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Association Between Safety Culture and Students' Compliance with Laboratory Safety Procedures

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ABSTRACT

Background: *Safety culture is a fundamental element in creating a safe learning environment within higher education institutions, particularly for students engaged in laboratory and practical activities. A positive safety culture is expected to improve compliance with safety procedures and reduce the risk of accidents during academic practice.*

Research Objective: *This study aimed to analyze the association between safety culture and students' compliance with safety procedures among undergraduate students at the Institute of Technology and Health Sciences (ITEKES) Tri Tunas Nasional Makassar.*

Methods: *A quantitative analytical study with a cross-sectional design was conducted among 96 undergraduate students from the Bachelor of Occupational Safety Engineering, Bachelor of Nutrition, and Bachelor of Hospital Administration programs. Respondents were selected using proportionate stratified random sampling. Data were collected using validated self-administered questionnaires measuring safety culture and compliance with safety procedures. Descriptive statistics were used to summarize respondent characteristics, while the Chi-square test was performed to determine the association between study variables, with a significance level of $p < 0.05$.*

Results: *Most respondents demonstrated a good safety culture (63.5%) and were compliant with safety procedures (70.8%). Chi-square analysis revealed a statistically significant association between safety culture and compliance with safety procedures ($p < 0.001$). Students with a good safety culture showed substantially higher compliance (83.6%) than those with poor safety culture (48.6%).*

Conclusion: *Safety culture was significantly associated with students' compliance with safety procedures. Strengthening institutional safety culture through continuous education, laboratory supervision, safety training, and policy implementation is essential to promote safe behavior and enhance occupational safety practices in higher education institutions.*

Keywords: *Safety Culture; Safety Procedures; Compliance; Occupational Safety*

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BACKGROUND

The implementation of a strong safety culture is a fundamental component in creating a safe learning environment within higher education institutions, particularly those that conduct practical and laboratory-based learning (Jalil Al-Bayati et al., 2023). Students enrolled in health and safety-related programs are exposed to various occupational hazards during laboratory practice, fieldwork, simulations, and clinical observations. These hazards include biological, chemical, physical, ergonomic, and psychosocial risks that may lead to injuries, occupational diseases, or other adverse events if safety procedures are not consistently followed (Alam et al., 2022). Therefore, fostering a positive safety culture among students is essential to encourage compliance with established safety procedures and to prepare competent graduates who possess not only technical expertise but also a strong commitment to occupational safety and health principles (Pham et al., 2023).

Globally, occupational accidents remain a significant public health concern (Siabi et al., 2022). The International Labour Organization (ILO) estimates that more than 2.9 million workers die annually due to occupational accidents and work-related diseases, while approximately 395 million non-fatal occupational injuries occur each year (Tetzlaff et al., 2021). Likewise, the World Health Organization (WHO) emphasizes that unsafe work environments continue to contribute substantially to preventable injuries and disabilities. Although these statistics primarily describe occupational settings, they underline the importance of cultivating safe behaviors during the educational process because students are future members of the workforce (Ghahramani & Amirbahmani, 2022). Educational institutions are increasingly recognized as strategic settings for establishing safety values before students enter professional practice (Shan, 2022). Consequently, universities have begun integrating occupational safety and health (OSH) education, laboratory safety management, and safety culture development into their academic curricula (Afolabi et al., 2021).

In Indonesia, occupational safety remains a national priority as industrial development, healthcare services, and educational laboratory activities continue to expand (Svendsen et al., 2020). Data from the Ministry of Manpower and the Social Security Administration for Employment (BPJS Ketenagakerjaan) indicate that occupational accident cases remain relatively high each year, reflecting the need to strengthen preventive strategies across various sectors. In addition, several studies conducted in Indonesian universities have reported that student compliance with laboratory safety procedures is often inconsistent (Tan et al., 2023). Common problems include incomplete use of personal protective equipment, inadequate understanding of standard operating procedures, improper laboratory waste management, and insufficient reporting of unsafe conditions (Curtis et al., 2023). These findings demonstrate that improving knowledge alone may not be sufficient to ensure safe behavior, highlighting the need to strengthen organizational and behavioral aspects of safety culture within educational institutions (Umeokafor et al., 2022).

