

Factors associated with personal protective equipment (PPE) compliance among large-vessel fishermen at TPI Puger Wetan: A stimulus–organism–response (SOR) theory-based analysis

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ABSTRACT

Background: Large-vessel fishermen face substantial occupational hazards, yet compliance with personal protective equipment (PPE) requirements remains low. The stimulus–organism–response (SOR) theory provides a framework for examining factors associated with PPE compliance.

Objectives: To identify factors associated with PPE compliance among large-vessel fishermen at the Puger Wetan Fish Landing Site (TPI Puger Wetan).

Methods: This analytical cross-sectional study included 52 fishermen selected through simple random sampling. Data were collected through structured questionnaire-based interviews. Associations were examined using the Fisher–Freeman–Halton exact test ($\alpha = 0.05$) because the chi-square test assumptions were not met. Cramér's V was used to assess association strength.

Results: Most respondents (63.5%) were noncompliant with PPE requirements. Significant associations were found for educational attainment ($p = 0.004$), knowledge ($p < 0.001$), PPE training ($p = 0.005$), regulations ($p = 0.012$), and reward-and-punishment systems ($p < 0.001$), with Cramér's V values ranging from 0.41 to 0.62. Age, length of service, working hours, attitude, PPE availability, and supervision showed no significant associations.

Conclusions: Educational attainment, knowledge, training, regulations, and reward-and-punishment systems were significantly associated with PPE compliance. Strengthening occupational safety education, training, and policy implementation may improve compliance. However, the cross-sectional design and unadjusted analyses preclude causal inferences.

Keywords: compliance, large-vessel fishermen, occupational safety, personal protective equipment, stimulus–organism–response theory.

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INTRODUCTION

Indonesia is a maritime nation comprising 17,499 islands, with approximately 3.25 million km² of marine waters and an Exclusive Economic Zone (EEZ) covering approximately 2.55 million km² (Ministry of Marine Affairs and Fisheries [KKP], 2022). These extensive marine resources support the fisheries sector, which provides an important source of livelihood for coastal communities. Nevertheless, commercial fishing remains a high-risk occupation, particularly for fishermen working aboard large vessels who are exposed to unpredictable weather, rough sea conditions, vessel-related hazards, fishing equipment, and prolonged working hours (Soykan, 2023; Nguyen et al., 2024). In this study, large-vessel fishermen are defined as those working aboard fishing vessels exceeding 30 gross tonnage (GT). Under Indonesian regulations, fishing areas are classified according to vessel size, with vessels exceeding 30 GT assigned to fishing lane III, which extends farther offshore than the areas designated for smaller fishing vessels (Regulation of the Minister of Marine Affairs and Fisheries No. 18 of 2021). Consequently, fishermen operating larger vessels face distinct occupational hazards and safety requirements. These risks are particularly relevant to Jember Regency, where challenging wave conditions along the southern coast and inadequate safety practices have been associated with fishing accidents and fatalities (Indrayani et al., 2023). Evidence from other maritime settings further highlights the importance of personal protective equipment (PPE) in reducing the consequences of fishing accidents. Kincl et al. (2023) examined 375 commercial fishing incidents recorded in Oregon and Washington, United States, between 2000 and 2018, identifying 93 fatalities, 90% of which resulted from drowning. Only 2% of the victims were reported to have been wearing an immersion suit properly. Although these findings are specific to the study population and cannot be generalized to Indonesian fishermen, they underscore the importance of appropriate protective equipment in high-risk fishing environments.

Compliance with PPE requirements depends on various individual and occupational factors. Previous research has highlighted the importance of occupational safety and health (OSH) knowledge, with Ardillah (2023) reporting that 76.7% of fishermen in the study population had inadequate OSH knowledge. Other studies have examined the relationships between age, educational attainment, length of service, working hours, knowledge, and occupational safety outcomes among fishermen (Indrayani et al., 2023; Nguyen et al., 2024; Jamil et al., 2026). For example, Jamil et al. (2026) identified significant associations between occupational accidents and several factors, including PPE compliance, working hours, length of service, knowledge, weather conditions, and the availability of facilities and infrastructure among traditional fishermen in Bojo Village, Barru Regency. Although these findings provide valuable insights into occupational risks, associations with workplace accidents do not necessarily explain the factors directly related to PPE compliance. Therefore, examining PPE compliance as a distinct occupational safety behavior is important for understanding fishermen's adherence to established safety practices.

