Categorical Analysis of Variance on Knowledge, Compliance and Impact of Hand Hygiene among Healthcare Professionals during COVID-19 Outbreak in South-East, Nigeria

Abstract

This paper examined the knowledge, compliance and impact of hand hygiene among healthcare professionals during COVID-19 outbreak in South-East, Nigeria. The data used in this study were collected from twenty (20) hospitals in South-East, Nigeria using questionnaire with closed-type question forms. A total number of 600 questionnaires were used in this study. Two-way CATANOVA was used to examine the gender and health profession that have well knowledge, compliance and impact experience of hand hygiene during COVID-19 outbreak. The result showed no statistically significant difference in the knowledge, compliance and impact experience of hand hygiene among four major health professions (medical doctors, nurses, pharmacists, laboratory scientists) and also between the genders at a 5% significance level. The findings showed that the changing of healthcare professional from one health profession to another does not affect the knowledge, compliance and impact experience of hand hygiene. It was noticed that 599(99.8%) healthcare professionals have good knowledge of hand hygiene, 395(65.8%) practice hand hygiene every time, and 507(84.5%) have high impact experience of hand hygiene. There is enhancement in the knowledge, compliance and impact experience of hand hygiene of healthcare professionals as their years of service increase.

Keyword: CATANOVA**,** Hand hygiene, Healthcare associated infection, Healthcare profession, Compliance, Knowledge, Impact

1. Introduction

Healthcare professionals are always on the front when any pandemic occurs since they play vital roles in response to pandemics. They are the primary sector that has contact with patients and are prone to exposure to infected cases in healthcare industries; as their professional obligation, they must be at their workplaces even if their health is at risk. Nevertheless, they should also protect their health while they are treating patients. It has been reported that the level of knowledge directly affects the individual perception of openness to a disease (Ogolodom et al., 2020). Most healthcare-associated infections can be transmitted from patient to patient via the hands of healthcare workers. In other words, healthcare workers' hands due to poor hand hygiene are the most usual type of vehicle for the transmission of healthcare-associated infections (Allergranzi *et al*., 2011). For instance, nurses' hands come into contact with patients and are frequently contaminated during routine patient care such as auscultation and palpation, or while touching contaminated surfaces, devices, or materials such as changing dressing (Karabay *et al*., 2005; Kampf and Loffler, 2010; Ogunsola and Adesiji, 2008). The contaminated hands of healthcare workers have been involved in healthcare-associated infections (HAIs) outbreaks. An outbreak of post-operative infection was traced to a contaminated jar of exfoliating cream in a nurse's home. The investigation suggested the microorganism was transmitted to patients via the hands of the nurse who wore artificial fingernails (Cimon et al., 2017). There is a report that the prevalence of HAIs continues to rise, and it is estimated that annually hundreds of millions of patients suffer from healthcare-associated infections all over the world. Therefore, effective hand hygiene is the simplest proven method to reduce the prevalence of healthcare-associated infections.

Hand hygiene is known as any method applied to remove or destroy microorganisms on hands. It is a comprehensive term that refers to hand-washing, hand antisepsis, and actions taken to maintain healthy hands and fingernails. Hand hygiene was thought to be a key factor in reducing hospital-acquired infection during the initial development of healthcare systems (Ott and French, 2009; Akyol, 2007). The battle with healthcare-associated infections (HAIs) started in 1846 when Semmelweis, the Hungarian Obstetrician, observed that puerperal fever was more common in the maternity ward where physicians and medical students provided care to women in labor than in the ward where midwives assisted healthcare deliveries. He noted that physicians and medical students were contaminating their hands while performing autopsies and later attending the examination of women without hand washing. Arguably, he was the first to recognize the importance of hand hygiene in controlling the transmission of infection (Trampuz and Widmer, 2004; National Library of Medicine, 2013). Equally important was the work of Florence Nightingale during the Crimean War, when she called for a basic public health military hospital in Scutari in 1854. Her intervention to improve personal hygiene, cleanliness in the hospital environment, living conditions, and food led to a decrease in the number of deaths. She was one of the first people who identified the relationship between nursing and infection control (Meers *et al*., 1992; Minnaar, 2008; Smith and Lokhorst, 2009).

There are several works of literature on healthcare-associated infections (HAIs) such as Boyce *et al*. (2002) who stated that the main routes of cross-transmission of potentially harmful germs to patients in a healthcare facility are healthcare workers' hands, air circulating in the hospital, patients' exposure to colonized surface, for intanstance, beds, chairs, tables, floors, hospital equipment, sharing non-invasive objects like a stethoscope, pressure cuffs, and so on.
Barker *et al*. (2004) carried out a study on the contamination of fingers with viruses and demonstrated that fingers could be contaminated with norovirus and it could sequentially transfer

the virus to up to seven clean surfaces and from contaminated cleaning clothes to clean hands and surfaces.

Watutantrige et al., (2012) carried out a study on hand contamination and hand-washing practices among medical students and demonstrated harmful microorganisms can be transferred to hands from contaminated surfaces people come into contact with in their daily activities. Contaminated hands can transmit disease to oneself as well as to others.

Duckro *et al*., (2005) studied the transmission of vancomycin-resistant *enterococci* and concluded that hands were responsible for transferring vancomycin-resistant *enterococci* from the contaminated environment or patients' intact skin to other clean sites.

Harrison *et al*., (2003) found that even small manual pull disposable folded towels and towel dispensers that are considered hands-free can become contaminated if the surfaces at the dispenser exit are touched. This usually occurs when the paper towel is dispensed with difficulty and the frequency of occurrence varies considerably, depending on the compatibility of the paper towel and the dispenser. The potential for contamination should be considered in the design, construction, and use of paper towel dispensers.

Cambell (2010), argues that hand hygiene is not only the responsibility of the infection control department and recommends a multidisciplinary approach; hospital administration, other key leaders and health professionals leaders are the key to success for hand hygiene compliance within a hospital and suggested that the defaulters should be disciplined as though they have violated hospital policy, starting with personal counseling to verbal warning and eventually to a written warning placed in their file.

