Knowledge, Attitudes, and Practices Regarding Proton Pump Inhibitor Utilization among Primary Care Doctors in Muscat Governorate, Oman

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Abstract

Background: Proton pump inhibitors (PPIs) are the mainstay of treatment for stomach acid-related disorders. However, despite guidelines delineating appropriate indications for PPI therapy, overutilization and inappropriate prescribing are common, contributing to increased costs, resource mismanagement, and the risk of adverse reactions and drug-drug interactions. As the main prescribers of PPIs, primary care doctors play an important role in mitigating the overuse of these medications.

Objective: This study explores PPI-related knowledge, attitudes, and practices regarding the use of PPIs among doctors working in primary care settings in Muscat Governorate, Oman.

Methods: This cross-sectional study targeted general practitioners (GPs) and family physicians working in Muscat Governorate, Oman. The study was performed during April 2022 to Jan 2023. A validated, self-assessed questionnaire assessed the participants' sociodemographic characteristics and knowledge, attitudes, and practices related to PPI prescription and utilization.

Results: Of the 211 respondents who took part in the study, 79.4% were GPs and 20.6% were family physicians. Most were female (82.4%), Omani (76.1%), and 30-40 years old (60.0%). Only 20.9% of doctors demonstrated good knowledge concerning PPI-related indications, prescription appropriateness, and possible side effects; however, the majority showed positive attitudes towards PPI overuse (96.7%), and good PPI prescribing practices (96.1%). Doctors more frequently attributed PPI overuse to patient insistence (67.6%), rather than doctor misuse (34.3%). No statistically significant relationship was observed between selected demographic characteristics and knowledge, attitude, and practice levels.

Conclusion: Additional education initiatives are necessary to increase knowledge of PPI-related indications and prescription appropriateness among primary care doctors in Oman. In addition, further research is recommended to determine how doctors' knowledge, attitudes, and practices affect actual prescribing trends. Finally, because PPIs are available to patients even without a prescription, additional research is needed to assess awareness of appropriate PPI indications among members of the general public.

Keywords: *Proton pump inhibitors, inappropriate prescribing, attitude of health personnel, health knowledge, attitudes, practice, evidence-based practice, primary care physicians, Oman.*

INTRODUCTION

Proton pump inhibitors (PPIs) are considered the most effective drugs to inhibit the secretion of hydrochloric acid in the stomach [1]. These membrane-permeable benzimidazole derivatives are widely used in the treatment of many gastrointestinal tract conditions, including gastroesophageal reflux disease (GERD), peptic ulcer disease, and dyspepsia [2]. Furthermore, this class of drugs is commonly prescribed for the prevention of nonsteroidal anti-inflammatory drug (NSAID)-induced ulcers and stress ulcers, the treatment of hypersecretory conditions like Zollinger-Ellison syndrome, as well as the eradication of Helicobacter pylori infection in combination with antibiotics [2].

In terms of mechanism of action, PPIs are absorbed into the proximal small bowel before traveling by circulatory action to the parietal cells of the stomach where they irreversibly block hydrogen potassium adenosine triphosphatase—also known as the proton pump—the gastric enzyme involved in the final step of the acid secretion process [1, 3]. The first PPI, omeprazole, was introduced into clinical practice in 1989. Since then, five other drugs in the same class have been approved by the United States Food and Drug Administration (FDA) for the management of acid-related disorders, including lansoprazole, pantoprazole, rabeprazole, esomeprazole, and dexlansoprazole [1]. Ilaprazole, a novel PPI developed in 2008, has shown some success in the treatment of GERD and duodenal ulcers; however, it has not yet been approved by the FDA pending clinical trials [4, 5].

