Vol. 4, No. 1, 2026
DOI: 10.61975/gjset.v4i1.116

ORIGINAL ARTICLE

Rational Use of Proton Pump Inhibitors Among the Early Aging Population: Evidence from a Community Health Center in Indonesia

Suryawati Suryawati[1,*], Lulu Animalika[2], Maghyan Narisa[2], Hijra Novia Suardi[1], Zahratul Aini[3], Vera Dewi Mulia[4], and Desi Maghfirah[5]

[1]Pharmacology Unit, Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; [2]Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; [3]Department of Family Medicine, Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; [4]Pathology Anatomy Unit, Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; [5]Gastroenterohepatology Division, Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh, 23111

* Correspondence: suryawatie@usk.ac.id

Article History

Received
11 February 2026

Accepted
17 April 2026

Available Online
29 April 2026

Keywords

Evidence-based medicine
Proton pump inhibitors
GERD
Dyspepsia
Omeprazole

Abstract

Proton pump inhibitors (PPIs) are among the most commonly prescribed medications worldwide and are widely used for the management of acid-related disorders, particularly among adults in their early ageing period, where concerns about inappropriate prescribing remain prevalent. This study aimed to evaluate the rational use of PPIs among adults aged ≥46 years at a primary healthcare centre in Banda Aceh, Indonesia. This study focuses on the appropriateness of indications, dosages, and durations, as well as potential drug–drug interactions. Dose appropriateness was assessed using Lexicomp standard adult dosing. Duration and appropriateness of indications were assessed according to the Indonesian Gastroenterology Consensus. A retrospective cross-sectional study was conducted, comprising 1,997 records. A sample of 107 patients who met the predefined inclusion and exclusion criteria was analysed. Most patients were aged 56–65 years and predominantly female, with dyspepsia as the main indication. Omeprazole was prescribed in all cases, commonly at 20 mg twice daily. Nearly half of prescriptions were inappropriate, and appropriate dosing was limited. While treatment duration was generally adequate, some cases were shorter than recommended. Potential drug–drug interactions were identified but were mostly of low clinical significance. Overall, the rational use of PPIs among the patients in this primary healthcare setting remains suboptimal, particularly in terms of indication and dosing. These findings highlight the need to strengthen adherence to clinical guidelines and to implement regular medication reviews to promote safer, more rational PPI use in this population.

Introduction

Proton pump inhibitors (PPIs) are among the most commonly prescribed drug classes worldwide. A systematic review involving more than 28 million users across 23 countries reported that nearly one-quarter of adults use these agents. Their use is particularly prevalent among adults for the management of gastrointestinal disorders such as gastroesophageal reflux disease (GERD), esophagitis, and the prevention of gastrointestinal injury associated with medicine use [1,2].

Given their extensive use, ensuring the rational use of PPIs is essential for optimizing therapeutic outcomes and minimizing potential harm. According to the World Health Organization, rational use of medicines means patients receive medications appropriate to their clinical needs, in doses that meet their individual requirements, for an adequate duration, and at an affordable cost. Nevertheless, irrational use of medicines remains a major global health concern, contributing to

medication errors, adverse drug reactions, increased healthcare costs, and higher morbidity and mortality [3].

In the context of PPIs, inappropriate prescribing has become a persistent clinical issue across both Western and Eastern countries. PPI therapy is frequently initiated without appropriate indications, underscoring the global nature of this problem [4]. Inappropriate use includes ulcer prophylaxis in patients without risk factors and overtreatment of functional dyspepsia, both of which may expose patients to adverse drug reactions and drug–drug interactions. Moreover, accumulating evidence indicates that long-term PPI use is associated with serious adverse outcomes, including *Clostridium difficile* infection, magnesium deficiency, osteoporosis, and kidney disease. Despite growing awareness of these risks, factors contributing to inappropriate PPI use in clinical practice remain insufficiently understood, limiting the development of effective targeted interventions [5].

This issue is particularly important among adults aged ≥46 years, the target population of this study, as has been investigated in several Indonesian studies [6,7]. This group is more likely to receive long-term PPI therapy and is more vulnerable to its potential risks. Aging is associated with multiple changes in gastrointestinal function, including reduced digestive enzyme production and alterations in gastric physiology, which increase susceptibility to gastrointestinal disorders. Furthermore, due to multiple degenerative health problems, polypharmacy becomes something that cannot be avoided, which results in the complexity of managing chronic conditions and leads to inappropriate use of medications, including PPIs [8].

