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CAN KNOWLEDGE ON BIOLOGICAL RISKS IMPROVE BIORISK MANAGEMENT LEVEL OF UNIVERSITY BIOSCIENCE LABORATORIES?

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ABSTRACT

University biorisk management infrastructure in Kenya is poorly developed despite the rapid emergence of highly infectious diseases. Similarly, life scientists at universities (students, lecturers, and laboratory technologists) have been indicted in incidences of fatal and nonfatal injuries. The main objective of the study was to determine if there is a linear relationship between the biorisk knowledge levels and the Biological Risk Management Level of university bioscience laboratories. It was part of a larger doctoral study that investigated the predictors of biorisk management. The study design was a quantitative, descriptive survey type and was delivered through a survey by both the researchers and online to 1300 university students, lecturers, and laboratory technologists with a response rate of 79.5%. A questionnaire designed to capture independent variable (level of biorisk knowledge of life scientists) and dependent variable (Biorisk Management Level) scores were used. Excel and IBM SPSS software assisted in computing analysis of variance (ANOVA), Pearson correlation coefficients, and simple linear regression analysis. Data were summarized as tables and other descriptive statistics. A majority (55.4%) of the respondents did not exhibit high biorisk knowledge. Less than half (45.6%) of the respondents reported high biorisk knowledge. Simple linear regression analysis revealed that 21.9% of the variation in Biological Risk Management Level at the universities was explained by variation in biorisk knowledge (R Square= .219, $p<0.001$). It was concluded that as biorisk knowledge increases so does the biorisk management level. To improve biorisk management at the universities, there is a need to develop biorisk knowledge of life scientists. Universities and other key partners should develop the capacity of life scientists in biorisk knowledge while future studies should consider other types of knowledge other than self-rated knowledge.

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

Introduction

A recent study established that university biorisk management infrastructure in Kenya is poorly developed (Muruka et al., 2022) despite the rapid emergence of highly infectious diseases (Morse, 1995). Although several socio-economic, demographic and environmental factors facilitate the emergence and spread of these diseases (World Health Organization, 2005), their biosafety and biosecurity consequences could be minimized through a well-established biorisk management system. Biorisk Management encompasses biosafety (an organization's coordinated and documented activities to prevent unintentional occupational exposure within a facility), prevention of theft, misuse, or intentional release of biological agents (biosecurity), prevention of release of biological agents outside the facility (biocontainment) and ethics (Whitby & Pearson, 2012; National Science and Technology Council, 2022). It is defined as the "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, 2011a). Biorisk Management is considered essential for preventing and effectively responding to biological threats (National Science and Technology Council, 2022).

The need to identify knowledge gaps in biorisk management is urgent and it has been postulated that a successful biorisk mitigation program relies on adequate knowledge of exposure pathways and hazard potential of the pathogen (National Science and Technology Council, 2022). With the emergence of highly infectious diseases, new knowledge gaps in science-based biorisk practices continually arise. Contemporary reports have indicated that there is increased incidences of major biosafety (Bal, 1995) and biosecurity (Abramova, F.A., Grinbergt, L.M., Yampolskayat, O.V. & Walker, 1993; Chai, S., Hampton, K. & Dorj, 2008 ; Clevestig, 2009) breaches that have resulted in death and serious illness at the university bioscience laboratories. Senior university professors and students have been indicted. In a pioneering study on university bioscience biorisk management in Kenya, Muruka and colleagues (2022) concluded that there is a linear relationship between the biorisk perception levels and the Biological Risk Management Level of university bioscience laboratories (Muruka et al., 2022). However, there was no statistically significant difference between different levels of demand for biorisk mitigation and levels of biorisk perception score among universities. This suggests that biorisk perception levels alone would not be sufficient for efficient and effective management of biological risks at the university bioscience laboratories in Kenya, a finding that demands for scientific exploration of other factors that may drive better management practices of biological risks at the universities. This immediately flags knowledge in biological risks as a possible key parameter for study.

There is an abundance of empirical evidence that associates knowledge with better and appropriate management of life sustaining activities (York et al., 2016) and improved individual performance and better service delivery (Mothamaha & Govender, 2014). For example in other disciplines such as wildlife management (Ocholla et al., 2016; Thakadu, 1997; Kadykalo et al., 2021), . Knowledge on a matter is important in the way it is gathered, understood, and applied (or not) in decision making (Hoed et al., 2020). Obviously, as put forth by Chebet (2020), knowledge is slowly becoming the key factor in production after labor, land as well as capital (Chebet, 2020).

