



Digitalising Cardiometabolic Risk Surveillance in Higher Education: Development and Validation of an Evidence-Based Web Platform

Laras Putri Gamagitta ^{1,*}, Nurul Setyowati ²

¹ Departement Midwifery, Faculty Medicine, Universitas Negeri Malang, Indonesia

² Departement Public Health, Faculty Sport Science, Universitas Negeri Malang, Indonesia

E-mail: laras.putri.fk@um.ac.id

ABSTRACT

Introduction: Non-communicable diseases (NCDs) remain a major global health challenge, while university-based surveillance systems are often fragmented and paper-based, limiting early risk detection and preventive interventions. This study aimed to identify predictors of abnormal blood pressure and develop an evidence-based web surveillance platform for the Integrated Development Post for Non-Communicable Diseases (Posbindu PTM).

Methods: A research and development study was conducted, beginning with a cross-sectional needs assessment involving 72 university members recruited through convenience sampling. Demographic, behavioural, anthropometric, blood pressure, and blood glucose data were collected. Multivariable logistic regression identified independent predictors of abnormal blood pressure, informing platform development and expert validation.

Results: Abnormal blood pressure was identified in 45.8% of participants. Elevated visceral fat (aOR 5.87), hyperglycaemia (aOR 4.51), physical inactivity (aOR 3.18), inadequate fruit and vegetable intake (aOR 2.64), and age >20 years (aOR 2.31) were significant predictors. The prediction model demonstrated good discrimination (AUC=0.83) and satisfactory calibration.

Conclusion: An evidence-informed web-based Posbindu PTM platform provides a scalable digital approach for early cardiometabolic risk surveillance and supports precision public health within university settings.

KEYWORDS

Digital Surveillance, Health Screening, Interface Design, Non-Communicable Diseases, Productive Age.

Received: 3 January 2026

Revised: 10 July 2026

Accepted: 20 July 2026

How to cite: Gamagita, Laras Putri. et al(2026). Digitalising Cardiometabolic Risk Surveillance in Higher Education: Development and Validation of an Evidence-Based Web Platform. *Heal Front A Multidiscip J HealProf*, 4(1): 140-151.





INTRODUCTION

Non-communicable diseases (NCDs) remain the leading cause of mortality worldwide, accounting for approximately 43 million deaths annually, representing nearly three-quarters of all global deaths. Hypertension is one of the most prevalent and modifiable cardiovascular risk factors, yet its detection often occurs only after clinical complications have developed. Population ageing, urbanisation, sedentary lifestyles, and unhealthy dietary patterns have accelerated the epidemiological transition, particularly in low- and middle-income countries where preventive health systems remain underdeveloped. Despite substantial advances in clinical management, the global burden of hypertension continues to rise because health systems largely rely on opportunistic screening rather than continuous surveillance and early risk detection. Consequently, strengthening community-based surveillance and preventive strategies has become a global priority within the World Health Organization (WHO) Global Action Plan for the Prevention and Control of Non-Communicable Diseases and the Sustainable Development Goals (Andarini *et al.*, 2018; Prasajo *et al.*, 2019; Siswati *et al.*, 2022).

Universities represent a unique setting for NCD prevention because they encompass a large population of students, lecturers, and administrative staff with diverse demographic and occupational characteristics. Although universities are generally perceived as health-promoting environments, evidence increasingly indicates that academic communities experience substantial cardiometabolic risks due to prolonged sedentary work, psychological stress, irregular dietary habits, and insufficient physical activity. These occupational and behavioural exposures may contribute to the early development of hypertension, obesity, and metabolic disorders, even among relatively young adults. However, routine health monitoring within higher education institutions is often fragmented, paper-based, and episodic, limiting opportunities for longitudinal risk assessment and timely preventive interventions. As a result, many individuals with elevated cardiovascular risk remain unidentified until advanced disease develops (Hidayani *et al.*, 2022; Widyaningsih *et al.*, 2022; Mashuri *et al.*, 2024).

