Nuclear Security Awareness Survey at a University

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Abstract

The concept of assessing safety culture in an organization emerged with its application at the nuclear power industry and has expanded since then. An assessment of nuclear security, on the contrary, is still under-developed, especially at non-nuclear facilities, such as academic institutions and medical facilities. To identify the level of the awareness and understanding of credible nuclear and radiological threats, response preparedness, security culture, and the integrity of nuclear security systems among non-radioactive material users at a university setting; a campus-wide survey was deployed. A total of 3,336 non-radioactive material users, including students, faculty, and staff participated in the survey. The survey was divided into three categories: general awareness (GA), school specific awareness (SSA), and behavior response (BR) awareness. Because the overall population of a university is rarely homogenous, six demographic characteristic groups of age, gender, work-status, degree, ethnicity, and nationality were added to the survey to identify the disparities in the attitudes that exist within the group of non-radioactive material users and the survey response. The results indicated significant association of the demographic groups of gender, age, work-status, degree, and ethnicity with the mean response scores across the three survey categories. An ordinal logistic regression was performed to identify and predict the impact of the demographic characteristics on the survey response. Findings from this study predicted the work status demographic group of undergraduates and graduates (younger age sub-groups) to possess higher level of general and behavioral response awareness than the remaining relatively higher work status sub-groups and the corresponding older age demographic sub-groups. The results from the school specific awareness category demonstrated contradictory outcome than the GA and BR survey categories. The results of this investigation are valuable as it provides a provisional understanding of the disparities in perception on the degree of nuclear and radiological security awareness across a group of diverse socio-demographic characteristics.

Keywords: ANOVA, ordinal logistic regression, nuclear security, radiological material security, demographics

I.   Introduction

Nuclear facilities, including nuclear power plants, fuel cycle facilities, and governmental laboratories, are regulated to ensure operations are safe and secure. These facilities potentially expose their stakeholders to radiation and other hazards. As such, they are logically inclined to adopt a strong safety culture to prevent accidents and protect workers, the public, and the environment. According to the US Nuclear Regulatory Commission (NRC), strong safety culture environments have been well established in NRC-regulated nuclear facilities, as they are "considered among the most secure of the nation's critical infrastructure" [*1*]. However, incidents involving the civilian uses of radioactive materials has occurred at nuclear power plants and fuel cycle facilities and during medical and industrial activities involving regulated materials. Assessments of these incidents revealed that weaknesses in the regulated 'entities' safety cultures were an underlying cause of the incidents or increased the severity of the incidents" [*1*]. An enforceable and impactful safety culture is crucial in all organizations housing ionizing radiation or radioactive material in order to maintain a sense of awareness and assurance throughout all institutional departments.

The focus on risk reduction in nuclear facilities over the past several decades has been centered around safety. Extensive studies in safety and safety culture have been conducted and applied in regulatory and industry oversight activities. Assessing organizational nuclear or radiological safety culture originated in the 1990s and has gained significant traction since then [*2*]. Increasingly though, nuclear security is gaining traction in its level of importance, especially in comparison to safety. Nuclear security is defined as "the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities" [*3*].

Just as having a strong safety culture is key to ensuring safe operations in nuclear facilities, a strong security culture is necessary for ensuring security of nuclear and radiological materials. According to the International Atomic Energy Agency (IAEA), nuclear security culture is defined as an "assembly of characteristics, attitudes, and behavior of individuals, organizations, and institutions that serves as a means to support and enhance nuclear security" [*4*]. Nuclear security culture assessments have begun to be conducted in nuclear facilities. However, these assessments have been lacking until recently in non-nuclear-specific industries, including universities and hospitals. These facilities need a better understanding of their nuclear security awareness and its importance. Strong nuclear security culture, along with preventative and protective measures, may help reduce malicious acts leading to unacceptable radiological conditions or other adverse situations [*4, 5*]. Furthermore, universities and hospitals are home to a significantly wider range of demographic backgrounds, notably educational and experiential, which render them more vulnerable to breaches of security and theft.

The attention of security culture at non-nuclear facilities is becoming increasingly important, particularly because the threat of non-state actors is credible. A strong security culture does not prevent non-human error events; however, it does play a large role in reducing and maintaining a low number of radiation incidents [*6*]. An additional element of nuclear security that a strong security culture enforces is the importance of radioactive material at all levels of danger. For example, in April 2019 the GAO released its Priority Open Recommendations to the NRC, highlighting four areas in which the NRC needed to effect change. The GAO stated that NRC failed to confirm the validity of purchasers' licenses of category three radioactive sources (low levels of radiation). Furthermore, these sources were not included in the National Source Tracking System, and nor are licenses verified with the License Verification System [*7*]. Such shortcomings in security protocols make the nation significantly more vulnerable and are particularly relevant to non-nuclear facilities, which house this lower category radioactive material.

