

Systematic Review



The National Burden of Hepatitis C Among Blood Donors in Pakistan: A Systematic Review and Meta-Analysis (1996-2024)

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Author's Contribution

^{1,3}Substantial contribution to the conception or design of the work; or the acquisition; ^{2,4}Active participation in methodology and literature review; ^{2,3}Analysis, or interpretation of data for the work, ^{1,5}Drafting the work and revising it critically for important intellectual content

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ABSTRACT

Objective: Hepatitis C virus (HCV) is a major public health risk globally, particularly in low- and middle-income countries like Pakistan. Blood donors represent an important group for monitoring HCV prevalence, as they can unknowingly harbor and transmit the virus. This systematic review and meta-analysis aim to assess the burden of HCV among blood donors in Pakistan from 1996 to 2024, offering insight into the epidemiology and regional disparities in the prevalence of the virus.

Methods: The review followed PRISMA guidelines, incorporating studies from databases including PubMed, Scopus, Embase, Google Scholar, Web of Science, PakMediNet, and Cochrane Library. Eligible studies (n=122) reported primary data on HCV prevalence in blood donors across Pakistan. The pooled prevalence of HCV was estimated using a random-effects model, and heterogeneity between studies was evaluated through I² statistics. Sensitivity analyses were performed to ensure the robustness of findings, and time-series analyses identified trends in HCV prevalence across years.

Results: The meta-analysis revealed an overall HCV prevalence of 2.71% among blood donors in Pakistan, based on 8.88 million donations screened. Significant regional variations were observed, with Punjab showing the highest prevalence (3.94%) and Balochistan the lowest (0.87%). Screening practices varied across provinces, contributing to these differences. A time-series analysis indicated fluctuating trends over the years, with notable spikes in certain years.

Conclusion: HCV prevalence among blood donors highlights ongoing transmission risks, the need for enhanced screening protocols and implementation of blood safety regulations in Pakistan.

Key words: Hepatitis C Virus, Prevalence, Pakistan, Blood Donors

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Introduction

Infection with Hepatitis C virus (HCV) is an increasing global concern because of its significant impact on morbidity and mortality.¹ The disease imposes a substantial health and economic burden on countries, especially developing ones due to its hepatic and extrahepatic effects.² The WHO (World Health

Organization) recently obtained officially authenticated data from 130 countries and supplemented it with partner-provided data from 70 countries. In 2019, it was estimated that 15.2 million people living with HCV had been diagnosed between 2015 and 2019, and 9.4 million received direct-acting antiviral (DAA) treatment during that period.³ Globally, about 58 million people were living with chronic HCV, with 1.5 million new infections

reported in 2019. In 2022, approximately 242,000 deaths were attributed to HCV, primarily due to cirrhosis and hepatocellular carcinoma.⁴ In 2016, at the 69th World Health Assembly (WHA), all 194 member states endorsed the Global Health Sector Strategy aimed at eradicating hepatitis infections by 2030.⁵ The disease has seen a downward trend in many countries due to the introduction of DAA, a ground-breaking treatment that offers prospects to reduce HCV infection and disease burden.³ Despite these advances in treatment, hepatitis C remains a pressing concern, particularly in low- and middle-income countries like Pakistan, where both the prevalence of infection and the associated risks are exceptionally high.⁶ Hepatitis C is a blood-borne virus, primarily transmitted through exposure to infected blood. The routes of transmission include the use of unsterilized medical instruments, unsafe blood transfusions, and injection drug use.⁷

Globally, the prevalence of HCV varies significantly across regions, with lower-income countries generally exhibiting higher rates of infection. According to WHO, the global seroprevalence of HCV is around 1%, but this figure obscures significant regional variations.⁸ Countries in North Africa, the Middle East, and South Asia have some of the highest prevalence rates, with Egypt and Pakistan being notable examples.

In South Asia, Pakistan has emerged as a country with alarmingly high HCV infection rates, with estimates suggesting that around 5-6% of the adult population is infected with HCV, translating to approximately 9-10 million individuals.⁹ These estimates vary widely across studies and are influenced by regional disparities in healthcare access and quality, as well as socio-economic and cultural factors. The rural population appears to be disproportionately affected due to inadequate access to healthcare services and poor awareness regarding safe medical practices.¹⁰

In Pakistan, the socio-economic factors, inadequate healthcare infrastructure, and poor blood screening assays significantly contribute to the transmission of HCV, placing specific groups, including blood recipients, at high risk of infection.¹¹ Among these key risk factors, unscreened blood transfusions have been consistently identified as a major contributor to the spread of HCV in Pakistan. This makes the population of blood donors an important group for monitoring the prevalence of hepatitis C. Blood donation is a critical component of healthcare systems, particularly in developing countries like Pakistan, where blood is frequently needed for medical emergencies, surgeries, and maternal care. The importance of ensuring

the safety of blood transfusions is paramount, as it directly impacts patient outcomes. However, in Pakistan, the blood donation process is often marred by insufficient screening for infectious diseases, including hepatitis C, particularly in rural and under-resourced areas. This has led to a situation where blood donors, rather than being a safe source of blood, have sometimes become vectors of disease transmission, particularly when screening protocols are not rigorously followed.

Gaining insight into the epidemiology of HCV in Pakistan is essential for designing and implementing cost-effective prevention and treatment strategies, aligning with global efforts to eliminate HCV. As stated above, blood donors are a vital population for the surveillance of infectious diseases like hepatitis C, as they represent a subgroup of individuals who are often asymptomatic and presumed to be healthy. However, because HCV can remain asymptomatic for years, blood donors can unknowingly harbor and transmit the virus, posing significant risks to recipients of blood transfusions. The prevalence of hepatitis C among blood donors is, therefore, a crucial metric, as it not only reflects the level of virus circulation in the general population but also points to potential gaps in the safety of blood transfusion services and the overall healthcare system. The screening of HCV has been introduced in Pakistan since August 1993 while the first study assessing the prevalence of HCV in blood donors was published in 1996. However, there is no systematic overview of literature on the prevalence of HCV in blood donors. The objective of this systematic review is to ascertain the burden of HCV among blood donors in Pakistan between 1996 and 2024.

Methodology

We searched the PROSPERO database (International Prospective Register of Systematic Reviews) and the Database of Abstracts of Reviews of Effects (<http://www.library.UCSF.edu>) to identify relevant published or ongoing projects. The protocol for this systematic review was registered on PROSPERO (ID CRD42024605145).

The review was conducted following the pre-defined methodological standards of the Centre for Evidence-Based Practice and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.¹³

The eligibility criteria was established based on the PICOS (Population, Intervention, Comparison, Outcome, Study design) framework, i.e. population (blood donors);

intervention/exposure (presence of HCV in blood donors); comparison (no specific comparison groups, but studies that reported prevalence rates of HCV in different regions or populations (urban vs. rural) were included); outcome (prevalence of HCV among blood donors, reported as a percentage or proportion); and study design (cross-sectional studies, observational studies, cohort studies, and annual reports, were included while case reports, commentaries, editorials, and studies with incomplete data were excluded).

A comprehensive and systematic literature search was conducted across multiple electronic databases, including PubMed, Scopus, Web of Science, Embase, Google Scholar, PakMediNet, and the Cochrane Library (both the Cochrane Database of Systematic Reviews and the Cochrane Controlled Register of Controlled Trials).

The search was conducted for studies published from 1996 (when the first article was published) to December 2024. The search strategy involved a combination of Medical Subject Headings (MeSH) terms and keywords related to Hepatitis C, blood donors, and Pakistan. The search terms used included "Hepatitis C" OR "HCV", "Blood donors", "Prevalence", "Epidemiology", "Pakistan".

Boolean operators such as "AND" and "OR" were used to refine and focus the search results. No language restrictions were applied, although only studies published in English were included. A hand-comb search of the reference lists from included studies and relevant reviews was also conducted to identify any additional relevant studies. Only articles reporting HCV incidence or prevalence based on primary data were included in this review. Exclusions applied to case reports, case series, editorials, letters to the editor, commentaries, reviews, studies referring to HCV as non-A non-B hepatitis, those with duplicate information, self-reported HCV prevalence, or studies involving Pakistani nationals living abroad.

The study selection process was conducted in two stages. First, the titles and abstracts were screened. All articles identified through the database search were imported into reference management software (EndNote™X8.2)¹⁴ for the removal of duplicates. Titles and abstracts of the remaining studies were then screened independently by two researchers (UW, SS) for relevance to the research question. This was followed by retrieval of full-text studies that met the initial screening criteria. These articles were independently reviewed by two researchers (UW, NS) based on the eligibility criteria. Any disagreements between researchers were resolved by discussion or

consultation with a third researcher. The study selection process was documented in a PRISMA flow diagram to visually represent the number of records identified, included, and excluded at each stage of the review.

A standardized data extraction form was developed to ensure consistency in the data collection process. Data were extracted independently by two researchers (UW, JB) and cross-checked for accuracy. The information extracted from each article included: study characteristics [author(s), year of publication, study location, and study design]; population characteristics [number of blood donors, age, gender distribution, and setting (urban or rural)]; outcome [prevalence of Hepatitis C virus among blood donors, reported as a percentage or proportion]; and screening methods [type of diagnostic test used for HCV screening, e.g., RDT, ELISA, CLIA, PCR]. To maintain transparency and reduce the risk of bias, any discrepancies in the extracted data were resolved through discussion between the researchers.

The methodological quality of the included studies was evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklist for prevalence data, chosen for its validity in assessing prevalence studies.¹⁵ Alternative tools, such as the Cochrane Risk of Bias tool, were considered unsuitable for this study design. Each publication was rated on nine JBI items, receiving scores of '1' (poor), '2' (good), or '3' (excellent), resulting in an aggregate quality score ranging from 9 to 27. Two reviewers (NS, UA) independently assessed the studies, resolving disagreements through discussion. Studies with a total score below 50% of the maximum (<13.5) were classified as poor quality.

The data were synthesized quantitatively through a meta-analysis using STATA v.14.2 (StataCorp, College Station, TX, USA). A random-effects model was used to check for the potential heterogeneity between studies. Heterogeneity was evaluated using the Cochran Q test and quantified by the I^2 index. Heterogeneity was deemed significant if the *p-value* from the Cochran Q test was less than 0.05. Publication bias was assessed using a Funnel plot, which plotted transformed proportions against sample size. The plot's symmetry was assessed with the Egger test, with a threshold of $p < 0.1$ indicating potential bias.

The mean, median, and range of HCV prevalence across different studies were calculated to understand the central tendency and spread of the prevalence data. A meta-analysis was performed through a random-effects model to pool the prevalence estimates from different studies.

Forest plot was used to visually display the individual prevalence estimates and their confidence intervals, alongside the overall pooled prevalence estimate.

A time series analysis was performed to see how the prevalence of HCV has changed overtime (1996-2024) to identify patterns, spikes, or declines in HCV prevalence over the years. Regression models were used to explore the association between time (years) and HCV prevalence. Further, a sensitivity analysis (Leave-One-Out Analysis) was conducted by systematically excluding each study from the meta-analysis to assess the impact of individual studies on the overall prevalence estimate.

