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Assessment of Biosafety and Biosecurity engagements among workers in some institutional research laboratories (Private & Public) in Abuja, Nigeria

Abstract

This study aims to evaluate the biosafety and biosecurity engagements among workers in some selected institutional research laboratories in Abuja, Nigeria. A biosafety and biosecurity survey was carried out from October 2021 to March 2022 (6 months) among 280 workers such as laboratory technologists, veterinary clinicians in institutional research laboratories (Private and Public) in Abuja, research officers and graduate students,. The data for this study was collected using a standardized and self-administered questionnaire that had 6 sections; Socio-Demographic, laboratory biosafety and biosecurity general knowledge, Laboratory biosecurity Agenda, Laboratory Biosecurity Plan, Achieve Laboratory Biosafety, Attitude towards Laboratory Biosafety. The predictors of biosecurity and biosafety engagement effect on the workplace (Private or Public) was significant with Omnibus χ^2 (5, N= 280) = 44.130, Hosmer-Lemeshow values χ^2 40.954, DF=7, $p< 0.05$. The interaction (Sector*Biosafety level) effect [F (5, 266) =5.43, $p<0.05$] was also statistically significant with its effect on the general knowledge of laboratory biosafety and biosecurity among the respondents. The relationship between the gender and position occupied in the laboratory and the assessment criteria was statistically significant F (15, 737) = 10.899, $p<0.05$; Wilks' Lambda=0.575 and partial eta squared=0.168. It was concluded that the laboratory biosecurity plan and attitude towards laboratory biosafety had a significant influence on the biosafety and biosecurity engagement of the workers based on where (private or public) they work. Also, general knowledge of the workers in the laboratory about biosafety and biosecurity is significantly dependent on the sector where they work and their various biosafety level.

INTRODUCTION

Crops, animal domestication and utilization of microorganism in enhancing some biological processes are ways that researchers are using to improve the environment via biotechnology. The arrival of genetic engineering and the associated transference of gene sequences from one unrelated species to the other, exposed biotechnology to public

scrutiny as African communities began to question its safety, appropriateness and morality (Anderson, 2012).

Genetic engineering modifies the functioning of genes in the same species or transfers genes from one species to another, giving rise to Genetically Modified Organisms (GMOs (Rigasa *et al*., 2015). The genetic material are both DNA and RNA and the DNA is the hereditary material found in eukaryotic cells nucleus (plant and animal) as well as the cytoplasm of prokaryotic cells (bacteria) which determines the organism's composition.

Biological materials that are worked on in the laboratories involve small and large volumes of live microorganisms often engineered for medical, biotechnology and pharmaceutical applications. (Kirunda and OtimOnap, 2014).

Healthcare systems and research institutions are Laboratories base in functions this are clinical, hospital, public health and academic laboratories that constitute the public and private sector's laboratory in promoting health care through their research and diagnostic activities (Shumail *et al*., 2020 and Reller *et al*., 2001). Biological laboratories activities includes samples analysis, disease diagnosis, experiments such as pharmaceutical development of novel drugs, epidemiological studies, and scientific research in public and private sectors. Examples of biological materials are pathogens, toxins, chemicals, genetically modified organisms that are been handled in laboratories for various experimental and diagnostic purposes all over the world (Fournier *et al*., 2013; Oladeinde *et al*., 2013).

While carrying out their activities, workers in research institutes do confront with occupational hazards and if appropriate protective practices not put in place, it will jeopardized their health and safety (Hofmann *et al*., 2017; Tompa *et al*., 2016; Valenti *et al*., 2016). Naturally occurring and emerging infectious diseases are not only a threat of biological agents, it also includes biological weapons and bioterrorism (Morens *et al*., 2004 and Frischknecht, 2003).

The potentially harmful biological agents in a containment such as toxins, chemicals or radiation are fundamental objective of any biosafety program (Kumar, 2014). Biosafety consciousness in laboratory is of ultimate importance in managing hazardous agents in the laboratory and the environment (Haagsma *et al*., 2012; Pedrosa and Cardoso, 2011). Typical laboratory safety measures includes safety training, use of personal protective equipment, review of experimental safety designs and laboratory safety policies enforcement to prevent potential risks associated with exposure to microorganisms in the laboratory.