It is therefore obvious that understanding the role of how knowledge of biorisks contributes towards the management of biological risks at the university bioscience laboratories content delivery environments is paramount. The problem addressed in this study was that while it is known that university biorisk management infrastructure in Kenya is poorly developed and there is rapid expansion of universities in Kenya, research has not been done to determine the relationship between biorisk knowledge and the level of Biorisk management practices at university bioscience laboratories. Knowledge generally means information that is acquired from authoritative external sources and that can therefore, presumably, be regarded as factual in nature (Trevethan, 2017) or just "justified true belief". Binmore (2011) defined knowledge as what was traditionally held to be justified true belief. In this study, biorisk knowledge meant self-rated knowledge or estimates of how much the university bioscience students, lecturers and laboratory technologists know or have learned about biological risks as deciphered from the biorisk knowledge score.

The main objective of the study was to evaluate the relationship between the level of biorisk knowledge and the level of biorisk management of university bioscience laboratories in Kenya.

Materials and Methods

The study used a descriptive quantitative cross-sectional survey design which permitted the deployment of questionnaires, quantitative testing of relationships, statistical testing and drawing of inferences. Both public and private Kenyan university bioscience laboratories formed the geographic area of study while key respondents were bioscience students, lecturers in biosciences and laboratory technologists/technicians. The study population included all university bioscience laboratories, all students taking degree courses in biological sciences, lecturers and laboratory technologists/technicians in biological sciences. The target population 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 16 out of 66 universities studied were randomly identified using the online random number generator. The universities selected for the study were either large (5), medium (5) or small (6) depending on the student population (Small: below 5,000 students; Medium: 5,001 -15,000 students and Large: >15,000 students) and also either public (10) or private (6). Data was collected using a structured questionnaire on demographic information, biorisk knowledge and levels of biorisk management with Likert-type scales. Knowledge generally means information that is acquired from authoritative external sources and that can therefore, presumably, be regarded as factual in nature (Trevethan, 2017) or just "justified true belief". Binmore (2011) defined knowledge as what was traditionally held to be justified true belief. In this study, biorisk knowledge meant self-rated knowledge or estimates of how much the university bioscience students, lecturers and laboratory technologists know or have learned about biological risks as deciphered from the biorisk knowledge score.

Instrument Reliability and Validity

The reliability of the scales instrument applied in this study was tested through the Cronbach's alpha coefficient test which is used as to measure the internal consistency of the scales used in a survey. The reliability test results for the Biorisk Knowledge Score was 0.906 indicating high internal consistency of the instrument. Studies involving inferential statistics require data to be normally distributed as evaluated by skewness and kurtosis indices. In this study, the skewness index was .096 while the kurtosis index was -0.841, confirming that the data was normally distributed. The acceptable range adopted for the study was from -2 to +2 for skewness index and from -3 to +3 for the kurtosis index. According to James and Ostrom (2011), kurtosis index from -10 to $+10$ is acceptable (James and Ostrom (2011). Validity was established by calculating the Composite Reliability (CR) which should be greater than 0.7 and Average Variance Extracted (AVE) should be greater than 0.5(Mihanpour et al., 2018). In the present study, CR for biorisk knowledge was 0.901 while the Average Variance Extracted (AVE) for biorisk knowledge was 0.607. For convergent validity to be confirmed, the AVE should be greater than 0.5 (Mihanpour et al., (2018). Therefore convergent validity and by extension, construct validity was confirmed (Carlson and Herdman (2012).

Variables

There was one dependent variable, the biological risk management level of university bioscience laboratories (BRML) with a total of 59 indicator questions distributed among three main constructs as follows: 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 1 and Muruka et al., (2022).

Table 1

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 sole independent variable questions were on *biorisk knowledge* score and was obtained from a set of nine (9) indicator questions: 54A-54I, the maximum score being 105. The data collection period commenced on 15th August 2019 and ended on 13th March 2020. Both online and researcher-administration of the questionnaires were used. At least one university student volunteer was recruited per university to facilitate the administration of the questionnaires to consenting respondents.

Both Excel Software and the IBM Statistical Package for Social Sciences (IBM SPSS) Software version 21 was used to analyze data. Relationships were computed using correlation coefficients, simple linear regression analysis, tests based on assumed population variance of 0.5, precision of 0.05, confidence level of 95% and an estimated response rate of 70%.

Results

Biorisk Knowledge Mean Construct Scores

The means of the nine (9) items, tested according to the biorisk knowledge score variable, are displayed in Table 2. All items had a mean score above 3.00 and a grand mean of 3.56 suggesting that the majority of the respondents agreed with the items' statements based on each variable and considered those items as major antecedents of knowledge on biological risks.

