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App-Based Cardiovascular Risk Monitoring among Adults with Hepatitis B and C in Primary Care: A Pre-Experimental Study

Resa Nirmala Jona[1]✉, Arlies Zenitha Victoria[1], Danny Putri Sulistyaningrum[1]

[1] Universitas Telogorejo Semarang, Semarang City, Central Java, Indonesia

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Abstract

Chronic hepatitis B and C infections are increasingly understood as systemic diseases with metabolic and cardiovascular implications. Community-based digital monitoring may support early detection and self-management of cardiovascular risk, but empirical evidence among adults with viral hepatitis remains limited. This study evaluated the preliminary effectiveness of an app-based monitoring and evaluation strategy for reducing cardiovascular risk among adult patients with hepatitis B and C in a primary care setting in Semarang, Indonesia. A pre-experimental one-group pre-test-post-test study was conducted from August to November 2025 among 30 adults aged 20-60 years with hepatitis B or C in the Tlogosari Wetan Community Health Center area. Participants used a heart health monitoring application for one month. The application enabled routine recording of blood pressure, resting heart rate, oxygen saturation, random blood glucose, medication reminders, and health education. Outcomes were systolic and diastolic blood pressure, resting heart rate, and cardiovascular risk category. Paired comparisons were analyzed using Wilcoxon signed-rank tests. Most participants were aged 41-60 years (63.3%), female (53.3%), diagnosed with hepatitis B (96.7%), and had a history of high cholesterol (63.3%) or diabetes mellitus (53.3%). Mean systolic blood pressure decreased from 147.9 to 135.1 mmHg (p=0.002), mean diastolic blood pressure from 93.1 to 85.6 mmHg (p=0.003), and mean resting heart rate from 85.7 to 79.2 beats/minute (p=0.004). Median cardiovascular risk score decreased from 2.0 to 1.0 (Z=-3.08; p=0.002). App-based cardiovascular monitoring was associated with significant short-term improvements in blood pressure, resting heart rate, and cardiovascular risk among adults with hepatitis B and C. Controlled studies with longer follow-up are warranted.

Corresponding Author:
✉ Resa Nirmala Jona
Universitas Telogorejo Semarang, Semarang City, Central Java, Indonesia
Email: resa@universitastelogorejo.ac.id

1. INTRODUCTION

Viral hepatitis remains a major public health challenge because chronic hepatitis B virus (HBV) and hepatitis C virus (HCV) infections contribute to liver cirrhosis, hepatocellular carcinoma, premature mortality, and substantial long-term health-system burden. Global modelling studies show that chronic HBV and HCV persist as high-priority communicable diseases, while community medicine literature increasingly emphasizes integrated chronic disease care rather than disease-specific vertical management (Barigela et al., 2021; Bhatt et al., 2023; Cooke et al., 2019; Gupta, 2024; Joshi et al., 2021; Kar et al., 2024; Lahariya et al., 2022; Mishra et al., 2022; Nirmala et al., 2025; Ott et al., 2012; Razavi-Shearer et al., 2018; Samudyatha et al., 2023; Schweitzer et al., 2015; Shukla P, Upadhyay RP, 2023; Stanaway et al., 2016; The Polaris Observatory HCV Collaborators, 2019; Wilson et al., 2024; Wulandari et al., 2022).

The clinical relevance of HBV and HCV extends beyond the liver. HCV has been associated with insulin resistance, diabetes mellitus, dyslipidemia, systemic inflammation, endothelial dysfunction, hypertension, atherosclerosis, cardiac arrhythmia, and cardiovascular mortality (Adinolfi et al., 2014; Butt et al., 2009; Cacoub et al., 2016; Lee et al., 2012; Matsumori, 2005; Modi & Liang, 2008; Negro, 2014; Petta, 2017; Rajewski et al., 2022; Wu et al., 2019). Although the association appears stronger for HCV than HBV, both infections may coexist with metabolic risk factors that intensify cardiovascular risk in adults who are managed in primary care settings (Adinolfi et al., 2014; Cacoub et al., 2016; Cooke et al., 2019; Modi & Liang, 2008; Negro, 2014; Petta, 2017; Rajewski et al., 2022; Razavi-Shearer et al., 2018; Stanaway et al., 2016; The Polaris Observatory HCV Collaborators, 2019; Wu et al., 2019). This interface between viral hepatitis, metabolic dysfunction, and cardiovascular disease is particularly important in low- and middle-income countries where delayed detection, fragmented follow-up, and limited specialist access are common (Ott et al., 2012; Schweitzer et al., 2015; Cooke et al., 2019; Razavi-Shearer et al., 2018; Stanaway et al., 2016; The Polaris Observatory HCV Collaborators, 2019; Arnett et al., 2019; Giovanni et al., 2020; Kaptoge et al., 2019; Lloyd-Jones et al., 2022; Mills et al., 2017; NCD Risk Factor Collaboration (NCD-RisC), 2021; Visseren et al., 2022; Yusuf et al., 2020).

