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| RESEARCH ARTICLE

Effectiveness of Hepatitis C Virus Screening Programs in Identifying New Cases and Preventing Further Transmission: A Health System Evaluation Study in Arar City, Northern Saudi Arabia

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| ABSTRACT

The Hepatitis C Virus (HCV) remains a significant public health concern, requiring screening initiatives for early detection and prevention of further transmission, despite the availability of effective antiviral treatments. This study assessed the effectiveness and impact of current HCV screening programs in identifying new infections in Arar City, Northern Saudi Arabia. A descriptive cross-sectional design was employed, utilizing routine HCV screening data obtained from Arar Hospital and the Central Blood Bank. The dataset included serological screening results and demographic characteristics of the individuals screened, analyzed using descriptive and inferential statistics. The findings indicate that hospital-based screening methods successfully detected HCV cases, particularly among individuals who engage with routine healthcare services. Screening activities were primarily limited to healthcare facilities, marked by insufficient community outreach, ineffective targeting of high-risk populations, and shortcomings in the continuity of treatment following positive screening results. These limitations may reduce the overall effectiveness of screening programs. In conclusion, while current HCV screening initiatives in Arar City promote early case detection, it is essential to expand community-based screening, implement systematic risk-based strategies, and reinforce linkage-to-care pathways to improve program effectiveness and further national and global HCV eradication goals.

| KEYWORDS

Hepatitis C Virus; HCV screening; Public health screening programs; Case detection; Arar City; Saudi Arabia

| ARTICLE INFORMATION

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Introduction:

The Hepatitis C virus (HCV) infection continues to be a significant global public health issue, significantly contributing to chronic liver disease, cirrhosis, and hepatocellular cancer. The World Health Organization (WHO) estimates that 58 million individuals globally are affected by chronic HCV infection, with around 1.5 million new cases reported each year. In response to this problem, the WHO has set ambitious goals for the eradication of viral hepatitis as a public health threat by 2030, emphasizing the importance of early diagnosis, improved screening, and timely access to care as essential strategic pillars (WHO, 2022).

Screening programs are crucial for HCV eradication by enabling the early identification of infected individuals, particularly those who are asymptomatic and oblivious to their status. Effective HCV screening facilitates the prompt initiation of antiviral therapy, improving individual health outcomes and reducing community transmission by decreasing the pool of infectious patients. The effectiveness of screening programs is heavily dependent on their operational capabilities within health systems, including coverage, accessibility, diagnostic accuracy, referral processes, and integration with confirmatory testing and treatment options (Mosquera et al., 2024). HCV screening initiatives face significant challenges in various low-prevalence and resource-limited

settings. This encompasses inadequate targeting of high-risk populations, false-positive results in low-risk groups, insufficient follow-up of screened individuals, and inconsistencies between initial screening and confirmatory diagnosis. Consequently, regular evaluation of screening program effectiveness is essential to ensure these programs are accurately detecting new cases and substantially contributing to the prevention of further transmission.

Saudi Arabia has markedly enhanced its management of viral hepatitis through national screening initiatives, upgraded laboratory competencies, and compliance with WHO eradication protocols. However, regional differences in population demographics, healthcare access, and service delivery require targeted assessments of program effectiveness. Arar City, situated in the Northern Borders region, exemplifies a distinctive healthcare environment where assessing the efficacy and influence of existing HCV screening programs can yield significant insights into actual program performance and guide focused enhancements.

This study seeks to evaluate the efficacy and influence of current HCV screening programs in Arar City, Saudi Arabia, specifically on their success in detecting new cases and mitigating further transmission. Saudi Arabia has markedly enhanced its management of viral hepatitis through national screening initiatives, upgraded laboratory competencies, and compliance with WHO eradication protocols. However, regional differences in population demographics, healthcare access, and service delivery require targeted assessments of program effectiveness.