Karabay *et al*. (2005) noted that hand hygiene compliance is seen more in junior nurses and newly recruited nurses and Akyol (2007) claims that hand hygiene compliance is higher among nurses compared to physicians and other health professionals. Takahashi and Turale (2010) reported that education and seminars are fundamental in promoting hand hygiene and helping staff to comply with the institutional protocols of infection control. Moreover, Maxfield and Dull (2011) suggested that healthcare workers' culture and hospital atmosphere should consider the infection control department as a resource and partner rather than an enforcer. Thus, the infection control staff can play a vital role in hand hygiene compliance by encouraging patients' monitoring of hand hygiene by observation. Ott and French (2009) suggested that hand hygiene adherence should go beyond education and training as it involved continuous motivation towards change and how that change can be sustained.

The problem is that despite the magnitude of healthcare-associated infections (HAIs) problems and the importance of adherence to infection control policies, hand hygiene practices had remained unacceptably low (Trampuz and Widmer, 2004; Takahashi and Turale, 2010). Hand hygiene compliance rates in different developed countries rarely exceed 50% (Maxfield and Dull, 2011; Mani *et al*, 2010). This may be due to several constraints such as heavy workload, the high number of clinical procedures, and the skin conditions of healthcare workers (Jang *et al*., 2010). It is a common habit that healthcare professionals tend to neglect hand hygiene practices. They usually tend to remove the gloves without washing their hands or use the same gloves to deliver intended care to multiple patients. Even when they remove their gloves, only 20% of health professionals clean their hands (Ott and French, 2009). The non-compliance with hand hygiene among healthcare professionals could increase the rate of cross-transmission of infection with microorganisms causing healthcare-associated infections (HAIs). These infections increase the incidence of mortality and morbidity of clients who come in contact with healthcare workers. They also increase the cost of healthcare delivery and prolong hospitalization. It is, therefore,

necessary to study the importance of hand-washing practices amongst healthcare professionals and its implication in infection control.

The major aim of this study is to examine the knowledge, compliance, and impact of hand hygiene of healthcare professionals in South-East, Nigeria during the COVID-19 outbreak in Nigeria. COVID-19 which is also known as Coronavirus disease was first reported in December 2019 in Wuhan, the capital city of Hubei province in central China. This disease was initially named novel Coronavirus-infected Pneumonia (NCIP) and the virus that caused it was named 2019 novel Coronavirus (2019-nCoV) by the World Health Organization (WHO). It was officially renamed by WHO as Coronavirus Disease-19 (COVID-19 in short form). WHO declared COVID-19 a global pandemic on the 11th of March, 2020 (Ogolodom et al., 2020; Mbachu et al., 2020). However, the first confirmed case of the pandemic of COVID-19 in Nigeria was reported on 27th February 2020 when an Italian citizen who works in Nigeria returned on 25th February 2020 from Milan, Italy, and fell sick on 26th February 2020 and was transferred to Lagos State Biosecurity Facilities for isolation and testing (Asogwa et al., 2020). According to Nigeria Centre for Disease Control (NCDC) (2022), as of 28th August 2022, Nigeria had recorded 263,471 cases and 3,148 deaths. Out of 263,471 that were recorded across the country, 12,744 were from South-East Nigeria. Moreover, Mbachu et al., (2020) studied the knowledge of healthcare workers on COVID-19 in a south-eastern Nigeria state and the study showed that out of 403 healthcare workers that participated in it, 357(88.59%) had good knowledge of COVID-19 infection and 328(81.39%) had knowledge of preventive practices of the virus. WHO said that COVID-19 is a contagious disease. To contain its spread, some measures were adopted by the Nigerian government which include social distancing, a ban on public gatherings including religious gatherings, continuous personal hygiene such as hand washing and use of hand sanitizers, use of face masks, limiting the number of passengers in public vehicles, locking down public places and cities.

The significance of this study is that the healthcare workers will be fully reminded of the importance of proper hand hygiene, especially in the health sector since hand hygiene practices of healthcare workers are considered to be the single most clinical and cost effective measure to prevent healthcare-associated infections (HAIs) (Takahashi and Turale, 2010). The study will also create awareness of hand hygiene among patients and society at large.

2. Materials and Methods

2.1 Data collection

The data used in this study were collected from twenty (20) hospitals in South-Eastern Nigeria using a questionnaire with closed-type question forms. South-East Nigeria is one of the geopolitical zones in Nigeria and it has five states which include: Abia, Anambra, Ebonyi, Enugu, and Imo. The questionnaires were distributed randomly in two (2) government hospitals and two (2) private hospitals in each state making it a total of twenty (20) hospitals. The questionnaire has four (4) sections which include; sections A, B, C, and D. Section A collects data on the socio-demographic characteristics of the participants, section B is on the participant's knowledge of hand hygiene, section C is on the participant's compliance to hand hygiene, and section D is on the impact of hand hygiene in the prevention of healthcare-associated infections especially COVID-19 infection. This study was conducted in August-October, 2022, and the World Health Organization (WHO) questionnaire format on hand hygiene (WHO, 2009) was adapted and modified to collect suitable data for this study. The researchers administered the questionnaires by themselves to the participants and throughout the study; the confidentiality of the participants was kept

2.2 Methodology

The methodologies used were descriptive statistics and categorical analysis of variance.

2.2.1 Descriptive statistics: According to McClave et al., (2005) descriptive statistics utilizes numerical and graphical methods to look for patterns in a data set, to summarize the information revealed in a data set, and to present the information in a convenient form.

2.2.2 CATANOVA: The categorical analysis of variance (CATANOVA) is a technique designed to identify the variation between treatments of interest to the researcher**.** This CATANOVA is used to solve problem in analysis of variance when the observations are nominal without any underlying metric and it was also formulated to solve erroneous analysis of nominal data by using chi-square test (Onukogu, 1985; Otaru and Ogbonda, 2020). In addition, there are several methods for analyzing categorical data in which some of these methods use data transformation before proceeding to analyse the data. The method to be used may depend on the classification of categorical data (Fienberg, 1973; Florian, 2008; Onukogu, 2014; Singh, 2004). In this research, two-way CATANOVA are adopted and there is no loss in generality using the method for unequal levels of factors that do not differ significantly.

