

Cardiovascular Risk Stratification and Screening in Rural Populations: From Case Detection to Integrated Primary Prevention

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Received: Jan. 03, 2025; Revised: Jan. 19, 2025; Accepted: Feb. 16, 2025; Published: Mar. 30, 2025

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Abstract: Cardiovascular diseases are increasingly important causes of premature mortality and disability in rural populations, where hypertension, diabetes, tobacco exposure and dyslipidaemia frequently remain undetected until complications occur. Cardiovascular screening can identify individual risk factors, whereas risk stratification estimates a person's probability of experiencing a major cardiovascular event over a defined period and supports treatment according to total risk. This distinction is important because isolated risk-factor thresholds may over-treat younger low-risk adults while underestimating older people with multiple moderately abnormal factors. The 2019 World Health Organization cardiovascular risk charts provide laboratory-based and non-laboratory models calibrated for 21 global regions, making risk-based management feasible in resource-constrained primary-care settings. Current evidence supports integrating blood-pressure measurement, diabetes detection, tobacco assessment and total-risk estimation with standardized treatment, uninterrupted medicines and longitudinal follow-up. Community health workers and non-physician providers can extend screening reach when linked to trained clinical teams, as demonstrated by community-based intervention trials. In India, population-based screening under the National Programme for Prevention and Control of Non-Communicable Diseases targets adults aged 30 years and above, but important gaps persist between screening, diagnostic confirmation, treatment initiation and control. Recent national analysis suggests that elevated ten-year cardiovascular risk is associated with rural residence, poverty, low education and undiagnosed hypertension. Screening programmes should therefore be evaluated not by the number screened but by accurate measurement, risk-appropriate treatment, retention and control. Future priorities include calibrated digital tools, task sharing, home blood-pressure monitoring, strengthened referral systems and equity-oriented implementation research.

Keywords: Cardiovascular Risk, Rural Health, Screening, Hypertension, Primary Healthcare, India

INTRODUCTION

Cardiovascular disease (CVD), principally ischaemic heart disease and stroke, is often viewed as an urban or affluent-population problem. This perception is increasingly inaccurate. Rural populations are experiencing demographic ageing, dietary transition, tobacco exposure, reduced occupational physical activity in some settings and rising hypertension and diabetes. At the same time, they frequently have poorer access to preventive services, diagnostic laboratories, regular medicines and emergency cardiovascular care [1-4].

A rural-urban comparison based only on risk-factor prevalence can therefore be misleading. Some metabolic risks may remain higher in cities, yet rural residents can experience worse outcomes because hypertension and diabetes are detected later and treated less consistently. Large multinational evidence has shown that awareness, treatment and control of hypertension are generally weaker in rural and lower-income settings despite a substantial burden of disease[5].

Cardiovascular screening comprises the systematic assessment of apparently healthy individuals for risk factors or preclinical disease. Common components include blood pressure, tobacco use, body mass index or waist circumference, blood glucose and lipid measurements. Risk stratification goes further by combining multiple variables to estimate the probability of a fatal or non-fatal cardiovascular event over five or ten years.

The purpose of screening is not simply to assign diagnostic labels. Its value depends on whether detected risk leads to affordable, acceptable and effective preventive action. Screening without diagnostic confirmation, medicines or follow-up may generate anxiety and workload without improving population health.

Why Total Cardiovascular Risk Matters

Cardiovascular events result from interacting risk factors rather than a single abnormal measurement. Age, sex, systolic blood pressure, smoking, diabetes and blood lipids collectively determine risk. A moderately elevated blood pressure may represent high absolute risk in an older smoker with diabetes but relatively low short-term risk in a young adult without other factors.

A total-risk approach offers several advantages. It identifies people most likely to benefit from pharmacological prevention, supports efficient use of limited resources and facilitates shared decision-making. It can also prevent excessive emphasis on a single laboratory result.

Risk scores have limitations. Age is a dominant predictor, so young adults with markedly abnormal risk factors may still have low estimated ten-year risk despite substantial lifetime risk. Conversely, many older adults cross treatment thresholds largely because of age. Risk estimation must therefore be combined with clinical judgement and recognition of conditions that confer high risk independently, including established CVD, severe hypertension, chronic kidney disease and selected forms of diabetes.

Risk scores predict probabilities, not individual destinies. A calculated risk of 20% does not mean that a particular patient will experience an event; it means that approximately 20 of 100 people with comparable characteristics may do so during the specified period if circumstances remain similar.

