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Integrated Cardiovascular Care System: Assessment of a complete implementation of a comprehensive cardiac system of care for Detection and Management of Cardiovascular Diseases in Ambala: A Pilot program.

Dr. Sukhpreet Singh, Dr. Kuldeep Singh, Dr. Hitesh Verma
ASMO (Medical Officer), Directorate General of Health Services, ASMO (Medical Officer)
Civil Surgeon Office, Ambala, Government of Haryana, 134003

Abstract:

Background: Cardiovascular diseases (CVDs) are a significant health challenge in Haryana, India, exacerbated by limited healthcare access, particularly among marginalized and economically disadvantaged communities. This disparity contributes to higher mortality rates and a greater disease burden in Haryana compared to the national average, highlighting the urgent need for innovative interventions.

Materials & Methods: This study assesses the implementation of a digitized cardiac care system in Ambala, aiming to improve CVD detection and management. The pilot introduced portable and digitized 12-lead ECG machines connected to mobile apps, enabling real-time diagnosis by specialists. A live dashboard facilitated monitoring, rapid diagnosis, and timely referrals. The system was implemented in five public health facilities in Ambala from January to November 2023.Using a mixed-methods approach, the study combined qualitative interviews and focus group discussions with healthcare professionals, exploring the platform's impact on early CVD detection. Quantitative data from the dashboard helped evaluate clinical outcomes.

Results and Discussions: The pilot project successfully collected around 15,000 ECG records, with diagnoses made in an average turnaround time of 3.5 minutes, leading to improved patient outcomes. However, challenges such as cardiologist shortages and gaps in the emergency medical system were identified. The study also highlighted the high prevalence of Ischemic Heart Diseases in Ambala, with Acute Myocardial Infarction being the most common condition, followed by Atrial Fibrillation and Ischemia.

Conclusion: The results indicate that the digitized cardiac care system significantly improved CVD management, enhanced care quality, and streamlined coordination with referral centers for timely treatment. These findings

suggest that the model, with adequate resources, can be successfully scaled across Haryana, offering an innovative solution to the region's cardiac care challenges.

Keywords: Digitised & doctor verified Cardiac system of Care, Cardiovascular Disease Detection & Management, STEMI in Public Health, Golden Hour & Mortality Rate, Real-time Monitoring Dashboard & Care Coordination, Pilot Program.

Key Messages:

What is already known on this topic:
Cardiovascular diseases (CVDs) are the leading cause of mortality in Haryana, exacerbated by inadequate healthcare infrastructure, rural-urban disparities, and limited adherence to critical treatment timelines like the "golden hour."

What this study adds:
The Ambala pilot implemented a digitized cardiac care system with portable ECG devices and real-time specialist support, reducing diagnostic turnaround to 3.5 minutes and enabling timely detection and referral of critical cases such as STEMI and identifying a pattern of CVD prevalence- specifically Acute MI and Ischemia, which needs early identification and necessary interventions to reduce the mortality burden of the state.

How this study might affect research, practice, or policy:
The pilot's success in providing improved cardiac care to all strata of the populace 24/7- highlights the feasibility of scaling such systems to improve cardiac care statewide. It demonstrates the value of integrating technology with training and public awareness to enhance early detection, efficient treatment, and healthcare equity.

Introduction:

1.1. Background:

Cardiovascular diseases (CVDs) represent a significant public health challenge in the state of Haryana, India. Situated in the northern region of the country, Haryana is characterized by a diverse population with varying socio-economic conditions and lifestyles, contributing to the complex landscape of CVDs in the state (WHO, 2021). Haryana, like many regions in India, is grappling with the rising burden of cardiovascular diseases. CVDs encompass a range of conditions affecting the heart and blood vessels, with coronary artery disease, hypertension, and stroke being among the most common (India: Health of the Nation's States).

Multiple factors contribute to the high incidence of CVDs in Haryana. Lifestyle-related risk factors, such as poor dietary habits, physical inactivity, tobacco use, and excessive alcohol consumption, are significant drivers of CVDs. Additionally, genetic predisposition and a growing elderly population further exacerbate the problem (Yusuf et al., 2004).

CVDs in Haryana are not evenly distributed across the state. Urban and rural disparities, as well as variations in access to healthcare services, create unique challenges in disease management. Additionally, burden of CVDs often disproportionately affects marginalized and economically disadvantaged communities in Haryana (Mullen et al., 2016). Efforts have been made to address the growing CVD burden in Haryana. The government has implemented various public health programs and policies aimed at promoting healthy lifestyles, early diagnosis, and affordable

treatment options for CVDs. However, effectiveness of these initiatives can vary, and continued efforts are needed to combat this health challenge effectively (Prabhakaran et al., 2017).

The supplementary table 1 highlights how Haryana is more affected in terms of mortality rate and Leading causes of DALYs (Disability-adjusted life years) than compared to overall India, indicating cardiovascular disease burden and its consequent impact on the populace of Haryana (India: Health of the Nation's States).

Leading cause of DALYs due to IHD is 11.7% and that of India is 8.7%, i.e. 3% more on average (India: Health of the Nation's States). Demographic prevalence of CVDs in Haryana has been found more in males compared to the females, whereas premature deaths in early productive years of life due to this disease burden, adds on to out of pocket expenditure, leading to poverty and economic burden of the state parallelly (India: Health of the Nation's States).

Current Scenario in India showcases that the average time of treatment (urban) of a cardiac patient/ Acute MI patient is around 4-6 hours, which is way beyond ***'the golden hour of 90 minutes'*** of the treatment, making it difficult for survival of the cardiac patient concerned (Thakur et al., 2020).

By reducing delay in presentation and thereby treatment, triaging and management- it is only possible to reduce the extent of damage in the heart muscles/ myocardial salvage. The main goal is to address the criticality of this time-dependent period to provide effective treatment and manage cardiac patients in a competent triaging manner for better survival outcomes (Guha et al., 2017).

National STEMI (ST-Elevation Myocardial Infarction) Guidelines serve as a crucial framework for the standardized and effective management of heart attack cases across the country. However, despite their significance and proven benefits in improving patient outcomes, implementation of these guidelines in Haryana is still pending. These guidelines, tailored to streamline the diagnosis, treatment, and management of STEMI cases, offer a structured approach to emergency care, including timely interventions like thrombolysis or primary percutaneous coronary intervention (PCI). Absence of their execution in Haryana suggests a gap in aligning local healthcare practices with these nationally recommended protocols, potentially impacting timely delivery of life-saving treatments for individuals experiencing a heart attack. Integration of the National STEMI Guidelines in Haryana's healthcare system stands as an important step towards ensuring standardized, high-quality care for cardiac emergencies, thereby potentially saving lives and reducing the burden of cardiovascular diseases in the region.