Zoonotic and plantnotic diseases caused agents are well-known and can be preventable if proper attention is being given to laboratory biosafety and containment of infectious agents (Nordmann, 2010). Prevention of laboratory accidents or intentional exposure to infectious pathogens is achievable if the laboratory biosafety and biosecurity are strictly adhere to by laboratory technicians especially on infections that can easily be contacted in the laboratory with great care and constant vigilance (Gaudioso and Zemlo, 2007). In

avoidance of infectious laboratory risks, training of laboratory researchers is a call for concern (Chamberlain *et al*., 2009).

According to Abhayaratne *et* al., (2020), laboratory safety and environmental safety are stipulated in WHO guidelines. A robust framework of international, regional and national regulations and safety guidelines for handling, storage, containment measures, waste management, transport, packaging, and labeling of biological organisms under contained use, including GMOs for risk assessment and management practices to ensure the protection of human, animal, and plant health as well as the environment (Beeckman and Rüdelsheim, 2020). Compliance with biosafety standards is essential for any research laboratories to get accreditation and certification (Masanza *et al*., 2010).

Abuja is the capital city of Nigeria located at coordinate 9.0765° N, 7.3986° E with an Area of 1,769 km^2. Abuja house both private and federal government agencies and institutes. Some of these agency and institutes have research laboratories where biological activities are carried out.

This research goal is to assess the biosafety and biosecurity engagements among workers in some selected institutional research laboratories in Abuja, Nigeria.

METHODOLOGY

Study area

A biosafety and biosecurity survey was carried out from October 2021 to March 2022 (6 months) with distribution of questionnaires among 280 workers such as laboratory technologists, research officers, veterinary clinicians in institutional laboratories and graduate students (Private and Public) in Abuja, Nigeria.

Sample size

Sample size was calculated with the formula postulated by Fosgate, (2009) and Thrusfield (2009):

$n = (Z_{1-\alpha/2})^2(1 - p)/e^2$

And If n / N > 0.1 then apply population correction factor corrected with a sample size, n $=n/[\ 1+ ((n-1)/\ N)]$. (Fosgate, 2009).

At 95% confidence interval (CI) ($Z_{1-\alpha/2}$ = 1.96), 5% error of margin and 5% non-response rates. Thus, the prevalence was assumed to be 25%., $Z_{1-\alpha/2}$ as standard normal Z value corresponding to a cumulative probability of 1-$\alpha/2$.

P = 0.25; precision = 0.05; α = 0.05

$Z_{1-\alpha/2} = Z_{0.975} = 1.96$

$$n = \frac{(0.25)\ (0.75)\ (1.96)^2}{(0.05)^2}$$

n = 288.12

n / N = 0.08 which is < 0.1, therefore the sample size for this study was 289

Study instrument

The data for this study was collected using a standardized and self-administered questionnaire. The existing literature and similar studies with some modification by the researchers was used in developing the questionnaire.

The questionnaire was divided into six sections namely Socio-Demographic, General knowledge of laboratory biosafety and biosecurity, Laboratory biosecurity Agenda, Laboratory Biosecurity Plan, Achieve Laboratory Biosafety, Attitude towards Laboratory Biosafety.

Statistical Analysis

The internal reliability of the response obtained from the distributed questionnaires was determined with Cronbach Alpha, Descriptive (frequency, percentage, skewness and kurtosis), inferential statistics were used in data analysis. Biosecurity and biosafety engagements prediction in workplace for (Private and Public) were evaluated using binary logistic regression[9] at $p<0.05$. A two-way (ANOVA) conducted to explore the impact on sector and biosafety level in laboratory biosafety and biosecurity general knowledge[9] at $p<0.05$. A two-way multivariate analysis of variance (MANOVA) to investigate gender and position on the differences in biosafety and biosecurity assessment criteria at $p<0.05$.

RESULTS AND DISCUSSION

The researcher produced 289 questionnaires and distribute them but 280 of them were completely filled by the time it was accepted from the respondents in this study. From Table 1, 55.4% of the respondents were male and 44.6% of them were female. The respondents in this study have 75% of them working in a public institute while 25% work in private research institute laboratories. Majority of the respondents were researchers (62.5%) from Table 1, 46.4% of them belongs to the veterinary service sector, 25.0% belongs to the human health sector. 50% of the respondents have a biosafety level 1 knowledge.

According to George and Mallery (2019), kurtosis accounts for the peakedness distribution of a descriptive statistic. A kurtosis value ±1.0 is adjudged excellent but a value within ±2.0 is acceptable, depending on the particular application. Skewness accounts for the degree at which a distribution of data moved from symmetry for the mean. It is adjudged excellent at a value between ±1.0. Also, a value within ±2.0 was acceptable (George and Mallery, 2019). From Table 1 in this study, the descriptive statistics of the respondents' skewness value between -0.840±0.416 and 1.732±0.416, and kurtosis value between -1.967±0.29 and 2.697±0.29. From the assertion of George and Mallery (2019), all the items in Table 1 could be adjudged acceptable from their skewness and kurtosis values.