This study assumed that the data follows:

- Multi-nominal distribution

$$P(\{n_{ijk}\};\{\pi_{ijk}\}) = \binom{n_{ij}}{n_{ij1},\dots,n_{ijK}} \prod_{k=1}^{K} (\pi_{ijk})^{n_{ijk}}$$

$$n_{ijk} = 0, 1, \cdots, n_{ij} \text{ and } \pi_{ijk} = \frac{n_{ijk}}{n_{ij}};\ 0 \le \pi_{ijk} \le 1$$

- Independence: The levels and blocks are each act independently. That is, n_{ijk} and $n_{i'j'k}$ are statistically independent $\forall i \neq i'$ and $\forall j \neq j'$.
- Constant variance: $\text{var}(n_{ijk}) = n\pi_{ijk}(1-\pi_{ijk})$. The variance is not constant because it depends on i, j and k.

$\pi_{ijk} > 0$, $\sum_{k=1}^{K} \pi_{ijk} = 1$, $\sum_{k}^{K} n_{ijk}$ is held fixed (i.e., grand total over k for j)

Table1: The data layout for two-way CATANOVA cross classification or randomized complete block design

	B(j)												
	b1				**b2**				**. . .**	**bJ**			
A(i)	1	2	….	K	1	2	….	K	. . .	1	2	….	K
1	n_{111}	n_{112}	….	n_{11K}	n_{121}	n_{122}	….	n_{12K}	….	n_{1J1}	n_{1J2}	….	n_{1JK}
2	n_{211}	n_{212}	….	n_{21K}	n_{221}	n_{222}	….	n_{22K}	….	n_{2J1}	n_{2J2}	….	n_{2JK}
.	.	.		.	.	.		.		.	.		.
.	.	.	….	.	.	.	….	.	….	.	.	….	.
.	.	.		.	.	.		.		.	.		.
I	n_{i11}	n_{i12}	….	n_{i1K}	n_{i21}	n_{i22}	….	n_{i2K}	….	n_{iJ1}	n_{iJ2}	….	n_{iJK}

Table 1 shows the data layout for two-way cross classification or a randomized complete block design in which a K-dimensional vector $[n_{ijk}]$ of nominal responses are observed in frequencies

in the ijth plot. In this Table 1, the main factor A ranging from 1 to I and main factor B ranging from 1 to J have from 1 to K quanta responses per unit.

Table 2: Summary for two-way CATANOVA cross classification of nominal data

Source	df	SS	Test Ratio	Critical Value	Hypothesis
Row(Ai)	I-1	RSS	χ^2_{RT}	$\chi^2_{(I-1)(K-1)}$	$HO_R: \pi_{ijk} = \pi_{jk} \forall_i$
Column(Bj)	J-1	CSS	χ^2_{CT}	$\chi^2_{(J-1)(K-1)}$	$HO_C: \pi_{ijk} = \pi_{ik} \forall_j$
Interaction(AB)	(I-1)(J-1)	NSS	χ^2_{NT}	$\chi^2_{(I-1)(J-1)(K-1)}$	$HO_{RC}: \pi_{ijk} = \pi_k \forall_{ij}$
Weight Units	n-IJ	WUSS	-		-
Total	n-1	TSS	-		-

Table 2 depicted CATANOVA table that contains the source of variation, degrees of freedom (df), sum of squares (SS) which is the trace of its variance-covariance matrix, test ratio from chi-square calculated, critical value from chi-square tabulated and hypotheses for the study.

Two-way CATANOVA cross classification model

$$E(\hat{\pi}_{ijk}) = \mu + \alpha_i + \beta_j + \gamma_{ij} \quad (1)$$

Where $\hat{\pi}_{ijk}$ is the probability that kthobservation occurs in the ith level of factor A and jth level of factor B, i.e., $\hat{\pi}_{ijk} = P_{ijk} = \frac{n_{ijk}}{n_{ij}}$, ($n_{ijk}$ is the kth observation in the ijth cell, n_{ij} is the sum of kth observation in the ijth cells, i.e., $n_{ij} = \sum_k n_{ijk}$), μ is a constant for kth observation, α_i ($i = 1, 2, \dots, I$) is the effect of the ith level of factor A, β_j ($j = 1, 2, \dots, J$) is the effect of the jth level of factor B, γ_{ij}(($i = 1, 2, \dots, I$) and ($j = 1, 2, \dots, J$)) is the interaction between the ith level of factor A and jth level of factor B. In nominal data, sum of square is the trace of its variance-covariance matrix and the parameter π_{ijk} may be considered fixed or random with probability density $h(\pi_{ijk})$ ranging from 0 to 1 depending on whether I and J are random or fixed (Anderson, 1958; Onukogu, 1985; Onukogu, 2014).

Hypotheses

$H_{0R}: \pi_{ijk} = \pi_{jk}$, i. e., $\alpha_i = 0 \forall_i$ (There is no row effect)
$H_{1R}: \pi_{ijk} \neq \pi_{jk}$, i. e., $\alpha_i \neq 0$ $for\ at\ least\ one\ (i)$ (There is row effect)

$H_{0C}: \pi_{ijk} = \pi_{ik}$, i. e., $\beta_j = 0 \forall_j$ (There is no column effect)
$H_{1C}: \pi_{ijk} \neq \pi_{ik}$, i. e., $\beta_j \neq 0$ $for\ at\ least\ one\ (j)$ (There is column effect)

$H_{0RC}: \pi_{ijk} = \pi_k$, i. e., $\gamma_{ij} = 0 \forall_{ij}$ (There is no interaction effect)
$H_{1RC}: \pi_{ijk} \neq \pi_k$, i. e., $\gamma_{ij} \neq 0$ $for\ at\ least\ one\ pair\ (ij)$ (There is an interaction effect)

Test Statistic

$$\chi^2_{RT} = \frac{(K-1)(n-1)RSS}{TSS} \sim \chi^2_{(I-1)(K-1)};\ \alpha$$

$$\chi^2_{CT} = \frac{(K-1)(n-1)CSS}{TSS} \sim \chi^2_{(J-1)(K-1)};\ \alpha$$

$$\chi^2_{NT} = \frac{(K-1)(n-1)NSS}{TSS} \sim \chi^2_{(I-1)(J-1)(K-1)};\ \alpha$$

Decision rule

Reject H_{0R} if $\chi^2_{RT} \geq \chi^2_{(I-1)(K-1)}$, H_{0C} if $\chi^2_{CT} \geq \chi^2_{(J-1)(K-1)}$, and H_{0RC} if $\chi^2_{NT} \geq \chi^2_{(I-1)(J-1)(K-1)}$ at specified level of significance (5%). Fail to reject if otherwise.