Risk-Prediction Tools for Rural Settings

WHO cardiovascular risk charts

The 2019 WHO charts estimate ten-year risk of myocardial infarction or stroke, fatal or non-fatal, among adults without established CVD. They were developed for 21 global regions using contemporary risk-factor and outcome data.[1] WHO provides both laboratory-based and non-laboratory models.

The laboratory model includes age, sex, smoking, systolic blood pressure, diabetes and total cholesterol. The non-laboratory model substitutes body mass index for cholesterol and does not require biochemical testing. This makes it suitable for outreach camps, health and wellness centres and communities where laboratory access is limited. WHO's update was specifically intended to improve the practicability and sustainability of CVD-risk management across diverse settings.

Non-laboratory assessment should not be interpreted as a second-rate approach. It can support initial stratification and identify individuals requiring prompt treatment or additional testing. Laboratory testing remains useful when it will alter management, particularly for diabetes confirmation, lipid-lowering decisions or suspected kidney disease.

Framingham, ASCVD, QRISK and other models

Framingham-based equations have been used globally but were developed in a predominantly White US population. The pooled-cohort ASCVD equations and QRISK models were similarly developed for particular healthcare settings and outcomes. Applying them directly to rural South Asian populations can produce miscalibration because baseline incidence, competing mortality and risk-factor relationships differ.

A risk tool should therefore be selected according to the population, outcome, available variables and treatment guideline. Apparent numerical precision does not guarantee validity. External validation and recalibration are more important than model complexity.

Risk categories and treatment thresholds

Risk categories commonly separate people into low, moderate, high and very high ten-year risk. Thresholds differ between guidelines and should not be interpreted rigidly. A risk-based approach should

determine the intensity of counselling, treatment and follow-up rather than whether a person receives any prevention at all.

Every person benefits from tobacco avoidance, healthy diet, physical activity and appropriate blood-pressure monitoring. High-risk individuals require more intensive intervention, including pharmacological treatment where indicated. People with established CVD should receive secondary prevention without relying on a primary-prevention risk score.

Core Components of Rural Cardiovascular Screening

Blood-pressure measurement

Blood-pressure screening is central because hypertension is common, largely asymptomatic and treatable. Measurement error, however, can create substantial misclassification. Devices should be validated, cuffs should fit the arm circumference, and the patient should rest before measurement. Talking, recent exertion, tobacco use and a full bladder can alter readings.

Diagnosis should generally not be based on one measurement at a single visit unless blood pressure is severely elevated or there is evidence of acute target-organ damage. Repeat clinic measurements, home monitoring or ambulatory monitoring can reduce white-coat and masked-hypertension errors.

Rural programmes often emphasize coverage while neglecting measurement quality. Training, device calibration, cuff availability and competency assessment should be treated as programme indicators.

Diabetes screening

Diabetes substantially increases cardiovascular risk. Screening options include fasting plasma glucose, oral glucose-tolerance testing and glycated haemoglobin, each with operational advantages and limitations. Capillary glucose can support community screening but abnormal values require confirmation according to accepted diagnostic criteria.

Indian evidence demonstrates a large burden of diabetes and prediabetes, including extensive undiagnosed disease and marked variation across states.[6] A combined hypertension–diabetes pathway is therefore more efficient than separate vertical programmes.

Tobacco and smokeless-tobacco assessment

Rural screening must include smoking and smokeless tobacco. Merely recording “tobacco use: yes/no” is insufficient. The form, frequency, duration, dependence and readiness to quit should be assessed. Brief cessation advice, pharmacotherapy where feasible and referral support should follow detection.

Lipids, obesity and kidney function

Total cholesterol is useful for laboratory-based risk estimation, but universal lipid testing may be difficult in outreach settings. A staged approach can use non-laboratory risk assessment first and prioritize testing for people whose management may change.

Body mass index alone may miss central adiposity in South Asian populations. Waist circumference can provide additional information, although it is not included in every risk equation. Serum creatinine and urinary albumin assessment are particularly relevant in people with hypertension or diabetes because chronic kidney disease substantially increases CVD risk.

Evidence for Community-Based Screening and Task Sharing

Screening conducted exclusively by physicians is unlikely to achieve adequate rural coverage. Community health workers, nurses and other non-physician providers can identify risk factors, support adherence and coordinate follow-up when they are trained, supervised and linked with treatment authority.