All analyses were carried out using the Statistical Package for the Social Sciences (SPSS) software, version 26.0 (IBM Corp., Armonk, NY). Appropriate indications for PPI treatment are identified and outlined in various guidelines. Nonetheless, high rates of PPI misuse and inappropriate prescriptions are reported globally [6-11]. Irrational use of PPIs can lead to unwanted sequelae,

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including unjustified consumption of healthcare resources, elevated healthcare costs, and an increased risk of adverse events [11]. In particular, long-term overutilization of PPIs can cause significant side effects, such as increased susceptibility to certain infections—including community-acquired pneumonia, Clostridium difficile, and spontaneous bacterial peritonitis—as a result of changes to the gastrointestinal microbiota [12, 13]. Furthermore, it can lead to the impaired absorption of various nutrients due to hypochlorhydria, subsequently leading to vitamin B12 deficiency, hypomagnesemia, and iron deficiency; associations with increased fracture risk and kidney injury have also been reported [14, 15]. There is also concern regarding rebound acid hypersecretion due to secondary hypergastrinemia once treatment is discontinued [13, 16].

Knowledge of approved indications of PPIs, positive attitudes, and a reasonable approach toward PPI prescribing practices among healthcare workers is crucial to reducing and controlling the inappropriate overuse of these medications [17]. To the best of our knowledge, no study has yet been conducted in Oman to investigate knowledge, attitudes, and practices toward PPI utilization and prescription among physicians, the main prescribers of such medications. Currently, the generalizability of findings reported in previous literature on this population is hampered by variations in medication availability, cultural diversity, education, and other factors. As such, our study aimed to explore knowledge, attitudes, and practices regarding the use of PPIs among doctors working in primary health centers in Muscat Governorate, including both local health centers (LHCs) and polyclinics providing primary care services.

MATERIALS AND METHODS

A cross-sectional study was conducted from April 2022 to Jan 2023 at LHCs and polyclinics providing primary health care services in Muscat Governorate, Oman. The target population included all male and female doctors of any nationality working in primary health care roles in these settings, namely general practitioners (GPs) and family physicians. These healthcare workers were targeted because they are considered the primary prescribers of PPIs.

The study participants included all doctors working in primary health care settings in Muscat Governorate. The sample size calculation was performed based on the number of LHCs and polyclinics in Muscat, the estimated number of doctors in each center, and an assumed level of PPI knowledge among doctors of 50% as per previous literature [18]. The sample size was calculated on the assumption that the whole population was 300 (30 health centers with an average of 10 doctors each) and to a 95% confidence interval (CI) and 5% margin of error, resulting in an optimal sample size of 169. However, an additional 10% was added to this target to overcome non-response issues. Therefore, the minimum sample size necessary was deemed to be 186, with the final sample consisting of 211 participants.

Data were collected using a self-assessed questionnaire developed after reviewing PPI prescribing guidelines and relevant previous literature [6]. The questionnaire was validated by calculating the content validity ratio (CVR) for each question following review and scoring by five expert gastroenterologists, with a CVR of >0.49 considered acceptable. The first part of the questionnaire assessed the demographic characteristics of the respondents, including their age, gender, nationality, job title (GP *vs.* family physician), number of years of work experience, and workplace type (LHC *vs.* polyclinic). The second, third, and fourth parts of the questionnaire evaluated the participants' PPI-related knowledge, attitudes, and behaviors, respectively.

The second section of the questionnaire comprised 13 questions related to the participant's knowledge of PPI-related indications, prescription appropriateness, and possible side effects. The respondents were requested to select responses of either 'yes' or 'no' to each question based on their knowledge [19]. Correct and incorrect responses received scores of 5 and 0 points, respectively. The third section included six questions designed to assess the respondents' attitudes to a series of statements relating to PPI overuse. These were scored on a five-point Likert scale indicating the degree of agreement with the statement as follows: 5 points for 'completely agree', 4 for 'almost agree', 3 for 'indifferent', 2 for 'almost disagree', and 1 for 'completely disagree'. Higher scores for the first two questionnaire sections represented better awareness/knowledge of PPIs and more positive attitudes, respectively [19].

