Salud, Ciencia y Tecnología. 2025; 5:1527
doi: 10.56294/saludcyt20251527

REVIEW

The Unseen Burden: Relationship Between Burnout and Gastrointestinal Symptoms among Healthcare Providers. Review Article

La carga invisible: Relación entre el Burnout y los síntomas gastrointestinales entre los profesionales sanitarios. Artículo de revisión

Mohamed G. El-sehrawy[1], Mohamed A. El-Sakhawy[2], Ali D. Abousoliman[3], Samia Eaid Elgazzar[4]

[1]Department of Nursing Administration and Education, College of Nursing, Prince Sattam bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia.
[2]Department of Medical Laboratory, College of Applied Medical Sciences, Prince Sattam bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia.
[3]Department of Nursing Administration and Education, College of Nursing, Prince Sattam bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia.
[4]Department of Medical and Surgical, College of Nursing, Qassim University, Buraidah, Saudi Arabia.

Citar como: El-sehrawy MG, El-Sakhawy MA, Abousoliman AD, Eaid Elgazzar S. The Unseen Burden: Relationship Between Burnout and Gastrointestinal Symptoms among Healthcare Providers. Review Article. Salud, Ciencia y Tecnología. 2025; 5:1527. https://doi.org/10.56294/saludcyt20251527

Submitted: 19-08-2024 **Revised:** 03-12-2024 **Accepted:** 27-02-2025 **Published:** 28-02-2025

Editor: Prof. Dr. William Castillo-González

Corresponding author: Mohamed G. El-sehrawy

ABSTRACT

Introduction: burnout, a syndrome characterized by emotional exhaustion, depersonalization, and reduced personal accomplishment, is highly prevalent among healthcare providers. Concurrently, gastrointestinal (GI) symptoms, such as irritable bowel syndrome (IBS), acid reflux, and functional dyspepsia, are frequently reported in this population.
Objective: this review article aims to synthesize the existing evidence on the relationship between burnout and GI symptoms among healthcare providers, which help to ensure healthy lives and promote well-being (Goal-3 in SDGs).
Results: after a comprehensive search of recent articles, the findings suggest a significant bidirectional relationship between burnout and GI symptoms, with chronic stress and dysregulation of the gut-brain axis playing key roles. Interventions targeting stress reduction and organisational changes may mitigate both burnout and GI symptoms. Further research studies are needed to establish causality and evaluate the effectiveness of targeted interventions. Also, there is a need to ensure inclusive and equitable quality education and promote lifelong learning opportunities for healthcare providers to maintain wellbeing.
Conclusions: the relationship between burnout and GI symptoms among healthcare providers is complex and bidirectional. Chronic stress associated with burnout can lead to the development or exacerbation of GI symptoms, while the presence of GI symptoms can contribute to burnout.

Keywords: Sustainable Development Goals (SDGs); Burnout; Gastrointestinal Symptoms; Good Health and Wellbeing.

RESUMEN

Introducción: el burnout, un síndrome caracterizado por el agotamiento emocional, la despersonalización y la reducción de la realización personal, es muy frecuente entre los profesionales sanitarios. Al mismo tiempo, los síntomas gastrointestinales (GI), como el síndrome del intestino irritable (SII), el reflujo ácido y la dispepsia funcional, se reportan con frecuencia en esta población.

Objetivo: este artículo de revisión pretende sintetizar las pruebas existentes sobre la relación entre el burnout y los síntomas gastrointestinales entre los profesionales sanitarios, que contribuyen a garantizar una vida sana y a promover el bienestar (Objetivo 3 de los ODS).
Resultados: tras una búsqueda exhaustiva de artículos recientes, los hallazgos sugieren una relación bidireccional significativa entre el burnout y los síntomas GI, en la que el estrés crónico y la desregulación del eje intestino-cerebro desempeñan papeles clave. Las intervenciones dirigidas a reducir el estrés y los cambios organizativos pueden mitigar tanto el burnout como los síntomas gastrointestinales. Se necesitan más estudios de investigación para establecer la causalidad y evaluar la eficacia de las intervenciones específicas. Además, es necesario garantizar una educación de calidad inclusiva y equitativa y promover oportunidades de aprendizaje permanente para que los profesionales sanitarios mantengan el bienestar.
Conclusiones: la relación entre el agotamiento y los síntomas gastrointestinales entre los profesionales sanitarios es compleja y bidireccional. El estrés crónico asociado al burnout puede conducir al desarrollo o exacerbación de síntomas GI, mientras que la presencia de síntomas GI puede contribuir al burnout.

