Assessing Hazard Level Perception of Colors: A Comparative Study with ANSI Recommendations

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Abstract

Every year, a significant number of people are injured while using products in their homes or as a result of their misuse, emphasizing the importance of risk communication. The purpose of this study is to assess the consistency of color perception and hazard rating among male and female participants in Pakistan with American National Standards Institute (ANSI) recommendations. Undergraduate students from various academic backgrounds participated in the study.

The findings show that color perception and hazard rating differed between male and female participants. Participants showed significant mean differences when comparing colors, with some colors rated as more dangerous than others. Surprisingly, the perceived hazard ratings generally matched ANSI recommendations. However, there were some inconsistencies, especially in the differentiation of certain colors. Notably, neither male nor female participants distinguished significantly among "Blue", "Green", and "Yellow." Females did not distinguish significantly between "Blue vs. Orange." Males, on the other hand, did not perceive "Green and Orange" as significantly different. In addition, they (males) did not significantly distinguish between "Yellow and Orange", and similarly they did not perceive a significant difference between "Red and Black." Both (male and female) participants perceived Red as the most hazardous. However, Female participants provided lower scores as compared to male participants.

These findings offer valuable insights into the complexities of color perception and its implications for warning label design. These results underscore the need for further research to better understand the relationship between color perception, cultural influences, and hazard communication, particularly in the context of product safety.

Keywords
Product Warning Labels, Hazard, Perception, Color, Pakistan

1. Introduction
A significant number of people are injured each year while either using or misusing products in their homes (Wogalter 2006). Prevention of injuries has constantly been a top priority for all (Gopang et al. 2017). Safety standards (guides to good practice) should be instituted to reduce the number of accidents (Khahro et al. 2020). As noted by Borade et

al. (2008), the importance of risk communication has grown significantly, particularly with the expansion of trade between developed and developing countries. In connection to this, Szopa and Soares (2021) emphasized that the use of warning labels has emerged as an essential measure to reduce the occurrence of injuries, illnesses, and property damage. It is critical to recognize that it is nearly impossible to completely eliminate all potential hazards. As a result, any hazard with the potential to cause harm requires a clear warning, as Chen et al. (2015) highlighted. Product warning labels play an important role in encouraging safe behavior and lowering the risk of injuries and health problems. Furthermore, they serve as constant reminders of potential hazards (Laughery and Wogalter 2006 and Lesch et al. 2003). However, ignorance of Warning signs can result in the decrease in the quality of life, and an increased risk of workplace accidents (Mehrifar et al. 2023).

According to Laughery and Wogalter (2014), warning labels are designed with three key features to effectively capture attention in accordance with varying levels of hazards. Those features are Color, Symbol, and Signal word. Signal words and/or safety symbols are frequently supplemented with color in warning labels to improve visibility (NEMA 2017). Colors are used to improve hazard communication because they draw attention by standing out in the environment and adding conspicuousness to safety signs (Wogalter 2006). Moreover, standard colors aid in the efficient communication, recognition, and comprehension of safety information (Wogalter et al. 2016). In addition to capturing attention and improving comprehension, color added to warnings also improves memorization (Zielinska et al. 2017). These declarations reflect the fact that colors can amplify warnings; however, different colors denote different levels of hazard.

The American National Standards Institute (ANSI) plays a critical role in providing recommendations for these design elements of warning label, with a particular emphasis on color coding to denote the severity of danger (Gungor 2023). For example, red is used to indicate the greatest level of danger, acting as a clear indicator of situations that, if not avoided, could result in fatal injuries. Orange, on the other hand, indicates a medium level of danger, highlighting situations that, if not avoided, could result in serious but non-fatal injuries (Kalsher et al. 2016). As Zielinska et al., (2017) reported, yellow is associated with the lowest level of hazard, indicating situations that, if not avoided, may result in minor or moderate injuries. Furthermore, according to Lesch et al. (2016), ANSI recommendations include the use of Blue, which is specifically designated to communicate important information or practices but not related to personal injury (Lesch et al. 2009). In addition to the previously mentioned color codes, the use of green is also recommended to convey safety information (Hall et al. 2012).

Numerous studies have been conducted around the world to assess how different groups and cultures perceive hazard levels based on color associations, with the results frequently compared to ANSI (American National Standards Institute) and ISO (International Organization for Standardization) recommendations. These studies, however, have revealed discrepancies that raise serious concerns. Considering the concern this study was conducted to explore the perceived hazard rating of people of Pakistan, which has the world's fifth-largest population.

