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Magnesium Deficiency in South Africa

—Insights from an Expert Consensus Panel

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Abstract

Background: Magnesium is an essential micronutrient, the deficiency of which is associated with chronic diseases such as neurological, cardiovascular and musculoskeletal disorders, posing a considerable health burden. Despite its importance for a healthy life, dietary magnesium intake among South Africans is generally low, increasing the risk of deficiency. In addition, magnesium deficiency often goes unrecognised in clinical practice, highlighting the need for increased awareness and guidance on its diagnosis and management. This article provides practical recommendations from experts, to guide healthcare professionals in the timely diagnosis and management of magnesium deficiency. **Methods:** An expert panel comprising four experts in endocrinology, pharmacology, clinical nutrition and general practice from India and South Africa convened to develop management recommendations for magnesium deficiency. A literature review was conducted to identify key studies on the prevalence, risk factors, diagnosis and treatment of magnesium deficiency. Consensus statements were created based on literature findings and panel discussions. **Results:** The expert panel established nine recommendations focusing on the identification of risk groups, diagnosis, the need for a simplified screening tool and the use of oral magnesium supplementation for the treatment of magnesium deficiency. **Conclusion:** Magnesium deficiency is a prevalent yet often overlooked condition in clinical practice. The expert panel recommends identifying at-risk groups, using a simple screening tool, and treating with oral magnesium supplements to help healthcare professionals in South Africa diagnose and manage the condition more effectively.

Keywords

South Africa, Magnesium Deficiency, Hypomagnesemia, Malnutrition, Magnesium Supplementation, Risk Groups, Expert Recommendations, Screening Tool

1. Introduction

Magnesium (Mg) is a critical micronutrient, recognized by the World Health Organization (WHO) as essential to human health [1]. Deficiency in Mg may lead to serious health consequences since it is involved in crucial physiological processes related to the musculoskeletal system, gene expression, nervous system, cardiovascular system, and immune response [2] [3]. For instance, Mg plays a role in regulating calcium (Ca) entry through ion channels, which affects cardiovascular, muscular, and neurological functions [3]. As a cofactor in more than 300 enzymatic reactions, Mg is involved in key biochemical processes such as DNA repair and energy metabolism [1]-[3]. Furthermore, Mg deficiency is associated with chronic, low-grade inflammation and chronic diseases such as diabetes, osteoporosis, and cardiovascular diseases (CVD) [3].

Despite the importance of Mg for the proper functioning of organ systems, both patients and healthcare providers (HCPs) around the world have limited awareness of the consequences of Mg deficiency. For instance, a nationwide cross-sectional survey assessing the public awareness of diet-related diseases in Poland revealed that less than 50% of the survey respondents were aware that inadequate intake of Ca and Mg may lead to disease development [4]. Furthermore, the challenges in accurately evaluating Mg status lead to Mg deficiency often being overlooked in clinical settings [5]. Consequently, it is essential to educate both HCPs and the public about the implications of Mg deficiency and to provide guidance on effective management strategies [6]. To achieve this objective, an expert panel was convened to identify population subgroups at risk of Mg deficiency, particularly in South Africa, and to develop recommendations for its screening, diagnosis, and treatment. This article summarizes the recommendations of the expert panel and aims to present practical guidance on the clinical management of Mg deficiency in South Africa.

2. Methods

A panel of four experts in endocrinology, pharmacology, clinical nutrition, and general practice from India and South Africa convened with the objective of creating practical recommendations on the diagnosis and treatment of Mg deficiency. Discussions focused on the following topics related to Mg deficiency: 1) causes; 2) prevalence; 3) diagnosis; 4) disease states; and 5) treatment. A PubMed-based literature search was conducted to identify key publications for each topic (Supplementary **Table 1**). Draft consensus statements were then prepared and

discussed during a virtual meeting held in April 2023 using the modified-Delphi method. The statements were further refined through subsequent rounds of review by the expert panel.

3. Results

A summary of the recommendations proposed by the panel for Mg deficiency diagnosis and treatment is provided in Table 1.

Table 1. Overview of the consensus statements.

