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**EPIDEMIOLOGICAL DYNAMICS AND PREVENTION STRATEGIES
FOR VIRAL HEPATITIS B AND C IN THE KYRGYZ REPUBLIC**

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ABSTRACT

BACKGROUND. Viral hepatitis B and C remain important public health concerns because of their potential progression to chronic liver disease, cirrhosis, and hepatocellular carcinoma. Epidemiological monitoring, vaccination, screening, and early diagnosis are therefore essential for reducing transmission and disease burden. Assessing recent trends in the Kyrgyz Republic is particularly important for evaluating the effectiveness of national prevention programmes and identifying regional and demographic groups requiring additional interventions.

AIM. This study aimed to examine the long-term epidemiological dynamics of acute viral hepatitis B and C in the Kyrgyz Republic from 2000 to 2023, with detailed analysis of registered cases, regional differences, population screening, blood-donor screening, and adult hepatitis B vaccination indicators during the most recent reporting period.

METHODOLOGY. The study analysed data provided by the Department of Disease Prevention and the State Sanitary and Epidemiological Surveillance Service. Time trends, regional and demographic characteristics, and the outcomes of screening and vaccination programmes were evaluated.

RESULTS. Registered acute hepatitis B incidence declined markedly over the long-term observation period and reached very low levels among children following the introduction of universal infant vaccination in 2000. In 2023, programme-based screening of 203,308 individuals identified HBV/HCV markers in 5,730 participants (2.82%). Higher screening positivity was recorded in Osh region, Jalal-Abad region, Osh city, and Talas region. During the first six months of the 2023 adult vaccination programme, 230,792 people received a first hepatitis B vaccine dose and 134,060 completed the three-dose schedule, corresponding to 58.1% of first-dose recipients. The increase in registered cases in 2023 coincided with expanded testing and should therefore be interpreted partly as improved detection rather than as evidence of a true increase in transmission alone.

CONCLUSION. The findings show a sustained decline in registered acute hepatitis B, particularly among children, alongside continuing gaps in adult vaccination completion, diagnostic confirmation, and linkage to care. The observed temporal association between vaccination implementation and declining childhood incidence is consistent with a beneficial population-level effect, although the aggregated observational data do not permit definitive causal attribution. Strengthening vaccination follow-up, screening, confirmatory diagnosis, treatment access, and surveillance in regions with higher programme positivity may further reduce the national burden of viral hepatitis.

Keywords: *screening programs, regional specifics, hepatitis B infection marker, morbidity dynamics, direct-acting antiviral drugs, vaccination*

INTRODUCTION

Viral hepatitis B and C remain significant public health problems, causing millions of new cases and economic losses annually. The main measures for combating these include mass hepatitis B vaccination, screening, and early diagnosis, which help prevent severe forms of the diseases and limit their spread. However, social, economic, and medical barriers complicate prevention and treatment efforts.

Evidence from the Kyrgyz Republic supports the importance of universal childhood hepatitis B vaccination. A nationally representative serosurvey among third-grade schoolchildren found very low hepatitis B surface antigen seroprevalence in the context of high vaccination coverage, indicating a substantial long-term population-level benefit of infant immunisation (1). Earlier national evidence also documented changes in the aetiological and epidemiological structure of acute viral hepatitis and hepatitis-related mortality, demonstrating the importance of laboratory confirmation when interpreting routine surveillance data (2). These studies provide a country-specific basis for evaluating long-term trends, but they do not directly establish the determinants of adult vaccination adherence or regional differences in access to screening.

The epidemiology of viral hepatitis in Kyrgyzstan has also been assessed through seroepidemiological and surveillance-based research. Akmatov et al. described changing patterns of viral hepatitis and the continuing importance of identifying infections that are not captured through routine clinical notification (3). Community-based programmes that combine HBV testing with vaccination can increase the identification of susceptible or infected individuals and create an opportunity to offer vaccination to eligible participants. However, completion rates and programme effects must be reported exactly as observed rather than attributed to unmeasured factors (4). The available literature therefore supports integrated testing and vaccination, while also showing that programme reach, follow-up, and linkage to care require separate evaluation.

Economic and organisational evidence further supports targeted hepatitis testing. Hutton et al. found that hepatitis B testing and vaccination can be cost-effective among adults seeking

care for sexually transmitted infections, although their analysis did not evaluate the affordability of polymerase chain reaction diagnostics in the Kyrgyz health system (5). Current screening recommendations emphasise serological testing of adults and repeated testing of people with ongoing exposure risks, while confirmatory molecular testing is required after an initial reactive result (6). These recommendations provide a framework for screening policy, but their implementation depends on laboratory capacity, referral pathways, and the ability to retain patients throughout the diagnostic and treatment cascade.

Digital clinical systems may facilitate implementation when they are linked to clear care pathways. Kim et al. described practical approaches for incorporating adult hepatitis B screening and immunisation into electronic health records, including identification of eligible patients and prompts for clinicians (7). Pattyn et al. reviewed the development, immunogenicity, safety, and public-health role of hepatitis B vaccines, providing broad evidence for vaccination as the principal preventive intervention against HBV infection (8). Neither source identifies migration or low educational attainment as determinants in the Kyrgyz Republic, such factors should be examined using country-specific behavioural and health-services data rather than inferred from unrelated settings.

The analysis revealed that previous studies have insufficiently integrated long-term morbidity trends, regional differences, screening outcomes, blood donor screening data, and adult hepatitis B vaccination coverage within a single epidemiological assessment of hepatitis B and C in the Kyrgyz Republic. Therefore, the present study aimed to analyse the epidemiological situation of hepatitis B and C in the Kyrgyz Republic on the basis of official statistical data, screening results, and vaccination records. The tasks included studying morbidity trends, analysing regional differences, evaluating screening and vaccination indicators, and identifying areas requiring strengthened diagnostic and preventive coverage. Socio-economic and healthcare-access factors are considered only as possible contextual explanations for regional morbidity disparities, since they were not directly measured in this study.

