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## RESEARCH ARTICLE

### REGARDING EPIDEMIOLOGICAL BURDEN OF MALARIA IN SAUDI ARABIA

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#### ABSTRACT

The study covers the epidemiological context of Malaria in Saudi Arabia while addressing important research issues involving its prevalence, risk factors, and control and preventative measures. With recurring epidemics affected by climatic, topographical, and human variables, Malaria has a long history in the area. Despite substantial efforts to eradicate the illness, Saudi Arabia still struggles with Malaria, especially in the Jazan area. Different Malaria serotypes, such as Plasmodium falciparum and Plasmodium vivax, are often found, which adds to their persistence. Elements including climate, human behavior, and medical infrastructure shape the landscape of Malaria. Saudi Arabia uses a complex strategy to address these issues, including cross-border cooperation, quick diagnosis, vector control, public awareness campaigns, research, and international alliances. To lessen the impact of Malaria and strive toward its elimination in Saudi Arabia, it is essential to comprehend these complexities and put evidence-based policies into practice

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## INTRODUCTION

Despite tremendous advancements in infrastructure and healthcare, Malaria continues to represent a serious health hazard in Saudi Arabia, particularly in regions where the illness is more prone to spread (Fatima et al., 2022). Globally, Malaria, a parasite-based infectious illness spread by mosquitoes, is a major public health problem. Worldwide attempts to manage and eradicate Malaria have made significant headway, but certain areas still deal with the disease's lingering effects. Saudi Arabia is one country in the Eastern Mediterranean region where Malaria remains a problem. We intend to thoroughly review the epidemiological burden of Malaria in Saudi Arabia in this research. We address important research issues to clarify the country's Malaria situation and provide evidence-based suggestions to strengthen preventive and control efforts. In the subsequent sections, we will address the research questions outlined below, providing a comprehensive overview of the epidemiological landscape of Malaria in Saudi Arabia and offering evidence-based recommendations to enhance prevention and control efforts.

#### Research Questions

- What is the current prevalence and distribution of Malaria in Saudi Arabia?

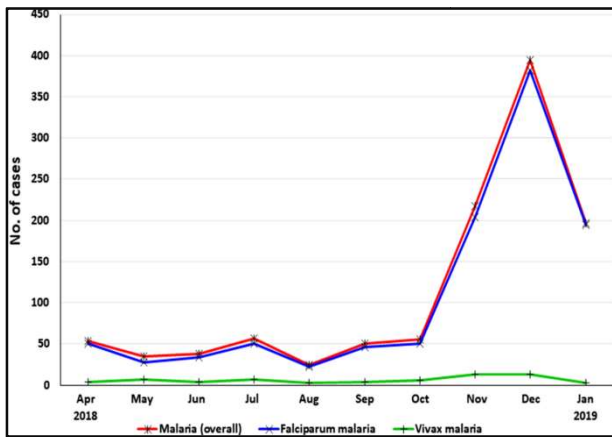
- What strategies can be recommended to enhance Malaria prevention and control efforts in Saudi Arabia?

This paper systematically examines these questions and contributes to the knowledge surrounding Malaria in Saudi Arabia. It supports the country's efforts to reduce the burden of this preventable and treatable disease.

**History of Malaria in Saudi Arabia:** Centuries of recurrent outbreaks and control initiatives have shaped the history of Malaria in Saudi Arabia. With evidence of its existence extending back to prehistoric times, this illness has been a persistent health concern in the area. The incidence of Malaria and its effects have changed throughout time due to climatic, geographic, and anthropogenic factors (Foque & Reeder, 2019). When trade routes linked Saudi Arabia to other regions in antiquity. Given that the mosquito species that transmit Malaria prefer warm, humid climates, the environment also impacts the disease's prevalence. In 1998, Saudi Arabia saw its most extensive record of Malaria cases at thirty-six thousand, one hundred and fifty-nine. Of these cases, sixty-one percent were in the Jazan-a region in Saudi Arabia. Jazan region currently is the only one in Saudi Arabia with indigenous Malaria cases (Al-Mekhlafi et al., 2021). Since then, significant study has been made to reduce the prevalence in the region and the presence of the primary vector, *Anopheles arabiensis*, Malaria (Alzahrani et al., 2017; Madkhali et

