

Review

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Review

An Uneven Century: Navigating Health Disparities in Maternal and Neonatal Care in the MENA Region Through Artificial Intelligence

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Abstract

This review article analyzes how decades of progress in maternal and neonatal health (MNH) are being threatened by global crises, conflicts, and socioeconomic inequities, which have led to significant health disparities in the Middle East and North Africa (MENA) region. The paper calls for context-specific research on the long-term effects of COVID-19 and its variants on MNH, as the absence of this data indicates a deep-seated deficiency in a public health infrastructure not yet equipped for sophisticated epidemiological surveillance during a crisis. While Artificial Intelligence (AI) offers transformative potential through improved diagnostics, predictive analytics, and enhanced healthcare delivery, its adoption in MENA region is hindered by digital infrastructure deficits, skill gaps, and complex data privacy and ethical concerns. This review argues that AI can only be a transformative agent if designed to address these multifaceted barriers. By reviewing current AI initiatives and their potential for equitable healthcare delivery, this review concludes with a proposed implementation roadmap for responsible and equitable AI integration to re-accelerate progress towards the Sustainable Development Goals (SDGs) for MNH in the MENA region.

Keywords: Maternal; Neonatal; AI; COVID-19 and MENA

1. Introduction

The global community has made significant, though uneven, progress in MNH over the past few decades. This progress is primarily due to concerted public health efforts, increased access to care, and medical innovations that have led to a general decline in mortality rates. Despite historical improvements, the pace of progress in maternal and neonatal health is no longer consistent, with some regions now showing a decline in key health indicators [1]. A complex interplay of systemic failures, global crises, and entrenched socio-economic and cultural barriers has caused a slowdown that now threatens to reverse decades of progress and put the 2030 SDGs specifically SDG 3.1: Maternal Mortality and SDG 3.2 at risk [2,3].

Against this backdrop, AI offers significant promise for advancing MNH through improved diagnostics, predictive analytics, and healthcare delivery. However, its effective implementation faces substantial regional, socio-economic, and geopolitical barriers, including digital infrastructure limitations, skill gaps, data privacy concerns, and unique ethical dilemmas within the MENA context [4]. While the global community has witnessed significant progress in MNH over recent decades, this positive trajectory has plateaued, with many regions experiencing reversals [5]. The MENA region presents a particularly acute case, where a complex interplay of systemic failures and global crises threatens to reverse hard-won gains and impede the achievement of SDGs for MNH [6].

This review argues that the MENA region represents a unique and particularly acute case of this global challenge. Despite some regional progress, a significant disparity exists between high-income Gulf nations and countries grappling with conflict, fragility, and economic hardship.

2. The MNH Global Crisis with Lens on MENA Region

Towards the end of the twentieth century and the beginning of the twenty-first century, global MNH attained an unprecedented level of elevation. The MDGs had an immense ability to precipitate the decline in Maternal Mortality Ratios (MMR) and in under-five mortality was immense [7]. As the service delivery system improved, progress was made in areas such as immunization, skilled birth attendance, and family planning access. By 2015, the world's MMR had, in fact, decreased almost 45% away from 1990 levels, while the Neonatal Mortality Rate (NMR) had fallen by nearly one-third [8-10]. These achievements were phenomenal statistical victories, saving millions of lives and improving human well-being [11]. Following significant advancements in MNH during the MDGs era, the post-2015 period has seen a concerning slowdown, and in some instances, reversals, in the decline of maternal and neonatal mortality rates. This stall is largely attributable to a complex interplay of systemic failures, global crises such as the COVID-19 pandemic and persistent socioeconomic inequities that have overwhelmed healthcare systems [12,13]. The MENA region, despite some overall improvements, exemplifies this global challenge, with vast disparities existing between high-income Gulf nations and conflict-affected countries.

2.1. Trends in Maternal and Neonatal Mortality

According to data from the WHO and UNICEF [1,14], maternal and neonatal mortality rates (MMR and NMR) in the MENA region have shown a positive overall trend, as summarized in Supplementary File Table S1.

Figure 1. Illustrates these trends, despite the general trend of improvement, the figure reveals considerable disparities in mortality rates among countries, highlighting the uneven distribution of progress. GCC countries, including the UAE have the most favorable outcomes, with an MMR, whereas such low cases represent probably the highest expenditure safe to stable health system in the world. Conversely, one interpretation of data from countries like Yemen, with an MMR of 118 and an NMR of 39, and Sudan, with an MMR of 256 and an NMR of 50, the data suggests that humanitarian crises severely undermine healthcare services, leading to poorer health outcomes.