Current cardiovascular prevention guidance prioritizes early risk identification, blood pressure control, diabetes and lipid management, smoking cessation, physical activity, weight management, and sustained self-management support (Arnett et al., 2019; Giovanni et al., 2020; Kaptoge et al., 2019; Lewington et al., 2002; Lloyd-Jones et al., 2022; Mancia et al., 2024; McManus et al., 2018; Mills et al., 2017; Ettehad et al., 2016; NCD Risk Factor Collaboration (NCD-RisC), 2021; Unger et al., 2020; Visseren et al., 2022; Whelton et al., 2018; Yusuf et al., 2020). In community settings, risk-based approaches allow limited resources to be directed toward individuals most likely to benefit from early intervention (Arnett et al., 2019; Giovanni et al., 2020; Kaptoge et al., 2019; Lloyd-Jones et al., 2022; Mills et al., 2017; NCD Risk Factor Collaboration (NCD-RisC), 2021; Visseren et al., 2022; Yusuf et al., 2020). The Indian Journal of Community Medicine has also published work on NCD service readiness, digital health, e-health assessment, hypertension and diabetes among vulnerable groups, standard treatment guidelines, and community-level prevention (Barigela et al., 2021; Bhatt et al., 2023; Gupta, 2024; Joshi et al., 2021; Kar et al., 2024; Lahariya et al., 2022; Mishra et al., 2022; Samudyatha et al., 2023; Shukla et al., 2023; Wilson et al., 2024; Wulandari et al., 2022). These articles support the rationale for pragmatic, community-adapted monitoring approaches in primary care.

Digital health and mHealth interventions can strengthen chronic disease management by enabling home or community-based recording of vital signs, medication

reminders, patient education, and feedback loops between patients and health workers (Bobrow et al., 2016; Burke et al., 2015; Free et al., 2013; Praveen et al., 2014; Hamine et al., 2015; Khoong et al., 2021; Kitsiou et al., 2017; Liu et al., 2023; Marcolino et al., 2018; Margolis et al., 2013; Michalakeas et al., 2020; Morawski et al., 2018; Omboni et al., 2020; Parati et al., 2021; Piette et al., 2015; Ramadass et al., 2024; Santo et al., 2016; Thakkar et al., 2016; Greenland et al., 2010; Zhao et al., 2025). Evidence from telemonitoring, text messaging, mobile applications, and clinical decision-support systems shows that mHealth can improve blood pressure control, medication adherence, and engagement, particularly when technologies are integrated with provider feedback and behavior change principles (Bobrow et al., 2016; Burke et al., 2015; Free et al., 2013; Praveen et al., 2014; Hamine et al., 2015; Khoong et al., 2021; Kitsiou et al., 2017; Liu et al., 2023; Marcolino et al., 2018; Margolis et al., 2013; Michalakeas et al., 2020; Morawski et al., 2018; Omboni et al., 2020; Parati et al., 2021; Perski, 2017; Piette et al., 2015; Ramadass et al., 2024; Santo et al., 2016; Thakkar et al., 2016; Greenland et al., 2010; Yardley et al., 2016; Zhao et al., 2025). However, few studies have focused on cardiovascular risk monitoring among adults with chronic viral hepatitis.

