Clinical Guideline for Detection and Management of Magnesium Deficiency in Ambulatory Care

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Article

Clinical Guideline for Detection and Management of Magnesium Deficiency in Ambulatory Care

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Abstract: *Background:* Magnesium (Mg) deficiency is associated with many common chronic conditions and potentially severe health care outcomes, including cardiovascular disease, cardiovascular risk factors, and diabetes. However, Mg deficiency is underdiagnosed and often underrecognized in the ambulatory health care setting, and nutrition education and training are often limited for health care providers (HCPs). *Methods:* A clinical guideline for detecting and treating Mg deficiency in the ambulatory care setting was developed. A pilot study was conducted in which HCPs received education on Mg and completed pre-test and post-test questionnaires to assess intervention efficacy of the guideline. *Results:* Ten HCPs participated in the pilot study via telephone or face-to-face session. There was a statistically significant increase in general Mg knowledge among HCPs, due to the intervention of presentation of the guideline, with a nonsignificant increase in clinical practice. However, 1-month follow-up survey results showed that HPCs were likely to incorporate Mg assessment and treatment tools from the guideline in their future practice. *Conclusions:* These findings suggest that use of the proposed clinical guideline may increase HCP knowledge and improve the diagnosis and treatment of Mg deficiency.

Keywords: magnesium deficiency; clinical guideline; ambulatory care; lack of knowledge; chronic disease

1. Introduction

Magnesium (Mg) is an essential mineral required for numerous physiological functions [1,2]. Chronic low dietary intake of Mg is widespread and is associated with adverse health outcomes such as hypertension, diabetes, osteoporosis, inflammation, cardiovascular diseases, other risk factors, and some cancers [1–5]. Nutrition education and training (including on Mg) for many health care providers (HCPs), including physicians, nurse practitioners, and physician assistants, among others, is generally limited [6]. Traditional and current HCP training does not incorporate the identification of Mg deficit in the diagnosis of acute and chronic diseases [7]. Schwalfenberg and Genuis [3] reported that trainee programs in physiology, nutrition, and dietetics provide health education on Mg, but discussion of nutritional deficits, including Mg deficiency, is lost in HCP education.

Currently, approximately 60% of adults have inadequate dietary intake of Mg due to common modern dietary practices, medications, and modern farming and cultivation techniques [8,9]. Mg deficiency is associated with increased risk of disease, illness, and complications (e.g., diabetes, hypertension, cardiovascular disorders, and depression), among other conditions. Many signs and symptoms of Mg deficiency are numerous, nonspecific, and widespread [10]. In addition, clinical diagnosis of Mg deficit is not straightforward. Multiple serum reference range values are used [11,12].

Previous studies suggest that increasing HCP education in nutrition can potentially improve recognition of Mg deficiency in the ambulatory setting [3,13,14] and addressing clinician awareness of nutritional Mg deficit can improve health care outcomes. Thus, increased awareness of the importance of Mg, prevention and treatment of Mg deficiency, and the role of this mineral in related disorders are needed in the ambulatory setting. Such awareness can be achieved through educational

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interventions that improve HCP knowledge and skills as well as attitudes regarding competency in that knowledge [15,16]. Targeted interventions for HCPs that use algorithm-based clinical guidelines have been shown to influence provider practice [17]. However, clinical guidelines for identification and treatment of Mg deficiency in the ambulatory care setting do not exist [18].

This study aimed to improve ambulatory HCP knowledge of Mg deficiency and to promote increased identification and management of Mg deficiency in ambulatory health care through a structured guideline leading to use of such knowledge in clinical practice. To organize the best available evidence to support clinical decision-making, improve quality of care, and provide optimal outcomes, a clinical guideline for detecting and treating Mg deficiency in the ambulatory care setting was developed and pilot tested using an educational intervention [18].

2. Materials and Methods

A guideline for recognition and treatment of Mg deficiency in ambulatory care (Clinical Guideline for Magnesium Deficiency, referred to hereinafter as the *guideline*) was developed following a comprehensive review of the peer-reviewed literature and expert advisement on Mg deficiency [18]. The complete guideline is presented in Appendix A. Both the guideline and the intervention were pilot tested in an educational program targeted to ambulatory HCPs [18]. The immediate goals were (1) to improve HCP knowledge regarding Mg deficiency and (2) to influence the incorporation of such knowledge through the adoption of the guideline in clinical practice [17–19]. The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Keiser University (protocol code IRB000FC19DN15, "Improving Healthcare Providers' Detection and Management of Magnesium Deficiency Through a Targeted Intervention and Clinical Guideline," approved December 15, 2019). Informed consent was obtained from all subjects involved in the study.