The studies included in this systematic review had their ethical approval for their respective study settings and design. Therefore, as this review depends on data from previously published studies, no ethical approval was needed. Although, the ethical guidelines outlined by the PRISMA statement were followed to ensure transparency and reproducibility in reporting the findings.

Results

Figure 1 presents the process (flow diagram) through which articles were selected based on PRISMA guidelines. The initial search identified 3,816 records, with an additional 11 records found through hand searching. After removing duplicates, 3,423 records remained for title and abstract screening. Following full-text screening and consensus on disagreements, 121 records representing 122 unique studies were included in the review.¹⁶⁻¹³⁶

Detailed information on the studies included and their characteristics is shown in Table 1. Among the 122 studies, 115 (94.26%) screened for anti-HCV antibodies while 7 (5.74%) screened for HCV RNA. The total number of blood donations screened for anti-HCV antibodies was 8,346,153 (94.04%) while 529,133 (5.96%) were screened for HCV RNA.

The overall prevalence of HCV among blood donors in different provinces and regions of Pakistan, based on the data from 1996 to 2024, was 2.71%. This calculation is based on a total sample size of 8,875,286 donors.

Regarding the screening assays used, 30.32% (n=37) studies utilized rapid diagnostic test (RDT), 38.52% (n=47) enzyme-linked immunosorbent assay (ELISA), 25.40% (n=31) chemiluminescence immunoassay (CLIA), and 5.74% (n=7) nucleic acid testing (NAT)/polymerase chain reaction (PCR).

Regional distribution of studies revealed that majority of the studies were conducted in the province of Punjab 40.16% (n=49), followed by Sindh 22.13% (n=27), Khyber Pakhtunkhwa 20.49% (n=25), Islamabad Capital Territory 6.55% (n=8), Balochistan 4.09% (n=5), Azad Jammu & Kashmir 4.09% (n=5), and Gilgit-Baltistan 2.45% (n=3).

From the 122 records studied in this systematic review, the overall sample size was 8,875,286 that tested the prevalence of HCV in blood donors. The sample size across the studies ranged from 80 (Khyber Pakhtunkhwa)²³ to 4.19 million (Sindh).¹³⁴ There was a wide variation in HCV prevalence among individual studies, e.g. it ranged from 0% (in Khyber Pakhtunkhwa)²³, 0.07% (Punjab)⁴², and 0.07% (AJK)¹³³ to 28% in Punjab Province.⁵⁴

Table 2: Province-wise pooled prevalence of HCV

Province/Region	Studies (n)	Sample size	HCV Positive (%)
Azad Jammu and Kashmir	5	45,842	476 (1.03%)
Balochistan	5	48,959	427 (0.87%)
Gilgit Baltistan	3	13,585	139 (1.02%)
Islamabad Capital Territory	8	571,730	13,748 (2.40%)
Khyber Pakhtunkhwa	25	981,432	23,795 (2.42%)
Punjab	49	2,055,717	81,180 (3.94%)
Sindh	27	5,158,021	121,541 (2.35%)
Total	122	8,875,286	241,306 (2.71%)

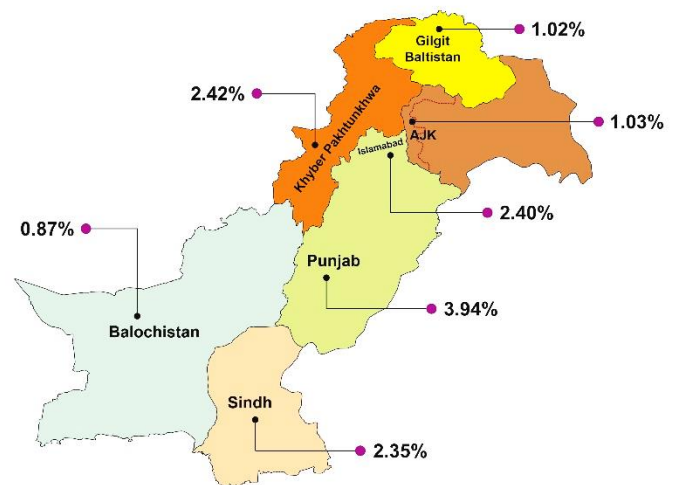


Fig. 2: Geographical distribution of HCV prevalence across Pakistan

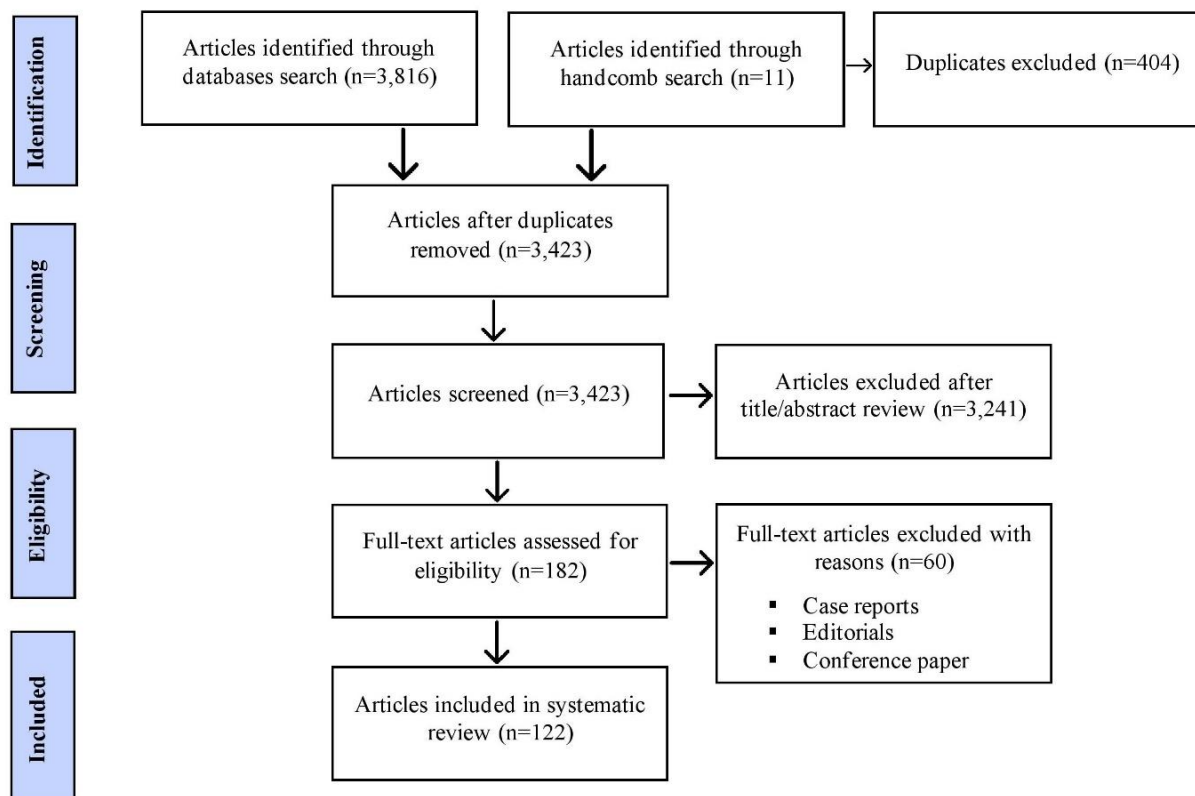


Fig. 1: Flowchart of the process through which articles were selected based on PRISMA

Table 1: Studies included in the systematic review that assessed the prevalence of HCV among blood donors across Pakistan

S. No.	Author	Year	Province/Region	Sample size	HCV Positive (%)	Technique
1.	Mujeeb <i>et al.</i> , ¹⁶	1996	Sindh	839	20 (2.38%)	ELISA
2.	Bhatti <i>et al.</i> , ¹⁷	1996	Punjab	750	36 (4.80%)	ELISA
3.	Kakepto <i>et al.</i> , ¹⁸	1996	Sindh	16,705	198 (1.18%)	ELISA
4.	Rehman <i>et al.</i> , ¹⁹	1996	Punjab	91	13 (14.28%)	ELISA
5.	Rehman <i>et al.</i> , ²⁰	1996	Sindh	2,557	15 (0.58%)	RDT
6.	Lone <i>et al.</i> , ²¹	1999	Punjab	186	8 (4.30%)	RDT
7.	Hashmi <i>et al.</i> , ²²	1999	Punjab	426	89 (20.89%)	RDT
8.	Jadoon <i>et al.</i> , ²³	1999	Khyber Pakhtunkhwa	80	0 (0%)	RDT
9.	Mujeeb <i>et al.</i> , ²⁴	2000	Sindh	612	3 (0.49%)	ELISA
10.	Ahmed <i>et al.</i> , ²⁵	2001	Sindh	1,410	96 (6.80%)	ELISA
11.	Ryas <i>et al.</i> , ²⁶	2001	Punjab	1,885	88 (4.66%)	ELISA
12.	Ahmad <i>et al.</i> , ²⁷	2002	Punjab	5,789	284 (4.90%)	RDT
13.	Khattak <i>et al.</i> , ²⁸	2002	Punjab	103,858	4,164 (4.00%)	ELISA
14.	Mumtaz <i>et al.</i> , ²⁹	2002	Punjab	553	34 (6.14%)	RDT
15.	Rahman <i>et al.</i> , ³⁰	2002	Punjab	166,183	7,312 (4.39%)	RDT
16.	Ali <i>et al.</i> , ³¹	2003	Balochistan	1,500	28 (1.86%)	ELISA
17.	Ahmad <i>et al.</i> , ³²	2004	Khyber Pakhtunkhwa	4,000	88 (2.20%)	ELISA
18.	Akhtar <i>et al.</i> , ³³	2004	Sindh	351,309	6,349 (1.80%)	ELISA
19.	Asif <i>et al.</i> , ³⁴	2004	ICT	3,430	164 (4.78%)	ELISA
20.	Mahmood <i>et al.</i> , ³⁵	2004	Punjab	6,000	16 (0.26%)	RDT
21.	Zaidi <i>et al.</i> , ³⁶	2004	Khyber Pakhtunkhwa	4,000	88 (2.20%)	ELISA
22.	Sirhindi <i>et al.</i> , ³⁷	2005	Punjab	18,216	758 (4.16%)	RDT

