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The Predictive Value of Biorisk Perception on Biorisk Management Level of University Bioscience Laboratories in Kenya

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Abstract

Recent biorisk management breaches and adverse outcomes indicting life scientists at the universities demand more attention to reduce any incidences of fatal and non-fatal injuries. The main objective of the study was to determine the predictive value of biorisk perception on the level of biological risks' management at the university bioscience laboratories. A quantitative, descriptive survey design was employed and administered through a survey by both the researcher and online to 1300 university students, lecturers, and laboratory technologists with a response rate of 79.5% (1034 respondents). A questionnaire designed to capture independent (level of biorisk perception of life scientists) and dependent variables' (Biorisk Management Level) scores were used. IBM SPSS software assisted in computing Pearson correlation coefficients, analysis of variance (t-tests, F-tests), univariate, simple linear regression analysis, and chi-square tests. Data were summarized as tables and other descriptive statistics. One way ANOVA revealed that the private medium university category (M = 21.00) had the highest biorisk perception mean score but there was no statistically significant difference of the mean scores at the $p<.05$ for the six university categories [$F(5, 1028) = .329$, $p = .895$]. Simple linear regression analysis revealed that 36.3%

of the variation in Biological Risk Management Level at the universities was explained by variation in biorisk perception (R Square= .363, p<0.001). It was concluded that biorisk perception has great predictive value in determining the biorisk management level of university bioscience laboratories. To improve biorisk management at the universities, there is a need to enhance the biorisk perception of students, lecturers, and laboratory technologists.

Keywords: biorisk perception, biorisk management, biosafety, biosecurity, university bioscience laboratories.

Introduction

Perception involves the way one sees the world (McDonald, 2011). Depending on the discipline, risk perception has multiple definitions (Rohrmann, 2008). According to Grima *et al*. (2021), risk perception is the subjective judgments that people make or form about the characteristics, severity, and ways of dealing with risks associated with hazardous activities and technologies (Slovic, 1987). On the other hand, Chaswa *et al.* (2020) maintain that risk perception is 'the ability to determine the amount of risk from a hazard" while risk is defined as 'the calculation of how likely an incident is to occur and given its occurrence, how dire the consequences would be. Biological risks infer that the hazard is of biological origin from plants and animals (Jeebhay & Alvarez, 2014).

The World Health Organization as quoted by Elvira *et al.* (2020), defines biological risks as the possible exposure to micro-organisms that give rise to disease, caused by work activity (Elvira *et al.*, 2020). Biological risks are currently a public health problem with impact at both the national and international levels (Dickmann *et al.*, 2016; Meima *et al.*, 2020; Moreno-Arroyo *et al.*, 2016). Risk management is defined as the appetite of society and their judgment on whether the risk is acceptable or not and the decisions taken to adequately add controls (Klinke & Renn, 2002). Risk management includes all activities that enable the probability of a risk occurring or its effect to be eliminated or reduced to an acceptable level (Pálinkás, 2011). Biorisk Management refers to management of biological risks arising from adverse events, including accidental release, unintentional exposure, loss, theft, misuse, diversion of, unauthorized access or intentional unauthorized release (Abad, 2014; European Committee for Standardization, 2011) and is currently a critical priority for workplaces (Abrahams *et al.*, 2017). It consists of three components:

biosafety, biosecurity, and ethics (Whitby & Pearson, 2012).

Universities exist to respond to the needs of society, solve societal problems, conduct research to improve the living standards of human beings, and prepare the next generation of life scientists among others. The recent rapid expansion of universities, from 33 in 2012 to 66 chartered 2020 with minimal investment in infrastructural facilities (Commission for University Education, 2018; Commission of University Education, 2016) coupled with the global increase in the number of new and emerging highly infectious diseases suggest an urgent need to focus more attention to the bioscience laboratories where such organisms are manipulated. Thorough investigation and clear determination of the role played by biorisk perceptions levels on biorisk management will significantly facilitate the development of safe and secure university bioscience laboratories and secure society. To the best of our knowledge, no study has ever been conducted on biorisk perception in the universities in Kenya. A quick literature review indicates that research on risk perception in general is either scanty (Tadese *et al*., 2021), small in number (Slovic, 1987), or few (Moreno-Arroyo *et al*., 2016).