Table 1: respondent's socio-demographic distribution

	Frequency	Percentage	Skewness	Kurtosis
Gender				
Male	155	55.4	0.217±0.416	-1.967±0.29
Female	125	44.6		

Age				
21-30	170	60.7	1.450±0.416	1.156±0.29
31-40	70	25.0		
41-50	20	7.1		
51-60	20	7.1		
Educational Qualification				
SSCE	55	19.6	-0.840±0.416	-0.460±0.29
NCE	5	1.8		
OND	5	1.8		
HND	5	1.8		
B.Sc	145	51.8		
Master	30	10.7		
Ph.D	35	12.5		
Place of work				
Private	70	25.0	-1.161±0.416	-0.657±0.29
Public	210	75.0		
Position in Organization				
Researcher	175	62.5	1.732±0.416	2.697±0.29
Laboratory Technologist	65	23.2		
Laboratory Technicians	25	8.9		
Laboratory Manager	10	3.6		
Laboratory Cleaner	5	1.8		
Service sector				
Animal Health	35	12.5	0.369±0.416	0.954±0.29
Veterinary	130	46.4		
Crop Protection	40	14.3		
Human Health	70	25.0		
Public Hygiene	5	1.8		
Biosafety Level				
0	20	7.1	0.912±0.416	1.915±0.29
1	140	50.0		
2	105	37.5		
3	5	1.8		
4	10	3.6		

Key words: SSCE=Senior Secondary Certificate i Education, NCE= National Certificate in Education, OND=Ordinary National Diploma, HND=Higher National Diploma, B.Sc.=Bachelor of Science, PhD=Doctor of Philosophy

Table 2.: Internal Reliability of responses

Categories	Cronbach's Alpha (α)	Mean ± S.D	Number of items
General knowledge of laboratory biosafety and biosecurity	0.647	20.23 ± 2.81	5
Laboratory biosecurity Agenda	0.785	18.32 ± 3.64	5
Laboratory Biosecurity Plan	0.828	19..52 ± 3.63	5
Achieve Laboratory Biosafety	0.814	19..84 ± 3.70	5
Attitude towards Laboratory Biosafety	0.857	21..46 ± 3.04	5

The rules of thumb for reliability test according to Aifuwa and Okogie (2015); George and Mallery (2003) gave a reliability test in Cronbach alpha represented as a values >0.9 = excellent, > 0.8 = good, > 0.7 = acceptable, > 0.6 = questionable, > 0.5 = poor, and < 0.5 =unacceptable.

From this study, reliability test on the category of items used in cronbach's alpha from 0.647 to 0.857 in Table 2, therefore, all results can be rated as "Acceptable".

Table 3: Binary Logistic Regression Analysis for the biosecurity and biosafety assessments prediction on the workplace (Private or Public)

Predictor	**Coefficients**	**Standard Error**	**Wald**	**df**	**Significance**	**Odd ratio**	**95% CI**
Constant	-3.477	1.229	8.000	1	0.005	0.831	-
G1	0.109	0.062	3.101	1	0.078	1.115	0.988-1.259
L1	0.034	0.061	0.308	1	0.579	1.034	0.918-1.164
L2	0.218	0.063	12.177	1	0.000	1.244	1.100-1.407
L3	0.056	0.053	1.132	1	0.287	1.057	0.954-1.172
L4	-0.159	0.067	5.613	1	0.018	0.853	0.748-0.973
Test							
					χ^2	Df	Significance
Omnibus					44.130	5	0.000
Hosmer and Lemeshow					40.954	7	0.000
Model Summary 2-Log Likelihood- 270.778 Cox and Snell R square- 0.146 Nagelkerke R square- 0.216							

G1- General knowledge of laboratory biosafety and biosecurity, L1- Laboratory biosecurity Agenda, L2- Laboratory Biosecurity Plan, L3- Achieve Laboratory Biosafety, L4- Attitude towards Laboratory Biosafety

Using the enter method, the results of the regression from Table 3 indicated that the model explained 21.6 of the variances and that the model was a significant predictor with Omnibus χ^2 (5, N= 280) = 44.130, p< 0.05. The analysis shows that the biosecurity and biosafety engagement measure did contribute significantly to the model, but the model is not fit with the Hosmer-Lemeshow values χ^2 40.954, df=7, p<0.05.

biosecurity and biosafety engagement influence on workplace (Private or Public) = -3.477 + (0.109* G1) + (0.034*L1) + (0.218*L2) + (0.056*L3) + (-0.159*L4)

The predictors of biosecurity and biosafety engagement influence on the workplace (Private or Public) is significant with Laboratory Biosecurity Plan (Wald=12.177, df=1) and Attitude towards Laboratory Biosafety (Wald=5.613, df=1) having significant influence individually on the workplace among the 5 predictors has indicated in Table 3.