23.	Chaudry <i>et al.</i> , ³⁸	2005	Punjab	890	54 (6.06%)	ELISA
24.	Ujjan <i>et al.</i> , ³⁹	2006	Punjab	3,677	246 (6.69%)	ELISA
25.	Mujeeb <i>et al.</i> , ⁴⁰	2006	Sindh	7,325	264 (3.60%)	ELISA
26.	Fayyaz <i>et al.</i> , ⁴¹	2006	Punjab	27,938	704 (2.51%)	RDT
27.	Khan <i>et al.</i> , ⁴²	2006	Punjab	1,426	1 (0.07%)	RDT
28.	Aziz <i>et al.</i> , ⁴³	2006	Gilgit-Baltistan	850	9 (1.05%)	ELISA
29.	Ahmad <i>et al.</i> , ⁴⁴	2006	Khyber Pakhtunkhwa	41,613	936 (2.24%)	RDT
30.	Sultan <i>et al.</i> , ⁴⁵	2007	Punjab	41,498	1,529 (3.68%)	ELISA
31.	Masood <i>et al.</i> , ⁴⁶	2007	Punjab	1,428	36 (2.52%)	ELISA
32.	Khan <i>et al.</i> , ⁴⁷	2007	Balochistan	1,474	26 (1.76%)	RDT
33.	Ishaq <i>et al.</i> , ⁴⁸	2007	Sindh	310	4 (1.29%)	RDT
34.	Ijaz <i>et al.</i> , ⁴⁹	2007	Punjab	7,431	397 (5.34%)	RDT
35.	Bhatti <i>et al.</i> , ⁵⁰	2007	Sindh	94,177	3,918 (4.16%)	CLIA
36.	Chaudhary <i>et al.</i> , ⁵¹	2007	Punjab	1,428	36 (2.52%)	ELISA
37.	Azam <i>et al.</i> , ⁵²	2007	Sindh	688	30 (4.36%)	RDT
38.	Alam <i>et al.</i> , ⁵³	2007	Gilgit-Baltistan	8,949	121 (1.35%)	RDT
39.	Ahmad <i>et al.</i> , ⁵⁴	2007	Punjab	300	84 (28%)	NAT
40.	Farooqi <i>et al.</i> , ⁵⁵	2007	Khyber Pakhtunkhwa	166,189	5,312 (3.19%)	RDT
41.	Nazar <i>et al.</i> , ⁵⁶	2008	Sindh	11,459	237 (2.068%)	RDT
42.	Mujeeb <i>et al.</i> , ⁵⁷	2008	Sindh	5,345	401 (7.50%)	ELISA
43.	Khattak <i>et al.</i> , ⁵⁸	2008	Khyber Pakhtunkhwa	1,131	46 (4.06%)	ELISA
44.	Waheed <i>et al.</i> , ⁵⁹	2009	ICT	18,202	602 (3.30%)	ELISA
45.	Manzoor <i>et al.</i> , ⁶⁰	2009	Punjab	6,659	512 (7.68%)	ELISA
46.	Abbas <i>et al.</i> , ⁶¹	2009	Sindh	804	121 (15%)	ELISA
47.	Shah <i>et al.</i> , ⁶²	2010	Khyber Pakhtunkhwa	32,042	502 (1.56%)	ELISA
48.	Safi <i>et al.</i> , ⁶³	2011	Khyber Pakhtunkhwa	62,251	1,622 (2.6%)	ELISA
49.	Bangash <i>et al.</i> , ⁶⁴	2011	Khyber Pakhtunkhwa	1,300	15 (1.1%)	RDT
50.	Khan <i>et al.</i> , ⁶⁵	2011	Khyber Pakhtunkhwa	7,148	477 (6.67%)	ELISA
51.	Borhany <i>et al.</i> , ⁶⁶	2011	Sindh	5,717	109 (1.90%)	ELISA
52.	Waheed <i>et al.</i> , ⁶⁷	2012	ICT	10,145	846 (8.33%)	ELISA
53.	Bhutta <i>et al.</i> , ⁶⁸	2012	Punjab	100	12 (12%)	ELISA
54.	Attallah <i>et al.</i> , ⁶⁹	2012	Khyber Pakhtunkhwa	127,828	3,147 (2.46%)	ELISA
55.	Umair <i>et al.</i> , ⁷⁰	2012	AJK	8,927	224 (2.5%)	ELISA
56.	Arshad <i>et al.</i> , ⁷¹	2012	Khyber Pakhtunkhwa	6,538	793 (12.12%)	NAT
57.	Tunio <i>et al.</i> , ⁷²	2013	Sindh	2,696	93 (3.44%)	CLIA
58.	Khan <i>et al.</i> , ⁷³	2013	Balochistan	356	74 (20.78%)	ELISA
59.	Irfan <i>et al.</i> , ⁷⁴	2013	Sindh	108,393	2,832 (2.61%)	CLIA
60.	Akhtar <i>et al.</i> , ⁷⁵	2013	Punjab	245	37 (17.78%)	ELISA
61.	Moiz <i>et al.</i> , ⁷⁶	2014	Sindh	42,830	708 (1.65%)	CLIA
62.	Iqbal <i>et al.</i> , ⁷⁷	2014	Punjab	217,847	6,400 (2.9%)	RDT
63.	Tabassum <i>et al.</i> , ⁷⁸	2014	Punjab	15,898	249 (1.56%)	ELISA
64.	Pervaiz <i>et al.</i> , ⁷⁹	2015	Punjab	5,894	857 (14.5%)	RDT
65.	Niazi <i>et al.</i> , ⁸⁰	2015	Punjab	56,772	1,046 (1.84%)	NAT
66.	Wazeer <i>et al.</i> , ⁸¹	2015	AJK	4,622	129 (2.79%)	RDT
67.	Hussain <i>et al.</i> , ⁸²	2015	Punjab	48,020	1,652 (3.44%)	RDT
68.	Sial <i>et al.</i> , ⁸³	2016	Punjab	29,522	743 (2.51%)	CLIA
69.	Karim <i>et al.</i> , ⁸⁴	2016	Khyber Pakhtunkhwa	5,318	56 (1.05%)	NAT
70.	Saeed <i>et al.</i> , ⁸⁵	2016	Punjab	18,274	479 (2.62%)	RDT
71.	Arshad <i>et al.</i> , ⁸⁶	2016	Sindh	16,602	282 (1.69%)	CLIA
72.	Ahmed <i>et al.</i> , ⁸⁷	2016	Khyber Pakhtunkhwa	8,439	42 (0.5%)	CLIA
73.	Zameer <i>et al.</i> , ⁸⁸	2017	Punjab	10,048	377 (3.75%)	RDT
74.	Wadood <i>et al.</i> , ⁸⁹	2017	Sindh	536	16 (2.98%)	ELISA
75.	Sultan <i>et al.</i> , ⁹⁰	2017	Sindh	16,957	361 (2.12%)	CLIA
76.	Saeed <i>et al.</i> , ⁹¹	2017	Punjab	18,274	480 (2.62%)	RDT
77.	Butt <i>et al.</i> , ⁹²	2017	Punjab	10,516	287 (2.72%)	CLIA
78.	Batool <i>et al.</i> , ⁹³	2017	Khyber Pakhtunkhwa	41,033	566 (1.37%)	CLIA
79.	Ahmed <i>et al.</i> , ⁹⁴	2017	AJK	10,519	53 (0.50%)	RDT
80.	Saba <i>et al.</i> , ⁹⁵	2018	Khyber Pakhtunkhwa	3,211	35 (1.09%)	CLIA

81.	Naz <i>et al.</i> , ⁹⁶	2018	Sindh	14,652	226 (1.54%)	CLIA
82.	Billah <i>et al.</i> , ⁹⁷	2018	Punjab	1,195	27(2.25%)	ELISA
83.	Rehman <i>et al.</i> , ⁹⁸	2018	Khyber Pakhtunkhwa	1,400	16 (1.14%)	ELISA
84.	Awan <i>et al.</i> , ⁹⁹	2018	ICT	30,470	392 (1.28%)	NAT
85.	Akhter <i>et al.</i> , ¹⁰⁰	2018	Punjab	7,270	196 (2.69%)	RDT
86.	Azeem <i>et al.</i> , ¹⁰¹	2018	Khyber Pakhtunkhwa	204,942	3189 (1.5%)	ELISA
87.	Wadood <i>et al.</i> , ¹⁰²	2019	Sindh	517	13 (2.51%)	ELISA
88.	Siddiqui <i>et al.</i> , ¹⁰³	2019	ICT	847	15 (1.7%)	CLIA
89.	Mengal <i>et al.</i> , ¹⁰⁴	2019	Balochistan	23,814	162 (0.68%)	CLIA
90.	Sadiq <i>et al.</i> , ¹⁰⁵	2019	Sindh	37,845	2208 (5.83%)	ELISA
91.	Zeeshan <i>et al.</i> , ¹⁰⁶	2019	Khyber Pakhtunkhwa	32,012	4,587 (14.32%)	CLIA
92.	Jiskani <i>et al.</i> , ¹⁰⁷	2019	Sindh	3,028	65 (2.14%)	ELISA
93.	Hameed <i>et al.</i> , ¹⁰⁸	2019	Punjab	76,530	2,095 (2.73%)	RDT
94.	Latif <i>et al.</i> , ¹⁰⁹	2019	Gilgit-Baltistan	3,786	9 (0.23%)	CLIA
95.	Ahmed <i>et al.</i> , ¹¹⁰	2019	AJK	10,519	62 (0.58%)	CLIA
96.	Zaheer <i>et al.</i> , ¹¹¹	2019	ICT	75,348	941 (1.24%)	CLIA
97.	Ahmad <i>et al.</i> , ¹¹²	2019	Punjab	79,774	1,404 (1.75%)	RDT
98.	Rauf and Cheema ¹¹³	2019	Punjab	6,594	214 (3.24%)	CLIA
99.	Saba <i>et al.</i> , ¹¹⁴	2021	Khyber Pakhtunkhwa	41,817	577 (1.37%)	CLIA
100.	Khan <i>et al.</i> , ¹¹⁵	2021	Khyber Pakhtunkhwa	119,263	908 (0.76%)	CLIA
101.	Qadir <i>et al.</i> , ¹¹⁶	2021	Sindh	29,732	908 (3%)	CLIA
102.	Ghazanfer <i>et al.</i> , ¹¹⁷	2021	Punjab	84,305	1,283 (1.52%)	RDT
103.	Saeed and Ullah ¹¹⁸	2021	ICT	312,320	8,951 (2.86%)	CLIA
104.	Bhatti <i>et al.</i> , ¹¹⁹	2021	Punjab	400	9 (2.25%)	RDT
105.	Arshad <i>et al.</i> , ¹²⁰	2021	Punjab	200	25 (12.5%)	RDT
106.	Ghazanfar <i>et al.</i> , ¹²¹	2022	Punjab	223,242	3,105 (1.391%)	RDT
107.	Bhatti <i>et al.</i> , ¹²²	2022	ICT	120,968	1837 (1.5%)	NAT
108.	Ullah <i>et al.</i> , ¹²³	2022	Punjab	7,858	77 (0.97%)	ELISA
109.	Zorob <i>et al.</i> , ¹²⁴	2023	Punjab	15,405	83 (0.53%)	CLIA
110.	Shah <i>et al.</i> , ¹²⁵	2023	Khyber Pakhtunkhwa	6,311	20 (0.316%)	ELISA
111.	Jamal <i>et al.</i> , ¹²⁶ (a)	2023	Sindh	185,781	20,807 (11.19%)	CLIA
112.	Jamal <i>et al.</i> , ¹²⁶ (b)	2023	Punjab	406,039	38,979 (9.59%)	CLIA
113.	Kashif <i>et al.</i> , ¹²⁷	2023	Punjab	1,500	106 (7.06%)	RDT
114.	Ali <i>et al.</i> , ¹²⁸	2023	Khyber Pakhtunkhwa	625	9 (1.44 %)	CLIA
115.	Sabir <i>et al.</i> , ¹²⁹	2023	Punjab	308,767	4,457 (1.4%)	NAT
116.	Aslam <i>et al.</i> , ¹³⁰	2023	Punjab	6,380	72 (1.12%)	ELISA
117.	Amjed <i>et al.</i> , ¹³¹	2023	Punjab	2,236	28 (1.25%)	RDT
118.	Saba <i>et al.</i> , ¹³²	2024	Khyber Pakhtunkhwa	62,185	749 (1.20%)	CLIA
119.	Wazeer <i>et al.</i> , ¹³³	2024	AJK	11,255	8 (0.07%)	CLIA
120.	Jamal <i>et al.</i> , ¹³⁴	2024	Sindh	4,199,195	812,66 (1.93%)	CLIA
121.	Haleem <i>et al.</i> , ¹³⁵	2024	Balochistan	21,815	137 (0.62%)	CLIA
122.	Khan <i>et al.</i> , ¹³⁶	2024	Khyber Pakhtunkhwa	756	15 (1.98%)	ELISA
Total				8,875,286	241,306 (2.71%)	