1.2 Lacunas in CVD Management in Haryana:(A short Gap- Analysis)/ Rationale

1. *Limited Cardiac Care Infrastructure:* Haryana has struggled with limited cardiac care infrastructure. Currently, the State has only four cardiac cath labs, predominantly operated in public-private partnership (PPP) mode. This limited infrastructure makes it difficult for residents, especially in rural areas, to access critical cardiac care services.

2. *Lack of ECG Services:* Electrocardiography (ECG) services, vital for comprehensive cardiac diagnostics, are available only up to community Health Center (CHC) levels and that too not uniformly within the state. This scarcity of ECG services impedes early detection and thorough evaluation of heart-related conditions. ECHO machines have been provided at selected District Civil Hospitals, however due to lack of trained specialists, they are lying unutilized, leading to a gap in cardiac failure detection methods in the early stages.

3. *Interpretation Skill Gap:* One of the most significant challenges in CVD management is the shortage of the requisite skills to accurately interpret electrocardiogram (ECG) results. As a result, a substantial number of patients at risk of cardiac events are being missed, leading to delayed diagnoses and treatments.

4. *Shortage of Physicians/Specialists:* Scarcity of physicians, cardiologists or medical officers in various districts of Haryana hampers the effective implementation of structured CVD programs and the National ST-Elevation Myocardial Infarction (STEMI) guidelines. This shortage of medical professionals affects the state's ability to provide timely and efficient cardiac care services.

5. *Unavailability of data access:* Unavailability of structured data monitoring and evaluation systems for CVDs further makes it difficult to make informed decisions.

These factors highlight the need for implementing a digitized, comprehensive, 24/7 doctor-verified cardiac care system. This system aims to enable faster and more accurate detection of cardiovascular diseases while establishing a robust management protocol for timely treatment and referral for reperfusion therapies, as demonstrated by the Ambala Pilot Project.

1.3. Haryana's effort to tackle the burden and challenges:

CVDs as the leading cause of death, contribute to approximately 80-85% of NCD mortality in India, accounting for around 50 lakh deaths out of the total 65-70 lakh NCD-related deaths. This makes up a significant portion of the 1 crore total annual deaths recorded in the Indian population.

CVDs pose a significant health challenge in the state of Haryana, with various obstacles hindering their effective management. The State Government is actively working to address these gaps in CVD care by implementing targeted measures and initiatives.

Cath Labs in PPP mode: The Government of Haryana faces a shortage of cardiologists within the Haryana Civil Medical Services. To address this, the government has established cardiac catheterization labs under the Public-Private Partnership (PPP) model, thereby enhancing access to specialist care for the public. Currently, there are four cath labs located in the civil hospitals of Ambala, Panchkula, Faridabad, and Gurgaon, staffed with cardiologists who contribute to improving CVD management across the State.

Thrombolytics drugs availability: The Govt. of Haryana has already devised plans for training provisions to doctors for proper thrombolysis at the PHC and CHC levels and even for medicine procurement, specifically the high-level thrombolytic agents namely- Alteplase, Reteplase and Tenecteplase- all are in the essential drug list to be procured by the Govt and are in all District Headquarters of the Govt.

Ambulance availability: State-of-the-art Advanced Life Support ambulances, equipped with multiparameter monitors and staffed by trained Emergency Medical Technicians (EMTs), have been deployed across all districts, with a total of 400 ambulances in service to ensure the safe transport of patients. Additionally, multiparameter monitors have been procured for numerous healthcare facilities, including Primary Health Centers (PHCs) and Community Health Centers (CHCs).

The State of Haryana spans an area of approximately 44,000 square kilometers, divided into 22 districts, each covering around 2,000 square kilometers. To strengthen inter and intra district connectivity, the government is establishing a network centered around District Headquarters in these areas. The state is linked to four cardiac

catheterization labs located in district hospitals through a Public-Private Partnership (PPP) model and two government medical colleges, providing a total of six advanced cardiac care facilities for managing and treating cardiovascular patients. However, these cath labs have been established in suboptimal locations, limiting their accessibility and effectiveness.

The Government acknowledges the need for a digitized, comprehensive cardiac care system to deliver 24/7 diagnostic services. This initiative is designed to enhance early diagnosis and improve overall management, effectively tackling the increasing burden of CVDs and the related challenges faced by the state.
District Ambala has chosen Tricog Health India's advanced digitized platform for a pilot study targeting the district's population. This decision is based on its proven effectiveness, as highlighted in literature, including its successful implementation in Goa's STEMI management program. The platform is designed to provide real-time cardiac diagnostics, streamline workflows, and improve the timeliness and accuracy of detecting and managing critical cardiac conditions like STEMI. By leveraging this technology, the initiative aims to strengthen Ambala's healthcare infrastructure for cardiovascular diseases, offering enhanced diagnostic capabilities, treatment protocols, and referral mechanisms to address the growing cardiac care needs of the region. (Salve et al., 2021)

1.4 Objectives of the pilot programme:

1. Evaluate the effectiveness of the digitized ECG machine, complemented by consultation reporting from specialists, in detecting cardiovascular diseases.

2. Determine the potential impact of this technology and feasibility to scale-up the same on improving the timely detection and referral of cardiovascular disease cases.

2. Materials & Methods: *Ambala Pilot:(January 2023- November 2023)*

2.1 Study setting & Methodology:

The Government of Haryana has made significant strides in improving access to cardiac catheterization lab facilities, extending services not only to Ambala but also to its rural areas, as highlighted in Supplementary Figure 1. However, a critical challenge remains—the lack of accessible specialized doctors or cardiologists to interpret ECG reports (as per Supplementary Appendix 2) and provide timely diagnoses. This gap hampers the effectiveness of further treatment planning and intervention for patients. Bridging this gap is crucial to ensure that the facilities are fully optimized, enabling early detection of cardiac conditions and seamless referral for advanced care when necessary. Strengthening the availability of expert medical professionals is key to addressing this pressing issue and enhancing the overall quality of cardiac care in the state.

Recognizing this challenge, it was decided that a concrete intervention was needed at the community level to diagnose and treat CVDs. Deployment of a digitized comprehensive cardiac system of care for timely detection and management of CVDs includes a 12-lead digitized portable ECG platform linked to mobile phones with dedicated apps, having round-the-clock diagnosis services by doctors, a real-time monitoring and evaluation dashboard system to enhance timely CVD detection and management in the healthcare facilities of District Civil Hospital (DCH) Ambala City, Sub-District Civil Hospitals (SDCH) Ambala cantt and Naraingarh, TB Hospital Ambala City, and CHC Barara.

