Journal of Multidisciplinary Healthcare

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Proton Pump Inhibitor Safety Knowledge and Stress Ulcer Prophylaxis Appropriateness Among Resident Physicians: A Cross-Sectional Study

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Purpose/Introduction: Proton pump inhibitors (PPIs) are commonly prescribed for stress ulcer prophylaxis (SUP) in non-critically ill hospitalized patients despite limited evidence supporting routine use. This leads to unnecessary medication exposure and possible adverse effects. This study evaluated medical residents' knowledge of PPI-related adverse effects and the appropriateness of SUP indications, and examined differences across specialties and the relationship between safety knowledge and prescribing decisions.

Methods: We carried out a cross-sectional electronic survey of medical residents enrolled in Saudi Commission for Health Specialties (SCFHS) accredited programs. The questionnaire was sent by the SCFHS, which had nine Likert-scale items assessing PPI risk knowledge and SUP appropriateness. A response rate could not be calculated because the total number of survey recipients was not available. Composite scores were calculated for knowledge, appropriateness, and overall competency. Group comparisons and correlations were analyzed using standard parametric methods.

Results: A total of 119 residents completed the survey. The mean PPI risk knowledge score was 3.31 ± 0.65, with 47.1% achieving competency. The mean SUP appropriateness score was 2.85 ± 0.39, and only 5.9% met the competency threshold. Correct identification of inappropriate SUP use was particularly low for high-dose corticosteroids alone (5.0%), dual antiplatelet therapy alone (10.9%), and mechanical ventilation for less than 24 hours (19.3%). Internal medicine residents demonstrated higher knowledge and overall competency scores than other specialties, while appropriateness scores did not differ by specialty. No significant correlation was observed between knowledge and appropriateness ($r = 0.10$, $p = 0.262$).

Conclusion: Residents demonstrated moderate awareness of PPI-related risks but limited recognition of appropriate SUP indications in non-critically ill patients. These findings suggest that medication safety knowledge alone may not correspond to guideline-concordant prescribing decisions and highlight opportunities to strengthen targeted educational efforts.

Keywords: proton pump inhibitors, stress ulcer prophylaxis, resident physicians, survey, cross-sectional study, prescribing appropriateness

Introduction

Proton pump inhibitors (PPIs) are among the most frequently prescribed medications in hospital and ambulatory settings due to their efficacy and favorable short-term safety profile. However, increasing observational evidence has raised concerns about potential adverse effects associated with prolonged or unnecessary PPI exposure, including infectious, skeletal, renal, and nutritional complications.[1–3] These safety signals, along with a high volume of PPI prescriptions, have led to increased evaluation of prescribing practices and deprescribing strategies across healthcare systems.

One notable driver of PPI use in hospitals is SUP. While SUP is recommended for select critically ill patients at high risk for stress-related mucosal bleeding, evidence for routine use in non-critically ill inpatients is limited.[4,5] Despite this, SUP is often used without a guideline-supported reason.[5–7] Studies have shown high rates of inappropriate SUP use in non-intensive care unit (ICU) patients, a modifiable source of PPI overuse.[5–8] This was also noted in studies conducted in

https://doi.org/10.2147/JMDH.S601718
Received: 6 February 2026
Accepted: 22 April 2026
Published: 7 May 2026

Saudi Arabia.[1,7,9–11] This inappropriate use may lead to unnecessary adverse effects, higher healthcare costs, and the continuation of therapy beyond hospitalization.

Trainee physicians play a central role in inpatient medication decisions, including initiation and continuation of PPIs. Their knowledge, specialty training, and familiarity with SUP indications therefore influence prescribing decisions during hospitalization. Prior studies from several regions have shown variable awareness of PPI-related risks and inconsistent familiarity with SUP guidelines among physicians and trainees.[1–3,12]

However, much of the available evidence originates from North America, Europe, or Asia, and relatively few investigations have examined trainee understanding of both PPI safety and SUP appropriateness within Gulf training environments.[4–6] International research has also reported substantial use of SUP or acid-suppressive therapy without clear guideline-supported indications in non-critically ill hospitalized patients.[2,5,6] Prior literature has often evaluated prescribing behaviors, safety awareness, or guideline familiarity independently. Less is known about how these domains relate within trainee prescribing decisions. Exploring this relationship may provide useful insight for educational and stewardship initiatives.

Given these observations, further characterization of trainee knowledge and SUP decision-making may help inform educational needs, guideline dissemination, and stewardship priorities within residency programs. Therefore, the objective of this study was to evaluate medical residents' knowledge of SUP and PPI-related risks in non-critically ill patients in Saudi Arabia. Specific objectives were to: (1) assess residents' awareness of PPI-associated adverse effects; (2) evaluate knowledge of evidence-based indications and non-indications for SUP; (3) compare knowledge and appropriateness scores across medical specialties and genders; and (4) examine the relationship between PPI risk knowledge and SUP appropriateness. Identifying these knowledge gaps may help inform targeted educational strategies and institutional policies to promote rational, evidence-based prescribing practices.

Methods

Study Design, Setting, and Participants

This was a descriptive, cross-sectional study conducted among medical residents in Saudi Arabia. The study aimed to assess residents' knowledge and perceptions regarding SUP in non-critically ill patients and their awareness of PPI-related risks. The study survey was distributed from May 2021 to July 2021. Eligible participants were residents enrolled in Saudi Commission for Health Specialties (SCFHS)-accredited training programs across multiple specialties, including internal medicine, emergency medicine, family medicine, and other specialties. The "Other" category comprised residents from Neurology, Surgery, Obstetrics and Gynecology, Pediatrics, Dermatology, and Radiology. Data were collected through an electronic survey distributed via Email by SCFHS. Participation was voluntary, and all responses were collected anonymously.

Survey Development and Content Validity

The questionnaire was developed based on previously published studies and institutional guidelines on the use of SUP and PPI therapy in non-critically ill patients.[4,5,13] The survey consisted of two sections: the first section collected demographic information, including age, gender, nationality, and specialty, and the second section comprised nine statements evaluating two distinct knowledge domains: (1) awareness of four established PPI-associated adverse effects (respiratory infections, Clostridioides difficile infections, osteoporosis, and drug-drug interactions), and (2) knowledge of appropriate indications for SUP in five clinical scenarios (coagulopathy, burns ≥35% body surface area, mechanical ventilation <24 hours, dual antiplatelet therapy alone, and high-dose corticosteroids alone).