Drivers of Mg deficiency	
Consensus statement 1	Dietary intake of Mg among South Africans is low and the reasons for it include increased consumption of processed foods, growth of food in nutrient-poor environments, and socioeconomic factors that lead to low dietary diversity.
Prevalence and diagnosis of Mg deficiency	
Consensus statement 2	Mg deficiency is commonly observed in clinical practice but is largely unrecognised as Mg levels are rarely evaluated and clinicians are unaware of the clinical states in which deficiency may occur.
Consensus statement 3	Diagnosing Mg deficiency is challenging as the serum Mg test is not always accurate or reliable, and access to accurate diagnostic tests may be limited.
Risk factors for Mg deficiency	
Consensus statement 4	Mg deficiency is associated with several chronic diseases like hypertension, diabetes, osteoporosis, CVD, chronic kidney disease (CKD) and metabolic syndrome (MetS) and their clinical manifestation should raise the index of suspicion for Mg deficiency.
Consensus statement 5	Mg deficiency is common in those on long-term proton pump inhibitors (PPIs), and specific population groups like those who engage in intense exercise, those with sleeping difficulties or those experiencing stress or fatigue. The presence of these risk factors should raise the index of suspicion for Mg deficiency.
Recommendations for oral Mg supplementation	
Consensus statement 6a	Oral Mg supplementation should be considered for patients with chronic diseases like hypertension, diabetes, CVD, CKD and MetS, given the association between such diseases and Mg deficiency, and the positive outcomes from intervention studies with Mg.
Consensus statement 6b	Oral Mg supplementation should also be considered for those on long-term PPIs, and specific population groups like those who engage in intense exercise, those with sleeping difficulties or those experiencing stress or fatigue.
Consensus statement 7	Based on the available clinical data and our clinical experience, the therapeutic dose of oral Mg should be 300 mg - 600 mg/day. Long-term treatment (of more than 3 months) may be required.
Consensus statement 8	Based on our clinical experience, prophylactic Mg supplementation may be considered for certain patients after they have been advised on proper dietary habits. The prophylactic dose of oral Mg should be <250 mg/day and should be prescribed for at least 3 months.
Consensus statement 9	Oral Mg supplemented at recommended doses is generally well-tolerated.

3.1. Drivers of Mg Deficiency

Consensus statement 1: Dietary intake of Mg among South Africans is low, and the reasons for this include increased consumption of processed foods, growth of food in nutrient-poor environments, and socioeconomic factors that lead to low dietary diversity [3] [6].

Mg deficiency is often a result of inadequate dietary intake and poor uptake of Mg [5] [6]. Many large population groups in various countries do not meet the recommended dietary allowance for Mg, putting them at risk of Mg deficiency [6]. For instance, 44% to 68% of adult South Africans consume less than 67% of the daily recommended Mg intake, varying by ethnic group [7].

Low socioeconomic status significantly impacts dietary Mg intake. Foods high in fat and/or sugar are often more energy-dense and less expensive than micronutrient-rich foods such as fruits and vegetables, leading to unhealthy eating habits [8]. This situation is exacerbated by increasing wealth inequality, which has left over half of the population living below the poverty line, putting them at risk of Mg deficiency [9]. In addition, urbanization has led to a shift from nutrient-rich rural diets to those dominated by highly processed, nutrient-poor foods, including in South Africa, where the consumption of processed foods is on the rise [6] [10]. Moreover, the Mg content of agricultural products like wheat has declined by nearly 20% over the past 50 years due to declining soil quality [6].

Alcohol consumption also increases the risk of Mg deficiency, as it can lead to Mg losses from tissues and elevate Mg excretion rates by up to three times [6] [11]. According to the South African Demographic and Health Survey (SADHS) 2016, up to 11% of women and 45% of men in the age group of 20 years old reported consuming alcohol within the week prior to the survey, underscoring the potential risk of Mg deficiency in this population [12]. The survey also reported that "problem drinking," assessed using the "Cutting down, Annoyance by criticism, Guilty feeling, and Eye-openers" (CAGE) test, was present in 3% of women and 16% of men studied [12].

3.2. Prevalence and Diagnosis of Mg Deficiency

Consensus statement 2: Mg deficiency is commonly observed in clinical practice but is largely unrecognised, as Mg levels are rarely evaluated and clinicians are unaware of the clinical states in which deficiency may occur [6].

Hypomagnesemia is typically defined as serum Mg levels below 0.7 mmol/L [5]. However, as serum Mg levels are not frequently assessed (refer to the discussions under consensus statement 3), this discussion will focus on overall Mg deficiency rather than hypomagnesemia based on serum levels alone.