1.1 Objectives

The objective of this study was to compare the perception of people in Pakistan in relation to colors for indicating varying levels with ANSI recommendations.

2. Literature Review

Various studies are carried out to explore the inconsistencies between the perception of people belonging to different cultures and the recommended standards and guidelines. According to studies conducted by Braun & Silver (1995); Chapanis (1994) and David L. (1999), respondents perceived the level of hazard for different colors, i.e., RED, ORANGE, and YELLOW, as increasing, which was consistent with ANSI recommendations. Whereas in the study of Wogalter et al. (1998), participants reported a higher level of hazard to YELLOW than to ORANGE. In 1991, Wogalter et al. reported the same thing. The other study conducted by Lesch et al. (2009) discovered that participants with ANSI responded inconsistently that ORANGE communicated a higher level of hazard than RED. In a study conducted by Borade et al. (2008), participants ranked RED (76%) 7th on a 7-point scale, followed by ORANGE (40%) ranked 6th, BLACK (30%) & YELLOW (28%) ranked 5^{th} and 4^{th} respectively, and BLUE (26 %) the last one.

Furthermore, Wang & Or (2015) conducted a study to differentiate between different professions, specifically industrial workers, and students. Their findings revealed significant differences in color preferences between these two groups. When given the option of choosing between red and black, students tended to choose black. Industrial workers, on the other hand, preferred red. This contrast in color preferences suggests that black is perceived as more dangerous than pink and white, which is supported by Buchmüller et al. (2022). Moreover, Yuan et al. (2021) investigated the relationship between the processing of safety colors and the use of the Event-related Potentials (ERPs) technique. Their research revealed that warning signs with yellow backgrounds received more attention than those with white backgrounds. Surprisingly, there was no distinction between signs with blue and white backgrounds. Furthermore, Chan and Ng (2009) found that when combined with auditory alarms, the difference in perceived hazard levels between blue and yellow was statistically insignificant for participants.

In a separate study, Zielinska et al. (2017) discovered a significant disparity in the ordering of colors recommended by ISO (International Organization for Standardization), ANSI, and FHWA (Federal Highway Administration, USA). They compared the safety standard colors available in the recommendation of ANSI, ISO, and FHWA to fluorescent colors. Surprisingly, red received the highest rating across all formats.

Chinese participants were chosen for experimentation in a study conducted by Luximon et al. (1998) to validate findings regarding the variation in the perception of warning labels among different cultures. The questionnaires used in the study were in three languages: Chinese, English, and bilingual. The goal was to investigate differences in perception based on language. Interestingly, there were no significant differences in color perception across all three questionnaires. However, Chinese participants rated the orange color the lowest of all.

These findings highlight the fact that people from different cultures perceive colors differently, raising the question: Does the perceived hazard level of Pakistani participants align with ANSI recommendations? This study was carried out to answer this question.

3. Methods

3.1 Participants

Undergraduate students of the Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro, and Department of Public Health and Allied Sciences, Fatimah Jinnah Women University Rawalpindi participated in the study.

3.1 Experiment Design

The experiment was designed according to the instructions outlined by Lesch et al. (2009). The study was carried out using the Google Docs platform and consisted of two distinct sections. Participants were asked to provide information about various socioeconomic factors, such as age, place of upbringing, and mother tongue, in the first section. In the second section, participants rated the perceived hazard levels associated with various colors. These colors were displayed in a rectangular area that was approximately 2.56 inches long and 0.6 inches tall.

4. Data Collection and Analysis

Data was collected on personal computers in a dedicated computer lab after thorough instructions and informed consent from all participants. Participants initially shared demographic information such as age, gender, education level, and place of upbringing. Following that, participants completed tasks in which they evaluated the perceived hazard levels of warning label components and their intricate configurations. A nine-point scale was used, with one representing "not at all hazardous" and nine representing "extremely hazardous." SPSS (Statistical Package for Social Sciences) version 22 was used to analyze the data. To begin, descriptive statistics like frequency, percentage, and mean were calculated to provide a summary of the data. Following that, for repeated measures, ANOVA (Analysis of Variance) within subjects was used, with Bonferroni correction applied for multiple comparisons.