al., 2020). Throughout the 20th century, Saudi Arabia undertook significant endeavors to combat the scourge of Malaria (Kumaraswamy & Quamar, 2020). These efforts aimed to curtail the disease's impact and witnessed a marked reduction in Malaria cases. Diverse strategies were employed in the fight against Malaria within Saudi Arabia, encompassing the application of pesticide spraying, the distribution of bed nets, and the provision of treatment to those afflicted. Despite these concerted actions, Malaria continues to persist within the nation, with one pivotal contributing factor being the varied topography of Saudi Arabia, which provides conducive breeding grounds for Malaria-transmitting mosquitoes (Al-Mekhlafi et al., 2021). Furthermore, the formidable challenge of domestic and international population migration impedes Malaria prevention endeavors. Nevertheless, Saudi Arabia has made commendable strides in its battle against Malaria in recent years, as Oyegoke et al. detailed in 2022. The government has played a pivotal role by allocating resources toward monitoring, research, and public health initiatives, resulting in a notable decrease in Malaria cases.

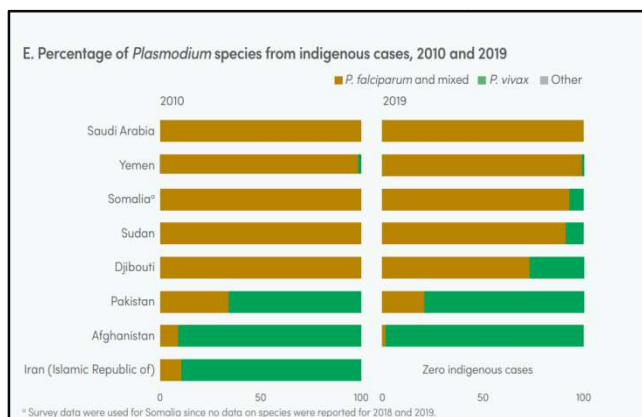
**Prevalence of Malaria in Saudi Arabia:** It is crucial to answer Research Question 1: "What is the current prevalence and distribution of Malaria in Saudi Arabia?" As a vital component of the epidemiological burden of this illness. In order to offer a more thorough analysis, we have included a graph named "Prevalence of Malaria in Saudi Arabia," which shows the monthly distribution of the cases throughout the research period of Al-Mekhlafi et al. (2021).



Source: (Al-Mekhlafi et al., 2021)

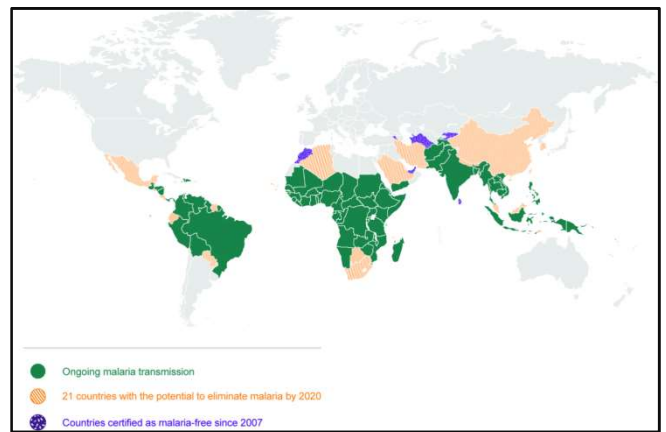
Figure Showing Monthly Distribution of Malaria in Jazan

The graph clearly illustrates the continuous transmission throughout the year in Saudi Arabia (Al-Mekhlafi et al., 2021). The surge in cases serves as a critical data point in understanding the disease's potential for rapid escalation in specific areas.



Source: (Annex 2 - C. WHO Eastern Mediterranean Region B. Malaria Funding A, 2010)

Figure 2. Figure showing the Percentages of Plasmodium Species in 2010 and 2019



(Source: Rabinovich et al., 2017)

Figure 3. Malaria Eradication Progress

It is crucial to remember that although the study's data offers insights into the incidence of Malaria in Saudi Arabia, it is also essential to consider the broader context of Malaria in nearby regions. It supports regional coordination in Malaria control efforts and assists in locating probable infection origins. Knowing how Saudi Arabia's Malaria incidence compares to other nations with comparable ecological circumstances may benefit policymakers and academics.

