of Participants

Most respondents (60.5%, n = 167) had moderate knowledge about hand hygiene, 35.3% had poor knowledge and 4.2% had good knowledge (see Figure 2). Overall, out of 20, the median knowledge score was 10.00 with IQR 2 and was not normally distributed, $p <$ 0.001, with left skewness since the mean score of 9.87 < median score of 10.00. The individual hand hygiene knowledge aspects which contributed to the overall aggregated knowledge score are shown in

with correct response in red.

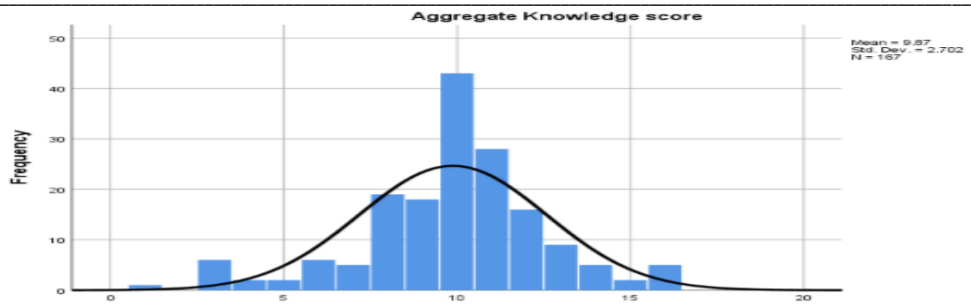

Fig 1 : shows nursing students knowledge score, 35.3% had poor score, 60.5% had moderate, 4.2% had a good score. The median knowledge for all participants was 10.00 with IQR 2

Table 1 below shows that despite most students (63.0%) knowing that hands are the correct main route of cross contamination, more than half (51.9%) wrongly mentioned that the main source of germs was the hospital instead of the patient. More than half of students did not know the type of hand hygiene required before palpation, before giving injections, after making a patients bed, after emptying bedpans, and after removing gloves. Students responded well on how to reduce the likelihood of colonisation by not wearing jewellery or artificial nails.

Table 1: shows the student responses which were aggregated to contribute to the overall knowledge score (i.e. Dependent variable)

Qn	Variable	Responses	
19	Main route of cross-contamination between patients	n = 162, HCW hands not clean 63.0%, Air circulating in hospital 6.2%, Patients exposure to colonised surfaces 21.0%, Sharing non-invasive objects 9.9%	
20	Frequent source of germs for HAI	n = 162, Hospitals water system 9.9%, Hospital air 4.9%, Germs already present on or within the patient 33.3%, Hospital environment 51.9%	
21	Hand Hygiene actions to prevent transmission of germs to patient	n = 160, Before touching a patient	Yes 90%, No 10%
		n = 149, Immediately after a risk of body fluid exposure	Yes 81.9%, No 18.1%
		n = 141, After exposure to immediate surroundings of a patient	Yes 54.6%, No 45.4%
		n = 149, Immediately before a clean/aseptic procedure	Yes 85.9%, No 14.1%
22	Hand Hygiene actions to prevent transmission of germs to HCW	n = 155, After touching a patient	Yes 80.6%, No 19.4%
		n = 156, Immediately after a risk of body fluid exposure	Yes 84.6%, No 15.4%
		n = 153, Immediately before a clean/aseptic procedure	Yes 72.5%, No 27.5%
		n = 151, After exposure to immediate surroundings of a patient	Yes 72.2%, No 27.8%
23	Type of hand hygiene required	n = 160, Before palpation of abdomen	Rubbing 33.8%, Washing 66.3%, None 0%
		n = 160, Before giving injection	Rubbing 31.9%, Washing 66.9%, None 1.2%
		n = 161, After empting bed pan	Rubbing 5.0%, Washing 94.4%, None 0.6%
		n = 160, After removing examination gloves	Rubbing 12.5%, Washing 86.9%, None 0.6%
		n = 160, After making a patients bed	Rubbing 18.9%, Washing 81.3%, None 0%
		n = 160, After visible exposure to blood	Rubbing 8.1%, Washing 91.9%, None 0%
24	Following to avoid, increases likelihood of colonisation of hands with harmful germs	n = 162, Wearing jewellery	Yes 92.0%, No 8.0%
		n = 157, Damaged Skin	Yes 96.2%, No 3.8%
		n = 159, Artificial fingernails	Yes 97.5%, No 2.5%
		n = 154, Regular use of a hand cream	Yes 43.5%, No 52.1%