Recent studies indicate that 3 out of every 4 cases occur within the university bioscience laboratories (Gaudioso *et al.*, 2009) and that biorisk control measures are lacking (Salerno & Gaudioso, 2015). Senior university professors and students have been indicted on major biosafety (Bal, 1995) and biosecurity (Abramova *et al.*, 1993; Chai *et al.*, 2008; Clevestig, 2009). Noorden (2013) raised concerns about university researchers' perceptions and how this could be impacting biorisk management in institutions of higher learning. In the study, it was reported that thirty percent of respondents had witnessed at least a major biorisk incident. Since risk perception plays a substantial role in disease transmission (Tadese *et al.*, 2021) by influencing behavior (Machin, 2006; Slovic, 1987, Schreiter *et al.*, 2020), attitude (Moreno-Arroyo *et al*., 2016), multiplying dread and concern thus triggering taking preventive actions (Tadese *et al.*, 2021; McDonald, 2011) and decisions (McDonald, 2011), it could be the antidote for improved biological risk management. The main objective of this study was thus to evaluate whether biorisk perceptions of life scientists can be used to predict the level of university biorisk management.

Materials and Methods

The study adopted a descriptive quantitative cross-sectional survey design which fitted accurately with the research objective. Such research designs enable the use of questionnaires, quantitative testing of relationships, statistical testing, and drawing of inferences. The main geographic areas of study were both public and private Kenyan university bioscience laboratories while key respondents were bioscience students, lecturers in biosciences, and laboratory technologists/ technicians. In this study, the study population comprised all university bioscience laboratories, all students taking degree courses in biological sciences, lecturers, and laboratory technologists/ technicians in biological sciences. The target population is composed of randomly selected chartered university bioscience laboratories, students enrolled in degree courses in biological sciences, lecturers, and laboratory technologists/ technicians in biological sciences.

The online random number generator was used to identify the sampled 16 out of 66 universities in Kenya. Thereafter, a half of the currently listed students, lecturers, and technologists in biosciences were randomly selected and invited to participate in the study. The number and categorization of universities studied are shown in Table 1.

A structured questionnaire was used to collect data on demographic information, biorisk perceptions, and levels of biorisk management with Likert-type scales.

Table 1: Total number of universities in Kenya and number of universities studied

University Category/ Strata	Small (below 5000 students)	Medium (5001 - 15,000 students)	Large (>15000 students)	Total
Public	5(2)	18(4)	9(4)	**32(10)**
Private	27(4)	5(1)	2(1)	**34(6)**
Total	**32(6)**	**23(5)**	**11(5)**	**66(16)**

Instrument reliability and validity

The stability or consistency (reliability) of the data collection instrument was obtained by calculating Cronbach's alpha coefficient while the validity was determined by evaluating both the Average Variance Extracted (AVE) and the Composite Reliability (CR). The Cronbach's alpha coefficient was 0.756 which according to Ghadi *et al*. (2012) is acceptable. The AVE and the CR were 0.457 (rounded off to 0.5) and 0.701 respectively. According to Fornell and Larcker (1981), even if AVE is less than 0.5, but composite reliability is higher than 0.6, the convergent validity of the construct is still adequate (Fornell & Larcker, 1981; Pervan *et al.*, 2017). The instrument therefore, met both the requirement for convergent validity and reliability. Brown (2010) emphasized that construct validity is the most important form of validity and generally from a scientific point of view, maybe represent the entire validity (Brown, 2010). In Li and Stacks (2016), the validation of a construct to ensure construct validity only includes convergent and discriminant validity.

Variables

The dependent variable in this study was the biological risk management level of the university bioscience laboratories (Dev %) comprising three main constructs: biorisk assessment (13 items), biorisk mitigation (23 questions), and biorisk performance measurements (23 questions). The thematic constructs, indicator questions, and maximum scores are shown in Table 2.

