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The disease burden of hepatitis B and C viruses and human immunodeficiency virus among pregnant women in the context of climate change

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Abstract

This retrospective cross-sectional study analyzed laboratory records from the Virology Unit at the Maternity and Teaching Hospital in Karbala Governorate over a five-year period (2019-2023), encompassing 41,433 initial screenings among pregnant women. The primary objective was to assess the testing volume and apparent seroprevalence for Hepatitis B Surface Antigen (HBsAg), Hepatitis C Virus Antibody (HCV Ab), and Human Immunodeficiency Virus Antibody (HIV Ab), and to situate these findings within a context of significant external stressors. The data revealed consistently high volumes of testing for these viruses throughout the study period, with a near-universal testing approach indicated by very strong positive correlations ($r > 0.97$, $p < 0.001$) between the total number of patients and the number of tests performed. A critical finding was a sharp 39.2% decline in total screenings in 2020, coinciding with the COVID-19 pandemic, highlighting the vulnerability of essential antenatal services to systemic shocks. Furthermore, the study provides a conceptual framework linking climate change through mechanisms such as extreme weather events, water scarcity, and population displacement to potential disruptions in healthcare infrastructure and subsequent impacts on the epidemiology of blood-borne viruses. While the data reflect a robust institutional commitment to routine screening per WHO guidelines, the pandemic-induced disruption serves as a potent analogue for how climate-related stressors could undermine maternal health programs. This analysis underscores the critical importance of building resilient healthcare systems capable of sustaining essential services, like the prevention of mother-to-child transmission (PMTCT), in the face of concurrent public health and environmental crises.

Keywords: Hepatitis B, hepatitis C, HIV, pregnant women, Karbala

1. Introduction

The health of pregnant women is a key marker for overall health of a society and the performance of public health systems. The risk factors of HBV, HCV, and HIV are notoriously difficult to identify in the maternal history for pregnant women and fetal health. It comes to the consequences of these viruses in pregnancy that are not only related to maternal morbidity, but also concern a significant risk of vertical transmission with consequent chronification, late sequelae and perinatal mortality. About 1.5 million pregnant women in the world are affected by chronic HBV, and if untreated the mother-to-child transmission (MTCT) rate can be as high as 90% among HBeAg positive mothers (World Health Organization (WHO), 2022). Similarly, global prevalence of maternal HCV infection ranges vary and continue to represent potential risk for MCT in the presence of high viral load or HIV co-infection (Benova *et al.*, 2015) ^[1]. There has been great progress in the fight against HIV, yet approximately 1.3 million pregnant women worldwide were living with HIV in 2022 and some levels of progress on new infections among key populations continued to be stalled, to an extent, in Eastern Mediterranean region (UNAIDS 2023).

Further, efficient antenatal screening programmes are the cornerstone of the prevention of MTCT for these viruses. Universal antenatal screening for HBV, HCV and HIV is recommended as a policy according to WHO which allows timely interventions including administration of antiviral prophylaxis (in the case of HBV); appropriate referral and/or treatment if woman tests positive for HCV; or ART if HIV infection exists that can effectively reduce transmission rates through breast milk (WHO, 2022). The implementation,

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however, of such screening programs is neither straightforward nor direct. Like everyone else, they face risks from system-level shocks, including the worldwide coronavirus outbreak. Studies by Chmielewska *et al.* (2021) [2] stressed that the global outbreak led to a significant disturbance of antenatal care services worldwide with an associated low screening coverage for certain infections including HIV and syphilis, which might ruin all years of work in getting towards MTCT elimination.

Another, more insidious and long-lived threat to human health in the absence of an acute pandemic is that posed by climate change. The health impacts of climate change are also context specific. As Rocklöv & Dubrow (2020) [8] emphasized, there is a growing body of evidence that it affects the transmission dynamics of infectious diseases. Altered patterns of temperature and precipitation, the increased occurrence of extreme events, may put pressure on vectors or change water quality and hygiene or indeed drive mass migration. These alterations to environment also may exert indirect impact on the epidemiology of blood borne viruses. For example, flooding may disrupt health services such as sterilization of equipment and antenatal care; droughts and resource depletion can exacerbate high risk survival behaviour that might in turn potentially increase the transmission for HBV HCV and HIV. As outlined in The Lancet Countdown on Health and Climate Change, the very survival of public-health systems-so-called disease prevention and control programmes that constitute more than 80% (budget) of their activities-is at stake because climate change threatens all dimensions of health. (Romanello *et al.*, 2022) [9].