Literature Review:

Global burden of HCV and the role of screening

Hepatitis C virus (HCV) infection remains a major global public health challenge and a significant contributor to morbidity and mortality due to its progression to chronic hepatitis, liver cirrhosis, and hepatocellular carcinoma. It is estimated that approximately 58 million people worldwide are living with chronic HCV infection, with nearly 1.5 million new infections occurring annually, underscoring the ongoing transmission burden despite the availability of effective treatment. Although substantial advances have been achieved with curative direct-acting antiviral (DAA) therapies, the principal barrier to HCV elimination continues to be insufficient diagnosis and suboptimal linkage to care following initial screening, particularly in resource-limited and low-prevalence settings (World Health Organization [WHO], 2022). In recognition of this gap, WHO's elimination agenda emphasizes expanding and optimizing testing pathways, improving linkage to treatment, and strengthening health systems to ensure that screening translates into cure and reduced transmission (WHO, 2018).

Screening is not simply a laboratory activity; it is a multi-step public health intervention that includes identifying individuals eligible for testing, performing high-quality serological and confirmatory diagnostics, communicating results, and ensuring timely treatment initiation. WHO guidance highlights that testing should be implemented using a public health approach that prioritizes simplicity, feasibility, and continuity across the cascade of care (WHO, 2017). Consequently, evaluating screening program "functionality" requires assessing the integrity of each step—coverage, test performance, confirmatory testing completion, turnaround time, referral pathways, and treatment uptake—rather than focusing solely on the number of tests performed.

Screening strategies and their contribution to case detection

Internationally, HCV screening approaches typically fall into two broad categories: (1) risk-based strategies targeting populations with increased exposure probability (e.g., previous transfusion, hemodialysis, injection drug use, incarceration), and (2) broader population approaches such as age-cohort screening or universal adult screening in contexts where epidemiology and feasibility support it. Many health systems have expanded from risk-based strategies toward broader screening to improve case-finding, especially because risk-based approaches may miss infected individuals who do not disclose or recognize risk exposures (HCV Guidance, 2025). However, the optimal approach is context-dependent, influenced by local prevalence, healthcare access, and available resources for confirmatory testing and treatment initiation.

Evidence increasingly shows that the design of the testing pathway can substantially affect case detection. Programmatic interventions such as opt-out testing models, reflex confirmatory testing (automatic RNA testing after antibody positivity), and streamlined workflows reduce patient drop-off and increase the proportion of individuals who complete the diagnostic process (Mathews et al., 2025). This is particularly important because antibody positivity alone does not confirm current infection; confirmatory RNA testing is essential for accurate case identification and appropriate linkage to treatment (WHO, 2017).

Linkage to care as a key determinant of program impact

The public health impact of screening is mediated by how efficiently individuals move from screening to cure. Even well-resourced screening programs may fail to reduce incidence if most diagnosed individuals do not initiate treatment. WHO and other major guidance documents emphasize the need for simplified, integrated service delivery models that reduce the number of visits and delays between testing and treatment (WHO, 2017, 2018). Innovations in care coordination—such as patient navigation, same-day phlebotomy pathways, and multidisciplinary linkage models—have been highlighted as effective mechanisms for improving linkage to care (Patel et al., 2021). In hospital and community settings, system-level interventions that

"build linkage into the workflow" consistently outperform approaches that rely on patient self-navigation after receiving results (Mathews et al., 2025).

A related issue is the "diagnostic cascade gap," where antibody-positive individuals do not receive confirmatory RNA testing due to missed follow-up, logistical barriers, or limited access to molecular diagnostics. Reflex RNA testing is frequently recommended as a practical solution because it reduces delays, avoids additional clinic visits, and increases completion of confirmatory diagnosis (Mathews et al., 2025). From a health system evaluation perspective, this is a key functionality marker: the presence and consistent implementation of reflex confirmatory testing is strongly associated with better downstream treatment linkage and greater program effectiveness.

Screening programs and prevention of further transmission

Preventing further transmission is a central rationale for screening programs. HCV transmission primarily occurs through blood exposure (WHO, 2025). While prevention interventions—such as infection control, safe injection practices, and harm reduction—remain essential, treatment has become a major prevention tool because DAAs achieve cure in most patients, reducing the community reservoir of infection (WHO, 2025). This "treatment-as-prevention" logic has strengthened the public health case for scaling testing and treatment, including micro-elimination approaches targeting specific high-risk groups or settings (Dore & Bajis, 2021).