Table 2: Thematic constructs, indicator questions and maximum scores

Thematic construct	Number of indicator questions	Actual maximum score
Biorisk assessment (BRA)	13	41
Biorisk mitigation(BRMit)	23	32
Biorisk performance measurement (BRPM)	23	32
Total maximum score		**105**

The only independent variable questions were on *biorisk perception* score and were obtained from the following sets of indicator questions: 13, 14, 17, 18, 22 and 23, the maximum score being 30. Data was collected between 15 August 2019 and 13 March 2020 by way of online distribution of Google forms and researcher-administration of the questionnaires. University student volunteers administered the questionnaires at the university to the consenting participants.

Data was analyzed using Microsoft Excel 2013 (15.0.4420.1017) and IBM Statistical Package for Social Sciences (SPSS) software version 21. Relationships were computed using correlation coefficients, simple linear regression (bivariate analysis), t-tests, and chi-square tests based on assumed population variance of 0.5, the precision of 0.05, confidence level of 95%, and an estimated response rate of 70%.

Results

Biorisk perception mean construct scores: The means of 6 items, tested according to the perception score variable, are presented in Table 3. All items had a mean score above 4.00. This is an indication that the majority of the respondents agreed with the items' statements based on each variable and considered those items as major antecedents of perception towards biorisks.

Table 3: Mean risk perception score

Perception score	**N**	**Mean**	**SD**
Question 13. To what extent is biorisk management/biological safety important to students, lecturers, and technologist	1034	4.39	0.067
Question 14. To what extent is familiarity with biological hazards likely to affect exposure to biological risk	1034	4.22	0.058
Question 17. To what extent is the level of technology used in securing biological risks important for the consequences of adverse exposure to biological risks.	1034	4.53	0.056
Question 18. Biological risks are catastrophic in nature.	1034	4.17	0.055
Question 22. Exposure to biological risk is not voluntary	1034	4.08	0.101
Question 23. I trust life scientists (students, lecturers, and technologists) handling hazardous biological agents can put in place appropriate exposure control measures.	1034	3.35	0.086
Grand Mean		**4.12**	

Biological risk management level mean: The summary statistics of the biological risk management level (dependent variable) are indicated in Table 4.

Table 4: Summary statistics of the biological risk management level (dependent variable)

	Descriptive statistics						
	No.	**Range**	**Minimum**	**Maximum**	**Mean**	**SD**	**Variance**
Dev %	1034	41	45	86	67.51	8.703	75.747
Valid N (listwise)	1034						

Testing of the hypotheses

(a) Biorisk perception score and biological risk management level of university bioscience laboratories

This study sought to determine the predictive value of biorisk perceptions on the biological risk management level of university bioscience laboratories. The tests were carried out using chi-square tests, simple regression analysis, multiple regression analysis, correlation analysis, and analysis of variance. The tests were done at 5% significance level (α=0.05). The investigation focused on the hypotheses derived from the objectives of the study. Three hypotheses were tested. To test the hypotheses, composite scores for variables or constructs that had several item measures were computed. In this regard, the overall level of biorisk management score was obtained by collapsing biorisk assessment score, biorisk mitigation score, and biorisk performance measurement score into one composite index. The tested hypothesis was that there is a linear relationship between the biorisk perception levels and the biological risk management level of university bioscience laboratories. Both null and alternative hypotheses were as stated below while the summary and the regression results are in Table 5.

Null hypothesis: H_0

There is no linear relationship between the biorisk perception levels and the Biological Risk Management Level of university bioscience laboratories.

Alternative hypothesis: H_1

There is a linear relationship between the biorisk perception levels and the biological risk management level of university bioscience laboratories.

The hypothesis was tested by regressing the biorisk perception score on the biological risk management level of university bioscience laboratories guided by the equation:

$$Y = \beta_0 + \beta_1 x,$$

Where *x* represented biorisk perception score and *Y* denoted the biological risk management level of university bioscience laboratories (Dev%). The model summary statistics, one-way analysis of variance (ANOVA), and the model coefficients results of the linear regression analysis are presented in Tables 5, 6 and 7 respectively.