The importance of a systematic understanding of nuclear security is imperative to fostering a commitment to safety, security and protection. Historically, surveys and interviews have been widely used and served

as tools for an initial nuclear security culture evaluation. This study was intended to evaluate nuclear security culture in a university setting, as it analyzes workplace mentalities pertaining to nuclear security, correlates various demographics with tendencies to respond in a particular manner and assists in determining the corrective measures required to enhance security culture. The questionnaire created took inspiration using a theme similar to surveys developed to assess nuclear security in other nuclear settings [*4–6*]. This survey was adapted to be more conducive to a university system, which is home to faculty and staff from a wide range of educational backgrounds. In addition to assessing nuclear security culture in a university setting, this study was intended to serve as a model to other non-nuclear facilities to further their perspective regarding nuclear security culture. Although these facilities are home to a significantly lower amount of radioactive material than government research laboratories and nuclear power plants, this knowledge may better educate radiation workers and the general population in preventing malicious acts involving nuclear and radioactive material. Radioactive material, regardless of the category, poses risk, meaning the assessment of nuclear security awareness and culture is relevant to institutions of any type.

Most of the existing literature studies largely focus on information security awareness and the influence that employees' demographic characteristics have on cybersecurity awareness and security policy compliance [*8, 9*]. Barrera [*10*] found a positive correlation between the cybersecurity awareness level of individuals and their education level in an academic setting. Findings by Dinev et al. [*8*] showed that cultural factors are statistically significant in influencing user behavior towards protective information technologies, whereas, Banerjee and Jones [*11*] identified the influence of gender differences towards computer fraud and ethical behavior of information system. Other investigations have also confirmed the influence of demographic differences on compliance behavior and awareness issues. Impaired driving and crashes [*12*], and Opioid overdose deaths and public heath practice [*13*], considered age, gender, and ethnicity characteristics into account.

The intent of this study is to facilitate our understanding on how certain non-radioactive material user characteristics, such as, their demographics are linked to their awareness of organizational policies and radiation related threats. This paper complements our previous work on radiation users and their level of awareness, policy knowledge, policy adherence and belief and attitude with respect to nuclear and radiological security culture at an academic setting. By understanding radiation and non-radiation user profiles, effective and differentiated strategies can be devised to educate the public accordingly.

II.   Methodology

To evaluate the phenomena that allow for inferences about nuclear security culture at a university setting, a campus-wide survey was designed and implemented. The survey contained a series of eleven questions across three broad categories: general awareness (GA), school specific awareness (SSA) and behavior responses (BR). The survey responses were kept confidential in an attempt to increase responses and avoid any potential reprisal.

Drawing upon the survey study performed by Rane et al. [*6*], the authors in this study assessed the perceptions and attitudes of non-radioactive material users towards radiological and nuclear security awareness. Because the overall population of a university is rarely homogenous, six demographic questions were also added to the survey to identify the disparities in the attitudes that exist within the group of non-radioactive material users. The socio-demographic characteristics of age, gender, education level, work status, ethnicity and nationality/continent were reported for each survey respondent. The survey was distributed using Qualtrics XM© (Qualtrics, Provo, UT) to a total of 31,684 non-radioactive material users of the university population, including students, faculty, and staff. This number was based on confirmed email messages delivered. Three thousand three hundred thirty-six (3,336) respondents (10.53% participation) completed the survey.

The general awareness or "GA" category of the survey comprised of five questions. The "GA" category questions were tailored towards a basic understanding and awareness of the differences and synergies of security and safety. The school specific awareness or the "SSA" category contained four questions with the goal to determine the level of agreement or disagreement towards the knowledge and the presence of radioactive material on campus. The questions from the "SSA" category were mostly framed to test the public confidence and support for nuclear security at a university setting. The final category of behavior response awareness or "BR" explored the participant's understanding of university's emergency notification systems and the perceived adequacy of campus security to protect against nuclear or radiological threats. The "BR" category comprised of the remaining three questions. The response options to each of the survey questions were 'strongly agree' to 'strongly disagree' on a seven-point Likert scale. A numerical value of 1 being 'strongly agree' and seven being 'strongly disagree'. Table 1 shows the list of survey questions used in the study.

Table 1. Survey questionnaire list categorized across the three broad categories of general awareness (GA), school specific awareness (SSA), and behavioral responses (BR)

Category	Questions
General Awareness (GA)	1. I clearly know the difference between safety and nuclear and radioactive material security 2. Nuclear and radioactive material security is as important as safety 3. Last year, the US government's total budget was $4.1 trillion of which $12.8 billion was devoted to nuclear security. Knowing this, I feel secure about how much money the US spends on nuclear security each year 4. Most of my ideas about radiation are influenced by media (i.e., news, movies, TV etc.)
School Specific Awareness (SSA)	1. I am aware that there is radioactive material on University's campus 2. Knowing that there are radioactive sources in University campus increases my personal stress level. 3. I think my university does a good job at protecting and security the radioactive material that is present on campus 4. My university is ready to respond appropriately to nuclear and radioactive security threats
Behavior Responses (BR)	1. If I saw something that seemed like a nuclear and radioactive material safety or security risk, I would know how to appropriately inform the authorities 2. If I received an alert on my phone about a nuclear or radioactive material threat while on campus, I would know what to do 3. I trust that my university's alert system will notify me of a nuclear or radioactive threat as soon as it happens on campus.