Biorisk management training in biosafety and biosecurity is paramount and this was emphasized in the studies conducted by Heckert *et al.*, (2011), Goswami *et al.*, (2011), Hakim *et al.*, (2012) and Qasmi *et al.*, (2012) in developing countries.

From the study of (Mugirya, 2008), was of the opinion that the highest risk lied within the inability of any African country be able to prevent its laboratories from inadvertently releasing of viral or bacterial pathogens being used for research in the laboratories into the environment. The inadequate training of biorisk management in Africa affects the efforts to improve biosafety and biosecurity in developing countries (Previsani, 2009). Biosafety and biosecurity engagement largely rely on the employer of labour in each various institute laboratories.

Table 4: Two ways ANOVA for the evaluation of the impact of sector and Biosafety level on their general knowledge of laboratory biosafety and biosecurity

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	R^2	Sig.	Partial Eta Squared
Sector	G1	192.602	4	48.151	10.197		.000	0.133
Biosafety level	G1	168.393	4	42.098	8.915		.000	0.118
Sector * Biosafety level	G1	128.120	5	25.624	5.426	0.432	.000	0.093
Within		1256.083	266	4.722				
Corrected model		953.827	13	73.371	15.538		.000	0.432
Total		116825.000	280					

G1- Laboratory biosafety and biosecurity general knowledge

In the two-way analysis of variance (ANOVA) conducted to explore the impact of the sector and Biosafety level on laboratory biosafety and biosecurity general knowledge. The sectors were categorized into five groups (Group 1: Animal health, Group 2: Veterinary, Group 3:

Crop protection, Group 4: Human health and Group 5: Public Hygiene). From Table 4, has a statistical significant main effect for sector [F (4, 266) = 10.197, p<0.05] however, the effect on size was small (partial eta squared= 0.133). Comparisons in post-hoc using the Tukey HSD test indicated that the mean score for the veterinary group (M=18.77, SD=2.84) found to be significantly different from the Animal health group (M=22.00, SD=1.53), crop protection group (M=22.50, SD=2.26) and Human health group (M=20.71, SD=1.99). It was only the public hygiene group (M=20.23, SD=2.81) that was not significant with the other groups. Effect for biosafety level [F (4, 266) = 8.915, p<0.05] and the interaction (Sector * Biosafety level) effect [F (5, 266) =5.43, p<0.05] were also statistically significant with their effect on the general knowledge of laboratory biosafety and biosecurity among the respondents in this study. Training in biosafety and biosecurity cannot be over emphasize in reducing risk in laboratories (Rice *et al* 2015), this corroborated the earlier reports on the inadequate training capacity of Biosafety and biosecurity in Africa (Food and Agricultural organization (FAO), (2010).

Table 5: Multivariate analysis of variance (MANOVA) reports for effect of gender and position on the biosafety and biosecurity engagement

Source	Dependent variable	F	df1, df2	Sig.	partial eta squared	Wilks' Lambda	df1, df2	F	Sig.	partial eta squared

Gender	G1	18.332		0.000	0.063					
	L1	14.549		0.000	0.051					
	L2	38.992	1, 271	0.000	0.126	0.836	5, 267	10.475	0.000	0.164
	L3	2.561		0.111	0.009					
	L4	4.136		0.043	0.015					
Position	G1	8.606		0.000	0.113					
	L1	23.125		0.000	0.254					
	L2	22.722	4, 271	0.000	0.251	0.437	20, 886	12.550	0.000	0.187
	L3	6.453		0.000	0.087					
	L4	3.078		0.017	0.043					
Gender * Position	G1	21.812		0.000	0.194					
	L1	20.097		0.000	0.182					
	L2	16.747	3, 271	0.000	0.156	0.575	15, 737	10.899	0.000	0.168
	L3	15.684		0.000	0.148					
	L4	7.103		0.000	0.073					