The final section of the questionnaire included 10 questions related to the participants' own PPI prescribing practices. The first item consisted of a 'yes' or 'no' question assessing whether the respondent had prescribed PPIs over the preceding year; if so, they were directed to answer the following nine questions. The remaining questions were scored on a five-point Likert scale indicating the frequency of the practice in question as follows: 1 point for 'always', 2 for 'often', 3 for 'sometimes', 4 for 'seldom', and 5 for 'never', with a higher score indicating lower dependency on PPIs, corresponding to better behaviors and practices [19].

For the present study, percent scores of 50-70% for each corresponding section of the questionnaire were deemed to indicate moderate levels of knowledge, neutral attitudes, and fair practices in line with Bloom's cut-off values for evidence-based medicine [18, 20]. Each participant's knowledge score was divided into three categories: good knowledge (>70%), moderate knowledge (50-70%), and poor knowledge (<50%) [18, 20].

All analyses were carried out using the Statistical Package for the Social Sciences (SPSS) software,

version 26.0 (IBM Corp., Armonk, NY). Quantitative data were summarized using descriptive statistics. Continuous variables were presented as means, medians, and standard deviations, while categorical variables were presented as frequencies and percentages. Mean scores between two unrelated groups were compared using an independent samples t-test. The relationship between demographic characteristics and knowledge, attitude, and practice scores was determined using a Chi-squared test (either Fisher's exact test or likelihood ratio). A p-value of <0.05 was considered statistically significant.

Ethical approval and permission to conduct this study were obtained from The Research Council (MoH/CSR/21/25146), Oman, and all study procedures were conducted following local institutional ethical standards. The dignity and rights of the participants were safeguarded at all times, including their freedom to withdraw from the study if desired. Data confidentiality was maintained throughout the study period and the questionnaire was anonymous to protect the participants' privacy and encourage truthful responses. Written informed consent was obtained from all respondents before they completed the questionnaire and participation in the study.

RESULTS

Demographic Characteristics

A total of 211 respondents took part in the study. The demographic characteristics of these participants are presented in Table **1**. The majority of the participants were of Omani nationality (76.1%), female (82.4%), and 30-40 years of age (60.0%). Overall, 79.4% were GPs, with the remaining 20.6% being family physicians. Most participants had at least five years of work experience or more (78.6%) and worked in LHCs (97.6%).

Table 1: Demographic characteristics of the participants (N = 211).

Characteristic	Sub-groups	n (%)*
Gender	Male	37 (17.6)
	Female	173 (82.4)
Nationality	Omani	159 (76.1)
	Non-Omani	50 (23.9)
Age (years)	<30	31 (14.8)
	30-40	126 (60.0)
	41-50	42 (20.0)
	51-60	11 (5.2)
Job title	GP	166 (79.4)
	Family physician	43 (20.6)
Work experience (years)	<5	45 (21.4)
	5-10	80 (38.1)
	>10	85 (40.5)
Workplace type	LHC	204 (97.6)
	Polyclinic	5 (2.4)

GP, general practitioner; LHC, local health center. *Percentages calculated out of the total number of responses per variable due to missing data.

Table 2: Associations between PPI-related knowledge level and demographic characteristics.

Character-istic	Sub-groups	Knowledge, n (%)*			p-value†
		Good	Moderate	Poor	
Gender	Male	8 (21.6)	21 (56.8)	8 (21.6)	0.969
	Female	36 (20.8)	102 (59.0)	35 (20.2)	
Nationality	Omani	28 (17.6)	98 (61.6)	33 (20.8)	0.096
	Non-Omani	16 (32.0)	24 (48.0)	10 (20.0)	
Age (years)	<30	4 (12.9)	18 (58.1)	9 (29.0)	0.300
	30-40	25 (19.8)	79 (62.7)	22 (17.5)	
	41-50	10 (23.8)	22 (52.4)	10 (23.8)	
	51-60	5 (45.5)	4 (36.4)	2 (18.2)	
Job title	GP	34 (20.5)	94 (56.6)	38 (22.9)	0.230
	Family physician	10 (23.3)	28 (65.1)	5 (11.6)	
Work experience (years)	<5	5 (11.1)	28 (62.2)	12 (26.7)	0.280
	5-10	17 (21.3)	49 (61.3)	14 (17.5)	
	>10	22 (25.9)	46 (54.1)	17 (20.0)	
Workplace type	LHC	41 (20.1)	121 (59.3)	42 (20.6)	0.122
	Polyclinic	3 (60.0)	1 (20.0)	1 (20.0)	