Hand hygiene Perception of Participants

Students were of the perception that 51.43% (SD 23.9%) of all hospitalized patients developed HAI (figure 3) despite 90.4% of participants mentioning that hand hygiene was either highly or very highly effective at preventing HAI. More than half (58.1%) of students mentioned that a big effort was required to perform good hand hygiene. Students recognised that 71.6% (SD 21.1%) of situations required performing hand hygiene. Overall most students (71.3%) indicated that hand hygiene at SGH was either a high priority or a very high priority.

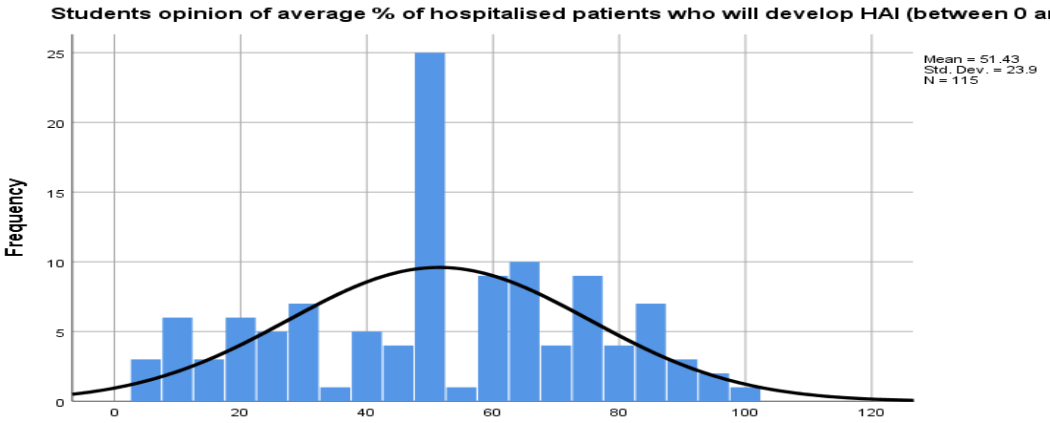

Figure 2: shows participants opinion about the average percentage of hospitalised patients who will develop HAI (between 0 and 100%)

Association between demographics/ training factors and hand hygiene knowledge – crosstabulation and fisher's exact test

The Fisher's exact test of independence (see Table 2 toTable 5) showed that mostly training factors were significantly associated with hand hygiene knowledge, these were: year of study (p=0.018), program of study (p=0.003), routine use of alcohol-based hand rub (p=0.017), perception of average percentage of hospitalised patients who develop HAI (p=0.015). Demographics and training factors not associated with hand hygiene knowledge included: ward, home city, gender, age, religion, marital status, mode of learning, years of experience, mother's highest education, father's highest education, and household size.

Year of Study

Table 2: shows cross tabulation between year of study and hand nursing student's hygiene knowledge

			Nursing Student hand Hygiene Knowledge score			Total
			Poor (< 50%)	Moderate (50 - 74%)	Good (> 75%)	
Year of study	First	Count	23	52	7	82
		% within Year of study	28.0%	63.4%	8.5%	100.%
	Second	Count	18	16	0	34
		% within Year of study	52.9%	47.1%	0.0%	100.%
	Third	Count	18	31	0	49
		% within Year of study	36.7%	63.3%	0.0%	100.%
Total		Count	59	99	7	165
		% within Year of study	35.8%	60.0%	4.2%	100.%

Program of Study

Table 3: shows cross tabulation between program of study and nursing student's hand hygiene knowledge

			Aggregate Knowledge score			Total
			Poor (< 50%)	Moderate (50 -74%)	Good(>75%)	
Program of study	General Nursing	Count	45	74	2	121
		% within Program	37.2%	61.2%	1.7%	100.%
	Midwifery	Count	3	19	3	25
		% within Program	12.0%	76.0%	12.0%	100.%
	Public Health Nursing	Count	9	8	2	19
		% within Program	47.4%	42.1%	10.5%	100.%
Total		Count	57	101	7	165
		% within Program	34.5%	61.2%	4.2%	100.%