Beyond individual characteristics, organizational and environmental conditions may also shape PPE compliance. These include PPE availability, OSH training, workplace supervision, safety regulations, and reward-and-punishment systems (Uyumsal et al., 2023; Sulkhani et al., 2025). Sulkhani et al. (2025) examined occupational safety practices aboard purse-seine fishing vessels in Indonesian waters

using structured observations, interviews, and document reviews, highlighting the importance of assessing safety practices within actual fishing environments. These considerations are particularly relevant to Puger, one of the major marine fisheries centers in Jember Regency, which has been reported to have approximately 8,338.5 km² of waters within Indonesia's EEZ (Pratama et al., 2023). The occupational hazards associated with fishing activities in this region were further illustrated by an incident in 2025 involving six fishermen who went missing in the southern waters of Jember, with extreme weather conditions hampering search operations (Muttaqin, 2025). Such incidents highlight the potentially hazardous conditions under which fishing activities are conducted and reinforce the need for effective occupational safety practices. Furthermore, Government Regulation No. 50 of 2012 concerning the Implementation of Occupational Safety and Health Management Systems emphasizes the prevention of occupational accidents and diseases through systematic hazard identification and control (President of the Republic of Indonesia, 2012). Accordingly, understanding the factors associated with PPE compliance among fishermen operating from TPI Puger Wetan is essential for informing context-specific occupational safety initiatives.

The stimulus–organism–response (SOR) theory developed by Mehrabian and Russell (1974) offers a conceptual framework for examining the individual and external factors associated with PPE compliance. Within this framework, external conditions, including PPE availability, OSH training, supervision by fishing group leaders, workplace regulations, and reward-and-punishment systems, are categorized as stimuli. Individual characteristics, including age, educational attainment, length of service, daily working hours, knowledge, and attitudes, represent organism-related factors, while PPE compliance constitutes the behavioral response. This framework enables the systematic classification of factors potentially associated with fishermen's safety behaviors. However, the present study applies the SOR theory solely as a conceptual framework for selecting and categorizing variables rather than testing causal pathways or mediation mechanisms.

Despite growing research on occupational safety among fishermen, a practical gap remains in how and when PPE compliance is assessed across different stages of fishing activities. PPE-related practices extend from pre-departure preparation and onboard operations to post-voyage activities, including unloading and sorting catches, cleaning fishing equipment, and maintaining protective equipment. Although assessing compliance across these stages could provide a more comprehensive understanding of safety behavior, direct observation during fishing voyages presents logistical and safety challenges. Researchers may be exposed to hazardous working conditions, while their presence aboard fishing vessels could interfere with routine operations. Previous studies have employed observations, interviews, and document reviews to evaluate occupational safety practices in fishing environments (Sulkhani et al., 2025). However, these approaches may require direct access to active fishing operations. To address these practical constraints, the present study adopts a post-voyage, self-reported assessment of PPE compliance at TPI Puger Wetan. Specifically, post-voyage PPE compliance refers to fishermen's reported use, care, and storage of PPE during activities conducted after returning to shore, including catch handling, unloading, sorting, and cleaning fishing gear. This approach provides a feasible means of examining PPE-related practices without exposing researchers to the hazards associated with onboard observation, although it does not capture PPE use throughout the entire fishing voyage.

Based on these considerations, this study aims to identify factors associated with post-voyage PPE compliance among large-vessel fishermen at TPI Puger Wetan using the SOR theoretical framework. Specifically, the study examines organism-related factors, including age, educational attainment, length of service, daily working hours, knowledge, and attitudes, alongside stimulus-related factors, including PPE availability, OSH training, supervision, workplace regulations, and reward-and-punishment systems. By integrating these factors within the SOR framework, this study seeks to provide a structured understanding of PPE compliance in a specific fishing occupational context. The findings may contribute to the application of behavioral theory in occupational safety research and inform the development of targeted, context-sensitive interventions to strengthen PPE compliance and safety practices among fishermen.

METHODS

Study Design and Participants

This study employed an analytical cross-sectional design in which the independent and dependent variables were assessed simultaneously without any intervention. Based on the stimulus–organism–response (SOR) theoretical framework, the independent variables were classified into organism-related factors, including age, educational attainment, length of service, daily working hours, knowledge, and attitudes, and stimulus-related factors, including PPE availability, training participation, supervision by fishing group leaders, workplace regulations, and reward-and-punishment systems. The dependent variable, representing the response component, was post-voyage compliance with personal protective equipment (PPE) requirements among large-vessel fishermen. The SOR framework was used to guide variable selection and classification rather than to test causal relationships or mediating pathways.