Each statement was rated on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). To enhance measurement validity and minimize acquiescence bias, four items were deliberately worded as negative statements to assess common clinical misconceptions. Specifically, the item assessing drug-drug interaction awareness was phrased as "PPIs have no drug-drug interactions" (negatively worded), and three appropriateness items were phrased to identify non-indications: "Mechanical ventilation for less than 24 hours should receive SUP," "Patients on dual antiplatelet therapy alone should receive SUP," and "Patients receiving high doses of corticosteroids alone should receive SUP." This approach required participants to disagree with incorrect statements or

agree with correct negative statements, thereby reducing the tendency to automatically agree with all items and improving the discriminatory power of the instrument. During statistical analysis, these four negatively worded items were reverse-coded using the standard formula for 5-point Likert scales: reverse-coded score = (6 - original score), ensuring that higher scores consistently represented correct knowledge across all items and enabling meaningful composite score calculation.

Two consultant clinical pharmacists, one critical care pharmacist, and one internal medicine consultant reviewed the content to assess its validity. Reviewers assessed the relevance, clarity, and accuracy of each item based on current clinical practice guidelines. Minor wording modifications were made based on expert feedback to improve clarity and reduce ambiguity.

Survey Distribution and Data Collection

The survey was created in electronic format using SurveyMonkey Inc. (San Mateo, California, USA) as the survey platform. SCFHS distributed the survey link to eligible residents via their institutional Email addresses. The survey was distributed via the SCFHS to residents enrolled in accredited training programs. The total number of residents who received the survey invitation was not available; therefore, a response rate could not be calculated. The final sample represents a voluntary, self-selected group of respondents. Participants received a brief introductory message explaining the study purpose, estimated completion time, voluntary nature of participation, and assurance of anonymity. No identifying information was collected, and responses were automatically recorded in the SurveyMonkey database. Reminder emails were sent after the initial distribution to maximize response rates.

Data Management and Quality Control

Survey responses were exported from SurveyMonkey to Microsoft Excel for initial organization and cleaning. The data were then transferred to Stata version 19.0 (StataCorp LLC, College Station, TX, USA) for statistical analysis. During data cleaning, we excluded participants who did not complete all nine knowledge items. We also removed responses from residents who reported clinical experience outside the 1–4 year range to ensure the sample reflected the intended trainee cohort. After these exclusions, 119 complete and valid responses remained for analysis.

Operational Definitions and Scoring

Survey responses were originally coded on a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree). To ensure consistent interpretation across all items and enable meaningful composite score calculation, the four negatively-worded items (drug-drug interactions, mechanical ventilation <24 hours, dual antiplatelet therapy, and high-dose corticosteroids) underwent reverse coding. For 5-point Likert scales, reverse coding is performed using the formula: reverse-coded score = (number of scale points + 1) - original score, which in this case equals (6 - original score).

This transformation systematically inverted the response values so that higher scores consistently indicated better knowledge or more appropriate beliefs across all nine items, with scores of 4–5 representing correct responses and scores of 1–2 representing incorrect responses.

Three composite scores were calculated as the arithmetic mean of constituent items, ranging from 1 to 5. The knowledge score assessed residents' awareness and understanding of four established adverse effects associated with proton pump inhibitor therapy: respiratory infections (including community-acquired and hospital-acquired pneumonia), Clostridioides difficile infections, osteoporosis and bone fractures, and clinically significant drug-drug interactions. This score reflects factual knowledge of PPI-related harms documented in the medical literature and emphasized in patient safety initiatives.

The appropriateness score assessed residents' knowledge of evidence-based indications for SUP, specifically their ability to correctly identify clinical scenarios that do and do not warrant prophylactic acid suppression therapy according to current guidelines.

This domain included five clinical scenarios: coagulopathy and burns involving ≥35% of body surface area (both appropriate indications for SUP); and mechanical ventilation for less than 24 hours, dual antiplatelet therapy alone, and

high-dose corticosteroids alone (all not routine indications according to current guidelines, including the 2025 ACC/AHA ACS guideline). Higher scores reflected better alignment with evidence-based SUP prescribing.

The 2025 ACC/AHA ACS guideline for acute coronary syndromes recommends PPI therapy for patients on antithrombotic therapy who have high gastrointestinal bleeding risk (Class 1 recommendation).[14] However, current SUP guidelines for hospitalized non-critically ill patients do not consider dual antiplatelet therapy alone, in the absence of additional gastrointestinal bleeding risk factors, to be an indication for routine SUP. Similarly, high-dose corticosteroids alone do not constitute an indication for SUP without additional bleeding risk factors. Some institutional protocols and earlier practices, however, have classified these as routine indications requiring prophylactic therapy in the inpatient setting, creating clinical uncertainty. Higher scores on the appropriateness domain reflected better alignment with evidence-based SUP prescribing guidelines for hospitalized non-critically ill patients.

The overall competency score was calculated as the mean of all nine items (four knowledge items plus five appropriateness items), providing a comprehensive assessment of residents' understanding of both PPI risks and appropriate SUP use. This composite measure integrates factual knowledge with clinical application, reflecting overall competence in rational PPI/SUP prescribing.

For binary performance classification, responses of "Agree" or "Strongly Agree" (scores ≥4 after reverse coding where applicable) to correctly-oriented items were classified as demonstrating correct knowledge. A composite score ≥3.5 was defined as achieving competency, representing an average response of "Agree" or better across items, which indicates consistent demonstration of the knowledge or judgment being assessed. This threshold was selected based on standard educational assessment practices where agreement with correct statements indicates mastery of content.

Statistical Analysis

Continuous variables were assessed for normality using visual inspection (histograms with normal curve overlays) and the Shapiro–Wilk test. Normally distributed data were presented as mean ± standard deviation, while non-normally distributed data were presented as median with interquartile range. Categorical variables were presented as frequencies and percentages. For composite scores, we reported mean ± standard deviation, median, interquartile range, range, and the proportion achieving competency (score ≥3.5). For individual items, we reported mean Likert scores ± standard deviation and the percentage of residents responding correctly.

Between-group comparisons utilized one-way analysis of variance (ANOVA) to compare composite scores across specialty groups (internal medicine, emergency medicine, family medicine, and other specialties), with F-statistics and corresponding p-values reported. Independent samples *t*-tests compared scores between genders (male vs. female), with Levene's test used to assess equality of variances. The t-statistic, degrees of freedom, and p-values are reported for all comparisons.

