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The Role of Artificial Intelligence in Predicting and Preventing Lifestyle-Related Diseases in Rural Saudi Arabia: A systematic review

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Abstract:

Saudi Arabia, with a population of 32 million and a gross national income of \$22,000 per capita, is considered a high-income country. The country has made strong progress in managing infectious diseases and lowering infant and child mortality. However, it now faces a growing health challenge: the rapid rise of noncommunicable diseases (NCDs), particularly those linked to lifestyle choices. Conditions such as obesity, hypertension, and diabetes are increasing quickly and affect people across all age groups and backgrounds. These diseases are now among the top causes of death globally and contribute heavily to premature mortality. They are also major risk factors for heart disease and type 2 diabetes. Addressing these issues requires prevention, early detection, and intervention. Artificial intelligence (AI) can help. AI technologies, including machine learning and data analytics, can analyze large amounts of health data to identify individuals at risk. Tools like wearable devices and mobile apps can monitor physical activity, diet, and metabolic indicators in real time. AI can also analyze electronic health records to predict who may develop diabetes or high blood pressure. This allows healthcare providers to act before symptoms appear. In rural areas of Saudi Arabia, where access to care may be limited, AI-based tools can provide targeted and timely support. Mobile applications powered by AI can offer personalized advice, promote healthy behaviors, and help reduce disease risk. This research aims to examine the prevalence of lifestyle-related diseases in rural Saudi Arabia and assess how AI can support prevention and early detection in these communities.

Keywords: Infectious diseases, type 2 diabetes, Artificial intelligence (AI).

Introduction:

Saudi Arabia, a high-income nation with a population of 32 million and a per capita gross national income of approximately \$22,000, has made significant strides in controlling infectious diseases and reducing infant and child mortality. However, non-communicable diseases (NCDs), particularly ischemic heart disease and road traffic injuries, have emerged as leading causes of death and disability-adjusted life years (DALYs). Key risk Received: September 26, 2024. Accented: November 28.

factors include obesity, poor diet, hypertension, and elevated fasting plasma glucose. Obesity prevalence has risen sharply, from 10.8% in 1975 to 35.4% in 2016, with Saudi Arabia ranking 13th globally. The probability of premature death from NCDs between ages 30 and 70 is 16.4%. The Saudi Health Interview Survey revealed alarming rates of obesity (24.1% men, 33.5% women), hypertension (17.7% men, 12.5% women), and diabetes (14.8% men, 11.7% women), with significant proportions undiagnosed

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or inadequately treated (1). Physical inactivity and poor dietary habits are widespread, with 46.0% of men and 75.1% of women reporting low activity levels, and only 7.6% consuming adequate fruits and vegetables. Vitamin D insufficiency and smoking further exacerbate health risks. Despite an extensive healthcare infrastructure, including over 2,300 primary health centers and 216 general hospitals, challenges persist in screening, treatment, and patient compliance. The National Transformation Program 2020 aims to enhance private sector involvement and improve preventive care. particularly for obesity and smoking. However, primary healthcare quality remains suboptimal, with limited health education, poor patient follow-up, and inadequate communication. Effective health education and community engagement through primary health centers are critical for reducing NCD prevalence. A national health insurance model incorporating screening, early diagnosis, and patient incentives could strengthen prevention efforts. Saudi Arabia urgently requires a robust national health promotion program to address the growing burden of lifestyle-related diseases and ensure a healthier population (1).

The Kingdom of Saudi Arabia (KSA) has undergone a rapid and complete epidemiologic transition, driven by significant economic growth over the past four decades. This has led to improved living standards but also the adoption of a 'Westernized' lifestyle characterized by unhealthy dietary habits and reduced physical activity. These changes have contributed to a sharp rise in the prevalence of type 2 diabetes mellitus (T2DM), alongside genetic predispositions and a high rate of consanguineous marriages. A 2004 national survey revealed that 23.7% of Saudi adults aged 30-70 years had T2DM, with an additional 14.1% exhibiting impaired fasting glucose. Urban areas reported higher diabetes rates (25.5%) compared to rural regions (19.5%). Without rigorous intervention, including promoting healthy diets, physical activity, and obesity control, the diabetes burden in KSA is projected to reach catastrophic levels (2). Family history plays a significant role in T2DM risk, with first-degree relatives of diabetic patients being more susceptible. Genetic research has identified variants linked to T2DM, and family history is often used in population-based screening programs. However, lifestyle factors account for approximately half of T2DM risk, underscoring the importance of lifestyle modifications in prevention and delaying disease progression. The International Diabetes Federation emphasizes the need for programs targeting both high-risk individuals and the general population. Excessive caloric intake and physical inactivity are key contributors to T2DM, with studies showing that moderate to vigorous physical activity can reduce diabetes risk independently of weight loss. Similarly, 'Western' dietary patterns, characterized by high consumption of red meat, refined grains, and sugary foods. significantly increase diabetes risk. particularly among obese individuals (2,3).