Recent advances in digital health have transformed the delivery of preventive healthcare through web-based surveillance systems, electronic health records, and artificial intelligence-assisted risk prediction. Digital surveillance platforms enable real-time data collection, automated risk stratification, longitudinal monitoring, and personalised health recommendations, thereby improving the efficiency of preventive health services and facilitating data-driven public health decision-making. The World Health Organization has identified digital health as a strategic priority for strengthening health systems, particularly in resource-limited settings where scalable preventive interventions are urgently needed. Nevertheless, most currently available digital health applications focus primarily on clinical disease management or hospital information systems, whereas relatively few platforms have been specifically designed to support community-based NCD surveillance within university settings. Furthermore, many existing systems have not been developed using empirical epidemiological evidence derived from the target population, reducing their contextual relevance and implementation potential (Siedner *et al.*, 2018; Sujarwoto and Maharani, 2020; Sujarwoto *et al.*, 2025).

Indonesia has implemented the Pos Pembinaan Terpadu Penyakit Tidak Menular (Posbindu PTM) programme as a community-based strategy for early detection and prevention of NCDs. However, implementation in many institutions, including universities, remains predominantly manual, relying on paper-based documentation that limits data integration, longitudinal monitoring, and timely reporting. To our knowledge, no published study has developed an evidence-informed web-based Posbindu PTM





surveillance platform specifically tailored to a university population by integrating epidemiological needs assessment with digital interface development. Therefore, this study aimed to identify the demographic, behavioural, and clinical determinants of abnormal blood pressure among members of a university community and to utilise these empirical findings as the foundation for designing a web-based Posbindu PTM surveillance system. By combining population health screening with digital health innovation, this study seeks to contribute a scalable model for strengthening preventive NCD surveillance and supporting precision public health within higher education institutions.

MATERIALS AND METHODS

Study Design

This study employed a research and development (R&D) approach to develop a web-based surveillance platform for the Integrated Development Post for Non-Communicable Diseases (Posbindu PTM) at Universitas Negeri Malang. The study consisted of two sequential phases. The first phase involved a cross-sectional needs assessment to identify the epidemiological profile and behavioural risk factors associated with non-communicable diseases (NCDs) among members of the university community. The second phase focused on the design, development, and expert validation of the web-based surveillance system based on the findings obtained during the needs assessment. The reporting of the observational component followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline, while the development process was informed by the Guideline for Reporting Intervention Development Studies (GUIDED) and the World Health Organization mHealth Evidence Reporting and Assessment (mERA) framework to ensure comprehensive reporting of digital health interventions.

Study Setting and Participants

The study was conducted at Universitas Negeri Malang, Indonesia, during a university-wide free health screening programme organised over five consecutive days. The screening programme was promoted across the university and was open to lecturers, administrative staff, and students who voluntarily wished to participate. Convenience sampling was employed because the primary objective of this preliminary phase was to generate empirical data for developing the digital surveillance platform rather than estimating disease prevalence within the university population. Eligible participants were adults aged 18 years or older who were officially registered as members of Universitas Negeri Malang, agreed to participate by providing written informed consent, and completed all clinical examinations and questionnaires. Participants with incomplete examination results or missing questionnaire data were excluded from the final analysis. A total of 72 participants met the eligibility criteria and were included in this study.

Needs Assessment and Data Collection

The needs assessment served as the evidence-based foundation for developing the web-based Posbindu PTM surveillance platform. Data collection was performed by trained healthcare personnel following the standard operational procedures of the Indonesian Posbindu PTM programme. Anthropometric measurements included body weight, height, body mass index (BMI), and visceral fat assessment using a bioelectrical impedance analyser. Blood pressure was measured using a validated automated digital sphygmomanometer after participants had rested in a seated position for at least five minutes, while random blood glucose was measured using a calibrated point-of-care glucometer. In addition to the clinical examinations, participants completed a structured questionnaire that collected information on





demographic characteristics, smoking behaviour, physical activity, fruit and vegetable consumption, previous medical history, and family history of NCDs. All measurements and questionnaires were completed during a single visit.