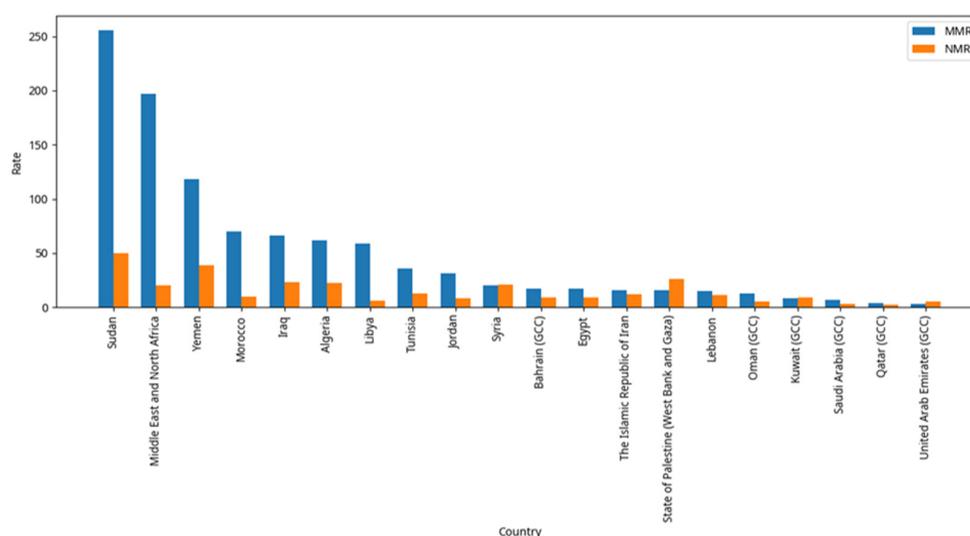


Figure 1. The disparities in MMR and NMR for MENA region. There are significant disparities in the MMR and NMR across the MENA region, with countries affected by humanitarian crises like Sudan and Yemen having the highest rates. Conversely, GCC countries, such as Qatar and the UAE, exhibit the lowest mortality rates, reflecting a stark contrast in health outcomes.

Figure 2. The "Overall change in MMR between 2000 and 2023" column shows that all listed countries experienced a significant decline, with some achieving a reduction of over 70% (e.g., State of Palestine (before war- October 2023) and UAE)

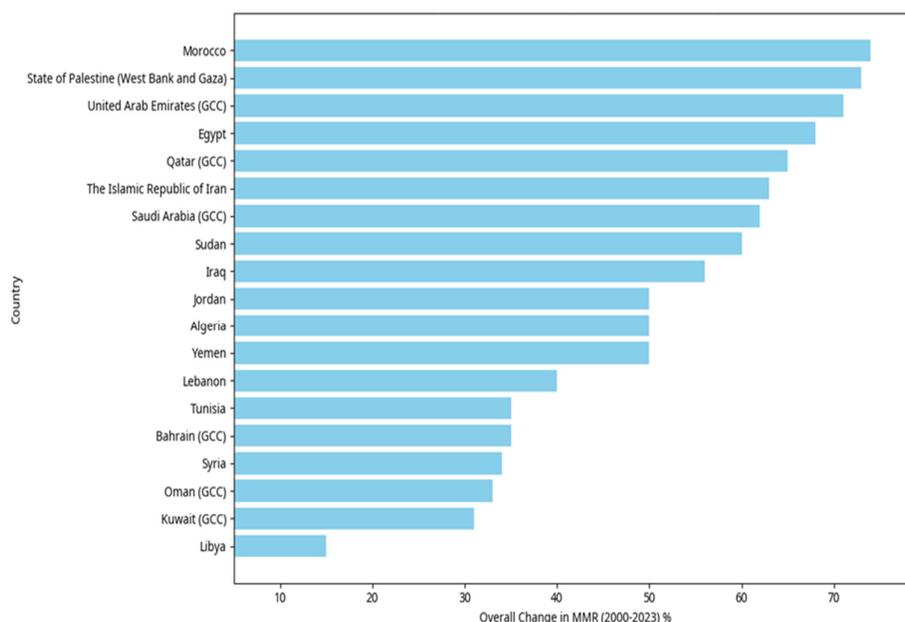


Figure 2. The overall change in MMR between 2000-2023. However, despite this individual progress, a considerable gap and an uneven distribution of progress remain evident when comparing MMR across different nations. For example, while countries like Morocco and the United Arab Emirates have achieved a reduction of over 70%, others still face substantial challenges.