5. Results and Discussion

5.1 Demographics

Table 1 provides a comprehensive overview of the study participants' demographic characteristics. To begin, it reveals that the participants' mean age is 20.45 years, which serves as a central reference point for understanding the age distribution within the study group. The participants are further classified by gender, with 32 male and 32 female identified. The mean age of male participants is slightly higher at 20.81 years, and the data has a relatively low standard deviation of 0.896, indicating that male participants' ages cluster closely around this mean. Female participants, on the other hand, have a slightly lower mean age of 20.09 years, with a slightly higher standard deviation of 1.353, indicating a slightly wider age range among the female participants.

Table 1: Demographics

AGE (Years)	Mean (20.45)		
GENDER	Male (32) Age Mean = 20.81 SD = 0.896		Female (32) Age Mean = 20.09 SD = 1.353
EDUCATION	Undergraduate (64)	Mehran University of Engineering and Technology (32)	Fatimah Jinnah Women University (32)
GROWNUP PLACE	Rural (30)		Urban (34)

Furthermore, the Table 1 provides information about the participants' educational backgrounds. The study group's 64 participants are all classified as "Undergraduate," indicating a consistent educational level. Furthermore, the participants are drawn from two distinct institutions: Mehran University of Engineering and Technology, Jamshoro, and Fatimah Jinnah Women University, Rawalpindi, with each university contributing an equal number of participants, for a total of 32 people from each university.
Finally, the table addresses the participants' birthplaces, categorizing them as "Rural" or "Urban." Thirty of the participants are from rural areas, while 34 are from urban areas. This distinction provides useful contextual information about the participants' backgrounds, which could be useful when analyzing their perceptions and responses in the study. Overall, the demographic data in Table 1 provides a foundational understanding of the participant composition, shedding light on factors such as age, gender, education, and upbringing location that may have an impact on the research outcomes.

5.2 Perceived Hazard Rating for Color

The analysis of variance (ANOVA) on male and female participants' perceived hazard level ratings with color as the variable (including Blue, Black, Green, Orange, Red, and Yellow) revealed a significant main effect of color, denoted by $F(5, 155) = 51.102$, $p < 0.001$, and $F(5, 155) = 63.376$, $p < 0.001$, respectively.

Table 2: Mean perceived hazard ratings in response to colors.

Male						
Color	BLUE	GREEN	YELLOW	ORANGE	RED	BLACK
Mean	3.00	3.19	3.69	4.72	8.13	7.44
Standard Deviation	2.048	2.101	1.512	1.922	0.976	1.883
Female						
Mean	3.81	2.91	3.31	4.78	8.00	7.16
Standard Deviation	1.575	1.802	1.655	1.593	1.368	1.706

The statistics provided in Table 2 show how male and female participants perceived the hazard levels associated with various colors. In terms of numbers, from male participants, Blue had the lowest average rating (M = 3.00) of any color. Red, on the other hand, received the highest ratings (M = 8.13). Female participants rated Green (Mean = 2.91) the lowest and red the highest with a mean value of 8.00.

Blue (3.00), Green (3.19), Yellow (3.69), Orange (4.72), Black (7.44), and Red (8.13) are the colors ranked in order from lowest to highest mean hazard rating among male participants. This indicates that male participants perceived Blue as the least dangerous color, while participants perceived Red as the most dangerous as shown in Figure 1.

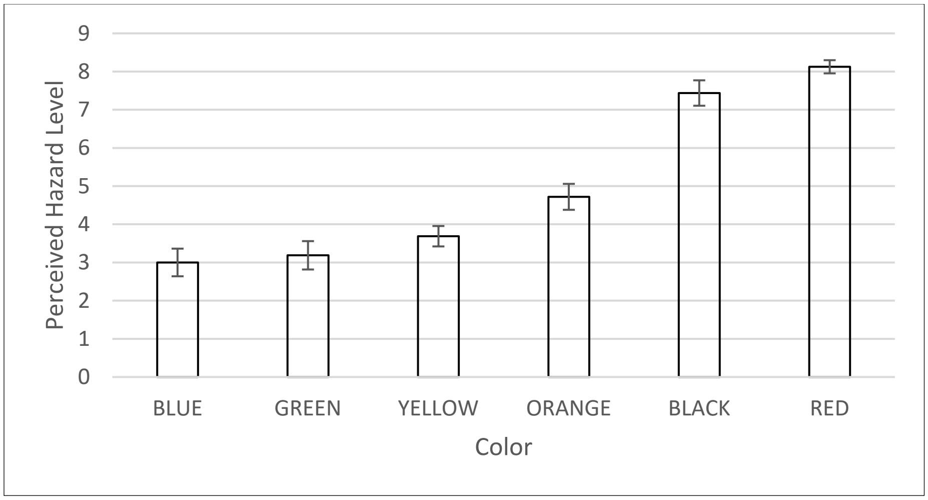

Figure 1: Order of colors in response to mean perceived hazard ratings by male participants.