Pearson's Chi-square test was used to test the goodness-of-fit and to investigate the association between the socio-demographic categorical groups. Multilinear regression analysis was performed on the data to seek answers to questions such as "are there any relations between the dependent and the independent variables?". The Analysis of Variance (ANOVA) findings were followed by post hoc analysis to further evaluate the pairwise differences between the means of the demographic sub-groups. Based on the value of significance (<0.05) or (>0.05), an ordinal logistic regression was performed to make future-oriented predictions regarding the response variable. IBM SPSS Statistical version 25 (IBM Corp, Armonk, NY) was used to conduct all the analyses. The study was approved by the university Institutional Review Board (IRB).

The racial/ethnic variables included the categories: White, African Americans or Black, Hispanic or Latinos, Asians, American Indian or Alaskan Native, Native American or Other Pacific Islander and Not Hispanic or Latino. The responses with more than one ethnicity were excluded from the analyses. The nationality demographic characteristics of the survey participants represented a total of eighty-seven nationalities. Based on the grouping schemata of Emerging Nuclear Energy Countries listed by World of Nuclear Association the participant nationalities were grouped into: North America, Europe, Middle East and North Africa, West Central and Southern Africa, Central and South America, Central and Southern Asia, South East and Oceania, and East Asia **[14]**.

III. Results and Discussion

The likelihood ratio test (Chi-square test) on socio-demographic variables of age, degree, gender, ethnicity, work status and nationality demonstrated a strong correlation and dependence between the demographic groups (i.e., $p < 0.05$). The ANOVA statistics was performed on "GA", "SSA" and "BR" survey categories to investigate the significance of the six independent demographic variables on the respondent's nuclear security awareness in each category.

An examination of Table 2 clearly showed that the demographic variables of age, gender, ethnicity, and nationality/continent were significant predictors of general awareness survey responses. The demographic variables of degree and work status presented no significant relationship with the dependent variable, thus making no impact on the mean response scores for the general awareness category. The demographic variable of age, gender, work status, and nationality/continent in the school specific awareness survey category showed significance ($p < 0.05$) with the dependent variable. On the contrary the degree and ethnicity indicated no significant effect ($p > 0.05$) on the mean scores of the school specific awareness survey category. The demographic variable of age, gender and degree contributed to the mean scores of behavior response survey category, as opposed to work status, ethnicity, and nationality/continent.

Table 2. The significance of the demographic variables on the survey category response (general awareness (GA), school specific awareness (SSA) and behavior response (BR))

Demographics	General awareness (p-value) [a]	School specific awareness (p-value) [b]	Behavior response (p-value) [c]
Age	0.001	0.072	0.027
Degree	0.175	0.150	0.006
Gender	<0.001	0.031	<0.001
Work Status	0.329	0.002	0.106
Ethnicity	<0.001	0.481	0.599
Nationality/Continent	0.012	<0.001	0.430

a. R Squared =0.050 (Adjusted R Square =0.038)
b. R Squared =0.035 (Adjusted R Square =0.023)
c. R Squared =0.083 (Adjusted R Square =0.072)

Fisher's least significant difference (LSD) post-hoc test was performed to compare the means of different sub-groups of the significant demographic variables at $p < 0.05$ and 95% confidence level (CI). A positive mean difference (score) signified that the primary sub-group had higher mean score than the secondary or the successive sub-group (considering two sub-groups at a time), meaning the responses were inclined more towards 7(strongly disagree) on the seven-point Likert scale. A negative mean difference (score) indicated a low mean score on the primary sub-group than the secondary sub-group of the demographic variable, with the survey response being more towards 1 (strongly agree) on a 1-7 numeric scale.