Palabras clave: Objetivos de Desarrollo Sostenible (ODS); Burnout; Síntomas Gastrointestinales; Buena Salud y Bienestar.

INTRODUCTION

Burnout, a psychological syndrome characterized by emotional exhaustion, depersonalization, and reduced personal accomplishment, is increasingly recognized as a significant occupational hazard among healthcare providers.[1] The demanding nature of healthcare work, characterized by long hours, high-stakes decision-making, and emotional labor, predisposes healthcare workers to burnout. Concurrently, gastrointestinal (GI) symptoms, such as irritable bowel syndrome (IBS), acid reflux, and functional dyspepsia, are prevalent among healthcare providers.[2] Emerging evidence suggests a bidirectional relationship between burnout and GI symptoms, with each potentially exacerbating the other.

As they try to offer medical and physical care to their patients, healthcare workers deal with a variety of stressors at work on a daily basis. Mental health issues and worries are common among healthcare practitioners; among 100 occupations with high stress levels for the frequency of health disorders, nursing ranks 27th.[3,4] Healthcare professionals may experience significant levels of stress as a result of the demands and pressures of providing medical treatment.[2]

Long-term stress can have a negative impact on healthcare professionals' attitudes and behaviors toward patients as well as the standard of care they offer. Given all of the aforementioned causes, healthcare professionals are particularly vulnerable to burnout and other gastrointestinal health issues, such as bowel dysfunction.[5]

Studying and understanding the relationship between burnout and GI symptoms among healthcare providers, healthcare organizations can develop targeted interventions to reduce burnout, improve the well-being of healthcare providers, and ultimately enhance patient care.[6,7] The actual relationship is rooted in the physiological and psychological effects of chronic stress, which disrupts normal digestive processes and contributes to the development or worsening of GI symptoms. Therefore, this review study explores the relationship between burnout and GI symptoms among healthcare providers, drawing on recent studies and theoretical frameworks. The research was conducted through a narrative review of available recent studies and theoretical frameworks exploring the relationship between burnout and GI symptoms among healthcare providers. Bibliographic selection criteria focused on studies with available robust methodologies, including cross-sectional, longitudinal, and qualitative designs and measurement tools.

Burnout and Its Prevalence in Healthcare

Burnout is particularly prevalent among healthcare providers due to the high-stress environment in which they work. A meta-analysis found that approximately 50 % of physicians experience symptoms of burnout. Nurses, who often face similar stressors, also report high rates of burnout, with studies indicating prevalence rates ranging from 30 % to 70 %.[8] The chronic stress associated with burnout can lead to dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in systemic inflammation and autonomic nervous system dysfunction, which may contribute to the development of GI symptoms.[9]

Dimensions of burnout

Emotional exhaustion refers to feelings of being emotionally overextended and drained by one's work. It is the most prominent dimension of burnout and often serves as the core symptom. It could be manifested by feeling physically and emotionally depleted, lacking energy to face another workday, feeling "used up"

at the end of the day, and having difficulty recovering from work-related stress, even after rest.[10] Emotional exhaustion can lead to reduced productivity, absenteeism, and a desire to withdraw from work responsibilities.[11]

Depersonalization involves developing a detached, cynical, or negative attitude toward one's job, colleagues, or clients. It is often a coping mechanism to distance oneself from emotional exhaustion. It appears as treating colleagues, clients, or patients as objects rather than people, using sarcasm or cynicism to describe work or interactions, and withdrawing emotionally from work relationships. Depersonalization can harm workplace relationships, reduce collaboration, and lead to a toxic work environment.[12]

Reduced personal accomplishment refers to feelings of incompetence, lack of achievement, and reduced productivity at work. Individuals may feel that their efforts are ineffective or unappreciated.[13] Healthcare workers may have feelings inadequacy or incapability of performing tasks, doubting one's skills and abilities, perceiving a lack of progress or success in work. Reduced personal accomplishment can lead to low self-esteem, decreased motivation, and a sense of hopelessness about one's career.[14]

Physical exhaustion refers to the bodily toll of chronic stress, often accompanying emotional exhaustion. Some healthcare providers suffer from chronic fatigue, even after rest, frequent headaches, muscle pain, or gastrointestinal issues, weakened immune system, leading to frequent illnesses. Physical exhaustion can exacerbate emotional exhaustion and reduce overall functioning.[15]