GP, general practitioner; LHC, local health center. *Percentages calculated out of the total number of responses per variable due to missing data. †Using likelihood ratio.

Table 3: Correct responses to PPI-related knowledge questions.

Questions	Correct response, n (%)*
Do PPIs treat acid-related diseases by suppressing hydrochloric acid secretion?	187 (88.6)
Can stress ulcers be prevented with PPIs?	147 (69.7)
Do PPIs have an anti-emetic effect?	95 (45.0)
Does omeprazole have the longest acid suppression time compared to other PPIs?	92 (43.6)
Can omeprazole be prescribed to pediatric patients?	134 (63.5)
Can omeprazole be prescribed to pregnant patients?	75 (35.5)
Can PPIs be prescribed to patients taking warfarin?	102 (48.3)
Is it beneficial to increase PPI dose frequency to improve effect, rather than a single dose?	118 (55.9)
For Helicobacter pylori eradication therapy, should PPIs be taken only for 7 days?	183 (86.7)
Is the course of PPI treatment for severe esophagitis 2 to 4 weeks?	64 (30.3)
Can PPIs cause a rash/hypersensitivity reaction?	174 (82.5)
Can PPIs cause diarrhea?	151 (71.6)
Can long-term PPI use cause adverse reactions such as osteoporosis, pneumonia, *etc.*?	152 (72.0)

PPIs, proton pump inhibitors. *Percentages calculated out of the total number of responses per variable due to missing data.

PPI-Related Knowledge

The mean total knowledge score was 7.93 ± 1.95, for a mean percent score of 61.02% ± 15.04%, indicating moderate levels of knowledge. Only 20.9% (95% CI: 15.6-27.0%) of the participants demonstrated good levels of knowledge. However, as demonstrated in Table **2**, no statistically significant associations were observed between demographic characteristics and level of knowledge concerning PPIs. The frequency of correct responses to each of the individual knowledge questions is shown in Table **3**.

Table 4: Associations between PPI-related attitudes and demographic characteristics.

Characteristic	Sub-groups	Attitudes, n (%)*		p-value
		Positive	Neutral	
Gender	Male	33 (91.7)	3 (8.3)	0.100†
	Female	169 (97.7)	4 (2.3)	
Nationality	Omani	154 (97.5)	4 (2.5)	0.362†
	Non-Omani	47 (94.0)	3 (6.0)	
Age (years)	<30	29 (93.5)	2 (6.5)	0.553‡
	30-40	122 (97.6)	3 (2.4)	
	41-50	40 (95.2)	2 (4.8)	
	51-60	11 (100.0)	0 (0.0)	
Job title	GP	159 (96.4)	6 (3.6)	1.000†
	Family physician	42 (97.7)	1 (2.3)	
Work experience (years)	<5	43 (95.6)	2 (4.4)	0.845‡
	5-10	77 (97.5)	2 (2.5)	
	>10	82 (96.5)	3 (3.5)	
Workplace type	LHC	196 (96.6)	7 (3.4)	1.000†
	Polyclinic	5 (100.0)	0 (0.0)	

GP, general practitioner; LHC, local health center. *Percentages calculated out of the total number of responses per variable due to missing data. †Using Fisher's exact test. ‡Using likelihood ratio.