Routine use of Alcohol-based hand rub

Table 4 : shows cross tabulation between 'routine use of alcohol hand rub' and nursing student's hand hygiene knowledge

			Aggregate Knowledge score			Total
			Poor (< 50%)	Moderate (50 - 74%)	Good (> 75%)	
Routinely use of alcohol-based handrub for hand hygiene?	Yes	Count	31	49	0	80
		% within users	38.8%	61.3%	0.0%	100.0%
	No	Count	24	49	7	80
		% within users	30.0%	61.3%	8.8%	100.0%
Total		Count	55	98	7	160
		% within users	34.4%	61.3%	4.4%	100.0%

Average percentage of patients to develop HAI

Table 5: shows cross tabulation between nursing student's hand hygiene knowledge and perception of average % of patients who develop HAI

			Aggregate Knowledge score			Total
			Poor (< 50%)	Moderate (50 -74%)	Good (> 75%)	
Perception of average percentage of hospitalised patients who develop HAI	0 - 20%	Count	3	15	0	18
		%	16.7%	83.3%	0.0%	100.0%
	21 - 40%	Count	2	13	3	18
		%	11.1%	72.2%	16.7%	100.0%
	41 - 60%	Count	18	19	2	39
		%	46.2%	48.7%	5.1%	100.0%
	61 - 80%	Count	12	15	0	27
		%	44.4%	55.6%	0.0%	100.0%
	81 - 100%	Count	3	10	0	13
		%	23.1%	76.9%	0.0%	100.0%
Total		Count	38	72	5	115
		%	33.0%	62.6%	4.3%	100.0%

Univariate analysis with multinomial regression

Selection of predictor variables

Six predictor variables showed a significant univariate association (at p = 0.1 cutoff) with the respondent's knowledge score, all were training factors except one. They included: year of study, program of study, having undergone formal training in the last three years, Year in which formal training was undertaken, routine use of alcohol-based hand rub, and perception of percentage of hospitalised patients who develop HAI. No test assumptions were violated such as multicollinearity (i.e. VIF < 5), proportional odds (Durbin Watson test between 1.5 – 2.5) and no outliers.

Multivariate analysis with multinomial regression

Adjusted odds ratio for nursing students hand hygiene knowledge by demographic and training factors

As shown in Table 6a significant unique contribution was made by general nursing students with a moderate knowledge score. The multivariate multinomial regression model shows that students training to be general nurses compared to public health nurses were 24 times more likely to obtain a moderate knowledge score, adjusted odds ratio (AOR) = 24.859 (95% CI 1.382 – 446.993), p = 0.029. The significant result is confirmed because the confidence interval does not cross1.0. Despite midwifery students being 8 times more likely than public health nursing students to obtain a moderate knowledge score, the result showed no statistical significance AOR = 8.619 (95% CI 0.094 – 791.447), p = 0.350. The remaining five variables also showed no statistical significance. The reference was poor hand hygiene knowledge score. For the predictor variables, the last category was used as reference and its Exp (B) value denoted as 0b in Table 6. Missing data was not included in the statistical analysis.