The results of LSD method for the general awareness category (Figure 1) showed that the age sub-group of 18-21 significantly differed from 31-40 and 50+ age sub-groups. With a positive mean difference, the 18-21 age sub-group reported less general awareness towards nuclear security than the other age sub-groups. The age sub-group of 50+, on the contrary reported more nuclear and radiological security general awareness compared to others. A significant difference in the perceptions of female and male genders were observed. The female sub-group displayed a higher mean score than the male sub-group, implying less self-reported awareness among the females. Among the demographic group of ethnicities, the sub-group of Asians reported to be more aware than the sub-group of Blacks or African Americans and Hispanic or Latinos. With the small number of people identified as Hawaiian and Pacific Islander and American Indian or Alaskan Natives, the statistical variance was high, rendering the test non-significant. The ethnicity sub-group of Whites reported to be more aware than African Americans but less aware than Asians and equally aware than Hispanic or Latinos. Similarly, for the nationality/continent group of the demographic variable, Central and Southern Asia reported more general nuclear security self-awareness than North America and other nationalities. The nationality/continent sub-group of sub-Saharan Africans demonstrated no statistical significance due to small sample size.
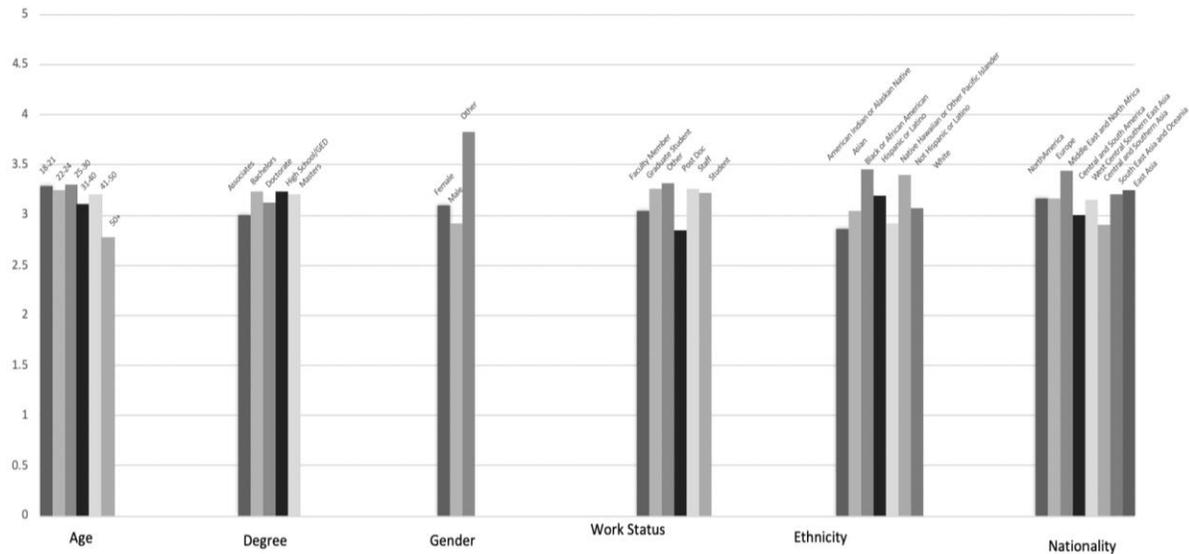

Figure 1. General awareness mean response score vs the socio-demographic characteristic subgroups

The gender demographic characteristic group of the school specific awareness category shown in Figure. 2, produced similar results to the gender demographic group of general awareness category of the survey. The sub-group of females with a positive mean difference, self-reported to be less aware than males in the "SSA" category questionnaire. The sub-group of graduate students, with a positive mean difference, perceived themselves to be less aware/knowledgeable than the staff and the undergraduate students in the work status demographic characteristic group. The sub-group of Europeans in the nationality/continent demographic characteristic group produced a positive mean difference score compared to other continents, indicating less "SSA" awareness and knowledge. The subgroup with Middle East and North Africa backgrounds felt less aware than Central and South America and Central and Southern Asian backgrounds. Similar to the results obtained in the "GA" category, Central and Southern Asian backgrounds felt more aware than the nationality/continent sub-group of North America, Europe, and West Central Southern East African backgrounds in the "SSA" category. The subgroup of Central and Southern America and Southeast Asia and Oceania presented no significant difference in the "SSA" category.
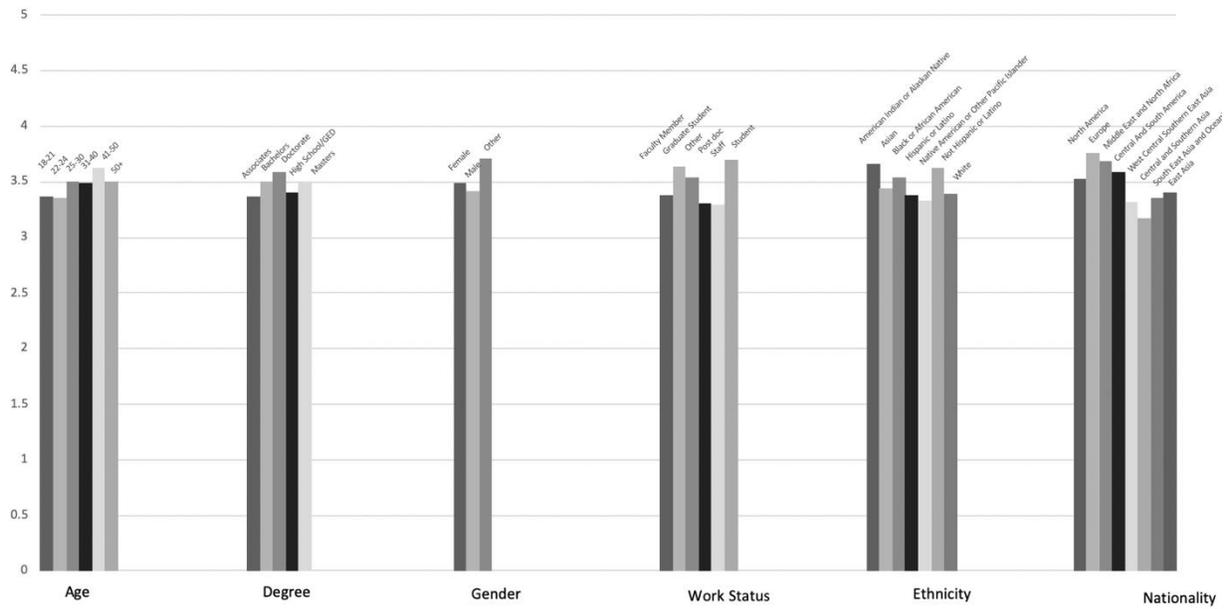
Figure 2. School specific awareness mean response score vs the socio-demographic characteristic subgroups