G1- General knowledge of laboratory biosafety and biosecurity, L1- Laboratory biosecurity Agenda, L2- Laboratory Biosecurity Plan, L3- Achieve Laboratory Biosafety, L4- Attitude towards Laboratory Biosafety

Table 6: Descriptive analysis of the independent and dependent variable for the two-way MANOVA

Dependent Variable	Gender (Mean ± S.E)		Position (Mean ± S.E)				
	Male	Female	Researcher	Laboratory Technologist	Laboratory Technicians	Laboratory Manager	Laboratory Cleaner
G1	18.86±0.31	20.70±0.35	20.99±0.18	19.24±0.31	20.75±0.47	18.50±0.73	20.00±1.04
L1	17.61±0.41	17.94±0.45	19.13±0.23	16.44±0.40	18.50±0.61	21.00±0.94	10.00±1.34
L2	18.33±0.41	19.70±0.45	20.17±0.23	18.83±0.40	19.42±0.61	22.50±0.94	10.00±1.34
L3	19.60±0.44	20.91±0.48	20.61±0.24	18.36±0.43	19.50±0.65	22.00±1.01	22.00±1.43
L4	21.26±0.39	22.96±0.43	21.50±0.22	21.01±0.39	22.92±0.59	22.00±0.91	25.00±1.29

G1- General knowledge of laboratory biosafety and biosecurity, L1- Laboratory biosecurity Agenda, L2- Laboratory Biosecurity Plan, L3- Achieve Laboratory Biosafety, L4- Attitude towards Laboratory Biosafety

A multivariate analysis of variance (MANOVA) carried out to investigate on gender and position engagements criteria differences on biosafety and biosecurity. Five dependent

variables were used: General knowledge of laboratory biosafety and biosecurity, Laboratory biosecurity Agenda, Laboratory Biosecurity Plan, Achieve Laboratory Biosafety and Attitude towards Laboratory Biosafety. The independent variable on gender and position, a preliminary assumption testing used in checking for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity with no violations noted. From Table 5, statistical significant difference in males and females combined with dependent variables: F (5, 267) = 10.475, p<0.05; Wilks' Lambda=0.836; partial eta squared=0.164 and dependent variables results were considered separately, the only difference was not to reach statistical significance by using a Bonferroni adjusted alpha level of 0.017 to Achieve Laboratory Biosafety: F (1, 271) =2.561, p=0.111 and partial eta squared=0.009. Mean scores from Table 6 shows that females reported slightly higher levels in Achieve Laboratory Biosafety (M=20.91, SE=0.48) than males (M=19.60, SE=0.44).

Examining the second independent variable (position) in Table 5, a statistical significant difference between the different positions occupied by respondents in their various research institute (Researcher, Laboratory Technologist, Laboratory Technicians, Laboratory Manager and Laboratory Cleaner) combined with dependent variables: F (20, 886) = 12.550, p<0.05; Wilks' Lambda=0.437 and partial eta squared=0.187. All dependent variables were statistically significant as the results for dependent variables were also considered separately, using a Bonferroni adjusted alpha level of 0.017.

Considering the two independent variables (gender and position) impact on the dependable variable shows in Table 5, a statistically significant between variables: F (15, 737) = 10.899, $p<0.05$; Wilks' Lambda=0.575 and partial eta squared=0.168. Results for dependent variables were also considered separately, using a Bonferroni adjusted alpha level of 0.017 and all dependent variables were statistically significant with Attitude towards Laboratory Biosafety: F (3, 271) =7.103, $p<0.05$, having smallest effect on size (partial eta squared= 0.073). Examining mean scores from Table 6 shows that females reported slightly higher levels of attitude towards Laboratory Biosafety (M=22.96, SE=0.43) than males (M=21.26, SE=0.39), the study of Odetokun *et al.,* (2017) is of contrary view since they find out that good knowledge in laboratory biosafety research facilities is more likely to be associated with male researchers and those working in research institute laboratories than female.

CONCLUSION

This study has clearly shown that the laboratory biosecurity plan and attitude towards laboratory biosafety where someone works have a significant influence on their biosafety and biosecurity engagement. Also, it can be deduced from this study that general knowledge of the workers in the laboratory about biosafety and biosecurity is significantly dependent on the sector where they work and also their various biosafety level. In addition, the study shows that gender and position had significant effect on all the biosafety and

biosecurity assessment criteria with female researchers and laboratory technicians having more inclination on how their research facilities do with the assessment.

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