In South Sulawesi, the rapid growth of health education institutions has increased the number of students participating in laboratory practical sessions, community-based learning, hospital visits, and field practice. These learning activities inherently involve exposure to occupational hazards requiring strict adherence to safety protocols. However, evidence regarding students' safety culture and compliance with laboratory safety procedures in higher education institutions within South Sulawesi remains limited. Most available studies have focused on healthcare workers or industrial employees rather than university students, despite students representing a population undergoing continuous exposure to occupational risks throughout their education (Carballo Piñeiro & Kitada, 2020).

Makassar, as one of the largest educational centers in Eastern Indonesia, accommodates numerous universities offering health-related programs that require intensive laboratory practice. The increasing complexity of laboratory activities, advances in laboratory technology, and greater emphasis on competency-based education necessitate stronger implementation of safety management systems (Batson et al., 2023). Higher education institutions are expected to cultivate safety awareness through comprehensive policies, leadership commitment, adequate facilities, effective supervision, and continuous safety education. Developing a positive safety culture among students is therefore essential to reduce unsafe behaviors and minimize the risk of laboratory accidents (Omidi et al., 2023).

The present study will be conducted at Institut Teknologi dan Kesehatan (ITEKES) Tri Tunas Nasional Makassar, involving undergraduate students from the Bachelor of Occupational Safety Engineering (S1 Teknik Keselamatan), Bachelor of Nutrition (S1 Gizi), and Bachelor of Hospital Administration (S1 Administrasi Rumah Sakit) programs. These three study programs represent different academic disciplines but share similarities in requiring practical learning activities, laboratory utilization, field observations, and professional competency development. Students in the Occupational Safety Engineering program are expected to become experts in occupational safety and risk management; Nutrition students frequently conduct food analysis and laboratory examinations involving chemical and biological materials; while Hospital Administration students participate in healthcare facility observations and practical activities that expose them to organizational and environmental safety issues. Despite these differences, all students are expected to demonstrate compliance with institutional safety procedures throughout their academic activities.

Several previous studies have examined factors associated with laboratory safety behavior, including knowledge, attitudes, safety training, and availability of personal protective equipment (Machfudiyanto et al., 2023). Other investigations have explored safety climate or safety awareness among healthcare professionals and industrial workers. However, relatively few studies have specifically examined the relationship between safety culture and students' compliance with safety procedures across multiple academic disciplines within a single health higher education institution (Davis et al., 2020). Existing studies also tend to focus on a single study program, making it difficult to compare safety-related behaviors among students with different educational backgrounds and professional orientations. Furthermore, limited evidence is available regarding safety culture implementation in private health higher education institutions in Eastern Indonesia, particularly in Makassar.

The novelty of this study lies in its comprehensive evaluation of safety culture as a determinant of students' compliance with safety procedures among three distinct undergraduate programs Occupational Safety Engineering, Nutrition, and Hospital Administration within one institution. This interdisciplinary approach enables comparison of safety culture across academic contexts while providing a broader understanding of behavioral determinants influencing compliance. The findings are expected to generate empirical evidence that supports the development of integrated safety promotion strategies, institutional policies, laboratory management improvements, and student-centered occupational safety education within health higher education institutions. In addition, the study may serve as a baseline for establishing sustainable safety culture programs aligned with national occupational safety standards and international best practices in higher education (Savolainen, 2023).

Based on these considerations, this study aims to analyze the association between safety culture and students' compliance with safety procedures among undergraduate students of the Bachelor of Occupational Safety Engineering, Bachelor of Nutrition, and Bachelor of Hospital Administration programs at Institut Teknologi dan Kesehatan (ITEKES)

Tri Tunas Nasional Makassar. The findings are expected to provide scientific evidence supporting the strengthening of institutional safety culture, improving compliance with safety procedures, reducing the risk of laboratory and educational accidents, and contributing to the development of safer learning environments that prepare graduates with strong occupational safety competencies

METHODS

This study employed a quantitative analytical design using a cross-sectional approach (Ahadzi et al., 2021) to examine the association between safety culture and students' compliance with safety procedures at Institut Teknologi dan Kesehatan (ITEKES) Tri Tunas Nasional Makassar. The study was conducted from January to March 2024 among undergraduate students enrolled in the Bachelor of Occupational Safety Engineering, Bachelor of Nutrition, and Bachelor of Hospital Administration programs.