Pearson correlation coefficients were calculated to assess linear relationships between knowledge and Appropriateness composite scores. Correlation strength was interpreted as weak ($|r| < 0.3$), moderate ($|r| = 0.3–0.7$), or strong ($|r| > 0.7$), with statistical significance assessed at $p < 0.05$. Results were illustrated using horizontal bar charts, a histogram with normal curve overlay, a forest plot with 95% confidence intervals, and a scatter plot with linear regression line.

Sensitivity Analysis

Given the evolving nature of guidelines regarding SUP indications, we conducted a pre-specified sensitivity analysis for two potentially controversial items: dual antiplatelet therapy (DAPT) and high-dose corticosteroids. While current American College of Cardiology/American Heart Association (ACC/AHA) guideline list the first item as Class 1 recommendation (in patients with high risk of gastrointestinal bleeding), and additional risk factors such as concurrent anticoagulation, prior gastrointestinal bleeding, or critical illness is required for the other item, some institutional protocols and earlier guidelines classified them as routine indications requiring prophylactic therapy.

In the primary analysis, we scored responses indicating that DAPT or corticosteroids alone require SUP as incorrect, consistent with current evidence-based guidelines that do not support routine prophylaxis for these indications in the absence of additional risk factors. In the sensitivity analysis, we treated beliefs that DAPT or corticosteroids require SUP as acceptable responses, acknowledging clinical uncertainty and variability in institutional practices. Specifically, the

reverse coding transformation initially applied to these items (6 - original score) was reversed back to the original scoring direction for the sensitivity analysis, treating disagreement with "should NOT receive SUP" as correct rather than incorrect. Appropriateness scores were recalculated under both scoring approaches, and paired *t*-tests were used to compare primary versus sensitivity analysis scores. We also compared the proportion of residents achieving competency (score ≥3.5) under each scoring method. This sensitivity analysis assessed whether our findings of inadequate appropriateness knowledge were robust to different interpretations of these controversial indications, or were artifacts of strict adherence to current guideline definitions.

All 119 participants completed all survey items; therefore, no imputation for missing data was necessary. No formal sample size calculation was performed for this descriptive, cross-sectional study. A post-hoc power analysis indicated that with n = 119, the study had approximately 20.2% power to detect the observed correlation of r = 0.10 between knowledge and appropriateness scores at $\alpha = 0.05$. The sample size of 119 residents represents a convenience sample of available medical residents at participating institutions during the study period, providing sufficient precision for estimating proportions and detecting moderate to large effect sizes in comparative analyses. A two-tailed p-value of <0.05 was considered statistically significant for all tests. All statistical analyses were performed using Stata version 19.0 (StataCorp LLC, College Station, TX, USA).

Ethical Considerations

This study was approved by the Regional Research Ethics Committee of the Ministry of Health, Saudi Arabia (Registration No. H-04-Q-001), date 19 May 2021. This study was conducted in accordance with the principles of the Declaration of Helsinki. Participation was voluntary, and completion of the survey implied informed consent. No identifying information was collected, ensuring participant anonymity. All data were stored securely and accessed only by the research team.

Results

Participant Characteristics

A total of 119 medical residents participated in the study. The mean age of participants was 27.1 ± 2.2 years (range: 24–38 years). Most participants were male (n=70, 58.8%), and the majority held Saudi nationality (n=115, 96.6%). Regarding specialty, 49 residents (41.2%) were in internal medicine, 18 (15.1%) in emergency medicine, 17 (14.3%) in family medicine, and 35 (29.4%) in other specialties (Table 1).

Table 1 Demographic Characteristics of Surveyed Medical Residents (n = 119)

Variable	N (%) or Mean ± SD
Age (years)	27.1 ± 2.2 (24–38)
Gender – Male	70 (58.8%)
Gender – Female	49 (41.2%)
Saudi nationality – Yes	115 (96.6%)
Saudi nationality – No	4 (3.4%)
Specialty:	
Internal Medicine	49 (41.2%)
Emergency Medicine	18 (15.1%)
Family Medicine	17 (14.3%)
Other	35 (29.4%)

Notes: Values are presented as number (percentage) unless otherwise indicated. Age is presented as mean ± standard deviation (range).

Table 2 Descriptive Statistics of Composite Scores (n = 119)

Score	Mean ± SD	Median	IQR	Range	n (%) ≥3.5
Knowledge Score	3.31 ± 0.65	3.25	2.75–3.75	1.75–5.00	56 (47.1%)
Appropriateness Score	2.85 ± 0.39	2.80	2.60–3.00	1.80–3.80	7 (5.9%)
Overall Competency	3.05 ± 0.38	3.11	2.78–3.33	2.11–4.00	15 (12.6%)

Notes: Scores range from 1–5, with higher scores indicating better knowledge/appropriateness. IQR = Interquartile range. ≥3.5 indicates good performance (mean response of "Agree" or better).

Overall Performance on Composite Scores

The mean knowledge score, assessing awareness of PPI-related adverse effects, was 3.31 ± 0.65 (median = 3.25, IQR = 2.75–3.75, range = 1.75–5.00). Fifty-six residents (47.1%) achieved the competency threshold (score ≥3.5) for this domain. The mean appropriateness score, evaluating knowledge of evidence-based SUP indications, was lower at 2.85 ± 0.39 (median = 2.80, IQR = 2.60–3.00, range = 1.80–3.80). Only seven residents (5.9%) achieved competency in this domain. The overall competency score, integrating both knowledge and appropriateness domains, was 3.05 ± 0.38 (median = 3.11, IQR = 2.78–3.33, range = 2.11–4.00), with 15 residents (12.6%) meeting the competency threshold (Table 2). The distribution of overall competency scores approximated a normal distribution with slight negative skewness (Figure 1).

Item-Level Analysis of PPI Risk Knowledge and SUP Appropriateness

Among the four PPI risk knowledge items, osteoporosis risk received the highest mean score (3.54 ± 1.05), with 54.6% of residents responding correctly. Drug-drug interaction awareness yielded a mean score of 3.36 ± 1.11 (51.3% correct). Clostridioides difficile infection risk had a mean score of 3.39 ± 1.14 (47.1% correct). Respiratory infection risk received the lowest mean score (2.94 ± 1.08), with only 32.8% of residents demonstrating correct knowledge (Table 3 and Figure 2).