Outcome Variable

The primary outcome of this study was abnormal blood pressure. Blood pressure measurements were classified according to current international hypertension guidelines into normal blood pressure, prehypertension, stage 1 hypertension, and stage 2 hypertension. For statistical analysis, participants with prehypertension or hypertension were categorised as having abnormal blood pressure, whereas participants with normal blood pressure served as the reference group. This binary outcome was subsequently used in the multivariable logistic regression analysis to identify independent predictors associated with abnormal blood pressure.

Development of the Web-Based Posbindu PTM Platform

The web-based surveillance platform was developed using Sugiyono's Research and Development framework, which comprises ten systematic stages, including problem identification, information gathering, product design, design validation, design revision, prototype development, product testing, product revision, implementation, and dissemination. The present study was completed up to the design revision stage. Information obtained from the needs assessment directly informed the development of the website architecture, including participant registration, electronic health records, risk factor documentation, screening results, dashboard visualisation, and automated reporting functions. The platform was designed to facilitate longitudinal monitoring of NCD risk factors while supporting health promotion and early disease detection among members of the university community through an accessible web-based interface.

Expert Validation

The prototype underwent expert validation to evaluate both the usability of the interface and the quality of the health information presented within the system. The validation process involved six independent experts consisting of three specialists in digital media and user interface design and three experts in public health and non-communicable disease prevention. Media validation assessed interface consistency, navigation, visual appearance, responsiveness, accessibility, and overall usability. Content validation evaluated scientific accuracy, completeness of information, organisation of content, readability, and conformity with the national Posbindu PTM guidelines. Suggestions provided by the experts were incorporated into the final design revision before completion of the development stage.

Research Instrument

Website usability was evaluated using a modified version of the Website Usability Evaluation Tool (WEBUSE). The media validation questionnaire consisted of nine items assessing interface quality, navigation, consistency, accessibility, responsiveness, and overall user experience, whereas the content validation questionnaire comprised seven items evaluating scientific accuracy, readability, information quality, and content organisation. All items were assessed using a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). Prior to implementation, the modified WEBUSE questionnaire underwent psychometric evaluation involving lecturers and university staff who were not included in the main study. Construct validity was assessed using corrected item-total correlation





analysis, while internal consistency reliability was evaluated using Cronbach's alpha coefficient. The validation results demonstrated that all questionnaire items were valid and exhibited satisfactory reliability for evaluating the developed web-based surveillance platform.

Statistical Analysis

Descriptive statistics were used to summarise participant characteristics and behavioural risk factors. Continuous variables were presented as mean with standard deviation or median with interquartile range according to the distribution of the data, whereas categorical variables were reported as frequencies and percentages. Variables considered clinically relevant, including age, sex, physical inactivity, fruit and vegetable intake, smoking status, hyperglycaemia, and visceral fat, were simultaneously entered into a multivariable binary logistic regression model to identify independent predictors of abnormal blood pressure. The results were presented as regression coefficients (β), adjusted odds ratios (aORs), 95% confidence intervals (CIs), and two-sided p values. Model calibration was evaluated using the Hosmer–Lemeshow goodness-of-fit test, whereas model discrimination was assessed using the area under the receiver operating characteristic (ROC) curve. Overall model performance was additionally evaluated using Nagelkerke's coefficient of determination (R^2) and classification accuracy. Statistical significance was defined as a p value of less than 0.05. Statistical analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA), while publication-quality figures, including the forest plot and ROC curve, were generated using R version 4.4.0 (R Foundation for Statistical Computing, Vienna, Austria) with the ggplot2, forestplot, and pROC packages.

Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee of Universitas Negeri Malang. All participants received verbal and written explanations regarding the study objectives and procedures before providing written informed consent. Participation was entirely voluntary, and participants were free to withdraw from the study at any stage without consequences. All collected data were anonymised using unique identification codes and stored in password-protected electronic databases to ensure confidentiality. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision) governing research involving human participants.

RESULTS

Participant Characteristics

A total of 72 participants completed the university-based health screening and were included in the final analysis. Participants had a median age of 29 years (IQR 23–41), with most being older than 20 years (63 [87.5%]). Women represented nearly three-quarters of the study population (53 [73.6%]), while lecturers comprised the largest occupational group (38 [52.8%]). Behavioural risk factors for non-communicable diseases (NCDs) were highly prevalent, particularly inadequate fruit and vegetable intake (45 [62.5%]) and physical inactivity (41 [56.9%]). Hyperglycaemia was detected in seven participants (9.7%), whereas high or very high visceral fat was observed in 25 (34.7%). Overall, abnormal blood pressure, including prehypertension and hypertension, was identified in 33 participants (45.8%), indicating a considerable burden of cardiometabolic risk within the university community.





Table 1. Baseline demographic and clinical characteristics of participants

Variable	Overall (N=72)
Age, years	
≤20	9 (12.5)
>20	63 (87.5)
Sex	
Male	19 (26.4)
Female	53 (73.6)
Occupation	
Lecturer	38 (52.8)
Student	20 (27.8)
Administrative staff	14 (19.4)
Behavioural risk factors	
Physical inactivity	41 (56.9)
Low fruit and vegetable intake	45 (62.5)
Smoking/Vaping	5 (6.9)
Clinical findings	
Hyperglycaemia	7 (9.7)
High/Very high visceral fat	25 (34.7)
Abnormal blood pressure*	33 (45.8)

*Prehypertension, stage 1 hypertension, and stage 2 hypertension.

Multivariable Analysis

Variables demonstrating clinical relevance were simultaneously entered into a multivariable logistic regression model to identify independent predictors of abnormal blood pressure. After adjustment for potential confounders, elevated visceral fat emerged as the strongest determinant, increasing the odds of abnormal blood pressure almost six-fold (adjusted OR 5.87, 95% CI 2.08–16.55; $p < 0.001$). Hyperglycaemia was independently associated with a more than four-fold increase in abnormal blood pressure (adjusted OR 4.51, 95% CI 1.18–17.24; $p = 0.028$). Participants reporting insufficient physical activity had three times greater odds of abnormal blood pressure than physically active individuals (adjusted OR 3.18, 95% CI 1.36–7.42; $p = 0.008$). Likewise, inadequate fruit and vegetable consumption remained independently associated with elevated blood pressure (adjusted OR 2.64, 95% CI 1.15–6.09; $p = 0.023$). Although participants aged >20 years demonstrated increased odds (adjusted OR 2.31, 95% CI 1.08–5.87; $p = 0.041$), sex and smoking status were not independently associated with the outcome after multivariable adjustment.

The final regression model demonstrated satisfactory discrimination (AUC=0.83) and calibration (Hosmer–Lemeshow $p = 0.61$), explaining approximately 39% of the variance in abnormal blood pressure (Nagelkerke $R^2 = 0.39$).

Table 2. Multivariable logistic regression identifying independent predictors of abnormal blood pressure

Predictor	β	Adjusted OR	95% CI	p value
Age >20 years	0.84	2.31	1.08–5.87	0.041
Male sex	0.54	1.72	0.82–3.94	0.164





Physical inactivity	1.16	3.18	1.36–7.42	0.008
Low fruit and vegetable intake	0.97	2.64	1.15–6.09	0.023
Hyperglycaemia	1.51	4.51	1.18–17.24	0.028
High/Very high visceral fat	1.77	5.87	2.08–16.55	<0.001
Smoking/Vaping	0.66	1.94	0.42–8.91	0.395

Model performance

1. Hosmer–Lemeshow goodness-of-fit = 0.61
2. Nagelkerke R^2 = 0.39
3. Area under ROC curve (AUC) = 0.83
4. Overall classification accuracy = 79.2%