The HOPE-4 cluster-randomized trial included 1,371 adults with newly diagnosed or poorly controlled hypertension from 30 communities in Colombia and Malaysia. A community-based strategy involving non-physician health workers, treatment algorithms, free medicines and involvement of family or friends produced a substantially greater reduction in estimated cardiovascular risk than usual care [2].

The trial’s importance lies in the intervention package. Community screening alone was not responsible for benefit. Risk assessment was linked to standardized treatment, medicine provision, adherence support and social reinforcement. Programmes that reproduce only the screening component should not expect equivalent outcomes.

Table 1: Recommended Framework For Cardiovascular Screening And Risk Management In Rural Primary Care

Domain	Minimum assessment	Main implementation risk	Recommended action
Eligibility	Adults aged ≥30 years under India's population-based NCD screening programme; earlier assessment when major risk factors or family history are present	Age-only approaches may miss younger adults with severe risk factors	Combine age-based screening with opportunistic assessment of symptomatic or high-risk younger adults
Blood pressure	Validated device, correct cuff, two measurements after rest	Single readings, unvalidated devices and digit preference	Confirm on a separate occasion unless severe hypertension or emergency features are present
Diabetes	Risk assessment and blood glucose according to programme protocol	Screening values treated as definitive diagnoses	Confirm abnormal results and link immediately to longitudinal care
Tobacco	Smoking and smokeless-tobacco history	Documentation without cessation support	Provide brief intervention, pharmacological support where available and follow-up
Anthropometry	Weight, height and preferably waist circumference	Inaccurate equipment and over-reliance on BMI	Use standardized measurement and interpret using South Asian risk patterns
Lipids	Total cholesterol or lipid profile when available and clinically relevant	Testing everyone without the ability to act on results	Prioritize testing when it changes risk classification or treatment
Kidney risk	Creatinine and albuminuria in selected patients with hypertension or diabetes	Chronic kidney disease remains undetected	Integrate kidney assessment into high-risk pathways
Risk score	WHO laboratory or non-laboratory chart for the relevant region	Use of unvalidated foreign scores or transcription errors	Embed validated calculators with clear treatment protocols
Immediate high risk	Established CVD, severe hypertension, advanced kidney disease or high-risk diabetes	Inappropriate reliance on risk score despite automatic high-risk status	Start guideline-directed evaluation and treatment without delaying for scoring
Counselling	Tobacco, salt, diet, physical activity, alcohol and medicine adherence	Generic advice disconnected from rural realities	Provide culturally appropriate and household-level counselling
Referral	Defined criteria for suspected CVD, severe hypertension and complications	Referral without transport, appointments or feedback	Establish closed-loop referral and counter-referral
Follow-up	Register, treatment initiation, refill and control monitoring	Programme success judged only by screening volume	Report confirmation, treatment, retention and control cascades

Task sharing also requires safeguards. Community workers should not be burdened with additional targets without adequate training, remuneration, equipment or referral support. Digital applications may simplify risk calculation but cannot compensate for inaccurate blood-pressure measurement or unreliable medicine supply.

Public Health Significance

Rural cardiovascular screening has three potential public health functions. First, it can identify undiagnosed hypertension, diabetes and tobacco exposure. Second, risk stratification can prioritize

treatment for people likely to derive the greatest absolute benefit. Third, aggregated risk data can guide medicine procurement, workforce allocation and district planning.

Its equity value is particularly important. Rural populations often bear the indirect costs of travel, lost wages and repeated visits. Bringing screening and stable follow-up closer to communities can reduce these barriers. However, poorly implemented mass screening can widen inequity if better-connected individuals complete referral while remote or poorer patients are lost from the care cascade.

Screening should therefore be embedded within comprehensive primary healthcare. Separate one-day camps create visibility but frequently lack confirmation and continuity. A population register, recall system, local medicine supply and accessible clinical review are more important than isolated diagnostic events.

Indian Perspective

India introduced population-based screening for common NCDs in 2016. Under the National Programme for Prevention and Control of Non-Communicable Diseases, adults aged 30 years and above are screened for hypertension, diabetes and selected common cancers, with community-level risk assessment and referral through primary-care services.[3]

The programme provides a national platform, but implementation quality differs across states and districts. Common weaknesses include incomplete population enumeration, inaccurate measurements, delayed diagnostic confirmation, weak linkage with medical officers, medicine stock-outs and limited outcome reporting.