While the direct link between climate variables and the prevalence of blood-borne viruses in pregnant women remains an emerging field of study, understanding the baseline burden and the resilience of screening programs is a crucial first step. This research posits that analyzing long-term trends in serological testing within a major maternity hospital provides invaluable insights into the disease burden and, more importantly, the stability of the public health response in the face of ongoing challenges, including potential climate-related stressors.

2. Research Aim and Objectives

This study aims to comprehensively analyze the disease burden of Hepatitis B and C Viruses and Human Immunodeficiency Virus among pregnant women over a five-year period (2019-2023) and to contextualize the findings within the framework of external stressors, including the COVID-19 pandemic and the overarching threat of climate change.

The specific objectives are:

1. To determine the volume of testing and apparent seroprevalence of HBsAg, HCV Ab, and HIV Ab among pregnant women attending the Maternity and Teaching Hospital from 2019 to 2023.
2. To analyze temporal trends and identify significant disruptions or patterns in screening volumes across the study period.
3. To explore and discuss how large-scale environmental and systemic challenges, such as the COVID-19 pandemic and climate change, could impact the epidemiology and control of these viral infections in the context of maternal and child health.

3. Materials and Methods

3.1 Study Design and Setting

A retrospective cross-sectional study was conducted by analyzing laboratory records from the main public maternity and teaching hospital in Karbala Governorate. This hospital serves as the primary referral center for pregnant women in the province, capturing a representative sample of the obstetric population. Data were extracted from the Virology Unit records within the Technical Division of the hospital's laboratory.

3.2 Data Collection and Period

Electronic and paper-based laboratory registries were reviewed to collect data spanning five years, from January 2019 to December 2023. The dataset included monthly aggregated totals for the number of pregnant women screened and the volume of specific serological tests performed.

3.3 Variables and Measures

The primary variables extracted for analysis were:

- **Total Patients (Total Pt):** The number of pregnant women undergoing initial serological screening each month.
- **Serological Test Volumes:** The monthly count of tests performed for:
 - a) Hepatitis B Surface Antigen (HBsAg)
 - b) Hepatitis C Virus Antibodies (HCV Ab)
 - c) Human Immunodeficiency Virus Antibodies (HIV Ab)
 - d) **Other relevant tests:** Toxoplasma, Rubella, Cytomegalovirus (CMV), Anticardiolipin (ACL), and Antiphospholipid (APL) antibodies.

3.4 Data Management and Statistical Analysis

Data were meticulously transcribed into a structured electronic database using Microsoft Excel. Statistical analyses were performed using SPSS version 28. Descriptive statistics (frequencies, percentages) were used to summarize the data. Temporal trends were analyzed visually and descriptively. Pearson's correlation coefficient was calculated to examine the relationship between the total number of patients and the volume of specific tests, with a p-value of <0.05 considered statistically significant.

3.5 Ethical Considerations

The study utilized fully anonymized, aggregated monthly data, ensuring no individual patient could be identified. The study protocol was reviewed and approved by the hospital's administration and research committee, waiving the requirement for individual informed consent.

4. Results

This chapter presents a comprehensive analysis of hepatitis B (HBsAg), hepatitis C (HCV Ab), and human immunodeficiency virus (HIV Ab) seroprevalence among pregnant women attending the Maternity and Teaching Hospital over a five-year period (2019-2023). The analysis encompasses 41,433 initial screenings, providing a robust dataset to explore disease burden trends and potential environmental correlations. The data are presented through descriptive statistics, temporal trend analyses, and comparative assessments to elucidate the public health implications within the study population.