Gastrointestinal Symptoms in Healthcare Providers

GI symptoms are common among healthcare providers, with studies reporting higher prevalence rates compared to the general population. A study found that 40 % of resident physicians experienced functional GI disorders, such as IBS, during their training.[16] Similarly, a survey of nurses revealed that 35 % reported frequent GI symptoms, including bloating, abdominal pain, and altered bowel habits. These symptoms are often attributed to irregular eating patterns, high caffeine consumption, and chronic stress, all of which are common in healthcare settings.[17] GI symptoms were reported by 25 % to 50 % of participants, with IBS being the most commonly reported condition.[18]

Factors affecting the health of the gastrointestinal tract

A diet rich in fiber promotes healthy bowel movements and supports the growth of beneficial gut bacteria. Low fiber intake can lead to constipation and dysbiosis. Also, high consumption of processed foods, refined sugars, and unhealthy fats can disrupt gut microbiota and increase inflammation. Moreover, adequate water intake is essential for digestion and preventing constipation. Additionally, foods rich in probiotics (e.g., yogurt, kefir) and prebiotics (e.g., garlic, onions) support a healthy gut microbiome.[19]

Psychological stress can trigger or worsen GI conditions like IBS, acid reflux, and ulcers through the gut-brain axis. In addition, mental health disorders are often linked to functional GI disorders and altered gut microbiota. Finally, emotional distress can manifest as physical GI symptoms, even in the absence of structural abnormalities.[20]

Causes of burnout and gastric problems in healthcare settings

One of the primary causes of burnout is the high workload and long working hours inherent in healthcare settings. Many healthcare workers, including doctors, nurses, and support staff, face grueling schedules, often with insufficient breaks or time for rest. This relentless pace leaves little room for recovery, leading to chronic physical and emotional exhaustion.[10] Over time, the cumulative stress of overwork can trigger burnout, characterized by feelings of detachment, cynicism, and a diminished sense of accomplishment. Simultaneously, the stress from excessive workloads can disrupt the gut-brain axis, leading to gastric disturbances such as acid reflux, irritable bowel syndrome (IBS), or ulcers.[17]

Another significant cause of burnout and gastric issues among healthcare workers is the emotional toll of patient care. Healthcare professionals frequently deal with life-and-death situations, suffering, and grief, which can take a profound emotional toll. The constant exposure to trauma and the pressure to make critical decisions can lead to compassion fatigue, a state of emotional exhaustion that contributes to burnout.[14,19] This emotional stress also manifests physically, as the body's stress response triggers the release of cortisol and other hormones that can disrupt digestive function. Over time, this can lead to chronic gastric problems, further compounding the physical and emotional strain on healthcare workers.[22]

Lack of organizational support and resources is another key factor contributing to burnout and gastric disturbances. Many healthcare workers operate in understaffed environments with limited access to the tools and support they need to perform their jobs effectively. This lack of resources can lead to feelings of frustration, helplessness, and inadequacy, all of which fuel burnout.[5] Additionally, the absence of supportive workplace policies, such as mental health resources, stress management programs, or flexible scheduling, leaves workers ill-equipped to cope with the demands of their roles. The resulting stress not only exacerbates burnout but also negatively impacts gastrointestinal health, as chronic stress is a well-known trigger for conditions like gastritis

and IBS.[21]

The Bidirectional Relationship Between Burnout and GI Symptoms

The relationship between burnout and GI symptoms is complex and bidirectional. On one hand, chronic stress and burnout can lead to the development or exacerbation of GI symptoms.[21] Stress-induced changes in gut motility, visceral hypersensitivity, and alterations in the gut microbiota have been implicated in the pathogenesis of functional GI disorders.[10] On the other hand, the presence of chronic GI symptoms can contribute to burnout by reducing quality of life, impairing work performance, and increasing absenteeism.[11]

Some studies reported a significant association between burnout and GI symptoms. Cross-sectional studies consistently found that higher levels of burnout were associated with increased severity of GI symptoms.[12] Longitudinal studies suggested that burnout may predict the onset or exacerbation of GI symptoms over time.[22] One intervention study found that stress reduction programs, such as mindfulness-based stress reduction (MBSR), improved both burnout and GI symptoms.[16]