The guideline was presented as an educational intervention to HCPs either in a group face-to-face session or individually by telephone. Evaluation of intervention effectiveness in enhancing knowledge of Mg in clinical practice was measured via pre- vs post-intervention test questionnaires (Appendix S1) [18]. For the face-to-face and telephone groups, the educational intervention began with administration of the pre-test questionnaire to assess participant knowledge. The questionnaire included 17 questions (13 on Mg knowledge and 4 on Mg use in clinical practice) and was designed to be scored with a Likert-type scale to assess guideline effectiveness. The lead author (S.C.-D.) gave an oral presentation describing the intervention and shared a poster version; copies were provided to participants. The face-to-face group then completed the post-test questionnaire. The telephone group was provided the pre-test questionnaire verbally, the intervention and guideline were discussed, and then the post-test questionnaire was administered.

Mean ± SD scores were calculated pre-test and post-test for all questions ($N = 17$), for general Mg knowledge questions ($n = 13$), and for clinical practice questions ($n = 4$). Pre-test vs post-test mean scores for each set of questions were tested for statistical significance using a paired t test. Additionally, effect size testing was performed for each set of questions using Cohen's D.

One month later, a 6-question follow-up survey (Appendix S2) was administered to assess HCP integration of guideline knowledge and actual application to clinical practice [18]. Each question had 4 possible responses (*rarely*, *sometimes*, *most of the time*, or *always*). Numeric score ranges were assigned for each category; mean ± SD scores for 9 of 10 participants (1 was lost to follow-up) were calculated for each question [18].

3. Results

The guideline was presented as an educational intervention to 10 practitioners. Two HCPs participated in the group face-to-face session and 8 participated individually by telephone. Participant demographics are presented in Table 1.

 doi:10.20944/preprints202501.2016.v1

Table 1. Participant demographics.

Participant ID	Professional experience, y	Gender	Degree	Experience with Mg, y	Presentation type
A1	1–3	Female	APN/MSN	Don't know	Telephone
B2	1–3	Female	APN/MSN	None	Face-to-face session
C3	5–10	Female	APN/DNP	5–10	Telephone
D4	≥10	Female	APN/DNP	5–10	Telephone
E5	1–3	Female	APN/MSN	1–5	Telephone
F6	≥10	Female	APN/MSN	5–10	Telephone
G7	3–5	Female	APN/MSN	5–10	Telephone
H8	5–10	Female	APN/MSN	5–10	Telephone
I9	≥10	Male	MD	5–10	Face-to-face session
J10	1–3	Female	APN/MSN	1–5	Telephone

Abbreviations: APN, advanced practice nurse; DNP, doctor of nursing practice; MD, doctor of medicine; Mg, magnesium; MSN, master of science in nursing.

Improvement in Mg knowledge was statistically significant for the 17-question educational intervention (possible score range = 170–510), with mean ± SD pre-test and post-test scores of 431 ± 46.8 and 492 ± 14, respectively (p = 0.0018; Table 2). The effect size for the teaching intervention was very large (Cohen's D = 1.77).

Table 2. Participant pre-test and post-test scores.

Participant ID	General Mg knowledge (13 questions)		Clinical practice (4 questions)		Total (17 questions)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
A1	340	370	120	120	460	490
B2	340	370	110	120	450	490
C3	260	370	110	100	370	470
D4	320	360	120	120	440	480
E5	350	370	120	120	470	490
F6	320	390	120	120	440	510
G7	300	390	120	120	420	510
H8	290	370	40	120	330	490
I9	360	390	120	120	480	510
J10	330	360	120	120	450	480
Score, mean ± SD	321 ± 30.3	374 ± 11.7	110 ± 24.9	118 ± 6.32	431 ± 46.8	492 ± 14
p value		0.00049		0.35		0.0018
Cohen's D		2.30		0.44		1.77

Abbreviation: Mg, magnesium.

The educational intervention significantly increased participants' general Mg knowledge (questions 1–13; total score range = 130–390), with mean ± SD pre-test and post-test scores of 321 ± 30.3 and 374 ± 11.7, respectively (p = 0.00049). The effect size for increased general knowledge was extremely large (Cohen's D = 2.30).

Increased clinical practice application (questions 14–17; possible score range = 40–120) was observed among HCPs but was not statistically significant, with mean ± SD pre-test and post-test scores of 110 ± 24.9 and 118 ± 6.32, respectively (p = 0.35). The effect size for clinical practice application was small (Cohen's D = 0.44).

Table 3 presents the responses to the follow-up survey administered 1 month after the intervention. Participants reported that the guideline was *sometimes* used (question 1), and they intended to *always* use the guideline as an at-a-glance tool and laboratory reference (question 2). Participants reported that they *always* found this information helpful (question 3). Participants answered *most of the time* when asked about their intention to use Mg deficiency in their differential diagnosis (question 4), their intention to test for serum Mg (question 5), and whether they are treating

 doi:10.20944/preprints202501.2016.v1

their patients for Mg deficiency (question 6). These findings suggest that HCPs were likely to implement Mg assessment in their routine clinical practice after they received the educational intervention.