2.2. Systemic Vulnerabilities and Compounding Crises: MENA

The hard-won progress in MNH in the MENA region is being reversed by a set of escalating crises functioning as "threat multipliers". These crises do not act in isolation but exploit and aggravate the existing systematic vulnerabilities of the health sector. The COVID-19 pandemic, for example, exposed the fragility of national health systems by diverting critical resources and deterring pregnant women from seeking care, leading to increased preventable complications and deaths [15]. Furthermore women with long COVID have been found to be at a higher risk for adverse maternal and neonatal outcomes, including preterm birth and an increased need for neonatal intensive care. Similarly, a systematic review noted a stillbirth rate of 9.9 per 1000 total births in babies born to COVID-19 mothers, although it concluded that the overall rate of stillbirth was low [16,17]. The potential for COVID-19 to impact fetal brain development has been a significant area of research. Theoretical mechanisms for such an impact include maternal immune activation, placental disruption leading to conditions like preeclampsia and intrauterine growth restriction and altered epigenetic processes. However, a central and surprising finding has fundamentally shifted the understanding of this risk. A study on neurodevelopmental outcomes at six months found a profound distinction: infants born [18]. Additionally, while the Omicron variant of COVID -19 is associated with a significantly lower risk of critical care admission and preterm birth in pregnant women compared to the Delta variant, its overall risk relative to uninfected pregnancies remains to be conclusively determined [19]. As of yet, there is a paucity of research on this topic within the MENA region. These potential risks indirectly impede the achievement of SDG 3. 1& 2 of 2030.

This is further compounded by significant financial barriers, such as high out-of-pocket (OOP) healthcare expenditures. This strain is intensified by economic downturns, political instability, and conflicts. In countries such as Egypt, where OOP payments form a substantial portion of health

spending, susceptible families are often confronted with a choice between MNH care and other basic necessities. Such a financial strain, an existing vulnerability, is exacerbated by economic turning downward, political instability, and conflicts [20].

The devastating impact of conflicts, exemplified by the war in Gaza and Sudan, further dismantles healthcare infrastructure and exacerbates humanitarian crises, leading to dire MNH outcomes, for example, the observed outcome from Gaza documented high prevalence of low birth weight (10.8%), maternal anemia (50.4%), high stress levels (62.08%). In Sudan, a significant majority of women (86.6%) lack access to healthcare services, with adverse outcomes linked to factors like delivery mode and gestational age [21,22]. Furthermore, systemic information and geopolitical barriers impede effective implementation of health solutions, including AI. In remote areas, 'information poverty' often compounds 'geographic poverty,' hindering access to care. Effective AI utilization necessitates massive, high-quality datasets, yet the MENA region faces significant challenges due to data and trust issues. Political tensions and a lack of standardized data governance frameworks foster mistrust regarding privacy and cross-border data sharing [23-25]. The absence of robust digital security also renders health data vulnerable to cyber-attacks, while the politicization of health issues can lead to inequitable resource distribution, creating a profound 'AI-equity gap' where resource-limited countries lag behind those heavily investing in digital health infrastructure [26-28]. This disparity risks creating a two-tiered healthcare system, where access to life-saving AI interventions is determined by geography and economic stability [29].

3. AI: A Catalyst for MNH Progress in MENA

While the application of AI in MNH is still in its nascent stages, its rapid expansion across global healthcare systems, including the MENA region, signals a promising frontier for improving health equity and achieving sustainable development goals related to health and wellbeing [4,30].

AI4GH Innovation Hub is a collaborative effort to establish an AI innovation network to improve sexual, reproductive, and maternal health outcomes across the MENA Region. This intervention emphasizes strengthening health systems through the utilization of responsible AI solutions. The hub seeks to build a vibrant community of practice among African innovators, researchers, and other stakeholders that would result in local AI innovations catering to the needs of the region.