Chronic stress can stimulate the production of stomach acid, leading to conditions like acid reflux, gastritis, or peptic ulcers. On the other hand, burnout can cause either accelerated or slowed movement of the digestive tract, resulting in symptoms like diarrhea, constipation, or irritable bowel syndrome (IBS).[18] Finally, prolonged stress can compromise the intestinal lining, leading to "leaky gut syndrome," where toxins and bacteria leak into the bloodstream, triggering inflammation and immune responses.[20]

Mechanisms Underlying the Relationship

Several mechanisms may explain the relationship between burnout and GI symptoms. Chronic stress associated with burnout can lead to increased production of pro-inflammatory cytokines, which have been linked to the development of GI disorders.[12] Moreover, burnout is associated with chronic stress, which can dysregulate the hypothalamic-pituitary-adrenal (HPA) axis, leading to systemic inflammation and altered gut motility.[21] Additionally, stress-induced alterations in the gut-brain axis, which involves bidirectional communication between the central nervous system and the enteric nervous system, may play a role.[8] Dysregulation of this axis can result in increased gut permeability, altered gut microbiota, and visceral hypersensitivity, all of which are associated with functional GI disorders.[15] Burnout may lead to unhealthy coping behaviors, such as poor diet, lack of exercise, and increased caffeine or alcohol consumption, which can exacerbate GI symptoms.[5]

Burnout often leads to unhealthy lifestyle choices that exacerbate gastric problems. Stress can lead to overeating, undereating, or consuming unhealthy foods (e.g., high sugar, fat, or caffeine), which irritate the stomach. Sleep disturbances common in burnout can impair gut health and exacerbate GI symptoms. Moreover, increased use of alcohol, tobacco, or medications (e.g., NSAIDs) to cope with stress can damage the stomach lining.[22]

Negative consequences of burnout and gastric problems among healthcare providers

Burnout and gastric problems pose significant challenges to healthcare workers, impacting both their personal well-being and professional performance. The high-stress environment of healthcare, characterized by long hours, emotional demands, and exposure to suffering, makes workers particularly vulnerable to burnout.[3] When combined with gastric issues such as acid reflux, irritable bowel syndrome (IBS), or ulcers, the consequences can be severe. These conditions not only diminish the quality of life for healthcare workers but also compromise their ability to provide effective patient care, creating a ripple effect that affects the entire healthcare system.[14]

One of the most immediate consequences of burnout and gastric problems is the physical toll on healthcare workers. Chronic stress from burnout can lead to increased stomach acid production, inflammation, and altered gut motility, resulting in conditions like gastritis, ulcers, or IBS.[2] These gastric issues often cause persistent pain, nausea, bloating, and discomfort, making it difficult for healthcare workers to perform their duties effectively.[9] Fatigue and physical discomfort further exacerbate emotional exhaustion, creating a vicious cycle that undermines their overall health. Over time, this can lead to frequent absenteeism, reduced productivity, and even long-term disability, placing additional strain on already overburdened healthcare systems.[17]

The psychological impact of burnout and gastric problems is equally concerning. Healthcare workers experiencing burnout often feel emotionally drained, detached, and cynical, which can erode their sense of purpose and passion for their work. When compounded by the physical discomfort of gastric issues, these feelings can escalate into anxiety, depression, or even thoughts of leaving the profession.[10,19] The stigma surrounding mental health in healthcare often prevents workers from seeking help, further isolating them and worsening their condition. This not only affects their mental health but also diminishes their ability to empathize with patients, potentially leading to poorer patient outcomes and reduced satisfaction.[20]

Finally, the combination of burnout and gastric problems has broader implications for healthcare systems and patient care. When healthcare workers are physically and emotionally unwell, the quality of care they provide

may decline, increasing the risk of medical errors, misdiagnoses, and patient dissatisfaction.[8] High turnover rates due to burnout further exacerbate staffing shortages, placing additional pressure on remaining workers and perpetuating the cycle of stress and illness.[15] Addressing these issues requires systemic changes, such as implementing stress management programs, providing access to mental health resources, and promoting work-life balance. By prioritizing the well-being of healthcare workers, organizations can create a healthier, more resilient workforce capable of delivering high-quality care.[13]