While the prevalence of Mg deficiency may be as high as 30% in some countries, it is highly underestimated in clinical practice, as clinicians seldom assess Mg levels and may miss moderate or subclinical signs of deficiency [5] [6]. The diverse and non-specific symptoms of Mg deficiency, such as depression, fatigue, muscle spasms, or arrhythmias, can overlap with those of other electrolyte imbalances,

complicating the diagnostic process [5]. Diagnosing subacute or chronic Mg deficiency is challenging, as early signs of tissue damage are not easily detectable [6]. A retrospective observational study of hospitalized patients in the U.S. revealed that Mg levels were not assessed at admission for more than 50% of patients, suggesting that this issue is often deprioritized by clinicians [13].

Consensus statement 3: Diagnosing Mg deficiency is challenging, as the serum Mg test is not always accurate or reliable, and access to accurate diagnostic tests may be limited [6].

The lack of simple, cost-effective, and reliable assessment methods poses a significant barrier to diagnosis [6]. Although serum Mg tests are widely available, they are not routinely included in the standard "electrolyte panel" [6]. Furthermore, since serum Mg constitutes less than 1% of total body Mg, normal serum levels do not necessarily exclude Mg deficiency [6]. However, serum Mg testing is inexpensive and can serve as a complementary measurement to confirm Mg deficiency [6]. Other methods, such as Mg load retention tests, are time-consuming and difficult to obtain [6]. Therefore, a simple, straightforward, and reliable screening tool for Mg deficiency is needed.

3.3. Mg Deficiency and Chronic Diseases

Consensus statement 4: Mg deficiency is associated with several chronic diseases such as hypertension, diabetes, osteoporosis, CVD, chronic kidney disease (CKD), and metabolic syndrome (MetS), and their clinical manifestation should raise the index of suspicion for Mg deficiency [6].

Mg deficiency is associated with several chronic diseases prevalent in South Africa. For instance, a dietary Mg intake of less than 200 mg/day was found to be independently associated with an increased risk of hypertension, with a stronger association among overweight or obese individuals [14]. A WHO-Strategic Advisory Group of Experts (SAGE) study found that over 75% of South African adults aged 50 years and older have hypertension, suggesting a potentially high prevalence of Mg deficiency in South Africa [15].

A prospective cohort study revealed that high Mg intake is associated with a 15% lower risk of type 2 diabetes, compared to low Mg intake [16]. According to the SADHS, 13% of women and 8% of men aged 15 years and older in South Africa have diabetes, further suggesting a possible high prevalence of Mg deficiency in this demographic [12].

A systematic review of 30 clinical trials found a correlation between Mg deficiency and an increased incidence of CVD, cardiac arrhythmias, and mortality [17]. In a case-control study, patients with CKD exhibited significantly lower serum Mg levels, which were associated with a higher risk of CVD [18]. In addition, a population-based cohort study reported a CKD prevalence of 6.7% in rural South Africa, increasing the risk of Mg deficiency in this group [19]. Pooled data show a prevalence of 1.3% for stroke and 4.3% for coronary heart disease in South Africans, which further raises the risk of Mg deficiency in this population [20].

Mg deficiency is also associated with abnormal Ca metabolism, potentially leading to bone loss and osteoporosis [3]. Furthermore, Ca supplementation in individuals with osteoporosis can lead to Mg deficiency due to competitive inhibition for absorption [6]. A pooled analysis of 4 observational studies found that women with osteoporosis had lower serum Mg levels [21]. A retrospective analysis estimated that 35.9% of patients aged 50 years and older have osteoporosis, thereby putting them at risk for Mg deficiency [22].

MetS, a cluster of metabolic conditions, was prevalent in 43% of a study population in South Africa [23]. MetS is associated with obesity, hypertension, dyslipidemia, and type 2 diabetes, which exacerbate the risks of CVD and CKD [24] [25]. A meta-analysis found that an increase of 150 mg/day dietary Mg intake was associated with a 12% lower risk of developing MetS [25].

Clinicians should be aware of the high prevalence of these chronic conditions in South Africa, which raises the index of suspicion for Mg deficiency in this population.

3.4. Populations at Risk of Mg Deficiency

Consensus statement 5: Mg deficiency is common in those on long-term proton pump inhibitors (PPIs), and in specific population groups such as those who engage in intense exercise, those with sleeping difficulties, or those experiencing stress or fatigue. The presence of these risk factors should raise the index of suspicion for Mg deficiency [6].