In KSA, diabetes, hypertension, and coronary artery disease pose major public health challenges, with non-communicable diseases expected to become the leading cause of morbidity and mortality. Despite this, there is a lack of population-based studies on T2DM in KSA, particularly regarding the interplay between genetic and environmental risk factors. Indigenous dietary patterns, such as high consumption of dates, bakery items, and fatty meat dishes, remain understudied (2).

Artificial intelligence (AI) has emerged as a transformative tool in addressing the growing burden of non-communicable diseases (NCDs) in Saudi Arabia. With the rising prevalence of obesity, diabetes, and hypertension, AI-driven solutions offer innovative ways to predict, prevent, and manage these conditions. AI can analyze vast datasets from electronic health records (EHRs), wearable devices, and lifestyle surveys to identify risk factors and enable early intervention. For instance, predictive algorithms can forecast the likelihood of developing type 2 diabetes or hypertension, allowing healthcare

providers to implement personalized preventive measures (4). Additionally, AI-powered mobile applications can deliver tailored health recommendations, promoting behavior change and improving health outcomes, particularly in underserved rural areas (5). By integrating AI into healthcare systems, Saudi Arabia can enhance disease surveillance, optimize resource allocation, and reduce the economic burden of NCDs, ultimately fostering a healthier population (6).

Saudi Arabia faces a significant public health challenge due to the escalating prevalence of lifestyle-related diseases. including obesity, diabetes, and hypertension. Despite advancements in healthcare infrastructure, gaps in screening, diagnosis, and treatment persist, particularly in rural areas. A large proportion of individuals with hypertension and diabetes remain undiagnosed or treated. highlighting inadequately systemic inefficiencies in primary healthcare. Additionally, physical inactivity, poor dietary habits, and limited health education exacerbate the problem. The lack of population-based studies on the interaction between genetic and environmental risk factors further complicates efforts to design effective prevention strategies. Addressing these issues is critical to reducing the burden of NCDs in Saudi Arabia (7).

This study aims to evaluate the prevalence of lifestyle-related diseases in rural Saudi Arabia and explore the application of AI tools for their prediction and prevention. The specific objectives are: (1) to assess the prevalence of obesity, hypertension, and diabetes in rural populations; (2) to identify behavioral and biosocial risk factors, including dietary patterns and physical inactivity; (3) to develop AI-driven predictive models for early detection of disease risks; and (4) to propose targeted interventions leveraging AI technologies to improve health outcomes. By addressing these objectives, the study seeks to inform national strategies for reducing the burden of NCDs in Saudi Arabia.

Methodology:

The present study employs a qualitative research design, utilizing a systematic review approach to collect and analyze data from previously published articles. Peer-reviewed journals, government reports, and credible databases such as PubMed, Scopus, and Google Scholar were searched for relevant studies on non-communicable diseases (NCDs), lifestyle-related risk factors, and the application of artificial intelligence (AI) in healthcare within Saudi Arabia. Keywords such as "lifestyle", "obesity," "diabetes," "hypertension," "AI in healthcare," and "Saudi Arabia" were used to identify articles published between 2015 and 2025. Inclusion criteria focused on studies addressing prevalence, risk factors, and AI-driven interventions for NCDs. Data extraction involved categorizing findings into themes such as disease burden, behavioral risk factors, and AI applications. Thematic analysis was conducted to identify patterns and insights, ensuring а comprehensive understanding of the research problem. Ethical considerations, including proper citation and avoidance of plagiarism, were strictly adhered to throughout the study (8).