For the behavior response category, the 50+ age sub-group reported more awareness towards responding to a potential nuclear or radiological threat than other age sub-groups. The age sub-group of 41-50 showed no significant difference and thus reported to be equally aware as the 50+ age sub-group. The sub-group of bachelors (B.S.) degree in the education degree demographic group reported more "BR" awareness than the high-school degree sub-group. All other sub-groups in the degree group showed no significant difference. The male sub-group of gender demographic group reported more awareness than the females. Figure. 3 shows the mean response of behavior response survey category with respect to the socio-demographic characteristic subgroups.

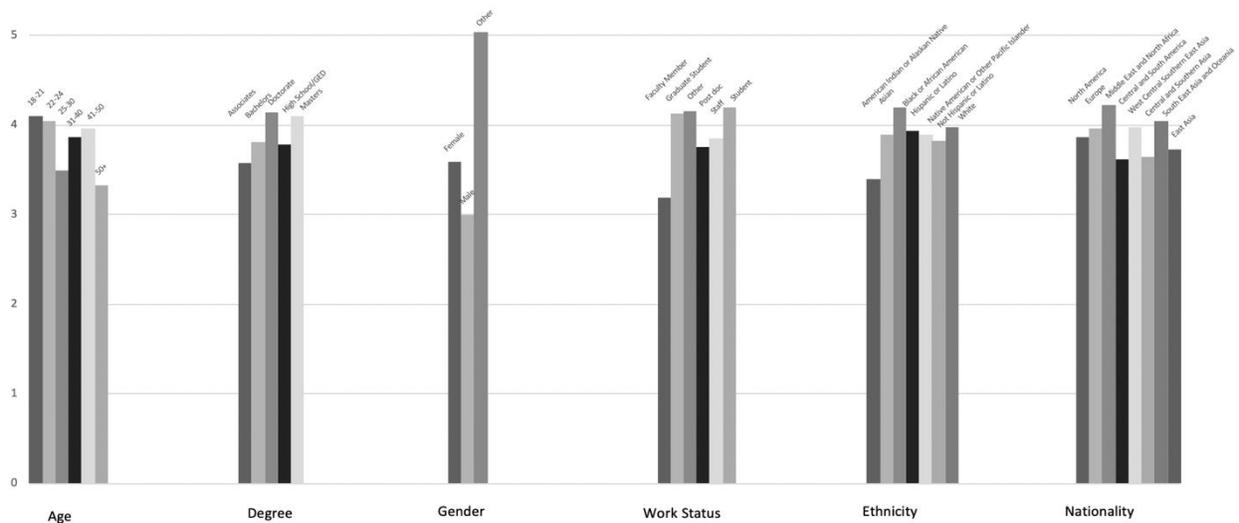**Figure 3. Behavior response awareness mean score vs the socio-demographic characteristic subgroups**

An ordered logit model was estimated to investigate if the socio-demographic characteristic variable groups and subgroups predict the survey responses of the awareness towards nuclear and radiological security. An ordinal regression analysis was performed on all twelve survey questions. For the sake of brevity, the paper only discusses the results of three questions (one question per survey category). The selected questions are given in Table 3.

