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Digital epidemiology investments, Saudi Arabia

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Abstract

Problem Traditional epidemiological surveillance methods are often limited by delays in reporting and fragmented data systems. Saudi Arabia faces additional public health challenges from mass gatherings during Hajj and Umrah, an increasing burden of noncommunicable diseases and rapid urbanization, highlighting the need for investing in digital epidemiology.

Approach Saudi Arabia has accelerated digital transformation in health care through Vision 2030 initiatives. The strategies include health information exchange platforms, analytics driven by artificial intelligence, telemedicine services and digital monitoring systems used during Hajj. We review current initiatives to invest in digital epidemiology in Saudi Arabia, implementation challenges and policy priorities.

Local setting Saudi Arabia's health system operates under a predominantly public model. The health ministry is the main provider, regulator and finance provider of most health-care services. Health-care coverage is nearly universal, with citizens receiving services free of charge through the public system. Ongoing reforms aim to gradually decentralize certain functions.

Relevant changes The initiatives under Vision 2030 have supported disease surveillance, data integration and public health response capacities. Existing digital health reforms have created a foundation for integrating digital epidemiology into routine public health practice. However, challenges remain, including fragmented interoperability between institutions, workforce shortages, unequal digital access, and concerns about data governance, privacy and algorithmic bias.

Lessons learnt Saudi Arabia's experience suggests that digital epidemiology is more effective when integrated within broader digital health reforms. Successful implementation requires not only digital infrastructure, but also workforce development, ethical governance, transparency and mechanisms for integrating digital data into public health decision-making.

Introduction

Epidemiology, the core discipline of public health, has traditionally depended on different data collection methods, including population surveys, vital statistics and medical records. These traditional methods have offered important insights into disease trends, risk factors and outcomes. However, these methods are often limited by delays, underreporting and geographic biases, which can slow public health responses, especially during infectious disease outbreaks.¹

The digital revolution has transformed public health surveillance. The integration of digital technologies such as artificial intelligence (AI), big data analytics (that is, large amounts of highly varied data from many different sources that may be processed rapidly), real-time geospatial mapping, mobile health applications, social media monitoring and wearable biosensors has given rise to the field of digital epidemiology. Unlike traditional methods, digital epidemiology enables continuous, real-time collection and analysis of different data streams, ranging from electronic medical records and pharmacy transactions to social network feeds and smartphone-based symptom checkers. These data sources, when analysed using machine learning algorithms and computational models, facilitate early detection of infectious disease outbreaks, risk stratification and the development of tailored public health interventions.¹

Saudi Arabia has several distinct public health challenges.²⁻⁴ First, the annual Hajj and Umrah pilgrimages bring millions of people from around the world into close contact, heightening the risk of infectious disease outbreaks.² Second, the country faces a growing burden of noncommunicable diseases, including diabetes, obesity, hypertension and

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cardiovascular disease, which are driven by sedentary lifestyles and dietary transitions.³
Third, the rapid urbanization of the Saudi Arabian community has reshaped living conditions, mobility patterns and environmental exposures, creating new public health risks.⁴ These factors not only increase the risk of disease transmission but also demand real-time monitoring, predictive analytics and rapid response capabilities. In this context, this article highlights the rationale for Saudi Arabia's investment in digital epidemiology and outlines reforms that have created a foundation for integrating digital epidemiology into routine public health practice.

Local setting

Saudi Arabia's health system operates under a predominantly public model, with the health ministry serving as the main provider, regulator, and financier of most health-care services. The health ministry manages most hospitals and primary health care centres. Several semi-governmental organizations, such as the National Guard Health Affairs, the Ministry of Defence Health Services and university hospitals, offer services to specific populations. The private sector also plays an increasingly important role, particularly in urban areas, resulting in a mixed health system. The Saudi Arabian government is currently implementing a health-care privatization programme aimed at expanding the private sector's role in service delivery and reducing the financial burden on the public system. Governance within the Saudi Arabian health system is centralized, with the health ministry and other national bodies, such as the Saudi Health Council and the Public Health Authority, overseeing strategy, regulation and implementation. Ongoing reforms under the Health Sector Transformation Programme aim to gradually decentralize certain functions. Health-care coverage in Saudi Arabia is nearly universal, with citizens receiving services free of charge through the public system, while residents and expatriates are covered through mandatory private health insurance. The system incorporates some co-payment mechanisms in the private sector, mainly for services beyond basic coverage or at premium facilities.^{5,6}

Approach

Vision 2030, Saudi Arabia's long-term national strategy, includes the National Digital Transformation Programme, which promotes digital transformation and AI integration across sectors, including health care.⁷ The strategies under Vision 2030 include health information

exchange platforms, AI-driven analytics, telemedicine services and digital monitoring systems during Hajj. Saudi Arabia has compelling reasons to invest in digital epidemiology, given its distinct health challenges and evolving population dynamics. With the annual pilgrimages, these digital tools can enable real-time surveillance, rapid contact tracing and crowd health monitoring to prevent and manage such events more effectively. For noncommunicable diseases, digital epidemiology can facilitate continuous monitoring of the risk factors through mobile health applications, wearable sensors and population-level data analytics, which supports early intervention and health promotion. Given the rapid urbanization of the Saudi Arabian population, digital platforms allow integration of environmental, behavioural and clinical data to help policy-makers design healthier and more sustainable urban environments.