The present study was developed as a continuation of previous local research identifying diabetes mellitus, lifestyle, and hypercholesterolemia as factors associated with cardiovascular disorders among adults with hepatitis B and C (Nirmala et al., 2025). The study aimed to evaluate the preliminary effectiveness of an app-based monitoring and evaluation strategy for preventing cardiovascular disorders among adult hepatitis B and C patients in a primary care area in Semarang, Indonesia.

2. METHODS

A pre-experimental one-group pre-test-post-test design was used. The study was conducted from August to November 2025 in the Tlogosari Wetan Community Health Center catchment area, Semarang City, Indonesia. This design was selected as a pragmatic preliminary evaluation before planning a controlled effectiveness trial. Reporting was guided by relevant principles for intervention, observational, and digital health studies (Craig et al., 2008; Donkin et al., 2013; Eysenbach et al., 2011; Michie et al., 2013; Schulz et al., 2019; Skivington et al., 2021; Von Elm et al., 2008).

The study population comprised adult patients aged 20-60 years with hepatitis B or C recorded in the community health center area. A purposive sampling approach was used because the intervention required participants who were identifiable, reachable, and able to use or be assisted in using the mobile application. The final sample consisted of 30 participants. Inclusion criteria were diagnosis of hepatitis B or C, adult age, residence in the community health center area, willingness to participate, and provision of informed consent. Participants with severe acute illness preventing participation were excluded.

The intervention was an app-based heart health monitoring strategy developed after focus group discussions with community health center staff and community cadres. The FGD explored the information needed by patients and health workers, the type of variables feasible for community monitoring, and the usability requirements for adult patients. The application was developed in collaboration with information technology experts and reviewed by experts in information technology and gastroenterology-hepatology.

The application supported entry and follow-up of blood pressure, heart rate, oxygen saturation, random blood glucose, medication history, medication reminders, and educational information. Participants were instructed to use the application during a one-month monitoring period. Cadres, enumerators, and health center staff supported participant orientation and helped ensure that measurements were recorded consistently. The mechanism of action was based on repeated risk visibility, reminders, self-monitoring,

and feedback-oriented health education, which are consistent with behavior change and digital engagement frameworks (Burke et al., 2015; Hamine et al., 2015; Kitsiou et al., 2017; Marcolino et al., 2018; Michalakeas et al., 2020; Perski, 2017; Ramadass et al., 2024; Santo et al., 2016; Yardley et al., 2016; Zhao et al., 2025).

Primary outcome was change in cardiovascular risk category between baseline and one-month follow-up. Secondary outcomes were changes in systolic blood pressure, diastolic blood pressure, and resting heart rate. Baseline characteristics included age group, sex, hepatitis type, history of diabetes mellitus, and history of hypercholesterolemia. Cardiovascular risk was categorized by the study team using the risk assessment procedure applied during community monitoring; higher scores indicated higher risk.

Before the intervention, enumerators recorded baseline demographic and clinical characteristics and measured baseline cardiovascular indicators. After one month of application-supported monitoring, the same indicators were reassessed. The data collection process was supervised by the research team in coordination with the community health center. Descriptive statistics were used to summarize participant characteristics. Continuous variables were presented as mean and standard deviation, and categorical variables as frequency and percentage. Because the sample was small and the cardiovascular risk score was ordinal, pre-post comparisons were analyzed using Wilcoxon signed-rank tests. A p-value below 0.05 was considered statistically significant. Effect magnitude for the ordinal risk score was estimated using r=Z/square root of N.