Collectively, these factors create significant clinical challenges in the management of gastrointestinal disorders among older adults, particularly in the context of increasing PPI use. Previous studies have reported that inappropriate PPI use occurs in approximately 40–65% of patients, primarily due to prolonged therapy without clear indications. This raises important concerns regarding patient safety, treatment effectiveness, and unnecessary healthcare expenditures [9].

Evidence regarding the rational use of proton pump inhibitors (PPIs) in Indonesia remains limited, particularly in primary healthcare settings. Existing studies have predominantly been conducted in hospital settings, including inpatient evaluations of the appropriateness of PPI prescribing [10]. Studies involving outpatient populations are also largely hospital-based and focus mainly on drug interactions rather than comprehensive rational use [11]. Collectively, these findings indicate a lack of evidence from primary healthcare settings, where prescribing practices may differ due to limited diagnostic resources and a higher reliance on empirical treatment.

Furthermore, another important aspect is drug–drug interactions, which pose an important concern in patients receiving proton pump inhibitors. PPIs may alter the pharmacokinetics of concomitant medications by inhibiting cytochrome P450 enzymes, particularly CYP2C19, and by increasing gastric pH, thereby affecting drug absorption [12]. Clinically relevant interactions have been reported with several commonly used medications, including clopidogrel (reduced antiplatelet effect via CYP2C19 inhibition), warfarin (increased bleeding risk), methotrexate (reduced clearance), digoxin (increased absorption), and levothyroxine (reduced absorption) [13,14]. These interactions may have important clinical consequences, particularly in older adults with multiple comorbidities and complex medication regimens [15]. This aspect also needs to be investigated to ensure the safety and efficacy in patients receiving PPT treatment.

This study was conducted in a primary healthcare center in Banda Aceh, a setting that represents first-line healthcare services within the Indonesian health system. Primary care plays a critical role in initial diagnosis and treatment; however, it is often characterized by limited diagnostic facilities and high patient volume, which may influence prescribing behavior. In addition, published data on PPI use from this region remain scarce. Therefore, this study

provides important local evidence to better understand prescribing patterns and support more rational use of PPIs in similar primary care settings. Therefore, this study aims to evaluate the rational use of proton pump inhibitors among adults aged ≥46 years attending an elderly clinic at the Batoh Community Health Center in Banda Aceh, with specific objectives to assess the appropriateness of indications, dosages, and durations of therapy, as well as potential drug–drug interactions.

Materials and Methods

Study Design and Setting

This study employed a retrospective cross-sectional design using medical records from patients who received proton pump inhibitor (PPI) therapy at the Elderly Clinic of the Batoh Community Health Center in Banda Aceh, Indonesia. Data were collected through a review of medical records and prescription data from May to August 2024.

The study was conducted in a primary healthcare setting that provides first-line medical services for the community, including the management of common gastrointestinal conditions. Ethical approval for this study was obtained from the Health Research Ethics Committee, Faculty of Medicine, Universitas Syiah Kuala, with approval number 165/EA/FK/2024 (KEPPKN Registration Number 1171012P).

Data Source and Sample Selection

The study population comprised all medical records of patients aged ≥46 years registered at the Elderly Clinic of the Batoh Community Health Center, Banda Aceh, from May to August 2024, yielding a total of 1,997 records. A consecutive sampling approach was used, in which all records were screened, and those meeting the inclusion and exclusion criteria were included in the study. Of the 1,997 records screened, records that did not meet the inclusion criteria or were incomplete or illegible were excluded. A total of 107 records were included in the final analysis.

Data Extraction and Analysis

Data were extracted from medical records and prescription sheets using a structured data collection form developed by the investigators. Two clinical pharmacists independently reviewed all eligible records to ensure the accuracy and consistency of data extraction, including patient demographics, diagnoses, PPI regimens, dosing, treatment duration, and co-prescribed medications.

Any discrepancies in data extraction or in the classification of appropriateness were discussed and resolved by consensus. As this study used a structured protocol with predefined criteria, formal inter-rater reliability testing was not performed; instead, consensus adjudication was used to ensure uniform classification.

Data analysis was performed using Microsoft Excel. Descriptive statistics were used to summarise the data. Categorical variables were presented as frequencies and percentages. Missing or incomplete data were handled by excluding records lacking sufficient information for key study variables, as specified in the sample selection criteria.