2.3 Data Analysis

The statistical package for the social sciences (SPSS) version 28 was used to obtain descriptive analyses in this study. The categorical variables such as gender, age group, marital status, profession, and years of service were presented in frequency and percentages. Two-way CATANOVA analysis was used to examine the gender and healthcare professionals that have well knowledge and compliance on hand hygiene during COVID-19 outbreak. The experience on the impact of hand hygiene in preventing COVID-19 among healthcare professionals with different years of service was also examined using two-way CATANOVA analysis. The level of significance for test of the knowledge, compliance and impact of hand hygiene of healthcare professionals was set at a 5% significance level. Results were interpreted and conclusions were drawn.

2.4 Ethical approval

The anonymity and confidentiality of the participants were highly kept. Therefore, all procedures performed in this research that involved healthcare professionals were in accordance with the ethical standards of the Nigerian hospitals.

3. Results

The results in this section were obtained from the data collected after administering questionnaires to the participants. A total number of 620 questionnaires were distributed and we noticed that 600(96.8%) copies were returned and properly completed while 20(3.2%) copies were not returned. Thus, 600 questionnaires were used to carry out the analyses.

3.1 Socio-demographic of the respondents

Table 3 showed socio-demographic study of the respondents. From Table 3, it was noticed that out of 600 respondents, there were 241(40.2%) males and 359(59.8%) females. The ages of the respondents ranged from 15 – 60 years and above. The most occurrence age group were those aged 30 - 44 years and they made up 55.7% (n = 334) of the study group. It was noticed that 482(80.3%) respondents are married. The study focused on the four major professions which the analysis showed that there were 398(66.3%) nurses, 62(10.3%) doctors, 98(16.3%) laboratory scientists, and 42(7.0%) pharmacists. In the years of service, it was noticed that 514(85.7%) professionals have had 1 – 10 years working experience.

Table 3: The sociodemographic characteristics of the respondents

Sociodemographic varibles		Frequency	Percentage%
Gender of the respondents	Male	241	40.2%
	Female	359	59.8%
	Total	**600**	**100.0%**
Age of the respondents	15 - 29 years	144	24.0%
	30 - 44 years	334	55.7%
	45 - 59 years	114	19.0%
	60+ years	8	1.3%
	Total	**600**	**100.0%**
Marital Status of respondents	Married	482	80.3%
	Single	118	19.7%
	Total	**600**	**100.0%**
Profession of the respondents	Nurse	398	66.3%
	Medical Doctor	62	10.3%
	Lab. Scientist	98	16.3%
	Pharmacist	42	7.0%
	Total	**600**	**100.0%**
Years of service of respondents	1-10 years	514	85.7%
	11 - 20 years	52	8.7%
	20+ years	34	5.7%
	Total	**600**	**100.0%**

3.2 Knowledge of hand hygiene among four healthcare professions during COVID-19

This section 3.2 focuses on the knowledge of hand hygiene among four major healthcare professions during COVID-19 outbreak in south-eastern Nigeria. Two-way CATANOVA cross classification or randomized complete block design was used to carry out the analysis (see Appendix Table 1 for the observations).

Table 4: CATANOVA table for significance in the knowledge of hand hygiene among four major healthcare professions

Source	DF	Sum of Squares	Test Ratio	Critical Value	Decision
Gender (Row)	1	0.0050	1.49	3.84	not significant, (accept H_{0R})
Healthcare professions (Column)	3	0.0017	0.51	7.81	not significant, (accept H_{0C})
Gender*Healthcare professions	3	0.0049	1.48	7.81	not significant, (accept H_{0RC})
Within unit	592	1.9851	-	-	
Total	599	1.9967	-	-	

Table 4 showed results that were obtained after analyzing data in Appendix Table 1. The results showed that there is no statistically significant difference ($\chi^2_{RT(Cal)} = 1.49 < \chi^2_{RT(Tab)} = 3.84$) in the knowledge of hand hygiene among the four major healthcare professions and it was also noticed that the two genders have the same knowledge of hand hygiene during COVID-19 outbreak since $\chi^2_{CT(Cal)} = 0.51 < \chi^2_{CT(Tab)} = 7.81$. Moreover, there is no statistically

significant difference ($\chi^2_{NT(Cal)} = 1.48 < \chi^2_{NT(Tab)} = 7.81$) in the interaction between gender and healthcare professions at a 5% significance level. The no statistically significant difference among the four professions means that no particular healthcare profession has knowledge of hand hygiene more than another profession and no statistically significant difference in the gender means that no particular gender has knowledge of hand hygiene more than another gender. The no statistically significant difference in the interaction between healthcare professions and gender means that being a particular gender in a particular healthcare profession doesn't change the knowledge of hand hygiene practice of that worker.

Table 5: Items used to examine the level of knowledge of hand hygiene among four major healthcare professions