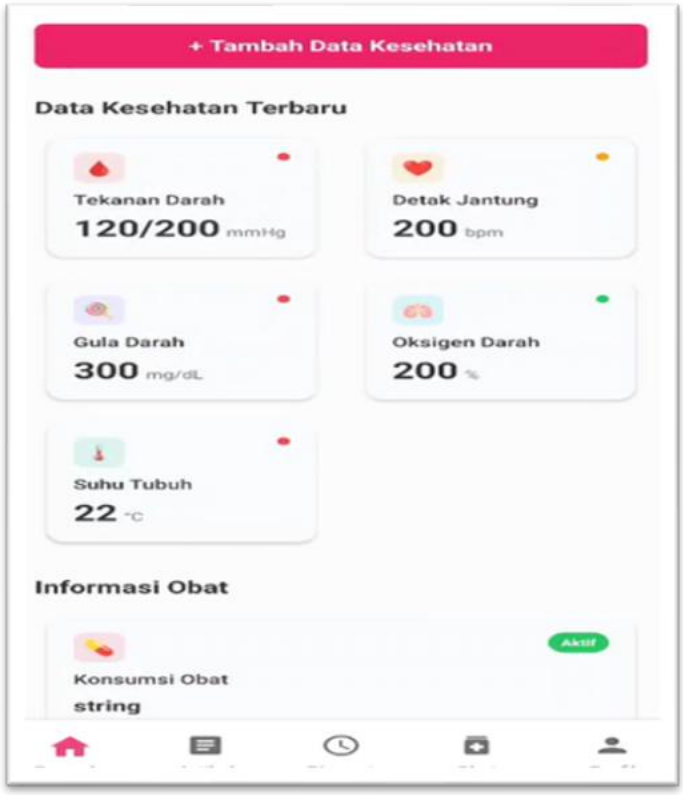

Figure 1. Heart Health App.

This app features a comprehensive set of functions, including monitoring of blood pressure, heart rate, oxygen saturation, and random blood glucose, as well as medication

reminders and health information. This application is used by respondents during a one-month monitoring period; the indicators observed are blood pressure, heart rate, and the risk of cardiovascular disorders.

The study received ethical approval from the Research Ethics Committee of the Institute for Research Development and Community Service, Universitas Telogorejo Semarang, approval number 106/IX/EC/P3M/STIKES/2025. Participants received information about the study objectives, procedures, benefits, possible inconvenience, voluntary participation, confidentiality, and the right to withdraw. Written informed consent was obtained before data collection.

3. RESULTS AND DISCUSSION

Table 1. The characteristics of the respondents.

Variable	Category	Frequency (n)	Percentage (%)
Age	20-40 years	11	36.7
	41-60 years	19	63.3
	Total	30	100.0
Sex	Male	14	46.7
	Female	16	53.3
	Total	30	100.0
Type of hepatitis	Hepatitis B	29	96.7
	Hepatitis C	1	3.3
	Total	30	100.0
History of diabetes mellitus	Yes	16	53.3
	No	14	46.7
	Total	30	100.0
History of high cholesterol	Yes	19	63.3
	No	11	36.7
	Total	30	100.0

Table 1 shows that the study included 30 adult participants with hepatitis B or C. Most participants were aged 41-60 years (63.3%), female (53.3%), and diagnosed with hepatitis B (96.7%). More than half had a history of diabetes mellitus (53.3%), and nearly two-thirds had a history of high cholesterol (63.3%).

Table 2. Changes in blood pressure and resting heart rate after app-based monitoring.

Outcome	Pre-test, mean +/- SD	Post-test, mean +/- SD	p-value
Systolic blood pressure (mmHg)	147.9 +/- 11.8	135.1 +/- 9.7	0.002
Diastolic blood pressure (mmHg)	93.1 +/- 8.2	85.6 +/- 7.1	0.003
Resting heart rate (beats/minute)	85.7 +/- 8.9	79.2 +/- 7.8	0.004

Table 2 shows that the blood pressure decreased significantly after the one-month app-based monitoring strategy. Mean systolic blood pressure decreased from 147.9 +/- 11.8 mmHg at baseline to 135.1 +/- 9.7 mmHg after the intervention (p=0.002). Mean diastolic blood pressure decreased from 93.1 +/- 8.2 mmHg to 85.6 +/- 7.1 mmHg (p=0.003).

Table 3. Change in cardiovascular risk score after app-based monitoring.

Outcome	Pre-test median	Post-test median	Z statistic	p-value	Effect size r
Cardiovascular risk score	2.0	1.0	-3.08	0.002	0.56

Resting heart rate also decreased significantly, from 85.7 +/- 8.9 beats/minute at baseline to 79.2 +/- 7.8 beats/minute after the intervention (p=0.004) (Table 2). The median cardiovascular risk score decreased from 2.0 to 1.0. The Wilcoxon signed-rank test showed a statistically significant reduction in risk score (Z=-3.08; p=0.002), corresponding to a large effect estimate (r=0.56) for this preliminary sample (Table 3).