Table 5: Associations between PPI-related practices and demographic characteristics.

Characteristic	Sub-groups	Practices, n (%)*		p-value
		Good	Moderate	
Gender	Male	31 (93.9)	2 (6.1)	0.619†
	Female	164 (96.5)	6 (3.5)	
Nationality	Omani	149 (96.1)	6 (3.9)	1.000†
	Non-Omani	45 (95.7)	2 (4.3)	
Age (years)	<30	26 (92.9)	2 (7.1)	0.625‡
	30-40	119 (96.7)	4 (3.3)	
	41-50	39 (95.1)	2 (4.9)	
	51-60	11 (100.0)	0 (0.0)	
Job title	GP	152 (95.0)	8 (5.0)	0.209†
	Family physician	42 (100.0)	0 (0.0)	
Work experience (years)	<5	40 (95.2)	2 (4.8)	0.186‡
	5-10	73 (93.6)	5 (6.4)	
	>10	82 (98.8)	1 (1.2)	
Workplace type	LHC	189 (95.9)	8 (4.1)	1.000†
	Polyclinic	5 (100.0)	0 (0.0)	

GP, general practitioner; LHC, local health center. *Percentages calculated out of the total number of responses per variable due to missing data. †Using Fisher's exact test. ‡Using likelihood ratio.

PPI-Related Attitudes

Overall, 96.7% of the respondents reported positive attitudes towards PPI overuse, with the remaining 3.3% reporting neutral attitudes. No statistically significant relationships were observed between any demographic characteristics and the participants' attitudes as can be seen in Table **4**.

PPI-Related Practices

Overall, 96.1% demonstrated good practices, with the remaining 3.9% demonstrating moderate practices. No statistically significant relationships were observed between any demographic characteristics and the participants' practices as can be seen in Table **5**.

Table 6: Agreement with PPI-related attitude statements.

Statement	Agree/ strongly agree, n (%)*
At present, overuse of PPIs is common in Oman	186 (88.6)
The main cause of PPI overuse is due to doctors' abuse of these drugs	72 (34.3)
The main cause of PPI overuse is patients' insistence on taking these drugs	142 (67.6)
Overuse of PPIs will increase medical costs and adverse drug reactions	180 (85.7)
Large-scale education initiatives for medical staff regarding the appropriate use of PPIs are necessary	193 (91.9)
Strengthening community awareness regarding the appropriate use of PPIs is necessary	198 (94.3)

PPIs, proton pump inhibitors. *Percentages calculated out of the total number of responses per variable due to missing data.

Table 7: Frequency of PPI-related practices.

Questions	Often/ always, n (%)*
Do you prescribe PPIs for long periods of time (*i.e.*, for >4 weeks)?	49 (24.0)
Do you periodically reassess the need for chronic PPI therapy?	121 (59.3)
Do you discontinue PPIs after symptoms improve?	129 (63.2)
Do you discuss side effects with the patient before prescribing PPIs?	104 (51.2)
Do you conduct medication reconciliation (*i.e.*, a drug history) before prescribing PPIs to prevent possible drug-drug interactions?	130 (64.0)
Do you prescribe PPIs for abdominal pain?	19 (9.3)
Do you prescribe PPIs in combination with NSAIDs?	54 (26.5)
Do you prescribe PPIs for nausea and vomiting?	16 (7.8)
Do you prescribe PPIs for acid reflux?	123 (61.2)

NSAIDs, nonsteroidal anti-inflammatory drugs; PPIs, and proton pump inhibitors. *Percentages calculated out of the total number of responses per variable due to missing data.

The frequency of agreement to various attitude statements is shown in Table **6**. Most participants (88.6%) believed that PPI overuse was common in Oman; however, 67.6% believed that this was due to the patient's insistence on taking these drugs, with only 34.3% believing that the cause of this problem was due to doctors' prescribing habits. In addition, most participants (85.7%) agreed that overuse of PPIs results in increased medical costs and adverse drug reactions. The vast majority believed that education/awareness initiatives regarding PPI appropriateness were necessary, both to educate medical staff (94.3%) and to strengthen community awareness (91.9%).