Table 2

Mean Biorisk Knowledge Score

Question	N	Mean	Standard Deviation
Question 54A. Please RATE your knowledge about the following terms: [Risk]	1034	3.863158	0.793732
Question 54B. Please RATE your knowledge about the following terms: [Risk assessment]	1034	3.736842	0.840599
Question 54C. Please RATE your knowledge about the following terms: [Risk Mitigation]	1034	3.578947	0.984766
Question 54D. Please RATE your knowledge about the following terms: [Biorisk]	1034	3.505263	0.897676
Question 54E. Please RATE your knowledge about the following terms: [Biorisk Management]	1034	3.368421	0.851190
Question 54F. Please RATE your knowledge about the following terms: [Biosafety]	1034	3.736842	0.827847
Question 54G. Please RATE your knowledge about the following terms: [Biosecurity]	1034	3.463158	0.965473
Question 54H. Please RATE your knowledge about the following terms: [Occupational Safety & Health]	1034	3.663158	1.144929
Question 54I. Please RATE your knowledge about the following terms: [Biorisk Performance Measurement]	1034	3.094737	1.158444
Grand Mean		**3.556725**	

Biological Risk Management Level Mean Score

The lowest mean score was 45 while the highest was 86 with mean score of 67.51, standard deviation of 8.703, and a range of 41 for 1034 respondents. The variance stood at 75.747.

Proportion of respondents and Levels of Biorisk Knowledge

There were a total of 1034 respondents out of which 55.4% did not have high biorisk knowledge. The rest of the respondents (45.6%) reported high biorisk knowledge as presented in Table 3.

Table 3

The Proportion of Respondents and Levels of Biorisk* Knowledge *by Category

Biorisk Knowledge Category	**No.**	**%**
Not High Knowledge	573	55.4
High Knowledge	461	45.6
Total	**1034**	**100**

Testing of the Hypothesis

Relationship between Biorisk Knowledge Score and Biological Risk Management Level

The tested hypothesis was that there is a linear relationship between the biorisk knowledge levels and the Biological Risk Management Level of university bioscience laboratories. Both the null hypothesis and the alternative hypothesis were stated as below:

Null Hypothesis: H_0

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

Alternative Hypothesis: H_1

There is a linear relationship between the biorisk knowledge levels and the Biological Risk Management Level of university bioscience laboratories.

This hypothesis was tested by regressing biorisk knowledge score on the Biological Risk Management Level of University Bioscience Laboratories guided by the equation:

$$Y= \beta0+\beta1x$$

where x represented biorisk knowledge score and Y denoted the Biological Risk Management Level of University Bioscience Laboratories (BRML). The results of the regression analysis are shown in tables 4, 5 and 6.

Table 4

Model Summary Statistics of the Linear Regression Analysis of Biorisk Knowledge Score on Biological Risk Management Level of University Bioscience Laboratories

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.467	.219	.218	7.697

Table 5

One Way Analysis of Variance of Biorisk Knowledge Score by Biological Risk Management Level of University Bioscience Laboratories

Source	*df*	*Sum of Squares*	*Mean Square*	*F*	*p*
Between groups	1	17099.455	17099.455	288.594	.000
Within groups	1032	61146.928	59.251		
Total	**1033**	78246.383			

Table 6

Regression Coefficients Results for Biorisk Knowledge Score and Biological Risk Management Level of University Bioscience Laboratories

Model	Unstandardized Coefficients		Standardized Coefficients	t	*p*	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	54.179	.820		66.036	.000		
Knowledge Score	.521	.031	.467	16.988	.000	1.000	1.000

Notes: a. Predictors: (Constant), Knowledge Score, b. Dependent Variable: Biological Risk Management Level (BRML)

A simple linear regression analysis was conducted to predict the Biological Risk Management Level of University Bioscience Laboratories *(dependent variable)* based on biorisk knowledge score *(independent variable)*. The results in table 4 show that the influence of biorisk Knowledge score on the Biological Risk Management Level of University Bioscience Laboratories (BRML) was significant (F (1, 1032) = 288.594, p<.001). From the table, 21.9% of the variation in the Biological Risk Management Level of University Bioscience Laboratories (BRML) was explained by variation in biorisk knowledge score (R Square= .219, p<0.001). The coefficient of biorisk Knowledge score (β) was also statistically significant (β=.521, t=16.988, p<.001). In overall, the linear regression results in table 4 indicate that biorisk knowledge score has positive effect on the Biological Risk Management Level of University Bioscience Laboratories (BRML). The hypothesis that biorisk knowledge score influences the Biological Risk Management Level of University Bioscience Laboratories (BRML) was confirmed. As biorisk knowledge score increases so does the Biological Risk Management Level of University Bioscience Laboratories (BRML).

This relationship can be represented by the equation:

$Y = \beta0 + \beta1x$

Consequently, the regression equation was developed and expressed as:

Biological Risk Management Level of University Bioscience Laboratories (BRML) = 54.179 + 0.521* (*Biorisk Knowledge Score*).