The study was conducted at the Puger Wetan Fish Landing Site (TPI Puger Wetan), Puger Subdistrict, Jember Regency, Indonesia, between March and May 2026, including study preparation, data collection, and final reporting. The site was purposively selected because it is a major fishing center in Jember Regency, characterized by substantial large-vessel fishing activities, high fishing mobility, and occupational hazards associated with the challenging sea conditions along Java's southern coast.The study population comprised 4,122 active large-vessel fishermen registered at TPI Puger Wetan, according to records obtained from the Puger Coastal Fishing Port Technical Implementation Unit (UPT PPP Puger). The list of registered fishermen served as the sampling frame. Eligible fishermen were assigned sequential identification numbers, and participants were randomly selected using a random number generator until the required sample of 52 fishermen was obtained. Selected participants were approached at TPI Puger Wetan, informed about the study objectives, procedures, and potential benefits, and invited to provide written informed consent before participating. Simple random sampling was selected because the target population shared broadly similar occupational characteristics and work-related hazards.

The minimum sample size was determined using the finite population proportion formula:

$$n = [Z^2 \times P(1 - P) \times N] / [d^2 \times (N - 1) + Z^2 \times P(1 - P)]$$

where n represents the minimum required sample size, Z is the standard normal value corresponding to a 95% confidence level (1.96), P is the estimated population proportion (0.88), d is the desired margin of error (0.10), and N is the population size (4,122). Substituting these values yielded a minimum sample size of 40.18, which was rounded up to 41 participants. A further 25% allowance was applied to account for potential nonresponse or incomplete data (41 × 1.25 = 51.25), resulting in a final target sample of 52 fishermen. This calculation was intended to estimate a population proportion rather than ensure sufficient statistical power for all 11 bivariate comparisons or multivariable analyses.

Eligible participants were active fishermen aged 17 years or older, with at least one month of fishing experience, sufficient communication ability to complete the interview, and willingness to provide written informed consent. Fishermen were excluded if they were ill or unavailable during data collection, withdrew during the interview, owned fishing vessels but did not personally participate in fishing activities, or had more than 20% missing questionnaire responses. Age was initially classified into six categories: 15–24, 25–34, 35–44, 45–54, 55–64, and 65–74 years. Because no participants were younger than 25 years, the 15–24-year category was excluded from the final descriptive tables.

Ethical approval statement

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Before data collection, all participants received information regarding the study objectives, procedures, potential benefits, and risks. Written informed consent was obtained from each participant, and participation was entirely voluntary. Participants were informed of their right to withdraw at any stage without consequences. The study protocol was reviewed and approved by Health Research Ethics Committee Faculty of Dentistry University of Jember, under approval number 4214/UN25.8/KEPK/DL/2026, dated 20th March 2026.

Research Instruments

Data were collected using a structured questionnaire developed within the SOR theoretical framework and adapted from previous studies examining PPE compliance among fishermen. The questionnaire covered participant characteristics, organism-related factors, stimulus-related factors, and post-voyage PPE compliance. Trained interviewers administered the questionnaire through structured face-to-face interviews using standardized procedures. Interviews were supplemented by observations of PPE availability and use. Formal psychometric evaluation, including pilot testing, item–total correlation analysis, and internal consistency assessment using Cronbach's alpha, was not conducted before data collection. This limitation was considered when interpreting the findings.

PPE-related knowledge was assessed using 12 questions addressing the definition, functions, benefits, appropriate use, and recommended timing of PPE use; relevant safety regulations; risks associated with nonuse; PPE requirements for specific fishing activities; life jacket use; and occupational risks associated with sun exposure. Each question had one correct answer, scored as 1 for a correct response and 0 for an incorrect response. Total scores were converted into percentages using the formula (obtained score/12) × 100%. Knowledge was classified as good (≥76%), adequate (56–75%), or poor (≤55%).

Attitudes toward PPE use were assessed using 11 statements rated on a four-point Likert scale. The statements addressed perceived PPE importance, adherence to PPE requirements, comfort during PPE use, willingness to use PPE without supervision, and perceived protective benefits. Nine positively worded items (items 1–5, 7–9, and 11) were scored from 1 (strongly disagree) to 4 (strongly agree), whereas two negatively worded items (items 6 and 10) were reverse-scored. Item scores were summed to obtain an overall attitude score for each participant. Participants scoring at or above the sample mean were classified as having a positive attitude, whereas those scoring below the mean were classified as having a negative attitude.

Additional organism-related variables, including age, educational attainment, length of service, and daily working hours, were assessed using individual closed-ended questions. PPE availability was evaluated using a checklist covering eight types of protective equipment: safety helmets, thick anti-slip gloves, anti-slip boots, life jackets, flashlights, raincoats, hearing protection, and masks. The checklist assessed two dimensions: equipment availability aboard the vessel and adequacy relative to crew size. Each checked item received 1 point, whereas unchecked items received 0 points. The resulting scores were used to classify PPE availability into available and unavailable categories.