The majority of the doctors (95.2%) reported having prescribed PPIs over the past year. The frequency of prescription practices in this group is shown in Table **7**. Approximately one-quarter prescribed PPIs for more than a month at a time (24.1%). Most doctors reported reassessing the need for chronic therapy (59.3%), discussing potential side effects with the patient (51.2%), and discontinuing treatment following symptom improvement (63.2%). Additionally, 64.0% of

Table 8: Correlations between knowledge, attitudes, and practices.

Domain	Sub-groups	Knowledge, n (%)*			p-value†	Spearman rho	p-value†
		Good	Moderate	Poor			
Attitudes	Positive	43 (97.7)	119 (96.7)	41 (95.3)	0.826	0.024	0.727
	Neutral	1 (2.3)	4 (3.3)	2 (4.7)			
Practices	Good	41 (95.3)	115 (97.5)	40 (93.0)	0.448	0.093	0.184
	Moderate	2 (4.7)	3 (2.5)	3 (7.0)			

*Percentages calculated out of the total number of responses per variable due to missing data. †Using likelihood ratio.

respondents took patient drug histories to avoid potential drug-drug interactions.

Correlations between PPI-Related Knowledge, Attitudes, and Practices

No correlations were noted between the levels of knowledge, attitudes, and practices of the respondents, as shown in Table **8**.

DISCUSSION

Our cross-sectional study targeted a sample of physicians working in LHCs and polyclinics providing primary health care services in Muscat Governorate, Oman. Crucially, the study found that although the vast majority reported positive attitudes (96.7%) and good practices (96.1%), only 20.1% demonstrated good levels of knowledge concerning PPI-related indications, prescription appropriateness, and possible side effects. However, no significant associations were observed between knowledge, attitude, and practice levels and any of the studied sociodemographic characteristics; moreover, no correlations were noted between different dimensions of knowledge, attitude, and practice, likely because of the high degree of homogeneity in attitudes and practices among the respondents.

Studies from Saudi Arabia, China, and India consistently report poor levels of knowledge regarding PPIs among healthcare professionals, despite generally positive attitudes toward their use [18-22]. Similar trends were observed in France, where most GPs were unaware of PPI-related adverse effects but were open to de-prescribing if needed [22]. Poor PPI knowledge in Saudi Arabia was linked to younger age, lower education level, and less clinical experience, with positive correlations between knowledge, attitude, and practice scores [18]. Similarly, Luo *et al.* reported worse knowledge among younger, less educated, female healthcare professionals, and those working in private hospitals [19]. In contrast, Koggel *et al.* identified older age as a predictor of inappropriate PPI prescribing in Dutch primary care [23].

In contrast, our results showed no associations between demographic characteristics and knowledge, attitudes, or practices, nor correlations between these dimensions. This discrepancy in findings may be due to the inclusion of other types of healthcare professionals in both the Saudi Arabian and Chinese studies, including physicians, nurses, and community pharmacists, as well as the inclusion of healthcare professionals working in secondary and tertiary health settings, not just primary care [18, 19]. In addition, we did not assess the level of educational attainment, which could have impacted the findings as both education level and type of care setting may influence awareness of guidelines governing rational drug prescription [18].

Research highlights various reasons for inappropriate PPI prescribing, such as preventive use in patients without risk factors, overtreatment of non-acid-related conditions, and unnecessary continuation of short-term treatments [23-27]. In particular, prophylactic acid-suppressive treatment for hospitalized patients at low risk of stress ulceration appears to be a major cause of PPI overuse [26, 27]. This is concerning because prescribing trends among hospitalized inpatients tend to have repercussions for primary care [28, 29].