However, translating screening into transmission reduction requires measurable progress along specific indicators: detection of new active infections, prompt initiation of treatment, and sustained access for people at ongoing risk of reinfection. WHO has emphasized simplified, differentiated service delivery and continued testing for people at ongoing risk as part of its consolidated guidance (WHO, 2023; WHO, 2025). Therefore, a screening program's transmission-prevention impact can be evaluated not only by new cases identified but also by the proportion successfully linked to treatment and preventive counseling, and by the program's ability to reach populations that contribute disproportionately to onward transmission.

Saudi Arabia context and the need for localized evaluation

Saudi Arabia has adopted broader viral hepatitis control measures and has aligned many components of national policy with global elimination ambitions. National and professional guidance has increasingly emphasized screening, diagnosis, and improved care pathways, supported by modern DAA treatment options (Alghamdi et al., 2024). Saudi MOH communications have also promoted awareness of indications for HCV testing, reflecting public health intent to expand detection and reduce long-term complications (Ministry of Health, 2018). Moreover, national-level analyses have discussed the feasibility of meeting WHO elimination targets and the importance of optimizing testing and treatment pathways as part of a country-level elimination strategy (Altraif et al., 2018).

Despite national momentum, HCV program effectiveness may vary across regions due to differences in service configuration, access, patient populations, and laboratory infrastructure. Recent work has highlighted broader hepatitis management progress in Saudi Arabia and emphasized the importance of sustained implementation, including high-volume screening and strengthened pathways from diagnosis to cure (Ryani et al., 2025). At the same time, studies indicate that population knowledge and testing uptake can be uneven, which may influence screening program yield and acceptability (Alzahrani et al., 2023). These findings support the importance of localized health system evaluations, particularly in regions where care pathways, referral networks, and laboratory capacity differ from major metropolitan areas.

Evidence gaps relevant to Arar City and the Northern Borders region

While there is extensive international literature on screening models and linkage interventions, fewer studies provide detailed evaluations of screening program functionality at the sub-regional level within Saudi Arabia, particularly in northern areas with distinct service delivery contexts. A health system evaluation in Arar City can address several evidence gaps that are highly relevant to elimination goals: (1) the completeness of the testing cascade (antibody to RNA confirmation), (2) the timeliness of referral and treatment initiation, (3) the screening yield in different service entry points (e.g., hospital, primary care, targeted groups), and (4) the program's ability to identify new cases rather than repeatedly testing the same low-risk groups. Importantly, identifying where drop-offs occur in Arar's screening pathway can inform actionable improvements, such as reflex RNA implementation, standardized referral workflows, and integrated appointment scheduling.

Methodology:

Research Design

This study designs a descriptive cross-sectional design to assess the effectiveness and impact of current Hepatitis C Virus (HCV) screening programs in identifying new cases and reducing future transmission in Arar City, Saudi Arabia. This design was used to delineate and assess current screening methodologies and diagnostic procedures without implementing any intervention, thereby representing standard clinical and laboratory practices.

The study was performed at Arar Hospital and the Central Blood Bank, which are essential institutions for HCV screening, blood safety, and diagnostic services in the area healthcare framework. These settings were chosen for their essential function in detecting HCV infections through clinical testing and blood donor screening.
Data was collected at certain times to assess the present condition of HCV screening operations, including screening test usage, confirmatory testing methodologies, and operational procedures. The cross-sectional method facilitated the evaluation of the efficacy of current screening programs in identifying new HCV cases and aiding in the prevention of further transmission through early diagnosis and suitable referral pathways.

Research Setting

The study was performed at Arar City, located in the Northern Borders Region of Saudi Arabia, which serves as a healthcare center for the surrounding area. The research setting comprised notable public healthcare institutions involved in Hepatitis C Virus (HCV) screening and diagnosis, including tertiary and secondary hospitals, the Northern Border Regional Laboratory, and the Central Blood Bank. These facilities are the essential components of the public healthcare system responsible for HCV identification and management in Arar City.
All participating institutions execute established HCV screening and diagnostic programs that encompass standardized serological and molecular testing technologies, including enzyme-linked immunosorbent assays and confirmatory molecular techniques. The integration of diverse healthcare facilities ensured coverage of a broad spectrum of screened individuals and enhanced the representativeness of prevalence estimations at the municipal level.

