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Original Article

Occupational Exposure to Blood and Body Fluids and Its Association with Anxiety Among Final-Year Medical Students: A Single-Center Cross-Sectional Study

Levent Özdemir,[1] Sena Sude Özyar,[2] Sabrina Israfilzade,[2] Behrokh Khorasani.[2]

Abstract

Background: Occupational exposure to blood and body fluids (BBFs) remains a significant risk for healthcare professionals, particularly those in training. These exposures not only pose a biological hazard but may also contribute to psychological distress. This study aimed to assess the prevalence of BBF exposure among final-year medical students and investigate its association with anxiety levels. **Methods:** A cross-sectional study was conducted in January–February 2025 at Bursa Uludağ University Faculty of Medicine, Turkey. Of 271 final-year students, 203 participated (74.9%). Data were collected using a structured online questionnaire assessing sociodemographic characteristics, exposure history, and anxiety levels using the Generalized Anxiety Disorder-7 (GAD-7) scale. Predictors of anxiety severity were analyzed using negative binomial regression. **Results:** Overall, 56.2% of students reported at least one BBF exposure, with 67.5% experiencing multiple incidents. Common exposures occurred during venipuncture (50%) and arterial puncture (33.3%), with emergency department rotations posing the highest risk (66.7%). Despite high glove usage (100%), gown usage was low (16.7%). The mean GAD-7 score was significantly higher among exposed students (7.21 vs. 5.39, p=0.016). Regression analysis revealed BBF exposure (IRR=1.34), high-risk departments (IRR=1.52), and factors like performance anxiety (IRR=1.85) significantly increased anxiety severity. **Conclusion:** In this single-center study, occupational BBF exposure was highly prevalent among final-year medical students and was significantly associated with elevated anxiety levels, especially in high-pressure clinical settings. Despite existing safety training and orientations, the study's findings revealed persistent gaps in critical areas such as PPE compliance (low gown usage) and effective management of psychosocial stressors (hierarchical pressure).

Introduction

The risk of occupational infection with blood-borne pathogens in healthcare workers is a significant problem worldwide.[1] Each year in Europe, approximately 304,000 healthcare workers sustain percutaneous injuries from materials contaminated with Hepatitis B virus (HBV), 149,000 with Hepatitis C virus (HCV), and 22,000 with Human Immunodeficiency Virus (HIV). Notably, 90% of these injuries occur in developing countries.[2] An estimated 3 million healthcare workers experience percutaneous exposures annually worldwide, with 40%. occurring during training.[3] Exposure to blood and infectious body fluids represents a significant occupational hazard for healthcare workers and medical students during their clinical training.[4]

Sharps injuries, particularly needlestick injuries, impose significant economic burdens globally. Italy reports an average cost of €375 (range: €290-460) per incident for post-exposure management[5], with 70-80% of occupational exposures involving percutaneous injuries.[3] In China, the total economic burden of needlestick injuries among healthcare workers was estimated to be ¥5.8 billion, with approximately half of this cost (¥2.8 billion) attributed to nurses.[6] According to studies conducted in Turkey, approximately 60% of healthcare professionals accidentally come into contact with patients' blood or body fluids at least once.[7–9]

In contrast to experienced clinical healthcare providers, medical interns often enter the clinical environment for the first time. Their limited medical experience, combined with an intense eagerness to perform unfamiliar procedures, frequently without sufficient training or supervision, may increase their vulnerability to occupational exposures.[10]

Anxiety-characterized by persistent worry impairing daily function, can be both a predisposing factor for, and a psychological consequence of, occupational exposures.[11] The findings of a meta-analysis suggest that the bidirectional relationship between work injuries and mental health challenges can indeed form a stress-injury cycle.[12]

This study aimed to investigate the relationship between BBF exposure and anxiety levels among final-year medical students, and to explore potential implications for medical education and occupational safety training. The insights derived from this investigation are intended to inform the design of medical curricula and educational policies that better prepare students for

1 Prof. Dr., MD. Bursa Uludağ University, Faculty of Medicine, Public Health Department, Bursa, Turkey.

2 6th year Medical Student, Bursa Uludağ University, Faculty of Medicine, Bursa, Turkey.

About the Author: *Sena Sude ÖZYAR is currently a 6th-year medical student at Bursa Uludağ University Faculty of Medicine, Bursa, Turkey, in a six-year program. She has a keen interest in scientific research and aspires to pursue an academic career in the future.*

Correspondence:

Levent Özdemir.