The project addresses crucial problems, including unintended pregnancies, early and forced marriages, complications of unsafe abortions, and gender-based violence [31]. This initiative highlights a concerted effort to leverage AI for broader public health improvements beyond direct clinical applications, focusing on systemic enhancements and equitable access to information and services. Despite the initiatives and challenges discussed earlier, several notable AI initiatives and projects are underway across the MENA region, specifically targeting MNH.

3.1. AI for Predictive Analytics and Clinical Decision Support

In Qatar AI solutions are actively being explored and implemented to enhance MNH, with a particular emphasis on precision medicine and predictive analytics. Studies are evaluating the efficacy of AI algorithms in predicting the mode of delivery, aiming to optimize birth planning and reduce complications [32]. This focus on predictive modeling extends to broader precision medicine initiatives within MNH. For instance, the AMAL-For- Qatar project is a pioneering endeavor that seeks to revolutionize prenatal care by integrating advanced AI to automate the analysis of fetal data, thereby enabling earlier and more accurate detection of potential issues [33,34].

The kingdom of Saudi Arabia (KSA) is actively integrating AI into its healthcare system, with initiatives including the evaluation of algorithms for predicting the mode of delivery [35]. The commitment to AI integration is further demonstrated by ongoing surveys assessing healthcare professionals' perspectives and readiness to adopt AI in pediatric critical care, highlighting a proactive approach to workforce preparedness [36]. A key area of development is using the application as predictive modeling to identify high-risk pregnancies and improve maternal and

newborn health outcomes [37,38]. The Saudi Data and Artificial Intelligence Authority (SDAIA) play a pivotal role in driving the integration of AI across various sectors, including healthcare, to enhance service quality and address existing challenges [39].

Tunisia is also making strides in leveraging AI to improve MNH [40], the country is witnessing the introduction of AI-assisted electronic clinical decision support systems (eCDSS) specifically designed for antenatal and perinatal care, with the overarching goal of reducing maternal and neonatal mortality [41].

In the field of neonatology in Morocco, studies are exploring the feasibility and implementation of AI in university hospitals to optimize early detection, risk assessment, and personalized management of conditions such as Respiratory Distress Syndrome (RDS) in newborns [42].

3.2. AI in Medical Imaging, Diagnostics and Manpower

For MBZUAI by Mohamed Bin Zayed university located in UAE is spearheading developments in prenatal and postnatal health improvement through AI development in medical imaging and ultrasound analysis. Amongst the most innovative accomplishments, FetalCLIP is an application of AI in fetal ultrasound imaging interpretation, created in the BioMedIA Lab. This model also executes the precise measurement of fetal anatomy, which is important for assessment of its growth and development so as to enable health providers to facilitate healthier pregnancies and babies all around the world [43].

While research and initiatives in Egypt are exploring the application of AI for crucial aspects such as fetal monitoring in maternity units, accompanied by efforts to educate nursing staff on the perspectives and attitudes surrounding AI integration [44]. The role of AI in empowering obstetrical and gynecological nurses is gaining prominence, with the aim of enhancing women's safety and overall healthcare delivery [45].

3.3. AI for Mobile Health (mHealth) and Community Engagement

The GAIN MHI project in Lebanon stands as a compelling case study for the successful integration of AI-driven, gamified mHealth interventions in improving maternal health outcomes within resource-constrained settings. The study evaluating GAIN MHI demonstrated its effectiveness in enhancing Antenatal Care (ANC) utilization and improving both maternal and neonatal outcomes, particularly when healthcare providers (HCPs) were actively engaged in the intervention [46]. The study showed significantly higher odds of pregnant women having at least four ANC visits, having all recommended ultrasounds and lab tests, and increasing supplement intake in the group where HCPs were involved. There were also improvements in term delivery and a drastic 52.15% reduction in NMR resulting from the intervention. These findings underscore the critical importance of harnessing digital tools along with direct clinical support to break down systemic barriers to maternal health in resource-poor settings [46].

Other counties within MENA region not mentioned above appear to initiatives/ approaches in an early, strategic phase, with a strong emphasis on public announcements, conference events and press release aim at developing the necessary technological infrastructure to support future AI applications in healthcare, particularly within MNH. The initiatives haven't yet resulted in peer-reviewed scientific studies.

4. The Potential of AI to Re-Accelerate Equity (with a MENA-Specific Lens)

AI can re-accelerate progress in MNH in the MENA region by offering low-tech, scalable solutions that bypass traditional infrastructure limitations. Instead of focusing on large, expensive systems, the key lies in leveraging existing mobile technology and data-driven insights to improve resource allocation and the capacity of healthcare workers.