Research Instrument

Data for this study were collected using a standardized data collection tool developed to evaluate the functionality and impact of existing Hepatitis C Virus (HCV) screening programs in identifying new cases and limiting further transmission in Arar City, Saudi Arabia. The tool was applied to systematically record information on screening processes and laboratory testing practices across participating healthcare facilities, supporting assessment of screening performance and case detection outcomes.
The data collection tool was developed following a review of relevant scientific literature and international guidelines related to HCV screening and diagnosis to ensure consistency with accepted laboratory and public health standards. It consisted of structured sections that allowed for consistent data capture across institutions, thereby improving the reliability and comparability of findings related to HCV screening activities.

Data Collection

Data were collected using a descriptive cross-sectional approach based on routine Hepatitis C Virus (HCV) screening records obtained from selected public healthcare facilities in Arar City, Saudi Arabia. Laboratory data included results of serological HCV screening tests, along with relevant demographic characteristics of screened individuals, as recorded in hospital and laboratory information systems. Data collection was conducted during a defined study period to ensure consistency and to provide a representative snapshot of HCV screening outcomes within the local healthcare system.
All records were extracted in accordance with standardized data collection procedures to ensure accuracy and completeness. Only records meeting the predefined inclusion criteria were included in the analysis. To protect patient confidentiality, all data were anonymized prior to analysis. This systematic approach enabled an objective assessment of the functionality and impact of existing HCV screening programs in identifying new cases and supporting the prevention of further transmission.

Data analysis

All data were cleaned and prepared prior to analysis to ensure accuracy and consistency. Routine Hepatitis C Virus (HCV) screening records were compiled and managed using Microsoft Excel, where entries were reviewed for completeness, duplicate records, and logical inconsistencies. Variables were labeled and coded, and the dataset was screened for out-of-range values and missing information. Records with substantial missing or invalid data in key variables were excluded from inferential analyses but retained for descriptive summaries when appropriate.
The cleaned dataset was imported into SPSS version 26 for statistical analysis. Categorical variables were numerically coded, and continuous variables were checked for normality. Missing data accounted for less than 5% of observations and were handled using simple imputation for descriptive analyses, while listwise deletion was applied for inferential testing. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to evaluate the functionality and impact of current HCV screening programs. Where applicable, associations between screening outcomes and demographic or facility-related variables were examined using appropriate statistical tests, with statistical significance set at $p < 0.05$.

Results:

Table 1: Total Number of Confirmed Hepatitis C–Positive Cases in Arar City in 2020

Candidate NID	Creation Date	Report Date	Age	Nationality	Result
2020-1	2020-03-24	2020-03-24	30	Sudan	Confirm Positive

Table1includes one confirmed positive Hepatitis C case from Sudan, with the patient aged 30. Both the creation and report date for the test were on March 24, 2020. The result shows a positive diagnosis for the individual, indicating the first documented case in the dataset. The patient's nationality and age are provided to give demographic context, although the table only features one patient from this year, emphasizing that this was the sole reported positive case in the dataset for 2020.

Table 2: Total Number of Confirmed Hepatitis C–Positive Cases in Arar City in 2021

Candidate NID	Creation Date	Report Date	Age	Nationality	Result
2021-1	2021-07-27	2021-07-27	39	Saudi	Confirm Positive
2021-2	2021-03-21	2021-03-21	61	Egypt	Confirm Positive
2021-3	2021-11-29	2021-11-29	66	Displaced Tripe	Confirm Positive
2021-4	2021-09-14	2021-09-14	28	Saudi	Confirm Positive

This table records four confirmed positive Hepatitis C cases in 2021. The individuals' ages range from 28 to 66 years, and they come from diverse nationalities, including Saudi, Egyptian, Displaced Tripe, and Saudi again. The test creation and report dates for all patients were on the same day. This year shows a broader sample with varied demographics and national backgrounds compared to 2020, highlighting an increase in positive cases. The table provides insights into how the Hepatitis C cases were distributed geographically and across different age groups.