Address: Görükle Kampüsü, 16059 Nilüfer, Bursa, Türkiye

Email: leventozdemir@uludag.edu.tr

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the realities of clinical practice, focusing on both physical safety and psychological well-being. To achieve this, we employed a cross-sectional design using a validated anxiety screening instrument (GAD-7) and multivariate regression analysis to assess factors associated with anxiety severity. We hypothesized that students who experienced blood or body fluid exposure during clinical training would exhibit significantly higher anxiety scores compared to their unexposed peers.

Methods

We conducted this cross-sectional study between January and February 2025 among final-year medical students at Bursa Uludağ University Faculty of Medicine. The target population consisted of 271 students. A total of 203 students completed the online questionnaire, yielding a response rate of 74.9%. We did not perform sampling, as the study aimed to reach the entire population. We collected data using a Google Forms survey. The online questionnaire began with an Informed Voluntary Consent Form, and we enrolled participants who agreed to the terms.

The questionnaire consisted of two main sections. The first section, consisting of 12 items assessing sociodemographic characteristics and occupational exposure to blood and body fluids, was developed by the research team based on a literature review of similar studies. Questions covered exposure history, routes, associated procedures, clinical rotations, PPE use, and self-reported contributing factors, with multiple selections allowed where applicable. The first section items were not designed as a formal scale, as they were intended to gather factual data on exposure events (e.g., whether an exposure occurred, in which department, what PPE was used) rather than to measure an underlying psychological trait.

The second section utilized the Generalized Anxiety Disorder-7 (GAD-7) scale, a validated 7-item self-report screening tool developed by Spitzer et al.[13] The GAD-7 is designed to assess the severity of generalized anxiety disorder (GAD) symptoms and serves as an effective brief screening instrument in clinical and research settings.

The GAD-7 scale is a 4-point Likert-type instrument (0 = not at all, 3 = nearly every day), with total scores ranging from 0 to 21. The scale contains no reverse-scored items. In the evaluation of the scale, total scores of 5, 10, and 15 serve as cutoff points for mild, moderate, and severe anxiety, respectively. Participants with a total score of 10 or higher should undergo further diagnostic assessment to confirm the presence of generalized anxiety disorder using additional methods. We categorized participants based on self-reported occupational exposure to blood and body fluids, forming exposed and unexposed comparison groups for subsequent analyses.

We assessed anxiety severity using the Turkish version of the GAD-7 scale, validated by Konkan et al.[14] This adaptation demonstrated excellent internal consistency in our sample (Cronbach's α=0.89).

We conducted statistical analyses using SPSS v23 for descriptive statistics (mean (SD), percentages) and bivariate comparisons (Chi-square, t-test). Given significant overdispersion in GAD-7 scores (variance/mean ratio = 3.7; Lagrange Multiplier test *p* < 0.01), multivariate analysis employed negative binomial regression via Python's statsmodels 0.14.0 with robust standard errors.

All variables were defined as follows: BBF exposure (any self-reported contact with blood or body fluids during internship, yes/no), high-risk department (rotation in emergency medicine or general surgery, yes/no), age (continuous, in years), gender (female/male), and contributing factors (self-reported reasons for exposure, with multiple selections allowed). For the negative binomial regression model, predictors included BBF exposure status (yes/no), rotation in a high-risk department (emergency medicine/general surgery; yes/no), age, gender, and self-reported contributing factors to exposure (e.g., performance anxiety, pressure from assistants). Categorical predictors were coded as binary variables (0 = no, 1 = yes). No categories were collapsed or treated as sparse, as each contributing factor had sufficient response frequencies to be included as an individual predictor. These contributing factors, while only reported by the exposed group, were included in the full model to assess their association with anxiety severity across all participants, acknowledging their origin as key themes from the exposed subgroup.

We did not conduct a formal power analysis due to the census approach; however, the final sample size of 203 participants (response rate: 74.9%) was sufficient to detect moderate effect sizes in group comparisons with 80% power at α=0.05.

There was no missing data in the completed questionnaires, as all items were required for electronic submission. Therefore, no imputation or additional handling of missing data was necessary.