MATERIALS AND METHODS

This study was based on secondary analysis of aggregated official administrative and epidemiological data on viral hepatitis B and C in the Kyrgyz Republic. The principal source was State Reporting Form No. 1, “Report on Infectious, Parasitic and Non-infectious Diseases”, maintained by the Department of Disease Prevention and the State Sanitary and Epidemiological Surveillance Service of the Ministry of Health of the Kyrgyz Republic (9).

The dataset contained annual registered acute and chronic hepatitis B and C indicators and the long-term series used in the figures. Supplementary historical interpretation was informed by published national research on the aetiology and epidemiology of acute viral hepatitis (2). Cases are reported by healthcare facilities through district, city, and regional surveillance structures and are subsequently aggregated nationally. The analysis retained the acute or chronic classification recorded in the source data. Because individual clinical records, laboratory algorithms, and case-investigation forms were unavailable, the classification of individual cases could not be independently verified. In late 2022 and 2023, the national programme expanded free HBV and HCV testing and treatment through primary healthcare facilities, this programme change was considered when interpreting the increase in registered cases during 2023.

Aggregated records supplied by the Blood Service of the Kyrgyz Republic were used to assess hepatitis B and C markers among blood donors from 2004 to 2020 (10). Donors undergo pre-donation assessment, including review of medical history, examination, and exclusion of persons with permanent or temporary contraindications to donation. The analysed indicators comprised the annual number of donations screened, reactive hepatitis B surface antigen results, and reactive antibodies to hepatitis C virus. The administrative dataset did not contain individual-level donor histories, repeat-donor status, confirmatory testing results, or nucleic-acid testing results for each donation. Accordingly, the donor findings were interpreted as trends in screening-marker reactivity within a selected donor population, not as estimates of HBV or HCV prevalence in the general population. This distinction is important because pre-donation selection and changes in the proportion of repeat donors can influence marker positivity independently of population transmission.

Population screening data were obtained from the national viral hepatitis prevention programme launched in late 2022 and expanded in 2023. The screening sample was programmatic rather than population-randomised: it included individuals who were reached through healthcare facilities and prevention activities, with attention to adults, healthcare workers, pregnant women, blood donors, persons with possible exposure risks, and other groups prioritised by the national programme. The study analysed the number of screened individuals, the number and percentage of positive results, and regional differences in screening positivity. The available dataset did not allow reconstruction of individual-level sampling procedures, test history, or confirmatory diagnostic pathways. Therefore, screening results were interpreted as indicators of detected infection markers within the programme, not as prevalence estimates from a representative serosurvey.

Nosocomial infection prevention and control was considered as a contextual component of hepatitis prevention rather than as a separately audited outcome. The study did not include direct hospital audits, assessment of sterilisation quality, or facility-level monitoring of infection-control compliance. Therefore, conclusions about nosocomial transmission were limited to the interpretation of official epidemiological data and existing national prevention measures.

For analysis, the data were structured by year, region or major city, and available socio-demographic characteristics such as age and sex. The following indicators were used: 1) the annual registered incidence rate, defined as the number of newly registered acute hepatitis B or C cases reported through the sanitary-epidemiological surveillance system during a calendar year per 100,000 population; 2) the absolute case count, defined as the total number of registered hepatitis B or C cases in the corresponding year or region; 3) screening positivity, calculated as the number of screened individuals with detected HBV/HCV markers divided by the total number of individuals screened and expressed as a percentage; and 4) three-dose hepatitis B vaccination completion, calculated as the proportion of individuals who received the first vaccine dose and subsequently completed the full three-dose course.

Additionally, hepatitis B vaccination coverage data were obtained from the Department of Disease Prevention of the State Sanitary and Epidemiological Surveillance Service of the Ministry of Health of the Kyrgyz Republic (9) and were analysed to assess adult vaccination uptake and completion of the three-dose course. Aspects considered included total vaccination coverage, completion of the full three-dose course, and regional vaccination dynamics. Regional vaccination dynamics were defined as changes in the numbers and proportions of individuals receiving the first, second, and third vaccine doses across the reporting periods and regions. Vaccination-course interruption was defined as failure to receive a subsequent scheduled dose among individuals who had initiated the vaccination course. This approach allowed for the identification of both successful results from the vaccination programme and existing gaps that affect its effectiveness.

Data processing was performed using SPSS Statistics software (version 27, IBM, USA). The analysis was descriptive because the study used aggregated administrative series rather than individual-level observations. Annual case counts and registered incidence rates were compared across years, while screening and vaccination indicators were calculated as proportions using the denominators available in the source datasets. Absolute and relative changes were used to describe temporal patterns. Where confidence intervals were available in the administrative tables, they were reported as supplied, no individual-level adjustment for

age, sex, repeated participation, or other covariates was possible. Trend interpretation considered changes in surveillance practice and programme coverage, particularly the expansion of testing in 2023 and the disruption of routine services in 2020. Graphs and tables were used to display long-term dynamics, regional screening positivity, donor-marker trends, and completion of the adult vaccination schedule.

Special attention in the study was given to mass population screening data, organised since early 2023. As part of this programme, 203,308 individuals were examined, of whom 5,730 (2.82%) had markers of hepatitis B and C infection. The obtained data allowed for a comparative analysis of infection prevalence across regions, identifying areas with the highest infection rates and evaluating the effectiveness of early detection programmes.

The completeness and comparability of routine registration were assessed by examining changes in reporting patterns and known programme disruptions. The reduction in registered infectious diseases during 2020 was interpreted cautiously because international studies documented substantial interruptions in viral hepatitis testing, clinical consultations, referrals, treatment initiation, and prevention activities during the COVID-19 pandemic (12,13). Data from 2020 were therefore retained in the time series but were not treated as direct evidence of a corresponding reduction in community transmission. The analysis used only aggregated records and did not contain personal identifiers. Administrative data were processed in accordance with institutional confidentiality requirements.