Table 3. Selected survey category questions for ordinal regression analysis

Survey category	Selected question	Responses						
		Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
General awareness	I clearly know the difference between safety and security	1	2	3	4	5	6	7
School specific awareness	I am aware that there is radioactive material on university campus	1	2	3	4	5	6	7
Behavior response	If I saw something that seemed like a nuclear and radiological material safety or security risk, I would know how to appropriately inform the authorities.	1	2	3	4	5	6	7

Table 4. Ordinal linear regression analysis for the selected question in the general awareness survey category questionnaire

Ordinal Logistic Comparisons	Wald Statistic	P-Value	Exp(B)	CI	
				Lower 95	Upper 95
Degree					
Associates vs. Bachelor	5.003	0.025	0.55	0.33	0.93
Associates vs. High School	7.673	0.006	0.49	0.30	0.81
Associates vs. Master	5.697	0.017	0.50	0.28	0.88
Gender					
Female vs. Male	135.169	<0.001	2.37	2.054	2.75
Age					
18-21 vs. 50+	11.597	<0.001	3.66	1.73	7.72
22-24 vs. 50+	10.850	<0.001	3.38	1.64	6.99
25-30 vs. 50+	10.956	<0.001	3.33	1.63	6.78
31-40 vs. 50+	6.944	0.008	2.67	1.29	5.54
Work Status					
Faculty member vs. graduate student	6.660	0.01	0.17	0.05	0.66
Faculty member vs. staff	5.962	0.015	0.18	0.05	0.72
Faculty member vs. undergraduate student	7.059	0.008	0.16	0.04	0.62
Graduate student vs. Postdoc	4.724	0.03	3.21	1.12	9.19
Postdoc vs. undergraduate student	5.190	0.023	0.29	0.10	0.84
Ethnicity					
Asian vs. Black or African American	5.009	0.025	0.49	0.27	0.92
White vs. Black or African American	9.850	0.002	0.44	0.26	0.73
Black or African American vs. Hispanic or Latino	6.562	0.010	2.55	1.25	5.23
Nationality					
Europe vs. Central and Southern Asia	6.829	0.009	2.23	1.22	4.08
Central and South America vs. Central and Southern Asia	3.896	0.048	2.48	1.01	6.10
Central and Southern Asia vs. South East Asia and Oceania	3.989	0.046	0.49	0.25	0.99
Central and Southern Asia vs. East Asia	4.340	0.037	0.59	0.36	0.97

Degree of Freedom (d.f.) for the Wald test = 1 for all tests above

Results of ordinal logistic regression for general awareness questionnaire presented some significance in the outcome. The output of the ordinal logistic regression is given in Table 4. The Wald tests showed that all six independent demographic variables contributed significantly to the model. The degree subgroup of the demographic variable indicated that an individual with a bachelor's degree and master's degree were 1.81 times and 2.00 times more likely to agree with the "GA" selected awareness question than someone who holds an associate degree.

The odds ratio for gender demographic group was relatively simpler with only two sub-groups. Females presented 2.37 times more confidence than males in their awareness and knowledge towards nuclear security and safety and were more likely to strongly agree with the proposed statement. It was found that 50+ age sub-group would generally disagree with the projected general awareness statement than the other age groups.

The faculty member sub-groups in the work status demographic group were predicted to be less likely to strongly agree with the proposed general awareness question than the sub-groups of graduate students, undergraduate students, and the staff members. The sub-group of undergraduates were predicted to be more aware and hence more likely to agree with the statement than the sub-group of post-docs. This finding although, contradictory to the univariate ANOVA analysis, shared common inferences with the past research performed by Rane et al., **[6]**, where nuclear security awareness score was found to decrease with an increase in years of experience as a radioactive material user.

The sub-group of Black or African Americans in the ethnicity demographic group were found to be 2.04 times and 2.27 times more likely to select the strongly agree response option than Asians and Whites, respectively. The sub-group of Central and Southern Asia in the nationality/continent demographic group were 2.23 times and 2.48 times more likely to disagree with the statement than the sub-groups of Europe and Central and South America, respectively. The sub-group of Central and Southern Asia was however 1.69 times more likely to agree with the statement than the sub-group of East Asia.

Table 5. Ordinal linear regression analysis for the selected question in the school specific awareness survey category questionnaire.

Ordinal Logistic Comparisons	Wald Statistic	P-Value	Exp (B)	CI	
				Lower 95	Upper 95
Gender					
Female vs Male	132.229	<0.001	2.41	2.07	2.80
Age					
18-21 vs 31-40	6.950	.008	0.39	0.20	0.79
22-24 vs 31-40	11.287	.001	0.32	0.16	0.62
25-30 vs 31-40	7.297	.007	0.40	0.21	0.78
25-30 vs 50+	4.896	.027	0.46	0.23	0.92
Work Status					
Faculty Member vs Graduate Student	6.492	.011	0.13	0.03	0.62
Faculty Member vs Undergraduate Student	7.913	.005	0.10	0.02	0.50
Graduate Student vs Staff	13.512	<0.001	2.68	1.59	4.54
Undergraduate Student vs Staff	17.406	<0.001	0.29	0.16	0.52
Ethnicity					
Asian vs. White	4.823	.028	1.50	1.04	2.16
White vs Black/African American	4.129	.042	0.58	0.35	0.98
Nationality/Continents					
North America vs Europe	12.489	<0.001	0.51	0.36	0.74
North America vs Middle East and North Africa	5.187	.023	0.36	0.15	0.87
Europe vs. Central and South America	6.626	.010	3.10	1.31	7.35
Europe vs Central and Southern Asia	4.526	.033	1.94	1.05	3.57
Europe and East Asia	4.131	.042	1.90	1.02	3.53
Middle East and North Africa vs Central and South America	6.186	.013	4.48	1.37	14.62
Middle East and North Africa vs Central and Southern Asia	4.308	.038	2.80	1.06	7.42
Middle East and North Africa vs South East Asia and Oceania	3.898	.048	2.98	1.01	8.83
Middle East and North Africa vs East Asia	4.119	.042	2.75	1.04	7.28