S/N	Items		Frequency	Percentage (%)
1.	Do the healthcare workers hands cause cross-transmission of potentially harmful germs such as COVID-19 to patients in a healthcare facility?	**YES**	599	99.8%
		NO	1	0.2%
		Total	**600**	**100.0%**
2.	Does air circulating cause cross-transmission of potentially harmful germs such as COVID-19 to patients in a healthcare facility?	**YES**	599	99.8%
		NO	1	0.2%
		Total	**600**	**100.0%**
3.	Do patients' exposure to colonized surfaces such as beds, chairs, tables, floors, etc cause cross-transmission of potentially harmful germs such as COVID-19 to patients in a healthcare facility?	**YES**	599	99.8%
		NO	1	0.2%
		Total	**600**	**100.0%**
4.	Do the sharing non-invasive objects like stethoscope, pressure cuffs, etc cause cross-transmission of potentially harmful germs such as COVID-19 to patients in a healthcare facility?	**YES**	596	99.3%
		NO	4	0.7%
		Total	**600**	**100.0%**
5.	Does the hand hygiene action before/after touching a patient prevent transmission of germs such as COVID-19 between patient and healthcare workers?	**YES**	597	99.5%
		NO	3	0.5%
		Total	**600**	**100.0%**
6.	Does the hand hygiene action immediately after a risk of body fluid exposure prevent transmission of germs such as COVID-19 between patient and healthcare workers?	**YES**	597	99.5%
		NO	3	0.5%
		Total	**600**	**100.0%**
7.	Does the hand hygiene action after exposure to the immediate surroundings of a patient prevent transmission of germs such as COVID-19 between patient and healthcare workers?	**YES**	600	100.0%
		NO	0	0.0%
		Total	**600**	**100.0%**
8.	Does the hand hygiene action immediately after exposure to clean/aseptic procedure prevent transmission of germs such as COVID-19 between patient and healthcare workers?	**YES**	597	99.5%
		NO	3	0.5%
		Total	**600**	**100.0%**
9.	Does wearing jewelry increase harbouring of germs such as COVID-19?	**YES**	595	99.2%
		NO	5	0.8%
		Total	**600**	**100.0%**
10.	Does damaged skin increase harbouring of germs such as COVID-19?	**YES**	591	98.5%
		NO	9	1.5%
		Total	**600**	**100.0%**
11.	Does wearing of artificial fingernails increase harbouring germs such as COVID-19?	**YES**	598	99.7%
		NO	2	0.3%
		Total	**600**	**100.0%**
12.	Does regular use of a hand cream increase harbouring of germs such as COVID-19?	**YES**	590	98.33%
		NO	10	1.67%
		Total	**600**	**100.0%**
13.	Were the educational activities that you participated in important to improve your hand hygiene practice in this COVID-19 outbreak?	**YES**	600	100%
		NO	0	0.0%
		Total	**600**	**100.0%**

The data analysis in Table 5 helped the researchers to examine the level of knowledge of hand hygiene among four major healthcare professions during COVID-19 outbreak in south-eastern Nigeria. The analysis was based on 600 respondents that returned their questionnaires. The result showed that 599(99.8%) respondents said that healthcare workers hands, air circulating, and patients' exposure to colonized surfaces such as beds, chairs, tables, floors, etc cause cross-transmission of potentially harmful germs such as COVID-19 to patients in a healthcare facility, 596(99.3%) respondents revealed that sharing non-invasive objects like stethoscope, pressure cuffs, etc cause cross-transmission of potentially harmful germs such as COVID-19 to patients in a healthcare facility, 597(99.5%) respondents indicated that hand hygiene action before/after touching a patient, immediately after a risk of body fluid exposure, and immediately after exposure to clean/aseptic procedure prevent transmission of germs such as COVID-19 between patients and healthcare workers, 600(100%) respondents answered that hand hygiene action after exposure to the immediate surroundings of a patient prevent transmission of germs such as COVID-19 between patient and healthcare workers, 595(99.2%) respondents said that wearing jewelry increase harbouring of germs such as COVID-19, 591(98.5%) respondents revealed that damaged skin increase harbouring of germs such as COVID-19, 598(99.7%) respondents said that wearing of artificial fingernails increase harbouring germs such as COVID-19, 590(98.33%) respondents said that regular use of a hand cream increase harbouring of germs such as COVID-19, and 600(100%) respondents said that hand hygiene educational activities are import to improve healthcare professionals hand hygiene practice especially in this era of COVID-19 outbreak.

3.3 Compliance to hand hygiene among four healthcare professions during COVID-19

This section 3.3 focuses on the compliance to hand hygiene among four major healthcare professions during COVID-19 outbreak in south-eastern Nigeria. Two-way CATANOVA cross classification or randomized complete block design was used to carry out the analysis (see Appendix Table 2 for the observations).

Table 6: CATANOVA table for significance in the compliance to hand hygiene among four major healthcare professions

Source	DF	Sum of Squares	Test Ratio	Critical Value	Decision
Gender (Row)	1	1.58	3.50	3.84	not significant, (accept H_{0R})
Healthcare professions (Column)	3	2.47	5.49	7.81	not significant, (accept H_{0C})
Gender*Healthcare professions	3	1.40	3.10	7.81	not significant, (accept H_{0RC})
Within unit	592	264.47	-	-	
Total	599	269.92	-	-	

Table 6 showed results that were obtained after analyzing data in Appendix Table 2. As can see from the results that there is no statistically significant difference ($\chi^2_{RT(Cal)} = 3.50 < \chi^2_{RT(Tab)} = 3.84$) in the compliance to hand hygiene among the four major healthcare professions and it was also noticed that the two genders have the same level of compliance to hand hygiene during COVID-19 outbreak since $\chi^2_{CT(Cal)} = 5.49 < \chi^2_{CT(Tab)} = 7.81$. The results also showed that there is no statistically significant difference ($\chi^2_{NT(Cal)} = 3.10 <$

$\chi^2_{NT(Tab)} = 7.81$) in the interaction between gender and healthcare professions at a 5% significance level. The no statistically significant difference among the professions means that no particular healthcare profession practices to hand hygiene more than another profession and no statistically significant difference in the gender means that no particular gender practices hand hygiene more than another gender. The no statistically significant difference in the interaction between healthcare professions and gender means that being a particular gender in a particular healthcare profession has no contribution or effect in the way healthcare profession practices hand hygiene.

