RESEARCH PAPER

Association Between Chronic Proton Pump Inhibitor Use and Hypomagnesemia Among Patients with Chronic Kidney Disease

Huma Andleeb Choudhary[1], Gohar Ali Khan[2], Aiman Tufail[3], Waseem Ahsen[4], Meshqat Ullah Khan[5], Shahid Ahmed[6]

[1]Women Medical Officer, Senior Registrar, Department of Internal Medicine, Govt General Hospital Samanbad, Faisalabad, Punjab, Pakistan
[2]Assistant Professor, Department of General Medicine, Khalifa Gul Nawaz Teaching Hospital/ Bannu Medical College, Bannu, KP, Pakistan
[3]House Officer, Department of Medicine, Civil Hospital LUMHS Hyderabad, Sindh, Pakistan.
[4]Professor, HOD Medicine, Islam Medical College / Islam Central Hospital, Sialkot, Punjab, Pakistan.
[5]Speciality Registrar, Department of Internal Medicine, Khalifa Gulnawaz Teaching Hospital, Bannu, KP, Pakistan.
[6]Professor, Department of Medicine and Allied, Liaquat College of Medicine and Darul Sehat Hospital, Karachi, Sindh, Pakistan.

***Corresponding:** Gohar Ali Khan,
Assistant Professor, Department of General Medicine,
Khalifa Gul Nawaz Teaching Hospital/ Bannu Medical College, Bannu, KP, Pakistan.
Email: goharalikhan715@yahoo.com

Received: 12-08-2026, Revised: 28-09-2026, Accepted: 11-10-2026, Published: 25-10-2026

ABSTRACT

Background: Proton pump inhibitors (PPIs) are commonly used drugs which have the potential to impair intestinal magnesium absorption. Electrolyte disturbances may be especially problematic if someone has chronic kidney disease (CKD) and takes medications for a long time.

Objective: To determine the association between chronic PPI use and hypomagnesemia among patients with CKD.

Methods: A comparative analytical cross-sectional study was conducted at Government General Hospital, Samanabad, Faisalabad, from 1st February 2026 to 30th July 2026. A total of 120 patients with CKD were included, comprising 60 chronic PPI users and 60 non-users. Groups were compared for serum magnesium levels and hypomagnesemia was considered to be serum magnesium less than 1.7 mg/dL. Logistic regression analysis was employed to evaluate the relationship between PPI use and hypomagnesemia, adjusting for other potential confounders.

Results: PPI users had significantly lower mean serum magnesium levels than non-users (1.78 ± 0.29 mg/dL vs 1.93 ± 0.31 mg/dL, respectively, p=0.008). The prevalence of hypomagnesemia was higher in PPI users than non-users (p=0.049). The unadjusted odds ratio was 2.31 (p=0.049). The association was not statistically significant; however, after adjustment for potential confounders (p=0.079).

Conclusion: Chronic PPI use was associated with lower serum magnesium levels and a higher frequency of hypomagnesemia among patients with CKD, although the adjusted association was not statistically significant. Further studies with larger samples are needed to clarify this relationship.

Keywords: Chronic kidney Disease, Proton Pump Inhibitors, Hypomagnesemia, Serum Magnesium, Electrolyte Disturbances

How to cite this article: Choudhary HA, Khan GA, Tufail A, Ahsen W, Khan MU, Ahmed S. Association Between Chronic Proton Pump Inhibitor Use and Hypomagnesemia Among Patients with Chronic Kidney Disease. IJDDT. 2026;16(89s): 19-24; DOI: 10.25258/ijddt.16.89s.3

INTRODUCTION

Chronic kidney disease (CKD) is a significant global health problem associated with sustained abnormalities in kidney structure or function that have significant implications for cardiovascular health, electrolyte homeostasis, and long-term survival.[1] The Global Burden of Disease study estimated that in 2021, around 673.7 million people were estimated to be living with CKD, reflecting the considerable and increasing burden of CKD in terms of morbidity and mortality globally.[2]