According to the US Food and Drug Administration, long-term use of prescription PPIs is linked to Mg deficiency [26]. A systematic review and meta-analysis indicated that PPI use is significantly associated with the development of hypomagnesemia and decreased Mg absorption [27].

Strenuous exercise can also increase the risk of Mg deficiency due to increased urinary and sweat losses, raising Mg requirements by 10% to 20% [28]. Intense exercise may lead to a urinary Mg loss of up to 30%, resulting in a plasma Mg reduction of approximately 10%, with low plasma Mg concentrations persisting for up to 18 days after strenuous exertion [29].

A systematic review revealed that higher Mg intake was correlated with better sleep quality [30]. A prospective cohort study in 3964 participants revealed that those in the highest quartile of Mg intake were 28% less likely to report sleeping for fewer than 7 hours [31].

Chronic stress, often experienced by white-collar workers, may contribute to increased Mg loss [32] [33]. A study on young adults subjected to chronic or subchronic stress found significant reductions in Mg levels after 3 months of exposure [33]. Conversely, Mg deficiency may also increase susceptibility to stress by upregulating stress responses, with several studies demonstrating a relationship between Mg deficiency or low Mg intake and increased stress [34].

In addition, Mg deficiency has also been associated with chronic fatigue syndrome (CFS). A case-control study showed that patients with CFS had lower red

blood cell Mg concentrations compared to healthy control subjects (1.60 mmol/L vs 1.70 mmol/L; $p < 0.001$) [35]. Furthermore, CFS could also lead to stress and anxiety, resulting in Mg deficiency [35].

3.5. Recommended Patient Groups for Oral Mg Supplementation

Consensus statement 6a: Oral Mg supplementation should be considered for patients with chronic diseases like hypertension, diabetes, osteoporosis, CVD, CKD, and MetS, given the association between such diseases and Mg deficiency, and the positive outcomes from intervention studies with Mg [6].

Oral Mg supplementation is effective for managing various chronic conditions [2]. For example, a meta-analysis of 34 randomized controlled trials (RCTs) found that Mg supplementation at 300 mg/day significantly reduced systolic blood pressure (SBP) and diastolic blood pressure (DBP) [36]. A systematic review and meta-analysis of 25 RCTs demonstrated improved glucose parameters in diabetic patients receiving Mg supplementation [37]. Another meta-analysis revealed significant improvements in fasting blood glucose levels among diabetics who received Mg supplementation, with greater benefit observed in those with hypomagnesemia [38]. An observational prospective study on patients with a fragility femoral fracture found that oral Mg supplementation with a dosage of 375 mg for 30 days improved pain management, quality of life, and balance [39]. Given the potential role of vitamin C in osteoporosis, fracture prevention, and bone mineral density, combined vitamin C and Mg supplementation could be beneficial for these patients [40].

A meta-analysis of 24 RCTs found that Mg supplementation may positively affect type 2 diabetes and associated cardiovascular risk factors [38]. A cross-sectional study showed that increased Mg intake reduced the risks of fatal coronary heart disease and sudden cardiac death by 7% and 18%, respectively [41]. Mg supplementation has also shown positive effects on CKD-mineral bone disorder in hemodialysis patients, as demonstrated in a systematic review and meta-analysis of 8 studies [42]. Another meta-analysis of 22 RCTs reported beneficial effects of Mg supplementation on individual components of MetS, including SBP, DBP, and lipid profiles [25]. A RCT involving patients with MetS showed that 16 weeks of oral supplementation of 382 mg Mg improved the condition by reducing blood pressure, hyperglycemia and hypertriglyceridemia [43].

Consensus statement 6b: Oral Mg supplementation should also be considered for those on long-term PPIs, and specific population groups such as those who engage in intense exercise, those with sleeping difficulties, or those experiencing stress or fatigue [6].

A study examining oral Mg supplementation in PPI users found that high-dose Mg supplementation (30 - 40 mmol/day) partially corrected Mg deficiency [44]. Given that long-term PPI use is common in patients with gastrointestinal (GI) concerns [26], enteric-coated tablets, which pose a lower risk of GI irritation, could be beneficial for these patients [45].