From the data analysis in Table 7, the researchers sought to ascertain the level of compliance to hand hygiene among four major healthcare professions. The analysis was based on 600 respondents that returned their questionnaires. The result showed that 476(79.3%) respondents said that they routinely use an alcohol based hand-rub for hand hygiene during COVID-19 outbreak, 507(84.5%) respondents revealed that the use of alcohol based hand-rub made hand hygiene easier for them to practice in their daily work, 338(56.3%) respondents indicated that the use of alcohol based hand-rubs tolerate well in their hands, 467(77.8%) respondents said that they always use hand-rub method of hand hygiene before touching a patient while 133(22.2%) said that they always use hand-wash method of hand hygiene before touching a patient during COVID-19 outbreak, 170(28.3%) respondents said that they always use hand-rub method of hand hygiene after touching a patient while 430(71.7%) said that they always use hand-wash method of hand hygiene after touching a patient during COVID-19 outbreak, 431(71.8%) respondents said that they always use hand-rub method of hand hygiene before giving an injection while 169(28.2%) said that they always use hand-wash method of hand hygiene before giving an injection during COVID-19 outbreak, 64(27.3%) respondents said that they always use hand-rub method of hand hygiene after giving an injection while 436(72.7%) said that they always use hand-wash method of hand hygiene after giving an injection during COVID-19 outbreak, 112(18.7%) respondents said that they always use hand-rub method of hand hygiene after removing examination gloves while 488(81.3%) said that they always use hand-wash method of hand hygiene after removing examination gloves during COVID-19 outbreak, 325(54.2%) respondents said that they always use hand-rub method of hand hygiene after making patient's bed or expose to a patient surroundings while 275(45.8%) said that they always use hand-wash method of hand hygiene after making patient's bed or expose to a patient surroundings during COVID-19 outbreak, 284(47.3%) respondents said that they always use hand-rub method of hand hygiene after visible exposure to blood or body fluid while 316(52.7%) said that they always use hand-wash method of hand hygiene after visible exposure to blood or body fluid during COVID-19 outbreak, 513(85.5%) respondents revealed that heavy patients/work-loads prevent healthcare professionals from always practicing hand hygiene during COVID-19 outbreak, and 441(73.5%) respondents said that hand hygiene equipment not being at convenient places prevent healthcare professionals from practicing hand hygiene during COVID-19 outbreak.

Table 7: Items used to examine the level of compliance to hand hygiene among four major healthcare professions

S/N	Items		Frequency	Percentage (%)
1.	Do you routinely use an alcohol based hand-rub for hand hygiene during COVID-19 outbreak?	**Yes**	476	79.3%
		No	124	20.7%
		Total	**600**	**100.0%**
2.	Has the use of alcohol based hand-rub made hand hygiene easier to practice in your daily work?	**Yes**	507	84.5%
		No	93	15.5%
		Total	**600**	**100.0%**
3	Is the use of alcohol based hand-rubs well tolerated by your hands?	**Yes**	338	56.3%
		No	262	43.7%
		Total	**600**	**100.0%**
4	Which method of hand hygiene do you always use before touching a patient during COVID-19 outbreak?	**Handrub**	467	77.8%
		Handwash	133	22.2%
		Total	**600**	**100.0%**
5	Which method of hand hygiene do you always use after touching a patient during COVID-19 outbreak?	**Handrub**	170	28.3%
		Handwash	430	71.7%
		Total	**600**	**100.0%**
6	Which method of hand hygiene do you always use before giving an injection during COVID-19 outbreak?	**Handrub**	431	71.8%
		Handwash	169	28.2%
		Total	**600**	**100.0%**
7.	Which method of hand hygiene do you always use after giving an injection in this COVID-19 outbreak?	**Handrub**	64	27.3%
		Handwash	436	72.7%
		Total	**600**	**100.0%**
8.	Which method of hand hygiene do you always use after removing examination gloves during COVID-19 outbreak?	**Handrub**	112	18.7%
		Handwash	488	81.3%
		Total	**600**	**100.0%**
9.	Which method of hand hygiene do you always use after making patient's bed or expose to a patient surroundings during COVID-19 outbreak?	**Handrub**	325	54.2%
		Handwash	275	45.8%
		Total	**600**	**100.0%**
10.	Which method of hand hygiene do you always use after visible exposure to blood or body fluid during COVID-19 outbreak?	**Handrub**	284	47.3%
		Handwash	316	52.7%
		Total	**600**	**100.0%**
11.	Do heavy patients/work-loads prevent healthcare professionals from practicing hand hygiene during COVID-19 outbreak?	**Yes**	513	85.5%
		No	87	14.5%
		Total	**600**	**100.0%**
12.	Does the hand hygiene equipment not being at convenient places prevent healthcare professionals from always practicing hand hygiene during COVID-19 outbreak?	**Yes**	441	73.5%
		No	159	26.5%
		Total	**600**	**100.0%**
14.	Do putting hand gloves always prevent healthcare professionals from practicing hand hygiene during COVID-19 outbreak?	**Yes**	486	81.0%
		No	114	19.0%
		Total	**600**	**100.0%**

3.4 Impact of hand hygiene practice to healthcare professions during COVID-19

This section 3.4 focuses on the impact of hand hygiene practice to healthcare professions during COVID-19 outbreak in south-eastern Nigeria. Two-way CATANOVA cross classification or randomized complete block design was used to carry out the analysis (see Appendix Table 3 for the observations).

Table 8: CATANOVA table for significance in the impact of hand hygiene among four major healthcare professions

Source	DF	Sum of Squares	Test Ratio	Critical Value	Decision
Years of service (Row)	2	2.27	8.63	5.99	significant, (reject H_{0R})
Healthcare professions (Column)	3	1.68	6.42	7.81	not significant, (accept H_{0C})
Years of service*Healthcare professions	6	1.36	5.20	12.59	not significant, (accept H_{0RC})
Within unit	588	151.86	-	-	
Total	599	157.17	-	-	

From the result in Table 8 which was obtained after analyzing data in Appendix Table 3, we noticed that there is statistically significant difference ($\chi^2{}_{RT(Cal)} = 8.63 < \chi^2{}_{RT(tab)} = 5.99$) in the years of service of healthcare professionals at a 5% significance level. The statistically significant difference in the years of service of healthcare professionals means that the experience of impact of hand hygiene across the years of service is not the same during COVID-19 outbreak. The result also showed that there is no statistically significant difference ($\chi^2{}_{CT(Cal)} = 6.42 < \chi^2{}_{CT(tab)} = 7.81$) in the experience of impact of hand hygiene among four healthcare professions during COVID-19 outbreak at a 5% significance level. This means that the level of impact of hand hygiene among the four healthcare professions is the same. Moreover, the result also showed that there is no statistically significant difference ($\chi^2{}_{NT(Cal)} = 5.20 < \chi^2{}_{NT(tab)} = 12.59$) in the interaction between the years of service and healthcare professions at a 5% significance level. This is to say that the experience of impact of hand hygiene in the years of service in health sector is not affected when a healthcare professional changes from one healthcare profession to another.