4.1. Improving Care with Limited Infrastructure

The scope of AI in MENA is not to substitute human healthcare professionals but rather to empower them in their delivery of services in remote or under-resourced settings. Low tech AI solutions that are operated with nothing more than a smartphone or basic feature phone enhance their capacity in care to fill critical gaps. For instance, AI-powered chatbots and SMS services can give pregnant women personalized health information, breastfeeding counseling [47]. Similarly, AI can be used to analyze basic medical images captured with handheld, low-cost ultrasound devices, allowing trained midwives or community health workers to detect high-risk conditions like placenta previa or fetal growth restriction, which would otherwise go undiagnosed due to a lack of specialized radiologists [48-50].

4.2. Optimizing Resource Allocation

In a region with fragmented health systems and severe resource shortages, AI can become a powerful tool for strategic resource allocation. By analyzing data from mobile health applications, clinic visits, and even public health databases, AI models can predict disease outbreaks, identify underserved populations, and forecast spikes in demand for obstetric care in specific regions [51,52]. This predictive capability allows governments and aid organizations to proactively dispatch mobile clinics, allocate essential supplies, and deploy skilled medical staff where they are needed most. In conflict zones, for instance, an AI model could analyze real-time data on displacement patterns and conflict intensity to predict humanitarian health needs, ensuring that a limited supply of medical resources reaches the most vulnerable populations.

4.3. Enhancing Training and Capacity-Building

AI can help to address the acute shortage of healthcare professionals and the lack of specialized training in the region. AI-driven training simulations and virtual reality (VR) platforms can provide an affordable way to educate and improve skill healthcare workers, from doctors to community health workers [53]. AI can also be a clinical decision support tool guiding frontline worker operating in remote areas that are faced with complex cases that they cannot handle alone with their own expertise. With it, they have the knowhow to make a better decision on the spot, with that shore up expertise on site improving patient outcomes and building their local capacity. By leveraging these AI-powered tools, the MENA region can start building a more resilient and equitable health workforce in MNH.

4.4. AI Implementation Roadmap for MNH in the MENA Region

Based on the gap identified within the current review, a roadmap for suggested implantation of AI tool especially for MENA region to overcome the barriers discussed earlier. The proposed three-phased timeline is to be looked at. The first phase of the roadmap, titled "Foundational Elements," is to focus on the creation of appropriate data governance, digital infrastructure, and workforce training. The second phase, "Strategic Development," aims to focus on testing and scaling effective AI projects, while the third phase, "Sustainable Integration," focuses on regional cooperation, equitable access, and ethical and privacy-related continuous monitoring and adaptation. This phased approach highlights the interconnected AI deployment efforts within technology, ethics, and collaboration.