RESULTS

The long-term dynamics of registered acute viral hepatitis B and C in the Kyrgyz Republic from 2000 to 2023 showed different temporal patterns, with the most pronounced decline in hepatitis B becoming evident after approximately 2010 (Fig. 1). The downward pattern coincided with the maturation of cohorts vaccinated in infancy after introduction of universal hepatitis B vaccination in 2000. Changes in the later years must also be interpreted in the context of expanded detection of previously undiagnosed infections and modifications to national screening and reporting practices. Consequently, the time series describes registered incidence and cannot by itself separate changes in transmission from changes in case ascertainment.

The decrease in registered hepatitis B incidence coincided with the inclusion of hepatitis B vaccination in the national immunisation calendar in 2000. Vaccination of newborns progressively increased the proportion of younger cohorts protected against infection, while screening of donated blood and infection-prevention standards in healthcare facilities addressed

additional routes of blood-borne transmission. For hepatitis C, for which no vaccine is available, prevention depends on safe medical and cosmetic procedures, blood safety, harm-reduction measures, testing, and treatment of infected individuals. Expanded screening and improved laboratory access can initially increase the number of registered infections by detecting cases that were previously unrecognised. Public information is also relevant, but the present administrative datasets did not measure knowledge, risk behaviour, treatment uptake, or exposure to educational campaigns, their independent contribution to the observed trends therefore could not be quantified.

The most notable reduction in registered incidence was observed for acute hepatitis B and was especially pronounced among children. The vaccination programme launched in 2000 was followed by a progressive decline and near-elimination of registered childhood cases by 2014 (Fig. 2). This temporal correspondence is consistent with the expected population-level effect of universal infant hepatitis B vaccination, although the ecological design does not permit individual vaccination records to be linked directly to subsequent infection outcomes.

Before universal vaccination, the registered incidence among children younger than 6 years remained high and reached peak values of approximately 380 cases per 100,000 population. Several years after implementation of the programme, incidence declined sharply and reached its lowest recorded levels by 2014. A similar pattern was observed among children aged 7-14 years as vaccinated birth cohorts entered this age group. The available aggregated data did not include individual vaccination status, maternal HBsAg status, timing of the birth dose, or documented transmission routes. The decline should therefore be interpreted as a population-level association with programme implementation rather than as direct proof of herd immunity or a measure of the relative contribution of mother-to-child and horizontal transmission. Nevertheless, sustained delivery of the complete infant schedule remains essential because infection acquired early in life carries a high risk of chronicity.

The childhood incidence series demonstrates the practical value of maintaining high and timely infant vaccination coverage and monitoring outcomes over successive birth cohorts. It also identifies the need to preserve birth-dose delivery, completion of the national schedule, vaccine supply, cold-chain continuity, and follow-up of infants born to mothers with HBV infection. Clinical guidance on diagnosis and treatment (11) complements these preventive measures but does not, by itself, document the policy decision to expand a national vaccination programme. Programme implementation and epidemiological outcomes were therefore evaluated using the administrative vaccination and surveillance datasets rather than inferred from the clinical guideline.

Particular attention was given to registered acute hepatitis B and C during 2018-2023 (Fig. 3). These data represent newly registered acute cases and should not be combined with chronic infections identified through programme screening. The observed increase in 2023 occurred during expansion of free testing and referral through primary healthcare facilities, creating greater opportunity to identify both symptomatic acute infections and previously unrecognised chronic infections. Because the surveillance dataset did not permit linkage between individual screening records and subsequent case notifications, the magnitude of the ascertainment effect could not be calculated.

Programme screening and adult vaccination were distinct activities with different denominators. In 2023, 203,308 individuals underwent programme-based screening and 5,730 had reactive HBV/HCV markers, corresponding to 2.82% screening positivity. Separately, 230,792 adults received the first hepatitis B vaccine dose during the reporting period shown in Table 2. The increase in registered hepatitis B and C cases in 2023 should therefore be interpreted alongside the expansion of testing, but it cannot be attributed quantitatively to screening without person-level linkage and confirmation data.

In 2023, the registered incidence rates of acute hepatitis B and acute hepatitis C in the Kyrgyz Republic were 2.3 and 1.2 cases per 100,000 population, respectively, according to State Reporting Form No. 1 (9). Compared with 2018, the registered incidence of acute hepatitis B decreased from 5.2 to 2.3 cases per 100,000 population, corresponding to an approximately 2.3-fold reduction. Regional analysis of the same sanitary-epidemiological surveillance data showed differences in the distribution of registered acute hepatitis B and C cases across the country. Osh, Chui, and Batken regions, as well as the cities of Bishkek and Osh, recorded comparatively high numbers of registered acute hepatitis B and C cases in 2023. The registered incidence of acute hepatitis B in 2023 decreased by 2.3 times compared with 2018. This result is linked to several factors, including adult vaccination, initiated under state funding, as well as efforts to raise public awareness about prevention measures and the importance of vaccination.

The COVID-19 pandemic was an important external influence on the 2020 data. International analyses reported interruptions in hepatitis testing, consultations, referrals, vaccination, and treatment during the pandemic, making lower notification counts an unreliable proxy for lower transmission (12,13). In the Kyrgyz series, the reduction in registered hepatitis during 2020 may similarly reflect reduced healthcare attendance, testing, and reporting. Subsequent increases should be interpreted against this temporarily depressed baseline and the later expansion of screening rather than automatically classified as epidemic growth.