**Malaria Eradication Progress:** Several countries and territories have successfully achieved Malaria-free status and been certified by WHO. These nations include the United Arab Emirates (certified in 2007), Morocco (certified in 2010), Turkmenistan (certified in 2010), Armenia (certified in 2011), Maldives (certified in 2015), Sri Lanka (certified in 2016), and Kyrgyzstan (certified in 2016). Further, it is essential to note that Paraguay and Argentina have submitted official requests for certification of Malaria eradication and are now working to achieve this status (Habtamu et al., 2022). It is crucial to recognize that not all nations with a three-year streak of indigenous Malaria cases have applied for formal certification from the World Health Organization. It highlights the challenges and variances in eradicating various geographic areas. To effectively combat Malaria, constant surveillance and focused interventions are crucial. The graph and supplementary map show how common Malaria is in Saudi Arabia. The interconnectedness of Malaria transmission is further highlighted by this evidence, which should be considered when creating comprehensive plans to answer Research Question 1 and improve Malaria prevention and control efforts in the region.

**Symptoms and Diagnostics:** In Saudi Arabia, Malaria presents a range of symptoms that can vary in severity. The following symptoms are typical (Darraj, 2020): fever, chills, sweats, headache, muscular pains, and weariness. Early diagnosis is frequently difficult because of these flu-like symptoms' susceptibility to misdiagnosis. In some situations, particularly in those involving Plasmodium falciparum infection, some people may also present with more severe symptoms such as anemia, jaundice, and organ failure (Shamarukh et al., 2019; Zekar & Sharman, 2020). Early detection and intervention are essential to avert problems and lower transmission. Diagnostic methods for Malaria in Saudi Arabia primarily involve laboratory testing. Blood samples are collected from suspected cases and examined for the presence of Malaria parasites. Rapid diagnostic tests (RDTs) and microscopy are the two main diagnostic techniques.

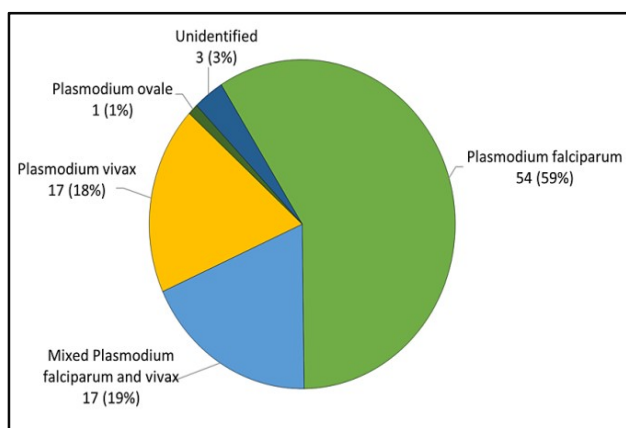
- **Microscopy:** This traditional method involves staining and examining blood smears under a microscope (Wakid & Alahmady, 2020). Trained technicians can identify the type of Malaria parasite and determine the parasite density. While effective, microscopy requires skilled personnel and can be time-consuming.
- **Rapid Diagnostic Tests (RDTs):** RDTs are user-friendly, quick, and require minimal training (Jain et al., 2021). They detect specific Malaria antigens in a patient's blood, providing a

rapid diagnosis. RDTs have significantly improved access to Malaria diagnosis in remote areas of Saudi Arabia.

Depending on variables like resource availability and the location of healthcare institutions, the diagnostic approach may change. Polymerase chain reaction (PCR) represents a valuable molecular tool utilized for monitoring and research, as highlighted in recent studies (Fitri *et al.*, 2022). Saudi Arabia is currently engaged in proactive endeavors to enhance its diagnostic infrastructure, widen the availability of Rapid Diagnostic Tests (RDTs), and enhance the training of healthcare personnel, as elucidated by Azizi *et al.* in 2021. Such strategic measures are paramount in effectively managing and ultimately eradicating Malaria within the region.

**Serotypes of Malaria in Saudi Arabia:** To comprehensively address Research Question 2, which delves into the pivotal factors impacting the persistence of Malaria in Saudi Arabia, it is imperative to investigate the diverse serotypes of Malaria prevalent in the region. Understanding these serotypes' presence and prevalence is indispensable for developing effective Malaria control strategies. In this context, serotypes refer to various *Plasmodium* species and strains responsible for causing Malaria infections. In Saudi Arabia, Malaria primarily stems from two main serotypes: *Plasmodium falciparum* and *Plasmodium vivax*, occasionally accompanied by instances of *Plasmodium Malaria* and *Plasmodium ovale* (Al-Awadhi *et al.*, 2021; Malaria, n.d.). Each of these serotypes presents unique characteristics and challenges in the context of Malaria prevention.