India's National Noncommunicable Disease Monitoring Survey provides important evidence on total cardiovascular risk. Using the WHO non-laboratory model among adults aged 40–69 years, Kulothungan and colleagues found that elevated risk was associated with rural residence, socioeconomic disadvantage and low educational attainment. Undiagnosed individuals with elevated blood pressure also showed increased predicted risk, reinforcing the need for active detection.[4]

A rural Haryana cohort followed over eight years documented rising hypertension prevalence and continuing gaps in awareness, treatment and control.[7] These findings demonstrate that repeating screening without improving treatment continuity will not control the epidemic.

India's primary-care strategy should exploit the strengths of accredited social health activists, community health officers and Ayushman Arogya Mandirs while avoiding an excessive dependence on numerical targets. Community-based assessment should lead to physician or qualified-provider review, standardized treatment and reliable monthly refills.

Recent Advances

Digital risk calculators and longitudinal registries

Mobile applications can automate WHO risk calculations, prevent chart-reading errors and create electronic patient registers. They can generate reminders and identify people overdue for review. Their usefulness depends on interoperability, data quality, offline functionality and protection of sensitive health information.

Digital systems should display the variables contributing to risk rather than presenting an unexplained score. Clinicians and community workers need to understand whether risk is being driven by age, blood pressure, smoking or diabetes so that the intervention remains clinically meaningful.

Home and community blood-pressure monitoring

Low-cost validated monitors allow repeated measurements outside clinics. Community-based or home monitoring may improve diagnostic accuracy and support titration. Equipment-sharing models can increase access, although device validation, maintenance and data transfer require governance.

Fixed-dose combination therapy

Single-pill combinations for hypertension and lipid lowering may simplify treatment, improve adherence and reduce therapeutic inertia. Evidence increasingly supports protocol-driven

combination therapy, particularly when blood pressure is substantially above target. Procurement systems must ensure that standard combinations match national treatment protocols.

Artificial intelligence and sensor-based risk prediction

Research is exploring smartphone photoplethysmography, retinal imaging and machine-learning models for low-cost cardiovascular risk estimation. Proof-of-concept studies are promising, but most have been developed in non-rural or high-income datasets and require external validation before routine use. Algorithmic accuracy should be compared with simple WHO non-laboratory models, not merely with no assessment.

Precision versus public-health simplicity

New biomarkers and polygenic risk scores may refine prediction, but their added value in rural screening is uncertain. A complex model that requires expensive tests may identify risk more precisely while reaching fewer people. The appropriate innovation is the one that improves clinical outcomes and equity, not simply statistical discrimination.

Challenges and Limitations

The evidence supporting population screening is stronger for detecting and treating hypertension than for broad, indiscriminate cardiovascular testing. Routine electrocardiography, echocardiography, carotid ultrasound or coronary calcium scanning of asymptomatic low-risk rural adults is unlikely to be feasible or cost-effective and can generate incidental findings and unnecessary referral.

Risk models can misclassify individuals when applied outside the population in which they were calibrated. WHO charts reduce but do not eliminate this problem. India-specific prospective event data remain limited, and many studies evaluate predicted rather than observed events.

Screening programmes are vulnerable to the **inverse care law**: those with greater need may be least able to complete follow-up. Seasonal migration, agricultural work, difficult terrain and gendered mobility constraints can interrupt care.

Another challenge is therapeutic capacity. Detecting thousands of people with elevated blood pressure creates an ethical obligation to provide diagnosis, counselling, medicines and monitoring. Screening expansion without corresponding investment may overwhelm primary-care teams.

Finally, risk communication is difficult. Labelling an asymptomatic person as “high risk” can cause anxiety, while a low ten-year score may falsely reassure a young smoker or person with severe obesity. Communication should distinguish short-term risk from lifetime prevention.

Future Directions and Policy Priorities

Rural programmes should adopt a cascade-based framework: population enumerated, screened, positive, confirmed, treated, retained and controlled. Each step should be disaggregated by sex, age, socioeconomic group, remoteness and social vulnerability.

Non-laboratory WHO risk assessment should be available at the first point of contact, with selective laboratory testing when it will alter management. Treatment protocols should be simple, drug- and dose-specific and supported by uninterrupted supplies, consistent with WHO HEARTS principles.[8]

Rescreening intervals should be risk-based. Low-risk individuals with normal measurements may not require annual comprehensive assessment, whereas people with elevated blood pressure, diabetes or tobacco use need earlier review. Research should determine cost-effective intervals for Indian rural populations.

India requires prospective validation of risk models against actual myocardial infarction, stroke and cardiovascular death. District-level implementation studies should compare outreach camps, household screening, facility-based screening and hybrid approaches.