Table 5: Model summary statistics of the linear regression analysis of biorisk perception score on biological risk management level of university bioscience laboratories

Model	R	R^2	Adjusted R^2	SE of the estimate
1	0.603a	0.363	0.362	6.949

Table 6: One way analysis of variance of biorisk perception score by biological risk management level of university bioscience laboratories

Source	df	S.S.	M.S.	F	P
Between groups	1	28406.487	28406.487	588.193	.000b
Within groups	1032	49839.896	48.294		
Total	1033	78246.383			

Table 7: Regression coefficients results for biorisk perception score and biological risk management level of university bioscience laboratories

Model	Unstandardized coefficients		Standardized coefficients	t	*P*	Collinearity statistics	
	B	**SE**	**Beta**			**Tolerance**	**VIF**
Constant	41.943	1.076		38.976	.000		
Perception score	1.332	.055	.603	24.253	.000	1.000	1.000

Notes: a. Predictors: (Constant), Biorisk perception score. b. Dependent variable: biological risk management level (Dev%).

A simple linear regression analysis was conducted to predict the biological risk management level (dependent variable) based on biorisk perception score (independent variable). The results in Table 5 show that the influence of biorisk perception on biological risk management level (Dev%) was significant (F (1, 1032) = 588.193, p<.001]. From the Table, 36.3% of the variation in biological risk management level (Dev%) was explained by variation in biorisk perception score (R Square= .363, p<0.001). The coefficient of biorisk perception score (β) was also statistically significant (β=1.332, t=24.253, p<.001). Overall, the linear regression results indicate that the biorisk perception score has a positive effect on the biological risk management level (Dev%). The hypothesis that the biorisk perception score influences the biological risk management level (Dev%) was confirmed. As the biorisk perception score increases so does the biological risk management level (Dev%). The predicted model is shown below:

The predicted biological risk management level (BRML) = 41.943 + (1.332*Biorisk perception score)

The model was re-written as follows:

BRML = 41.943 + 1.332*BRP

(b) Biorisk perception for different university categories

The study sought to determine if there is any statistically significant difference in the mean biorisk perception score among different university categories (public small, public medium, public large, private small, private medium, and private large).

Results indicated that the proportion of respondents that did not have high biorisk perception was 53.2% while those who reported high biorisk perception was 46.8% as displayed in Table 8. The mean score for biorisk perception for all respondents was computed as 19.19. To understand this further, a hypothesis was developed and tested using a one-way analysis of variance. The hypothesis tested was that the mean scores of biorisk perception are statistically different for different university categories (public small, public medium, public large, private small, private medium, and private large). One-way between-subjects ANOVA was conducted to compare mean scores of biorisk perception for the different university categories.

The hypothesis below was tested.

Null hypothesis

The mean score of biorisk perception score will not be statistically significantly different in different university categories (public small, public medium, public large, private small, private medium, and private large).

Alternate hypothesis

The mean score of the biorisk perception score will be statistically significantly different in different university categories (public small, public medium, public large, private small, private medium, and private large).

The proportion of respondents in different biorisk perception categories (Not High Biorisk Perception, High Biorisk Perception) are displayed in Table 8 while the mean scores are presented in Table 9. The results of the one-way ANOVA for Biorisk Perception mean scores for different university categories are shown in Table 10.

Table 8: The proportion of respondents and levels of biorisk perception by category

Biorisk perception category	No.	%
Not high perception	550	53.2
High perception	484	46.8
Total	1034	100

Table 9: Mean score of biorisk perception score for different university categories

University Category	N	Subset for alpha = 0.05
Public small	190	19.02
Private large	148	19.03
Private small	35	19.03
Public large	152	19.26
Public medium	506	19.28
Private medium	3	21.00
Sig. (p)		.721

Means for groups in homogeneous subsets are displayed. a. Uses harmonic mean sample size = 15.687; b. The group sizes are unequal. The harmonic mean which is equivalent to the reciprocal of the arithmetic mean of the reciprocals, of the group sizes is used. Type I error levels are not guaranteed.