Patients with CKD are especially susceptible to mineral and electrolyte disturbances, as the kidneys are a major regulator of the balance of magnesium, potassium, calcium, and other important electrolytes.[3] The ability of kidneys to handle magnesium can change as kidney function decreases, which can make clinical management more challenging for these patients; therefore, it is important to identify potentially modifiable medication-related risk factors in the care of patients with CKD.[4]

Proton pump inhibitors (PPIs) such as omeprazole, pantoprazole, esomeprazole, and lansoprazole are

commonly prescribed for gastroesophageal reflux disease (GERD), peptic ulcer disease (PUD), and for gastrointestinal complications in certain patients on long-term therapy.[5] These agents are generally safe to use, but chronic use of PPIs has been linked to some potential side effects such as hypomagnesemia.[6] This association is thought to be due to decreased intestinal magnesium absorption, which may be mediated by changes in intestinal magnesium transport pathways.[7] An observational meta-analysis of 131,507 patients showed that use of PPIs was associated with hypomagnesemia, which occurred in 19.4% of patients compared to 13.5% of non-users.[8] The use of PPIs had an adjusted OR of 1.71 (95% CI 1.33-2.19) for hypomagnesemia, and high-dose use had an even higher OR.[8]

In a 2023 study of PPI-associated hypomagnesemia in patients with severe hypomagnesemia, renal impairment was independently associated with PPI-related hypomagnesemia (OR 3.85, 95% CI 2.58-5.75), as well as diuretic use and high-dose PPI therapy.[9] Patients receiving PPI therapy were more likely to experience hypomagnesemia than those who were not taking them (69.7% vs. 35.7%).[9]

Moreover, PPI use was also associated with increased risk of hypomagnesemia in patients on hemodialysis compared to those who were not taking PPIs in a 2022 systematic review and meta-analysis (pooled OR 2.79, 95% CI 1.95-4.00).[10] The results suggest a possible role of chronic acid-suppressive therapy in magnesium disturbances in those with poor renal function.[10] The association can differ based on the level of CKD, PPI use, and other clinical factors, however, and should be studied in particular patient populations.[10]

This issue holds special clinical significance in Pakistan since excessive PPI usage and electrolyte disturbances are common in day-to-day practice.[11] In 2025, the cross-sectional study conducted at Hayatabad Medical Complex, Peshawar, revealed that hypomagnesemia was found in 51.5% of patients with PPI use; longer duration of PPI use and diabetes mellitus were identified as important associated factors.[11]

These local findings add to the body of evidence that suggests that PPI use is associated with a decrease in magnesium levels, but specific evidence assessing the association between PPI use and magnesium levels in patients with established CKD is limited. This evidence gap has been well supported, with regard to the association between chronic PPI use and hypomagnesemia, in the population of CKD, and potential confounders included in the investigation included: age, diabetes mellitus, CKD stage, PPI dose and duration, and concomitant diuretic therapy. Accordingly, the present study aimed to determine the association between chronic proton pump inhibitor use and hypomagnesemia among patients with CKD, comparing serum magnesium levels and the frequency of hypomagnesemia between PPI users and non-users. The results could be useful in identifying patients who may be more likely to benefit from more prudent prescribing of PPIs and targeted magnesium monitoring in the blood.

METHODS

A comparative analytical cross-sectional study was performed to evaluate the relationship between chronic proton pump inhibitor (PPI) use and hypomagnesemia in patients with chronic kidney disease (CKD). Serum magnesium levels and the frequency of hypomagnesemia were compared between CKD patients receiving long-term PPI therapy and those not receiving PPIs.

This study was carried out in the Department of Medicine, Government General Hospital, Samanabad, Faisalabad, Pakistan, during 6 months period from 1st February 2026 to 30th July 2026.

In total, 120 patients were included: 60 chronic PPI users and 60 non-users. The sample size was determined pragmatically based on the recruitment ability over the study period. Hughes et al. reported hypomagnesemia in 18.4% of PPI users compared with 6.8% of non-users with CKD.[12]

A non-probability consecutive sampling technique was employed, whereby eligible patients attending the Medicine outpatient department were recruited consecutively. Chronic PPI use was defined as using PPIs for more than three months and non-users as not using PPIs for three months prior.