Potential drug–drug interactions involving PPIs were identified using Drug Interaction Checker at Drugs.com and classified into five categories based on clinical significance: no interaction, minor, moderate, major, and unknown. Only documented concomitant medications were included in the analysis; over-the-counter or unrecorded medications could not be assessed. Assessment of the appropriateness of dose and duration was performed only for prescriptions with appropriate indications. Prescriptions with inappropriate indications were excluded from dose and duration analyses.

Demographic and Clinical Characteristics

Demographic variables comprised gender (male and female). For age, an operational definition used in several Indonesian studies is also applied in this study [6,7]. The category includes: early elderly (46-55 years), late elderly (56–65 years), and advanced elderly (≥65 years). Clinical diagnoses were recorded and classified as dyspepsia, gastroesophageal reflux disease (GERD), gastric ulcer, and other non-related conditions.

Types of Proton Pump Inhibitors

Data on proton pump inhibitor (PPI) use were extracted from medical records and/or prescription charts. Each prescription containing a PPI was identified and classified according to its active pharmaceutical ingredient. The PPIs recorded in this study included omeprazole, lansoprazole, pantoprazole, rabeprazole, and other available agents if applicable.

Appropriateness of Proton Pump Inhibitor Indications, Dose, and Duration

Appropriateness of indication, dose, and duration was assessed using established references: the Indonesian Gastroenterology Consensus [16] and the Drug Information Handbook [17]. Details are presented in Table 1. The use of PPIs classified in this study is GERD, dyspepsia, gastric ulcer, and other diagnoses, including non-dyspepsia, non-GERD, and non-gastric ulcer. These criteria were applied uniformly across patients, as no specific dose or duration adjustments for age or comorbidities were documented in the medical records.

Table 1. Recommended proton pump inhibitor dose and duration according to clinical indication.

Indication	Recommended Dose	Recommended Duration	Source
GERD (non-erosive / mild)	Omeprazole 20 mg once daily (or equivalent PPI dose)	4–8 weeks	PGI Consensus
GERD (erosive esophagitis)	Omeprazole 20–40 mg once daily	8 weeks (can extend based on severity)	PGI Consensus
Maintenance therapy (GERD)	Lowest effective dose (e.g., omeprazole 10–20 mg daily)	Long-term, reassessed periodically	PGI Consensus
Dyspepsia (empirical therapy)	Standard PPI dose (e.g., omeprazole 20 mg daily)	2–4 weeks	PGI Consensus
Peptic ulcer (gastric/duodenal)	Omeprazole 20 mg once daily (can increase to 40 mg)	4–8 weeks	Drug Information Handbook and PGI Consensus
H. pylori eradication	PPI standard dose twice daily (e.g., omeprazole 20 mg twice daily)	10–14 days (triple therapy)	PGI Consensus
NSAID-induced ulcer prophylaxis	Omeprazole 20 mg once daily	During NSAID use	Drug Information Handbook
Stress ulcer prophylaxis (SUP)	Omeprazole 20 mg daily (or IV equivalent if indicated)	Only during ICU/high-risk condition	Drug Information Handbook and PGI Consensus
Upper GI bleeding	High-dose PPI (e.g., omeprazole IV bolus + infusion or 40 mg twice daily oral)	72 hours IV → then oral up to 4–8 weeks	PGI Consensus

Potential Drug Interaction

Potential drug–drug interactions were evaluated by reviewing concomitant medications documented in medical records and assessing their interaction profiles using Drugs.com. Interactions involving Proton Pump Inhibitors were classified into five categories: no interaction, minor, moderate, major, or unknown, based on the level of clinical significance.

Results and Discussion

This study followed a structured selection and assessment process to identify eligible medical records and evaluate proton pump inhibitor (PPI) use. A total of 1,997 medical records from the

Batoeh Community Health Center in Banda Aceh, collected between May and August 2024, were initially screened for eligibility. After applying the inclusion and exclusion criteria, records with incomplete or ineligible information were excluded, resulting in 107 records included in the final analysis. These records were then used to identify patients receiving PPI therapy and to evaluate the appropriateness of the indications, dosages, and durations. The flow of study selection and categorization is presented in Figure 1.