Wermeling *et al.* interviewed 10 GPs in Germany to explore factors affecting inappropriate PPI prescribing practices in primary care [17]. While all GPs held similarly positive attitudes toward PPIs and their perceived effectiveness, there were considerable differences in knowledge and prescribing behaviors. The GPs with a history of inappropriate prescriptions were less aware of appropriate indications for treatment, often prescribing PPIs alongside NSAIDs for patients at low risk of ulceration, or with other, innocuous drugs like paracetamol. Moreover, they also relied on the initial prescribing physician's decision. In contrast, GPs who frequently discontinued inappropriate PPI prescriptions were more aware of evidence-based indications, placed more trust in their decision-making capabilities, and recognized the consequences of unnecessary drug use, emphasizing the need for a definitive diagnosis [17].

Batuwitage *et al.* found that an educational intervention in the United Kingdom (UK) did not reduce the number of hospitalized patients receiving PPIs upon admission, with many prescriptions given for non-dyspepsia-related symptoms [8]. The researchers suggested that the long-term nature of PPI prescriptions led both primary care and admitting physicians to continue them without questioning the need for con vtinuation [8]. They recommended that financial incentives or active education, rather than merely distributing written materials, might have more success in changing physician behavior about prescribing practices. Indeed, the vast majority of physicians in the current study (94.3%) believed that local education/awareness initiatives regarding PPI appropriateness were necessary to educate medical staff. Additional education initiatives

are therefore recommended to increase knowledge of PPI-related indications and prescription appropriateness among primary care doctors in Oman.

According to evidence-based guidelines, 'de-prescribing' of PPI treatment should be considered for adult patients with heartburn and mild-to-moderate GERD or esophagitis who have completed at least 4 weeks of treatment and in whom there is evidence of symptom resolution [30]. However, such recommendations do not apply to patients with a current or previous history of Barrett's esophagus, severe esophagitis (*i.e.*, grades C or D), or those with a documented history of bleeding gastrointestinal ulcers [30]. The American Gastroenterological Association recently released a clinical practice update with best practice advice statements to govern the de-prescribing of PPIs [31].

One of the key takeaways was that physicians should routinely re-evaluate patients on chronic PPI therapy to determine whether they still have reasonable indications for taking PPIs; if not, de-prescribing should be considered. Moreover, even if justified indications for continuing PPIs remain, physicians should determine whether patients might benefit from a 'stepping-down' of treatment in which the dose or dose frequency is gradually tapered down or reduced over time, such as moving from twice-daily to once-daily treatment [31].

Raghunath *et al.* conducted a qualitative study with GPs in the UK to discuss PPI prescribing behaviors [32]. The findings revealed that GPs in training and those with academic backgrounds were more cautious in initiating PPI treatment, stressing the need for a concrete diagnosis, whereas service-based GPs were more pragmatic. Several GPs raised concerns about patient preferences influencing PPI prescribing decisions and the risk of legal liability for missed diagnoses [32]. Although most acknowledged the importance of reviewing long-term PPI treatment, they debated the practical feasibility of the traditional 'step-up, step-down' approach, citing patients' multiple concerns and unwillingness to attend repeated appointments [32]. Other researchers have similarly hypothesized that clinical recommendations on the use of PPIs may be too rigid and disconnected from real-world patient expectations and the actual experiences of GPs [8].

Raghunath *et al.* also noted that the effectiveness and tolerability of PPIs might encourage patients to insist on their use despite doctors' recommendations [32]. Moreover, even if appropriately prescribed, patients may continue to take PPIs unsupervised due to their over-the-counter (OTC) availability [33]. Similarly, primary care physicians in our study often attributed PPI overuse to patients' insistence on taking these medications, rather than inappropriate prescribing. Consequently, most doctors stressed the need for initiatives designed to strengthen community awareness of appropriate PPI use, addressing concerns regarding the widespread lack of knowledge and inappropriate use of medicines among the general public in Oman [34].