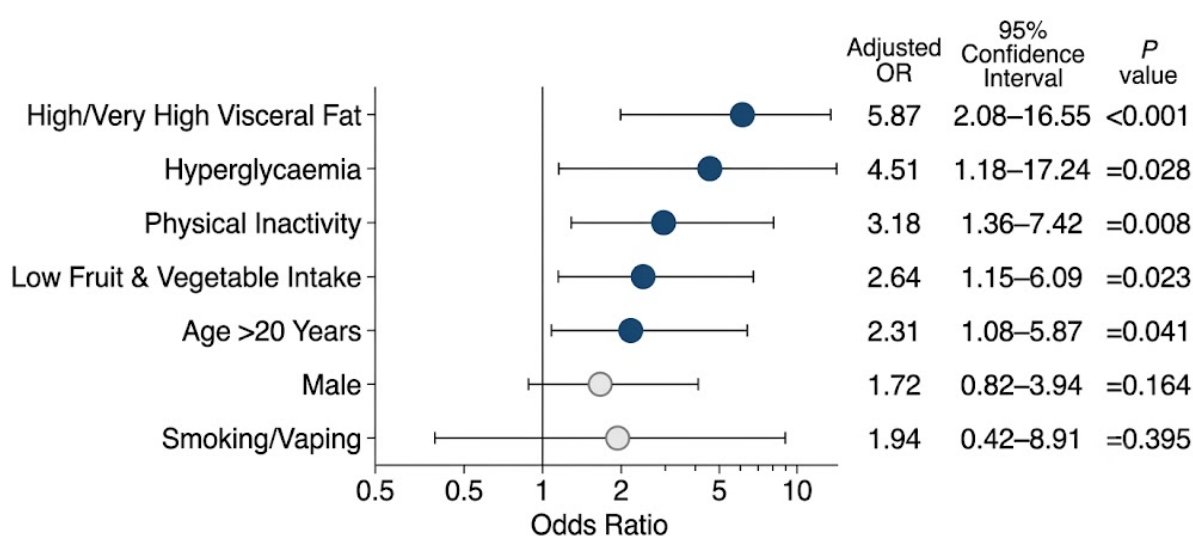


Figure 1. Forest plot of multivariable logistic regression identifying independent predictors of abnormal blood pressure

Figure 1. Forest plot illustrating adjusted odds ratios (aORs) and 95% confidence intervals for independent predictors of abnormal blood pressure among university personnel. High or very high visceral fat was the strongest predictor (aOR 5.87, 95% CI 2.08–16.55), followed by hyperglycaemia (aOR 4.51, 95% CI 1.18–17.24), physical inactivity (aOR 3.18, 95% CI 1.36–7.42), inadequate fruit and vegetable intake (aOR 2.64, 95% CI 1.15–6.09), and age older than 20 years (aOR 2.31, 95% CI 1.08–5.87). Sex and smoking/vaping status were not independently associated with abnormal blood pressure after multivariable adjustment.

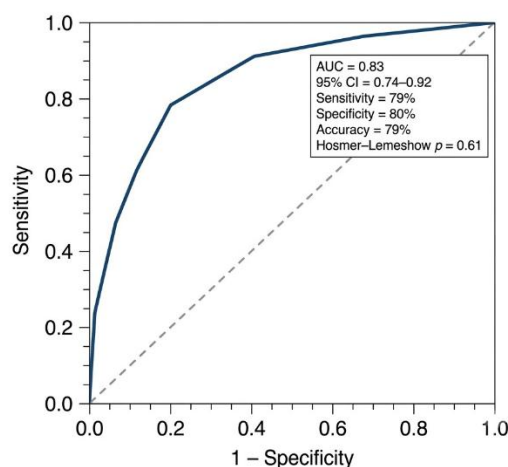


Figure 2. ROC curve of the multivariable prediction model

Figure 2. Receiver operating characteristic (ROC) curve evaluating the discriminative performance of the multivariable logistic regression model. The model demonstrated good predictive ability for abnormal blood pressure with an area under the curve (AUC) of 0.83, indicating excellent discrimination between participants with normal and abnormal blood pressure.