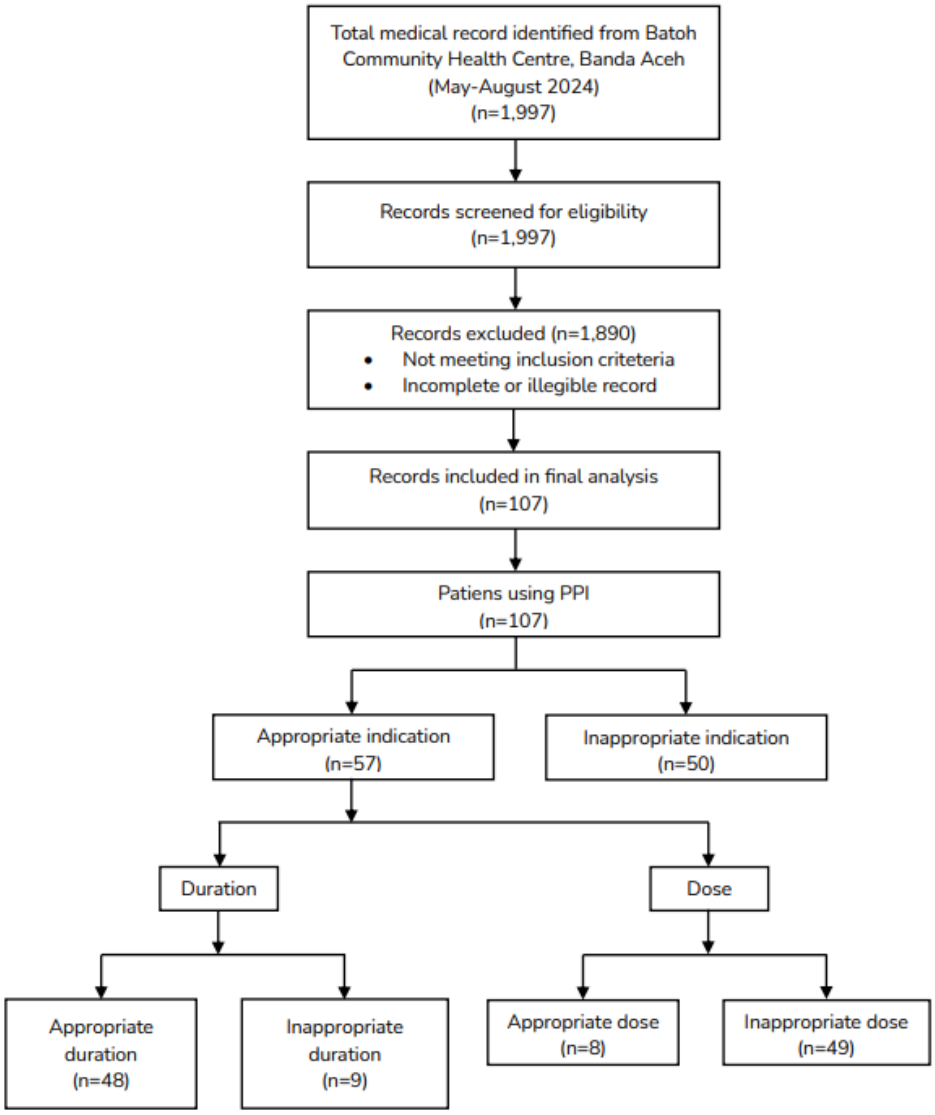

Figure 1. Flow diagram of data extraction.

Results of Demographic and Clinical Characteristics

A total of 107 patients were included in this study. Patient characteristics can be seen in Table 2. The majority were female (60.7%, n = 65), while males accounted for 39.3% (n = 42). Most patients were aged 56–65 years (41.1%, n=44), followed by 46–55 years (38.3%, n=41) and >65 years (20.6%, n=22). Dyspepsia was the most frequent clinical diagnosis (45.8%, n = 49), followed by other non-dyspepsia conditions (46.7%, n = 50). Gastroesophageal reflux disease (GERD) accounted for 6.5% (n = 7), while gastric ulcer was rare (0.9%, n = 1).

The predominance of female patients observed in this study is consistent with prior evidence that women are more likely than men to seek healthcare services for various conditions. This pattern has been widely reported in different populations and disease contexts [18–21]. In the

context of acid-related disorders, studies suggest that women may report symptoms more frequently and are therefore more likely to receive medical evaluation and pharmacological treatment, including proton pump inhibitors (PPIs) [22,23].