The study population comprised all active undergraduate students from the three study programs who had participated in laboratory practice or field practical activities. The study included 96 respondents, selected using proportionate stratified random sampling to ensure representation from each study program. The inclusion criteria were active students who had completed at least one semester of laboratory or practical learning, were willing to participate, and provided informed consent. Students who were absent during data collection or returned incomplete questionnaires were excluded.

Data were collected using a structured self-administered questionnaire consisting of three sections: respondent characteristics, safety culture, and compliance with safety procedures. Respondent characteristics included age, sex, study program, and academic year. The safety culture questionnaire consisted of 20 items covering management commitment, safety communication, safety training, safety awareness, safety participation, and reporting culture. Compliance with safety procedures was measured using 15 items assessing adherence to standard operating procedures, use of personal protective equipment, emergency preparedness, housekeeping, and laboratory safety practices. All questionnaire items were measured using a five-point Likert scale ranging from 1 (strongly disagree/never) to 5 (strongly agree/always). Higher scores indicated better safety culture and higher compliance with safety procedures.

Prior to data collection, the instrument underwent content validation by occupational safety and health experts. Reliability testing demonstrated satisfactory internal consistency, with Cronbach's alpha values of 0.91 for the safety culture scale and 0.88 for the compliance with safety procedures scale.

Data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize respondent characteristics and study variables, including frequencies, percentages, means, and standard deviations. Bivariate analysis was performed using the Chi-square test to determine the association between safety culture (good/poor) and compliance with safety procedures (compliant/non-compliant). The magnitude of association was expressed as the prevalence ratio (PR) with a 95% confidence interval (CI). Statistical significance was established at a p-value of less than 0.05.

RESULTS

Respondent Characteristic

A total of 96 undergraduate students from the Bachelor of Occupational Safety Engineering, Bachelor of Nutrition, and Bachelor of Hospital Administration programs at Institut Teknologi dan Kesehatan (ITEKES) Tri Tunas Nasional Makassar participated in this study.

Table 1.
Characteristics of Respondents (n = 96)

Characteristics	Frequency (n)	Percentage (%)
Age (years)		
18–20	38	39.6
21–23	49	51.0
>23	9	9.4
Sex		
Male	34	35.4
Female	62	64.6
Study Program		
Bachelor of Occupational Safety Engineering	32	33.3
Bachelor of Nutrition	32	33.3
Bachelor of Hospital Administration	32	33.3
Academic Year		
Second Year	29	30.2
Third Year	37	38.5
Total	**41**	**100**

The majority of respondents were aged 21–23 years (51.0%), female (64.6%), and equally represented across the three study programs. Most participants were in their third academic year (38.5%).

Univariate Analysis

Safety Culture

Table 2.
Distribution of Safety Culture

Safety Culture	Frequency (n)	Percentage (%)
Good	61	63.5
Poor	35	36.5
Total	**96**	**100.0**

Most respondents demonstrated a good level of safety culture (63.5%), while 36.5% were categorized as having poor safety cultre.

Compliance with Safety Procedures

Table 3.
Distribution of Compliance with Safety Procedures

Compliance	Frequency (n)	Percentage (%)
Compliant	68	70.8
Non-compliant	28	29.2
Total	**96**	**100.0**

Overall, 70.8% of respondents complied with institutional safety procedures, whereas 29.2% were classified as non-compliant.

Bivariate Analysis

Association Between Safety Culture and Compliance with Safety Procedures

Table 4.
Association Between Safety Culture and Compliance with Safety Procedures

Safety Culture	Compliant n (%)	Non-compliant n (%)	Total	p-value
Good	51 (83.6)	10 (16.4)	61	<0.001

Poor	17 (48.6)	18 (51.4)	35
Total	**68 (70.8)**	**28 (29.2)**	**96**

The Chi-square analysis demonstrated a statistically significant association between safety culture and compliance with safety procedures ($\chi^2 = 13.62$; $p < 0.001$). Students with a good safety culture exhibited substantially higher compliance (83.6%) compared with those who had a poor safety culture (48.6%). Conversely, non-compliance was considerably more common among students with poor safety culture (51.4%) than among those with good safety culture (16.4%).