Performance on SUP appropriateness items revealed variability. Burns ≥35% body surface area as an indication for SUP received the highest mean score (4.18 ± 0.82), with 79.8% correct responses. Coagulopathy as an indication yielded

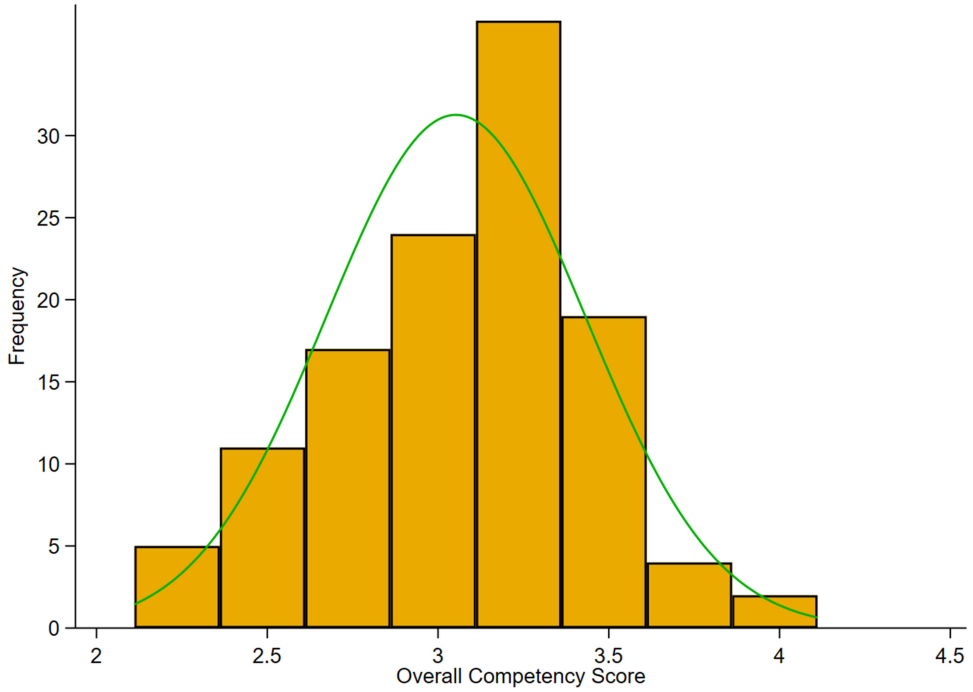

Figure 1 Distribution of Overall Competency Scores (n = 119).
Notes: Overall Competency Score (1–5, higher=better). Mean = 3.05 ± 0.38; Median = 3.11; Range = 2.11–4.00.

Table 3 Item-Level Analysis: Knowledge and Appropriateness (n = 119)

Item	Mean ± SD	% Correct	Interpretation	Category
PPI → Respiratory infection risk	2.94 ± 1.08	32.8%	Knowledge gap	Knowledge
PPI → C. difficile infection risk	3.39 ± 1.14	47.1%	Knowledge gap	Knowledge
PPI → Osteoporosis risk	3.54 ± 1.05	54.6%	Moderate awareness	Knowledge
PPIs have drug-drug interactions	3.36 ± 1.11	51.3%	Moderate awareness	Knowledge
Coagulopathy → SUP indicated	3.34 ± 0.90	40.3%	Knowledge gap	Appropriateness
Burns ≥35% BSA → SUP indicated	4.18 ± 0.82	79.8%	Strength	Appropriateness
MV <24h → SUP NOT indicated	2.53 ± 1.09	19.3%	Critical misconception	Appropriateness
DAPT alone → SUP NOT indicated	2.13 ± 1.01	10.9%	Critical misconception	Appropriateness
High-dose steroids → SUP NOT indicated	2.08 ± 0.89	5.0%	Critical misconception	Appropriateness

Notes: % Correct based on Agree/Strongly Agree responses. Higher mean scores indicate stronger agreement. For items with "NOT indicated", low mean scores suggest residents incorrectly believe SUP is indicated.

a mean score of 3.34 ± 0.90 (40.3% correct). Three items assessing knowledge that certain conditions do not routinely require SUP showed critically low performance. For mechanical ventilation <24 hours, the mean score was 2.53 ± 1.09 (19.3% correct). Dual antiplatelet therapy alone received a mean score of 2.13 ± 1.01 (10.9% correct). High-dose corticosteroids alone demonstrated the lowest performance, with a mean score of 2.08 ± 0.89 and only 5.0% correct responses (Table 3 and Figure 3). The majority of residents incorrectly answered questions about conditions that do not require SUP. Figure 4 presents the percentage of residents achieving correct knowledge for each item, with a reference line at the 50% threshold demonstrating that six of nine items (66.7%) fell below this benchmark.

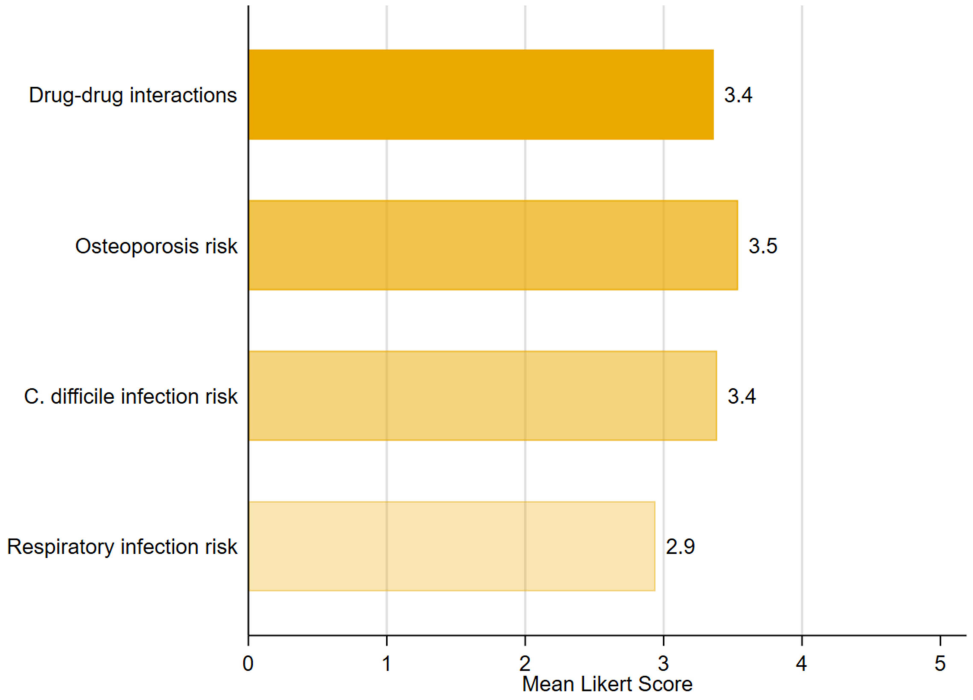

Figure 2 Mean Likert Scores for PPI-Related Risks (n = 119).
Notes: Each item was rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Higher mean scores indicate stronger agreement with statements regarding the potential risks of proton pump inhibitor (PPI) therapy. Values above each bar represent mean scores.