Data from Sentinel Epidemiological Surveillance, conducted in 2015, allow for a more accurate assessment of the aetiological structure of viral hepatitis B and C (2). Sentinel epidemiological surveillance of acute viral hepatitis was conducted in 2015-2016 in infectious-disease hospitals in Bishkek, Jalal-Abad, and Naryn, where every fifth patient presenting with jaundice was tested for markers of viral hepatitis A, B, C, and D; a total of 2,860 blood samples were examined. The resulting etiological structure of acute viral hepatitis comprised hepatitis A, 60.5%; hepatitis B, 16.9%; hepatitis C, 4.5%; hepatitis D, 1.7%; mixed viral hepatitis infection, 1.2%; and unclassified “non-A, non-C” hepatitis, 15.2%. In comparison, State Reporting Form No. 1 reported hepatitis B and hepatitis C as 3.1% and 1.3%, respectively, of the overall structure of registered acute viral hepatitis. Thus, the sentinel surveillance identified substantially higher proportions of acute hepatitis B and C than routine official reporting.

The higher proportions of hepatitis B and C identified through sentinel surveillance than through routine reporting are consistent with recognised limitations of passive notification systems. Asymptomatic infection, incomplete healthcare seeking, limited laboratory access, and failure to complete confirmatory testing can all reduce case ascertainment (14). The unclassified “non-A, non-C” category in the 2015 sentinel dataset reflects the historical testing and reporting structure and should not be interpreted as direct evidence of a newly emerging pathogen. Instead, it indicates that the available diagnostic panel or documentation did not establish an aetiology for all jaundice cases. Standardised testing algorithms and explicit reporting of assay and confirmation procedures are therefore needed to improve comparability.

Regional screening data showed higher marker positivity in Osh region, Osh city, Jalal-Abad region, and Talas region. These differences may reflect variation in the populations reached by the programme as well as differences in healthcare access, population mobility, prior exposure, and local testing practices. The programme was not based on a population-randomised sample, and the administrative data did not directly measure migration, household density, informal medical procedures, injecting drug use, or other behavioural exposures. These factors can therefore be considered hypotheses for future investigation but should not be presented as established explanations for the regional pattern. A rigorous regional comparison would require age- and sex-specific denominators, consistent eligibility criteria, information on whether screening was first-time or repeated, separate HBV and HCV results, and confirmation of active infection. It would also be necessary to record the setting in which participants were recruited, because screening delivered through primary care, maternity services, blood donation, workplace programmes, and targeted outreach may reach populations with different

baseline risks. Without these variables, differences in programme positivity cannot be separated reliably into epidemiological and service-delivery components.

The discrepancy between sentinel surveillance and routine reporting underscores the importance of standardised diagnostic pathways. International guidance recommends an initial serological testing strategy followed by appropriate confirmatory testing and clinical assessment, with the algorithm adapted to epidemiological setting and laboratory capacity (14,15). Rapid diagnostic tests and enzyme immunoassays can expand access to initial testing, while molecular tests are needed to confirm active HCV infection and to support treatment decisions. Consistent definitions of acute and chronic infection are also required so that trends are not distorted by changes in classification.

Improving medical reporting requires more than increasing the number of tests. Healthcare personnel need standardised protocols for test selection, interpretation, notification, counselling, confirmatory diagnosis, and referral. Global hepatitis strategies emphasise integrated surveillance, reliable commodity supply, decentralised services, and linkage from diagnosis to treatment as core components of elimination programmes (16,17). Public communication should explain the asymptomatic nature of many chronic infections, the availability of hepatitis B vaccination, the absence of a hepatitis C vaccine, and the importance of completing confirmatory testing and treatment assessment.

Data from the Republican Blood Centre show a significant level of viral hepatitis B and C prevalence among blood donors in the Kyrgyz Republic from 2004 to 2020 (Table 1). Of 525,897 examined donors, hepatitis B markers were found in 21,679 individuals (4.2%±0.5%), and hepatitis C markers in 10,868 individuals (2.2%±0.4%). This level of infection highlights the high epidemiological significance of donor screening for identifying inactive chronic hepatitis, which may remain asymptomatic but pose a risk of infection transmission.

The identified indicators show dynamic changes in the frequency of infection. For example, over the period in question, there has been a trend towards a reduction in the proportion of infections. The proportion of positive results for hepatitis B markers decreased from 5.2% in 2004 to 2.7% in 2020. For hepatitis C, the trend was also positive: from 3.6% at the beginning of the period to 0.8% in 2020. The declining proportion of HBV- and HCV-positive blood donors should not be interpreted solely as evidence of an improvement in the general epidemiological situation. It may also reflect strengthened pre-donation selection and deferral of individuals with known infection or other risk factors, as well as improved access to testing and diagnosis outside the blood donation system. Changes in the proportion of repeat donors may also have contributed, because previously screened repeat donors are less likely to

test positive than first-time donors. However, individual-level information on donor history, repeat-donor status, and previous testing was not available in the present dataset. Therefore, the relative contribution of these factors could not be quantified.

Broader prevention measures may also have contributed to the declining proportion of reactive donor results, including hepatitis B vaccination, improved infection-prevention practices, and earlier diagnosis outside the blood-donation system (15-18). Modern donor screening reduces transfusion risk, but a reactive screening result is not equivalent to a confirmed clinical diagnosis. In 2020, only 298 new chronic hepatitis B cases and 185 chronic hepatitis C cases were registered through routine reporting (2), whereas substantially more reactive markers were observed among donors. This difference is compatible with asymptomatic infection, selection effects, and incomplete linkage between screening and routine notification. Donors with reactive results should therefore receive confidential counselling, confirmatory testing, clinical evaluation, and referral for treatment when indicated.

The analysis of neonatal hepatitis B vaccination data in the Kyrgyz Republic shows the significant impact of preventive measures on reducing incidence (Fig. 2). Since the beginning of 2023, within the framework of the national vaccination and screening program, adult vaccination was offered and a significant portion of the population has been covered (Table 2).