Multinomial Logistic Regression Parameter Estimates									
Aggregate Knowledge score[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% CI for Exp(B)	
								Lower Bound	Upper Bound
Moderate (50 - 74%)	Intercept	-5.798	4.152	1.950	1	.163			
	Year of study=First	.108	1.144	.009	1	.925	1.114	.118	10.489
	Year of study=Second	.367	1.364	.073	1	.788	1.444	.100	20.923
	Year of study=Third	0[b]	.	.	0	.	.	.	.
	Program of study=GN	**3.213**	**1.474**	**4.751**	**1**	**.029**	**24.859**	**1.382**	**446.993**
	Program of study=M	2.154	2.306	.872	1	.350	8.619	.094	791.477
	Program of study=PHN	0[b]	.	.	0	.	.	.	.
	Formal training in the last 3 years=Yes	2.803	3.388	.684	1	.408	16.492	.022	12616.543
	Formal training in the last three years=No	0[b]	.	.	0	.	.	.	.
	Year of Training=2018	2.383	1.485	2.575	1	.109	10.834	.590	198.970
	Year of Training=2017	-1.363	1.478	.851	1	.356	.256	.014	4.634
	Year of Training=2016	1.283	1.360	.889	1	.346	3.607	.251	51.898
	Year of Training=Before 2016	0[b]	.	.	0	.	.	.	.
	Use an alcohol-based handrub=Yes	-1.497	.768	3.803	1	.051	.224	.050	1.008
	Use an alcohol-based handrub=No	0[b]	.	.	0	.	.	.	.
	Average % of hospitalised patients=0-20%	3.030	1.746	3.012	1	.083	20.698	.676	634.106
	Average % of hospitalised patients=21-40%	1.926	1.646	1.369	1	.242	6.859	.273	172.636
	Average % of hospitalised patients =41-60%	-.495	1.228	.163	1	.687	.610	.055	6.761
	Average % of hospitalised patients =61-80%	1.722	1.379	1.560	1	.212	5.595	.375	83.457
	Average % of hospitalised patients=81-100%	0[b]	.	.	0	.	.	.	.
Good (> 75%)	Intercept	44.049	47492.862	.000	1	.999			
	Year of study=First	1.767	12711.467	.000	1	1.000	5.851	.000	.[c]
	Year of study=Second	-.836	.000	.	1	.	.434	.434	.434
	Year of study=Third	0[b]	.	.	0	.	.	.	.
	Program of study=RN	-32.073	9053.695	.000	1	.997	1.178E-14	.000	.[c]
	Program of study=RM	36.975	23488.558	.000	1	.999	1142610257660108.000	.000	.[c]

	Program of study=PHN	0[b]	.	.	0	.	.	.	.
	Formal training in hand hygiene in the last 3 years=Yes	-33.685	51909.771	.000	1	.999	2.348E-15	.000	.[c]
	Formal training in hand hygiene in the last three years=No	0[b]	.	.	0	.	.	.	.
	Year of Training=2018	-32.695	8287.956	.000	1	.997	6.323E-15	.000	.[c]
	Year of Training=2017	-36.241	.000	.	1	.	1.822E-16	1.822E-16	1.822E-16
	Year of Training=2016	-33.035	12948.304	.000	1	.998	4.498E-15	.000	.[c]
	Year of Training=Before 2016	0[b]	.	.	0	.	.	.	.
	Use an alcohol-based handrub=Yes	-33.371	27099.036	.000	1	.999	3.214E-15	.000	.[c]
	Use an alcohol-based handrub=No	0[b]	.	.	0	.	.	.	.
	Average % of hospitalised patients=0-20%	-31.725	.000	.	1	.	1.667E-14	1.667E-14	1.667E-14
	Average % of hospitalised patients=21-40%	39.942	22378.166	.000	1	.999	2220816148709758808.000	.000	.[c]
	Average % of hospitalised patients =41-60%	3.729	15468.506	.000	1	1.000	41.628	.000	.[c]
	Average % of hospitalised patients =61-80%	-32.377	.000	.	1	.	8.688E-15	8.688E-15	8.688E-15
	Average % of hospitalised patients=81-100%	0[b]	.	.	0	.	.	.	.
a. The reference category is: Poor (< 50%).									
b. This parameter is set to zero because it is redundant.									
c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing. GN =General Nursing, M = Midwifery, PHN = Public Health Nursing									

Table 6 shows the results of multivariate multinomial regression results, the reference group was poor knowledge score. Furthermore, SPSS used the last category of each predictor variable as the reference hence it'sexp (B) or β is denoted 0b