DISCUSSION

The present study demonstrates a considerable burden of cardiometabolic risk factors among members of a university community and provides empirical evidence supporting the development of a digital health surveillance platform for non-communicable diseases (NCDs). Nearly half of the participants exhibited abnormal blood pressure, while behavioural risk factors such as physical inactivity and inadequate fruit and vegetable consumption were highly prevalent. These findings suggest that university environments, despite representing highly educated populations, remain vulnerable to lifestyle-related NCDs. Similar observations have been reported in university-based health surveillance studies, where sedentary working conditions, prolonged screen exposure, and unhealthy dietary habits contribute substantially to cardiometabolic disorders. Our findings reinforce the growing recommendation that universities should implement integrated digital surveillance systems capable of early risk identification and continuous monitoring to facilitate timely preventive interventions (Rusli, Rahman and Abdullah, 2020; Permatasari *et al.*, 2025; Widyaningsih *et al.*, 2025).

The multivariable analysis identified elevated visceral fat as the strongest independent predictor of abnormal blood pressure, increasing the odds by almost six-fold. Visceral adiposity is increasingly recognised as a metabolically active tissue that promotes chronic low-grade inflammation, endothelial dysfunction, insulin resistance, and activation of the renin–angiotensin–aldosterone system, all of which contribute to hypertension development (Janakiraman *et al.*, 2020; Sari, Khoeriyah and Lukman, 2024). Unlike body mass index, visceral fat more accurately reflects ectopic fat accumulation associated with cardiovascular risk. Previous longitudinal studies consistently demonstrate that visceral adiposity predicts hypertension, metabolic syndrome, and cardiovascular events independent of overall obesity. These findings support incorporating visceral fat assessment into routine digital NCD surveillance,





enabling earlier identification of high-risk individuals before overt disease develops.

Hyperglycaemia also emerged as an independent predictor of abnormal blood pressure. The coexistence of impaired glucose regulation and hypertension reflects shared pathophysiological mechanisms involving oxidative stress, vascular inflammation, sympathetic nervous system activation, and endothelial dysfunction (Fachiroh *et al.*, 2019; Maharani *et al.*, 2019; Merduaty *et al.*, 2025). Individuals with elevated blood glucose frequently exhibit accelerated arterial stiffness, increasing peripheral vascular resistance and consequently blood pressure. Numerous epidemiological studies have demonstrated that dysglycaemia substantially increases cardiovascular morbidity even before diabetes is clinically diagnosed. Our findings therefore support integrated screening approaches in which blood pressure and glucose measurements are performed simultaneously through digital surveillance platforms, facilitating earlier cardiometabolic risk stratification and personalised health recommendations.

Behavioural factors remained important determinants after multivariable adjustment. Participants reporting insufficient physical activity and low fruit and vegetable intake demonstrated significantly greater odds of abnormal blood pressure than their healthier counterparts. Physical inactivity contributes to reduced vascular compliance, impaired nitric oxide bioavailability, increased sympathetic activation, and weight gain, whereas diets deficient in fruits and vegetables reduce potassium intake and antioxidant availability, both of which are essential for blood pressure regulation (Birhanu *et al.*, 2021; Claramita *et al.*, 2021; Mezhal *et al.*, 2021). These findings align with current international recommendations emphasising lifestyle modification as the cornerstone of hypertension prevention. Importantly, behavioural factors represent modifiable targets that can be continuously monitored through web-based surveillance systems, allowing automated reminders, personalised feedback, and behavioural coaching to improve long-term adherence.