Table 9: Items used to examine the level of impact of hand hygiene experience among four major healthcare professions

S/N	Items		Frequency	Percentage (%)
1.	Among all patient safety issues, does the hand hygiene among healthcare professionals at your institution prevent the spread of COVID-19?	Not at all	14	2.3%
		Very Well	586	97.7%
		Total	**600**	**100.0%**
2.	Do the results of hand hygiene observation in your ward help you and your colleagues to improve your hand hygiene during COVID-19 outbreak?	Not at all	6	1.0%
		Very Well	594	99.0%
		Total	**600**	**100.0%**
3.	Do the impacts of hand hygiene make leaders and managers at your institution support and openly promote hand hygiene during COVID-19 outbreak?	Not at all	25	4.2%
		Very Well	575	95.8%
		Total	**600**	**100.0%**
4.	Do the impacts of hand hygiene among healthcare professionals make hand hygiene posters to be displayed at point of care as reminders during COVID-19 outbreak?	Not at all	17	2.8%
		Very Well	583	97.2%
		Total	**600**	**100.0%**
5.	Do the impacts of hand hygiene among healthcare professionals make healthcare workers receive education on hand hygiene during COVID-19 outbreak?	Not at all	4	0.7%
		Very Well	596	99.3%
		Total	**600**	**100.0%**
6.	Do the impacts of hand hygiene among healthcare professionals make healthcare workers receive regular feedback on their hand hygiene performance during COVID-19 outbreak?	Not at all	49	8.2%
		Very Well	551	91.8%
		Total	**600**	**100.0%**
7.	Do the impacts of hand hygiene among healthcare professionals make patients to be invited to remind healthcare workers to perform hand hygiene during COVID-19 outbreak?	Not at all	433	72.2%
		Very Well	167	27.8%
		Total	**600**	**100.0%**

The data analysis in Table 9 was used to examine the level of impact of hand hygiene experience among four major healthcare professions during COVID-19 outbreak in south-eastern Nigeria. The analysis was based on 600 respondents that returned their questionnaires. The result showed that 586(97.7%) respondents revealed that among all patient safety issues, hand hygiene among healthcare professionals at their health institutions prevent the spread of germs; for instance, COVID-19 infection, 594(99.0%) respondents said that the results of hand hygiene observation in their wards help them and their colleagues to improve their hand hygiene during COVID-19 outbreak, 575(95.8%) respondents said that the impacts of hand hygiene make leaders and managers at their institutions support and openly promote hand hygiene during COVID-19 outbreak, 583(97.2%) respondents said that the impacts of hand hygiene among healthcare professionals make hand hygiene posters to be displayed at point of care as reminders during COVID-19 outbreak, 596(99.3%) respondents said that the impacts of hand hygiene among healthcare professionals make healthcare workers receive education on hand hygiene during COVID-19 outbreak, 551(91.8%) respondents said that the impacts of hand hygiene among healthcare professionals make healthcare workers receive regular feedback on their hand hygiene performance during COVID-19 outbreak, and 167(27.8%) respondents said that the impacts of hand hygiene among healthcare professionals make patients to be invited to remind healthcare workers to perform hand hygiene during COVID-19 outbreak.

4. Discussion

Our findings in section 3.2 of this study showed that out of 600 healthcare professionals that participated in this study, 599(99.8%) participants have indicated good knowledge of hand hygiene,(see Appendix Table 1), which are in agreement with the report of previous studies in a tertiary hospital Southwestern Nigeria, in Lagos University Teaching Hospital Nigeria, semi urban communities of Sokoto state, Nigeria, and tertiary healthcare in India that reported 99%, 91.7%, 83%, 74% respectively (Agbana et al., 2020; Timothy, 2013; Umar et al., 2017; Devnani et al., 2011). Our findings showed that the thirteen questions used to know the level of knowledge of hand hygiene among the healthcare professionals during COVID-19 pandemic scored not less than 90% (see Table 5) and this means that the participants have high level of hand hygiene knowledge. These findings agreed with the findings by Agbana et al., 2020 and Timothy, 2013. The finding showed that all the participants (100%) had a hand hygiene education during COVID-19 outbreak and this was in line with the finding by Takahashi and Turale (2010) who reported that education and seminars are fundamental in promoting hand hygiene and help healthcare workers to comply with the institutional protocols of infection control.

Our findings in section 3.3 of this study showed that out of 600 respondents, 395(65.8%) participants revealed that they practice hand hygiene every time while 205(34.2%) respondents said that they don't always practice hand hygiene. This compliance rate of 65.8% found in this study was slightly difference from the compliance rate of 62.8% reported by Oko et al., (2022). The finding in this study showed that the compliance rate (65.8%) of hand hygiene was moderately high and it disagreed with the finding by Al-Wazzan et al., (2011), Kolola et al., (2017), Ngugi et al., (2019), and Onyedibe et al., (2020) who reported compliance rate of 33.4% in Kuwait, 22% in Ethiopia, 22% in Kenya, and 31% in Northern part of Nigeria. The increase in the compliance rate (65.5%) observed in this study could be because of the public campaign on hand hygiene in the country due to the recent COVID-19 pandemic which is one of the WHO multimodal hand hygiene improvement strategy (see Appendix Table 2). The researchers tried to ascertain the level of compliance to hand hygiene among the healthcare professionals during this era of COVID-19 pandemic and our findings (see Table 7) showed that the healthcare professionals in South-Eastern, Nigeria have high compliance rate to hand hygiene during COVID-19 outbreak. The finding also showed that they were commonly used hand-wash (71.7%) method of hand hygiene after touching a patient than hand-rub (28.3%) and this finding agreed with the finding by Oko et al., (2022) who reported that soap and water (41.41%) were majorly used by the healthcare workers than alcohol-based hand-rub (18.59%).

Our findings in section 3.4 of this study showed that out of 600 respondents, 507(84.5%) said that they have high experience of impact of hand hygiene while 93(15.5) said that they have low experience of impact of hand hygiene during COVID-19 outbreak in South-Eastern, Nigeria. The findings showed that the percentage, 85.7% (n = 600), of healthcare professionals who have worked 1-10 years are more than others. It was noticed that out of 514 healthcare professionals who have worked 1-10 years, 88(17.12%) have low experience of impact of hand hygiene while 426(82.88%) have high experience of impact of hand hygiene. Out of 52 healthcare professionals who have worked 11-20 years, 5(9.62%) have low experience of impact of hand hygiene while 47(90.38%) have high experience of impact of hand hygiene and all the 34 healthcare

professionals who have worked up to 20 years and above have high experience of impact of hand hygiene in health sector (see Appendix Table 3). Our findings showed that the seven questions used to ascertain the impact level of hand hygiene scored not less than 90% (see Table 9) and this means that the participants have high positive experience of hand hygiene impact level.