2.2 Implementation Workflow: Protocol

When a symptomatic patient visits the Emergency Outpatient Department (OPD), a 12-lead ECG is routinely performed as part of the initial diagnostic process. Emergency OPD doctors are trained to carefully evaluate all symptoms that could potentially indicate a cardiac event, such as an infarct, or other cardiac-related conditions. Even when patients present with atypical symptoms, such as pain in the trunk region, the attending doctors will prioritize conducting a 12-lead ECG. This diagnostic approach ensures that possible cardiac issues are identified promptly. Based on the ECG findings, the medical team can make informed decisions about the patient's treatment plan, enabling timely and accurate interventions to improve outcomes (a detailed flow chart of STEMI protocol to be followed has been charted in Supplementary Appendix-1).

As the 12 leads are connected to the appropriate areas on the patient's body, the ECG data is automatically transmitted digitally to a team of Cardiologists located at the service provider's office (Bhograj et al., 2019). The Cardiologists are responsible for generating the ECG report within a turn-around time of 5- 10 minutes. This report is accessible through the app and is also distributed via WhatsApp or can be printed through any regular printer connection. The doctor in the health facility thus makes an informed decision based on the diagnosis to further treat/ refer the patient in the nearby Cath Lab in the District Hospital.

All healthcare personnel with the app receive immediate access to the ECG report as soon as it becomes available. In cases where the ECG results indicate a critical condition, an alarm sets off indicating the alert that the patient requires immediate attention for further treatment procedures, and simultaneously, a cardiologist from the service provider's team contacts the attending physician at the relevant Health Care Facilities to bring the criticality of the patient to their attention. This ensured that no critical patients went untreated. Access to a dashboard for monitoring the daily progress of healthcare facilities was also provided to the administrative authorities for necessary monitoring and evaluation.

Study Size: Around 11,200 ECGs were collected in the study time frame of the pilot for rapid diagnosis of critical cases. All the patients having cardiac symptoms, over 18 years of age had been considered.

2.2.1. Research Method outline :

The research utilized a mixed method approach to investigate the implementation of the cardiac system of care across five public health facilities in Haryana from January 2023 to November 2023.

Participants: Qualitatively, the study involved conducting interviews and focus group discussions *with healthcare professionals from two healthcare facilities in Haryana*. This qualitative aspect aimed to assess the impact of a comprehensive digitized platform on the early intervention of cardiovascular disease cases. Simultaneously, the quantitative phase involved statistical analysis of predetermined parameters tracked on a real-time dashboard taken *from symptomatic patients undergoing ECG, who are 18 years or older.*

This quantitative component aimed to measure and monitor the clinical outcomes of the pilot program. By integrating these methods, the study obtained a comprehensive understanding of the program's impact, providing detailed insights into the research outcomes.

Data Collection and Analysis: All ECG cases, above 18 year participants, based on random sampling (in the entire period of study) were included for analysis on demographics, treatment and outcomes. Descriptive data analysis and

survival analysis were done using IBM SPSS Statistics 29.0.1.0. No potential bias has been introduced in the sampling or analytical processes.

2.2.2. Unique Features of the digitized comprehensive cardiac system of care:

i. *Continuous 24/7 Reporting by a Specialist:* the platform allows technicians to promptly identify critical cases, even when no specialist is present at the facility or during off-duty hours.

ii. *Durable and Compact ECG Machine:* This platform of ECG machines are built to be sturdy and damage-resistant, reducing the need for frequent maintenance.

iii *Paperless Solution:* The platform eliminates the need for ECG paper, as digital reports are readily available and can be shared via mobile devices. If a hard copy is necessary, the ECG can be printed on A4-sized paper.

iv. *Portable ECG Machine:* The ECG machine is easily transportable and can be used in various locations, including medical camps.

v. *Battery-Free Operation:* The machine can run on a phone battery when connected, eliminating the need for external power sources or additional batteries.

vi. *Teleconsultation:* A care coordination app enables teleconsultations between primary and the cath lab health facilities.

vii. *Interpretation of Critical Reports in Under 10 Minutes:* Critical reports are interpreted and delivered within a speedy 10-minute timeframe.

viii. *Critical Alert Notifications Through the App:* The app provides critical alert notifications within the facility.

ix. *Dashboard and Application for Real-Time Monitoring:* Officials have access to a dashboard and application for real-time monitoring of ECG data.

x. *Follow-up Calls by the Service Provider Team for Critical Patients:* Critical patients receive follow-up calls from the Service Provider team, connecting them with doctors as needed.

xi. *24/7 Toll-Free Support Number:* It was informed that round-the-clock toll-free support number is available for assistance and maintenance. It was provided to the healthcare facilities to reach out to the helpline number for any technological or otherwise assistance, if needed.

2.3 Ethical approval and Informed Consent:

Ethical clearance was obtained from the Institutional Ethical Committee, Civil Surgeon Office, Ambala, Haryana (Supplementary Appendix- 4). Informed consent was secured from participants (Supplementary Appendix 3), and data handling complied with privacy regulations and ethical standards.

3. Results & Discussions: Pilot outcomes:

3.1 Quantitative assessment on the implementation processes:

As of November, 2023, the pilot project yielded the following results:

11,200 ECGs were categorized into Normal, Abnormal and Critical-

Normal ECGs (4329 people): A normal electrocardiogram (ECG) depicts the typical electrical activity of the heart within normal ranges, indicating a healthy cardiac function.

Abnormal ECG (5916 people): An abnormal electrocardiogram (ECG) shows deviations from the expected or healthy electrical patterns of the heart, suggesting potential cardiac irregularities or conditions.

Critical ECG (962 people): A critical electrocardiogram (ECG) signifies immediate medical attention is required due to severe or life-threatening cardiac abnormalities or acute conditions detected in the heart's electrical activity.

The detail is tabulated in Table 1. The facility-wise distribution with demographic patterning as per age categories have been illustrated in Figures 1 and 2.

These ECGs were distributed among various healthcare facilities, with different numbers of normal, abnormal, and critical cases. 8.58% of the total patients were found to be critical. Out of the 962 patients with critical ECGs, 200 of them were STEMI Critical, which accounted for 1.78% of the total population who were screened. These critical patients were provided with initial treatment and referred to the Cath Lab in the District Hospital, Ambala for timely intervention. The remaining 5916 patients with abnormal ECGs were referred to physicians for further treatment. The overall turn around time for reporting and diagnosis was around 3.5 minutes.

As per the distribution of screenings in the different Health facilities at Ambala, DCH Ambala followed by Civil Hospital Ambala Cantt and SDH Naraingarh screened the most number of patients because of highest footfall and thereby had the most critical patients identified who were then triaged for treatment at the higher center at the earliest for better survival outcomes.