RDT: Rapid Diagnostic Test; ELISA: Enzyme Linked Immunosorbent Assay; CLIA: Chemiluminescence Immunoassay; NAT: Nucleic Acid Testing; AJK: Azad Jammu & Kashmir; ICT: Islamabad Capital Territory

Table 2 shows the pooled subgroup prevalence of HCV among blood donors, stratified by province. The Punjab province reported the highest prevalence at 3.94% (49 studies, 2,055,717 samples), followed by Khyber Pakhtunkhwa at 2.42% (25 studies, 981,432 samples), Sindh at 2.35% (27 studies, 5,158,021 samples), and Islamabad Capital Territory at 2.40% (8 studies, 571,730 samples). Lower prevalence rates were observed in Azad Jammu & Kashmir at 1.03% (5 studies, 45,842 samples),

Gilgit-Baltistan at 1.02% (3 studies, 13,585 samples), and Balochistan at 0.87% (5 studies, 48,959 samples). Fig. 2 shows a map of Pakistan to visually represent the geographical distribution of HCV prevalence across Pakistan, highlighting regional variations. The central tendency and spread of HCV prevalence across different provinces/regions were as follows; mean prevalence, 2.07%; median prevalence, 2.35%; and range, 3.07% (from 0.87% in Balochistan to 3.94% in Punjab).

For assessing the potential for publication bias, a Funnel plot (Fig. 3) was constructed by plotting the standard error against log of the prevalence estimates from each study. Funnel plot asymmetry was evaluated visually, and Egger's test was conducted for Funnel plot asymmetry. According to Egger's test results (after adjusting for zero prevalence values), the coefficient for standard error was 88.46 ($p < 0.0001$), and the intercept (const) -4.01 ($p < 0.0001$). As the p-value for the coefficient of the standard error is < 0.0001 , it indicated a statistically significant relationship between the standard error and the log prevalence estimates. Hence, suggesting potential publication bias. Likewise, the intercept (const) is negative and statistically significant, indicating asymmetry in the Funnel plot.

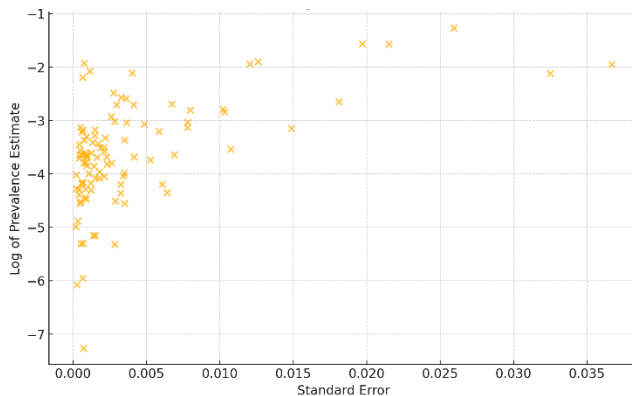


Fig. 3: Funnel plot: Assessing potential for publication bias

The Forest plot (Fig. 4 a & b) visually represents the individual HCV prevalence estimates with their assumed confidence intervals ($\pm 0.5\%$) for each year, alongside the overall pooled prevalence estimate. The relatively tight clustering of individual estimates around the overall mean suggests the stability of the prevalence trend, with no single year showing a significant deviation.

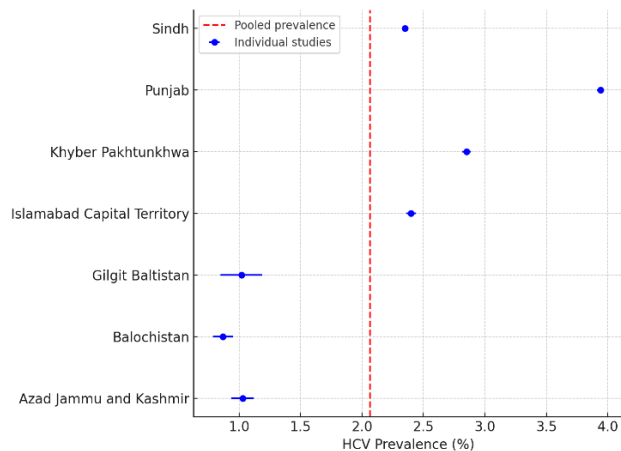


Fig. 4 (a): Forest plot: HCV prevalence across regions

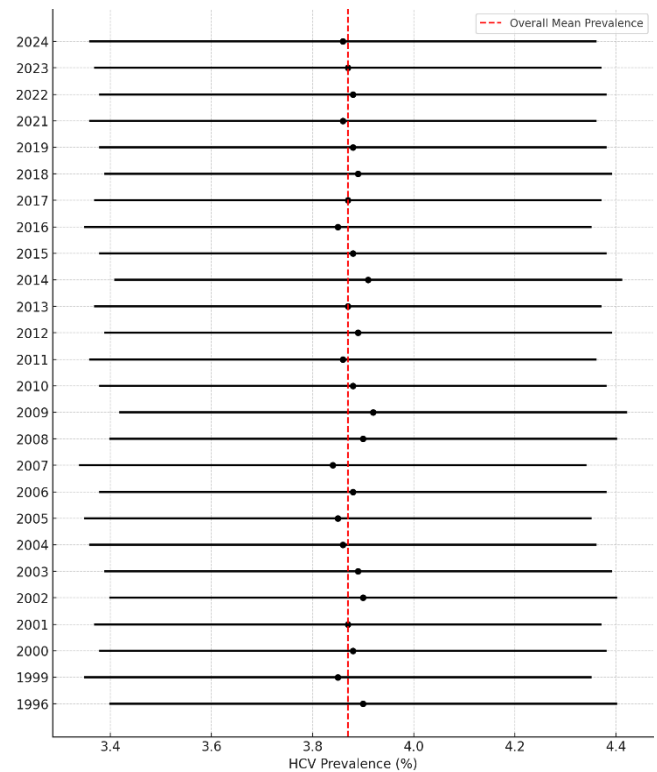


Fig. 4 (b): Forest plot: HCV prevalence estimates and confidence intervals

In Fig. 5, a time series plot is shown with the trend of HCV prevalence among blood donors across Pakistan from 1996

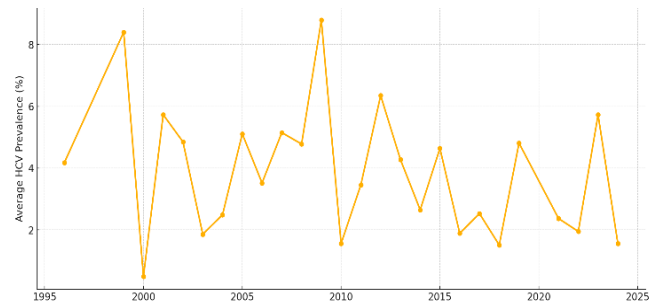


Fig. 5: HCV prevalence trend in blood donors

to 2024. The analysis showed three key phases; (1) initial fluctuations (1996–2005), during which prevalence varied, peaking in 1999 (8.4%) and 2005 (5.11%), with some outliers possibly due to testing limitations or localized outbreaks; (2) stabilization and moderate increase (2006–2015), during which prevalence averaged between 3.5% and 5%, with occasional spikes, reflecting consistent reporting across provinces; and (3) declining trend (2016–2024), when a steady decline began in 2016, stabilizing around 1.5%-2.5%, with the lowest point in 2024 (1.56%) indicating better screening and preventive measures.

The linear regression analysis (Fig. 6) suggested the slope (rate of change) is -0.0700 , indicating a decreasing trend in HCV prevalence, with an average decline of 0.07% per year. The intercept is 144.66 , suggesting that, based on the linear model, the estimated starting prevalence in 1996 would align with a theoretical intercept. The red regression line in the plot shows the declining trend (negative slope), confirming that HCV prevalence has generally decreased across the years.

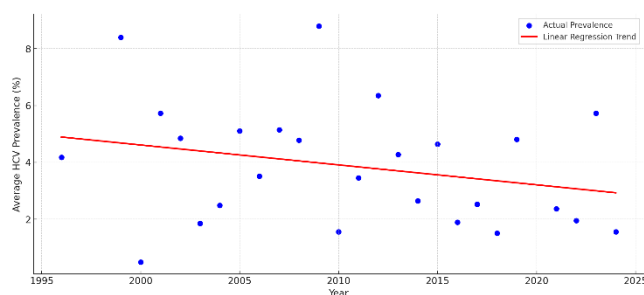


Fig. 6: Linear regression: HCV prevalence (%) over time

The Leave-One-Out (LOO) analysis plot shows (Fig. 7) how the overall mean HCV prevalence changes when each study (year) is excluded from the analysis. The overall mean HCV prevalence across all years is approximately 3.87% , suggesting that no individual year had a significant impact on the overall mean HCV prevalence, with deviations falling within the defined threshold of $\pm 0.5\%$. This suggests that the overall mean estimate is stable and not heavily influenced by any specific year.

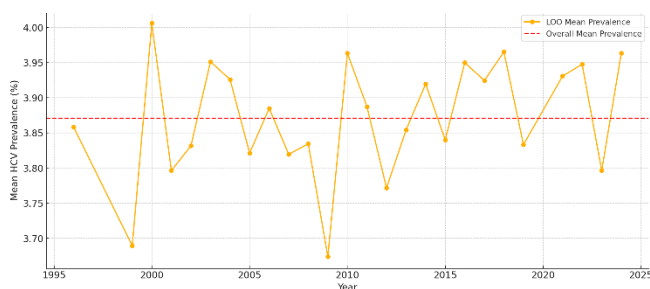


Fig. 7: Leave-One-Out analysis: Mean prevalence over time

Discussion

The majority of blood donations ($\sim 82\%$) in Pakistan are collected through family or replacement donations, rather than from voluntary non-remunerated donors,^{137,138} which is the gold standard recommended by WHO and national blood safety legislations for ensuring blood safety.^{139,140} Family or replacement donations occur when patients' relatives or friends donate blood in exchange for transfusions, a practice that increases the risk of

transmitting infectious diseases like HCV, as these donors may feel pressured to donate even when they are not fully aware of their health status.¹⁴¹ In 2019, Pakistan's blood banking network comprised 650 facilities across the public, private, and NGO sectors. These blood banks varied widely in size, with some collecting fewer than 500 units annually, while others exceeded 100,000 units per year. In the same year, around 2.7 million units of blood were collected nationwide.¹⁴²

Additionally, the overall infrastructure for blood donation and transfusion services in Pakistan remains underdeveloped. Although some progress has been made through the German-funded national blood transfusion programme in establishing regional blood centres and improving the safety of blood transfusions, many facilities still lack the resources necessary for proper screening and storage.¹⁴³

In rural areas, where healthcare access is particularly limited, blood donations are often handled by on-job trained technicians, which may not rigorously screen donations for HCV or other infectious agents. These gaps in the system allow contaminated blood to enter the blood supply chain, further contributing to the spread of hepatitis C.