Adults aged 18 years or older, of either sex, with a documented diagnosis of CKD for at least three months, who were not receiving maintenance dialysis, were included. Patients were eligible for the PPI group if they had been on PPIs for at least three months or if they had not used PPIs for the previous three months. Patients on PPIs for at least 3 months or without PPIs for the last 3 months were included in the PPI group and PPI-free group, respectively. Informed consent was obtained in writing from all participants.

Patients who received maintenance hemodialysis or peritoneal dialysis, patients who had a history of kidney transplantation, patients who had taken magnesium supplements or magnesium-containing antacids or laxatives in the last four weeks, and patients who had persistent vomiting/diarrhea in the last two weeks were excluded. Patients who had previously been diagnosed with a malabsorption disorder, those with an active gastrointestinal disease that causes significant magnesium loss, and those who did not have a complete medication history or serum magnesium levels were also excluded.

After getting approval from the institutional ethical review committee and the permission of hospital administration, data were collected by a structured, pretested questionnaire. Demographic data (age, sex, and BMI) were obtained, as were clinical data (CKD duration, underlying etiology, comorbidities, and estimated glomerular filtration rate (eGFR) and CKD stage). Drug name, daily dose, duration, frequency, and indication for treatment were included for PPI-related information. Potential confounders documented were concomitant medications, especially diuretics, and relevant comorbidities, such as diabetes mellitus. Blood samples were obtained in a standard laboratory fashion to determine serum magnesium, and other biochemical

parameters were obtained from routine laboratory tests or medical records. Hypomagnesemia was considered to be a magnesium level of less than 1.7 mg/dL (or 0.70 mmol/L), when that was the lower limit of the laboratory reference range. The primary outcome was the frequency of hypomagnesemia, while the secondary outcome was the difference in serum magnesium levels between the two groups. Participant confidentiality was maintained using unique identification codes and secure data storage.

IBM SPSS Statistics, version 26, was used for data analysis. The Shapiro-Wilk test and graphical methods were used to check for normality for continuous variables. Variables with a normal distribution were reported as mean±standard deviation, and those that were not normally distributed were reported as median and interquartile range. Categorical variable(s) were reported as frequencies and percentages. The independent-samples t-test and Mann-Whitney U test were used to compare continuous variables. The frequencies of hypomagnesemia were compared among groups using the chi-square test. Binary logistic regression was used to assess the association between chronic PPI use and hypomagnesemia, and the odds ratios (ORs) and 95% confidence intervals (CIs) are presented, both before and after adjusting for other risk factors. The potential confounders were age, sex, CKD stage or eGFR, diabetes mellitus, the use of diuretics, and other relevant medications. A two-sided p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 120 patients with chronic kidney disease were included, comprising 60 chronic proton pump inhibitor (PPI) users and 60 non-users. The mean age was comparable between PPI users and non-users (p=0.49). The two groups of patients were similar in terms of age, with the majority in the 60+ age group. Among the users, 56.7% were males and 53.3% were males among non-users. The mean body mass index was 26.1 ± 4.2 kg/m² among PPI users and 25.7 ± 4.5 kg/m² among non-users. Smoking status was also comparable between the groups, with no statistically significant differences in the baseline sociodemographic characteristics (Table 1).

Table 1

Sociodemographic and clinical characteristics by PPI exposure

Variable	Category	PPI users (n=60)	Non-users (n=60)	p-value
Age (years)	Mean ± SD	56.8 ± 12.1	55.2 ± 13.0	0.49
Age group	18-39 years	8 (13.3%)	10 (16.7%)	0.78
	40-59 years	25 (41.7%)	24 (40.0%)	
	≥60 years	27 (45.0%)	26 (43.3%)	
Sex	Male	34 (56.7%)	32 (53.3%)	0.71
	Female	26 (43.3%)	28 (46.7%)	
Body mass index (kg/m²)	Mean ± SD	26.1 ± 4.2	25.7 ± 4.5	0.61
Smoking status	Current smoker	9 (15.0%)	8 (13.3%)	0.79
	Non-smoker / former smoker	51 (85.0%)	52 (86.7%)	

The median duration of CKD was 4.0 years (IQR: 2.0-7.0) among PPI users and 3.5 years (IQR: 2.0-6.0) among non-users. Stage 3 CKD was the most frequent disease stage in both groups, affecting 46.7% of PPI users and 50.0% of non-users. The most prevalent underlying cause was diabetic kidney disease, followed by hypertensive nephropathy. A higher proportion of patients with PPI use had diabetes mellitus (48.3%) than the non-users (45.0%), and hypertension (70.0%) was also more prevalent in the PPI users than in the non-users (66.7%). The use of other medications that may affect magnesium levels was also comparable between groups, with no statistically significant difference in the clinical characteristics and other medications used (Table 2).