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Here, in this graph, it clearly indicates that the cardiac criticals and mostly screened individuals in the Health facilities range in the age group of 61-70 years- the age where an individual is most at risk for a cardiovascular symptom.

It is noticed that the critical male population footfall is around 55.8% of the total critical cases observed whereas it is around 44.2% of female critical case prevalence.

As evident from supplementary table 2 and the graphical representation in supplementary figure 2, males are more susceptible to critical cardiac conditions in the population screened, as compared to women of the same age range and the mean age for critical cardiac ailment is consistent at all Health facilities within the age range of 60-70 years of age, though at CHC Barara, it is noticeable that males even at 55 years of age, are getting more affected with critical cardiac conditions, and that needs to be addressed in this particular population cohort being screened. Interestingly, 754 Female patients and 741 male patients were a part of the pilot, making the female: Male ratio of screening= 1.01:1.

The supplementary table 3 and the box-plot graph presentation in Figure 3 clearly demonstrate that across all the 5 Health facilities at Ambala, the mean turn-around time is consistently found to be between 3-3.5 minutes which is

quite an effective turn-around-time of detection for the critical patient identification for further treatment triaging and better survival outcomes. It is also to be noted here that **14.65%** of the total critical patients were detected at odd-hours or beyond working hours during the middle of the night, which emphasizes on the efficiency of the digitized cardiac system of care implemented round the clock.

A comprehensive supplementary table 4 and illustration of figure 4- the graph exhibit the screening of the number of patients for individual and most commonly occurring cardiac ailments (AFIB- Atrial Fibrillation; ACUMI- Acute Myocardial Infarction; VT- Ventricular Tachycardia; OLD MI- Old/ Evolved Myocardial Infarction; ISCHEMIA; and CHB- Complete Heart Block at different Health facilities and the respective turn around time of management for each of these cardiovascular diseases, indicating the pattern of most common and critical CVD case footfall at the Health facilities and their respective turn around time of diagnosis for further management, which in most cases, as observed is within 5 minutes and lower, an excellent framework for every CVD case management.

The most prevalent patterns found occurring in the population cohort were Acute Myocardial Infarctions, followed by Atrial Fibrillation and Ischemia, with next in prevalence occurrence of Ventricular Tachycardia and Complete Heart Block. The Ischemic Heart Disease (IHD) which is characterized- constituting ACUMI, OLD MI and ISCHEMIA hence has been found to be the most prevalent cardiac condition in the state of Haryana. These diseases were diagnosed within 2.5-3 minutes of their presentation reflecting a well-managed triaging process of the pilot implementation.

The outcome as identified through these pilot can be highlighted in these major pointers:

- Timely and precise diagnosis of the Cardiac Ailments were reported.
- Timely referral and triaging lead to greater survival outcomes of critical patients.

3.2 Qualitative assessment on the implementation processes:

Qualitative analysis of the interviews with medical professionals from SDH Naraingarh and CHC Barara reveals insights into their CVD/STEMI management practices and the impact of a digitized comprehensive cardiac system of care. Following is a consolidated qualitative analyses encompassing both centers:

CVD Management Practices:

i. Both centers follow a similar approach to CVD/STEMI management, involving symptom-based patient identification and immediate ECG assessment.

ii. Loading doses of medications such as Aspirin, Clopidogrel, and others are administered to suspected STEMI patients before referring them to higher cardiac centers.

A digitized comprehensive cardiac system of care:

i. Introduction of a digitized comprehensive cardiac system of care has significantly improved the entire diagnosis and management process.

ii. It assists in accurate interpretation, especially in absence of cardiac specialists, leading to better referral decisions and also reducing unnecessary referral burden on the referred cath labs or higher cardiac facilities.

Patient Footfall:

i. Digitized comprehensive cardiac system of care has contributed to an increase in the number of patients undergoing ECG testing at both centers.

Follow-Up Systems:

ii. Both centers have established systems for tracking and follow-up of critical patients, recording ECG details, severity, and contact information for further monitoring, in properly labeled registers.

Challenges and Suggestions:

i. Challenges include minor discrepancies in reporting and the preference for physical copies of ECG reports.

ii. Technical issues, such as compatibility with mobile handsets, are reported but are being addressed.

Coordination with Referral Centers:

i. Both centers coordinate with referral centers, providing patient details and pre-intimations.

ii. Coordination with ALS ambulances for patient transfers is efficient.

Quality of Care Metrics:

i. Improved quality of care is evident through better survival outcomes and early detection of critical patients.

ii. A Digitized ECG platform, complemented by specialist opinions & diagnosis, and proper Monitoring & Evaluation have contributed to these improved outcomes.

Patterns in Other Critical Patients:

i. While no specific patterns are reported in the detection of other critical CVD cases, all centers adhere to the "Golden Hour" for critical patient management.

Training for Doctors:

i. In primary care centers, where there are no physicians available, the doctors with M.B.B.S. degrees disclosed that they do not feel confident enough to interpret the ECGs and they were happy to receive the digitized interpretation from the platform to make informed decisions.

ii. Both centers mention the lack of physical training for doctors. Online platforms are used for training, but hands-on training is needed.

iii. Lack of training has been brought forward by the doctors as a concern and hence requested for a comprehensive on-site training for managing CVD cases in Primary Healthcare Centers.

Awareness:

i. While there has been an improvement in awareness regarding CVD symptoms, as identified in both the centers, yet there is still a significant gap that needs to be addressed through Information, Education and Communication measures (IEC). A pamphlet for IEC measure has been provided in Supplementary Appendix 5.

Overall, the introduction of a digitized comprehensive cardiac system of care has positively impacted the CVD/STEMI management process at SDH Naraingarh and CHC Barara, leading to early detection and timely referrals of critical patients, despite the challenges faced in terms of report distribution and patient awareness. Collaborative approach of both centers can contribute to better patient care and improved outcomes.

Best Practices: Follow-up monitoring of the identified critical patients in SDH Naraingarh and the availability of a STEMI kit that includes all the loading dose medications at a place in managing CVD cases in times of emergencies, as reported in CHC Barara are some of the best practices being followed for early detection, triaging, management, referral and subsequent treatment procedures for the critical patient concerned and also for evaluation and monitoring of the patient in the long-run to have updates on the survival outcomes.

Implementation of a digitized comprehensive cardiac system of care at Ambala has brought about a significant transformation in cardiovascular disease (CVD) management. This innovative technology has not only improved the diagnostic process but also positively impacted the quality of care, leading to better patient outcomes.

An interesting observation has been the increased patient footfall. Introduction of a digitized comprehensive cardiac system of care seems to have encouraged more patients to seek ECG testing. This reflects a growing awareness of the technology and the desire for better cardiac care. The knowledge that advanced technology is available has attracted more patients to access these services, thus potentially improving early detection and treatment for CVD. Patients have expressed their gratitude for the prompt and effective management of their conditions, and these positive outcomes reinforce the importance of the technology.