The findings from this current systematic review and meta-analysis of HCV prevalence among blood donors in Pakistan indicate significant public health concerns. With an overall pooled prevalence of 2.71% from 1996 to 2024, the study underscores the constant challenge of HCV transmission in a resource-constrained healthcare setting.

The observed pooled prevalence of 2.71% among blood donors suggests a continued circulation of HCV within the general population, considering that blood donors are usually considered a healthy cohort. This prevalence aligns with previous studies indicating that HCV infection in Pakistan is disproportionately high when compared with other countries such as Turkey (0.07%),¹⁴⁴ Canada (0.07%),¹⁴⁵ Yemen (0.82%),¹⁴⁶ and China (0.53%).¹⁴⁷ However, in contrast when compared with certain developing countries, our findings were on the lower side, e.g. 8.8% in Ethiopia,¹⁴⁸ $5\text{--}25\%$ in Egypt,¹⁴⁹ 3.21% in Kenya,¹⁵⁰ and 3.6% in Nigeria.¹⁵¹

Blood donors unknowingly carrying HCV present a significant transmission risk, especially in areas where screening mechanisms are inadequate. As asymptomatic carriers, these donors exemplify the hidden burden of the disease, further complicating efforts to eliminate HCV as a public health concern.

The current findings showed considerable regional variations in HCV prevalence among blood donors. The province of Punjab reported the highest prevalence (3.94%), followed by Khyber Pakhtunkhwa (2.42%) and Sindh (2.35%). These disparities reflect the uneven distribution of healthcare resources and differences in blood safety measures across the provinces. Punjab's high prevalence could be attributed to a combination of poor screening practices, both behavioral and serological. Conversely, regions such as Balochistan (0.87%) and Gilgit-Baltistan (1.02%) reported lower prevalence rates, though these figures could also reflect under-reporting or limited access to diagnostic services.

Unsafe blood transfusions remain a critical factor in HCV transmission in Pakistan. Although the government introduced HCV screening in 1993, inconsistencies in implementation and low-quality screening kits have undermined efforts to ensure safe blood donations.¹⁵²

The time-series analysis indicated fluctuating trends in HCV prevalence over the study period, with notable spikes in 2007, 2013, and 2023. These fluctuations may reflect shifts in public health interventions, including targeted awareness campaigns and enhanced diagnostic capabilities during certain years. The slight downward trend in prevalence observed in the regression analysis suggests some progress in controlling HCV transmission. However, the continued presence of the virus in 2024 emphasizes that Pakistan remains far from achieving the WHO's goal of HCV elimination by 2030.

Pakistan must adopt a multi-pronged strategy to reduce the burden of HCV among blood donors and achieve elimination targets. This includes (but not limited to) strengthening of blood safety regulatory authorities, expanding access to blood transfusion services in rural areas, enhancing public awareness campaigns, integrating treatment with prevention programmes, and establishing a nationwide HCV surveillance programme focusing on high-risk populations, including blood donors, to enable better monitoring and control of the disease.

Conclusion

The prevalence of hepatitis C among blood donors in Pakistan represents a significant public health concern. As one of the highest HCV-burdened countries in the world, Pakistan must prioritize the development of robust screening and prevention protocols to safeguard both blood donors and recipients. Strengthening healthcare infrastructure, particularly in rural areas, improving public

awareness, implementing blood safety legislations, and adhering to WHO-recommended guidelines for blood donation and screening practices are essential steps toward reducing the transmission of hepatitis C. The study offers a comprehensive overview of the epidemiological landscape of HCV in Pakistan, serving as a foundation for future policy development and research efforts. Addressing the gaps in blood safety practices and healthcare delivery will be pivotal in controlling the spread of HCV and safeguarding the health of both donors and recipients.

Limitations

The potential limitations of this review include differences in study settings (e.g., urban vs. rural blood donors) and variations in sample sizes may impact the generalizability of the findings. Likewise, the heterogeneity between studies in terms of screening tests used for HCV screening (RDT vs. ELISA vs. CLIA vs. PCR/NAT) could introduce bias as all have different levels of sensitivity and specificity.

References

1. Stanaway JD, Flaxman AD, Naghavi M, Fitzmaurice C, Vos T, Abubakar I, et al. The global burden of viral hepatitis from 1990 to 2013: Findings from the Global Burden of Disease Study 2013. *Lancet*. 2016;388(10049):1081-1088. [https://doi.org/10.1016/S0140-6736\(16\)30579-7](https://doi.org/10.1016/S0140-6736(16)30579-7).
2. Younossi Z, Park H, Henry L, Adeyemi A, Stepanova M. Extrahepatic manifestations of hepatitis C: A meta-analysis of prevalence, quality of life, and economic burden. *Gastroenterology*. 2016;150(7):1599-1608. <https://doi.org/10.1053/j.gastro.2016.02.039>.
3. Cui F, Blach S, Manzengo Mingiedi C, Gonzalez MA, Sabry Alaama A, Mozalevskis A, et al. Global reporting of progress towards elimination of hepatitis B and hepatitis C. *Lancet Gastroenterol Hepatol*. 2023;8(4):332-342. [https://doi.org/10.1016/S2468-1253\(22\)00386-7](https://doi.org/10.1016/S2468-1253(22)00386-7).
4. Abu-Freha N, Mathew Jacob B, Elhoashla A, Afawi Z, Abu-Hammad T, Elsana F, et al. Chronic hepatitis C: Diagnosis and treatment made easy. *Eur J Gen Pract*. 2022;28(1):102-108. <http://doi.org/10.1080/13814788.2022.2056161>.
5. World Health Organization (WHO). Global Health Sector Strategy on Viral Hepatitis 2016-2021. Available at <https://www.who.int/bitstream/handle/10665/246177/WHO-HIV-2016.06-eng.pdf> accessed on 14 October 2024
6. Qureshi H, Mahmood H, Sabry A, Hermez J. Barriers and Strategies for Hepatitis B and C Elimination in Pakistan. *J Infect Dis*. 2023 ;228(Suppl 3): S204-S210. <http://doi.org/10.1093/infdis/jiad022>.
7. Lei JH, Liang J, Gong X, Xiao XQ, Chen Z, Peng F. Analysis of transmission routes of Hepatitis C Virus Based on Virus Genotyping in 341 Cases with Different Suspected initial infection time points in Hunan Province, China. *Med Sci*

- Monit. 2018 ;24:5232-5241.
<http://doi.org/10.12659/MSM.907424>.
8. Polaris Observatory HCV Collaborators. Global prevalence and genotype distribution of hepatitis C virus infection in 2015: A modelling study. *Lancet Gastroenterol Hepatol*. 2017;2(3):161-176.
[http://doi.org/10.1016/S2468-1253\(16\)30181-9](http://doi.org/10.1016/S2468-1253(16)30181-9).
9. Arshad A, Ashfaq UA. Epidemiology of Hepatitis C Infection in Pakistan: Current Estimate and Major Risk Factors. *Crit Rev Eukaryotic Gene Expr*. 2017;27(1):63-77.
<http://doi.org/10.1615/CritRevEukaryotGeneExpr.2017018953>.
10. Qureshi H, Bile KM, Jooma R, Alam SE, Afridi HUR. Prevalence of hepatitis B and C viral infections in Pakistan: Findings of a national survey appealing for effective prevention and control measures. *East Mediterr. Health J*. 2010;16 Suppl:S15-S23.
11. Waheed U, Saba N, Wazeer A, Ahmed S. A Systematic Review and Meta-Analysis on the Epidemiology of Hepatitis B and Hepatitis C Virus among Beta-Thalassemia Major Patients in Pakistan. *J Lab Physicians*. 2021;13(3):270-276.
<http://doi.org/10.1055/s-0041-1731110>.
12. CEBaP. Development of evidence-based guidelines and systematic reviews: methodological charter. Available at <https://www.cebap.org/storage/cebap/information-methodology-charter-cebap.pdf> accessed on 4 June 2024.
13. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339:b2535. <http://doi.org/10.1136/bmj.b2535>.
14. The EndNote Team. EndNote X9. Philadelphia, PA: Clarivate; 2013.
15. Johanna Briggs Institute Checklist for Prevalence Studies: Critical Appraisal Tools for Use in JBI Systematic Reviews. Available at https://jbi.global/sites/default/files/2019-05/JBI_Critical_Appraisal-Checklist_for_Prevalence_Studies2017_0.pdf accessed on 1 October 2024.
16. Mujeeb SA, Mehmood K. Prevalence of HBV, HCV, and HIV infections among family blood donors. *Ann Saudi Med*. 1996;16(6):702-703.
<http://doi.org/10.5144/0256-4947.1996.702>.
17. Bhatti FA, Shaheen N, Tariq WZ, Amin A, Saleem M. Epidemiology of hepatitis C virus in blood donors in Northern Pakistan. *Pak Armed Forces Med J*. 1996;46(2):91-92.
18. Kakepoto GN, Bhally HS, Khaliq G. Epidemiology of blood-borne viruses: A study of healthy blood donors in Southern Pakistan. *Southeast Asian J Trop Med Public Health*. 1996;27(4):703-706.
19. Rehman K, Khan AA, Haider Z, Shahzad A, J Iqbal, Khan RU et al. Prevalence of Seromarkers of HBV and HCV in Health Care Personnel and Apparently Healthy Blood Donors. *J Pak Med Assoc*. 1996;46(7):152-154.
20. Rehman N, Hashmi KZ. Hepatitis in volunteer blood donors: a local experience. *Infectious Dis J Pak* 1996; 3: 24.
21. Lone DS, Aman S, Aslam M. Prevalence of Hepatitis C Virus antibody in Blood Donors of Lahore. *Biomedica*. 1999;15:103-107.
22. Hashmi ZY, Chaudary A, Ahmed M, Ashraf M. Healthy voluntary blood donors; incidence of anti-HCV antibodies. *Prof Med J*. 1999; 6: 551-555.
23. Jadoon HA, Ahmed Z. Prevalence of antiHCV in blood donors of Hazara (NWFP). *Pak J Med Res*. 1999; 38: 7-9.
24. Mujeeb SA, Aamir K, Mehmood K. Seroprevalence of HBV, HCV and HIV infections among college going first time voluntary blood donors. *J Pak Med Assoc*. 2000;50(8):269-270.
25. Ahmed MU, Aziz MU. Anti-hepatitis C antibodies study in professional and volunteer blood donors. *Ann Abbasi Shaheed Hosp Karachi Med Dent Coll*. 2001;6:278-279.
26. Ryas M, Hussain T, Bhatti FA, Ahmed F, Tariq WZ, Khattak MF. Epidemiology of Hepatitis C virus infection in blood donors in Northern Pakistan. *J Rawal Med Coll*. 2001;5(2):56-59.
27. Ahmad S, Gull J, Bano KA, Aftab M, Kokhar MS. Prevalence of anti-Hepatitis C antibodies in healthy blood donors at Services Hospital Lahore. *Pak Postgrad Med J*. 2002;13(1):18-20.
28. Khattak MF, Salamat N, Bhatti FA, Qureshi TZ. Seroprevalence of hepatitis B, C and HIV in blood donors in northern Pakistan. *J Pak Med Assoc*. 2002;52(9):398-402.
29. Mumtaz S, Rehman MU, Muzaffar M, Ul Hassan M, Iqbal W. Frequency of seropositive blood donors for hepatitis B, C and HIV viruses in Railway Hospital Rawalpindi. *Pak J Med Res*. 2002;41(2):51-53.
30. Rahman M, Akhtar G, Lodhi Y. Seroprevalence of Hepatitis-C antibodies in blood donors. *Pak J Med Sci*. 2002;18(3):193-196.
31. Ali N, Nadeem M, Qamar A, Qureshi AH, Ejaz A. Frequency of Hepatitis C virus antibodies in blood donors in Combined Military Hospital, Quetta. *Pak J Med Sci*. 2003;19(1):41-44.
32. Ahmad J, Taj AS, Rehim A, Shah A, Rehman M. Frequency of hepatitis B and hepatitis C in healthy blood donors of NWFP: a single center experience. *J Post Med Inst*. 2004;18(3):343-352.
33. Akhtar S, Younus M, Adil S, Jafri SH, Hassan F. Hepatitis C virus infection in asymptomatic male volunteer blood donors in Karachi, Pakistan. *J Viral Hepat*. 2004;11(6):527-535.
34. Asif N, Khokhar N, Ilahi F. Seroprevalence of HBV, HCV and HIV infection among volunteer non-remunerated and replacement donors in Northern Pakistan. *Pak J Med Sci*. 2004;20:24-28.
35. Mahmood MA, Khawar S, Anjum AH, Ahmed SM, Rafiq S, Nazir I, et al. Prevalence of hepatitis B, C and HIV infection in blood donors of Multan region. *Ann King Edward Med Coll*. 2004;10(4):459-461.
36. Zaidi A, Tariq WZ, Haider KA, Ali L, Sattar A, Faqeer F, et al. Seroprevalence of hepatitis B, C and HIV in healthy blood donors in Northwest of Pakistan. *Pak J Pathol*. 2004;15(1):11-16.
37. Sirhindi GA, Khan AA, Alam SS, Ghori MA, Rehman R, Soomro NA et al. Frequency of Hepatitis B, C and Human Immunodeficiency virus in blood donors at Shaikh Zayed Hospital, Lahore. *Proceeding Shaikh Zayed Postgrad Med Inst*. 2005;19(1):33-36.