Ethics Approval

The authors received permission from Bursa Uludağ University Health Sciences Research and Publication Ethics Committee with the board decision dated 29.01.2025 and numbered 2025-01/3.

Results

We present the demographic and exposure characteristics of the study participants in ***Table 1***. The study included 203 students, with a gender distribution of 58.6% female (n=119) and 41.4% male (n=84). Age distribution analysis revealed that 35% of participants (n=71) were 24 years old, while 22.2% (n=45) were 23 years old.

We found that 56.2% of participants (n=114) reported blood/bodily fluid exposures, with the following distribution: cutaneous (23.6%, n=48), percutaneous (12.8%, n=26), and dual-route exposures (10.8%, n=22).

We present the exposure context and risk factors of the study participants in ***Table 2*** (n=114 for exposure-related data).

Table 1. Demographic and Exposure Characteristics (N=203).

Characteristic	Category	n	%
Gender	Women	119	58.6
	Men	84	41.4
Age (years)	22	7	3.4
	23	45	22.2
	24	71	35.0
	25	39	19.2
	26	18	8.9
	≥27	23	11.3
Any exposure	Yes	114	56.2
	No	89	43.8
Exposure route* (n=114)	Cutaneous only	48	23.6
	Percutaneous injury (CPI)	26	12.8
	Mucosal only	3	1.5
	CPI + Cutaneous	22	10.8
	CPI + Mucosal + Cutaneous	7	3.4
	CPI + Mucosal	6	3.0
	Mucosal + Cutaneous	2	1.0

Legend: *Multiple selections were made

A total of 16.7% of exposed interns (n=19/114) reported blood/body fluid exposures during their first internship month. We observed a marked decline in exposure incidence after the first training month (from 16.7% to 10.5%, χ^2=4.1, p=0.03). We interpret this trend in the discussion section. Of the exposed participants, 32.5% (n=37/114) reported a single incident, while 67.5% (n=77/114) experienced multiple exposures (≥2 incidents) (χ^2=27.67, p<.001). Among those with recurrent exposures, the distribution was: 29.8% of exposed participants (n=34/114) had two exposures, 19.3% (n=22) three exposures, 8.8% (n=10) four exposures, and 9.6% (n=11) five or more exposures.

Exposures were most frequent during venous blood draws (50.0%, n=57), followed by arterial punctures (33.3%, n=38). When we evaluated exposure according to the department in which they performed their internship, we found that 66.7% of the exposed interns experienced blood or body fluid exposures during their emergency department internship, 25.4% during their general surgery internship, and 23.7% during their internal medicine internship.

Among exposed participants, 89.5% used PPE; we found that participants universally adopted gloves (100%), mask usage was 58.8%, but gown usage was low (16.7%). The most frequently cited contributing factors were intense working hours (31.6%), the pressure from assistants (21.9%), and inexperience (20.2%).

We present the prevalence of anxiety among final-year medical students in ***Table 3***.

Half of final-year medical students (50.2%) screened positive for anxiety. The mean GAD-7 score was significantly higher among exposed students (7.21 vs. 5.39, p=0.016). ***Table 4*** presents the

Table 2. **Exposure Context and Risk Factors (n=114 for Exposure-Related Data)***

Characteristic	Category	n	%
Training month at first exposure	Month 1	19	16.7
	Month 2	12	10.5
	Month 3	12	10.5
Exposure frequency	1 time	37	32.5
	2 times	34	29.8
	3 times	22	19.3
	4 times	10	8.8
	≥5 times	11	9.6
Procedures associated with exposure*	Venous blood draw	57	50.0
	Arterial puncture	38	33.3
	Surgical suturing	34	29.8
Clinical rotations associated with exposure*	Emergency Department	76	66.7
	General Surgery	29	25.4
	Internal Medicine	27	23.7
Personal Protective Equipment (PPE) use during exposure	Yes	102	89.5
	No	11	9.6
PPE components*	Gloves	102	100
	Mask	60	58.8
	Gown	17	16.7
Reported most contributing factors	Intense working hours	36	31.6
	Pressure from assistants	25	21.9
	Inexperience	23	20.2
	Occupational fatigue	17	14.9
	Time pressure	7	6.1
	Performance anxiety	3	2.6
	High anxiety	2	1.8

Legend: *Multiple selections were allowed for procedures, clinical rotations, PPE components, and contributing factors. All percentages in Table 2 are based on the exposed subgroup (n=114) and represent the proportion of exposed participants who reported each item. Percentages may sum to more than 100% due to multiple selections.