Degree of Freedom (d.f.) for the Wald test = 1 for all tests above

For the selected question/statement in the school specific awareness category the demographic variables of gender, age, work status, ethnicity and nationality showed notable significance (Table 5). The likelihood of the female gender sub-group choosing positively (lower numeric response) was 2.41 times higher than the males. The odds ratio of 0.39 and 0.32 showed that the age sub-group of 31-40 were less likely to choose a negative opinion towards the knowledge of radioactive material present on campus than the age sub-groups of 18-21 and 22-24. In addition, the 50+ age sub-group showed more school specific radiological and nuclear security awareness than the younger age sub-groups. This finding matched the work status demographic response of the "SSA" category, where the faculty members showed greater awareness towards the presence of radioactive material on campus than the graduates and undergraduates.

The Asian and the African American sub-groups in the ethnicity demographic group variable showed greater awareness in regard to the radioactive material on campus than their White counterpart. For the group of nationality, the results showed that the sub-groups of Europe and Middle East and North Africa

were more likely to show school specific nuclear and radiological awareness than other continents of Central and South America, Central and Southern Asia, Southeast Asia and Oceania, and East Asia.

Table 6. Ordinal linear regression analysis for the selected question in the behavior response awareness survey category questionnaire

Ordinal Logistic Comparisons	Wald Statistic	P-Value	Exp(B)	CI	
				Lower 95	Upper 95
Degree					
Associates vs Doctorate	7.813	0.005	0.39	0.20	0.75
Associates vs Master	6.437	0.011	0.48	0.27	0.85
Bachelor vs Doctorate	6.204	0.013	0.56	0.36	0.88
Bachelor vs Master Degree	6.103	0.013	0.70	0.53	0.93
Doctorate vs High School/GED	5.110	0.024	1.77	1.08	2.90
High School vs Master Degree	3.891	0.049	0.70	0.49	1.00
Gender					
Female vs. Male	125.946	<0.001	2.30	1.99	2.66
Age					
18-21 vs 25-30	4.017	0.045	1.44	1.01	2.06
18-21 vs 50+	9.173	0.002	3.15	1.50	6.61
22-24 vs 50+	8.180	0.004	2.86	1.39	5.89
25-30 vs 50+	4.691	0.030	2.18	1.08	4.42
31-40 vs 50+	5.232	0.022	2.33	1.13	4.88
Work Status					
Faculty Member vs Graduate Student	9.580	0.002	0.12	0.03	0.41
Faculty Member vs Staff	4.905	0.027	0.22	0.06	0.84
Faculty Member vs Undergraduate	10.728	0.001	0.11	0.03	0.41
Graduate Student vs Staff	4.930	0.026	1.74	1.07	2.83
Staff vs Undergraduate	6.697	0.010	0.49	0.28	0.84
Ethnicity					
White vs Black or African American	4.314	0.038	0.58	0.34	0.97
American Indian or Alaskan Native vs Black or African American	4.618	0.032	0.29	0.09	0.90
Black or African American vs Hispanic or Latino	4.757	0.029	2.22	0.45	10.99
Nationality/Continents					
West Central Southern East Africa vs Central and South America	4.019	0.045	0.21	0.04	0.97
Central and South America vs. East Asia	4.868	0.027	2.79	1.12	6.94

Degree of Freedom (d.f.) for the Wald test = 1 for all tests above

Table. 6 presents the ordinal logistic regression analysis results for the specific selected question in the "BR" category. Similar to the "GA" and "SSA" survey category, the Wald tests on the "BR" category showed that all six independent demographic variables contributed significantly to the model.

Under the univariate ANOVA analysis, the male respondents seemed to be more aware across the three survey categories. This finding, however, did not retain statistical significance under ordinal logistic analysis. As seen from Table 5, the gender sub-group of females were found to be 2.30 times more aware and were more likely to report anything unusual or suspicious than the male participants. Likewise, the

female respondents in the "SSA" and "GA" were predictive of a positive response than the male participants.