The adult vaccination programme launched in January 2023 targeted people who had not previously completed hepatitis B vaccination. The administrative data did not provide the total number of eligible adults, so population coverage could not be estimated. During the reporting period, 230,792 adults received the first dose, 193,154 received the second dose, and 134,060 completed the three-dose schedule. Thus, 83.7% of first-dose recipients received a second dose and 58.1% received all three doses. A total of 96,732 first-dose recipients had not completed the third dose by 5 July 2023. The dataset did not include individual reasons for non-completion, lack of awareness, scheduling difficulties, mobility, contraindications, and service-access barriers should therefore be investigated rather than assumed.

Population screening for hepatitis B and C, initiated in late 2022 and expanded in 2023, complemented the vaccination programme by identifying people requiring confirmatory evaluation and possible linkage to care (19-21). By the reporting point used in Table 3, 203,308 people had been screened and 5,730 had reactive HBV/HCV markers, yielding screening positivity of 2.82%. These results describe the population reached by the programme and do not constitute a nationally representative prevalence estimate. The distinction between a reactive marker and confirmed active infection is also essential when estimating treatment need.

The regional analysis of screening data revealed significant differences in HBV/HCV marker prevalence, expressed as screening positivity (Table 3). The highest proportions of positive screening results were recorded in the southern regions, such as Osh and Jalal-Abad regions, where the proportion of chronic hepatitis was 4.56% and 3.4%, respectively. In contrast, in Chui region and Bishkek, the infection rate was significantly lower, at 1.36% and 1.35%. These differences may be related to a higher level of medical awareness and accessibility of healthcare services in central and northern regions, as well as differences in socio-economic conditions, population density, and migration processes.

The screening data demonstrated marked regional differences in HBV/HCV screening positivity. Higher screening positivity was observed in Osh region, Osh city, Jalal-Abad region, and Talas region, indicating the need for particular attention to these areas when interpreting the distribution of detected HBV/HCV markers. In Jalal-Abad and Talas regions, screening positivity was 3.4% and 3.07%, respectively. These findings should be interpreted as the proportion of screened individuals with detected HBV/HCV markers rather than as population prevalence, because the screening programme was not based on a population-randomised sample. The observed regional variation provides a basis for identifying areas where access to screening, vaccination, diagnostic confirmation, and linkage to care may require further assessment.

DISCUSSION

The long-term Kyrgyz data show a marked reduction in registered acute hepatitis B, particularly among cohorts born after universal infant vaccination was introduced, while the 2023 programme data identify continuing gaps in adult vaccination completion and diagnosis. International recommendations support routine adult hepatitis B vaccination as a means of closing immunity gaps left by childhood-only strategies (22). Studies of vaccine response also demonstrate that immunogenicity can vary in people with occult HBV infection or impaired immune function, which is relevant when designing follow-up for selected clinical groups (23). Randomised trials of newer adult vaccines and an umbrella review of vaccination strategies confirm strong immunogenicity and an acceptable safety profile, but they do not establish a specific childhood coverage threshold for eliminating transmission in Kyrgyzstan (24,25). The national childhood trend should therefore be interpreted as locally observed evidence consistent with vaccination impact rather than as proof derived from those adult studies.

Expanded testing can alter the apparent epidemiological pattern by moving previously undiagnosed infections into the registered case system. Electronic health-record interventions

have improved identification of people eligible for hepatitis B screening and vaccination in healthcare settings, demonstrating the importance of operational prompts and follow-up procedures (26). Evidence from electronic clinical nudges similarly indicates that implementation tools can improve delivery processes when they are integrated into routine care, although effectiveness depends on workflow, local capacity, and patient follow-up (28). For hepatitis C, international modelling shows that the number of diagnosed and treated people increased between 2015 and 2020, but major gaps remained across the global care cascade (29). The increase in Kyrgyz notifications in 2023 is therefore compatible with expanded ascertainment, but the present data cannot quantify how much of the change reflects testing rather than transmission.

The regional variation in programme positivity should be interpreted within the broader constraints of the national health system. Global HBV estimates show substantial gaps between the number of people living with infection and the number diagnosed and treated (30), while elimination frameworks stress that effective biomedical interventions do not produce population benefit unless people can reach testing, confirmation, and care (31,32). The Kyrgyz health-system review describes uneven geographical distribution of health workers, shortages in primary care, co-payments, and continuing barriers to service access (33). These system-level constraints provide a plausible context for regional differences but do not prove why positivity was higher in any specific region. Future studies should link epidemiological records with rurality, migration, healthcare utilisation, laboratory access, treatment initiation, and retention in care. Clinical subgroups also require tailored strategies: dialysis patients may need enhanced vaccine schedules and follow-up of antibody response (27,34,37), while people with cirrhosis or immunosuppression may require specialised vaccination, HBV screening, and prophylaxis pathways (38,45).

The most pronounced national decline occurred among children and coincided with sustained implementation of universal hepatitis B vaccination. Reviews across different populations confirm that prophylactic hepatitis B vaccination substantially reduces HBV infection and that programme performance depends on timely administration and completion of recommended doses (35). Seroepidemiological studies also show the value of combining vaccination histories with biomarker data when evaluating population protection and residual susceptibility (36). The Kyrgyz administrative series lacks individual vaccination histories and serological profiles, so it cannot estimate vaccine effectiveness at the individual level. Nevertheless, the consistency between the cohort pattern, the national serosurvey (1), and the

established effectiveness of hepatitis B vaccination supports continued emphasis on timely infant vaccination and completion of adult catch-up schedules.