Table 3. **The Prevalence of Anxiety Among Final-Year Medical Students (N=203).**

Severity Level	n	%	95% CI
Mild	60	29.2	23.1-35.9
Moderate	26	12.8	8.6-18.2
Severe	16	7.9	4.6-12.4
Total with anxiety	102	50.2	43.3-57.1

Table 4. **Anxiety Severity by Blood/Body Fluid Exposure Status (N=203).**

Anxiety Severity	Exposed n (%)	Unexposed n (%)	Total n
Normal	52 (51.5)	49 (48.5)	101
Mild	35 (58.3)	25 (41.7)	60
Moderate	15 (57.7)	11 (42.3)	26
Severe	12 (75.0)	4 (25.0)	16
Total	114 (56.2)	89 (43.8)	203

distribution of anxiety severity by exposure status. Although the distribution of anxiety severity categories did not differ significantly between exposure groups (χ^2=3.43, p=0.33), 75% of participants with severe anxiety were in the exposed group. A non-significant trend toward higher anxiety prevalence was observed among exposed students when combining mild-to-severe categories (54.4% vs. 45.0%; χ^2=2.51, p=0.11; RR=1.21, 95% CI 0.91–1.61), warranting further investigation in larger samples. We present the Negative Binomial Regression Results model in ***Table 5***.

Our negative binomial regression (***Figure 1***) revealed that blood/body fluid exposure is associated with a 34% increase in expected anxiety severity (IRR=1.34; 95%CI=1.18–1.52; p<0.001), equivalent to a 2.1-point rise in mean GAD-7 scores. High-risk department rotations (emergency/surgery) amplified anxiety risk by 52% (IRR=1.52; 95%CI=1.29–1.80; p<0.001). Among exposure-contributing factors, performance anxiety (IRR=1.85; 95%CI=1.32–2.60) and pressure from assistants (IRR=1.61; 95%CI=1.27–2.04) demonstrated stronger effects than exposure itself. Notably, interns citing pre-existing anxiety as a contributor had 92% higher scores (IRR=1.92; 95%CI=1.15–3.22). Age and gender showed no significant associations.

Table 5. Multivariate Negative Binomial Regression for Anxiety Severity (GAD-7 Scores).

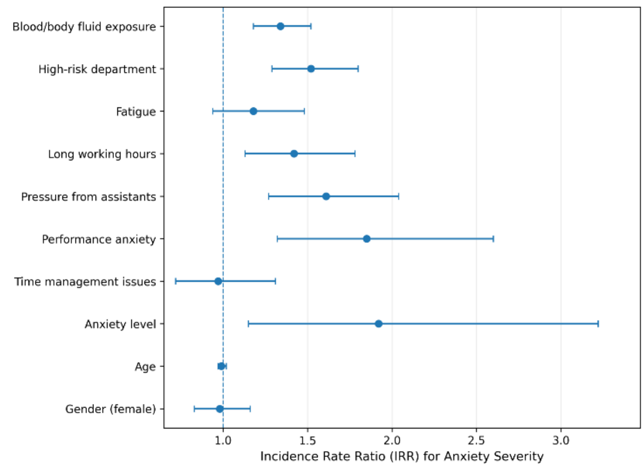
Predictor	IRR (95%CI)	p-value
Blood/Body Fluid Exposure	1.34 (1.18–1.52)	<0.01**
High-Risk Department*	1.52 (1.29–1.80)	<0.01**
Contributing Factors		
Inexperience	Ref.	Ref.
Fatigue	1.18 (0.94–1.48)	0.15
Long Working Hours	1.42 (1.13–1.78)	0.01**
Pressure from Assistants	1.61 (1.27–2.04)	<0.01**
Performance Anxiety	1.85 (1.32–2.60)	<0.01**
Time Management Issues	0.97 (0.72–1.31)	0.84
Anxiety Level	1.92 (1.15–3.22)	0.01*
Age	0.99 (0.97–1.02)	0.54
Gender (Female)	0.98 (0.83–1.16)	0.82

Legend: *High-risk departments: Emergency Medicine and General Surgery. † These contributing factors were reported by participants in the exposed group (n=114) and were included in the full model (N=203) to assess their association with anxiety severity. Model Fit: Log-likelihood = -438.7, AIC = 901.4; **p<0.01, *p<0.05