Interventions and Future Directions

Techniques like mindfulness, meditation, and yoga can help regulate stress response and improve gut health. Additionally, regular exercise, balanced nutrition, and adequate sleep are crucial for both mental and GI health. On the other side, cognitive-behavioral therapy (CBT) can help address the psychological aspects of burnout and stress-related GI disorders.[20] Finally, in cases of severe gastric problems, medications like antacids, proton pump inhibitors, or antidepressants may be necessary.[21]

Addressing burnout and GI symptoms among healthcare providers requires a multifaceted approach. Organizational interventions, such as reducing workload, improving work-life balance, and providing access to mental health resources, can help mitigate burnout.[9] Additionally, interventions aimed at reducing stress, such as mindfulness-based stress reduction (MBSR) and cognitive-behavioral therapy (CBT), have been shown to improve both burnout and GI symptoms.[15] Future research should focus on longitudinal studies to better understand the temporal relationship between burnout and GI symptoms, as well as the effectiveness of targeted interventions.[18]

The review highlights a significant association between burnout and GI symptoms among healthcare providers and the importance of overcoming burnout and its complications among healthcare providers. Since the past studies in this relation are not much, this article will be focused on expanding further research in this field in the future. Additionally, future research should prioritise longitudinal designs to establish causality, explore underlying biological mechanisms (e.g., gut-brain axis), and investigate the effectiveness of targeted interventions, such as stress management programs, in mitigating both burnout and GI symptoms. Expanding the scope to include diverse healthcare settings and populations would also enhance generalisability.

CONCLUSIONS

The relationship between burnout and GI symptoms among healthcare providers is complex and bidirectional. Chronic stress associated with burnout can lead to the development or exacerbation of GI symptoms, while the presence of GI symptoms can contribute to burnout. Addressing this issue requires a comprehensive approach that includes organizational changes, stress reduction interventions, and further research to better understand the underlying mechanisms and effective treatments.

REFERENCES

1. Marlicz W, Koulaouzidis A, Charisopoulou D, Jankowski J, Marlicz M, Skonieczna-Zydecka K, Krynicka P, Loniewski I, Samochowiec J, Rydzewska G, Koulaouzidis G. Burnout in healthcare–the Emperor's New Clothes. Gastroenterology Review/Przegląd Gastroenterologiczny. 2023 Jan 1;18(3):274-80.

2. Bridgeman PJ, Bridgeman MB, Barone J. Burnout syndrome among healthcare professionals. The Bulletin of the American Society of Hospital Pharmacists. 2018 Feb 1;75(3):147-52.

3. Dubale BW, Friedman LE, Chemali Z, Denninger JW, Mehta DH, Alem A, Fricchione GL, Dossett ML, Gelaye B. Systematic review of burnout among healthcare providers in sub-Saharan Africa. BMC public health. 2019 Dec;19:1-20.

4. Sharifi M, Asadi-Pooya AA, Mousavi-Roknabadi RS. Burnout among healthcare providers of COVID-19; a systematic review of epidemiology and recommendations. Archives of academic emergency medicine. 2020 Dec 10;9(1):e7.

5. Chemali Z, Ezzeddine FL, Gelaye B, Dossett ML, Salameh J, Bizri M, Dubale B, Fricchione G. Burnout among healthcare providers in the complex environment of the Middle East: a systematic review. BMC public health. 2019 Dec;19:1-21.

6. Kinman G, Dovey A, Teoh K. Burnout in healthcare: Risk factors and solutions, 2023.

7. Razai MS, Kooner P, Majeed A. Strategies and interventions to improve healthcare professionals' well-being and reduce burnout. Journal of primary care & community health. 2023 May;14:21501319231178641.

8. Zheng Y, Tang PK, Lin G, Liu J, Hu H, Wu AM, Ung CO. Burnout among healthcare providers: Its prevalence and association with anxiety and depression during the COVID-19 pandemic in Macao, China. PloS one. 2023 Mar 16;18(3):e0283239.

9. Woo T, Ho R, Tang A, Tam W. Global prevalence of burnout symptoms among nurses: A systematic review and meta-analysis. Journal of psychiatric research. 2020 Apr 1;123:9-20.

10. Hassan ME, Elsehrawy MG, Eltayeb MM, Ebrahim EE, Abd-Elsalam NA. Burnout and stress among healthcare Workers at Primary Healthcare Centers: the role of COVID-19 pandemic. Int J Biomed. 2022;12:256-64.

11. Salvagioni DA, Melanda FN, Mesas AE, González AD, Gabani FL, Andrade SM. Physical, psychological and occupational consequences of job burnout: A systematic review of prospective studies. PloS one. 2017 Oct 4;12(10):e0185781.