- *Plasmodium Malaria* and *Plasmodium ovale*: Despite being less prevalent in Saudi Arabia, these serotypes continue to support Malaria transmission (Hawadak *et al.*, 2021). Their capacity to avoid diagnosis due to relatively minor symptoms and the existence of asymptomatic carriers are two factors that may contribute to their persistence (Yman *et al.*, 2019).
- *Plasmodium falciparum*: The most severe Malaria cases in Saudi Arabia are caused by this serotype, which is renowned for its severity (Biselli *et al.*, 2022; Wngdahl *et al.*, 2019). Drug resistance, notably against chloroquine, and the existence of appropriate *Anopheles* mosquito vectors in the area can be blamed for *Plasmodium falciparum*'s persistence.
- *Plasmodium vivax*: *P. vivax* infections can become chronic, resulting in persistent transmission, while typically being regarded as less severe than *P. falciparum* (Angrisano & Robinson, 2022). In this serotype, developing latent liver stages (hypnozoites) might cause relapses, complicating efforts to eradicate the illness.



**Figure 4. Figure Showing a Trend in Infections from the Serotypes**

Factors contributing to the persistence of these serotypes in Saudi Arabia include favorable climatic conditions for mosquito breeding, population movement within the country and across borders, limited access to healthcare in remote areas, and drug resistance. Additionally, socio-economic factors, such as poverty and inadequate housing, can facilitate vector-human contact and contribute to the

ongoing transmission of Malaria. Understanding the serotypes of Malaria in Saudi Arabia and the factors contributing to their persistence is essential for tailoring effective control and prevention strategies (Altassan *et al.*, 2019). Addressing these factors through a multifaceted approach, including vector control, surveillance, and targeted treatment, will reduce the region's Malaria burden.

**Causes and Risk Factors:** Several interconnected factors in Saudi Arabia contribute to the persistence of Malaria in the region. Understanding these causes and risk factors is essential for effective Malaria prevention and control efforts.

- **Climate and Weather Patterns:** Climate and Weather Patterns: Saudi Arabia's hot, dry climate favors the growth of Malaria parasites and the mosquitoes that transmit the disease (Paz & Majeed, 2021). Rainfall creates temporary water bodies that serve as mosquito breeding grounds.
- **Human Behavior and Mobility:** Human migration, travel, and labor movements all significantly contribute to the spread of Malaria. People who are infected can spread the illness across borders. Additionally, engaging in outdoor activities when mosquitoes are most active increases the chance of coming into contact with infected mosquitoes.
- **Vector Resistance and Parasite Strain:** Developing insecticide resistance in *Anopheles* mosquitoes and drug-resistant Malaria parasites poses a significant challenge. It reduces the effectiveness of control measures.
- **Environmental Factors:** The country's diverse geography, including coastal areas, valleys, and mountains, also offers various ecological niches for Malaria vectors to thrive.
- **The Impact of Healthcare Infrastructure on Malaria Control:** The effectiveness of Malaria control efforts significantly relies on the availability and quality of healthcare services. In some areas of Saudi Arabia, inadequate healthcare infrastructure may pose challenges in promptly diagnosing and treating Malaria cases (Dinur-Schejter & Stepensky, 2022). This limitation in healthcare resources can impede the timely management of Malaria cases.
- **Socio-economic Determinants and Malaria Burden:** Populations with lower income levels may encounter difficulties accessing Malaria prevention and treatment services, resulting in delayed or inadequate care.
- **Promoting Public Awareness and Education:** One crucial aspect of Malaria control is raising public awareness about the transmission of the disease, preventive strategies, and early symptom recognition. Effective health education initiatives have the potential to motivate communities to adopt preventive measures and seek immediate medical attention when necessary.
- **Cross-Border Dynamics in Malaria Transmission:** Li *et al.* (2022) noted that Saudi Arabia shares borders with countries where Malaria is endemic. Cross-border trade involving goods and people could facilitate the introduction and spreading of the disease across borders. It underscores the importance of vigilance and coordinated efforts to address the region's cross-border Malaria transmission.

Understanding these causes and risk factors is imperative for designing targeted interventions and strategies to combat Malaria effectively in Saudi Arabia. Addressing these multifaceted challenges requires a coordinated effort from healthcare authorities, researchers, and the community.