The regression equation was simplified as:

BRML = 54.179 + 0.521* BRK, where BRML is *Biological Risk Management Level* of University Bioscience Laboratories and BRK is the *Biorisk Knowledge Score.*

Discussions

Linear Relationship between Biorisk Knowledge Levels and Biological Risk Management Level

In overall, the linear regression analysis results indicate that biorisk knowledge score has positive effect on the Biological Risk Management Level (BRML). The hypothesis that biorisk perception score influences the Biological Risk Management Level (BRML) was confirmed. As biorisk knowledge score increases so does the Biological Risk Management Level (BRML). This seem to support reports by Wachinger and Renn (2010) which concluded that knowledge influenced the thinking and judgment of people about the seriousness and acceptability of risks. In fact, according to the Weichselgartner and Pigeon (2015), development must be made risk-informed by acting upon knowledge. The Ministry of Public Health and Sanitation & Ministry of Medical Services (2006) noted that basic knowledge of risk mitigation procedures like disinfection and sterilization and other laboratory-associated risks such as chemical hazards is crucial for biosafety in the laboratory. The World Health Organiztion (2004) adds that such highly desirable knowledge also includes knowledge of laboratory and clinical practices and safety, including containment equipment, and engineering principles relevant to the design, operation and maintenance of facilities (World Health Organization, 2004). A number of studies (Al-Abhar et al., 2017, Bathula & Rakhimol, 2017) have pointed to the fact that lack of knowledge of biosafety issues leads to poor biorisk management such as improper handling and practice during sample collection, processing, and discarding, potentially exposing laboratory staff to pathogens and that such practices reduce the quality of laboratory services. Biological-risk assessment influences the levels of biosafety standards (Bathula & Rakhimol, 2017). It follows that knowledge in biological-risk assessment is critical for biorisk management.

In the present study, 45.6% had high (or good) biosafety knowledge compared to 13% from a study by (Al-Abhar et al., 2017). The highest percentage, 55.4% of respondents reported having low knowledge on laboratory safety risks. In a study by Meager et al., (2002), 68.4% of the staff in a pathology laboratory had knowledge while 43 (17.2%) did not give correct answers while another 14.4% were unclear in knowledge. These findings are not surprising. In a study (Shinwari, Z.K., Mancini, G.M., & Pinard, 2011), it was reported that life scientists have less knowledge of the technical and policy aspects of biorisk management. To buttress this point further, even students ((53.7% of respondents in bachelors programmes, 57.3% of respondents in masters programmes, and 81.5% of those in doctoral programmes) have recommended for educational modules in biorisk management (Shinwari, Z.K., Mancini, G.M., & Pinard, 2011) to enhance knowledge in different aspects of biorisk management such as dual use, biosafety, and biosecurity. These studies show significant differences in knowledge on biorisk management but this may be explained by the different methodologies deployed and the different study settings.

To be successful, deliberate efforts towards the improvement of Biological Risk Management Levels of university bioscience laboratories must give due attention and lay strong emphasis on knowledge of biorisks as a fundamental ingredient.

Conclusions

The aim of the study was to also determine if there is a linear relationship between the biorisk knowledge levels and the Biological Risk Management Level of university bioscience laboratories and establish the levels of biorisk knowledge among students, lecturers and technologist at the university bioscience laboratories in Kenya. It was concluded that majority of the respondents (55.4%) had low biorisk knowledge. It was also established that any increase in biorisk knowledge levels directly leads to higher scores on the biological risk management levels. This implies that enhancing the biological knowledge of bioscience lecturers, students and technologists has positive and direct impact on the level of biological risks' management at the universities. However, only 21.9% of the variation in biorisk management level was explained by biorisk knowledge suggesting that other factors such as biorisk perception as reported by Muruka et al., (2022) and others may be involved and should be investigated. The level of development of university biorisk management infrastructure in Kenya is also not well developed and this may be the direct result of low biorisk knowledge, among others. These results appear to be useful to bioscience laboratory managers. The findings also contribute to the ongoing debate on biorisk management at the universities by expounding on how biorisk knowledge may influence the status of biorisk management. Biorisk knowledge may have impact on biorisk perception which further affects biorisk communication. The study was limited to self-rated knowledge only.

Recommendations

It is recommended that a unified and collaborative approach by universities, biorisk practitioner communities, non-governmental stakeholder experts, international organizations such as International Federation of Biosafety Associations (IFBA) and international partners should be established to identify, finance and plug-in knowledge gaps and promote implementation of better biorisk management practices. Secondly, regulatory regimes for bioscience laboratories should promote capacity building in biorisk management for students, technologists and lecturers in bioscience education. In tandem with capacity building, further research should also be carried out to deepen our understanding of the mechanisms of how biorisk knowledge promotes biorisk management by expanding the research into more bioscience laboratories and involving more countries. Other aspects of knowledge other than self-rated knowledge should also be considered in future studies.

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