https://doi.org/10.2147/JMDH.S601718

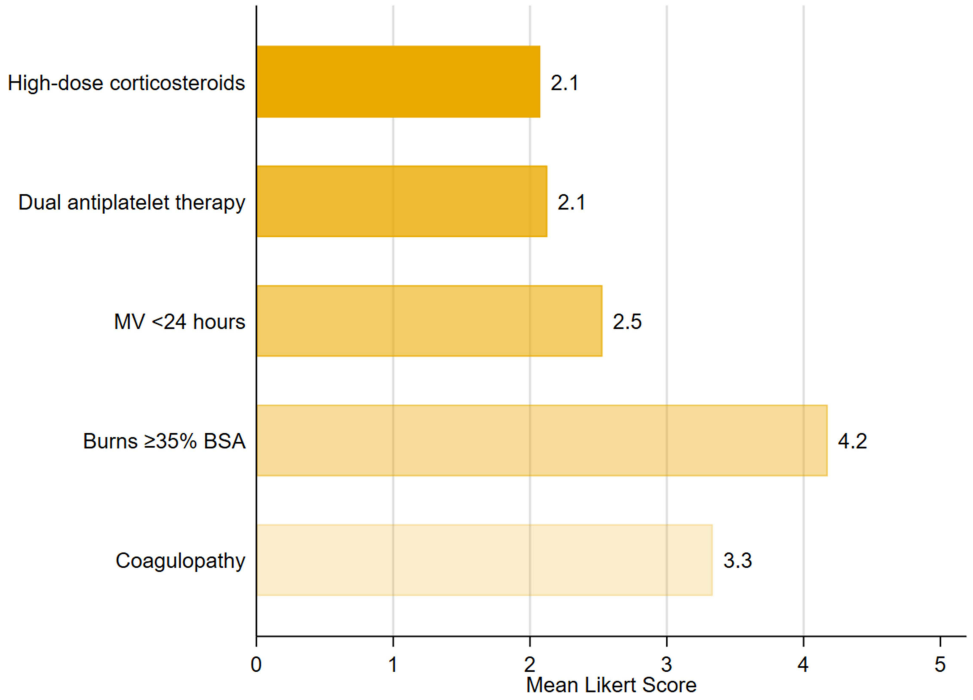

Figure 3 Mean Likert Scores for SUP Appropriateness (n = 119).
Notes: Responses were recorded on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Higher mean scores reflect stronger agreement with statements about stress ulcer prophylaxis (SUP) appropriateness. Note: MV <24h, dual antiplatelet therapy, and steroids questions were worded as "should NOT receive SUP". Numeric labels denote the mean score for each item.
Abbreviations: BSA, body surface area; MV, mechanical ventilation.

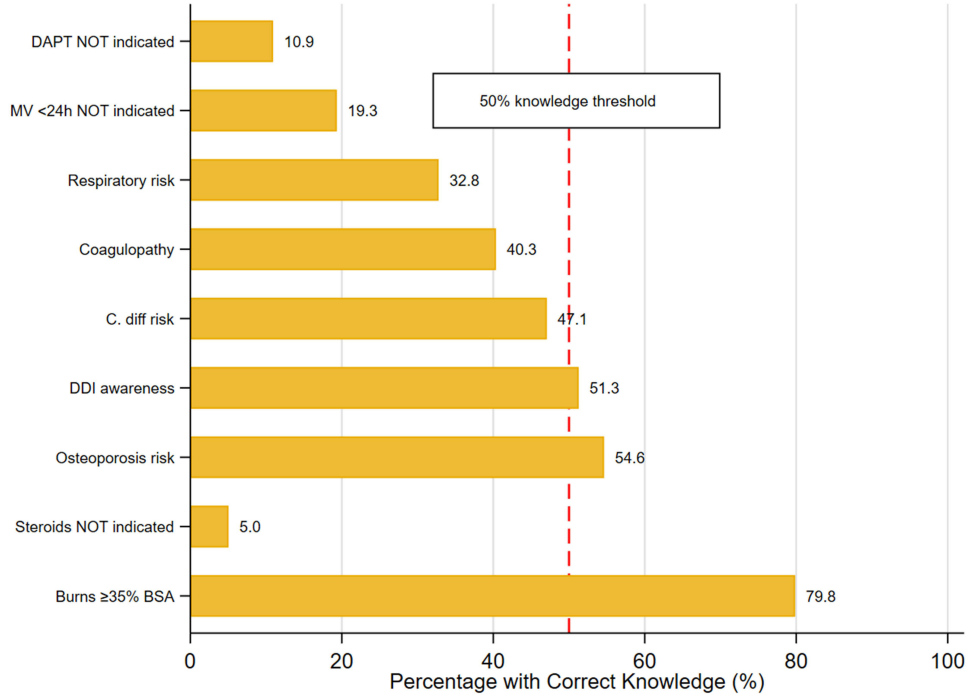

Figure 4 Percentage of Residents with Correct Knowledge by Item (n = 119).
Notes: Items below the 50% threshold were considered to represent major knowledge gaps.
Abbreviations: BSA, body surface area; C. diff, Clostridioides difficile; DAPT, dual antiplatelet therapy; DDI, drug-drug interaction; MV, mechanical ventilation.

https://doi.org/10.2147/JMDH.S601718

Table 4 Comparison of Scores by Specialty (n = 119)

Specialty	n	Knowledge Score	Appropriateness Score	Overall Competency
Internal Medicine	49	3.62 ± 0.59	2.86 ± 0.43	3.20 ± 0.36
Emergency Medicine	18	2.92 ± 0.56	2.90 ± 0.36	2.91 ± 0.38
Family Medicine	17	3.18 ± 0.68	2.88 ± 0.39	3.01 ± 0.31
Other	35	3.14 ± 0.58	2.79 ± 0.36	2.95 ± 0.38

Notes: Values presented as Mean ± SD. ANOVA results: Knowledge Score F=8.18, p<0.001; Appropriateness Score F=0.37, p=0.775; Overall Competency F=4.53, p=0.005. Scores range from 1–5, with higher scores indicating better performance.