Routine notification and screening answer different epidemiological questions. The United States household study by Roberts et al. evaluated HBV infection, vaccine-induced immunity, and susceptibility among at-risk populations, it did not concern hepatitis A transmission in middle-income countries (39). More generally, routine infectious-disease systems can underestimate incidence because asymptomatic individuals may not seek care, clinicians may not order testing, and diagnosed cases may not be completely reported (40). The Kyrgyz sentinel data similarly identified a larger proportion of hepatitis B and C among jaundice cases than routine reporting. The fall in notifications during 2020 requires additional caution because the COVID-19 pandemic disrupted hepatitis prevention, diagnosis, and treatment services internationally (41). These observations support triangulation of routine notification, sentinel surveillance, programme screening, donor screening, and laboratory data rather than reliance on a single source.

International comparisons are useful when the compared indicators and denominators are clearly defined. The Brazilian analysis by Pinto et al. illustrates how long-term HBV trends can be examined using routine epidemiological data while recognising differences in regional reporting and programme implementation (42). Long-term follow-up after primary hepatitis B vaccination has demonstrated persistent protection and anamnestic responses decades after the initial series (43). These findings support sustained vaccination policy, but they do not explain the historical “non-A, non-C” category in the Kyrgyz sentinel dataset. That category should remain an indicator of unresolved aetiology under the testing algorithm used at the time and should prompt broader, standardised diagnostic investigation rather than speculation about a new pathogen.

Blood-donor screening in the Kyrgyz Republic showed declining proportions of reactive hepatitis B and C markers between 2004 and 2020. Donor screening is essential for blood safety, but trends are affected by donor selection, repeat-donor composition, assay performance, and confirmatory algorithms (18). Rare infections can also occur in people who do not mount a protective response to standard hepatitis B vaccination, illustrating why screening and risk-based prevention remain necessary even in vaccinated populations (44). The current donor dataset did not contain individual histories or confirmation results, so it cannot establish whether the decline resulted from lower population transmission, more effective donor selection, or earlier diagnosis outside the donation system. Continued quality assurance and referral of donors with reactive results are therefore required.

Only 58.1% of adults who received a first hepatitis B vaccine dose during the reported 2023 programme period completed the three-dose schedule. This is a programme-completion indicator, not population vaccination coverage, because the total eligible adult population was unavailable. Adult vaccination recommendations and systematic evidence on hepatitis B vaccine strategies support efforts to improve initiation and completion while adapting schedules to clinical risk and immune status (22,25). Reminder systems, scheduled follow-up, electronic prompts, decentralised vaccination points, and active tracing of missed doses are plausible implementation options (7,26,28). Their effectiveness in the Kyrgyz setting should be evaluated prospectively, together with reasons for missed doses and differences between regions.

The 2023 screening programme detected reactive HBV/HCV markers in 2.82% of participants and demonstrated the feasibility of large-scale case finding. International guidance supports broad adult HBV and HCV testing combined with confirmatory diagnosis and linkage to care (6,14,47). Screening alone, however, does not reduce disease burden unless people with reactive results complete confirmatory testing and receive vaccination, monitoring, or antiviral treatment as appropriate. Therapeutic vaccination for chronic HBV and experimental nanovaccine platforms remain research approaches and should not be confused with established prophylactic vaccination or population screening (46,48). Programme evaluation should therefore report the full cascade from invitation and initial testing to confirmation, clinical assessment, treatment initiation, and retention in care.

The study integrates long-term routine surveillance, sentinel observations, donor-marker data, regional programme screening, and adult vaccination completion within one national analysis. This combined perspective is consistent with elimination frameworks that treat vaccination, testing, blood safety, treatment access, and monitoring as interconnected components rather than isolated interventions (16,17,19,32). Several limitations remain. The analysis used aggregated administrative records and could not verify individual case definitions, remove duplicate tests, distinguish first-time from repeat donors, or link screening results to confirmatory diagnosis and treatment. The programme sample was not population-randomised, and regional positivity should not be interpreted as prevalence. Changes in testing and reporting, especially during the COVID-19 pandemic and the 2023 programme expansion, limit causal interpretation of temporal changes. The observed patterns identify priorities for strengthened surveillance and service delivery but do not independently establish the causes of regional differences or the effectiveness of each intervention.

CONCLUSIONS

The epidemiological series from the Kyrgyz Republic showed a substantial long-term decline in registered acute hepatitis B, with the clearest reduction among children after universal infant vaccination was introduced in 2000. This temporal and cohort pattern is consistent with a beneficial population-level effect of vaccination, although the aggregated observational design does not permit definitive causal attribution. In 2023, programme screening covered 203,308 people and identified reactive HBV/HCV markers in 5,730 participants (2.82%). During the separate adult vaccination programme, 230,792 adults received a first hepatitis B vaccine dose and 134,060 completed the three-dose course (58.1%). The increase in registered cases during 2023 coincided with expanded testing and may therefore reflect improved ascertainment of previously unrecognised infection as well as any underlying change in transmission.

Regional differences in screening positivity support targeted assessment of service needs in Osh region, Osh city, Jalal-Abad region, and Talas region. Priority measures include maintaining timely infant vaccination, improving completion of adult vaccination schedules, expanding accessible HBV and HCV testing, ensuring confirmatory diagnosis, and linking people with confirmed infection to clinical evaluation and treatment. Mobile or decentralised services may be appropriate for remote communities, but their reach and effectiveness should be measured rather than assumed. Infection-prevention and blood-safety measures should be maintained in healthcare, dental, cosmetic, and other settings involving possible blood exposure. Stable supplies of tests and vaccines, clear referral pathways, trained personnel, and confidential patient follow-up are necessary for sustained programme performance.

Future research should use individual-level linked data to distinguish acute from chronic infection, confirm active HCV infection, identify duplicate testing, and follow patients from screening through diagnosis and treatment. Representative serosurveys would be required to estimate population prevalence and to test whether regional programme positivity reflects true geographic differences or selective participation. Evaluation of adult vaccine completion should examine reasons for missed doses and compare reminder, outreach, and decentralised delivery strategies. Facility-level research should assess sterilisation, injection safety, blood transfusion safety, use of single-use equipment, compliance with infection-prevention protocols, and staff training. These studies would provide stronger evidence for causal interpretation and allow national prevention resources to be directed toward interventions with demonstrated effectiveness.