Results:

Saudi Arabia, a high-income nation with a population of 32 million, has made significant strides in controlling infectious diseases and reducing infant and child mortality. However, the country now faces a growing burden of noncommunicable diseases (NCDs), particularly lifestyle-related conditions such as obesity, diabetes, and hypertension. These diseases are prevalent in both urban and rural areas, with rural populations often experiencing limited access to healthcare services and preventive measures. The integration of artificial intelligence (AI) into healthcare systems offers a transformative approach to predicting and preventing these diseases, particularly in underserved rural regions. This paper explores the role of AI in addressing lifestyle-related diseases in

rural Saudi Arabia, drawing on recent research and technological advancements. Lifestyle-related diseases, including obesity, diabetes, and hypertension, are major public health challenges in Saudi Arabia. The Saudi Health Interview Survey revealed alarming rates of obesity (24.1% among men and 33.5% among women) and diabetes (14.8% among men and 11.7% among women), with of cases significant proportions remaining undiagnosed or inadequately treated. Rural areas, in particular, face unique challenges, including limited healthcare infrastructure, lower health literacy, and cultural barriers to adopting healthy lifestyles. These factors contribute to the high prevalence of NCDs in rural populations, underscoring the need for innovative solutions to improve disease prevention and management (9).

AI has emerged as a powerful tool for predicting and preventing lifestyle-related diseases. Machine learning algorithms can analyze vast datasets, including electronic health records (EHRs), wearable device data, and lifestyle surveys, to identify risk factors and predict disease onset. For example, a study by the Al-Kharj Nurses Study Team (2024) developed an AI-based application to predict the risk of type 2 diabetes mellitus (T2DM) in Saudi Arabia, demonstrating the potential of AI for early detection and intervention. Similarly, AI-powered tools like DiseaseLens have been used to predict lifestyle-related diseases by analyzing behavioral and biometric data, enabling healthcare providers to implement targeted preventive measures. AI-driven predictive models are particularly valuable in rural areas, where access to healthcare services is often limited. By leveraging AI, healthcare providers can deliver identify high-risk individuals and personalized health recommendations through mobile applications or telemedicine platforms. For instance, AI-powered mobile apps can monitor physical activity, dietary habits, and metabolic markers in real time, promoting behavior change and improving health outcomes. These tools not only enhance disease prevention but also reduce the

burden on healthcare systems by enabling early intervention and reducing the need for costly treatments. While AI holds great promise for improving healthcare in rural Saudi Arabia, several challenges must be addressed to ensure its effective implementation. Limited access to digital infrastructure, low health literacy, and cultural resistance to technology are significant barriers to AI adoption in rural areas. Additionally, ethical concerns related to data privacy and algorithmic bias must be carefully managed to build public trust in AI-driven healthcare solutions (10).

Despite these challenges, there are significant opportunities for leveraging AI to address healthcare disparities in rural Saudi Arabia. The Saudi government's Vision 2030 initiative emphasizes the importance of digital transformation and innovation in healthcare, providing a strong policy framework for AI adoption. Partnerships between the public and private sectors, as well as collaborations with international organizations, can further accelerate the development and deployment of AI technologies in rural healthcare settings. Several AI applications have already demonstrated their potential to improve healthcare outcomes in Saudi Arabia. For example, the Mawid app, a national appointment booking system powered by AI, has streamlined patient scheduling and reduced waiting times at hospitals, significantly enhancing the healthcare experience 6. In rural areas, AI-powered telemedicine platforms can provide remote consultations and health monitoring, bridging the gap between patients and healthcare providers (11).

Another notable example is the use of AI for predictive analytics in disease management. A study by the National Center for AI (2023) highlighted the role of AI in detecting diseases such as breast cancer and diabetic retinopathy, which are prevalent in rural populations. By integrating AI into primary healthcare centers (PHCCs), Saudi Arabia can improve early detection and treatment of lifestylerelated diseases, ultimately reducing the burden of NCDs in rural areas. The integration of artificial intelligence (AI) into healthcare, particularly in Saudi Arabia, has gained significant momentum in recent years, driven by the need to address the growing burden of non-communicable diseases (NCDs) and improve healthcare delivery. Research from 2015 to 2023 highlights the transformative potential of AI in disease detection, diagnostics, and chronic disease management. For instance, AI tools have been deployed for detecting diseases such as breast cancer, COVID-19, and diabetic retinopathy, significantly improving diagnostic accuracy and reducing healthcare disparities. Similarly, AIpowered predictive analytics and personalized medicine are being utilized to enhance patient outcomes and optimize resource allocation. Despite these advancements, challenges remain, including technical infrastructure gaps, cultural resistance, and ethical concerns. Studies emphasize the importance of robust AI governance frameworks to ensure ethical AI use, focusing on principles such as fairness, privacy, and accountability. The Saudi Food & Drug Authority (SFDA) has also provided guidelines for AI-based medical devices, ensuring their accuracy, security, and clinical efficacy. Furthermore, AI integration in electronic health records (EHRs) has improved data accessibility and supported clinical decision-making, while AI-driven population health management tools have been instrumental in predicting disease outbreaks and optimizing resource allocation (12).