Table 2

CKD characteristics, comorbidities, and concomitant medication

Variable	Category	PPI users (n=60)	Non-users (n=60)	p-value
CKD duration (years)	Median (IQR)	4.0 (2.0-7.0)	3.5 (2.0-6.0)	0.44
CKD stage	Stage 1-2	8 (13.3%)	10 (16.7%)	0.76
	Stage 3	28 (46.7%)	30 (50.0%)	
	Stage 4	16 (26.7%)	14 (23.3%)	
	Stage 5, not on dialysis	8 (13.3%)	6 (10.0%)	
Underlying CKD cause	Diabetic kidney disease	25 (41.7%)	23 (38.3%)	0.88
	Hypertensive nephropathy	18 (30.0%)	20 (33.3%)	
	Other / undetermined	17 (28.3%)	17 (28.3%)	
Diabetes mellitus	Yes	29 (48.3%)	27 (45.0%)	0.71
Hypertension	Yes	42 (70.0%)	40 (66.7%)	0.69
Diuretic use	Any diuretic	24 (40.0%)	22 (36.7%)	0.70
	Loop diuretic	16 (26.7%)	14 (23.3%)	0.67
	Thiazide diuretic	8 (13.3%)	9 (15.0%)	0.79
Other magnesium-affecting medication	Documented use	7 (11.7%)	6 (10.0%)	0.77

Among the 60 chronic PPI users, omeprazole was the most frequently prescribed drug (40.0%), followed by pantoprazole (33.3%) and esomeprazole (16.7%). The standard dose therapy was reported in 73.3% of patients and the high dose therapy in 26.7% of patients. The median duration of PPI use was 10 months (IQR: 5-18), and 41.7% had been taking PPIs for at least 12 months. The majority of patients (80.0%) used PPIs once daily while 20.0% were using twice daily. The most frequent reason for therapy was gastroesophageal reflux disease/dyspepsia (51.7%), followed by peptic ulcer disease/gastritis (28.3%) (Table 3).

Table 3
PPI exposure characteristics among chronic PPI users (n=60)

Variable	Category	n (%) or value
PPI prescribed	Omeprazole	24 (40.0%)
	Pantoprazole	20 (33.3%)
	Esomeprazole	10 (16.7%)
	Lansoprazole / other	6 (10.0%)
Daily dose	Standard dose	44 (73.3%)
	High dose	16 (26.7%)
Duration of use	3-5 months	18 (30.0%)
	6-11 months	17 (28.3%)
	≥12 months	25 (41.7%)
Duration of use (months)	Median (IQR)	10 (5-18)
Frequency	Once daily	48 (80.0%)
	Twice daily	12 (20.0%)
Main indication	GERD / dyspepsia	31 (51.7%)
	Peptic ulcer / gastritis	17 (28.3%)
	Gastroprotection / other	12 (20.0%)

The mean level of Mg in serum was significantly lower in PPI users than non-users (p=0.008). The median serum magnesium level was also lower among PPI users (1.80 mg/dL, IQR: 1.60-1.98) compared with non-users (p=0.001). In PPI users, hypomagnesemia (serum magnesium < 1.7 mg/dL) was found in 31.7% of patients, while in non-users it was found in 16.7% of patients (p=0.049). There was no significant difference between the groups in serum creatinine, estimated glomerular filtration rate, serum potassium, and serum calcium (Table 4).