Discussion

Knowledge of hand hygiene

Most (60.5%, n = 167) nursing students had moderate hand hygiene knowledge while some (35.3%) had poor knowledge and a few (4.2%) had good knowledge. There was no second or third year nursing student with a good knowledge score and also in-service nurses (upgrading from enrolled nursing to general nursing) who had years of experience working in the health sector had moderate and poor hand hygiene knowledge in this study. This implies that as the year's progress from first to third and finally qualifying as a nurse, there was little residual knowledge of hand hygiene remaining hence the need for refresher lessons either in class for students or through continuous professional development for qualified nurses. This study contradicts two Zambian and one Nigerian cross-sectional studies.Chiboola, (2017) reported that most (67%) HCWs inclusive of nurses in Zambia had high knowledge about infection prevention practices (IPP) such as hand hygiene and Chitimwango, (2017) showed that the mean knowledge score among nurses was high with 83.2% (SD 11.5%)[**24**,**25**]. The Nigerian study by Olalekan *et al.,* (2018) showed that hand hygiene knowledge among HCWs including nurses was very good 13.0%, good 72.2% and poor 14.8%[**26**]. The inconsistency is because of differences

in study topics, differences in data collection tools, differences in knowledge scoring criteria. The literature reviewed reveals a knowledge gap exists; however, this may vary when compared with other LMICs. In comparison, this study's findings resonate with a Pakistani study by Salman *et al.,* (2018)where 85.1% of HCWs inclusive of nurses had moderate knowledge, 14.9% had poor knowledge and 0% had good knowledge and also a Sri Lankan study by Lien *et al.,* (2018) where 75.2% of HCWs inclusive of nurses had moderate hand hygiene knowledge[**27**,**28**]. The studies are comparable because of similarities in data collection method (using WHO validated knowledge questionnaire), and use of the same knowledge grading criteria (with <50 meaning poor, 50 – 74% moderate and ≥75% good).

Perception about hand hygiene

Perception of the HAI magnitude caused by ineffective hand hygiene is one of the major cues to action in the Health Belief Model. The mean (SD) of students perception that all hospitalised patients develop HAI was 51.43% (23.9%) which is double the HAI prevalence of 5.7% - 19.1% mentioned earlier and also shows that students strongly regard HAI as a significant healthcare problem[**3**,**4**]. 90.4% of students mentioned that hand hygiene was either highly or very highly effective. This study's results are similar to an Ethiopian study by Hussen *et al.,* (2017)where 94.1% of participants understood the effectiveness of hand hygiene in averting HAIs[**29**]. While other studies have mentioned that hand hygiene is effective, they have not given a percentage to compare with this study[**30**,**31**,**32**,**33**].A potential barrier to hand hygiene action is that more than half (58.1%) of students were of the perception that a big effort was required to perform good hand hygiene. The reasons for such a consideration should be explored in another study. The Zambian cross-sectional study by Chiboola, (2017) showed that despite all HCW including nurses having good attitude towards IPP, the practice was only at 20%[**24**]. Consistently, another Nigerian cross-sectional study by Kudavidnange *et al.,*(2014) found that despite poor practice, 47.5% of HCW had good attitude towards hand hygiene[**34**]. This highlights an anomaly that having knowledge and good perception may not always translate to adequate hand hygiene practices, this can be explored in depth using a qualitative approach. The mean (SD) of students in this study who recognised the percentage of situations requiring hand hygiene action was 71.6% (21.1%). However, students were not directly observed in the wards performing hand hygiene to calculate compliance.

Program of Study

Fisher's exact test of independence revealed that among student nurses at SCN, the program of study and knowledge score were highly significantly associated $\chi^2 = 14.68$, $p = 0.003$. Post hoc comparisons of different nursing programs (general nursing, midwifery and public health nursing) by knowledge score (poor, moderate or good) revealed that good hand hygiene knowledge was noted among general nursing students. This discrepancy probably arises because general nursing has been offered at SCN for decades since inception compared to the two new programs (midwifery and public health nursing) whose first intake began in 2018. This finding also implies that lecturers of general nursing students can share their teaching experiences about hand hygiene to improve the practice among other programs. Furthermore, intrinsic student factors such as differences in Intelligence Quotient could have potentially biased the results. No other study has examined hand hygiene knowledge in different nursing student cadres hence these findings are incomparable with other low and middle-income countries (LMIC) studies. Multivariate multinomial logistic regression was carried out to predict how various demographic and training factors interplayed to affect a student's knowledge score. Similar to the Fisher's exact test results, students pursuing general nursing contributed significantly to the model, Adjusted Odds Ratio (AOR) = 24.859 (95% CI 1.382 – 446.993), $p = 0.029$, while all other demographic and training factors did not. The odds of obtaining a moderate knowledge score for midwifery students was 8.619times more compared to that for public health nursing students. The difference in scores was likely because of the six months enrollment gap between programs.