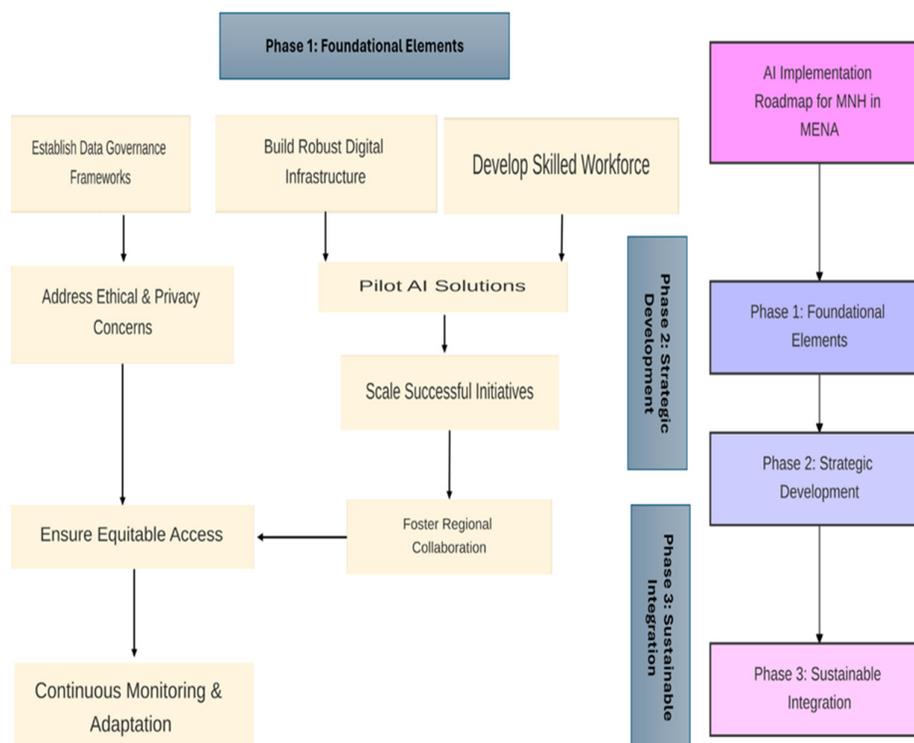


Figure 3. Suggested AI Implementation Roadmap for MNH in the MENA Region. This diagram outlines a three-phase approach Foundational Elements, Strategic Development, and Sustainable Integration essential for the effective and equitable deployment of AI solutions to improve MNH outcomes in the Middle East and North Africa region. It highlights key interdependencies and the iterative nature of successful AI integration, emphasizing the importance of addressing ethical and privacy concerns alongside technological and collaborative efforts.

5. Conclusions

Ultimately, this review concludes that while AI offers a powerful, conditional opportunity to re-accelerate progress in MNH and overcome the multifaceted barriers prevalent in the MENA region. Its transformative potential can only be fully realized by addressing the region's unique systemic vulnerabilities. This review also recommends and calls for context-specific research and action on the long-term effect of COVID-19 and its variants on MNH. The absence of variant-specific data from the region is not a superficial finding but a deep-seated indicator of a public health infrastructure that is not yet equipped for sophisticated epidemiological surveillance during a crisis.

On the other hand, AI is no longer a theoretical force, but a practical one could catalyze the re-acceleration of efforts toward the SDGs for MNH in the MENA region. As demonstrated in this review, AI has great potential in various fields, from predictive analytics and clinical decision support to medical imaging and diagnostics, as well as in engaging the community with mobile health (mHealth) applications. Various initiatives throughout Qatar, KSA, Tunisia, Morocco, UAE, and Egypt highlight the growing interest in unleashing AI's transformative potential for bettering MNH outcomes in the region. However, there are major challenges to the effective and equitable integration of AI in the MENA region. Two major roadblocks include the historical digital infrastructure deficit and an alarming shortage of professionals across disciplinary streams. In addition, there are deeper challenges surrounding data fairness, privacy, trust, and governance. The politicization of health issues and the creation of an "AI-equity gap" further threaten to create a two-tiered system where access to life saving AI interventions could be determined by geographic and economics factors rather

than medical need. These multifaceted barriers necessitate a nuanced and context-specific approach to AI implementation.

This, therefore, is an inflection point in the review: AI can serve as an agent of transformation only if its design and deployment are purposefully and closely aligned with the multi-layered barriers discussed. This will create a synergy between responsible AI use and efforts to tackle systemic vulnerabilities. These include digital infrastructure investment, comprehensive capacity building for health workers, the establishment of strong yet ethical data governance framework, and regional and international collaborations to close the "AI-equity gap". If the MENA region focuses on these foundational elements, it can tap the full potential of AI to overcome the current stagnation. For this reason, the review suggests an AI implementation roadmap for MNH in the MENA region, ensuring that every mother and newborn has access to quality care on any given day, irrespective of socio-economic or geographical backgrounds.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org. Table S1.

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Abbreviations

The following abbreviations are used in this manuscript:

MNH: maternal and neonatal health
MENA: Middle East and Northern Africa
COVID19: Coronavirus disease of 2019
SDGs: Sustainable Development Goals
MDGs: Millennium Development Goals
MMR: Maternal Mortality Ratios
NMR: Neonatal Mortality Rate
WHO: World Health Organization
UNICEF: United Nations Children's Fund
GCC: Gulf Cooperation Council
UAE: United Arab Emirates
U5MR: Under-Five Mortality Rate
OOP: out-of-pocket
KSA: The kingdom of Saudi Arabia
SDAIA: Saudi Data and Artificial Intelligence Authority
eCDSS: Electronic Clinical Decision Support Systems
RDS: Respiratory Distress Syndrome
ANC: Antenatal Care
HCPs: HealthCare Providers

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