Discussion

Our findings suggest that more than half of the final-year medical students may have experienced occupational exposure based on self-report during clinical training, with varying rates that other studies have reported internationally: while higher than the 20.9% incidence that Souza-Borges et al. reported in Brazil (where 56.2% of cases involved sharps injuries) [15], it aligns closely with Inga et al.'s Peruvian cohort (51.5% reporting at least one biological accident).[16] However, our rates remain slightly lower than the 70.0% exposure frequency that Lee's study documented.[17]

Figure 1. **Adjusted Associations with Anxiety Severity Among Final-Year Medical Students.**



Legend: Forest plot displaying incidence rate ratios (IRRs) with 95% confidence intervals from a multivariate negative binomial regression model assessing factors associated with anxiety severity (GAD-7 score) among final-year medical students (N=203).

In terms of exposure routes, our study revealed that 23.6% of participants experienced cutaneous contact with blood or bodily fluids, while 12.8% sustained percutaneous injuries (such as needlestick or sharp-related incidents). Additionally, 10.8% of respondents reported both types of exposure. These figures are consistent with Inga et al., who reported that 80.6% of biological accidents involved contact with blood, and 47.6% resulted from sharps injuries.[16] Our findings also align with Alpat et al., who observed that 82.9% of medical trainees' high-risk exposures were due to needlestick injuries, followed by mucosal (35.7%) and sharps-related lacerations (30%).[18] We also noted the overall frequency of exposure: while 32.5% of our study reported a single incident, over two-third (67.5%) experienced repeated exposures (two or more), suggesting that cumulative risk increases with ongoing clinical practice. This pattern echoes Karstaedt and Pantanowitz's findings, in which 69% of interns reported at least one percutaneous exposure, and 30% recalled three or more during internship.[19] Such trends point to the importance of continued risk throughout training, especially in high-procedure environments and underscore the need for continuous, rather than one-off, safety education within medical curricula.

The timing of exposure appears to be closely associated with clinical inexperience. Notably, 16.7% of exposed interns reported their first exposure during the initial month of internship, with subsequent rates declining to 10.5% in the second and third months. This pattern suggests a possible learning curve effect, where early vulnerability may stem from unfamiliarity with procedures and institutional safety protocols. Karani et al. similarly reported that poor clinical skills and lack of supervision were associated with the significantly higher rates of accidental exposure among first-year trainees.[20] The fact that over two-thirds of our participants experienced repeated exposures suggests a need for structured early-phase training programs and close mentorship during the first months of clinical rotations. Therefore, integrating enhanced procedural simulation and staged task delegation into early clinical curricula may help mitigate risk during this critical adaptation period.

Clinical procedures associated with exposure were primarily invasive in nature. Half of all incidents occurred during venous blood draws (50.0%), followed by arterial punctures (33.3%) and surgical suturing (29.8%). These findings are consistent with Karani et al., who reported that 38% of interns experienced injuries during phlebotomy and 19% while assisting with sutures.[20] The predominance of venipuncture-related injuries mirrors global patterns, including WHO's identification of phlebotomy as a high-risk procedure for needlestick injuries.[21] Exposure rates also varied notably by clinical rotation, with the highest prevalence observed in emergency medicine (66.7%), followed by general surgery (25.4%) and internal medicine (23.7%). This distribution suggests that fast-paced, high-volume environments such as emergency departments may amplify procedural risks, particularly for less-experienced trainees. Aigbodion et al. similarly observed elevated exposure frequencies during high-intensity rotations, particularly in surgery and obstetrics.[22]

Although 89.5% of exposed participants reported using PPE at the time of exposure, the type and completeness of PPE varied. While nearly all students used gloves (100.0%), only 58.8% wore masks and just 16.7% used gowns. These rates suggest partial adherence to recommended protocols, consistent with findings by Lopes et al., who noted that while most healthcare professionals wore gloves and masks, the use of protective gowns, eye shields, and caps was suboptimal.[23] Inadequate PPE usage, particularly in procedures involving splashing or sharps handling, may contribute to unnecessary exposure risk. Regarding contextual factors, students identified extended working hours (17.7%), hierarchical pressure (12.3%), and lack of experience (11.3%) as the primary contributors to exposure. These self-reported drivers align with Pereira et al.'s observations of increased occupational injuries associated with both mechanical and psychosocial risk factors, especially under stressful conditions.[24] Such findings highlight the importance of not only providing adequate PPE, but also fostering a culture of safety, supervision, and psychological support within training environments. While our study did not directly measure training effectiveness, these findings highlight potential gaps between knowledge and practice that warrant further investigation.