Comparison of Scores Across Specialty Groups

One-way analysis of variance revealed significant differences in knowledge scores across specialty groups ($F = 8.18$, $p < 0.001$). Internal medicine residents demonstrated the highest mean knowledge score (3.62 ± 0.59), followed by family medicine (3.18 ± 0.68), other specialties (3.14 ± 0.58), and emergency medicine (2.92 ± 0.56). In contrast, appropriateness scores did not differ significantly across specialties ($F = 0.37$, $p = 0.775$), with means ranging from 2.79 ± 0.36 (other specialties) to 2.90 ± 0.36 (emergency medicine). Overall competency scores demonstrated significant specialty differences ($F = 4.53$, $p = 0.005$), with internal medicine residents achieving the highest score (3.20 ± 0.36) and emergency medicine residents the lowest (2.91 ± 0.38) (Table 4 and Figure 5).

Correlation Between Knowledge and Appropriateness Domains

Pearson correlation analysis revealed a weak positive correlation between knowledge and appropriateness scores ($r = 0.10$, $p = 0.262$), which did not reach statistical significance (Table S1 and Figure 6). The scatter plot demonstrated substantial dispersion of data points with minimal adherence to the regression line, indicating that knowledge of PPI risks did not predict knowledge of appropriate SUP indications.

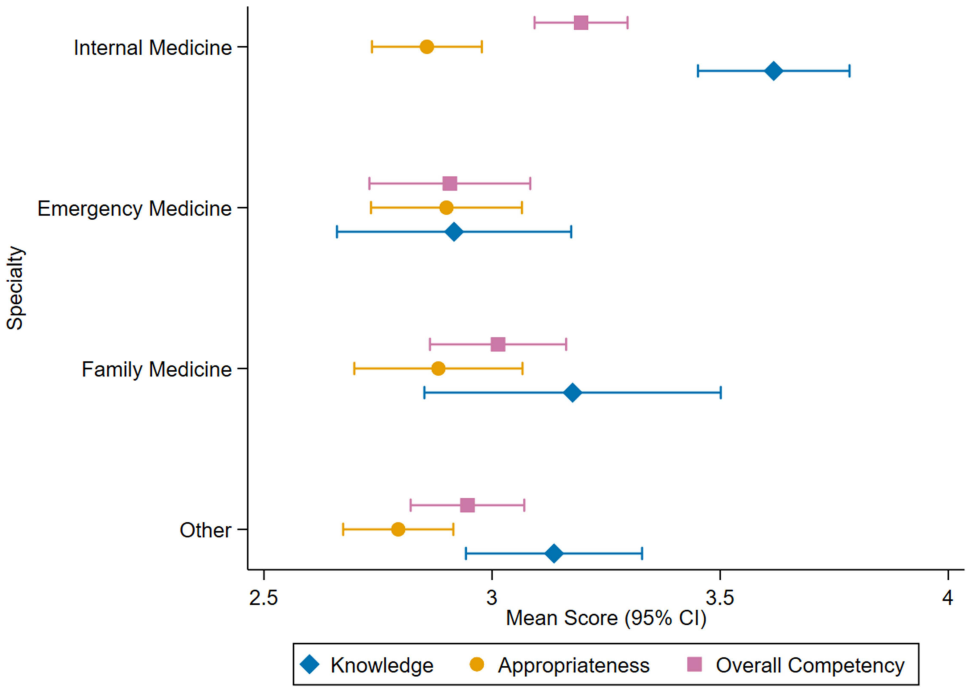

Figure 5 Comparison of Scores by Specialty with 95% Confidence Intervals.
Notes: Error bars represent 95% confidence intervals. Internal Medicine shows significantly higher knowledge and overall competency scores compared to other specialties (p<0.01).
Abbreviation: CI, confidence interval.

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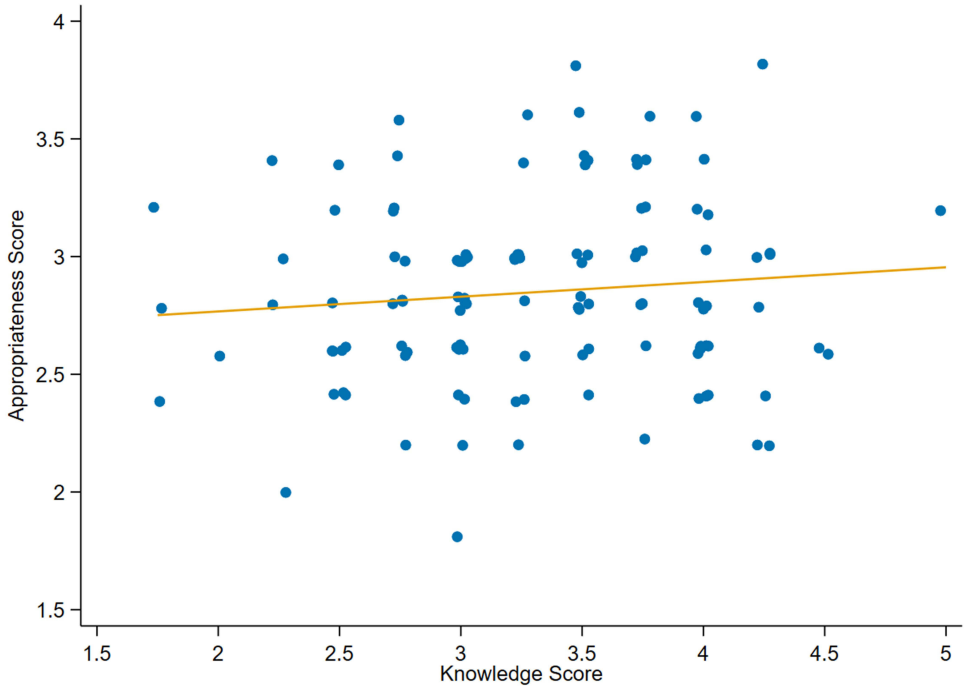

Figure 6 Correlation Between Knowledge and Appropriateness Scores (n = 119). Legends: Appropriateness Score (1–5, higher=better). Knowledge Score (1–5, higher=better). Pearson r = 0.104, p = 0.262. Weak positive correlation (not statistically significant).