The ethnicity sub-group of African Americans or Blacks, similar to "GA" results, were predictive to be more responsive on reporting suspicious activity to the authorities than most other ethnicities. Conversely, the "SSA" category results presented the likelihood of Asians to have a positive response than the other nationalities. The demographic dependency of age, work status and degree on the nuclear and radiological awareness was found to be complex and, in some cases, contradictory. In regard to the specific question in "BR" and "GA" category, the sub-group of faculty members were predictive to be less knowledgeable on the difference of safety and security and less responsive of noticing or reporting suspicious activity than other work-status demographic sub-groups. On the contrary, the presence of radioactive material on campus was perceived as common knowledge among the sub-group of faculty members (older age sub-groups) than sub-group of undergraduates and graduates (younger age sub-groups). The topic of nuclear security being fairly novel and recent may have made the terminology more relatable to the younger age groups than older age groups, thus possibly resulting in the perception disparities. Another factor to consider would be the difference in the percentage of respondents among the demographic groups. The survey respondents being overwhelmingly undergraduates (or graduates) and between 18-24 (77%) years of age would have led to results favoring the larger sample size than the smaller sample subjects of faculty and older age sub-groups.

The divergent perspectives obtained from the nationality/continent demographic group across the varying survey awareness categories, could possibly suggest a shift in the cultural interpretation and thinking among the survey respondents. The responses among the varying sub-groups of ethnicities and nationalities across the survey categories, however, seemed to be somewhat consistent. For example, the ANOVA post-hoc findings of ethnicity in the general awareness category was found to be closely related to the nationality/continent results, with Central and Southern Asia reporting more general nuclear security awareness than North America and the other nationalities. Also, with every continent being a part of a heterogenous population and global social exchanges, it is hard to predict a collective traditional response from a particular sub-group of nationality/continent.

IV.   Summary and Conclusion

The purpose of this study was to understand the awareness of nuclear security on a university campus and identify the demographic factors impacting the response. The survey consisted of a total of eleven questions, divided among three categories: general awareness (GA), school specific awareness (SSA), and behavior response (BR). The degree of awareness among the respondents was quantified on a scale of one through seven. Findings of the multiple linear regression analysis and the Fisher's Least Significance Difference post-hoc tests demonstrated significant association of the demographic groups of gender, age, work-status, degree, and ethnicity with the mean response scores across the three survey categories. To delineate the impact of the demographic variables even more and help predict the response, an ordinal logistic regression was performed on the three selected survey questions (one question from each category). From the prediction standpoint, the model suggested similar significance and predictor influences on the behavior response and the general awareness category. Consistent with past research [*6*], the demographic group of undergraduates and graduates and the corresponding younger age sub-groups were predicted to possess higher level of awareness towards the difference in nuclear safety and security (general awareness) and reporting of suspicious activity (behavior response), than the remaining demographic sub-groups. The results of multiple linear and ordinal logistic regression on the demographic group of gender across the three survey categories resulted in a conflicting outcome. While controlling for other factors (including age, work-status, degree, ethnicity, and nationality), males self-reported greater awareness than females, but conversely female respondents were predictive of being more radiologically aware than males across the survey categories.

In the SSA category, the effect of work status and age group on the knowledge of the presence of radioactive material on campus yielded an opposite response than "GA" and "BR" survey category responses. This result, however, is consistent with the reasonable assumption that the older and more experienced workforce in a university setting would consider themselves to possess greater awareness of institutional resources and assets than the relatively younger and less experienced demographic groups.

In contrast to the demographic groups of age and work status, study patterns between the demographic groups of ethnicities and nationalities in the survey responses were found to be disproportionate. The African American ethnicity group's response towards the difference in nuclear safety and security paralleled their perception towards reporting of suspicious activity. Conversely, the ethnicity group of Asians were significant predictors of greater school specific awareness than other ethnicities. Another notable finding, consistent with past research, was the observed attitude and perception similarities towards threat response. Similar to the results obtained from Rane et al. **[6]**, the current study demonstrated a rather negative response from the survey participants in regard to the university's response preparedness and campus readiness towards nuclear security threats. This finding suggests the importance of campus wide emergency drills and, most importantly, the necessary communication eliciting preparedness training among the radioactive and non-radioactive material users.

The study was able to empirically examine and predict the relationship between the survey response and demographic variables. Our research findings demonstrated that the demographic factors of age, work status, gender, and ethnicity, coexist in influencing organizational belief towards radiological awareness and threat response preparedness. Given the similarities observed in the findings between radioactive material users and non-radioactive material users, instilling and maintaining the foundational level of security awareness across a cross-section of radioactive and non-radioactive user population is recommended.

The results of this investigation have provided universities and other institutions possessing radioactive materials with some background understanding of nuclear security awareness among diverse demographic groups. It is important to note that the accuracy of the findings of this study relied on the self-report data and therefore it would be unwise to infer some general rule from our preliminary findings on nuclear and radiological security awareness. It is hoped that findings from this study will stimulate a more comprehensive analysis of the perceptions of nuclear security awareness across a diverse group of demographics and institutions. As part of future work, more comparative studies looking into the ambivalent responses received from the demographic group of ethnicities and nationalities towards nuclear and radiological security awareness in general is needed.

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VI.   Acknowledgements

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