Training participation, supervision, workplace regulations, and reward-and-punishment systems were each assessed using a dichotomous (yes/no) question. Training participation referred to involvement in PPE-related training or safety awareness activities organized by government agencies or relevant institutions. Supervision referred to pre-departure safety inspections conducted by fishing group leaders or authorized officials, including harbor masters, fisheries officers, or village authorities. Workplace regulations were assessed based on participants' awareness of rules requiring PPE use, while reward-and-punishment systems were assessed by whether PPE-related rewards or sanctions had been implemented.

Post-voyage PPE compliance was assessed using 22 items addressing self-reported PPE use, care, and storage during activities performed after returning to shore. These activities included unloading and sorting catches, cleaning fishing equipment, wearing appropriate protective boots and gloves during catch handling, and cleaning and storing PPE after use. Each item was rated on a four-point frequency scale: always (3), often (2), sometimes (1), and never (0). Total scores were converted into percentages using the formula (obtained score/66) × 100%. Compliance was categorized as compliant (≥76%), moderately compliant (56–75%), or noncompliant (≤55%). Assessments were conducted after participants returned from fishing voyages and therefore reflected self-reported post-voyage practices rather than directly observed PPE use at sea.

Potential Sources of Bias

Several potential sources of bias were considered. Selection bias was addressed by using the official registry of active large-vessel fishermen as the sampling frame and employing simple random sampling. Nevertheless, because interviews were conducted only with fishermen available at the study site during the data collection period, participation-related selection bias could not be excluded.

Information bias was addressed through standardized questionnaires and consistent interview procedures. However, reliance on self-reported information, particularly for PPE compliance, knowledge, and attitudes, introduced potential recall and social desirability biases. To mitigate these concerns, participants were

assured of the confidentiality of their responses, and interviewers used neutral language without suggesting preferred answers. Furthermore, the cross-sectional design precluded establishing temporal relationships between the explanatory variables and PPE compliance. Potential clustering among fishermen working aboard the same vessel was also not accounted for, despite the possibility of shared working conditions, occupational practices, and safety norms.

Data Analysis

Data were analyzed using descriptive and bivariate statistical methods. Descriptive analyses summarized categorical variables as frequencies and percentages. Bivariate analyses examined associations between organism- and stimulus-related factors and post-voyage PPE compliance. The chi-square (χ^2) test was initially considered for evaluating associations between categorical variables, with statistical significance set at $\alpha = 0.05$. However, when more than 20% of contingency table cells had expected frequencies below five, the Fisher–Freeman–Halton exact test was applied.

Because this assumption was violated across all contingency tables, with 33.3–75.0% of cells having expected frequencies below five, all reported p-values in Tables 2 and 3 were obtained using the Fisher–Freeman–Halton exact test. Association strength was assessed using Cramér's V, with 95% confidence intervals estimated from the noncentral chi-square distribution. All analyses were unadjusted because the limited sample size and sparse contingency tables restricted reliable multivariable adjustment for potential confounding factors. No adjustment for multiple comparisons was performed.

The dependent variable retained its original three categories (compliant, moderately compliant, and noncompliant) throughout the bivariate analyses. Accordingly, associations were evaluated using contingency tables with three outcome columns. Binary odds ratios were not calculated because the outcome was analyzed without dichotomization. Results were therefore reported using exact p-values and Cramér's V as the measure of association strength.

RESULTS

The descriptive characteristics of the 52 large-vessel fishermen, including organism-related factors, stimulus-related factors, and post-voyage personal protective equipment (PPE) compliance, are presented in Table 1. As shown in Table 1, the largest proportion of respondents was aged 45–54 years (36.5%), and most had worked as fishermen for more than 10 years (75.0%). Regarding educational attainment, 34.6% had completed only elementary school, while 11.5% had received no formal education. Most respondents worked at least nine hours per day (65.4%). Although 38.5% demonstrated good PPE-related knowledge and 61.5% reported positive attitudes toward PPE use, 36.5% had poor knowledge.

Regarding stimulus-related factors, 63.5% of respondents reported that PPE was available, whereas 63.5% had never received PPE-related training. Similarly, 63.5% reported an absence of workplace supervision, 53.8% reported no regulations requiring PPE use, and 69.2% indicated that no reward-and-punishment system had been implemented. Overall, 63.5% of respondents were classified as noncompliant with post-voyage PPE requirements, while only 23.1% met the criteria for compliance.