Despite existing formal training, as evidenced by participants completing our university's mandatory safety education, which includes:

- Transition to Clinic-Orientation Day (2021 curriculum): Dedicated modules on occupational risks, infection control, and stress management.
- Emergency Department-specific pre-rotation orientations: Covering BBF exposure risks, sharps injury prevention, and PPE protocols.

Our data reveals persistent gaps between knowledge and practice. Specifically, we observed: 56.2% exposure prevalence (higher than global averages); 66.7% exposures in ER (peak risk department); 67.5% recurrent exposures (≥2 incidents); and critically, gown usage at only 16.7% during exposures.

Roberts (2023) emphasizes that sharps injuries persist despite safety training, particularly among early-stage trainees and with non-engineered devices.[25] This aligns with Abere et al.'s (2020) report of 64% exposure prevalence among trained healthcare workers.[26] Further supporting this theory-practice gap, Datar et al. (2022) identified significant discrepancies between knowledge and practice in needlestick injury prevention among medical students mirroring our findings of recurrent exposures (67.5%) and low gown usage (16.7%) despite institutional training.[27]

This theory-practice disconnect suggests that current training may not fully address key areas critical for practical readiness and sustained safety behaviors, including: Real-world stress dynamics: Performance anxiety (IRR=1.85) and hierarchical pressure (IRR=1.61) persist despite didactic coverage, indicating a need for training that simulates and helps manage these psychological stressors in high-stakes environments.

Procedural fluency and mastery: 50% of exposures occurred during venipuncture a basic skill taught early suggesting that initial skill acquisition may not translate into robust, error-proof execution under pressure.

Behavioral sustainability and compliance: Recurrent exposures and consistently low PPE compliance (e.g., gown usage) indicate a failure in the long-term retention and consistent application of safety protocols.

To proactively address these potential gaps and enhance practical preparedness, we propose the following targeted interventions, which warrant further exploration and integration into medical curricula: Immersive ER simulations: Implementing Virtual Reality (VR) scenarios that realistically replicate chaotic trauma bays with bleeding patients could provide a safe environment for students to practice high-risk procedures under simulated pressure, thereby improving performance anxiety and procedural fluency. These interventions require further evaluation in future studies.

"Stress-tested" PPE drills: Conducting unannounced mock exposures or rapid-response PPE drills during clinical shifts could enhance muscle memory and ensure consistent, correct PPE usage under realistic conditions, addressing behavioral sustainability.

Anxiety-inoculation through integrated CBT techniques: Embedding cognitive-behavioral therapy (CBT) techniques from existing stress management modules directly into high-risk procedure training could help students recognize and manage their anxiety in real-time, preventing the stress-injury cycle.

Table 3 shows that 50.2% of final-year medical students in our study screened positive for anxiety, with 7.9% meeting the criteria for severe symptoms. This prevalence substantially exceeds the global average of 33.8% for medical students, as Quek et al. reported in a recent meta-analysis, and is also markedly higher than general population estimates, which range from 3% to 25%.[28,29] Moreover, we observed a statistically significant difference in GAD-7 scores between participants with and without exposure to blood or body fluids: the exposed group reported a mean score of 7.21 (5.38), significantly higher than the unexposed group (5.39 (5.15); p=0.016) (*Table 4*). Although the difference in anxiety severity categories (normal, mild, moderate, severe) did not reach statistical significance (p=0.33), 75% of those with severe anxiety had experienced exposure (*Table 5*), suggesting a vulnerable subgroup.

Although the non-significant chi-square test for categorical anxiety severity and the significant findings from the t-test and regression model may seem contradictory, this reflects the different nature of categorical and continuous variables. Categorizing continuous data into ordinal groups results in loss of information and reduced statistical efficiency[30]. The continuous GAD-7 scores therefore provide a more sensitive assessment of the exposure-anxiety relationship.