The Government of Haryana could infer from the above analyses that this digitized comprehensive cardiac system of care is a much needed platform for better management and intervention with respect to cardiovascular diseases. This can complement with the Government of Haryana's efforts in tackling the burdens and challenges posed forward by the rising cases of CVDs in Haryana. With appropriate solutions and continuous monitoring, the system can be optimized for even more significant benefits.

As the technology continues to evolve and adapt to the CVD healthcare landscape in Ambala, it holds the promise of significantly improving cardiac care and patient outcomes in the region. The government's suggestive step to scaling up this technology is tentatively a measure in the right direction towards achieving the goal of improving cardiac care in the state.

3.2 Discussions:

The pilot program conducted in Ambala revealed a substantial number of undetected cases, notably around 962 Critical cases of which 200 ST-elevation myocardial infarction (STEMI) cases, previously overlooked. This program has not only enhanced the diagnostic capabilities but also facilitated prompt referrals, ultimately leading to saving lives that might have otherwise been lost due to undiagnosed cardiac conditions.

Therefore, the Government of Haryana might consider the following during scale up:

3.2.1. Comprehensive Deployment of digitized comprehensive cardiac system of care: Full-scale implementation of a digitized comprehensive cardiac system of care across healthcare facilities throughout Haryana might be considered, to ensure widespread accessibility and utilization.

3.2.2. Training and Integration Initiatives: Initiating specialized training programs for healthcare professionals is crucial to seamlessly integrate digitized ECG platforms into existing healthcare systems, ensuring effective utilization and accurate diagnosis. Alongside, it is also important to train the physicians and doctors for initial management and triaging of CVD patients.

3.2.3. Public Awareness Campaigns: Initiating awareness campaigns aimed at educating the public about the importance of regular cardiovascular health check-ups and the availability of a digitized comprehensive cardiac system of care could significantly contribute to early detection and prevention of CVDs.

3.2.4. Collaboration and Partnerships: Encouraging collaboration between governmental bodies, healthcare providers, and technology firms can foster innovation and the development of advanced digitized comprehensive

cardiac systems of care tailored to address Haryana's specific healthcare needs. This includes collaboration with 7-8 private medical colleges, with whom, the Govt. of Haryana is envisioning to enter into MOUs to provide a complete coverage of patient management, treatment and care for CVD patients.

3.2.5. Preventive Screening for CVD: One of the noted unique features of this digitized cardiac system of care is the portability of the 12- lead ECG platform making it conducive and advantageous to be used in preventive screening camps for CVD or along with the Government of India NCD Screening Package, paving the way for earlier detection and diagnosis of CVD cases.

3.2.6. Monitoring and Evaluation: Establishing a monitoring and evaluation framework to assess the efficacy and impact of this digitized cardiac system of care on reducing the mortality burden associated with CVDs in Haryana is imperative. During the pilot programme, it has been noted that around 52.79% of individuals were detected with Abnormal ECGs which is equally a concerning matter and needs to be probed and acted on by the physicians and the doctors to combat the long-term mortality and morbidity rates of CVD cases, as these cases may further get aggravated to critical conditions of CVD.

3.2.7. Limitations: The study was limited to the geographic scope of Ambala in a short duration (11 months), which restricted generalizability and long-term outcome assessment, but can be reproducible on scale-up.

These pointers, if implemented effectively, have the potential to significantly enhance the state's cardiovascular healthcare landscape, ensuring timely detection, intervention, and improved management of cardiovascular diseases across all demographics in Haryana.

Author affiliations: **1. Dr. Kuldeep Singh,** Civil Surgeon Ambala, Civil Surgeon Office, Ambala, Haryana-134003; **2. Dr. Sukhpreet Singh**, ASMO, Civil Surgeon Office, Ambala, Haryana- 134003; **3. Dr. Hitesh Verma**, ASMO, Civil Surgeon Office, Ambala, Haryana- 134003.

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Figures & Tables:

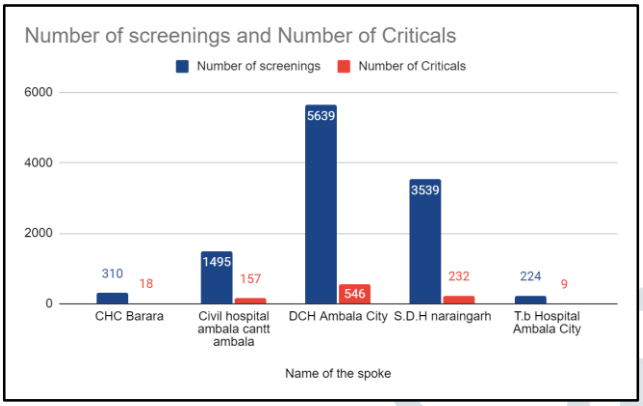


Figure 1a: Facility-wise distribution of the number of screenings recorded in each of the Health facilities over the pilot tenure.

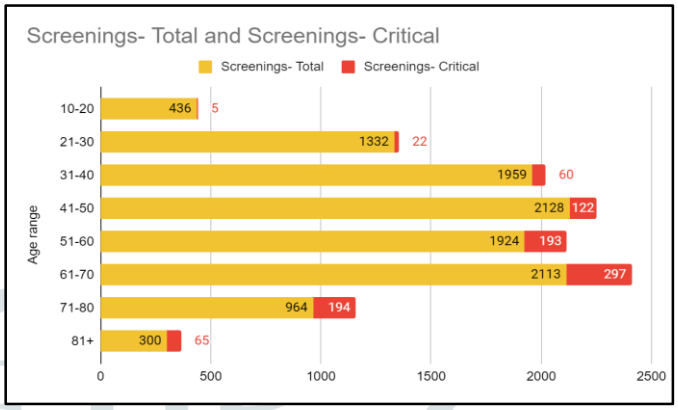


Figure 1b: Total screenings and Criticals identified plotted against age ranges for the population screened for CVD detection at different Health facilities at Ambala, Haryana.