Table 4
Laboratory parameters and serum magnesium by PPI exposure

Variable	PPI users (n=60) Mean ± SD/Median (IQR)	Non-users (n=60) Mean ± SD/Median (IQR)	p-value
Serum magnesium (mg/dL)	1.78 ± 0.29	1.93 ± 0.31	0.008
Serum magnesium (mg/dL)	1.80 (1.60-1.98)	1.94 (1.72-2.13)	0.001
Hypomagnesemia (<1.7 mg/dL)	19 (31.7%)	10 (16.7%)	0.049
No hypomagnesemia (≥1.7 mg/dL)	41 (68.3%)	50 (83.3%)	
Serum creatinine (mg/dL)	2.1 (1.5-3.2)	2.0 (1.4-3.0)	0.57
eGFR (mL/min/1.73 m²)	34.6 ± 17.8	36.8 ± 18.2	0.51
Serum potassium (mmol/L)	4.5 ± 0.6	4.4 ± 0.5	0.34
Serum calcium (mg/dL)	8.7 ± 0.6	8.8 ± 0.6	0.39

In the unadjusted analysis, chronic PPI use was associated with higher odds of hypomagnesemia (p=0.049). However, after adjustment for potential confounders, the association was no longer statistically significant (p=0.079). In the multivariable model, age, female sex, CKD stage, diabetes mellitus, diuretic use, and eGFR were not independently associated with hypomagnesemia. (Table 5).

Table 5
Association between PPI use and hypomagnesemia

Analysis	Odds ratio (95% CI)	p-value
Unadjusted association	2.31 (1.00-5.32)	0.049
Adjusted model: PPI use	2.18 (0.91-5.22)	0.079
Age (per year)	1.01 (0.98-1.04)	0.48
Female sex	1.21 (0.51-2.87)	0.66
CKD stage (per stage increase)	1.34 (0.91-1.98)	0.14
Diabetes mellitus	1.29 (0.54-3.09)	0.57
Diuretic use	1.58 (0.66-3.80)	0.31
eGFR (per 5 mL/min/1.73 m² increase)	0.96 (0.85-1.08)	0.49

DISCUSSION

The present study was designed to evaluate the association between chronic proton pump inhibitor (PPI) use and hypomagnesemia among patients with chronic kidney disease (CKD). In the results, mean serum magnesium was significantly lower among PPI users than non-users (p=0.008). There was a higher prevalence of hypomagnesemia in PPI users (31.7%) than non-users (16.7%) (p=0.049), suggesting that PPI use may be linked to magnesium depletion in that population. The results would have clinical implications as CKD will affect electrolyte homeostasis and PPIs are known to reduce the absorption of magnesium from the gut. However, the cross-sectional design would not prove causality, and the results should be interpreted within the boundaries of renal function, comorbidities, concurrent use of medications, and a relatively small number of subjects.

The lower serum magnesium levels among PPI users would be consistent with findings from the Atherosclerosis Risk in Communities (ARIC) study published in 2021, which investigated the relationship between PPI use, hypomagnesemia, and cardiovascular outcomes in 4,436 participants.[13] That study was not limited to CKD patients, but provided population-based evidence that was

applicable to the relationship between PPI use and magnesium status.

In line with this, a recent Nakamura et al. 2022 observational study of 264 Japanese outpatients showed that elderly PPI users had significantly lower serum magnesium levels than elderly non-users.[14] These data indicate that PPI exposure may also be linked to reduced magnesium levels, even in the absence of clinical magnesium deficiency. However, differences in age, baseline renal function, and patient selection may account for variations in the frequency of hypomagnesemia between studies.[14]

In addition, the estimated hypomagnesemia frequency among PPI users (31.7%) was generally similar to that found by Recart et al., who studied hospitalized patients who were receiving PPI therapy for long-term use and reported hypomagnesemia in 36% (95% CI 30-43%) of patients in 2021.[15] This is especially significant as it indicates that, in long-term PPI users, hypomagnesemia could be due to underlying renal disease, which also has been associated with low magnesium levels. The hospitalized population in that study, however, was not the same as the CKD population studied here, and results could not be interpreted as a CKD-specific effect of PPI therapy.[15]

The findings of the studies conducted in Pakistan would give regional context. In a cross-sectional study done at the Combined Military Hospital, Peshawar, in 2022, Siddiqi et al. studied the association of long-term use of PPI and serum magnesium levels. They had the same overall problem with magnesium deficiency, similar to long-term acid suppression.[16]