Year of Study

After examining the association between year of study and knowledge score, the Fisher's exact test of independence showed that there was a statistically significant relationship among nursing students $\chi^2 = 10.98$, $p = 0.018$. This provided strong evidence to reject the null hypothesis that there was no relationship between the year of study and student nurses hand hygiene knowledge at SCN. Furthermore, post hoc tests showed that nursing students in their first year at SCN were more likely to exhibit good knowledge about effective hand hygiene compared to second and third years. This probably happens because only first years are extensively oriented in the first semester for 11 weeks concerning IPP with emphasis to hand hygiene under fundamentals of nursing which is one of the foundational courses before commencing clinical placement. However, the result was not significant

because the p value of 0.006934 was higher than the Bonferroni adjusted p value of 0.00556. This is the first LMIC study to show such a relationship and thus findings are unique and unmatched. Nevertheless, as mentioned earlier, this finding emphasises the need to conduct refresher hand hygiene lessons and practicals especially for third years before graduation. When multinomial logistic regression was applied to account for confounders, no association was identified. Nonetheless, as shown inTable 6 second years were more likely than third years to obtain a moderate knowledge score. Higher knowledge score would have been expected in the third years (also graduating students) yet this was not the case probably because of differences in application of knowledge by students and 'relaxation' by third years with regards to basic nursing skills.

Routine use of alcohol-based hand rub

This study showed a statistically significant relationship between hand hygiene knowledge score and routine use of alcohol-based hand rub $\chi^2 = 8.195$, p = 0.017 via Fisher's exact test. Post hoc analysis revealed that nursing students with good knowledge about hand hygiene routinely used alcohol-based hand rub. The result was significant because the p value 0.00682 was less than the Bonferroni adjusted p value of 0.008333. This is the first study to show a relationship between self-reported use of alcohol-based hand rub and hand hygiene knowledge score. However, when multinomial logistic regression was used to account for confounders, there was no statistically significant relationship.

Study Strengths

The high response rate (81.1%) reduced the potential for non-response bias because the pickup/drop point for the questionnaire was located in a common central place. This study's findings demonstrate high inter-rater reliability when compared to other LMIC study's in Sri Lanka [**34**]and Pakistan[**28**] which also used the same scoring criteria, a WHO validated questionnaire and random sampling reported similar results that most students achieved a moderate knowledge score[**35**].

Study Limitations

A selected sample of 167 students from one nursing college meant that this is not a true representation of students hand hygiene knowledge in Zambia with more than 60 nursing colleges [**12**]. Furthermore, this study did not establish a temporal relationship showing that knowledge of hand hygiene is a prerequisite to good practice.

Conclusion

Despite the nursing student's first year foundation courses teaching hand hygiene and having practical's in the hospital, the prevalence of HAI remains high in Zambia. This study revealed that 60.5% of students had moderate knowledge of hand hygiene. Moreover, 90.4% of students were of the perception that despite hand hygiene being effective, more than half (58.1%) of the students indicated that a big effort was required to perform the act. Inference was made that only one training factor (i.e. program of study) was significantly associated with students' knowledge towards hand hygiene. In decreasing order of hand hygiene knowledge, general nursing students were better than midwifery students who were also better than public health nursing students. Based on the findings, public health nurses in Solwezi, Zambia were at highest risk of spreading HAI due to their inadequate hand hygiene knowledge. Hence nursing students may benefit from refresher lessons/practicals to improve application of knowledge into practice. At individual level, students must generate sufficient individual interest and professionalism to safeguard the patient's health through effective and consistent application of hand hygiene knowledge. Finally, high impact interventions to minimise HAI should target training factors with a greater likelihood of causing HAI. Implementing the tailored intervention will support Zambia's statutory instrument number 10 of 2018 on hand washing and hand hygiene under the Ministry of Local Government[**36**]. Globally, reduced HAI will compliment SDG 3[**11**].