Associations Between Organism-Related Factors and PPE Compliance

The associations between organism-related factors and post-voyage PPE compliance are presented in Table 2. Educational attainment was significantly associated with PPE compliance ($p = 0.004$; Cramér's $V = 0.41$). Fishermen with senior high school education demonstrated the highest proportion of compliance, whereas noncompliance was more prevalent among those with lower educational attainment. PPE-related knowledge was also significantly associated with compliance ($p < 0.001$; Cramér's $V = 0.51$), representing the strongest association among the organism-related factors. Fishermen with good knowledge were more likely to report compliance, while all respondents classified as having poor knowledge were noncompliant. In contrast, age ($p = 0.236$; Cramér's $V = 0.31$), length of service ($p = 0.240$), daily working hours ($p = 1.000$), and attitude ($p = 0.316$) were not significantly associated with PPE compliance. Although noncompliance appeared more prevalent among older fishermen and those with longer service, these descriptive patterns should be interpreted cautiously given the small sample size and nonsignificant associations.

Table 1. Frequency Distribution

Variable	Classification	n	%
Age	Early-career worker (25–34 years)	8	15.4
	Senior/middle-aged worker (35–44 years)	15	28.8
	Pre-retirement (45–54 years)	19	36.5
	Retirement age (55–64 years)	8	15.4
	Elderly (65–74 years)	2	3.8
Highest education	No formal schooling/illiterate	6	11.5
	Elementary school/equivalent	18	34.6
	Junior high school/equivalent	12	23.1
	Senior high school/equivalent	16	30.8
Length of service	≤10 years	13	25.0
	>10 years	39	75.0
Daily work duration	<8 hours	18	34.6
	≥9 hours	34	65.4
Knowledge of PPE	Good	20	38.5
	Adequate	13	25.0
	Poor	19	36.5
Attitude toward PPE use	Positive	32	61.5
	Negative	20	38.5
PPE availability	Available	33	63.5
	Not available	19	36.5
PPE training	Ever received	19	36.5
	Never received	33	63.5
Supervision	Present	19	36.5
	Absent	33	63.5
PPE use regulation	Present	24	46.2
	Absent	28	53.8
Reward-and-punishment system	Present	16	30.8
	Absent	36	69.2
Post-voyage PPE compliance	Compliant	12	23.1
	Moderately compliant	7	13.5
	Non-compliant	33	63.5
Total		52	100

Table 2. Cross-tabulation and Association Test Results for Organism Factors

Independent Variable	Classification	Compliant (n)	%	Moderately compliant (n)	%	Non-compliant (n)	%	p-value
Age	Early-career worker (25–34 years)	3	37.5	2	25.0	3	37.5	0.236
	Senior/middle-aged worker (35–44 years)	2	13.3	3	20.0	10	66.7	
	Pre-retirement (45–54 years)	7	36.8	1	5.3	11	57.9	
	Retirement age (55–64 years)	0	0	1	12.5	7	87.5	
	Elderly (65–74 years)	0	0	0	0	2	100	
Total		12	23.1	7	13.5	33	63.5	
Highest education	No formal schooling/illiterate	1	16.7	1	16.7	4	66.7	0.004
	Elementary school/equivalent	1	5.6	1	5.6	16	88.9	
	Junior high school/equivalent	1	8.3	3	25.0	8	66.7	
	Senior high school/equivalent	9	56.3	2	12.5	5	31.3	
Total		12	23.1	7	13.5	33	63.5	
Length of service	≤10 years	5	38.5	2	15.4	6	46.2	0.240
	>10 years	7	17.9	5	12.8	27	69.2	
Total		12	23.1	7	13.5	33	63.5	
Daily work duration	<8 hours	4	22.2	2	11.1	12	66.7	1.000
	≥9 hours	8	23.5	5	14.7	21	61.8	
Total		12	23.1	7	13.5	33	63.5	
Knowledge of PPE	Good	11	55.0	4	20.0	5	25.0	<0.001
	Adequate	1	7.7	3	23.1	9	69.2	
	Poor	0	0	0	0	19	100	
Total		12	23.1	7	13.5	33	63.5	
Attitude toward PPE use	Positive	8	25.0	6	18.8	18	56.3	0.316
	Negative	4	20.0	1	5.0	15	75.0	
Total		12	23.1	7	13.5	33	63.5	

Note: p-values were obtained using the Fisher–Freeman–Halton Exact Test because more than 20% of cells had expected counts <5. Effect size, Cramér's V (95% CI): age 0.31 (0.00–0.40); highest education 0.41 (0.12–0.56); length of service 0.23 (0.00–0.47); daily work duration 0.06 (0.00–0.22); knowledge of PPE 0.51 (0.28–0.68); attitude toward PPE use 0.22 (0.00–0.46).