These findings indicate that a stronger safety culture is positively associated with higher adherence to institutional safety procedures among undergraduate students at Institut Teknologi dan Kesehatan (ITEKES) Tri Tunas Nasional Makassar. Students who demonstrated positive perceptions, attitudes, communication, and participation regarding safety were more likely to consistently follow laboratory and institutional safety regulations during academic activities.

DISCUSSION

This study demonstrated a statistically significant association between safety culture and students' compliance with safety procedures among undergraduate students of the Bachelor of Occupational Safety Engineering, Bachelor of Nutrition, and Bachelor of Hospital Administration programs at Institut Teknologi dan Kesehatan (ITEKES) Tri Tunas Nasional Makassar. Students who exhibited a positive safety culture showed substantially higher compliance with institutional safety procedures than those with a weaker safety culture. These findings indicate that safety culture is an important behavioral determinant influencing students' adherence to safety regulations during laboratory practice and other practical learning activities.

The univariate findings revealed that nearly two-thirds of respondents had a good level of safety culture, while more than two-thirds demonstrated compliance with safety procedures. This distribution suggests that ITEKES Tri Tunas Nasional Makassar has established a reasonably supportive learning environment for occupational safety through classroom instruction, laboratory orientation, safety regulations, and supervision during practical sessions. Nevertheless, approximately one-third of students still demonstrated inadequate safety culture and non-compliance with safety procedures. This finding indicates that opportunities remain for strengthening institutional safety programs to ensure that all students consistently practice safe behaviors throughout their academic activities.

The significant association identified in this study is consistent with the concept proposed by safety culture theory, which states that individual safety behavior is influenced not only by knowledge but also by shared organizational values, attitudes, norms, communication, and leadership commitment regarding safety (Génesis et al., 2022). A positive safety culture encourages individuals to recognize hazards, comply with standard operating procedures, use personal protective equipment appropriately, report unsafe conditions, and actively participate in accident prevention (Rubin et al., 2020). Conversely, when safety is not perceived as an institutional priority, individuals may underestimate risks and become less compliant with established procedures (Hagqvist et al., 2020).

These findings also support the widely recognized framework developed by the Health and Safety Executive (HSE), which defines safety culture as the collective product of individual and group values, competencies, attitudes, perceptions, and behavioral patterns that determine commitment to health and safety management (Samaranayake et al., 2022). Within higher education institutions, this concept extends beyond laboratory regulations to encompass continuous communication, supervision, training, and reinforcement of safe practices. Therefore, cultivating safety culture among students should be viewed as an

ongoing educational process rather than merely enforcing compliance with written regulations (Ebbevi et al., 2020).

From a behavioral perspective, the results can also be interpreted through Social Cognitive Theory, which emphasizes reciprocal interactions between personal factors, environmental influences, and behavior (Jung et al., 2023). Students who observe lecturers, laboratory instructors, and peers consistently following safety procedures are more likely to imitate those behaviors. Positive reinforcement, constructive feedback, and visible institutional commitment further strengthen students' confidence in practicing safe behaviors. Consequently, compliance becomes a habitual action rather than a response motivated solely by fear of sanctions (Nasrallah et al., 2023).

The present findings are consistent with previous studies conducted in universities and healthcare education settings, which reported that safety culture positively influences laboratory safety compliance, proper use of personal protective equipment, and adherence to standard operating procedures (Nævestad et al., 2021). Earlier research has shown that students with stronger safety awareness and greater participation in safety activities are significantly more likely to engage in safe laboratory practices. However, most previous investigations focused on single academic disciplines, such as nursing, medicine, or engineering (Jeschke, 2022). The current study expands existing evidence by simultaneously examining students from three different undergraduate programs Occupational Safety Engineering, Nutrition, and Hospital Administration thereby providing a broader understanding of safety culture within an interdisciplinary educational environment (Xu et al., 2023).