38. Chaudry NT, Jameel W, Ihsan I, Nasreen S. Hepatitis C. Prof Med J. 2005;12:364-367. <https://doi.org/10.29309/TPMJ/2005.12.04.5082>.
39. Ujjan ID, Memon RA, Butt AR. Seroprevalence of HBsAg and anti-HCV in healthy blood donors. Pak J Gastroenterol. 2006;20(1):75-77.
40. Mujeeb SA, Nanan D, Sabir S, Altaf A, Kadir M. Hepatitis B and C infection in first-time blood donors in Karachi--a possible subgroup for sentinel surveillance. East Mediterr Health J. 2006;12(6):735-741.
41. Fayyaz M, Khan MA, Qazi MA, Chaudhary GM, Ahmed G. Hepatitis B, C & HIV; seroprevalence of infection in blood donors. Prof Med J. 2006;13(4):632-636. <https://doi.org/10.29309/TPMJ/2006.13.04.4941>.
42. Khan MA, Ashraf M, Rehman A, Ali A, Ashraf A, Ditta A. Prevalence of HBV, HCV, HIV in blood donors at Liyaqatpur. Prof Med J. 2006; 13(1):232-236. <https://doi.org/10.29309/TPMJ/2006.13.01.5050>
43. Aziz MS. Prevalence of anti hepatitis C antibodies and hepatitis B surface antigen in healthy blood donors in Baltistan. Pak Armed Forces Med J. 2006;56(2):189-91.
44. Ahmad A. Frequency of HBV surface antigen and Anti-HCV in healthy voluntary blood donors in Swat district. J Postgrad Med Ins. 2006; 20(2):187-190.
45. Sultan F, Mehmood T, Mahmood MT. Infectious pathogens in volunteer and replacement blood donors in Pakistan: a ten-year experience. Int J Infect Dis. 2007;11(5):407-412. <https://doi.org/10.1016/j.ijid.2006.10.004>
46. Masood R, Sardar MA, Mallhi AA. Seroprevalence of hepatitis B and C among the healthy blood donors at Fauji Foundation Hospital, Rawalpindi. Pak J Med Sci. 2007;23(1):64-67.
47. Khan ZA, Aslam MI, Ali S. The frequency of hepatitis B and C among volunteer blood donors in Balochistan. Hepatitis Monthly. 2007; 7(2):73-76.
48. Ishaq M, Ali SS, Karim N, Umrani NI, Hassan N. Frequency of hepatitis B and C virus among the healthy volunteer blood donors at Taulka Hospital Sujawal, District Thatta, Sindh. Ann Abbasi Shaheed Hosp Karachi Med Dent Coll. 2007;12(2):97-101.
49. Ijaz AU, Shafiq F, Toosi NA, Malik MN, Qadeer R. Hepatitis B and hepatitis C in blood donors: Analysis of 2-years data. Ann King Edward Med Coll 2007;13(1):59-61. <https://doi.org/10.21649/akemu.v13i1.4694>.
50. Bhatti FA, Ullah Z, Salamat N, Ayub M, Ghani E. Antihepatitis B core antigen testing, viral markers, and occult hepatitis B virus infection in Pakistani blood donors: implications for transfusion practice. Transfusion. 2007;47(1):74-79. <https://doi.org/10.1111/j.1537-2995.2007.01066.x>
51. Chaudhary IA, Samiullah, Khan SS, Masood R, Sardar MA, Mallhi AA. Seroprevalence of hepatitis B and C among the healthy blood donors at Fauji Foundation Hospital Rawalpindi. Pak J Med Sci. 2007;23(1):64-67.
52. Azam M, Jamal N, Imtiaz F, Haque Z, Ayoob Z. Blood donor screening for hepatitis and HIV. J Dow Univ Health Sci. 2007; 1(2):82-83.
53. Alam M, Naeem MA. Frequency of hepatitis B surface antigen and anti-hepatitis C antibodies in apparently healthy blood donors in northern areas. Pak J Pathol. 2007;18(1):11-14.
54. Ahmad N, Asgher M, Shafique M, Qureshi JA. An evidence of high prevalence of Hepatitis C virus in Faisalabad, Pakistan. Saudi Med J. 2007;28(3):390-395.
55. Farooqi JI, Farooqi RJ, Khan N, Mussarat. Frequency of Hepatitis B and C in selected groups of population in NWFP, Pakistan. J Postgrad Med Ins. 2007;21(3):165-168.
56. Nazar H, Nadia N, Shazia N, Zulfiqar A, Farhat A. Prevalence of Hepatitis B and Hepatitis C in blood donors of Karachi. Biomedica 2008; 24(9):116-117.
57. Mujeeb SA, Pearce MS. Temporal trends in hepatitis B and C infection in family blood donors from interior Sindh, Pakistan. BMC Infect Dis. 2008; 8:43. <https://doi.org/10.1186/1471-2334-8-43>
58. Khattak MN, Akhtar S, Mahmud S, Roshan TM. Factors influencing Hepatitis C virus Sero-prevalence among blood donors in Northwest Pakistan. J Public Health Policy. 2008; 29(2):207-25. <https://doi.org/10.1057/jphp.2008.7>.
59. Waheed U, Zaheer HA, Naseem L, Hasan K. Study of Hepatitis B and C virus seropositivity in healthy blood donors. Ann. Pak. Inst. Med. Sci. 2009; 5(4): 233-236.
60. Manzoor I, Hashmi NO, Daud SE, Ajmal SA, Fatima HI, Rasheed ZA. Seroprevalence of transfusion transmissible infections (TTIS) in blood donors. Biomedica 2009; 25(10):154-158.
61. Abbas S, Ali M, Muhammad A, Shaw S, Abbas S. Frequency of HCV infection and its genotypes among patients attending a liver clinic and voluntary blood donors in a rural area of Pakistan. Pak J Med Sci. 2009; 25(4):579-582.
62. Shah SM, Khattak IU, Ali A, Tariq M. Seropositivity for hepatitis B and C in voluntary blood donors. J Ayub Med Coll Abbottabad. 2010;22(3):149-151.
63. Safi SZ, Afzal MS, Waheed Y, Butt UJ, Fatima K, Parvez Y et al. Seroprevalence of hepatitis C and human immunodeficiency viruses in blood donors of northwestern Pakistan. Asian Biomed. 2011;5(3):389-392. <http://doi10.5372/1905-7415.0503.049>.
64. Bangash MH, Bangash TH, Alam S. Prevalence of hepatitis B and hepatitis C among healthy blood donors at Kurram agency. J Postgrad Med Inst. 2011; 23(2):140-145.
65. Khan NU, Ali I, Ahmad NU, Iqbal A, Rehman LU, Munir I, et al. Prevalence of active HCV infection among the blood donors of Khyber Pakhtunkhwa and FATA region of Pakistan and evaluation of the screening tests for anti-HCV. Virol J. 2011;8:154. <https://doi.org/10.1186/1743-422X-8-154>.
66. Borhany M, Shamsi T, Boota S. Transfusion transmitted infections in patients with hemophilia of Karachi, Pakistan. Clin Appl Thromb Hemost. 2011;17(6):651-655. <https://doi.org/10.1177/1076029611398122>.
67. Waheed U, Khan H, Satti HS, Ansari A, Malik MA, Zaheer HA. Transfusion Transmitted Infections among Blood Donors of a Teaching Hospital in Islamabad. Ann. Pak. Inst. Med. Sci. 2012; 8(4): 236-239.
68. Bhutta A, Tahir Z, Ayub S, Mushtaq S. Seroprevalence of anti-HCV in non-professional blood donors. Pak J Med Health Sci. 2012;6(1):175-178.