## DISCUSSION

This study offers insightful information on the incidence of Malaria in Saudi Arabia and its accompanying problems. The recurrence of isolated outbreaks underlines the continuous need for attention and control measures, although the disease's incidence is relatively low and has declined in recent years. Several contributing elements, including environmental circumstances, human behavior, and relevant vector species, highlight the significance of focused and

comprehensive treatments. We suggest strategies to strengthen Malaria prevention and control efforts in Saudi Arabia to address these issues successfully. In order to detect and address epidemics quickly, surveillance systems must be strengthened. In order to support vector control programs and promote preventative measures like bed nets, encouraging community involvement will also be essential. Additionally, to promote early case management and stop the spread of disease, it is crucial to improve the accessibility of diagnostic and treatment facilities, especially in remote areas. The government and the community in Saudi Arabia must maintain a consistent commitment to the fight against Malaria. It is essential to continue conducting research and surveillance to keep track of the evolving epidemiological situation and adjust measures as necessary. This all-encompassing strategy is essential to reducing the effects of Malaria and eventually working toward its eradication in Saudi Arabia.

**Prevention and Control:** In Saudi Arabia, tackling the significant epidemiological challenge posed by Malaria demands a multifaceted strategy for prevention and control. The nation has demonstrated substantial achievements in curtailing Malaria incidence, with a specific focus on a range of strategic measures and interventions:

- **Cross-Border Collaborations:** Owing to its proximity to Malaria-endemic countries, Saudi Arabia maintains active collaborations with neighboring nations to oversee and control Malaria transmission across borders. This collaborative approach is pivotal in preventing the re-establishment of the disease within its borders (World Health Organization [WHO], 2021).
- **Swift Diagnosis and Effective Treatment:** Ensuring the rapid diagnosis and effective treatment of Malaria cases is paramount in preventing complications and further transmission. Saudi Arabia has established a robust healthcare infrastructure to facilitate prompt diagnosis and administering appropriate anti-Malarial medications to patients.
- **Management of Disease Vectors:** Malaria primarily spreads through the Anopheles mosquito in Saudi Arabia. To counteract this mode of transmission, the government has implemented an extensive set of measures for vector control. Regular surveillance and monitoring of mosquito populations are carried out to enable timely and targeted interventions.
- **Public Awareness and Education:** Elevating awareness regarding the risks associated with Malaria and the critical importance of preventive measures is accomplished through public education campaigns. These campaigns target residents and travelers alike, underscoring the significance of utilizing bed nets and mosquito repellents and seeking immediate medical attention when symptoms manifest (Abdelwahab *et al.*, 2022 ).
- **Research and Surveillance:** Sustained research and surveillance initiatives are indispensable for monitoring the dynamic epidemiological landscape of Malaria. Saudi Arabia invests in research endeavors aimed at comprehending local Malaria strains, patterns of drug resistance, and emerging threats.
- **Engagement in International Partnerships:** Saudi Arabia actively engages with international entities, such as the World Health Organization (WHO) and the Roll Back Malaria Partnership, to tap into technical expertise, resources, and best practices in Malaria prevention and control (Shretta *et al.*, 2017).
- **Climate Resilience:** Recognizing the potential influence of climate change on the distribution of Malaria vectors, Saudi Arabia considers the ramifications of climate change on disease transmission. It adapts its strategies in response to these evolving environmental factors.

Saudi Arabia has made noteworthy strides in alleviating the epidemiological burden of Malaria by adopting a comprehensive approach encompassing vector control, expedited diagnosis and treatment, public awareness initiatives, regional cooperation, research activities, climate adaptation, and global partnerships. The commitment to these strategies and continuous surveillance efforts remains pivotal to realizing the ultimate goal of Malaria elimination within the nation.

## CONCLUSION

The comprehensive review of Saudi Arabia's Malaria epidemiology highlights the value of continuous public health initiatives, research, and monitoring. Despite enormous progress, Malaria remains a serious issue, particularly in areas with ideal transmission conditions. To adequately combat this sickness, a thorough plan is required. Malaria's current prevalence and distribution highlight the need for tailored solutions considering geographical variances. Constant attention must be paid to the issues with vector control, transportation, and temperature contributing to its persistence. It is recommended that healthcare infrastructure be enhanced, education and awareness campaigns be expanded, and research funding for innovative therapies be raised to boost preventative and control efforts. Although Saudi Arabia's commitment to eradicating Malaria is commendable, more work still needs to be done. Saudi Arabia has to continue making progress in eradicating Malaria. Thus, national government agencies must continue working together. The key to lowering the epidemiological burden of Malaria in the region will be to make a concerted effort backed by solid data and educated policy. Together, we can make Saudi Arabia healthier and Malaria-free, setting an example for the world in the battle against this deadly illness.

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