A subsequent quasi-experimental study in Rawalpindi between January 2022 and March 2023 compared patients assigned to omeprazole to those who were given non-PPI acid-suppressive therapy. This is in line with the pattern seen in the results and provides further evidence from the Pakistani population with a lower mean magnesium level in the PPI group when compared with the comparison group. Nevertheless, the different measurement units, study designs, and treatment duration should be considered when comparing the magnitude of the differences.[17]

Dar et al. (2026) provided more direct evidence in a cross-sectional study of 94 patients with diabetic kidney disease (DKD) stage 3-5 not receiving dialysis at Pak-Emirates Military Hospital, Rawalpindi. Of those participating, 61.7% were receiving PPI therapy, and the authors noted a possible association between PPI exposure and hypomagnesemia in this high-risk group.[18]

This study was especially applicable because it involved patients with kidney disease, and not a general medical population. The results of the present study would extend this line of investigation by comparing the frequency of hypomagnesemia between PPI users versus non-users in a wider spectrum of non-dialysis CKD stages, along with the measurement of serum magnesium levels. Both studies, however, had small numbers in each subgroup, which would restrict the accuracy of subgroup estimates.

In a larger study from Pakistan by Hadi et al. (2025), 303 patients were included who were taking PPIs for at least one month at Hayatabad Medical Complex, Peshawar. Hypomagnesemia was found in 51.5% of subjects. The authors also noted a correlation with older age, long-term use of PPIs, diabetes mellitus, and hypertension.[19] The frequency of 31.7% among PPI users in the present study was lower than the 51.5% reported by Hadi et al.2025 The difference could be due to the current study's inclusion of only patients with CKD, a non-user control group, a variation in duration of exposure, and a variation in the selection of participants and laboratory characteristics.[19] The overall prevalence of PPI use in the Peshawar study should not be taken as an unbiased estimate of excess risk due to PPIs, because a non-user group was not included.

The significance of renal impairment and other clinical parameters has also been recognized in the international literature. In 2023, Seah et al. published a study investigating PPI-associated hypomagnesemia in patients with severe hypomagnesemia, and observed that renal impairment was independently associated with PPI-related hypomagnesemia (OR 3.85, 95% CI 2.58-5.75).[20] High-dose PPI therapy (OR 1.96, 95% CI 1.29-2.98), diabetes mellitus (OR 4.62, 95% CI 3.05-7.00), and diuretic use (OR 1.68, 95% CI 1.09-2.61) were also identified as risk factors. Recurrence was more common in the PPI continuation group than the PPI cessation group (69.7% versus 35.7%; p=0.009).[20]

These observations give a possible clinical setting for the present investigation. The adjusted association between PPI use and hypomagnesemia was also increased (adjusted OR 2.18) but not statistically significant (p=0.079). The difference from Seah et al.'s findings may reflect the present study's smaller sample, fewer hypomagnesemia events, and different patient selection. It would thus be inappropriate to conclude that there was no association based on the non-significant adjusted result.[20]

The results of these studies should be interpreted in the context of the study design. The hypothesized results indicated that serum magnesium levels were lower, and the prevalence of hypomagnesemia was greater in CKD patients taking PPIs than in those who were not. The association, however, was not statistically significant after adjusting for the other factors, and the sample size of 120 patients restricted the precision of the regression estimates. Furthermore, the cross-sectional study did not provide information on the temporal order of events between exposure to PPI and magnesium depletion. The observed association may also have been affected by residual confounding due to dietary magnesium intake, nutritional status, gastrointestinal losses, CKD severity, and other medications. The effects of this relationship would be better understood with larger, multicentre studies and repeated magnesium measurements with detailed assessment of PPI exposure in future.

CONCLUSION

Hypomagnesemia was found to be more frequent in patients with chronic kidney disease using proton pump inhibitors chronically, and there was an association between proton pump inhibitor use and low serum magnesium levels. However, the association was no longer statistically significant after adjustment for potential confounders, highlighting the need for cautious interpretation. The results highlight the potential role of reassessing long-term PPI treatment and the need for monitoring of serum magnesium in selected patients with CKD, particularly those with other CKD risk factors. Larger prospective studies are necessary to shed light on and define the independent association and evidence for monitoring practices.