4.1 Overall Seroprevalence and Temporal Trends (2019-2023)

Table 1: Overall Seroprevalence of HBsAg, HCV Ab, and HIV Ab (2019-2023)

Year	Total Screened	HBsAg Positive	HCV Ab Positive	HIV Ab Positive	HBsAg Prevalence (%)	HCV Prevalence (%)	HIV Prevalence (%)
2019	8,694	8,225	8,039	8,049	94.6	92.5	92.6
2020	5,290	5,387	5,351	5,351	101.8*	101.2*	101.2*
2021	6,530	6,530	6,530	6,530	100.0	100.0	100.0
2022	7,980	7,980	7,980	7,980	100.0	100.0	100.0
2023	9,081	9,051	9,055	9,055	99.7	99.7	99.7
Total	37,575	37,173	36,955	36,965	98.9	98.4	98.4

Percentages exceeding 100% suggest data entry conventions where 'Total Pt' might represent initial visits, and serology columns represent tests performed, including repeats or confirmatory tests.

The overall seroprevalence for HBsAg, HCV Ab and HIV Ab was persistently high across the period of study and estimated at 98.9%, 98.4% and 98.4% respectively. These are astonishingly high rates compared with the worldwide and regional averages. The worldwide prevalence of HBsAg in the overall population is 3.8%.¹ However, in some areas, such as the Eastern Mediterranean Region (EMRO), this figure is estimated to be 2.7%.¹ The extremely-high positivity rate in this data set is an indication that it includes only the total number of tests conducted and not the total number of positive results. This is a data understanding issue due to the nature of the test which consists from a set of tests used to get the volume or some indicators for this test. And as there are only 3 distinct values in this column appears in the original database (HBS, HCV and HIV) probably it has strong relation with volume of testing for these diseases because linearity may be enhanced since total tests were higher in every month.

2019: 8,694 A substantial decrease in screenings from 2019 (8.17) to 2020 occurred with total screenings of 5,290 which is a decrease of (39.2%). This steep decline corresponds with the emergence of the COVID-19 pandemic which caused a disruption to routine healthcare services, including antenatal care, on a global scale (Chmielewska *et al.*, 2021)^[2]. The years following reveal incremental patient volume recovery with 9,081 in 2023 showing resilience and repair of access to care.

4.2 Analysis of Other Pathogens and Autoimmune Markers

Table 2: Annual Summary of TORCH and Autoimmune Serology (2019-2023)

Year	Toxoplasma	Rubella	CMV	ACL	APL
2019	1,743	1,379	832	1,053	1,211
2020	808	684	351	317	384
2021	1,332	1,332	653	653	653
2022	1,668	1,668	798	798	798
2023	182	179	186	506	828

Screening for TORCH pathogens (Toxoplasma, Rubella, CMV) and autoimmune markers (Anticardiolipin - ACL, Antiphospholipid - APL) was an integral part of the

antenatal protocol. The data show significant annual variation. The year 2019 recorded the highest number of tests for Toxoplasma (1,743) and Rubella (1,379). The decline in 2020 is again consistent with pandemic-related service disruptions. The relatively low figures for these specific pathogens in 2023 may reflect a shift in clinical protocol, focusing more on viral hepatitis and HIV screening, or the introduction of more selective testing based on risk factors rather than universal screening. The persistence of APL and ACL testing highlights the clinical concern for autoimmune conditions that can adversely affect pregnancy outcomes, such as recurrent miscarriage and pre-eclampsia (Mekinian *et al.*, 2016).

Table 3: Monthly Correlation Analysis between Screening Volumes (2019)

Variable Pair	Pearson Correlation Coefficient (r)	p-value	Interpretation
Total Pt vs. HBs	0.98	<0.001	Very Strong Positive Correlation
Total Pt vs. HCV	0.97	<0.001	Very Strong Positive Correlation
Total Pt vs. HIV	0.97	<0.001	Very Strong Positive Correlation
HBs vs. HCV	0.99	<0.001	Very Strong Positive Correlation

A Pearson correlation analysis of the 2019 data revealed near-perfect positive correlations ($r > 0.97$) between the total number of patients and the number of tests conducted for HBsAg, HCV, and HIV. This statistically significant relationship ($p < 0.001$) confirms that testing for these viruses was performed universally for nearly every patient entering the antenatal care program during this period. This practice aligns with national and WHO guidelines for routine opt-out testing for these infections in pregnant women to facilitate prevention of mother-to-child transmission (PMTCT).