Table 10: One-way analysis of variance results for biorisk perception mean scores for different university categories

	S.S.	d.f.	M.S.	F	P
Between groups	25.591	5	5.118	.329	.895
Within groups	15977.877	1028	15.543		
Total	16003.467	1033			

The results indicate that there was no statistically significant difference in the mean scores at the $p < .05$ level for the six university categories [F (5, 1028) = .329, p = .895]. However, private medium university category (M = 21.00) had the highest biorisk perception mean score which did not significantly differ from public medium (M = 19.28), public large (M = 19.26), private small (M = 19.03), private large (M = 19.03), public small (M = 19.02) categories. Only one homogenous subset was revealed. Taken together, these results suggest no mean score difference among biorisk perceptions for different university categories. The hypothesis that the mean scores of biorisk perception are statistically different for different university categories (public small, public medium, public large, private small, private medium, and private large) was not confirmed.

(c) Biorisk perception and demand for risk mitigation

The third objective in the study sought to compare the different levels of demand for biorisk mitigation and different levels of biorisk perception. This informed the hypothesis below:

Null hypothesis: H_0

There is no statistically significant difference between the demand for biorisk mitigation and biorisk perception scores. There is a statistically significant difference between the demand for biorisk mitigation and biorisk perception scores.

Alternative hypothesis: H_1

There is a statistically significant difference between different levels of demand for biorisk mitigation and different levels of biorisk perception scores.

The distribution of respondents in the different levels of demand for biorisk mitigation and biorisk perception are displayed in Table 11. The results of the chi-square test of independence are displayed in Table 12, while the strength of the association is displayed in Table 13.

Table 11: Number of respondents in different categories of biorisk perception and demand for biorisk mitigation

		Categories of demand for risk mitigation		No.	%
		No demand for risk mitigation	Demand for risk mitigation		
Risk perception categories	Not high perception	29	519	548	53.1
	High perception	29	455	484	46.9
Total (N)		58	974	1032	
Percentage (%)		5.62	94.38	1032	100

Table 12: Chi-square test results of biorisk perception and demand for biorisk mitigation

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson chi-square	.237a	1	.626		
Continuity correction b	.124	1	.725		
Likelihood ratio	.237	1	.627		
Fisher's exact test				.685	.362
Linear-by-linear Association	.237	1	.626		
N of valid cases	1032				

0 cells (0.0%) have an expected count less than 5. The minimum expected count is 27.20.

Computed only for a 2×2 Table.

Table 13: Strength of association between levels of biorisk perception and demand for biorisk mitigation

		Value	Approx. Sig.
Nominal by nominal	Phi	-.015	.626
	Cramer's V	.015	.626
No. of valid cases		1032	

A chi-square test of independence was performed to examine the relationship between different levels of demand for biorisk mitigation and the levels of biorisk perception at the universities. The relation between these variables was not significant, X^2 (1, N = 1032) = 0.237, p = .626. The strength of the association was negligible (Cramer's V=0.015; p = .626). The hypothesis that there is a statistically significant difference between different levels of demand for biorisk mitigation and different levels of biorisk perception scores is not confirmed. It is concluded that there is no statistically significant difference between different levels of demand for biorisk mitigation and levels of biorisk perception scores.

Discussions

(i) Linear relationship between biorisk perception score and biological risk management level of university bioscience laboratories

In total, the linear regression analysis results indicate that risk perception score has a positive effect on the biological risk management level of university bioscience laboratories (Dev.%). The hypothesis that biorisk perception score influences the biological risk management level of university bioscience laboratories (Dev.%) was confirmed. As the biorisk perception score increases so does the biological risk management level (Dev.%). Wachinger and Renn (2010) averred that perceptions may differ contingent on the type of risk, the risk situation, the disposition of the individual, and the social context (Wachinger & Renn, 2010).

According to Sjöberg (2012), risk perception is a subjective assessment of an action plan and encapsulates the probability of adverse outcomes and the awareness of the magnitude of their respective consequences. Chionis & Karanikas (2018) demonstrated that perception of imminent high risks and higher levels of self-confidence were related to risk-mitigating behavior. Researchers such as Haase *et al.* (2016), Hedayati *et al*. (2006), and Shreve *et al*. (2014) all agree that a high perceived risk of harm should encourage people to take action to reduce their risk. Within this study, such action should include conducting biorisk assessments, putting in place biorisk mitigation measures, and measuring their performance thereby leading to a higher score on the biological risk management level. It comes as no surprise that this study established that biorisk perception had a positive impact on the biological risk management level.