69. Attaullah S, Khan S, Khan J. Trend of transfusion transmitted infections frequency in blood donors: provide a road map for its prevention and control. *J Transl Med*. 2012;10:20. <https://doi.org/10.1186/1479-5876-10-20>.
70. Umair M, Mahmood RT, Muhammad Inam M, Waqas A, Wazir I. Sero-prevalence of hepatitis B, hepatitis C, human immunodeficiency virus, syphilis and malaria in blood donors of Mirpur, Azad Jammu and Kashmir, Pakistan. *J Pub Health Bio Sci*. 2012;1(4):110-114.
71. Arshad A, Arshad M, Pervaiz R, farzana, Javed A, Ahmad ND et al. Prevalence of active hepatitis-C infection in the general population of district Mardan, Khyber Pakhtunkhwa, Pakistan. *J Pub Health Bio Sci*. 2012; 1(1): 3-8.
72. Tunio SA, Bano S, Laghari ZA, Ali W, Shamim H, Afreen U. Seroprevalence of hepatitis B and hepatitis C among blood donors in Hyderabad, Pakistan. *Gomal J Med Sci*. 2013;11(2):220-223.
73. Khan A, Tareen AM, Ikram A, Rahman H, Wadood A, Qasim M. Prevalence of HCV among the young male blood donors of Quetta region of Balochistan, Pakistan. *Virol J*. 2013;10:83. <https://doi.org/10.1186/1743-422X-10-83>.
74. Irfan SM, Uddin J, Zaheer HA, Sultan S, Baig A. Trends in transfusion transmitted infections among replacement blood donors in Karachi, Pakistan. *Turk J Haematol*. 2013;30(2):163-167. <http://doi:10.4274/Tjh.2012.0132>.
75. Akhtar AM, Khan MA, Ijaz T, Iqbal Z, Rana MY, Maqbool A et al. Seroprevalence and determinants of hepatitis-C virus infection in blood donors of Lahore, Pakistan. *Pak J Zool*. 2013;45(1):1-7.
76. Moiz B, Moatter T, Shaikh U, Adil S, Ali N, Mahar F et al. Estimating window period blood donations for human immunodeficiency virus Type 1, hepatitis C virus, and hepatitis B virus by nucleic acid amplification testing in Southern Pakistan. *Transfusion*. 2014; 54(6):1652-1659. <https://doi.org/10.1111/trf.12521>.
77. Iqbal MA, Shazia, Usman. Prevalence of Hepatitis B and Hepatitis C carrier state among healthy blood donors in Rahim Yar Khan. *Journal of Sheikh Zayed Medical College* 2014;5(3):671-673.
78. Tabassum F, Ali B, Khurshid R. Prevalence of antibodies to hepatitis C virus among the population of Lahore City, Pakistan. *Pakistan J Zoology* 2014; 46(1).
79. Pervaiz A, Sipra FS, Rana TH, Qadeer I. Pre-donation screening of volunteer prisoner blood donors for hepatitis B and C in prisons of Punjab, Pakistan. *J Ayub Med Coll Abbottabad*. 2015;27(4):794-797.
80. Niazi SK, Bhatti FA, Salamat N, Ghani E, Tayyab M: Impact of nucleic acid amplification test on screening of blood donors in Northern Pakistan. *Transfusion*. 2015, 55(7):1803-1811. <https://doi.org/10.1111/trf.13017>.
81. Wazeer A, Azmat M, Qasim Z. Sero-Prevalence of hepatitis B, hepatitis C, human immunodeficiency virus, syphilis and malaria in blood donors of Mirpur, Azad Jammu Kashmir, Pakistan. *Proceedings of the XI Annual Conference of Asian Association of Transfusion Medicine, Islamabad, 2015*, p115.
82. Hussain A, Mumtaz HM, Aslam MS, Abbas Z. Seroprevalence of transfusion based transmissible infections among clinically healthy donors in the community of Multan. *Pakistan. J Inf Mol Biol*. 2015; 3(2):47-51. <http://dx.doi.org/10.14737/journal.jimb/2015/3.2.47.51>.
83. Sial GR, Khan S, Shahid SU, Bhatti S, Farooq F. Prevalence of transfusion transmitted infections in asymptomatic blood donors: Is syphilis alarming? *Biomedica* 2016;32(1):8-12.
84. Karim F, Nasar A, Alam I. Incidence of active HCV infection amongst blood donors of Mardan District, Pakistan. *Asian Pac J Cancer Prev*. 2016;17(1):235-238. <https://doi.org/10.7314/APJCP.2016.17.1.235>.
- Saeed M, Iram S, Hussain S, Rabeea M, Ahmad M, Ashraf M. Hepatitis C virus infection; frequency of a dumb murderer in blood donors' community of Lahore. *Professional Med J* 2016; 23(5): 546-552. <https://doi.org/10.29309/TPMJ/2016.23.05.1581>.
86. Arshad A, Borhany M, Anwar N, Naseer I, Ansari R, Boota S. Prevalence of transfusion transmissible infections in blood donors of Pakistan. *BMC Hematology*. 2016, 16:27. <http://doi.org/10.1186/s12878-016-0068-2>.
87. Ahmed T, Rahool, Khattak NN, Khan F, Uddin S, Khan MS. Prevalence of hepatitis B virus, hepatitis C virus and HIV in blood donors of different areas of Khyber Pakhtoonkhwa, Pakistan. *J. Bio. Env. Sci*. 2016; 9(1): 304-309.
88. Zameer M, Shahzad F, Khan FS, Farooq M, Ali H, Saeed U. Transfusion transmissible infections among healthy blood donors at blood bank from children's hospital and institute of child health Lahore. *Pak Armed Forces Med J*. 2017; 67(1):131-136.
89. Wadood M, Usman M, Moinuddin, Qamar K, Rizwan M, Nazir I. Seroprevalence of Hepatitis C among the apparently healthy blood donors of Karachi. *Baqai J. Health Sci*. 2017;20(1):19-24.
90. Sultan S, Nasir MI, Rafiq S, Baig MA, Akbani S, Irfan SM. Multiplex real-time RT-PCR assay for transfusion transmitted viruses in Sero-negative allogeneic blood donors: an experience from Southern Pakistan. *Malays J Pathology*. 2017;39(2):149-154.
91. Saeed M, Hussain S, Rasheed F, Ahmad M, Arif M, Hamid Rahmani MT. Silent killers: Transfusion Transmissible Infections-TTI, among asymptomatic population of Pakistan. *J Pak Med Assoc*. 2017;67(3):369-374.
92. Butt T, Butt B. Is Seroprevalence of Hepatitis B and C among blood donors changing in Northern Pakistan? *Pak Armed Forces Med J* 2017; 67(4): 627-629.
93. Batool Z, Durrani SH, Tariq S. Association of ABO And Rh blood group types to Hepatitis B, Hepatitis C, HIV and Syphilis infection, A five year' experience in Healthy Blood Donors in a Tertiary care hospital. *J Ayub Med Coll Abbottabad*. 2017;29(1):90-92.
94. Ahmed N, Hussain W, Waheed U. *AJK Blood Transfusion Authority Progress Report 2017*. 1st ed. Muzaffarabad: Department of Health, Government of Azad Jammu and Kashmir; 2017. Available from: <https://health.ajk.gov.pk/> [Accessed 2024 Jul 4]
95. Saba N, Afridi S. Epidemiology of transfusion transmitted infections among blood donors: Experience from regional blood Centre, Peshawar. *Proceedings from the annual conference of Pakistan Society of Haematology, Rawalpindi, February 2018*.

96. Naz A, Mukry SN, Naseer I, Shamsi TS. Evaluation of efficacy of serological methods for detection of HCV infection in blood donors: A single centre experience. *Pak J Med Sci.* 2018;34(5):1204-1208. <https://doi.org/10.12669/pjms.345.15707>.
97. Billah M, Shah SMR, Hashir MM. Hepatitis B and hepatitis C: Hepatitis B and hepatitis C frequency of hepatitis B and C among blood donors reporting at blood bank of Ibne-siena Hospital Multan, Pakistan. *Prof Med J* 2018; 25(08): 1245–1251. <https://doi.org/10.29309/TPMJ/2018.25.08.88>.
98. Rehman N, Orakzai MB, Hayat A, Azam S, Ahmad B, Khan I. Prevalence of Hepatitis C virus and its risk factors in blood donors in district Peshawar. *Pak J Pharm Sci.* 2018;31(1):83-87.
99. Awan SA, Junaid A, Sheikh S. Transfusion Transmissible Infections: Maximizing Donor Surveillance. *Cureus* 2018;10(12): e3787.
100. Akhter N, Fatima S, Batool Y, Samad A, Fayyaz N, Khan ZM. Seroprevalence of transfusion transmitted infections among healthy donors in a tertiary care hospital in Southern Punjab, Pakistan. *Biomedica* 2018 34(3):168-172.
101. Azeem R, Altaf N, Idrees M. Seroprevalence of transfusion transmissible infected blood donors in Northern Pakistan, *Adv Basic Med Sci.* 2018;2(1): 26-30.
102. Wadood M, Usman M. Comparative Analysis of Electrochemiluminescence Assay and Chemiluminescent Microparticle Immunoassay for the Screening of Hepatitis C. *Indian J Hematol Blood Transfusion.* 2019;35(1):131-136.
103. Siddiqui FM, Siddiqui N, Oluwatayo O, Jabeen S, Qadir SM. Prevalence of Transfusion-Transmissible Infections among Voluntary Blood Donors in Tertiary Health-Care Facility in Islamabad, Pakistan. *J Clin Trials.* 2019;9(6):1000383.
104. Mengal MH, Baloch AH. Progress Report 2019 – Quetta Regional Blood Centre. Department of Health, Government of Balochistan.
105. Sadiq S, Lakhani M, Baig, S, Qureshi M. Shah M. Accidental Diagnosis of infections among blood donors. *International Journal of Clinical Medicine.* 2019;10(10); 463-468. <https://doi.org/10.4236/ijcm.2019.1010039>.
106. Zeeshan M, Shah M, Anwar F, Hamza M, Ali I, Ahmad H, et al. Chemiluminescent microparticle immunoassay-based detection on blood donor and incidence of HCV virus in District Mardan Pakistan. *Journal of Entomology and Zoology Studies* 2019;7(6):557-560.
107. Jiskani SA, Talpur RA, Meghji KA, Soomro Q. Seropositivity of hepatitis B and C among volunteer blood donors at Tando Muhammad Khan. *Pak J Pathol* 2019; 30(3): 69-71.
108. Hameed S, Abdullah SM, Ali A. Prevalence of hepatitis C virus among healthy donors at a large Teaching Hospital in Lahore, Pakistan: a cause of concern for health policy makers. *Prof Med J.* 2019; 26(9): 1413-1418. <https://doi.org/10.29309/TPMJ/2019.26.09.1223>.
109. Latif A, Hussain A, Ali A. Progress Report 2019 – Gilgit Regional Blood Centre. Gilgit: Department of Health, Government of Gilgit-Baltistan. Available from: <https://gilgitbaltistan.gov.pk/> [Accessed 2024 Jul 13].
110. Ahmed N, Hussain W. Progress Report 2019 – Muzaffarabad Regional Blood Centre. Department of Health, Government of Azad Jammu and Kashmir.
111. Zaheer HA, Waheed U, Nasir K, Tahir S. Islamabad Blood Transfusion Authority Annual Report 2019 (1st ed.). Islamabad, Ministry of National Health Services, Pakistan.
112. Ahmad M, Saeed M, Hanif A, Waheed U, Arshad M, Ain NU et al. Slump of trends in transfusion-transmissible infectious diseases: Is syphilis alarming in Pakistan? *Glob J Transfusion Med* 2019;4(1):45-51.
113. Rauf R, Cheema A. Potential risk of transfusion-transmissible infections among blood donors in district Faisalabad of Pakistan. *Clin Med (Lond).* 2019;19(Suppl 3):27. <https://doi.org/10.7861/clinmedicine.19-3s-s27>.
114. Saba N, Nasir JA, Waheed U, Aslam S, Mohammad I, Wazeer A, et al. Seroprevalence of transfusion-transmitted infections among voluntary and Replacement blood donors at the Peshawar Regional Blood Centre, Khyber Pakhtunkhwa, Pakistan. *J Lab Physicians.* 2021;13(2):162-168. <https://doi.org/10.1055/s-0041-1729485>.
115. Khan MI, Ahmed N, Waqar S. Frequency and trends of hepatitis B & C, and human immune deficiency virus in blood donors presenting to blood bank of a Tertiary Hospital in Peshawar, Pakistan. *Prof Med J.* 2021; 28(04): 515-519. <https://doi.org/10.29309/TPMJ/2021.28.04.4798>.
116. Qadir H, Nasir N, Kouser H, Qadir N, Baig R, Qadir A. Seroprevalence of Hepatitis B, Hepatitis C, Human Immunodeficiency Virus, syphilis, and malaria among blood donors at tertiary care hospital blood bank. *JPMA* 2021;71(3): 897-899.
117. Ghazanfer S, Osman H. Frequency of TTIs in apparently healthy blood donors in Sialkot District, a small district of Punjab-Pakistan with big reservoir of TTIs. *J Haematol Stem Cel Res* 2021; 1(1): 29-33.
118. Saeed S, Ullah A. Temporal trends in the prevalence of hepatitis B, hepatitis C and human immuno-deficiency virus in blood donors of Pakistan. *Br J Haematol* 2021; 193(1): 77-232.
119. Bhatti AK, Waheed Q, Azhar M, Butt TM, Rafiq H, Abid MM. Prevalence of Blood Transfusion Diseases among Blood Donors. 6th ed. Pretoria, South Africa: Med Forum 2021;32(6):93-95.
120. Arshad S, Arif A, Ahmad R, Seemab Z, Shaheen F, Tanveer R. Hepatitis B, C, and HIV infections among blood donors at several hospitals in Lahore, Pakistan. *Journal of Pharmaceutical Research International* 2021;33(55A):112-126. <https://doi.org/10.9734/jpri/2021/v33i55A33814>.
121. Ghazanfar S, Hassan S, Shahid Z, Khan MS, Malik AR, Bhutta HS, Ikram N, Khan MS. Frequency of transfusion transmissible infections among blood donors of Rawalpindi District, Pakistan. *Afr Health Sci.* 2022;22(3):590-598. <https://doi.org/10.4314/ahs.v22i3.63>.
122. Bhatti MM, Junaid A, Sadiq F. The Prevalence of Transfusion Transmitted Infections among Blood Donors in Pakistan: A Retrospective Study. *Oman Med J.* 2022;37(3):e386. <https://doi.org/10.5001/omj.2022.65>.