A study involving active college students who took oral 350 mg Mg for 10 days reported significantly reduced muscle soreness and improved perceived recovery after Mg supplementation, with some evidence suggesting a positive impact on performance [46]. An RCT conducted with men in a strength-training program showed a greater increase in peak knee-extension torque among those receiving Mg supplementation compared to the placebo [47]. Mg supplements containing B vitamins should be considered for those who engage in intense exercise. However, a study involving 95 endurance athletes revealed that 70.5% of them consumed less than the recommended amount of vitamin B5, which is involved in muscle cell energy metabolism [48]. Additionally, Mg supplements containing ginseng could be beneficial, as short-term ginseng supplementation has been shown to reduce exercise-induced muscle damage by promoting inflammatory adaptation [49].

A study involving 46 elderly participants demonstrated significantly improved sleep time, sleep efficiency, and reduced insomnia with 8 weeks of 500 mg Mg supplementation versus placebo [50]. An RCT involving 264 healthy, Mg-deficient adults experiencing stress showed over a 40% reduction in stress and fatigue after receiving 300 mg of oral Mg daily for 8 weeks [51]. A systematic review of 10 studies on ginseng supplementation found significant improvements in fatigue scores in the supplemented group compared to the control group in 7 of the studies [52].

3.6. Recommended Dose of Oral Mg for Treatment and Prevention of Mg Deficiency

Consensus statement 7: Based on the available clinical data and our clinical experience, the therapeutic dose of oral Mg should be 300 - 600 mg/day. Long-term treatment (of more than 3 months) may be required [6] [53].

Consensus statement 8: Based on our clinical experience, prophylactic Mg supplementation may be considered for certain patients after they have been advised on proper dietary habits. The prophylactic dose of oral Mg should be <250 mg/day and should be prescribed for at least 3 months [6] [53].

Clinical judgement should guide appropriate Mg prescribing practices for both index and subclinical Mg deficiency, irrespective of the results of objective assessment measures [6]. Dosage recommendations should be patient-specific, accounting for factors such as increased body weight, which is common in patients with chronic diseases [54].

Based on clinical data and their clinical experience, the expert panel recommends treating hypomagnesemia, including in those with chronic conditions, with a daily therapeutic dose of 300 mg to 600 mg oral Mg [6]. As a reference, the standard recommended daily allowance for women and men is 300 mg to 320 mg, and 400 mg to 420 mg, respectively. Oral Mg can be prescribed for 3 months before re-evaluation, with long-term supplementation usually needed.

Although evidence on the benefits of low-dose oral Mg supplementation is lim-

ited, it may still be beneficial for the general population, as they often fail to meet the daily recommended intake of Mg [6]. Prophylactic doses should be reserved for patients without chronic conditions or those not at risk for Mg deficiency. Additionally, patients should adjust their diets in conjunction with Mg supplementation [53].

3.7. Safety of Oral Mg Supplementation

Consensus statement 9: Oral Mg supplemented at recommended doses is generally well tolerated [6] [53].

Mg doses of up to 600 mg/day are considered safe and effective [6] [53]. However, the formula and preparation of available oral Mg supplements can affect their bioavailability and tolerability [55].

Mg supplementation is rarely reported to cause symptomatic hypermagnesemia (serum Mg > 1.1 mmol/L) in individuals with normal renal function. However, renal function impairment may be a risk factor for adverse effects related to hypermagnesemia [2]. GI side effects, such as diarrhea, are common indicators of Mg toxicity, along with hypotension, muscle weakness, back pain, confusion, difficulty breathing, and cardiac arrhythmias [2].

In cases of mild Mg overdoses, supplementation and Mg-containing laxatives or antacids should be discontinued, and renal impairment should be assessed [2]. For severe Mg overdoses (serum Mg > 1.1 mmol/L), treatment may involve intravenous (IV) fluids, furosemide, IV calcium gluconate or calcium chloride, and possibly renal dialysis or artificial respiratory support [2].

Clinicians should be aware of potential drug-drug interactions and polypharmacy. For instance, $MgSO_4$ is known to interact with aminoglycoside antibiotics, antacids/laxatives, calcium channel blockers, corticosteroids, diuretics, neuromuscular blocking agents, and vitamin D analogs [56]. Therefore, the prescription of Mg supplements should take into account the patient's medical history and current medication regimen. Patients should be informed about the risk of overdose, with educational materials tailored to those taking supplementation for prevention versus treatment.

4. Discussion

High risk groups for Mg deficiency

The expert panel provided recommendations for identifying population subgroups at high risk for Mg deficiency who may benefit from oral Mg supplementation. This includes individuals with chronic conditions prevalent in South Africa, such as diabetes, osteoporosis, CVD, CKD, and MetS. In addition, Mg deficiency has been linked to long-term use of PPIs, intense exercise, poor sleep, stress, and fatigue.