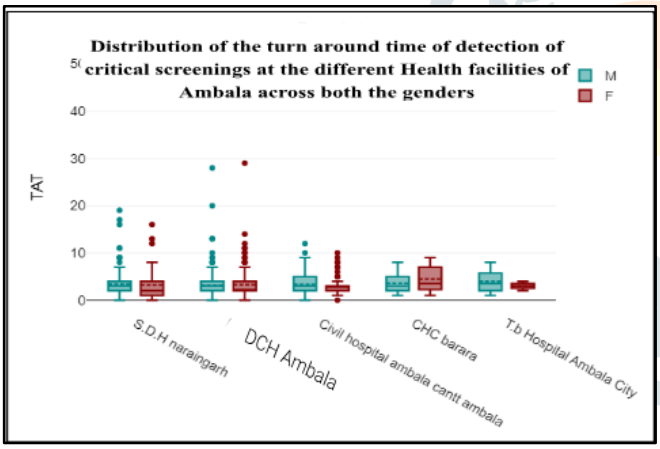


Figure 2: This box plot demonstrates the distribution of the turn around time of detection of critical screenings at the different Health facilities of Ambala across both the genders.

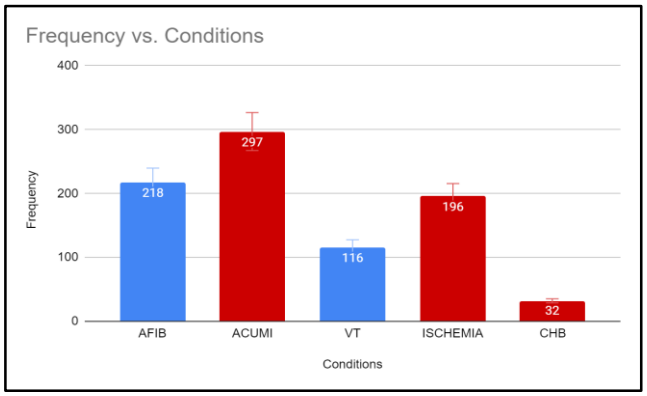
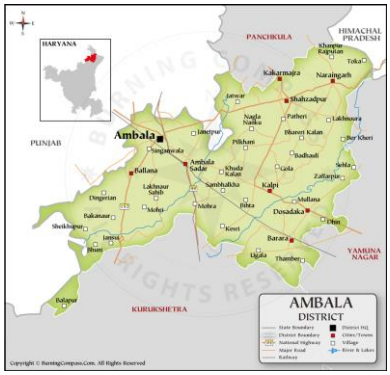


Figure 3: Representation of the screening of the number of patients for individual and most commonly occuring cardiac ailments at different Health facilities and the respective turn around time of management for each of these identified cardiovascular diseases at Ambala, Haryana.

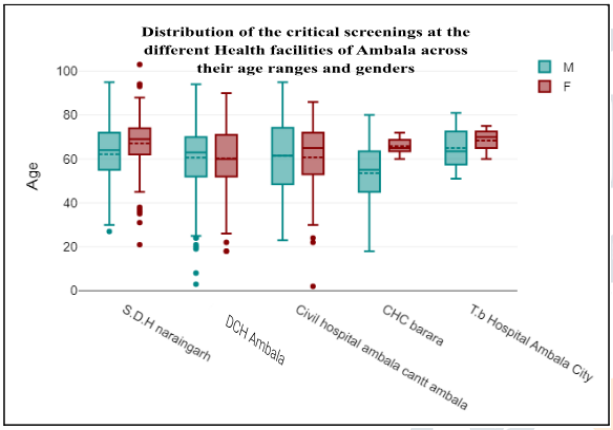
Facility wise Distribution:				
Name of Health facility	**Total ECGs**	**Normal ECGs**	**Abnormal ECGs**	**Critical ECGs**
CHC Barara	310	121	171	18 (5.8%)
Civil hospital Ambala Cantt	1495	582	756	157 (10.5%)
DCH Ambala City	5639	2051	3042	546 (9.68%)
S.D.H Naraingarh	3539	1478	1829	232 (6.55%)
T.B Hospital Ambala City	224	97	118	9 (4.02%)
TOTAL	**11207**	**4329**	**5916**	**962 (8.58%)**

Table 1: Facility wise distribution of the Health facilities/ health facilities and the total ECGs recorded along with the distribution of normal, abnormal and critical cases charted.

Supplementary Materials:



Suppl. Figure 1: Ambala pilot implementation sites in Haryana



Suppl. Figure 2: This boxplot demonstrates the distribution of the critical screenings at the different Health facilities of Ambala across their age ranges and genders.

Parameters	India	Haryana
Mortality rate due to CVDs	28.4%	**34.1%**
Leading cause of DALYs due to IHD	8.7%	**11.7%**

Suppl. Table 1: Comparative data of India and Haryana in terms of CVD mortality rate and leading cause of DALYs due to IHD

Parameter	Name of the Health facilities	Gender	Frequency	% within Spoke/ Hospital	Mean	Median	Std. Deviation
Age	S.D.H Naraingarh	M	147	63.36%	62.09	64	13.5
		F	85	36.64%	67.07	69	14.5
	DCH Ambala	M	296	54.21%	60.68	63	14.62
		F	250	45.79%	60.28	60	14.52
	Civil Hospital Ambala Cantt	M	76	48.41%	61.45	61.5	16.5
		F	81	51.59%	60.79	65	16.19
	CHC Barara	M	12	66.67%	53.58	**55**	18.12
		F	6	33.33%	65.83	65	4.45
	T.B. Hospital Ambala City	M	6	66.67%	65	63.5	11.33
		F	3	33.33%	68.33	70	7.64

Suppl. Table 2: A comprehensive table reflecting the distribution of demographics of patients' age and gender who were identified to be critical in the 5 Health facilities at Ambala. Male population details are coded in blue, whereas the Female population details are coded in pink.