Item-level correlation analysis identified several significant relationships (Table S1). Within the knowledge domain, positive correlations were observed between respiratory infection risk and C. difficile risk ($r = 0.36$, $p < 0.05$), respiratory infection risk and osteoporosis risk ($r = 0.23$, $p < 0.05$), and C. difficile risk and osteoporosis risk ($r = 0.45$, $p < 0.05$).

Cross-domain correlations revealed that C. difficile knowledge positively correlated with both burns appropriateness ($r = 0.22$, $p < 0.05$) and mechanical ventilation <24h appropriateness ($r = 0.21$, $p < 0.05$). Within the appropriateness domain, coagulopathy and burns showed positive correlation ($r = 0.22$, $p < 0.05$), while a strong positive correlation was observed between DAPT and corticosteroid items ($r = 0.48$, $p < 0.05$).

Negative correlations were observed between burns knowledge and mechanical ventilation <24h ($r = -0.25$, $p < 0.05$), DAPT ($r = -0.31$, $p < 0.05$), and corticosteroids ($r = -0.37$, $p < 0.05$), as well as between coagulopathy and DAPT ($r = -0.30$, $p < 0.05$). Negative correlations were observed between burns and coagulopathy items and DAPT, corticosteroid, and mechanical ventilation <24h items.

Gender Comparison

Independent samples *t*-tests revealed no statistically significant gender differences in any composite score. Male residents scored slightly higher on knowledge (3.38 ± 0.73 vs. 3.20 ± 0.51, $t = -1.45$, $p = 0.151$), appropriateness (2.88 ± 0.40 vs. 2.80 ± 0.38, $t = -1.04$, $p = 0.301$), and overall competency (3.10 ± 0.42 vs. 2.98 ± 0.31, $t = -1.71$, $p = 0.091$), but none of these differences reached statistical significance (Table S2).

Sensitivity Analysis

A sensitivity analysis was conducted to assess the robustness of findings regarding DAPT and high-dose corticosteroids as SUP indications. In the primary analysis, treating these as non-indications per current guidelines, 10.9% of residents correctly identified DAPT and 5.0% correctly identified corticosteroids as not requiring routine SUP. The mean Appropriateness Score was 2.85 ± 0.39, with 5.9% achieving competency.

In the sensitivity analysis, treating beliefs that DAPT and corticosteroids require SUP as acceptable given clinical uncertainty, 66.4% of residents held responses consistent with this permissive interpretation for both items. The mean

appropriateness Score increased significantly to 3.68 ± 0.58 (mean difference = 0.83 points, paired *t*-test: $t = -12.49$, $p < 0.001$), and 63.9% achieved the competency threshold. Appropriateness scores increased under the permissive definition.

Discussion

This study was conducted to address ongoing uncertainty regarding resident physicians' knowledge and appropriateness of PPI use, particularly in relation to SUP in non-critically ill patients. In a sample of residents from multiple specialties, mean knowledge scores indicated modest awareness of PPI-related risks, although 52.9% of residents did not meet the predefined competency threshold, while mean appropriateness scores for SUP scenarios were lower. Correlation analysis demonstrated a weak, non-significant association between knowledge and appropriateness scores.

The use of PPIs as SUP in hospitalized non-critically ill patients has been widely documented both locally and internationally.[5–8,10,11,15] Several factors may contribute to the continued use of PPIs as SUP in non-critically ill patients, including physician behaviors and prescribing attitudes. Prior studies have shown that many clinicians prescribe SUP as a precautionary or defensive measure, even in the absence of guideline-supported indications.[5] PPIs are also widely viewed as safe and convenient, which can lower the threshold for initiation and reduce motivation for deprescribing.[2,6] Institutional culture and habits have similarly been reported.8 Finally, unfamiliarity with SUP criteria and limited awareness of PPI-related adverse effects have been identified among physicians and trainees.[7,12]

One of the main findings of this study was that residents demonstrated a moderate level of knowledge regarding PPI-related risks. In this context, PPI-related risks refer to the potential adverse associations and safety concerns such as respiratory infections, Clostridioides difficile infection, osteoporosis or fracture risk and selected drug–drug interactions. These findings indicate that trainees are generally aware that PPIs are not entirely benign, even though they are widely perceived as safe and well-tolerated medications.

Similar observations have been reported in other regions. In Saudi Arabia, Asdaq et al found that clinicians were aware of several potential adverse effects associated with PPIs, although the depth of understanding varied across professional groups.[1] In India, Suryawanshi et al noted that residents recognized certain PPI-related complications but had limited familiarity with others, particularly drug interactions.[12] Studies from Syria and Latin America have described comparable patterns of partial awareness among physicians and trainees, indicating that knowledge in this area is improving but remains incomplete.[2,3] The implication of this finding is that basic awareness of PPI safety appears to be present among residents, but there may be gaps in more detailed or clinically relevant aspects of risk that could influence prescribing decisions. These gaps may be amenable to targeted educational efforts focused on adverse effects and interactions observed in routine practice, without assuming that lack of awareness alone is the primary driver of PPI overuse.

A second key finding of this study was that residents demonstrated low knowledge regarding appropriate indications for SUP in non-critically ill patients. This was reflected by a mean SUP appropriateness score of approximately 2.85, with only about 6% of residents meeting the predefined competency threshold. Item-level performance further highlighted gaps in decision-making, with only 5.0% of residents correctly identifying that high-dose corticosteroids alone do not warrant SUP and 10.9% recognizing that DAPT alone is insufficient to trigger SUP, underscoring the magnitude of these knowledge gaps. Similar patterns have been reported in previous work, where physicians frequently initiated SUP outside the ICU despite limited evidence of benefit and variable familiarity with guideline criteria.[5–8] These observations suggest that challenges in applying SUP criteria at the bedside are not unique to a single setting and may reflect gaps in guideline dissemination or training rather than intentional overuse.

A third notable finding was the presence of specialty-related differences in knowledge and overall competency, with internal medicine residents achieving higher scores compared to other groups. This pattern may partly reflect differences in clinical exposure, as internal medicine trainees are more likely to rotate through gastroenterology services. Furthermore, they manage patients with chronic gastrointestinal conditions, polypharmacy, and prolonged PPI use, which may increase familiarity with PPI safety. Similar specialty-related variation has been observed elsewhere. Koczka et al reported that internal medicine physicians demonstrated greater familiarity with SUP practices compared with surgical services in U.S. hospitals,[6] while Piñerúa-Gonsálvez et al found that gastroenterologists scored higher on knowledge and deprescribing familiarity than other specialties.[2] Although these differences are modest and should not be overinterpreted, they suggest that clinical context may play a role in shaping PPI-related knowledge.