Table 2. Patient characteristics.

Variable	Category	Frequency (n)	Percentage (%)
Gender			
	Female	65	60.7
	Male	42	39.3
Age			
	46-55 years	41	38.3
	56-65 years	44	41.1
	>65 years	22	20.6
Clinical Diagnosis			
	Dyspepsia	49	45.8
	GERD	7	6.5
	Gastric Ulcer	1	0.9
	Other diagnoses*	50	46.7
Total		107	100

*Other diagnoses include non-dyspepsia, non-GERD and non-gastric ulcer

The age distribution observed in this study, with the highest proportion of PPI users in the 56–65-year group, is consistent with recent global evidence. This indicates the increasing burden of gastrointestinal disorders with advancing age [2]. However, in contrast to several studies showing the highest utilization among individuals aged >65 years, the lower proportion of patients in this oldest age group in the present study may suggest differences in population demographics, prescribing patterns, or healthcare access.

The most common diagnosis underlying PPI prescribing in this study is consistent with current clinical guidelines [13]. Dyspepsia remains highly prevalent among patients aged ≥46 years, affecting approximately 20–27% of individuals aged ≥50 years, supporting its role as a major driver of PPI use as described by a previous study [24]. However, the relatively low proportion of GERD (6.5%) in this study contrasts with global trends where GERD is typically a primary indication for PPI therapy. This discrepancy may reflect underdiagnosis or the empirical treatment of uninvestigated dyspepsia in a primary health care center, which has limited diagnostic resources, time constraints, and insufficient training or awareness among healthcare providers.

Additionally, the high proportion of “other diagnoses” (46.7%) is consistent with recent reports highlighting the widespread use of PPIs for prophylactic or unclear indications. A global systematic review found that a notable proportion of PPI prescriptions (approximately 14–15%) lack a clearly documented indication, suggesting potential overuse or inappropriate prescribing practices [2]. Overall, the findings of this study are broadly consistent with recent literature regarding age-related trends and dyspepsia-driven prescribing. The lower prevalence of GERD highlights potential contextual differences in diagnostic and prescribing patterns.

Types of Proton Pump Inhibitors

Table 3 presents the overview of PPI therapy among the study population. All patients (100%) were prescribed omeprazole as the PPI of choice. The dosing regimen was consistent, with all patients receiving omeprazole 20 mg twice daily. Regarding the duration of therapy, most patients (82.2%) received PPI treatment for less than 7 days. A smaller proportion of patients (16.8%) were treated for 7–14 days, while only 0.93% received therapy for 14–21 days.

Table 3. PPI therapy overview.

Overview	Frequency n (%)
Type of PPI	
Omeprazole	107 (100)
PPI Dosage	
Omeprazole	
2 x 20 mg/day	107 (100)
PPI Duration of Administration	
Omeprazole	
2 x 20 mg <7 day	88 (82.2)
2 x 20 mg 7-14 day	18 (16.8)
2 x 20 mg 14-21 day	1 (0.93)

The findings of this study demonstrate a highly uniform prescribing pattern, with all patients receiving omeprazole at a standard dose of 20 mg twice daily and the majority undergoing short-term therapy (<7 days). The prescribing pattern may vary across different regions. A study of 62 primary care practices in England found that omeprazole was among the widely dispensed medications [25]. Pantoprazole, a newer drug, was identified as the most frequently prescribed PPI in a study conducted in the Republic of Srpska, Bosnia and Herzegovina [26]. This variation reflects regional prescribing policies, physician preference, or perceived safety advantages. The dominance of a single PPI (omeprazole in this study) is likely attributable to its wider availability and Indonesian healthcare policy. However, this homogeneous pattern could lead to ineffective prescribing when not continuously reviewed, as shown by a previous study in Malaysia, which urges healthcare professionals to review PPI use [27].

Appropriateness of PPI Indication

The appropriateness of PPI indications, doses, and durations is presented in Table 4. Of the 107 prescriptions included in this study, nearly half (n = 50; 46.7%) were classified as inappropriate. This occurred in patients without documented diagnoses of dyspepsia, GERD, or gastric ulcer. Among patients with appropriate indications (n = 57; 53.3%), dyspepsia was the most common diagnosis (n = 49; 45.8%), followed by gastroesophageal reflux disease (GERD) (n = 7; 6.5%) and gastric ulcer (n = 1; 0.9%).