Diagnosing Mg deficiency

The diagnosis of Mg deficiency should be patient-centric and comprehensive, considering symptoms, diet, lifestyle, and the presence of comorbidities [57]. Cur-

rent screening tools classify risk factors for Mg deficiency into "major" (e.g., diabetes, heart disease) and "minor" diagnostic criteria (e.g., coffee, alcohol, protein consumption) [57]. The panel recommended that meeting one major criterion and two or more minor criteria, or two major criteria without minor criteria, could indicate a risk of Mg deficiency [58]. Factors such as lifestyle, diet, chronic conditions, medications, and clinical signs and symptoms could be included in this assessment tool.

The Mg Deficiency Questionnaire (MDQ), such as the MDQ-62, is a non-invasive tool that provides a clinically useful estimate of Mg status [58]. However, due to its 62 questions, it can be time-consuming. More concise versions, such as the MDQ-23 and MDQ-10, which contain 23 and 10 questions, respectively, have demonstrated similar diagnostic utility while being more convenient than the MDQ-62 [58]. The panel proposed a further simplified questionnaire (**Table 2**) based on their experience to be used alongside a dietary Mg intake survey, such as the validated Mg Food Frequency Questionnaire, which offers a straightforward and reliable method for estimating average daily Mg intake [59]. Although a definitive diagnosis for Mg deficiency cannot be established solely with these tools, fulfilling one or more of the aforementioned criteria should raise the index of suspicion for Mg deficiency, especially if Mg intake is low, and warrants further investigation through laboratory testing [58]. Additional research is needed to explore risk factors and develop more reliable screening and assessment methods for accessible and accurate diagnosis.

Table 2. Simplified Mg deficiency questionaire.

Proposed questions
Do you suffer from chronic diseases such as high blood pressure, diabetes, osteoporosis, CVD, CKD, or MetS?
Are you on long-term PPIs?
Do you engage in intense exercise, or do you frequently experience muscle cramps or soreness?
Are you experiencing fatigue, stress, or sleeping difficulties?
Have you ever been diagnosed with Mg deficiency?

Barriers to managing Mg deficiency

Key barriers to diagnosing Mg deficiency include the presence of varied and non-specific symptoms, the low priority given to diagnosing Mg deficiency in clinical practice, and the challenges associated with diagnosing subclinical Mg deficiency. In addition, alleviating Mg deficiency may be hindered by the cost of Mg supplements or Mg-rich foods, particularly among individuals from lower socioeconomic backgrounds [8]. Since Mg supplements are generally not covered by insurance, cost remains a substantial barrier.

Strategies for managing Mg deficiency

Preventing Mg deficiency relies on HCPs being aware of its prevalence within

specific communities, as well as understanding the dietary and lifestyle practices, associated risk factors, potential for chronic diseases, and overall risk levels in those communities.

Clinicians should be informed about the significance of Mg deficiency to enhance awareness of the condition. Awareness initiatives should emphasize the prevalence of Mg deficiency and its link to chronic diseases in the community, along with the subclinical symptoms associated with it. Clearly communicating recommendations for the diagnosis and treatment of Mg deficiency is also important.

Improving communication between patients and HCPs can improve treatment adherence. Patients should be educated about the benefits of Mg supplementation and the risks of non-compliance, especially if they have co-morbid conditions. Clinicians can support patients by conducting lifestyle audits to help them reassess their dietary choices and healthcare expenditures, thereby improving adherence to treatment plans.

Although subclinical Mg deficiency may be asymptomatic, inadequate Mg intake is widespread [6]. Therefore, prophylactic Mg supplementation may be beneficial even for asymptomatic individuals or those not formally diagnosed with a deficiency.

Given the variety of oral Mg formulations available, the choice of Mg supplement should be tailored to meet individual patient needs. For example, Mg formulations which include ginseng could be beneficial for patients who engage in intense exercise and those experiencing stress, given the demonstrated benefits of ginseng supplementation in these groups. Enteric-coated Mg tablets have minimal GI side effects, making them suitable for patients with GI issues, those on long-term PPI medication, or individuals taking multiple medications, as they are less likely to interact negatively with other drugs in the stomach. Mg supplements containing vitamin C may also be helpful for those with osteoporosis. Chelated capsules provide improved absorption and may be especially beneficial for individuals with malabsorption issues, as well as for those experiencing fatigue, energy loss, or needing support for muscle recovery.