On the other hand, Green (2.91), Yellow (3.31), Blue (3.81), Orange (4.78), Black (7.16), and Red (8.00) are the color rankings for female participants, from lowest to highest mean hazard rating. In this case, female participants rated Green as the least dangerous color, while Red was rated as the most dangerous as shown in Figure 2.

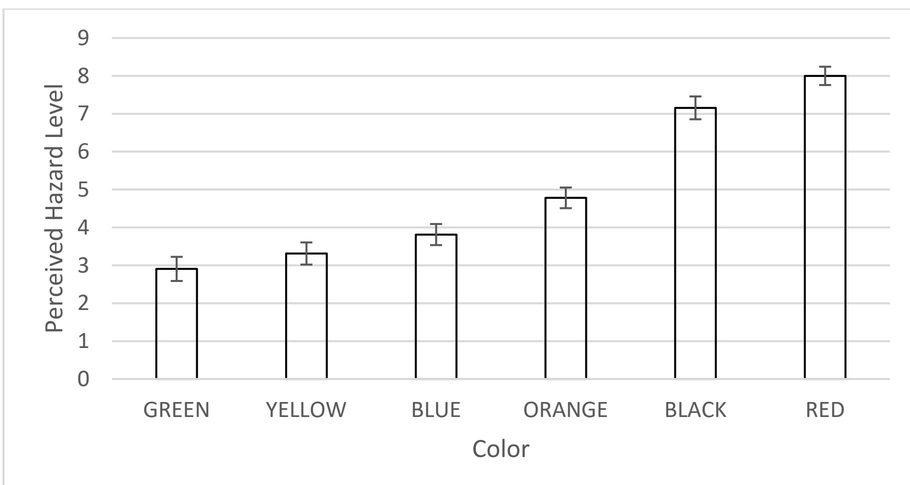

Figure 2: Order of colors in response to mean perceived hazard ratings by female participants.

When comparing gender rankings, both male and female participants consistently ranked Red as the most dangerous color. However, they have different perceptions of other colors. Male participants, for example, ranked Blue as the least hazardous, while female participants ranked it third least hazardous after Green and Yellow. Furthermore, male participants provided third rank, while female participants ranked it as the second least dangerous.

It's worth noting that the American National Standards Institute (ANSI) recommends a specific sequence of Yellow, Orange, and Red to indicate increasing levels of hazard in its ANSI Z535.4 guidelines. What's more, the order in which both male and female participants perceive these colors corresponds to the ANSI Z535.4 recommendations.

However, as demonstrated in Tables 3 and 4 both male and female participants did not make significant distinctions between some of these colors.

Table 3: Pairwise comparison of colors (male)

(I) color	(J) color	Mean Difference (I-J)	Sig.[b]
1	2	-.188	1.000
	3	-.688	1.000
	4	-1.719*	.032
	5	-5.125*	.000
	6	-4.438*	.000
2	3	-.500	1.000
	4	-1.531	.165
	5	-4.938*	.000
	6	-4.250*	.000
3	4	-1.031	.242
	5	-4.438*	.000
	6	-3.750*	.000
4	5	-3.406*	.000
	6	-2.719*	.000
5	6	.688	1.000

1 = Blue	2 = Green	3 = Yellow	4 = Orange	5 = Red	6 = Black

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Tables 3 and 4 compare colors as perceived by male and female respondents respectively, with numerical labels assigned to each color for clarity. To ensure robust statistical analysis, these examine the mean differences between various color pairs and assess their statistical significance using the Bonferroni adjustment for multiple comparisons. Each row in the table represents a different color comparison, with the associated mean difference (I-J) and significance level (Sig.) reported.

For male participatns, when comparing Blue (labeled as 1) to other colors, such as Green (2) and Yellow (3), the mean differences are -0.188 and -0.688, respectively. These differences are not statistically significant, as evidenced by p-values of 1.000, implying that they could have happened by chance. When comparing Blue to Orange (4) and Red (5), however, significant mean differences ($p<0.05$) are observed, with p-values of.032 and.000, respectively. Similarly, there is a significant mean difference between Blue and Black (6).