Table 4. Appropriateness of PPI indications.

Clinical Diagnosis	Appropriate n (%)	Inappropriate n (%)
Dyspepsia	49 (45.8)	
GERD	7 (1.9)	
Gastric Ulcer	1 (0.9)	
Non-dyspepsia, non-GERD and non-gastric ulcer		50 (46.7)
Total	57 (53.3)	50 (46.7)

Inappropriate PPI use was observed among patients with non-dyspepsia, non-GERD, and non-gastric ulcer diagnoses. Possibly the use was intended as prophylaxis for side effects of using certain medicines, such as non-steroidal anti-inflammatory drugs (NSAIDs). Such empirical prescribing has been widely recognized as a key contributor to PPI overuse. Therefore, the high rate of inappropriate use observed in this study is likely driven by a combination of diagnostic uncertainty, documentation gaps, and habitual prescribing practices.

In contrast, GERD and peptic ulcer disease were recorded in only 1.9% and 0.9% of cases, respectively. Given that these conditions represent primary indications for PPI therapy, their low prevalence may not necessarily reflect true disease burden but rather underdocumentation or variability in diagnostic practices. This further supports the possibility that clearly established clinical diagnoses do not consistently guide prescribing decisions.

Dyspepsia accounted for the largest proportion of indications (45.8%). Although dyspepsia is commonly considered an indication for PPI therapy, many cases are functional in nature, in which the benefit of prolonged PPI use remains uncertain. Current evidence suggests that PPI therapy in functional dyspepsia should be carefully evaluated, with strategies such as dose reduction, on-demand therapy, or switching to H2-receptor antagonists recommended to minimize unnecessary exposure [13]. The high proportion of dyspepsia-related prescribing in this study may therefore contribute substantially to the observed inappropriate use

From a clinical perspective, these findings highlight the need for improved diagnostic accuracy and more rational prescribing practices. The frequent initiation of PPI therapy without appropriate indications contributes to unnecessary medication use and may expose patients to avoidable harm. Previous studies have shown that inappropriate PPI use remains common in clinical practice [5]. Moreover, such inappropriate use has been associated with adverse outcomes, further underscoring the importance of ensuring appropriate indications for therapy.

Appropriateness of PPI Dose

The appropriateness of PPI dosage according to clinical diagnosis is presented in Table 5. Among prescriptions with appropriate indications, nearly half are classified as inappropriate dosing, which comes from patients with dyspepsia (n = 49, 45.8%). All patients with gastroesophageal reflux disease (GERD) (n = 7; 1.9%) and gastric ulcer (n = 1; 0.9%) received appropriate dosing with the same regimen.

Table 5. Appropriateness of PPI dose.

Clinical Diagnosis	**Dosage**	**Appropriate n (%)**	**Inappropriate n (%)**
Dyspepsia (n=49)	20 mg twice daily	-	49 (45.8)
GERD (n=7)	20 mg twice daily	7 (1.9)	-
Gastric Ulcer (n=1)	20 mg twice daily	1 (0.9)	-
Total		8 (14.0)	49 (86)

In this study, although omeprazole was consistently prescribed at a 20 mg strength, the predominant regimen was 20 mg twice daily across all clinical indications, including dyspepsia, GERD, and gastric ulcer. This practice was not in accordance with clinical guidelines. According to the dosing criteria applied, 20 mg once daily is recommended for symptomatic GERD without esophageal lesions, uninvestigated dyspepsia, and epigastric pain or burning symptoms.

However, the observed prescribing pattern suggests that dosing was not differentiated according to clinical indication. From a guideline perspective, PPI therapy is classified into low-, standard-, and high-dose regimens based on clinical indication, disease severity, and treatment purpose. In most cases, standard dosing (omeprazole 20 mg once daily) is sufficient for common acid-related conditions. In contrast, higher-intensity regimens, including twice-daily dosing, are reserved for more severe or refractory disease [13]. Therefore, the widespread use of 20 mg twice daily, irrespective of indication, reflects a lack of dose individualization and a deviation from guideline-based recommendations.

The high prevalence of inappropriate dosing observed in this study is consistent with previous studies reporting that PPI prescribing is often misaligned with clinical guidelines, reflecting suboptimal adherence to evidence-based practice [28].