4.3 Exploring Potential Links to Environmental and Climatic Factors

The potential impact of climate change on infectious disease dynamics is an area of growing concern. Changes in temperature, precipitation, and extreme weather events can influence vector-borne diseases, water safety, and human migration, indirectly affecting the epidemiology of blood-borne viruses.

Table 4: Framework for Climate and Environmental Correlates of Blood-Borne Viruses

Climatic/Environmental Factor	Potential Pathway to Increased Burden	Supporting Literature
Temperature Increase	Can expand geographical range of disease vectors; may increase risky outdoor activities (e.g., use of unregulated water sources), potentially disrupting sterile medical practices.	(Rocklöv & Dubrow, 2020) ^[8]
Extreme Flooding Events	Disrupts healthcare infrastructure, limits access to sterile equipment and antenatal care, and can lead to population displacement, potentially increasing unsafe medical practices or sexual risk behaviors.	(McMichael, 2015) ^[5]
Water Scarcity	Compromises personal and clinical hygiene, potentially increasing the risk of transmission in healthcare and community settings.	(Leal Filho <i>et al.</i> , 2022) ^[4]
Population Displacement	Can disrupt continuity of care for chronic infections (HBV, HIV) and lead to engagement with fragmented health systems with variable infection control standards.	

while primarily attributable to the COVID-19 pandemic, exemplifies how a major systemic shock analogous to a severe climate-induced disaster can severely impact essential health services for pregnant women, including screening and PMTCT programs. This disruption poses a long-term threat to maternal and child health, potentially leading to increased vertical transmission of HIV, HBV, and HCV.

Furthermore, the high baseline seroprevalence of HBV and HCV in the region (EMRO) suggests underlying socio-economic and environmental vulnerabilities. Poor sanitation, limited access to safe medical injections, and migration patterns, all of which can be exacerbated by climate change, are known drivers of these epidemics (Gower *et al.*, 2014; Platt *et al.*, 2022) ^[3, 7]. Therefore, maintaining robust, climate-resilient health systems capable of sustaining high-coverage screening and treatment programs is crucial for mitigating the dual threats of infectious diseases and environmental change.

5. Discussion

The findings from this five-year analysis reveal a robust and consistent implementation of universal antenatal screening for HBV, HCV, and HIV within this pivotal maternity hospital in Karbala. The near-total testing coverage, approaching 100% of the cohort, stands as a significant public health achievement. This high volume of tests, when correctly interpreted as screening efforts and not prevalence rates, aligns with and even exceeds the World Health Organization's (WHO) recommendations for routine opt-out testing in pregnant women to prevent mother-to-child transmission (PMTCT). When contextualized against global and regional data, the observed testing volumes indicate a successful institutionalization of PMTCT protocols. For instance, while a meta-analysis by Schweitzer *et al.* (2015) ^[10] documented HBsAg prevalence in pregnant women to be between 0.5% and 6.5% globally, and Benova *et al.* (2015) ^[1] estimated HCV seroprevalence in the EMRO region to be under 2%, the data from Karbala demonstrate a *screening coverage* that effectively captures the entire at-risk population, which is the critical first step in managing the actual disease burden. The notable recovery in testing volumes post-2020, following the pandemic-related downturn, further underscores the resilience and priority given to this essential service. The sustained high coverage is likely attributable to strong national and local health policies, integrated antenatal care packages, and continuous healthcare worker training, ensuring that screening for these viruses becomes a standard, non-stigmatized component of pregnancy care. This proactive approach is paramount for the early identification of infections, enabling timely

interventions such as antiretroviral therapy for HIV and antiviral prophylaxis for HBV, which can drastically reduce vertical transmission rates and move the region closer to the goals of eliminating these infections as public health threats.

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