Associations Between Stimulus-Related Factors and PPE Compliance

The associations between stimulus-related factors and post-voyage PPE compliance are summarized in Table 3. PPE training was significantly associated with compliance ($p = 0.005$; Cramér's $V = 0.45$). Compliance was higher among fishermen who had received PPE-related training than among those without training (47.4% vs. 9.1%).

The existence of PPE regulations was also significantly associated with compliance ($p = 0.012$; Cramér's $V = 0.41$). Noncompliance was lower among fishermen who reported the existence of PPE regulations than among those who reported no such regulations (45.8% vs. 78.6%).

The strongest association among all variables examined was observed for the reward-and-punishment system ($p < 0.001$; Cramér's $V = 0.62$). Fishermen reporting

the implementation of such a system demonstrated higher compliance than those reporting its absence.

Conversely, PPE availability (p = 0.075; Cramér's V = 0.32) and supervision (p = 0.230) were not significantly associated with compliance. Nevertheless, noncompliance was descriptively higher among fishermen without available PPE than among those reporting PPE availability (78.9% vs. 54.5%).

Overall, five of the 11 factors examined were significantly associated with post-voyage PPE compliance: educational attainment, knowledge, PPE training, regulations, and reward-and-punishment systems. All reported associations were unadjusted and should not be interpreted as causal relationships.

Table 3. Cross-tabulation and Association Test Results for Stimulus Factors

Independent Variable	Classification	Compliant (n)	%	Moderately compliant (n)	%	Non-compliant (n)	%	p-value
PPE availability	Available	8	24.2	7	21.2	18	54.5	0.075
	Not available	4	21.1	0	0	15	78.9	
Total		12	23.1	7	13.5	33	63.5	
PPE training	Ever received	9	47.4	1	5.3	9	47.4	0.005
	Never received	3	9.1	6	18.2	24	72.7	
Total		12	23.1	7	13.5	33	63.5	
Supervision	Present	7	36.8	2	10.5	10	52.6	0.230
	Absent	5	15.2	5	15.2	23	69.7	
Total		12	23.1	7	13.5	33	63.5	
PPE use regulation	Present	10	41.7	3	12.5	11	45.8	0.012
	Absent	2	7.1	4	14.3	22	78.6	
Total		12	23.1	7	13.5	33	63.5	
Reward-and-punishment system	Present	8	50.0	5	31.3	3	18.8	<0.001
	Absent	4	11.1	2	5.6	30	83.3	
Total		12	23.1	7	13.5	33	63.5	

Note: p-values were obtained using the Fisher–Freeman–Halton Exact Test because more than 20% of cells had expected counts <5. Effect size, Cramér's V (95% CI): PPE availability 0.32 (0.00–0.57); PPE training 0.45 (0.14–0.70); supervision 0.25 (0.00–0.49); PPE use regulation 0.41 (0.09–0.67); reward-and-punishment system 0.62 (0.33–0.88).

DISCUSSION

The findings of this study provide insights into the organism- and stimulus-related factors associated with post-voyage personal protective equipment (PPE) compliance among large-vessel fishermen. Within the stimulus–organism–response (SOR) framework, educational attainment and knowledge were significantly associated with compliance, whereas age, length of service, daily working hours, and attitudes showed no statistically significant associations. Among stimulus-related factors, PPE training, workplace regulations, and reward-and-punishment systems were significantly associated with compliance, while PPE availability and supervision were not. These findings suggest that cognitive and organizational factors may be particularly relevant to occupational safety practices in this fishing community. Although the SOR framework provides a useful structure for interpreting these relationships (Mehrabian & Russell, 1974; Chang et al., 2024; Lu et al., 2025), the present study examined only unadjusted bivariate associations and did not test the causal or mediating mechanisms underlying the theory.

Educational attainment and PPE-related knowledge emerged as significant organism-related factors. Fishermen with higher educational attainment generally demonstrated greater compliance, while those with good PPE knowledge were more likely to report appropriate safety practices. These findings suggest that the ability to understand occupational hazards and interpret safety information may be relevant to PPE compliance. Education may facilitate the comprehension of safety instructions, whereas specific PPE knowledge may support the recognition of occupational risks and appropriate protective practices (Indrayani et al., 2023; Ardillah, 2023). However, educational attainment and knowledge may be interrelated, and their independent associations with compliance could not be established without multivariable adjustment. Accordingly, these findings support the potential relevance of accessible, occupation-specific safety education rather than demonstrating a direct effect of education or knowledge on compliance.