Accuracy of Administration Duration

The appropriateness of PPI treatment duration according to clinical diagnosis is shown in Table 6. Among patients with an appropriate indication (n=57), the majority (84.2%) have an appropriate duration. Dyspepsia is the most common clinical diagnosis with appropriate treatment duration. In contrast, all patients with GERD and gastric ulcer were classified as

receiving an inappropriate treatment duration, predominantly less than 7 days (10.5% and 1.8%, respectively), with 1 GERD case (1.8%) treated for 7–14 days. Overall, appropriate treatment duration was observed in 48 patients (84.2%), while 9 patients (15.8%) received an inappropriate duration.

Table 6. Accuracy of administration duration.

Clinical Diagnosis	Duration	Appropriate n (%)	Inappropriate n (%)
Dyspepsia	<7 days	37 (64.9)	-
	7-14 days	11 (19.2)	-
	>14 days	-	1 (1.8)
GERD	<7 days	-	6 (10.5)
	7-14 days	-	1 (1.8)
Gastric Ulcer	<7 days	-	1 (1.8)
Total		48 (84.2)	9 (15.8)

The underlying clinical indication primarily determines the duration of PPI therapy. Long-term therapy is recommended for conditions associated with significant mucosal damage or acid hypersecretion, such as erosive GERD, Barrett's esophagus, peptic strictures, and Zollinger–Ellison syndrome. In contrast, short-term use is generally indicated for the initial management of GERD, Helicobacter pylori eradication, and peptic ulcer disease. In contrast, conditions such as functional dyspepsia require more cautious and periodically reassessed use [13].

All patients with GERD and gastric ulcer received treatment durations of less than 7 days. This is considerably shorter than recommended durations, which generally require several weeks of therapy to achieve adequate symptom control and mucosal healing. Clinical studies have shown that GERD treatment typically requires 8–12 weeks of PPI therapy [29]. Therefore, the shorter duration observed in this study may indicate under-treatment and suboptimal therapeutic outcomes.

This discrepancy between dyspepsia and other acid-related conditions suggests inconsistencies in aligning treatment duration with clinical indication. While shorter durations may be appropriate for dyspepsia, longer durations are required for GERD and peptic ulcer disease. The predominance of treatment durations of less than 7 days in these groups may reflect premature discontinuation or limited follow-up, which could compromise therapeutic effectiveness [5].

Overall, although adherence to the recommended duration appears relatively good in certain conditions, there remains a tendency toward insufficient treatment in indications that require longer therapy. These findings highlight the need for more individualized treatment planning and regular reassessment to ensure optimal and rational PPI use in primary care.

Potential Drug Interaction

The distribution of potential drug interactions associated with proton pump inhibitor (PPI) use is presented in Table 7. 319 drug combinations were evaluated across 107 prescriptions. The majority of combinations showed no interactions (87.1%). Moderate interactions were identified in a small proportion of cases, most commonly involving simvastatin (3.1%). Minor interactions were more frequently observed, particularly with vitamin B12 (6.0%) and glimepiride (3.1%), while interactions with sucralfate and ciprofloxacin were rare (0.3% each). Overall, clinically significant interactions were limited, with most PPI co-administrations considered safe.

Table 7. Potential drug–drug interactions with omeprazole.

PPI Drug Interactions	Drug	n	%
Moderate	Simvastatin	10	3.1
Minor	Vitamin B12	19	6.0
	Glimepiride	10	3.1
	Sucralfate	1	0.3
	Ciprofloxacin	1	0.3
No Interactions	-	278	87.1
Total combinations	Total	319	100

These findings are consistent with the known pharmacological profile of PPIs, for which numerous potential drug–drug interactions have been described. PPIs may influence the absorption and bioavailability of concomitant medications by increasing gastric pH. The omeprazole–simvastatin interaction is a CYP3A4-mediated pharmacokinetic interaction in which omeprazole may mildly inhibit simvastatin metabolism, leading to increased systemic exposure. Although generally of low clinical significance, it may increase the risk of statin-related adverse effects in high-risk patients, such as the elderly or those on high doses or multiple medications [30].