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Table 1. Data from the Republican Blood Centre on screening donors for hepatitis B and hepatitis C markers (2004-2020)

Year	Blood donors	Hepatitis B+ absolute number	%, m±	CI 95%	Hepatitis C+ absolute number	%, m±	CI 95%
2004	33,521	1,728	5.2±0.53	4.2-6.2	1,200	3.6±0.54	2.5-4.7
2008	26,912	1,452	5.4±0.59	4.2-6.6	989	3.7±0.6	2.5-4.9
2009	29,530	1,586	5.4±0.57	4.3-6.5	1,010	3.4±0.57	2.3-4.5
2010	35,252	1,836	5.2±0.5	4.2-6.2	1,014	2.9±0.53	1.9-3.9
2011	34,771	1,823	5.2±0.52	4.2-6.2	1,000	2.9±0.53	1.9-3.9
2012	36,434	1,651	4.5±0.48	3.6-5.4	962	2.6±0.51	1.6-3.6
2013	37,463	1,649	4.4±0.51	3.4-5.4	949	2.5±0.51	1.5-3.5
2014	41,156	1,818	4.4±0.48	3.5-5.3	750	1.8±0.49	0.8-2.8
2015	42,038	1,814	4.3±0.48	3.4-5.2	795	1.9±0.48	1-2.8
2016	42,219	1,660	3.9±0.48	3-4.8	587	1.4±0.48	0.4-2.4
2017	40,127	1,327	3.3±0.49	2.3-4.3	532	1.3±0.49	0.3-2.3
2018	43,461	1,212	2.8±0.47	1.9-3.7	444	1±0.47	0.1-1.9
2019	40,766	1,041	2.6±0.49	1.6-3.6	318	0.8±0.5	-0.2-1.8
2020	42,247	1,082	2.7±0.49	1.7-3.7	318	0.8±0.5	-0.2-1.8
Total	525,897	21,679	4.2±0.5	-	10,868	2.18±0.4	-

m – standard error of the percentage estimate; CI 95% – 95% confidence interval. Values are presented as percentage ± standard error. Source: compiled by the authors based on (10)

Table 2. Number of adults who received the full course of vaccination against hepatitis B

Date	Received vaccine against viral hepatitis					Did not receive the third dose	
	I dose+	II dose+	Did not receive II dose	III dose+	Did not receive III dose	Abs. no.	%
15.01.23-05.03.23	209,593	171,180	38,413	107,232	63,948	102,361	48.8
05.04.23	217,421	178,782	38,639	115,645	63,137	101,776	46.8
05.05.23	224,004	184,092	39,912	123,369	60,723	100,635	44.9
05.06.23	228,069	188,974	39,095	127,644	61,330	100,425	44
05.07.23	230,792	193,154	37,638	134,060	59,094	96,732	41.9
			38,739±611.2		61,646±15,168		45.3±2.02

Period from 15.01 to 05.07.23, data from the Department of Disease Prevention of the State Sanitary and Epidemiological Surveillance Service. Source: compiled by the authors based on (9)

Table 3. Preliminary results of population screening for hepatitis B and C infection by region (2023): screening positivity

No.	Regions and cities	Total screened n=203,308	Positive for HBV/HCV markers; n=5,730	%, m±	CI 95%
1	Bishkek City	17,852	241	1.35±0.7	-0.1-2.8
2	Chui Region	22,665	308	1.36±0.7	-
3	Issyk-Kul Region	19,002	209	1.1±0.7	-0.3-2.5
4	Talas Region	9,851	303	3.07±1	1.1-5
5	Naryn Region	17,534	261	1.49±0.8	0-3
6	Osh Region	59,825	2,728	4.56±0.4	3.8-5.3
7	Osh City	13,216	405	3.06±0.9	1.4-4.7
8	Jalal-Abad Region	28,008	954	3.4±0.6	2.2-4.6
9	Batken Region	15,355	321	2.09±0.8	0.5-3.7
10	Kyrgyz Republic	203,308	5,730	2.82±0.2	2.4-3.2

Source: compiled by the authors based on (9)