In contrast, attitudes toward PPE use were not significantly associated with compliance, despite most respondents reporting positive attitudes. This finding differs from Hariyanti et al. (2025), who identified attitudes as an important factor in fishermen's safety behavior. It may reflect a discrepancy between favorable safety attitudes and actual protective practices, although the present data cannot establish an attitude–behavior gap conclusively. Similarly, Maylinda and Munggaran (2025) reported that favorable knowledge and attitudes did not necessarily translate into PPE compliance among construction workers. Differences in study populations, occupational environments, and measurement approaches may partly explain these findings. In the present study, knowledge was assessed through 12 objectively scored questions, whereas attitudes were measured using 11 Likert-scale statements. PPE compliance was assessed through self-reported practices involving PPE use, care, and storage during post-voyage activities. These differences in measurement should be considered when interpreting the contrasting associations. The findings also highlight the importance of examining whether supportive working conditions facilitate the translation of safety awareness into consistent protective practices.

Age, length of service, and daily working hours were not significantly associated with PPE compliance. Although increasing age and occupational experience may contribute to greater awareness of workplace hazards (Indrayani et al., 2023), such characteristics do not necessarily correspond to consistent protective behavior. These findings differ from those of Suryani et al. (2023), who reported an association between age and occupational accidents among fishermen. However, the outcomes are not directly comparable, as occupational accidents and PPE compliance represent different aspects of workplace safety. Conversely, Mubarak et al. (2025) similarly found no significant associations between age, length of service, and PPE compliance among construction workers. Established work routines, perceived familiarity with occupational hazards, and shared crew practices may help explain the limited differences observed across demographic groups. Nevertheless, these mechanisms were not directly assessed and require further investigation. Moreover, the relatively small sample and sparse contingency tables limit the interpretation of nonsignificant findings.

Regarding stimulus-related factors, PPE availability was not significantly associated with compliance, although noncompliance was descriptively higher among fishermen reporting inadequate PPE availability. This finding is broadly consistent with Rizal (2022), who highlighted the limitations of PPE provision alone in promoting compliance among healthcare workers. However, the absence of

statistical significance should not be interpreted as evidence that equipment availability is unimportant. Access to appropriate protective equipment remains essential for safe working practices, but its availability may need to be accompanied by education, training, and organizational support. Similarly, supervision was not significantly associated with compliance. This contrasts with Mubarak et al. (2025), who identified supervision as an important factor in PPE compliance among construction workers. One possible explanation is that supervision in the present study was assessed only through a dichotomous measure of its presence or absence, without evaluating its frequency, quality, or consistency. As emphasized by Uyun and Widowati (2022), effective occupational safety supervision requires sustained implementation and appropriate enforcement. Further research incorporating more detailed measures of supervisory practices is therefore warranted.

PPE training and workplace regulations were significantly associated with compliance, highlighting the potential relevance of organizational support in occupational safety practices. Fishermen who had participated in PPE-related training demonstrated higher compliance than those without prior training. This finding is consistent with the broader emphasis on safety education and practical training in fishing environments (Sulkhani et al., 2025; Ridho et al., 2025). Training may provide opportunities to develop protective skills, improve hazard recognition, and reinforce safe working procedures. Similarly, fishermen who reported the existence of PPE regulations demonstrated lower noncompliance than those who reported no such regulations. Clear safety requirements may provide practical guidance and reinforce expectations regarding protective behavior. Nevertheless, training participation and regulatory awareness were measured using single yes/no items, preventing further assessment of training quality, regulatory enforcement, or the consistency of implementation. Therefore, these findings should be interpreted as associations rather than evidence of intervention effectiveness.

The reward-and-punishment system exhibited the largest observed association with PPE compliance (Cramér's V = 0.62). This finding suggests that reported organizational rewards and sanctions may be particularly relevant to protective behavior among large-vessel fishermen. Within the SOR framework, rewards and consequences can be conceptualized as external stimuli potentially associated with behavioral responses (Mehrabian & Russell, 1974). Previous studies have also highlighted the relevance of organizational policies, incentives, and workplace relationships to occupational safety practices (Nadya, 2024; Chang et al., 2024; Lu et al., 2025; Sulkhani et al., 2025). In fishing environments where crew members may operate within informal employment arrangements, such mechanisms could be especially salient. However, the present study did not directly assess employment arrangements, the types of incentives or sanctions applied, or their implementation frequency. Furthermore, the larger Cramér's V value does not establish that reward-and-punishment systems exert a stronger causal influence than other factors. These mechanisms should therefore be examined in future studies using more detailed organizational measures and appropriate longitudinal or intervention designs.