Indeed, Boster *et al.* reported successful results from a six-month intervention where patients with inappropriate PPI prescriptions were contacted by their primary care doctors to discuss the risks of continued use and explore alternative treatments or stepping down [35]. After the intervention, 44% of patients were successfully weaned to a reduced dose or had discontinued treatment entirely. A randomized controlled trial similarly reported success with a low-cost, leaflet-based educational intervention for adults with a history of chronic PPI use [36]. Alternatively, if direct-to-patient interventions are not feasible, Alhossan *et al.* and Asdaq *et al.* recommended additional training for pharmacists because such individuals are crucial in controlling the release of OTC drugs into the community and in providing layman education regarding safe and appropriate medication practices [7, 18].

It should be noted that while PPIs are widely used for treating conditions such as GERD and peptic ulcers, their use remains a topic of ongoing controversy. There are concerns about overprescription for conditions whose symptoms are mild enough to be effectively treated with less aggressive medications and about long-term use associated with adverse effects, including nutrient deficiencies, kidney disease, and infection risk [12-16, 37]. These controversies emphasize careful patient selection and regular reassessment of PPI therapy to ensure it is appropriate and safe.

LIMITATIONS

To the extent of our knowledge, this study is the first originating from Oman to assess the knowledge, attitudes, and practices of doctors about PPI utilization and prescription. As such, the results may help to increase awareness among physicians of the importance of basing PPI prescription practices on rational, evidence-based indications and for appropriate durations to reduce hospital resource misutilization and the likelihood of adverse effects stemming from long-term use. However, our study is subject to several limitations.

The self-reported nature of the data collection tool could have introduced bias into the findings, particularly recall and social desirability bias. In addition, the cross-sectional design of the study meant that we were unable to make causal inferences or identify temporal trends. Moreover, because our study was limited to doctors employed in primary care settings in Muscat Governorate, our findings may not be generalizable to those working in other regions of the country or at other levels of care. Another limitation was the disproportionate response rate of GPs compared to family physicians, accounting for 79.4% of the total number of respondents. While this may slightly skew the responses, at the same time, it also represents the distribution of doctors in primary healthcare clinics in Oman. However, over-inclusion of

GPs may distort the representativeness of results in general medical practice and across various specialties.

Finally, we recommend further research be conducted to compare how the PPI-related knowledge, attitudes, and practices of primary care doctors affect actual prescribing patterns and trends for this class of drugs. Since no local data are available on the exact manifestations of inappropriate use of PPIs in the national healthcare system, future studies should be designed to investigate prescribing practice and misuse of PPIs in this setting for targeted interventions and educational reforms.

CONCLUSION

Primary care doctors in Oman had only moderate levels of knowledge concerning PPI-related indications, prescription appropriateness, and possible side effects, despite holding positive attitudes and showing good practices toward PPIs utilization and prescription. Further research is necessary to determine how such findings may impact actual prescribing trends. Moreover, due to the OTC availability of these drugs, there is a need to conduct additional studies assessing awareness of appropriate indications for PPI use in the general community to reduce the possibility of medication misuse and unnecessary healthcare resource consumption.

ETHICS APPROVAL

Ethical approval and permission to conduct this study were obtained from The Research Council (MoH/ CSR/21/25146), Oman. All procedures performed in studies involving human participants were following the ethical standards of the institutional and/ or national research committee and the Helsinki Declaration.

CONSENT FOR PUBLICATION

Online informed consent was taken from survey respondents.

AVAILABILITY OF DATA

Upon a reasonable request, the associated author will provide the data.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

Al-Jassasi K suggested the research idea, reviewed literature, proposal writing, involved in data collection and entry, and manuscript draft writing. Al-Hosni M involved in data collection and entry, and manuscript draft writing. Al-Hadhrami R directly supervised the research process, provided assistance and guidance, and monitored research progress. Al-Ghafri M was co-supervising all processes of research and provided a datasheet of included health institutes.

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