Future research into markers for Mg deficiency and oral Mg supplementation will be essential for shaping prescribing practices.

5. Conclusion

Mg deficiency is a common condition that has significant implications for various chronic diseases. However, it is often overlooked in clinical settings, primarily due to limitations in diagnostic methods. This article offers practical guidance on identifying high-risk groups and managing Mg deficiency to enhance clinical practice and improve health outcomes in South Africa. These recommendations are grounded in current evidence and clinical experience. Nevertheless, additional research is needed to focus on diagnosis and the development of appropriate prophylactic and therapeutic oral Mg supplementation strategies.

Authors' Contributions

V.N., M.J.M., R.M. and S.S.P. participated in an expert roundtable meeting to discuss the recommendations detailed in this manuscript. All authors also reviewed, edited and approved the manuscript.

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Conflicts of Interest

This paper is funded by Procter & Gamble Health. The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article. V.N., M.J.M, R.M. and S.S.P. have received honoraria for expert roundtable participation from Procter & Gamble Health. P.M. and Y.W. are employees of Procter & Gamble.

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Supplementary Information

Table S1. Search queries for literature review. Relevant literature on magnesium (Mg) and guidelines and reviews on the diagnosis and treatment of Mg deficiency were identified on PubMed (March 2023). The search terms below were used for the literature review.

Topic	PubMed search term	Remarks
Mg deficiency		
Prevalence of Mg deficiency	"prevalence"[Title/Abstract AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Hypertension and Mg deficiency	"hypertension"[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Independent PubMed search was also conducted. Articles were screened for their relevancy. Articles not in English were excluded.
Diabetes and Mg deficiency	"diabetes"[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Independent PubMed search was also conducted. Articles were screened for their relevancy. Articles not in English were excluded.
Obesity and Mg deficiency	"obesity"[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Independent PubMed search was also conducted. Articles were screened for their relevancy. Articles not in English were excluded.
CVD and Mg deficiency	"cardiovascular disease "[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Kidney disease and Mg deficiency	"kidney disease "[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Metabolic syndrome and Mg deficiency	"metabolic syndrome"[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Osteoporosis and Mg deficiency	"osteoporosis"[Title/Abstract] AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English and those on primary hyperparathyroidism were excluded.

Continued

PPIs and Mg deficiency	(“proton-pump inhibitors"[Title/Abstract] OR “proton pump inhibitors"[Title/Abstract] OR “proton-pump inhibitor"[Title/Abstract] OR “proton pump inhibitor"[Title/Abstract] OR “PPI"[Title/Abstract] OR “PPIs"[Title/Abstract]) AND ("association"[Title/Abstract] OR "prevalence"[Title/Abstract]) AND ("magnesium deficiency"[Title/Abstract] OR "hypomagnesemia"[Title/Abstract] OR "hypomagnesaemia"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Mg supplementation		
Mg supplementation for hypertension	“hypertension"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Mg supplementation for diabetes	“diabetes"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded
Mg supplementation for obesity	“obesity"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded
Mg supplementation for CVD	“cardiovascular disease"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Mg supplementation for kidney disease	“kidney disease"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Mg supplementation for metabolic syndrome	“metabolic syndrome"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Mg supplementation for the elderly	“elderly"[Title/Abstract] AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Mg supplementation for long-term PPI users	(“proton-pump inhibitors"[Title/Abstract] OR “proton pump inhibitors"[Title/Abstract] OR “proton-pump inhibitor"[Title/Abstract] OR “proton pump inhibitor"[Title/Abstract] OR “PPI"[Title/Abstract] OR “PPIs"[Title/Abstract]) AND (“magnesium supplementation"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.
Low-dose Mg supplementation	("magnesium prophylaxis"[Title/Abstract] OR "low-dose magnesium"[Title/Abstract] OR "low dose magnesium"[Title/Abstract]) AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English, those on intravenous magnesium or in vivo (pre-clinical) trials were excluded.
Tolerability of Mg therapies	(“adverse event”[Title/Abstract] OR “adverse drug reaction”[Title/Abstract]) AND "magnesium supplementation"[Title/Abstract] AND ("2013"[Date - Publication]: "3000"[Date - Publication])	Articles were screened for their relevancy. Articles not in English were excluded.