Table 4. Risk of cardiovascular disorders.

Variable	Median Pre test	Median Post test	Z	p-value
Risk of cardiovascular disorders	2.0	1.0	-3.08	0.002

The results of the Wilcoxon test showed a p-value <0.05, which means there was a statistically significant reduction in the risk of cardiovascular disorders after implementing an application-based monitoring and evaluation strategy (Table 4).

Table 5. App-based cardiovascular monitoring workflow.

Step	Component	Operational description
1	Coordination	Research team coordinated with the community health center and community cadres.
2	Needs assessment	FGD identified application features required for heart health monitoring.
3	Application development	IT and gastroenterology-hepatology experts reviewed core functions.
4	Participant onboarding	Adults with hepatitis B/C were oriented to app-supported monitoring.
5	One-month monitoring	Blood pressure, heart rate, oxygen saturation, glucose, medication reminders, and education were monitored.
6	Post-test evaluation	Cardiovascular indicators and risk category were reassessed.

Table 5 summarizes the intervention workflow. The strategy began with community health center coordination and FGD-based application feature selection, followed by expert review, participant onboarding, one-month app-based monitoring, and post-intervention cardiovascular risk assessment.

This preliminary study found significant short-term reductions in blood pressure, resting heart rate, and cardiovascular risk category after one month of app-based monitoring among adults with hepatitis B and C. The findings are clinically meaningful because participants had a clustering of cardiovascular risk factors, including middle-to-late adult age, diabetes mellitus, hypercholesterolemia, and chronic viral hepatitis. These characteristics correspond to mechanisms described in the broader literature on inflammation, metabolic dysfunction, and cardiovascular risk (Cooke et al., 2019; Modi & Liang, 2008; Ott et al., 2012; Petta, 2017; Rajewski et al., 2022; Razavi-Shearer et al.,

2018; Schweitzer et al., 2015; Stanaway et al., 2016; The Polaris Observatory HCV Collaborators, 2019; Wu et al., 2019), (Di Angelantonio et al., 2009; Gersh, 2011; Harris et al., 2009; Moneta, 2011).

The decrease in systolic and diastolic blood pressure is consistent with studies showing that self-monitoring, telemonitoring, digital prompts, and structured feedback can improve blood pressure control (Bobrow et al., 2016; Praveen et al., 2014; Khoong et al., 2021; Liu et al., 2023; Margolis et al., 2013; McManus et al., 2018; Omboni et al., 2020; Parati et al., 2021; Piette et al., 2015; Greenland et al., 2010). Blood pressure reduction may reflect increased awareness, more frequent observation of abnormal values, medication reminders, and reinforced lifestyle education. Evidence from home blood pressure monitoring and telemedicine suggests that digital monitoring is most effective when it supports a continuous management loop rather than a passive data collection process (Khoong et al., 2021; Liu et al., 2023; Margolis et al., 2013; McManus et al., 2018; Omboni et al., 2020; Parati et al., 2021).

The reduction in resting heart rate may indicate improvement in autonomic balance, physical activity, anxiety regulation, or adherence to general health recommendations. Although resting heart rate was not the sole determinant of cardiovascular risk, it is a practical physiological marker that can be monitored in community-based interventions. Mobile applications that promote self-observation and healthy routines may contribute to behavioral activation, especially when health workers or cadres support adherence (Burke, et al., 2015; Hamine et al., 2015; Kitsiou et al., 2017; Marcolino et al., 2018; Michalakeas et al., 2020; Perski, 2017; Ramadass et al., 2024; Santo et al., 2016; Yardley et al., 2016; Zhao et al., 2025).