5. Conclusion

The findings of this study depicted no statistically significant difference in the knowledge, compliance and impact experience of hand hygiene among the four major healthcare professions (i.e., medical doctors, nurses, pharmacists and laboratory scientists) and it also showed that the genders have the same level of knowledge, compliance and impact experience of hand hygiene during COVID-19 outbreak in South-East, Nigeria. The findings showed that the changing of healthcare professional from one health profession to another does not affect the knowledge, compliance and impact experience of hand hygiene. We noticed that increase in the years of service increase the knowledge, compliance and impact experience of hand hygiene of healthcare professionals. The findings showed high observation of knowledge, compliance, and impact experience of hand hygiene among healthcare professionals in South-East, Nigeria and this might be as a result of several hand hygiene educations in their various health institutions or several public campaigns on hand hygiene in this era of COVID-19 pandemic. Thus, we recommend the continuation of sensitization of healthcare professionals, and in general healthcare workers, in South-East, Nigeria on the important of hand hygiene since information, education, seminars, and communication are fundamental in promoting hand hygiene. This sensitization may be through mandatory continuous professional development programme (MCPDP), mass media, social media, and any other means of communication. The healthcare authorities should also provide appropriate hand hygiene kits in both urban and rural areas. These we believe would reduce healthcare associated infections, hospital stay and cost.

To the best of our knowledge, there has been no study on the knowledge, compliance and impact of hand hygiene among the four major healthcare professions during COVID-19 outbreak in South-East, Nigeria using CATANOVA analysis as the statistical tool.

Declarations

Availability of data and material

The data are available.

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Competing interests

Authors have declared that no competing interests exist.

Authors' contributions

This work was carried out in collaboration among all authors All authors together conceptualized the idea. Author NME and OCA designed the study and wrote the first draft of the manuscript. Authors EOO, FOO, PNE and SOU revised the manuscript. All authors read and approved the final manuscript.

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Appendix

Computation of Sum of Squares

Total Sum of Square (TSS) = $n - \frac{\sum_k n_{\dots k}^2}{n}$ (1)

Within Unit Sum of Square (WUSS) = $n - \sum_{ij} \frac{\sum_k n_{ijk}^2}{n_{ij}}$ (2)

Between Row Sum of Square (BRSS) = $n - \sum_i \frac{\sum_k n_{i.k}^2}{n_i}$ (3)

Between Column Sum of Square (BCSS) = $n - \sum_j \frac{\sum_k n_{.jk}^2}{n_j}$ (4)

Row Sum of Square (RSS) = TSS – BRSS (5)

Column Sum of Square (CSS) = TSS – BCSS (6)

Interaction Sum of Square (NSS) = BCSS + BRSS – TSS – WUSS (7)

Appendix Table 1: Two-way contingency table depicting knowledge of hand hygiene among four major healthcare professions during COVID-19 outbreak

	Research question: Did you receive any formal training on hand hygiene practice during COVID-19 outbreak?													
	Healthcare professions (j)													
	Nurse (j_1)			**Medical Doctor (j_2)**			**Lab. Scientist (j_3)**			**Pharmacist (j_4)**			**Total $n_{i.k}$**		
Gender (i)	**YES**	**NO**	**Total $n_{i1.}$**	**YES**	**NO**	**Total $n_{i2.}$**	**YES**	**NO**	**Total $n_{i3.}$**	**YES**	**NO**	**Total $n_{i4.}$**	**YES**	**NO**	**Total $n_{i..}$**
Male	133	1	134	36	0	36	48	0	48	23	0	23	240	1	**241**
Female	264	0	264	26	0	26	50	0	50	19	0	19	359	0	**359**
Total n_{jk}	397	1	**398**	62	0	**62**	98	0	**98**	42	0	**42**	**599**	**1**	**600**

Appendix Table 2: Two-way contingency table depicting compliance to hand hygiene among four major healthcare professions during COVID-19 outbreak

	Research question: How often do you practice hand-wash or hand-rub before and after attending to patients during COVID-19 outbreak?														
	Healthcare professions (j)														
	Nurse (j_1)			**Medical Doctor (j_2)**			**Lab. Scientist (j_3)**			**Pharmacist (j_4)**			**Total $n_{i.k}$**		**Total $n_{i..}$**
Gender (i)	**Every time**	**Sometimes**	**Total $n_{i1.}$**	**Every time**	**Sometimes**	**Total $n_{i2.}$**	**Every time**	**Sometimes**	**Total $n_{i3.}$**	**Every time**	**Sometimes**	**Total $n_{i4.}$**	**Every time**	**Sometimes**	
Male	89	45	134	23	13	36	25	23	48	11	12	23	148	93	**241**
Female	185	79	264	14	12	26	36	14	50	12	7	19	247	112	**359**
Total $n_{.jk}$	274	124	**398**	37	25	**62**	59	37	**98**	23	19	**42**	**395**	**205**	**600**

Appendix Table 3: Two-way contingency table depicting impact of hand hygiene among four major healthcare professions during COVID-19 outbreak

	Research question: What is your experience on the impact of hand hygiene in preventing COVID-19 among healthcare professionals?														
	Healthcare professions (j)														
	Nurse (j_1)			**Medical Doctor (j_2)**			**Lab. Scientist (j_3)**			**Pharmacist (j_4)**			**Total $n_{i.k}$**		**Total $n_{i..}$**
Years of service (i)	**Low**	**High**	**Total $n_{i1.}$**	**Low**	**High**	**Total $n_{i2.}$**	**Low**	**High**	**Total $n_{i3.}$**	**Low**	**High**	**Total $n_{i4.}$**	**Low**	**High**	
1-10 years	51	289	340	16	39	55	13	75	88	8	23	31	88	426	**514**
11-20 years	5	27	32	0	6	6	0	7	7	0	7	7	5	47	**52**
20 years and above	0	26	26	0	1	1	0	3	3	0	4	4	0	34	**34**
Total $n_{.jk}$	56	342	**398**	16	46	**62**	13	85	**98**	8	34	**42**	**93**	**507**	**600**