123. Samiullah, Rasheed A, Saleem U, Ijaz A. Transfusion Related transmission of infections among blood donors of South Punjab. *Journal of Rawalpindi Medical College (JRMCI)*; 2022; 26(4): 558-562. <https://doi.org/10.37939/jrmc.v26i4.1874>.
124. Zorob T, Farooqi MA, Ahsan A, Zaki A, Rathore MA, Farooqi HMU. Prevalence and trends in Hepatitis B & C virus among blood donors in Pakistan: A Regional Transfusion Center Study. *Livers*. 2023; 3(2):271-281. <https://doi.org/10.3390/livers3020018>.
125. Shah H, Ur Rahman Z, Khan M, Zaman F, Badshah S. The Prevalence of blood borne diseases in blood donors of Peshawar, Khyber Pakhtunkhwa, Pakistan. *Recent Adv Antiinfect Drug Discov*. 2023;18(3):215-220. <https://doi.org/10.2174/2772434418666230213124806>.
126. Jamal S, Mansoor N, Ali A, Nadeem A, Aijaz J, Meraj F. Degree of blood safety of voluntary non-remunerated versus replacement blood donations: A multi-centre study of the large cohort of blood donors from two provinces of Pakistan. *Vox Sang*. 2023;118(12):1078-1085. <https://doi.org/10.1111/vox.13546>.
127. Raza SK, Bajwa H, Javaid H, Anwar R, Hashim M, Saleem K. Prevalence of transmissible infectious diseases among healthy blood donors in Faisalabad, Pakistan: Transmissible Infectious Diseases among Healthy Blood Donors. *Pakistan Journal of Health Sciences* 2023;4(03):142-146. <https://doi.org/10.54393/pjhs.v4i03.544>.
128. Ali S, Ali B, Khan BB, Khan M, Ali S, Iqbal A, et al. Sero-prevalence of hepatitis-C virus among blood donors in northern Pakistan. *MOJ Public Health*. 2023;12(1):37-41. <https://doi.org/10.15406/mojph.2023.12.00407>.
129. Sabir N, Ghafoor T, Fatima S, Lodhi R, Mehmood A, Zaman G. Prevalence and association of transfusion-transmissible infections with age of blood donors: A regional transfusion centre study in northern Pakistan. *J Coll Physicians Surg Pak*. 2023;33(9):978-982. <https://doi.org/10.29271/jcpsp.2023.09.978>.
130. Aslam U, Gohar A, Ahmad F, Hasan M, Nausherwan M. Transfusion transmitted infections in blood donors of Pakistan Red Crescent Lahore: A mixed method study. *Annals of King Edward Medical University* 2023;29(4):338-346. <https://doi.org/10.21649/akemu.v23i4.5068>.
131. Amjed S, Zaki MR, Khalid M, Hafeez H, Akbar A, Jafar J. Seroprevalence of transfusion-transmitted infection in different type of blood donors. *RJAHS* 2023;2(2):58. <https://doi.org/10.53389/RJAHS.2023020205>.
132. Saba N, Nisar M, Muhammad I. Progress Report 2023 – Peshawar Regional Blood Centre. Department of Health, Government of Khyber Pakhtunkhwa, Pakistan. 1st Edition 2024.
133. Wazeer A, Qasim Z. Progress Report 2023 – Mirpur Regional Blood Centre. State Ministry of Health, Government of AJK, Pakistan. 1st edition 2024.
134. Jamal DE, Waheed S, Gul S, Ali M. Prevalence and trends of Hepatitis C, Hepatitis B, and Human Immunodeficiency viruses over half a decade among healthy blood donors Across Sindh, Pakistan. *Cureus*. 2024;16(4):e58374. <https://doi.org/10.7759/cureus.58374>.
135. Haleem A, Mengal MH. Progress Report 2023 – Quetta Regional Blood Centre. Department of Health, Government of Balochistan, Pakistan. 1st edition 2024.
136. Khan Z, Hussain S, Ullah N, Arif M, Khalid S, Ullah R, Naeem M. Sero-prevalence of anti-HCV antibodies among the blood donors of District Bajaur, KP, Pakistan. *Pure and Applied Biology*. 2024;14(1): 36-42. <http://doi.org/10.19045/bspab.2025.140005>.
137. Waheed U, Wazeer A, Saba N, Qasim Z. Effectiveness of WhatsApp for blood donor mobilization campaigns during COVID-19 pandemic. *ISBT Science Series* 2020;15(4):378-80. <https://doi.org/10.1111/voxs.12572>.
138. Los APM, Waheed U, Kohorst P, Smid WM. Creation of an enabling environment for voluntary blood donation in Pakistan. *Vox Sang*. 2012; 103(Suppl. 1):100.
139. Saeed Q, Waheed U. Role of regulations in improving quality of blood transfusion services in Islamabad: Recent developments and future strategies. *Ann Pak Inst Med Sci*. 2023; 19(2): 52-56. <https://doi.org/10.48036/apims.v19i2.814>.
140. Zaheer HA, Waheed U. Legislative reforms of the blood transfusion system in Pakistan. *Transfus Med*. 2014;24(2):117-9. <https://doi.org/10.1111/tme.12107>.
141. Waheed U, Hosseini N. Social media and voluntary blood donation. *J Islamabad Med Dental Coll*. 2023;12(2) 68-70. <https://doi.org/10.35787/jimdc.v12i2.1010>.
142. Zaheer HA, Waheed U, Nasir K, Tahir S. Annual Data Collection Report 2019. Safe Blood Transfusion Programme, Ministry of National Health Services, Government of Pakistan.
143. Zaheer HA, Waheed U. Blood safety system reforms in Pakistan. *Blood Transfus*. 2014;12(4):452-7. <https://doi.org/10.2450/2014.0253-13>.
144. Acar A, Kemahli S, Altunay H, Kosan E, Oncul O, Gorenk L et al. HBV, HCV and HIV seroprevalence among blood donors in Istanbul, Turkey: how effective are the changes in the national blood transfusion policies? *Braz J Infect Dis*. 2010;14(1):41-46. <https://doi.org/10.1590/s1413-86702010000100009>.
145. O'Brien SF, Ehsani-Moghaddam B, Osmond L, Fan W, Goldman M, Drews SJ. Epidemiology of Hepatitis C over 28 years of monitoring Canadian blood donors: Insight into a low-risk undiagnosed population. *BMC Public Health*. 2024;24(1):2319. <https://doi.org/10.1186/s12889-024-19790-2>.
146. Al-Mohani SKM, Al-huthaifi OAA, Al-Nahham DSAM, Al-Sharai AAS, Al-Deen ANS, Hasan Shopil BA et al. The prevalence of Hepatitis B and C viruses among blood donors attending blood bank in Jiblah University Hospital, Ibb, Yemen. *J Comm Med and Pub Health Rep* 2024;5(07):1-6. <https://doi.org/10.38207/JCMPHR/2024/APR05070454>.
147. Zhou Q, Liu A, Wang S, Li J, He M, Chen L. Hepatitis C virus screening reactive among blood donors in mainland China: A systematic review and meta-analysis. *Transfus Med*. 2023;33(2):147-158. <https://doi.org/10.1111/tme.12935>.
148. Azerefeegn E, Worku M, Hailemariam M. Transfusion-transmissible infections among blood donors at Hawassa regional blood bank center, south Ethiopia. *International*

- Journal of Research Studies Microbiology and Biotechnology 2018; 4(3):10-16.
149. Mohamoud YA, Mumtaz GR, Riome S, Miller D, Abu-Raddad LJ. The epidemiology of hepatitis C virus in Egypt: a systematic review and data synthesis. BMC Infect Dis. 2013;13:288. [https://doi.org/ 10.1186/1471-2334-13-288](https://doi.org/10.1186/1471-2334-13-288).
150. Onyango CG, Ogonda L, Guyah B, Okoth P, Shiluli C, Humwa F, et al. Seroprevalence and determinants of transfusion transmissible infections among voluntary blood donors in Homabay, Kisumu and Siaya counties in western Kenya. BMC Res Notes. 2018;11(1):171. <https://doi.org/10.1186/s13104-018-3276-y>.
151. Okoroiwu HU, Okafor IM, Asemota EA, Okpokam DC. Seroprevalence of transfusion-transmissible infections (HBV, HCV, syphilis and HIV) among prospective blood donors in a tertiary health care facility in Calabar, Nigeria; an eleven years evaluation. BMC Public Health. 2018;18(1):645. <https://doi.org/10.1186/s12889-018-5555-x>.
152. Waheed U, Abdella YE, Saba NE, Arshad M, Wazeer A, Farooq A, Usman J, Arshad A, Zaheer HA. Evaluation of screening effectiveness of hepatitis B surface antigen and anti-HCV rapid test kits in Pakistan. J Lab Physicians. 2019;11(4):369-372. https://doi.org/10.4103/JLP.JLP_172_19.