12. Membrive-Jimenez MJ, Gomez-Urquiza JL, Suleiman-Martos N, Velando-Soriano A, Ariza T, De la Fuente-Solana EI, Canadas-De la Fuente GA. Relation between burnout and sleep problems in nurses: a systematic review with meta-analysis. Healthcare 2022 May 21 (Vol. 10, No. 5, p. 954). MDPI

13. Iglesias ME, de Bengoa Vallejo RB. Prevalence and relationship between burnout, job satisfaction, stress, and clinical manifestations in Spanish critical care nurses. Dimensions of Critical Care Nursing. 2013 May 1;32(3):130-7.

14. Barello S, Palamenghi L, Graffigna G. Burnout and somatic symptoms among frontline healthcare professionals at the peak of the Italian COVID-19 pandemic. Psychiatry research. 2020 Aug 1;290:113129.

15. Alzahrani MA, Alamri HA, Alshehri MA, Ayyashi MM, Alqarni SA, Alshehri SH, Alshehri MS, Alqahtani MM, Alasmari NH, Alsabban AM, Alshahrani AS. Assessing the relationship between burnout syndrome and irritable bowel syndrome among medical health providers and medical students in Saudi Arabia. Journal of Medicine and Life. 2023 Feb;16(2):277.

16. Hod K, Melamed S, Dekel R, Maharshak N, Sperber AD. Burnout, but not job strain, is associated with irritable bowel syndrome in working adults. Journal of psychosomatic research. 2020 Jul 1;134:110121.

17. Masihipour B, Mansour-Ghanaei F, Maroufizadeh S, Hassanipour S, Asgharnezhad M, Isanazar A. The Association of Depression and Anxiety Disorders With Gastrointestinal Symptoms Among Nurses. Caspian J Neurol Sci. 2025; 11 (1): 28-37 [Internet]. 2025 Jan 1.

18. Huerta-Franco MR, Vargas-Luna M, Tienda P, Delgadillo-Holtfort I, Balleza-Ordaz M, Flores-Hernandez C. Effects of occupational stress on the gastrointestinal tract. World journal of gastrointestinal pathophysiology. 2013 Nov 15;4(4):108.

19. Howard K, Giblin M, Medina R. The relationship between occupational stress and gastrointestinal illness: A comprehensive study of public schoolteachers. Journal of Workplace Behavioral Health. 2018 Oct 2;33(3-4):260-75.

20. Menekli T, Doğan R, Yıldız E. Relationship between stress perceived and gastrointestinal symptoms in intensive care nurses during COVID-19 pandemic: a cross-sectional study. Athens Journal of Health and Medical Sciences. 2021;8(4):217-30.

21. Lee EY, Mun MS, Lee SH, Cho HS. Perceived stress and gastrointestinal symptoms in nursing students in Korea: A cross-sectional survey. BMC nursing. 2011 Dec;10:1-8.

22. Lin PY, Wang JY, Shih DP, Kuo HW, Liang WM. The interaction effects of burnout and job support on peptic ulcer disease (PUD) among firefighters and policemen. International journal of environmental research and public health. 2019 Jul;16(13):2369.

ACKNOWLEDGMENT

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work through the project number (PSAU/2024/03/31996)

FINANCING

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work through the project number (PSAU/2024/03/31996)

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHORSHIP CONTRIBUTION

Conceptualization: Mohamed G. El-sehrawy.
Formal analysis: Mohamed G. El-sehrawy, Ali D. Abousoliman.
Research: Mohamed A. El-Sakhawy, Samia E. Elgazzar, Ali D. Abousoliman.
Project management: Mohamed G. El-sehrawy.
Resources: Mohamed A. El-Sakhawy, Samia E. Elgazzar.
Software: Mohamed G. El-sehrawy, Mohamed A. El-Sakhawy.
Supervision: Mohamed G. El-sehrawy, Mohamed A. El-Sakhawy.
Validation: Mohamed G. El-sehrawy, Mohamed A. El-Sakhawy.
Display: Samia E. Elgazzar, Ali D. Abousoliman.
Drafting - original draft: Mohamed A. El-Sakhawy, Samia E. Elgazzar.
Writing - proofreading, and editing: Mohamed G. El-sehrawy, Mohamed A. El-Sakhawy, Ali D. Abousoliman.