Table 3. Range of mean scores for 1-month follow-up survey.

Question	Mean score range for each question (n = 9 respondents)			
	Rarely (10–15)	Sometimes (15.1–24.9)	Most of the time (25–34.9)	Always (≥35)
1. Have you used the clinical guideline?		X		
2. Now that you have the clinical guideline, do you feel you have and or will continue to use the **at-a-glance tool** and **laboratory reference** to identify patients at risk for magnesium deficiency?				X
3. Do you find this clinical guideline helpful?				X
4. Do you include magnesium deficiency in your differential diagnosis?			X	
5. Do you test or intend to test for magnesium deficiency?			X	
6. Are you treating patients for magnesium deficiency?			X	

4. Discussion

This study pilot tested an educational intervention on a clinical guideline for recognition and treatment of Mg deficiency for the ambulatory care setting. There was a significant increase in general Mg knowledge among HCPs due to the education intervention, but the increase in clinical practice application was not significant. However, HCP responses to the 1-month post-test survey suggest that they are likely to implement the Mg assessment and treatment tools provided in the guideline in their future clinical practice. These findings strongly support the need for education on and application of the guideline as a tool to improve the recognition, diagnosis, and treatment of Mg deficit in the ambulatory setting.

Despite robust research on the role of Mg in chronic diseases, the importance of Mg for health remains underrecognized due to gaps in knowledge [8,10] and to lack of nutrition education and training for HCPs [6]. In the lead author's (S.C.-D.) more than 25 years of clinical experience, Mg blood testing is ordered notably less frequently in the ambulatory care setting compared with in the hospital. Most current laboratory values for serum Mg reference ranges are not reliable in the ambulatory setting, because patients with Mg deficiency may seem to have normal laboratory values when, in fact, they are deficient because serum Mg falls within traditional normal values [11,12,20,21]. Increased awareness is needed among HCPs in terms of Mg research and how this essential mineral affects several common conditions that present in clinical practice [8,12,22]. The guideline for Mg developed and tested in this study provides a tool to allay this situation [18].

This study substantiated the use of an at-a-glance tool and algorithm-based clinical Mg guideline in modifying clinician practice through increasing knowledge of and recognition of Mg deficiency. Widespread use of this guideline may improve recognition of Mg deficiency in the ambulatory care setting, which may decrease complications related to Mg depletion in common acute and chronic disease states (e.g., cardiac arrythmia, hypertension, or diabetes, among others). This use must be further assessed in a larger follow-up study that includes patient outcomes.

Limitations of this study include its small sample size and lack of a patient outcome measure. Notably, there appeared to be bias in the questions in the clinical segment, as participants seemed to anticipate what the researcher was looking for in terms of the "right answer." This hinderance was resolved by adding the 1-month follow-up survey, which showed that participants found that the clinical guideline (1) was helpful, (2) was being used, (3) incorporated knowledge of Mg deficiency

 doi:10.20944/preprints202501.2016.v1

in the differential diagnosis, (4) increased ordering related to Mg tests in clinical practice, and (5) definitively changed their clinical care. These results showed an inclination among HCPs to change clinical practice, which would not have been noted if this follow-up was not completed.

5. Conclusions

To our knowledge, this pilot study is the first to test a clinical guideline for Mg in the ambulatory setting. Although the study population was small, these highly statistically significant findings suggest that the guideline is useful, and a larger trial is prudent. This study is significant to ambulatory clinical practice because it

- offers an easy-to-use educational intervention shown to increase HCP knowledge of Mg deficiency,
- promotes the diagnosis and treatment of Mg deficit in various specialty ambulatory care practice settings, and
- provides research-updated laboratory values for serum Mg reference ranges germane to the ambulatory care setting.

This study opens to a broader goal: increasing Mg knowledge among clinicians so they can share it with patients. Clinicians should educate patients on and increase their awareness of low Mg in the modern diet, possible effects of medication use on Mg status, and association of low Mg status and immunity on specific disease processes commonly addressed in health care today. Additionally, tools attained by clinicians can improve Mg status monitoring and progress of patients undertaking dietary management, supplementation, and routine testing, which is currently more common in the hospital setting versus the ambulatory setting.

Areas for further research on the application of the guideline and tools presented here may include diet, Mg supplementation type and dosage, patient outcomes, and prevention of Mg deficiency. These efforts may potentially reduce complications of acute and chronic conditions associated with Mg deficiency.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org, Appendix S1: Pre-Test and Post-Test Magnesium Questionnaire With Key; Appendix S2: Post-Intervention 1-Month Follow-Up Survey With Key.

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Data Availability Statement: The original contributions presented in this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author(s).

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