REFERENCES

Romagnani, P., et al., Chronic kidney disease. Nature reviews Disease primers, 2025. 11(1): p. 8.

Tao, W., et al., Burden of chronic kidney disease and its attributable risk factors in 204 countries and territories, 1990–2021: Results from the Global Burden of Disease study 2021. Medicine, 2026. 105(32): p. e50111.

Deabes, A.A. and A. Essa, Fluid and electrolyte imbalance in renal dysfunction. Anaesthesia & Intensive Care Medicine, 2024. 25(5): p. 316-319.

Sadeghpour, M., et al., Unraveling the Mechanisms of Magnesium Supplementation in Alleviating Chronic Kidney Disease Complications and Progression: Balancing Risks and Benefits: Mg Supplementation in Chronic Kidney Disease. Biological Trace Element Research, 2025. 203(5): p. 2539-2549.

Wołowiec, Ł., et al., Pharmacodynamics, pharmacokinetics, interactions with other drugs, toxicity and clinical effectiveness of proton pump inhibitors. Frontiers in Pharmacology, 2025. 16: p. 1507812.

Rzepka, H., P. Stępowski, and M. Tajster, Hypomagnesemia as an underrecognized adverse effect of long-term proton pump inhibitor therapy: literature review. Journal of Education, Health and Sport, 2026. 95: p. 73646-73646.

Ehrenpreis, E.D., et al., A comprehensive review of hypomagnesemia. Disease-a-Month, 2022. 68(2): p. 101285.

Knights, F., et al., Assessment and management of hypomagnesaemia in primary care. bmj, 2026. 394.

Seah, S., et al., Proton-pump inhibitor use amongst patients with severe hypomagnesemia. Frontiers in pharmacology, 2023. 14: p. 1092476.

Wang, C., et al., Safety of proton pump inhibitors: an overview of systematic reviews and meta-analyses. BMJ Evidence-Based Medicine, 2026.

Hadi, K.N., et al., Association of hypomagnesemia with chronic use of proton-pump inhibitors in patients visiting a tertiary care hospital in Peshawar, Pakistan. Pakistan Journal of Medical Sciences, 2025. 41(5): p. 1388.

Hughes, J., et al., Prevalence and outcomes of proton pump inhibitor associated hypomagnesemia in chronic kidney disease. PLoS One, 2018. 13(5): p. e0197400.

Rooney, M.R., et al., Proton pump inhibitor use, hypomagnesemia and risk of cardiovascular diseases: the atherosclerosis risk in communities (ARIC) study. Journal of clinical gastroenterology, 2021. 55(8): p. 677.

Nakamura, N., et al., Monitoring of serum magnesium levels during long-term use of proton pump inhibitors in elderly japanese patients: is it really necessary or not? J Pharm Health Care Sci, 2022. 8(1): p. 35.

Recart, D.A., et al., Prevalence and risk factors of long-term proton pump inhibitors-associated hypomagnesemia: a cross-sectional study in hospitalized patients. Internal and Emergency Medicine, 2021. 16(3): p. 711-717.

Relationship Between Long-Term Proton Pump Inhibitor Use and Serum Magnesium Levels: A Cross-Sectional Study. Life and Science, 2023. 4(3): p. 6.

Khan, A., et al., Effects of Long-Term Proton Pump Inhibitor Use on Serum Electrolytes and Vitamin Levels: A Quasi-experimental Study in Pakistan. Cureus, 2025. 17(4): p. e82102.

Dar, A.R.A., et al., Are Proton Pump Inhibitors a Risk Factor for Hypomagnesemia in Patients with Diabetic Kidney Disease. Pakistan Armed Forces Medical Journal, 2026. 76(1): p. 26-29.

Hadi, K.N., et al., Association of hypomagnesemia with chronic use of proton-pump inhibitors in patients visiting a tertiary care hospital in Peshawar, Pakistan. Pak J Med Sci, 2025. 41(5): p. 1388-1392.

Seah, S., et al., Proton-pump inhibitor use amongst patients with severe hypomagnesemia. Front Pharmacol, 2023. 14: p. 1092476.