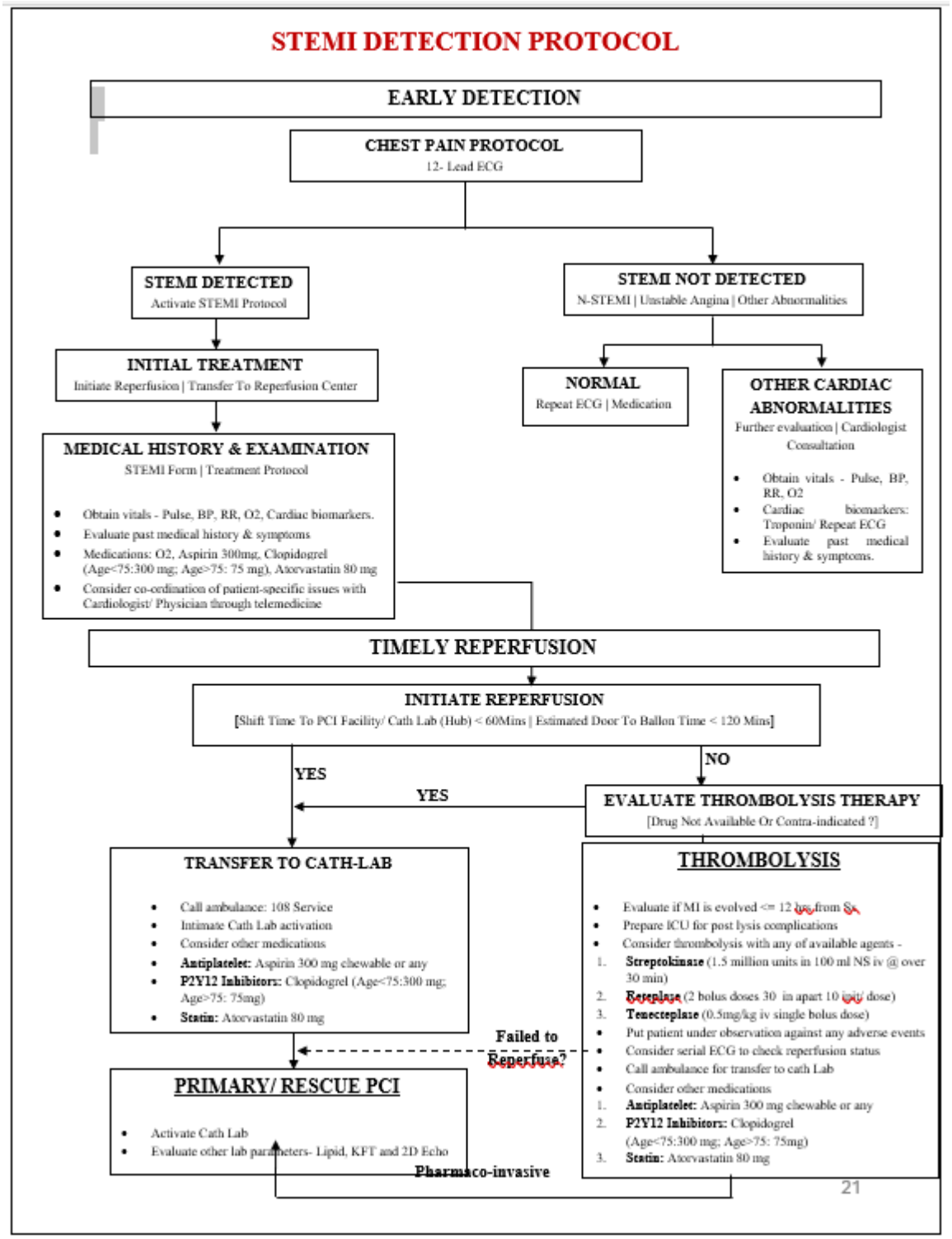
Parameter	Name of the Health facilities	Gender	Mean	Median	Std. Deviation
TAT	S.D.H Naraingarh	M	3.37	3	2.91
		F	3.22	2	2.8
	DCH Ambala	M	3.15	3	2.65
		F	3.28	2	3.93
	Civil Hospital Ambala Cantt	M	3.32	3	2.32
		F	2.98	3	1.97
	CHC barara	M	3.58	3	2.11
		F	4.5	3.5	3.27
	T.B Hospital Ambala City	M	4	3.5	2.76
		F	3	3	1

Suppl. Table 3: A comprehensive table reflecting the distribution of the turn-around-time of detection for the critical patients across all the 5 Health facilities at Ambala.

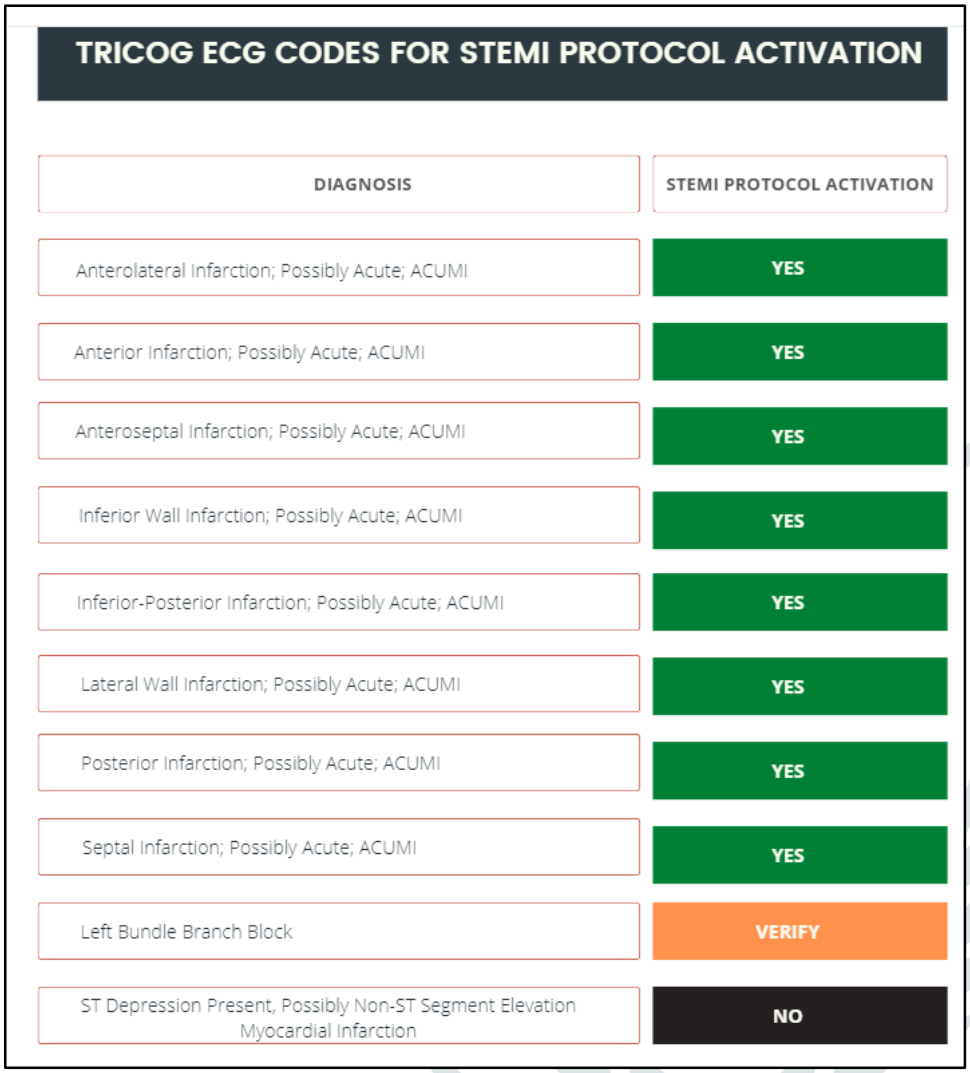
Conditions	Frequency	TAT
AFIB	218	2.56
ACUMI	297	2.9
VT	116	3.01
ISCHEMIA	196	4.5
CHB	32	4.06

Suppl. Table 4: A comprehensive table reflecting the diagnosis of different cardiac ailments mostly occurring in the screened critical cardiac patients in the population cohort corresponding to their respective mean Turn-around times (TAT) taken for their diagnosis since presentation.