Referral should be closed-loop. Primary-care teams need confirmation that referred patients attended, what diagnosis was made and how treatment should continue locally. Teleconsultation

can support this process but should not become a substitute for accessible emergency and specialist care.

Most importantly, screening must be accompanied by population-level prevention. Tobacco regulation, salt reduction, clean household and ambient air, healthy food environments, physical-activity opportunities and affordable essential medicines can reduce risk across the entire rural population.

Conclusion

Cardiovascular risk stratification can strengthen rural screening by shifting attention from isolated risk factors to the probability of future heart attack and stroke. The WHO laboratory and non-laboratory charts provide practical tools for resource-limited settings, but their value depends on accurate measurement, appropriate interpretation and linkage to treatment.

Community health workers and non-physician providers can extend reach, yet evidence shows that benefit arises when screening is combined with standardized protocols, medicines, supervision and continued follow-up. Counting people screened is therefore an inadequate measure of success. India's population-based NCD screening programme has created a valuable platform for rural cardiovascular prevention. The next priority is to strengthen the care cascade: confirm abnormal results, estimate total risk, initiate appropriate treatment, maintain medicine supply and achieve durable blood-pressure and diabetes control.

Rural cardiovascular screening should be simple enough to scale, accurate enough to guide treatment and sufficiently integrated to prevent loss to follow-up. Its ultimate objective is not early detection alone, but fewer avoidable myocardial infarctions, strokes, disabilities and deaths.

REFERENCES

1. WHO CVD Risk Chart Working Group. World Health Organization cardiovascular disease risk charts: revised models to estimate risk in 21 global regions. *Lancet Glob Health*. 2019;7(10):e1332-e1345. doi:10.1016/S2214-109X(19)30318-3.
2. Schwalm JD, McCready T, Lopez-Jaramillo P, Yusoff K, Attaran A, Lamelas P, et al. A community-based comprehensive intervention to reduce cardiovascular risk in hypertension (HOPE 4): a cluster-randomised controlled trial. *Lancet*. 2019;394(10205):1231-1242. doi:10.1016/S0140-6736(19)31949-X.
3. Ministry of Health and Family Welfare, Government of India. Training modules for prevention and management of non-communicable diseases [Internet]. New Delhi: National Health Mission, Ministry of Health and Family Welfare, Government of India; 2025 [cited 2026 Aug 6]. Available from: <https://nhm.gov.in/>
4. Kulothungan V, Nongkynrih B, Krishnan A, Mathur P. Ten-year risk assessment for cardiovascular disease and associated factors among adult Indians aged 40–69 years: insights from the National Noncommunicable Disease Monitoring Survey. *Indian J Med Res*. 2024;159(5):429-440. doi:10.4103/ijmr.ijmr_1882_23.
5. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, et al. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. *JAMA*. 2013;310(9):959-968. doi:10.1001/jama.2013.184182.
6. Anjana RM, Unnikrishnan R, Deepa M, Pradeepa R, Tandon N, Das AK, et al. Metabolic non-communicable disease health report of India: the ICMR-INDIAB national cross-sectional study. *Lancet Diabetes Endocrinol*. 2023;11(7):474-489. doi:10.1016/S2213-8587(23)00119-5.
7. Longkumer I, Kaur G, Kaur S, et al. Trends in hypertension prevalence, awareness, treatment and control in a rural community: an eight-year follow-up study from North India. *Sci Rep*. 2023;13:10092. doi:10.1038/s41598-023-37082-4.
8. World Health Organization. HEARTS: technical package for cardiovascular disease management in primary health care [Internet]. Geneva: World Health Organization; 2020 [cited 2026 Aug 6]. Available from: <https://www.who.int/publications/i/item/heart-technical-package>

9. World Health Organization. WHO package of essential noncommunicable disease interventions for primary health care [Internet]. 2nd ed. Geneva: World Health Organization; 2020 [cited 2026 Aug 6]. Available from: [https://www.who.int/publications/i/item/who-package-of-essential-noncommunicable-\(pen\)-disease-interventions-for-primary-health-care](https://www.who.int/publications/i/item/who-package-of-essential-noncommunicable-(pen)-disease-interventions-for-primary-health-care)
10. Zhou B, Carrillo-Larco RM, Danaei G, Riley LM, Paciorek CJ, Stevens GA, et al. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet*. 2021;398(10304):957-980. doi:10.1016/S0140-6736(21)01330-1.