Relevant changes

In line with Vision 2030, the health ministry established the National Platform for Health Information Exchange Services, which enables seamless data sharing among health-care providers and the National Health Information Center, which oversees the integration of health data and the interoperability of electronic medical records.^{8,9} Additionally, the Saudi Data and Artificial Intelligence Authority supports big data analytics and AI-driven health-care innovations. The national data bank of this authority consolidates various data sources, including health data, and provides an analytics platform for predictive modelling and disease trend forecasting. *Estishraf*, a predictive analytics platform developed by the Saudi Data and Artificial Intelligence Authority, uses AI to anticipate health-care needs and detect potential outbreaks or health crises, further advancing the capabilities of digital epidemiology.¹⁰ In addition, the Smart Hajj programme was established to digitize services for pilgrims and has become a model for large-scale public health monitoring. The programme uses digital tools, including mobile applications and connected sensors, to monitor pilgrims' health during Hajj.¹¹ This data-driven approach enables timely identification of health issues, such as respiratory infections or heatstroke, and provides updated information on potential public health risks, which is vital for outbreak prevention.¹²

Lessons learnt

Existing investments under Vision 2030, including health information exchange systems, AI-driven analytics platforms and digital monitoring tools used during Hajj, have created an

important foundation for adopting data-driven public health approaches. However, the implementation of digital epidemiology has faced several challenges. One important barrier is the fragmentation of data systems across different health-care providers and institutions, which limits data integration and interoperability. Another issue is the shortage of specialized professionals, including data scientists, epidemiologists and digital health experts, capable of managing and analysing large, complex data sets. Additionally, data privacy and ethical governance are ongoing concerns. As digital epidemiology relies on personal and location-based data, establishing robust legal frameworks and public trust is essential to prevent misuse and ensure transparency. Other obstacles include limited public awareness of digital epidemiology, uneven digital infrastructure in remote regions and resistance to adopting new technologies. Unequal access to digital technologies may also widen existing health disparities. At the same time, algorithmic bias and overreliance on proprietary or non-health data sources may affect the reliability and fairness of digital epidemiology systems.¹³

To effectively integrate digital epidemiology into Saudi Arabia's public health system, the development of a comprehensive national digital epidemiology strategy is needed (Box 1). This strategy should prioritize the establishment of a structured framework that guides the adoption of AI, big data analytics and wearable health technologies to track disease trends, predict outbreaks and implement personalized public health interventions. A central aspect of the proposed strategy would be the development of a national repository for epidemiological data that is accessible to researchers and policy-makers across the country.

In parallel, enhancing workforce training is important. Epidemiologists and public health professionals need digital skills to navigate emerging technologies. Specialized training programmes that focus on data analysis, epidemiological modelling and the use of digital health tools will ensure that professionals can effectively use these technologies to monitor health trends, detect outbreaks and implement preventative measures.

Additionally, strengthening international collaborations is an essential step to ensure that Saudi Arabia can learn from best practices and align its strategies with global health standards and thereby remain at the forefront of digital epidemiology.

Integrating ethical and governance considerations is crucial for the responsible implementation of digital epidemiology in Saudi Arabia. Clear policies must safeguard data

privacy, security and informed consent, ensuring that health information is used transparently and ethically. Establishing a national ethical governance framework and data protection regulations will help prevent misuse and build public trust. Transparent policies on data collection, sharing and algorithm use, alongside clear accountability and independent oversight mechanisms, are also important to maintain public confidence in large-scale data integration initiatives.

To conclude, an important lesson is that investment in digital infrastructure alone is insufficient (Box 2). Successful implementation also requires workforce training, clear governance frameworks, ethical oversight and transparent mechanisms for integrating digital data into routine public health decision-making. Additionally, digital epidemiology may be particularly valuable in settings with mass gatherings and rapidly changing population dynamics, where timely surveillance and rapid response are essential. Saudi Arabia's experience may therefore provide useful insights for countries seeking to strengthen digital public health systems or improve preparedness for large-scale public events.

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Competing interest:

None declared.

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Box 1. Pillars of a proposed national digital epidemiology strategy, Saudi Arabia

Technology frameworks

Establish clear guidelines for adopting AI, big data (large amounts of highly varied data from many different sources that may be processed rapidly) and wearable technology.

Integrate these tools into existing health systems.

Standardize protocols for disease tracking and personalized interventions.

National data repository

Create a centralized, accessible epidemiological database.

AI and data infrastructure

Invest in robust infrastructure for data collection, sharing and integration.

Enable real-time analysis from hospitals, health ministry applications and wearable devices.

Support predictive modelling for outbreak forecasting.

Workforce training

Train public health professionals on using large language models, machine learning and data analytics.

Develop specialized programmes in digital epidemiology and health modelling for health professionals.

International collaboration

Partner with global health bodies and experts.

Align strategies with international standards for global health security.

Ethical governance and data protection

Develop a national framework to ensure ethical data collection, storage and use.

Enforce privacy, consent and data security regulations.

AI: artificial intelligence.

Box 2. Summary of main lessons learnt

- Digital epidemiology is most effective when integrated into broader digital health reforms.
- Successful implementation requires infrastructure, workforce training and ethical governance.
- Digital epidemiology is particularly valuable for mass gatherings and rapidly changing population dynamics.