Furthermore, when Green (labeled as 2) is compared to other colors, such as Yellow (3) and Orange (4), the mean differences are -0.500 and -1.531. These differences are not statistically significant, as indicated by p-values of 1.000 and 0.165, implying that they could have occurred by chance. When comparing Green to Orange (4) and Red (5), however, significant mean differences ($p<0.05$) are observed, with p-values of.002 and.000, respectively. Similarly, there is a significant mean difference between Green and Black (6).

Likewise, when Yellow (labeled as 2) is compared to other colors, such as Orange (4), the mean difference is -1.031. This difference is not statistically significant, as evidenced by p-values of 0.242, implying that it could have happened by chance. When comparing Yellow to Red (5) and Black (6), however, significant mean differences ($p<0.05$) with p-values of 0.000 are observed.

Besides, when comparing Orange (labeled as 4) to other colors, such as Red (5) and Black (6), significant mean differences ($p<0.05$) with p-values of 0.000 are observed. In contrast, when Red (labeled as 5) is compared to Black (6), the mean difference is 0.688, with p-values of 1.000.

Table 4: Pairwise comparison of colors (female)

(I) color	(J) color	Mean Difference (I-J)	Sig.[b]
1	2	0.906	0.050
	3	0.5	1.000
	4	-0.969	0.084
	5	-4.188*	0.000
	6	-3.344*	0.000
2	3	-0.406	1.000
	4	-1.875*	0.002
	5	-5.094*	0.000
	6	-4.250*	0.000
3	4	-1.469*	0.004
	5	-4.688*	0.000
	6	-3.844*	0.000
4	5	-3.219*	0.000
	6	-2.375*	0.000
5	6	0.844	0.131

1 = Blue, 2 = Green, 3 = Yellow, 4 = Orange, 5 = Red, 6 = Black

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

For female participants, when comparing Blue (labeled as 1) to other colors, the mean differences for Green (2), Yellow (3), and Orange (4) are not statistically significant ($p >.05$), as indicated by p-values of 0.05, 1.000, and 0.084, respectively. When comparing Blue to Red (5) and Black (6), however, significant mean differences ($p<.05$) are found, as indicated by p-values of 0.000.

Likewise, when Green (labeled as 2) is compared to other colors, such as Yellow (3), the mean difference is found to be -0.406. This difference is not statistically significant, as evidenced by p-values of 1.000, implying that it could have happened by chance. Significant mean differences (p.05) are observed when comparing Green to Orange (4), Red (5), and Black (6), with p-values of.002, 0.00, and.000, respectively.

Similarly, when comparing Yellow (labeled as 3) to other colors such as Orange (4), Red (5), and Black (6), significant mean differences are observed (p-values less than 0.05). Similarly, when comparing Orange (labeled as 4) to other colors, such as Red (5) and Black (6), significant mean differences (p.05) with p-values of 0.000 are observed. In contrast, when Red (labeled as 5) is compared to Black (6), the mean difference is not statistically significant ($p >.05$), as indicated by a p-value of 0.131.

5.3 Discussions

The primary goal of this research was to investigate how warning colors are perceived in the context of Pakistani culture, particularly in terms of their implications for hazard levels. The American National Standards Institute (ANSI) has recommended specific colors to convey varying degrees of hazard, and while the results of this study were numerically consistent with ANSI's recommendations, there were some pairs of colors where participants did not show significant differentiation.

These findings provide important insights into how Pakistanis interpret the use of colors in product warning labels. When color was examined as a variable, the study found that it had a significant influence on participants' perceived hazard ratings, regardless of gender. Notably, the sequence of perceived hazard levels, from low to high, closely mirrored the American National Standards Institute (ANSI) guidelines in ANSI Z535.4. To indicate increasing levels While the overall color ranking corresponded to ANSI recommendations, no significant differences were observed between specific color pairs. For example, among male participants, Blue had the lowest perceived hazard rating, but this rating did not differ significantly from Green and Yellow. Female participants, on the other hand, perceived Green as the least hazardous color, and it did not significantly differ from Blue and Yellow in terms of perceived hazard. These color perception nuances highlight the complex interaction of cultural factors and individual preferences in shaping how warning colors are interpreted.

Similarly, participants in this study could not tell the difference between Blue and Green. This finding is consistent with the findings of Zielinska et al. (2017), who discovered a lack of significant differentiation between these two colors. Interestingly, Blue received the lowest mean score ratings from male participants in this study, mirroring the perceptions of participants in the United States as reported by (Lesch et al. 2009).