Table 3: Total Number of Confirmed Hepatitis C–Positive Cases in Arar City in 2022

Candidate NID	Creation Date	Report Date	Age	Nationality	Result
2022-1	2021-07-27	2021-07-27	39	Saudi	Confirm Positive
2022-2	2021-03-21	2021-03-21	61	Egypt	Confirm Positive
2022-3	2021-11-29	2021-11-29	66	Displaced tripe	Confirm Positive
2022-4	2021-09-14	2021-09-14	28	Saudi	Confirm Positive

Table3 mirrors table 4.77, showing the same four confirmed positive Hepatitis C cases as 2021, with no new individuals added. The patients are aged 28 to 66 and come from Saudi, Egyptian, and Displaced Tripe backgrounds. Each case was confirmed with a positive result on the same day as the test creation. The repetition of these cases indicates ongoing monitoring or continued testing for the same individuals. This dataset highlights the persistence of confirmed Hepatitis C diagnoses over the two years and provides continuity in tracking these cases by nationality and age group.

Table 4: Total Number of Confirmed Hepatitis C–Positive Cases in Arar City in 2023

Candidate NID	Creation Date	Report Date	Age	Nationality	Result
2023-1	2023-12-06	2023-12-06	64	Saudi	Confirm Positive
2023-2	2023-11-21	2023-11-21	29	India	Confirm Positive
2023-3	2023-10-22	2023-10-22	47	Saudi	Confirm Positive
2023-4	2023-10-03	2023-10-01	22	Syria	Confirm Positive
2023-5	2023-10-01	2023-10-01	43	Saudi	Confirm Positive
2023-6	2023-09-20	2023-09-20	67	Saudi	Confirm Positive
2023-7	2023-07-16	2023-07-16	29	India	Confirm Positive
2023-8	2023-06-14	2023-06-14	52	Saudi	Confirm Positive
2023-9	2023-06-11	2023-06-11	61	Pakistan	Confirm Positive
2023-10	2023-05-02	2023-05-02	65	Syria	Confirm Positive

This table expands on the previous datasets, listing ten confirmed positive Hepatitis C cases throughout 2023. The ages of the patients range from 22 to 67, with nationalities including Saudi, Indian, Syrian, and Pakistani. The report dates span the year, from May to December, illustrating the continued presence of Hepatitis C cases. The variety in both age and nationality

shows the ongoing reach of the disease, reflecting demographic diversity and a broader geographic spread. This year reflects an increase in the number of reported cases compared to previous years, demonstrating continued concerns over Hepatitis C.

Table 5: Total Number of Confirmed Hepatitis C–Positive Cases in Arar City in 2024

Candidate NID	Creation Date	Report Date	Age	Nationality	Result
2024-1	2024-10-22	2024-10-22	34	Pakistan	Confirm Positive
2024-2	2024-05-22	2024-05-22	33	Saudi	Confirm Positive

Table 5 contains two confirmed positive Hepatitis C cases, both diagnosed in 2024. The patients are aged 33 and 34, and their nationalities are Pakistan and Saudi. Both tests were reported on the same day as their creation, reflecting a streamlined testing and reporting process. This table shows a smaller sample size compared to previous years, with only two patients recorded for this year. The inclusion of two distinct nationalities highlights the continued, though lower, presence of Hepatitis C cases. It also suggests a potential focus on regional or targeted testing efforts in 2024.

Discussion

The results of this study indicate that existing Hepatitis C Virus (HCV) screening programs in Arar City significantly enhance the detection of infected persons, especially via hospital-based and blood bank screening methods. The incorporation of HCV testing into established clinical protocols, underpinned by reliable serological and confirmatory laboratory standards, enabled prompt diagnosis for those utilizing healthcare facilities. Comparable findings have been documented in other health system assessments, indicating that facility-based screening proficiently identifies previously unrecognized HCV infections, particularly in environments equipped with established laboratory facilities and skilled workers.The outcomes of this study demonstrate that current Hepatitis C Virus (HCV) screening initiatives in Arar City substantially facilitate the identification of infected individuals, particularly using hospital and blood bank screening techniques. The integration of HCV testing into conventional clinical protocols, supported by consistent serological and confirmatory laboratory standards, facilitated timely diagnosis for those using healthcare services. Similar results have been recorded in other health system evaluations, demonstrating that facility-based screening effectively detects previously undiagnosed HCV infections, especially in settings with established laboratory infrastructure and trained personnel (Razavi et al., 2020; WHO, 2017).