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References

1. WHO. Guidelines on Hand Hygiene in Health Care: a Summary. [Internet]. Geneva: World Health Organisation; 2009 [cited 2018 February 27]. Available from: http://www.who.int/gpsc/information _centre/hand-hygiene-summary/en/.
2. WHO. The burden of healthcare-associated infection worldwide fact sheet. [Internet]. 2010 [cited 2018 December 16]. Available from: https://www.who.int/gpsc/country_work/summary_20100430_en.pdf.
3. Nejad SB, Allegranzi B, Syed SB, Ellis B, Pittet D. Health-care-associated infection in Africa: a

systematic review. [Internet]. 2011 [cited 2017 November 9]. Available from: http://www.who.int /bulletin /volumes /89/10/11-088179/en/.
4. Khan HA, Baig FK, Mehboob R. Nosocomial infections: Epidemiology, prevention, control and surveillance. Asian Pacific Journal of Tropical Biomedicine. 2017;7(5):478-482
5. Gordis L. Epidemiology. 5th ed. Philadelphia, PA: Elsevier Saunders; 2014.
6. Labrague LJ, McEnroe-Petitte DM, van de Mortel T, Nasirudeen AM. A systematic review on hand hygiene knowledge and compliance in student nurses. International Nursing Review. 2017: 1-13.
7. WHO. Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level. [Internet]. Geneva: World Health Organisation; 2016 [cited 2018 September 22]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK401766/.
8. De Angelis G, Murthy A, Beyersmannd J, Harbartha S. Estimating the impact of healthcare-associated infections on length of stay and costs. Clinical Microbiology and Infection. 2010 ;16 (12):1729-1735.
9. GRZ/MOH. National Human Resource for Health Strategic Plan 2011-2015. [Internet]. Lusaka: Government Printers; 2011 [cited 2018 August 15]. Available from: https://www.uhc2030.org/ fileadmin/uploads/ihp/Documents/Country_Pages/ Zambia/ZambiaNHSP2011to2015final.pdf.
10. ZNPHI. Priorisiting Health Promotion, Disease Prevention and Control - A Transformational Agenda for the Zambian Health Sector. [Internet]. 2017 [cited 2018 February 28]. Available from: http://znphi.co.zm/thehealthpress/prioritising-health-promotion-disease-prevention-and-control-a-transformational-agenda-for-the-zambian-health-sector/.
11. UNDP. Sustainable Development Goals. [Internet]. [cited 2019 January 2]. Available from: http://www.zm.undp.org/content/zambia/en/home/ sustainable-development-goals.html.
12. GNC. Approved Training Institutions. [Internet]. 2017 [cited 2017 November 24]. Available from: http://www.gnc.org.zm/approved-training institut ions/.
13. School Management. 2018.
14. Kadam P, Bhalerao S. Sample size calculation. Int J Ayurveda Res. 2010;1(1):55-57.
15. WHO. Tools for evaluation and feedback. [Internet]. 2009 [cited 2017 November 24]. Available from: http://www.who.int/gpsc /5may /tools/evaluation_feedback/en/.
16. Paudel IS, Ghosh V, Adhikari P. Knowledge, Attitude and Practice of nursing students regarding hand hygiene in Western region of Nepal. JCMS Nepal. 2016;12(4):169-173.
17. Sharif A, Arbabisarjou A, Balouchi A, Ahmadidarrehsima S, Kashani HH. Knowledge, Attitude, and Performance of Nurses toward Hand Hygiene in Hospitals. Global Journal of Health Science. 2016;8(8):57-65.
18. Daniel WW, Cross CL. Biostatistics: A Foundation for Analysis in Health Sciences. 10th ed. Danvers: John Wiley & Sons; 2013.
19. Bruce N, Pope D, Stanistreet D. Quantitative Methods of Health Research. 1st ed. Chichester: Wiley; 2008.
20. Ranganathan P, Pramesh CS, Aggarwal R. Common pitfalls in statistical analysis: Logistic regression. Perspect Clin Res. 2017;8(3):148-151.
21. Zhang Z. Model building strategy for logistic regression: purposeful selection. Ann Transl Med 2016;4(6):111.
22. Ari E, Yildiz Z. Parallel Lines Assumption in Ordinal Logistic Regression and Analysis Approaches. International Interdisciplinary Journal of Scientific Research. 2014;1(3):8 - 23.
23. Yilmaz F, Ilter KH, Malhan S, Tekin N. Determination of Factors Affecting Length of Stay with Multinomial Logistic Regression in turkey. [Internet]. 2016 [cited 2019 January 24]. Available from: http://dergipark.gov.tr/download/article-file/220985.
24. Chiboola B. Knowledge, attitudes practice of infection prevention measure among health care providers at kafue district hospital, nchanga south mine hospital and maina soko military hospital. [Internet]. 2017 [cited 2018 April 8]. Available from: http://dspace.unza.zm:8080/ xmlui/handle/ 123456789/4465?show=full.
25. Chitimwango PC. Knowledge, Attitude and Practices of Nurses in Infection Prevention and Control within a Tertiary Hospital in Zambia. [Internet]. 2017 [cited 2018 March 17]. Available from: https://scholar.sun.ac.za/bitstream /handle / 10019.1/101156/chitimwango_knowledge_2017.p df?sequence=2&isAllowed=y.
26. Olalekan RM, Adedoyin OO, Funmilayo AA, Owobi OE. A Survey of Hand Washing Behavior and Awareness among Health Care Workers in Health Care Facilities in Kubwa District of Bwari Area Council, F.C.T. Abuja, Nigeria. Annals of Ecology and Environmental Science. 2018;2(2):1-18.
27. Lien LTQ, Chuc NTK, Hoa NQ, Lan PT, Thoa NTM, Riggi E, Tamhankar AJ, Lundborg CS. Knowledge and self-reported practices of infection