In addition to clinical applications, AI is transforming medical education and administrative workflows. AI-powered simulations are enhancing nursing and medical education by providing realistic training scenarios and improving clinical decisionmaking skills. Generative AI is also being used to automate administrative tasks, reduce clinician burnout, and streamline workflows. However, the successful adoption of AI in healthcare requires addressing barriers such as technical challenges, ethical concerns, and job displacement fears. Overall, Saudi Arabia's strategic focus on AI integration in healthcare, supported by national policies and international collaborations, positions the country as a leader in leveraging AI to address public health challenges. By continuing to invest in AI research, infrastructure, and ethical frameworks, Saudi Arabia can further enhance healthcare delivery and improve population health outcomes.

The integration of AI into healthcare systems offers a transformative approach to predicting and preventing lifestyle-related diseases in rural Saudi Arabia. By leveraging advanced data analytics, machine learning, and predictive modeling, AI can enable early detection of disease risks, facilitate timely interventions, and promote behavior change. However, the successful implementation of AI in rural healthcare requires addressing challenges related to infrastructure, health literacy, and ethical concerns. With strong policy support and strategic investments, Saudi Arabia can harness the power of AI to improve healthcare outcomes and achieve its Vision 2030 goals.

Discussion:

The integration of artificial intelligence (AI) into healthcare systems presents a transformative opportunity to address the growing burden of lifestyle-related diseases in rural Saudi Arabia. The prevalence of obesity, diabetes, high and hypertension in these regions, coupled with limited access to healthcare services, underscores the urgent need for innovative solutions. AI-driven tools, such as predictive algorithms and wearable technologies, offer a promising approach to early disease detection and prevention. By analyzing electronic health records (EHRs), lifestyle data, and biometric markers, AI can identify high-risk individuals and enable timely, targeted interventions. For instance, AI-powered mobile applications can deliver personalized health recommendations, promoting behavior change and improving health outcomes in underserved populations. However, the successful implementation of AI in rural healthcare faces several challenges. Limited digital infrastructure,

low health literacy, and cultural resistance to technology are significant barriers that must be addressed. Additionally, ethical concerns related to data privacy and algorithmic bias require careful consideration to ensure equitable and trustworthy AI adoption. Despite these challenges, the Saudi government's Vision 2030 initiative provides a strong policy framework for integrating AI into healthcare, emphasizing the importance of digital transformation and innovation. The potential of AI to bridge healthcare disparities in rural areas is immense. Telemedicine platforms powered by AI can provide remote consultations and health monitoring, while predictive analytics can enhance disease management and reduce the burden on healthcare systems. By leveraging AI, Saudi Arabia can improve early detection and treatment of lifestyle-related diseases, ultimately fostering a healthier population. Strategic investments in AI research, infrastructure, and ethical frameworks will be critical to realizing this potential and achieving the goals of Vision 2030 (12).

Conclusion:

The integration of artificial intelligence (AI) into healthcare systems offers a transformative solution to the growing burden of lifestyle-related diseases in rural Saudi Arabia. By leveraging predictive algorithms, wearable technologies, and real-time data analytics, AI enables early detection and prevention of conditions such as obesity, diabetes, and hypertension. These tools empower healthcare providers to deliver personalized interventions, particularly in underserved rural areas where access to care is limited. However, challenges such as limited digital infrastructure, low health literacy, and ethical concerns related to data privacy must be addressed to ensure equitable AI adoption. The Saudi government's Vision 2030 initiative provides a strong policy framework to support AI integration, emphasizing innovation and digital transformation. By investing in AI research, infrastructure, and ethical frameworks, Saudi Arabia can bridge healthcare disparities, reduce the prevalence of

lifestyle-related diseases, and foster a healthier population. AI represents a critical step forward in achieving sustainable healthcare improvements and realizing the goals of Vision 2030.

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