This finding aligns with prior research: Gaspar et al. demonstrated that workplace injuries can exacerbate anxiety, forming a "stress-injury" feedback loop.[11] Similarly, Granger and Turner's meta-analysis supports a bidirectional relationship between occupational trauma and anxiety disorders in healthcare workers.[12] These findings highlight the potential need for integrated occupational and psychological safety protocols in medical education, though further multi-center studies are needed to confirm generalizability.

In our study psychological factors, particularly hierarchical pressure (IRR=1.61) and performance anxiety (IRR=1.85), exerted stronger effects on anxiety than physical exposure (IRR=1.34). This suggests that the culture of medical training may pose greater mental health risks than occupational hazards themselves.The 92% increase in anxiety among interns who identified 'anxiety level' as an exposure contributor (IRR=1.92) is consistent with the conceptual framework of the stress-injury cycle proposed by Gaspar et al. (2020), though our cross-sectional design cannot establish causality.[11]

The findings of this study underscore the urgent need to enhance occupational safety education and psychological support within undergraduate medical curricula. The high rate of exposure, particularly during early internship months and in high-intensity departments like emergency medicine, signals a critical gap in procedural preparedness and supervision. Incorporating structured simulation-based training, task-specific risk briefings, and progressive skill acquisition modules may help reduce preventable exposures. Additionally, institutional policies should foster a non-punitive culture of reporting and ensure full compliance with PPE protocols. From a mental health perspective, the association between exposure and elevated anxiety highlights the necessity of integrating routine psychological screening and peer support systems into internship programs. Aligning with the principles outlined in the EU Directive 2010/32, interventions should be proactive, comprehensive, and culturally tailored to mitigate both physical and emotional harm.[31] Ultimately, fostering a culture of safety from the earliest stages of clinical training may yield long-term benefits for both patient care and workforce well-being.

Limitations

This study has several limitations that we acknowledge. First, the cross-sectional design fundamentally limits the strength of causal inferences between blood/body fluid exposures and anxiety levels, preventing conclusions about direct causation or directionality of effect. This inherent limitation may also contribute to the observed modest effect sizes and the lack of statistical significance in certain key associations, such as anxiety severity categories, as highlighted by our findings.

Second, reliance on self-reported data introduces potential recall bias (particularly for exposure incidents occurring early in internship) and social desirability bias in PPE compliance reporting. This self-reported nature, coupled with the absence of objective exposure verification and a lack of triangulation methods (e.g., direct observation, institutional records), limits data robustness and the ability to fully ascertain the true incidence and impact of exposures.

Third, the single-center nature of this study at a medical school constrains generalizability to other cultural or healthcare contexts.

Fourth, the 25.1% non-response rate may affect representativeness, as students with high anxiety might have been less likely to participate.

Fifth, while the GAD-7, although validated for screening, it cannot establish clinical diagnoses of anxiety disorders. Finally, related to the second point, the absence of objective exposure verification could lead to underreporting or inaccurate reporting of exposure frequency and severity.

Sixth, additionally, we did not assess other psychological factors such as depression, burnout, coping styles, or prior psychiatric history, nor did we measure potential confounders such as workload intensity, sleep patterns, caffeine use, or prior occupational safety training, all of which may influence both anxiety levels and exposure risk. Therefore, the stress-injury cycle framework, while conceptually relevant, remains hypothetical in the context of our study and requires further investigation with longitudinal designs. Despite these limitations, our findings align with global evidence on occupational risks in medical training and provide actionable insights for educational reform.

Therefore, our prevalence estimates should be interpreted with caution, and the findings regarding exposure frequency and timing may be subject to recall error.

Conclusion

This study found that over half of final-year medical students (56.2%) reported exposure to blood or body fluids during clinical training, with multiple incidents reported by 67.5%. Venous blood draws, emergency department rotations, and early internship months emerged as key risk contexts. Despite comprehensive safety training (including 2021 curriculum modules and ER-specific orientations), incomplete PPE adherence (gown use: 16.7%) and contributing factors like hierarchical pressure (21.9%) persisted. We found that exposure was significantly associated with elevated anxiety scores (mean GAD-7: 7.21 vs. 5.39, p=0.016), indicating a dual physical-mental health burden. These findings suggest a need to further examine and potentially adapt existing training approaches to better integrate stress-adapted simulations, real-time compliance feedback, and psychological safety practices. These findings generate hypotheses about potential curricular improvements and suggest the need for further research with objective measures of training effectiveness.

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