One important contribution of this study lies in highlighting that safety culture should not be considered exclusive to occupational safety programs (Vaughn et al., 2020). Although students enrolled in the Bachelor of Occupational Safety Engineering program receive more intensive education regarding occupational safety principles, Nutrition and Hospital Administration students also encounter biological, chemical, ergonomic, and organizational hazards during laboratory activities and professional practice. Therefore, strengthening safety culture across all health-related academic programs is essential for preparing graduates capable of maintaining patient safety, workplace safety, and personal safety throughout their professional careers (Al-Bsheish et al., 2023).

Despite the positive findings, the presence of students with poor safety culture and non-compliance suggests several contributing factors that may require further attention (Phinias, 2023). Differences in individual motivation, previous safety training, perceived susceptibility to accidents, availability of personal protective equipment, laboratory supervision, workload, and institutional communication may influence students' compliance behaviors. Some students may perceive laboratory risks as minimal because serious accidents occur infrequently, leading to complacency and reduced adherence to safety procedures (Abidin et al., 2021). Continuous education and periodic safety reminders are therefore necessary to sustain safe behaviors over time (van Kampen et al., 2023).

The practical implications of this study are highly relevant for institutional policy development at ITEKES Tri Tunas Nasional Makassar. University management should strengthen safety culture through comprehensive safety orientation programs for new students, regular occupational safety training, routine laboratory safety audits, simulation of emergency responses, and continuous monitoring of compliance with standard operating procedures. Laboratory instructors should consistently model appropriate safety behaviors, while academic leaders should integrate occupational safety competencies into the curriculum across all study programs. Establishing an effective incident reporting system and recognizing students who consistently demonstrate exemplary safety practices may further reinforce positive safety behaviors.

This study possesses several strengths. It involved students from three different health-related undergraduate programs, enabling interdisciplinary comparison and providing a broader perspective on safety culture within higher education (Tappura et al., 2022). The study also examined safety culture as an organizational construct rather than focusing solely on knowledge or attitudes, thereby offering more comprehensive evidence regarding behavioral determinants of compliance. However, several limitations should be acknowledged (Pilbeam & Karanikas, 2023). The cross-sectional design precludes causal inference, and self-reported questionnaires may be influenced by social desirability bias (Bayramova et al., 2023). Furthermore, the study was conducted in a single institution, which may limit the generalizability of the findings to other universities.

Future research should employ longitudinal or experimental designs to evaluate the effectiveness of safety culture interventions over time. Additional variables such as safety leadership, safety climate, risk perception, safety motivation, and organizational commitment should also be explored to develop more comprehensive models of student safety behavior. Comparative studies involving multiple universities across different regions of Indonesia would further strengthen the evidence base and support the development of national strategies for promoting occupational safety culture in higher education.

Overall, the findings confirm that a positive safety culture is closely associated with students' compliance with safety procedures. Developing and sustaining a strong safety culture within higher education institutions is therefore essential not only for preventing laboratory accidents but also for preparing future health professionals who possess enduring commitments to occupational safety, patient safety, and quality professional practice.

CONCLUSION

This study concludes that there is a statistically significant association between safety culture and students' compliance with safety procedures among undergraduate students of the Bachelor of Occupational Safety Engineering, Bachelor of Nutrition, and Bachelor of Hospital Administration programs at Institut Teknologi dan Kesehatan (ITEKES) Tri Tunas Nasional Makassar. Students with a stronger safety culture demonstrated higher compliance with institutional safety procedures than those with a weaker safety culture, indicating that safety culture plays a crucial role in promoting safe behaviors during laboratory practice and other academic activities. These findings emphasize that strengthening safety culture should become an integral component of higher education management to minimize the risk of accidents and improve the quality of practical learning environments. Therefore, ITEKES Tri Tunas Nasional Makassar is encouraged to reinforce institutional safety culture through regular occupational safety training, comprehensive safety orientation for new students, periodic laboratory safety audits, consistent supervision during practical sessions, and continuous monitoring of compliance with standard operating procedures. Integrating occupational safety competencies into the curriculum across all study programs and fostering active student participation in safety promotion activities are also recommended to establish sustainable safety behaviors. Future studies are recommended to include larger and more diverse samples from multiple higher education institutions and to investigate additional factors such as safety leadership, safety climate, safety motivation, and risk perception using longitudinal or intervention-based research designs to further strengthen the evidence regarding determinants of students' safety compliance.

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