In adults, the clinical relevance of even minor or moderate interactions should not be underestimated. Polypharmacy and age-related changes in pharmacokinetics and pharmacodynamics may increase susceptibility to adverse effects, highlighting the importance of careful medication review in this population. The findings of this study have important implications for clinical practice, particularly in the management of patients aged 46 years and older. Although most patients received appropriate treatment durations and most drug–drug interactions were of low clinical significance, substantial concerns remain regarding the appropriateness of indications and dosing. Nearly half of PPI prescriptions lacked appropriate clinical indications, and most patients received dosing regimens that did not align with guideline-based recommendations. In addition, shorter-than-recommended treatment durations were observed in conditions that require longer therapy, suggesting potential undertreatment.

Taken together, these findings highlight the need for more rational PPI prescribing. Inappropriate use, including incorrect indications, excessive dosing, and suboptimal duration, has been widely reported and remains a persistent issue in clinical practice. Importantly, prolonged or inappropriate PPI use has been associated with a range of adverse outcomes, including increased risk of fractures, kidney disease, vitamin deficiencies, and infections [14]. These risks further emphasize the clinical consequences of non-adherence to guideline-based prescribing.

These concerns are particularly relevant in adults aged 46 years and more, where inappropriate prescribing is often closely linked to polypharmacy and multiple comorbidities [31]. Age-related changes in pharmacokinetics and pharmacodynamics, combined with complex medication regimens, may further increase susceptibility to adverse drug events, even when interactions are classified as low severity.

From a clinical perspective, these findings underscore the need for a more structured and individualized approach to PPI prescribing in older patients. This includes ensuring that therapy is initiated for appropriate indications, selecting doses based on clinical need, and tailoring treatment duration to the underlying condition. Regular medication review is essential for identifying unnecessary therapy, optimizing dosing, and reassessing ongoing treatment. In addition, deprescribing or step-down strategies should be considered, particularly in patients receiving long-term or empirically initiated therapy.

Given that older adults with multimorbidity and polypharmacy are particularly vulnerable to medication-related adverse effects, understanding current prescribing patterns and evaluating the appropriateness of PPI use remain essential. In this context, careful assessment of both the safety of continued therapy and the potential for deprescribing is important for optimizing treatment outcomes and minimizing unnecessary exposure [15].

Strengths and Limitations

This study provides valuable real-world data on PPI prescribing patterns among older adults in a primary healthcare setting in Indonesia. It offers a comprehensive evaluation of rational PPI use, including the appropriateness of indication, dosing, duration, and potential drug–drug interactions. In addition, the use of a relatively large source population (n = 1,997) strengthens the representativeness of the findings within the study setting. It enhances the relevance of the results to routine clinical practice, particularly among elderly patients, who are more vulnerable to inappropriate prescribing and polypharmacy.

However, several limitations should be acknowledged. First, the study's retrospective design may limit the completeness and accuracy of the data, as it relies on information documented in medical records. Second, excluding incomplete or illegible records may introduce selection bias. Third, clinical diagnoses were based solely on documented records without microbiological or endoscopic confirmation, which may affect diagnostic accuracy. In addition, the absence of follow-up data prevents assessment of clinical outcomes, making it difficult to determine the direct impact of inappropriate PPI use on patient health. Finally, as the study was conducted in a single primary healthcare center and utilized a sampled population, the generalisability of the findings to other settings may be limited.

Conclusions

This study identified four key findings in PPI prescribing among older adults in a primary care setting: a high rate of inappropriate indications (46.7%), substantial inappropriate dosing (86.0%), generally appropriate treatment duration with evidence of potential under-treatment in GERD and gastric ulcer cases, and predominantly low-risk drug–drug interactions. Collectively, these findings indicate important gaps in the rational use of PPIs, particularly regarding indication documentation and dose individualization. To improve prescribing quality in primary care, several practice-oriented measures are recommended. These include routine prescribing audits to monitor PPI use, implementation of structured indication documentation in medical records to ensure prescribing transparency, and pharmacist-led medication review to support dose optimization and deprescribing decisions. Future research should focus on intervention-based studies evaluating the effectiveness of these strategies in improving prescribing appropriateness. In addition, prospective studies assessing deprescribing approaches and their impact on clinical outcomes in older adult populations are needed to support safer and more rational long-term PPI use.

Funding: This study does not receive external funding.

Ethical Clearance: The study was granted ethical approval as an exemption by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Syiah Kuala. This approval was recorded under KEPPKN Registration Number 1171012P and documented with Approval Number 165/EA/FK/2024.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors thank all the contributors

Conflicts of Interest: All the authors declare no conflicts of interest

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