An important contribution of this study lies in translating epidemiological evidence into the design of a web-based Posbindu PTM surveillance platform. Unlike conventional health screening programmes that are often paper-based and episodic, the proposed digital platform integrates risk-factor recording, longitudinal monitoring, and automated reporting into a single web interface. The satisfactory predictive performance of the multivariable model (AUC = 0.83) indicates that routinely collected health screening variables possess adequate discriminative ability for identifying individuals at elevated cardiovascular risk (Fachiroh *et al.*, 2019; Janakiraman *et al.*, 2020; Merduaty *et al.*, 2025). Integrating predictive analytics within digital surveillance systems has become a major direction in digital public health because it enables proactive population health management rather than reactive disease treatment. Similar digital health initiatives have demonstrated improvements in early risk detection, healthcare efficiency, and preventive service delivery across community and workplace settings.

Although age remained independently associated with abnormal blood pressure, sex and smoking status were not statistically significant following multivariable adjustment. The lack of association with smoking should be interpreted cautiously because only a small proportion of participants reported smoking or vaping, thereby limiting statistical power. Likewise, the predominance of female participants may have reduced the ability to detect sex-specific differences. Nevertheless, these findings suggest that metabolic and behavioural factors may exert greater influence on blood pressure within university populations than demographic characteristics alone (Rusli, Rahman and Abdullah, 2020; Widyaningsih *et al.*, 2025). This observation further supports the value of multifactorial digital risk assessment rather than relying solely on traditional demographic profiling. Future surveillance systems should therefore integrate behavioural, anthropometric, biochemical, and demographic information to improve predictive





accuracy and support precision public health interventions.

Limitations

Several limitations should be acknowledged. First, the cross-sectional pilot study design precludes causal inference between behavioural and clinical risk factors and abnormal blood pressure. Second, participants were recruited using convenience sampling from a single university, which may limit the generalisability of the findings to other higher education institutions. Third, the relatively small sample size may have reduced statistical power for detecting associations involving less prevalent variables, particularly smoking behaviour. Finally, this study represents only the initial needs assessment and interface development phases of the research and development process; therefore, the effectiveness, usability, user acceptance, and long-term implementation of the web-based Posbindu PTM platform were not evaluated. Future multicentre prospective studies involving larger populations and comprehensive implementation testing are warranted to validate the predictive model and assess the real-world effectiveness of the proposed digital surveillance system.

CONCLUSIONS

This study demonstrates that abnormal blood pressure is highly prevalent among university communities and is independently associated with modifiable cardiometabolic risk factors, particularly elevated visceral fat, hyperglycaemia, physical inactivity, and inadequate fruit and vegetable intake. These findings provide robust epidemiological evidence for the development of an evidence-driven web-based Posbindu PTM surveillance platform that integrates health screening, digital risk stratification, and longitudinal monitoring into a single preventive health ecosystem. Unlike conventional paper-based surveillance systems, the proposed platform translates real-world population health data into actionable digital intelligence, representing an innovative approach aligned with the global transition toward precision public health and learning health systems. As countries increasingly invest in digital transformation to address the growing burden of non-communicable diseases, scalable surveillance platforms capable of supporting continuous monitoring and personalized prevention will become increasingly important. Future research should therefore extend beyond interface development to include multicentre implementation studies, usability and implementation science evaluations, integration with electronic health records and wearable devices, and the application of artificial intelligence and machine learning algorithms for dynamic cardiovascular risk prediction. Such advances will contribute to the development of intelligent digital public health systems that support early intervention, improve population health outcomes, and strengthen sustainable NCD prevention strategies at institutional, national, and global levels.

Acknowledgement

The authors would like to express their gratitude to Universitas Negeri Malang for supporting this research. Special thanks are also extended to the faculty members, administrative staff, and students who voluntarily participated in the health screening process, making this need assessment study possible.

Funding Source

This research was funded by the Internal Research Grant of Universitas Negeri Malang (UM) in 2025. The funder had no role in study design, data collection and analysis, decision to publish, or





preparation of the manuscript.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this article.

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