Female participants in this study, on the other hand, rated Green as the color associated with the lowest level of hazard. This observation is consistent with the preferences of Indians, who rated Green as having the lowest perceived level of hazard, as documented by Borade et al. (2008).

Furthermore, both male and female participants consistently rated Red and Black as the most dangerous colors. According to these findings, Red and Black have distinct perceptual significance among both groups of respondents. This is consistent with the findings of a study by Lesch et al. (2009) which found similar results among Chinese participants. Surprisingly, participants in the United States demonstrated significant differentiation between these colors. In contrast, a study published in 2022 by Buchmüller et al. (2022) found that German participants rated Black as more dangerous than Red. According to a study conducted by Borade et al. (2008), Indians perceived Black as less dangerous than Red and even Orange.

These findings witness that cultural differences in color perception exist. These color perception differences spotlight on the impact of cultural and regional factors.

6. Conclusion

This study investigated the perception of warning colors within the context of Pakistani culture and its implications for hazard levels, with the goal of aligning these perceptions with the ANSI recommendations. The findings provide useful information about how Pakistanis interpret warning colors on product labels. Color had a significant impact on participants' perceived hazard ratings regardless of gender. Notably, the perceived hazard levels closely matched ANSI's recommendations in ANSI Z535.4, where the colors Yellow, Orange, and Red are used in ascending order to represent increasing levels of hazard. Certain color pairs, however, did not show significant differences in perception, unfolding the complex interplay of cultural elements and individual preferences in designing perceptions of warning colors. These cultural differences in color perception highlight the importance of different cultural backgrounds and individual perspectives on how colors are associated with hazard levels.

Integrating these suggestions into future research endeavors has the potential to make significant contributions to the development of more impactful and culturally tailored product warning labels. Such efforts would, in turn, improve consumer safety and comprehension not only in Pakistan but also on a larger scale. Furthermore, the findings of this study will be critical in guiding Pakistan in the formulation of product warning labels, which is a highly concerned missing aspect in the Pakistani context. The study presented the findings for one critical factor, the color of product warning labels. Other discrete components, such as symbols, signal words, and their combinations, should also be investigated in order to gain a comprehensive understanding of creating impactful warning labels that cater to the cultural and anthropological needs of the Pakistani population.

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Competing Interests
The authors declare none.

Ethical Standard
The authors assert that all procedure contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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Biographies

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Dr. Tauha Hussain Ali presently holds the position of a Professor within the Department of Civil Engineering at Mehran University of Engineering and Technology (MUET) in Jamshoro, Sindh, Pakistan. Notably, he also serves as the Vice-Chancellor, leading MUET, Pakistan. Dr. Ali embarked on his academic journey by obtaining a Bachelor of Engineering (B.E.) degree and a Postgraduate diploma (PGD) in Civil Engineering, both from MUET in Jamshoro, Sindh, Pakistan. He furthered his academic pursuits by earning a Master of Science (M.Sc.) in Project Management from the National University (NUS) in Singapore and achieving a PhD in Construction Health & Safety Management from Griffith University in Queensland, Australia. Dr. Ali has made significant contributions to the field of Construction Health and Safety, with a notable publication record consisting of articles in international and national journals as well as conference papers. His diverse research interests encompass areas such as Project Management, Project Risk Management, Safety and Health Management, Behavior-Based Safety, Job Hazard Analysis, Monitoring Safety Perceptions and Attitudes, Safety Performance Measurement, Safety Culture and Climate, Job Stress Risk Analysis in Construction Projects, Higher Education, and Leadership in Education.

Dr. Shakeel Ahmed Shaikh currently holds the position of an Associate Professor within the Department of Industrial Engineering and Management at Mehran University of Engineering and Technology (MUET) in Jamshoro, Sindh, Pakistan. Dr. Shaikh's academic journey began with the attainment of a Bachelor of Engineering (B.E.) degree in Industrial Engineering and Management, as well as a Postgraduate Diploma (PGD) in Manufacturing Engineering, both from MUET in Jamshoro, Sindh, Pakistan. He furthered his academic pursuits by earning a PhD in Manufacturing Engineering and Operations Management from the University of Nottingham in the United Kingdom. Dr. Shaikh has made notable contributions to the field of Ergonomics, boasting a record of several articles published in international and national journals and presentations at conferences. His diverse research interests encompass areas such as Human Factors Engineering, Condition Monitoring, Computer Integrated Manufacturing (CIM) in Small and Medium Enterprises (SMEs), Total Quality Management, and Motion Capture Analysis.