Taken together, these findings highlight the potential value of combining individual safety education with supportive organizational practices to promote PPE compliance among large-vessel fishermen. Within the SOR framework, knowledge and educational attainment represent relevant organism-related characteristics, whereas training, regulations, and reward-and-punishment systems represent organizational stimuli associated with the behavioral response. Practical

occupational safety initiatives could therefore prioritize accessible PPE education, task-specific training, clear safety requirements, and consistent implementation of appropriate supervisory and incentive mechanisms. However, the effectiveness of these strategies requires evaluation through prospective or intervention-based research. Future studies should also investigate crew-level safety norms, the quality of organizational support, and the processes through which individual knowledge and workplace conditions may interact to shape protective behavior.

Limitations of the study

Several limitations should be considered when interpreting these findings. First, the cross-sectional design precludes causal inference and does not establish temporal relationships between the explanatory variables and PPE compliance. Second, the study involved only 52 large-vessel fishermen from a single fishing site, limiting statistical power and the generalizability of the findings to other fishing populations. Third, PPE compliance was assessed through self-reported post-voyage practices, rather than direct observations throughout fishing operations. Consequently, the findings may not represent PPE use during voyages and remain susceptible to recall and social desirability biases.

Additional limitations concern measurement and statistical analysis. The questionnaire was not formally evaluated for validity or reliability, while several organizational variables were assessed using single dichotomous items, potentially introducing measurement error and misclassification. All associations were unadjusted, and the small sample size and sparse contingency tables prevented reliable multivariable adjustment for potential confounders. Several cells contained very small or zero frequencies, reducing statistical precision and limiting the interpretation of nonsignificant findings. Furthermore, 11 bivariate comparisons were conducted without adjustment for multiple testing, increasing the possibility of false-positive findings. Potential clustering among fishermen working aboard the same vessel was not accounted for, which may have affected statistical inference. Selection bias also remains possible because fishermen unavailable at the study site during data collection could not be interviewed. Future research should employ larger, multisite samples, validated instruments, and longitudinal or intervention designs, with appropriate consideration of confounding and vessel-level clustering. Such studies could also apply multivariable ordinal regression to examine the three-level compliance outcome more comprehensively.

CONCLUSIONS

This study identified several factors significantly associated with post-voyage personal protective equipment (PPE) compliance among large-vessel fishermen at TPI Puger Wetan. Educational attainment, PPE-related knowledge, safety training, workplace regulations, and reward-and-punishment systems were significantly associated with compliance, whereas age, length of service, daily working hours, attitudes, PPE availability, and supervision showed no statistically significant associations. These findings highlight the relevance of both individual cognitive characteristics and organizational safety practices in understanding PPE compliance within the stimulus–organism–response (SOR) framework. However, given the cross-sectional design and unadjusted analyses, causal relationships cannot be established.

The findings suggest that improving PPE compliance among large-vessel fishermen may require an integrated approach combining occupational safety education, practical training, and supportive organizational policies. These recommendations are informed by the observed associations and relevant occupational safety literature rather than by interventions directly evaluated in this study.

Boat owners (juragan) and relevant fisheries authorities could strengthen safety practices by establishing clear, task-specific PPE requirements and reinforcing them through regular safety briefings. Accessible visual materials, such as waterproof infographics displayed in prominent locations aboard fishing vessels, may help communicate essential safety procedures, building on previous occupational safety outreach initiatives conducted among fishing-boat craftsmen in Puger (Puspita et al., 2025). Providing appropriate, comfortable, and readily accessible PPE should also remain a priority.

Given the significant association between reward-and-punishment systems and PPE compliance, boat owners could consider positive reinforcement strategies, including recognition of consistent PPE use, free provision of protective equipment, and crew participation in developing safety rules. Any corrective measures for noncompliance should be educational, proportionate, consistent with applicable labor regulations, and respectful of workers' rights, without imposing financial penalties or reducing fishermen's income. Future intervention studies and program evaluations are needed to determine whether these proposed measures effectively improve PPE compliance and occupational safety outcomes.

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DATA AVAILABILITY

The data supporting the findings of this study were obtained through structured interviews and observations involving 52 large-vessel fishermen at TPI Puger Wetan, Jember Regency, Indonesia. The raw data are not publicly available due to ethical considerations and the need to protect participants' privacy and confidentiality. De-identified data may be made available by the corresponding author upon reasonable request, subject to applicable ethical requirements and confidentiality safeguards.

AI DISCLOSURE STATEMENT

This manuscript was edited using AI-assisted tools (Paperpal) solely to improve language clarity, grammar, and flow. AI generated no academic content. The command used was "Rephrase the sentence for clarity". All analyses, interpretations, discussions, conclusions, and recommendations were authored by me and informed by the literature.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this study.

PUBLISHER'S NOTE

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