control among various occupational groups in a rural and an urban hospital in Vietnam. Scientific Reports. 2018 ;8:1-6.

28. Salman M, Raza MH, Mustafa ZU, Shrestha S, Ali M, Fahham H, Asif N, Shehzadi N, Hussain K. Knowledge, attitudes and practices of hand hygiene among Pakistani health professionals: A cross-sectional study. J Infect Dev Ctries. 2018;12(1):63-66.

29. Hussen SH, Estifanos WM, Melese ES, Moga FE. Knowledge, Attitude and Practice of Infection Prevention Measures among Health Care Workers in Wolaitta Sodo Otona Teaching and Referral Hospital. J Nurs Care. 2017 ;6(4):1-7.

30. Abdella NM, Tefera MA, Eredie AE, Landers TF, Malefia YD, Alene KA. Hand hygiene compliance and associated factors among health care providers in Gondar University Hospital, Gondar, North West Ethiopia. BMC Public Health. 2014;14(96):1-7.

31. Kolola T, Gezahegn T. A twenty-four-hour observational study of hand hygiene compliance among health-care workers in Debre Berhan referral hospital, Ethiopia. Antimicrobial Resistance & Infection Control. 2017 ;6(109):1-5

32. Rynga D, Kumar S, Gaind R, Rai AK. Hand hygiene compliance and associated factors among health care workers in a tertiary care hospital: Self-reported behaviour and direct observation. Int J Infect Control. 2017 ;13(i1):1-9.

33. Desta M, Ayenew T, Sitotaw N, Tegegne N, Dires M, Getie M. Knowledge, practice and associated factors of infection prevention among healthcare workers in Debre Markos referral hospital, Northwest Ethiopia. BMC Health Services Research. 2018;18(465):1-10

34. Kudavidnange BP, Gunasekara DC, Hapuarachchi S. Knowledge, attitudes and practices on hand hygiene among ICU staff in Anuradhapura Teaching hospital. Anuradhapura Medical Journal. 2014 ;1:29-4

35. Shantikumar S. Validity, reliability and generalisability. [Internet]. 2018 [cited 2019 January 30]. Available from: https://www.healthknowledge.org.uk/content/validity-reliability-and-generalisability.

36. WHO. WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care Is Safer Care. [Internet]. Geneva: World Health Organisation; 2009 [cited 2018 February 28]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK144001/.

37. WHO. Evidence of hand hygiene to reduce transmission and infections by multi-drug resistant organisms in healthcare setting. [Internet]. 2014 [cited 2018 February 27]. Available from: http://41.77.4.165:6510/www.who.int/gpsc/5may/MDRO_literature-review.pdf.

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