The reduction in the median cardiovascular risk score supports the feasibility of using an app-based strategy in a primary care population with chronic infectious and metabolic risk. This finding is aligned with the direction of community medicine literature that encourages integration of digital health, risk-based NCD prevention, and primary health care strengthening (Barigela et al., 2021; Bhatt et al., 2023; Gupta, 2024; Joshi et al., 2021; Kar et al., 2024; Lahariya et al., 2022; Mishra et al., 2022; Samudyatha et al., 2023; Shukla et al., 2023; Wilson et al., 2024; Wulandari et al., 2022; Bobrow et al., 2016; Burke et al., 2015; Free et al., 2013; Praveen et al., 2014; Hamine et al., 2015; Khoong et al., 2021; Kitsiou et al., 2017; Liu et al., 2023; Marcolino et al., 2018; Margolis et al., 2013; Michalakeas et al., 2020; Morawski et al., 2018; Omboni et al., 2020; Parati et al., 2021; Piette et al., 2015; Ramadass et al., 2024; Santo et al., 2016; Thakkar et al., 2016; Zhao et al., 2025). For adults with hepatitis B and C, an mHealth approach may be particularly useful because the cardiovascular risk mechanism is multifactorial and requires repeated monitoring rather than one-time screening.

The intervention was not designed to replace clinical care. Instead, the application served as a structured monitoring aid that made cardiovascular indicators visible to patients and health workers. In low-resource settings, such a tool may support task-sharing with cadres, timely referral, and more consistent education. This is important because hypertension, diabetes, lipid disorders, and chronic viral hepatitis require sustained follow-up, and community-based surveillance can help close gaps between clinical visits (Arnett et al., 2019; Giovanni et al., 2020; Kaptoge et al., 2019; Lloyd-Jones et al., 2022; Mills et al., 2017; NCD Risk Factor Collaboration (NCD-RisC), 2021; Visseren et al., 2022; Yusuf et al., 2020; Bobrow et al., 2016; Free et al., 2013; Praveen et al., 2014; Khoong et al., 2021; Liu et al., 2023; Margolis et al., 2013; Morawski et al., 2018; Omboni et al., 2020; Parati et al., 2021; Piette et al., 2015; Thakkar et al., 2016; Greenland et al., 2010).

Several limitations must be considered. First, the one-group pre-test-post-test design cannot exclude regression to the mean, Hawthorne effects, medication changes, seasonal behavior changes, or other external influences. Second, the sample size was small and drawn purposively from one community health center area, limiting generalizability. Third, follow-up lasted only one month, so the sustainability of blood pressure and risk reductions cannot be established. Fourth, the cardiovascular risk score and application usability require more formal validation. Fifth, the study was not prospectively registered. These limitations indicate that the findings should be interpreted as preliminary effectiveness evidence.

Future studies should use a randomized or controlled quasi-experimental design, larger sample size, longer follow-up, and clearer measurement of app engagement. Future development should also include usability testing, data security assessment, integration with electronic medical records, and evaluation of clinical referral pathways. A mixed-methods process evaluation would help clarify which components, such as reminders, education, health worker feedback, or peer support, are most responsible for behavior change (Craig et al., 2008; Donkin et al., 2013; Eysenbach et al., 2011; Michie et al., 2013; Perski, 2017; Schulz et al., 2019; Skivington et al., 2021; Von Elm et al., 2008; Yardley et al., 2016).

4. CONCLUSION

An app-based monitoring and evaluation strategy was associated with significant short-term reductions in systolic blood pressure, diastolic blood pressure, resting heart rate, and cardiovascular risk score among adults with hepatitis B and C in a primary care setting. The findings support the feasibility of integrating mHealth-supported cardiovascular monitoring into community-based preventive care for patients with chronic viral hepatitis. Because the study was preliminary and uncontrolled, larger controlled studies with longer follow-up and formal application validation are needed before broad implementation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Resa Nirmala Jona (RNJ): Conceptualization, methodology, investigation, project administration, supervision, data curation, formal analysis, visualization, and writing-original draft. Arlies Zenitha Victoria (AZV): Methodology, investigation, validation, data curation, and writing-review and editing. Danny Putri Sulistyaningrum (DPS): Investigation, formal analysis, validation, visualization, and writing-review and editing. All authors contributed to the interpretation of the findings, critically reviewed the manuscript, approved the final version for publication, and agreed to be accountable for all aspects of the work.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

The authors used generative artificial intelligence (AI)-assisted technology solely to improve the language quality, sentence structure, readability, and overall organization of this manuscript, including paraphrasing selected text to enhance clarity while preserving the original scientific meaning.

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