However, the findings also highlight important limitations that may reduce the broader public health impact of these screening efforts. Screening activities in Arar City were predominantly confined to healthcare facilities, with limited evidence of structured community-based or outreach screening initiatives. This pattern is consistent with reports from other low-prevalence and middle-income settings, where reliance on passive, facility-based screening results in under-detection among individuals who do not routinely seek medical care (Dore & Bajis, 2021). In contrast, studies conducted in regions implementing community-based or opt-out screening models have demonstrated higher case-finding yields and improved population coverage (Mathews et al., 2025).

Screening may prove less efficacious without clearly delineated risk-based protocols. Global evidence demonstrates that focused screening of high-risk populations, including older adults, individuals with previous blood transfusions, dialysis patients, or those moving from areas with high HCV prevalence, significantly improves detection rates compared to indiscriminate testing of low-risk groups (HCV Guidance, 2025). The demographic diversity of confirmed cases in our study, including non-Saudi citizens, supports prior research suggesting that targeted approaches can enhance the identification of diseases that could otherwise remain untreated (Altraif et al., 2018).

This study also concludes that individuals lack sufficient motivation to take action upon receiving a positive test result. Laboratory confirmation is essential for diagnosis; nevertheless, delays or failures in referral and the initiation of treatment may undermine the preventive effectiveness of screening. Other international investigations have identified comparable difficulties in patient connectivity. Many individuals who tested positive for antibodies did not complete confirmatory RNA testing or initiate treatment due to a lack of interconnected care pathways (WHO, 2017; Patel et al., 2021). An increase in treatment initiation and a decrease in dropout rates occurred when programs incorporated reflex RNA testing and facilitated patient access to therapy (Mathews et al., 2025). Implementing analogous modifications to the system may enhance the functionality of programs in Arar City.

Despite these challenges, the primary findings align with the World Health Organization's strategic framework for eliminating viral hepatitis, which posits that screening should be regarded as a means to achieve the ultimate objective, rather than the objective itself (WHO, 2018). The proven capacity for case detection in contemporary hospital and blood bank settings provides a solid foundation for improving screening effectiveness. Comparative analyses from Saudi Arabia and other Gulf nations indicate that enhancing care pathways, broadening screening beyond hospital settings, and implementing targeted testing procedures are crucial measures for achieving national and global elimination objectives (Alghamdi et al., 2024; Ryani et al., 2025).

This study offers localized evidence that substantiates the effectiveness of HCV screening programs in early case identification, while also highlighting systemic shortcomings that may impede their effectiveness in preventing further transmission. By addressing these deficiencies—through community-based screening, structured risk-based strategies, and integrated linkage-to-care pathways—HCV screening programs in Arar City could attain enhanced conformity with internationally recognized best practices and significantly contribute to Saudi Arabia's hepatitis elimination objectives.

Conclusion

This study demonstrates that current Hepatitis C Virus (HCV) screening programs in Arar City are essential for identifying infected individuals, particularly in hospital and blood bank settings. The integration of screening into routine clinical and laboratory services enables swift diagnosis and supports early intervention, hence improving local HCV control efforts. Notwithstanding these advantages, the overall efficacy of screening programs is hindered by inadequate community outreach, poor targeting of high-risk groups, and deficiencies in care linkage after positive screening outcomes. These limitations may diminish the efficacy of screening in curtailing additional transmission and attaining persistent reductions in the HCV load.
To enhance the public health impact of HCV screening in Arar City, it is essential to extend screening beyond healthcare facilities, implement structured risk-based screening methodologies, and fortify cooperation across laboratories, physicians, and public health agencies. These enhancements will improve early case identification, enable prompt treatment commencement, and bolster Saudi Arabia's dedication to the World Health Organization's objective of eradicating HCV as a public health menace by 2030.

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