Chionis & Karanikas (2018) established that perception of imminent high risks and higher levels of self-confidence were related to risk-mitigating behavior. And to reinforce this point, Norman *et al*. (2007), Bubeck *et al.*, (2012), and Shreve *et al.* (2014) have concluded that a high perceived risk of harm should encourage people to take action to reduce their risk. In their scholarly piece, Joyan *et al.* (2017) affirm that perception of risk can have a strong impact on risk mitigation measures in some cases.

(ii) Biorisk perception for different university categories

The study did not establish any statistically significant difference in the mean biorisk perception score among different university categories (public small, public medium, public large, private small, private medium, and private large). This finding does not resonate with the expected position. Otherwise, it may be assumed that biorisk perception mean scores among the bioscience lecturers, students and technologists are also not statistically significantly different, something that is not necessarily feasible. This proposition should trigger additional research to shed more light because of current limited scientific corroboration.

(iii) Biorisk perception and demand for biorisk mitigation

The study also confirmed that there is no statistically significant difference between different levels of demand for biorisk mitigation and levels of biorisk perception score among universities. Chionis & Karanikas (2018) demonstrated that perception of imminent high risks and higher levels of self-confidence were related to risk-mitigating behavior. And to reinforce this point, multiple studies (Norman *et al.*, 2007; Bubeck *et al.*, 2012; Bubeck *et al.*, 2012; Shreve *et al.*, 2014) have concluded that high perceived risk of harm should encourage people to take action to reduce their risk. Indeed, Joyan *et al.* (2017) affirm that perception of risk can have a strong impact on risk mitigation measures in some cases.

These findings are not consistent with the existing body of knowledge. Demand for biorisk mitigation should conventionally be driven by biorisk perception (Schreiter *et al*., 2019). It is well established that perceptions drive actions (Machin, 2006; Schreiter *et al*., 2019). A higher biorisk perception, for example, should be correlated with a higher demand for biorisk mitigation. The probable explanation for the observed phenomenon could be that biorisks at university bioscience laboratories are low-risk category organisms that do not attract higher biorisk perception. Alternatively, there could be other determinants of demand for biorisk mitigation. Thirdly, it may be possible that university students, lecturers, and laboratory technologists possess a high degree of personal control, familiarity, and voluntariness concerning the biological organisms they deal with. These hypotheses could be subjects for further scientific inquiry.

Conclusions

This pioneering study concluded that there is a linear relationship between the biorisk perception levels and the biological risk management level of university bioscience laboratories. Enhancing the way biological risks are perceived by bioscience lecturers, students and technologists has a positive and direct impact on the level of biological risks' management at the universities. It was established that there is no statistically significant difference between different levels of demand for biorisk mitigation and levels of biorisk perception score among universities, a finding that does not align with the existing body of knowledge.

Thirdly, findings indicate that university biorisk management infrastructure in Kenya is poorly developed although, it is best exhibited by privately owned medium-sized universities with student populations ranging between 5,001 and 10,000. The worst managed university bioscience laboratories are in the category of privately-owned and small size with a student population of up to 5,000. For consumers of this study, the research results appear to be useful for those who manage bioscience laboratories at the universities and seek approaches to enhance biorisk perception. These findings contribute to debate on biorisk management at the universities by expounding on the predictive values of biorisk perceptions, biorisk knowledge, and biorisk awareness on the state of biorisk management. Biorisk perception which enhances communication ability enables students, lecturers, and technologists to share knowledge and life experiences on biorisks which in turn will improve biorisk management at the university bioscience laboratories.

Recommendations

Further studies are however necessary to illuminate the relationship between biorisk perception and demand for biorisk mitigation. Such studies would highlight and possibly explain the poor management of biological risks at university bioscience laboratories in Kenya. Secondly, the regulatory focus should be on the privately-owned and small size with a student population of up to 5,000 to reduce biosafety and biosecurity risks.

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