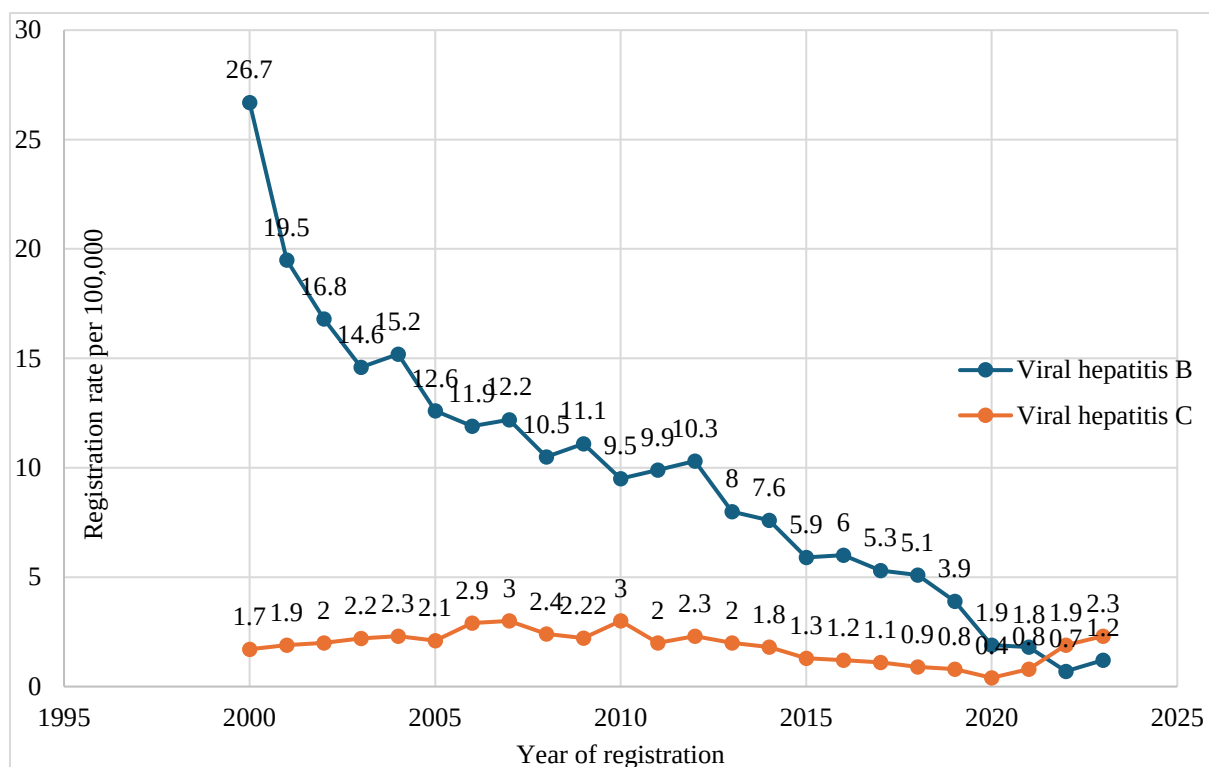


Fig. 1. Long-term dynamics of viral hepatitis B and C incidence in the Kyrgyz Republic (2000-2023). The figure presents acute cases only. Source: data from State Report Form No. 1 (9)

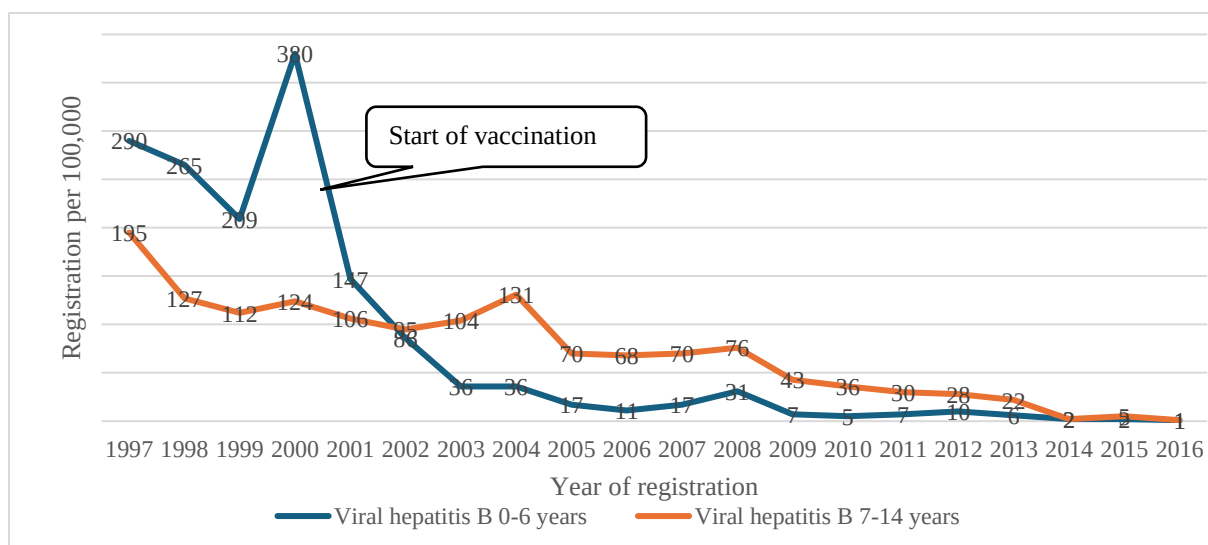


Fig. 2. Dynamics of hepatitis B incidence among children in the Kyrgyz Republic (1997-2016).
Source: data from State Report Form No. 1 (9)

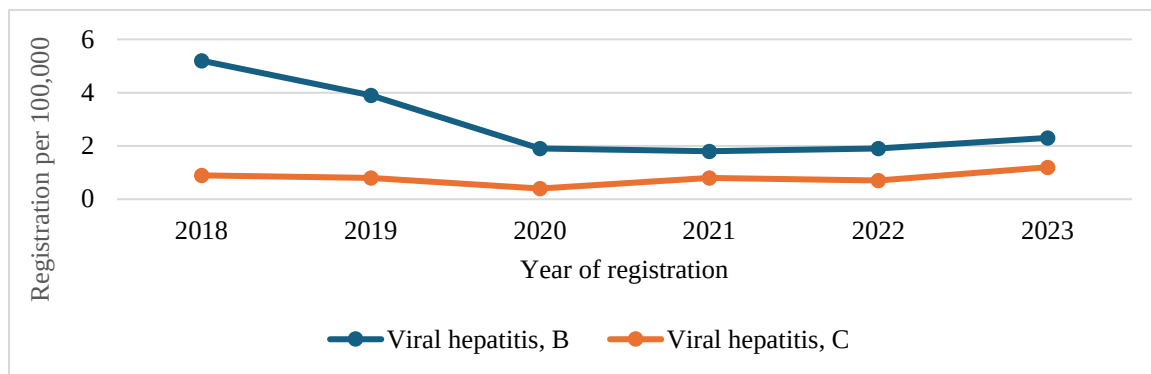


Figure 3. Registered acute hepatitis B and C in the Kyrgyz Republic, 2018-2023.

Source: compiled by the authors based on (9)