A particularly important finding of this study was the absence of a statistically significant correlation between knowledge of PPI-related risks and appropriateness of SUP decisions. This finding demonstrates that knowledge of PPI safety risks and knowledge of SUP indications represent independent competencies that do not predict one another. Residents may have awareness of PPI-related adverse effects without understanding when SUP is clinically warranted, and vice versa. This independence has important implications for educational design, as it suggests that teaching trainees about PPI risks will not automatically improve their ability to make evidence-based SUP decisions at the bedside. Comparable observations have been made in prior work indicating that prescribing behaviors around SUP are influenced by factors other than safety knowledge alone, including clinical habits, perceived risk of gastrointestinal bleeding, and variable familiarity with guideline recommendations.[5,8,16] For example, Hussain et al noted that knowledge of SUP indications was more closely associated with appropriate prescribing behaviors than awareness of adverse effects,[5] and Xing et al reported that lack of guideline familiarity was a more prominent contributor to inappropriate SUP use than attitudes toward PPI safety.[8] Similarly, educational interventions aimed at reducing inappropriate acid-suppressive therapy have tended to target guideline dissemination rather than risk awareness alone, further implying that these constructs are distinct in practice.[16] The weak correlation observed in our study ($r = 0.10$, $p = 0.262$) provides quantitative support for this conceptual separation and suggests that educational curricula should address both domains explicitly rather than assuming transfer of learning between them.

A final important finding was the marked change in SUP appropriateness scores observed in the sensitivity analysis when DAPT and high-dose corticosteroid use were treated as acceptable indications. Under this alternate assumption, mean appropriateness scores increased substantially and the proportion of residents meeting competency thresholds rose from very low levels to a clear majority. This shift highlights how variability in guideline interpretation and institutional practice can influence measured competency. Similar ambiguity has been described in prior studies, where clinicians reported uncertainty regarding whether antiplatelet therapy or corticosteroid regimens alone should trigger SUP, and where local protocols sometimes differed from national or international recommendations.[5,6] Xing et al also noted inconsistencies between institutional practices and published criteria for SUP in surgical populations, contributing to variability in prescribing behavior.[8] These observations suggest that part of the observed knowledge gap may reflect differences in how SUP indications are defined across settings rather than a lack of clinical reasoning alone.

These findings have practical implications for both training and system-level practice. Efforts to improve PPI and SUP prescribing should address safety knowledge and guideline use as related but distinct skills, since learning about medication risks does not automatically translate into appropriate prescribing decisions. Differences across specialties suggest that training may benefit from being tailored to clinical context rather than applied uniformly. The sensitivity of appropriateness scores to varying SUP criteria also highlights the need for clearer institutional guidance in non-ICU settings. Combining education with local protocols, decision support, and stewardship initiatives may therefore be more effective than relying on knowledge alone. Overall, these findings may indicate that PPI prescribing is shaped by both cognitive and system-level factors. These implications extend across disciplines, particularly for physicians, pharmacists, and clinical educators involved in inpatient medication management, and coordinated efforts will likely be needed to promote consistent, evidence-based prescribing.

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design captures knowledge and decision-making at one point and does not show how these may change during training. Second, the self-administered survey may introduce response bias. Also, one should not assume that responses fully represent real-world prescribing behavior. Third, although residents from different specialties were included, the study was conducted within a single national training environment. This fact is expected to limit how well the findings apply to other settings. Fourth, the SUP scenarios were adapted from guideline criteria, and performance may have been affected by differences in local protocols or prior educational exposure. Fifth, because the total number of residents who received the survey invitation was unknown, a response rate could not be determined. Moreover, the study was insufficiently powered to detect small correlations between knowledge and appropriateness scores, as post-hoc power analysis revealed only 20.2% power to detect the observed correlation of $r = 0.10$ at $\alpha = 0.05$. However, this should not affect the validity of the primary descriptive results. Future studies should incorporate a priori sample size calculations based on expected effect sizes. Additionally, survey items were presented in a fixed order rather than randomized, and therefore potential order effects, such as fatigue or carry-over effects, cannot be entirely ruled out. Lastly, the survey failed to evaluate actual prescribing practices, deprescribing behavior, or clinical outcomes. These limitations point to the need for future studies with longitudinal designs, objective prescribing data, and multicenter samples.

Future studies should examine how trainee knowledge translates into actual prescribing behavior to better understand how educational gaps influence real-world decisions. Research is also needed to evaluate targeted educational and stewardship interventions and to determine whether any improvements are sustained over time. Greater attention to system-level factors such as electronic order sets, discharge practices, and local prescribing policies may further clarify how organizational structures shape SUP use. Multicenter and international investigations could help identify how differences in training environments and healthcare systems influence prescribing practices. In addition, the role of pharmacists and interprofessional teams in deprescribing and medication reconciliation warrants further study, as do the clinical and economic consequences of inappropriate PPI continuation after discharge.

Conclusion

In conclusion, this study identified gaps in resident physicians' knowledge of PPI-related risks and the appropriateness of SUP in non-critically ill patients. Specialty differences were observed, and awareness of medication safety did not consistently align with guideline-based prescribing decisions. These findings suggest that improving PPI use in training environments may require attention to both safety knowledge and understanding of appropriate indications. While interpretation should consider the study's limitations, adding specific educational interventions and clear institutional guidelines may help improve appropriate SUP prescribing among medical residents.

Data Sharing Statement

All data generated or analyzed during this paper is included in this published article.

Ethics Approval

This study received ethical approval from the Regional Research Ethics Committee of the Ministry of Health, Saudi Arabia (Registration No. H-04-Q-001; 19 May 2021). Participation was voluntary, and informed consent was implied by completion of the survey. No personal identifiers were collected, preserving participant anonymity, and all data were securely stored with access restricted to the research team.

Acknowledgments

The Researchers would like to thank the Deanship of Graduate Studies and Scientific Research at Qassim University for financial support (QU-APC-2026).

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This research received no external grant funding for the study design, data collection, or analysis.

Disclosure

The authors declare no conflicts of interest in this work.

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