Appendix-1: STEMI Detection Protocol



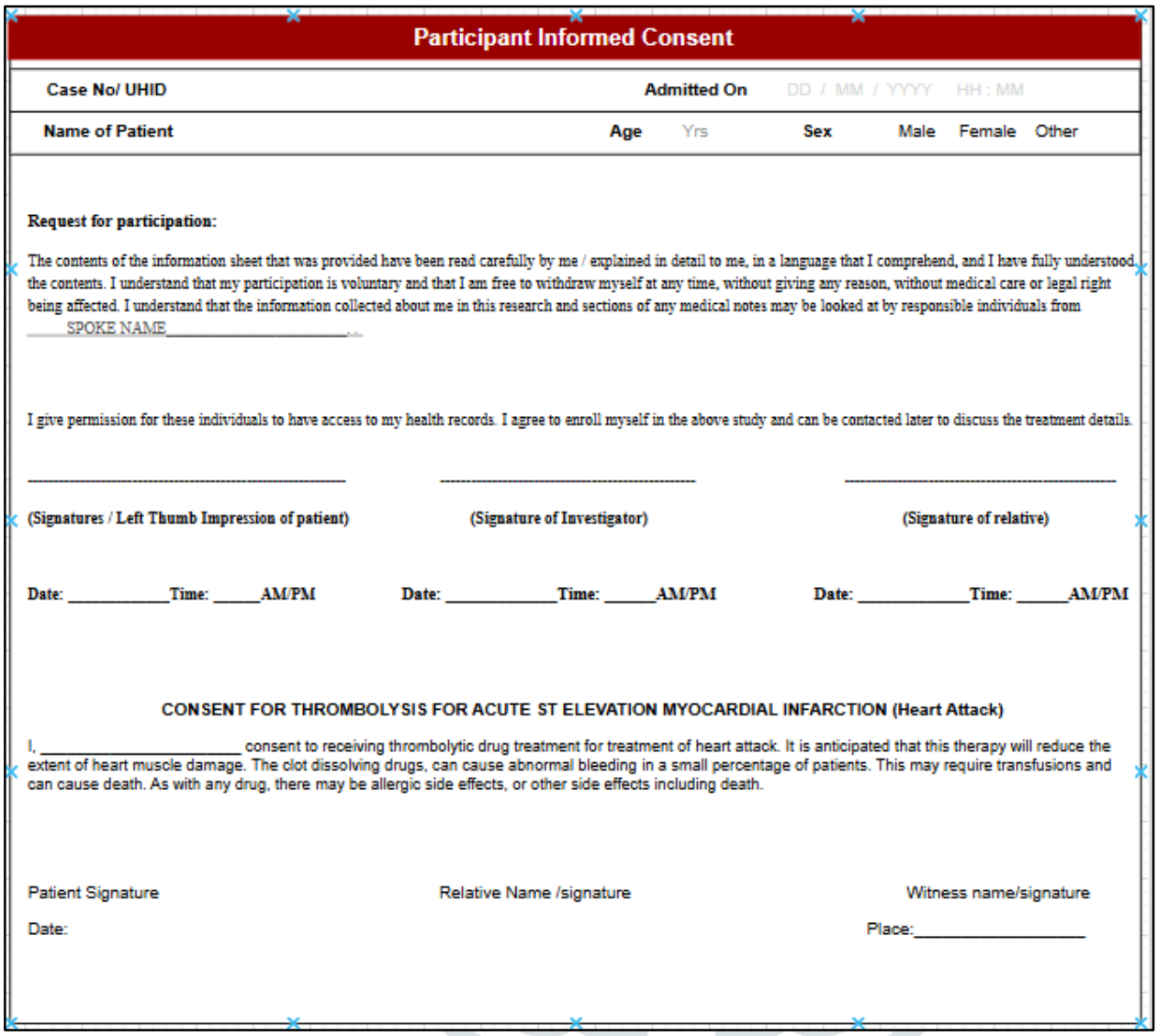
Appendix-2: **Tricog ECG codes for STEMI Protocol Activation: the Diagnosis and corresponding indications**



TRICOG ECG CODES FOR STEMI PROTOCOL ACTIVATION

DIAGNOSIS	STEMI PROTOCOL ACTIVATION
Anterolateral Infarction; Possibly Acute; ACUMI	YES
Anterior Infarction; Possibly Acute; ACUMI	YES
Anteroseptal Infarction; Possibly Acute; ACUMI	YES
Inferior Wall Infarction; Possibly Acute; ACUMI	YES
Inferior-Posterior Infarction; Possibly Acute; ACUMI	YES
Lateral Wall Infarction; Possibly Acute; ACUMI	YES
Posterior Infarction; Possibly Acute; ACUMI	YES
Septal Infarction; Possibly Acute; ACUMI	YES
Left Bundle Branch Block	VERIFY
ST Depression Present, Possibly Non-ST Segment Elevation Myocardial Infarction	NO

Appendix-3: Participant Informed Consent



Participant Informed Consent

Case No/ UHID	**Admitted On** DD / MM / YYYY HH : MM
Name of Patient	**Age** Yrs **Sex** Male Female Other

Request for participation:

The contents of the information sheet that was provided have been read carefully by me / explained in detail to me, in a language that I comprehend, and I have fully understood the contents. I understand that my participation is voluntary and that I am free to withdraw myself at any time, without giving any reason, without medical care or legal right being affected. I understand that the information collected about me in this research and sections of any medical notes may be looked at by responsible individuals from SPOKE NAME_____.

I give permission for these individuals to have access to my health records. I agree to enroll myself in the above study and can be contacted later to discuss the treatment details.

(Signatures / Left Thumb Impression of patient)	**(Signature of Investigator)**	**(Signature of relative)**
Date: _____Time: _____AM/PM	**Date: _____Time: _____AM/PM**	**Date: _____Time: _____AM/PM**

CONSENT FOR THROMBOLYSIS FOR ACUTE ST ELEVATION MYOCARDIAL INFARCTION (Heart Attack)

I, _____ consent to receiving thrombolytic drug treatment for treatment of heart attack. It is anticipated that this therapy will reduce the extent of heart muscle damage. The clot dissolving drugs, can cause abnormal bleeding in a small percentage of patients. This may require transfusions and can cause death. As with any drug, there may be allergic side effects, or other side effects including death.

Patient Signature	Relative Name /signature	Witness name/signature
Date:		Place:_____

Appendix-4: Ethical approval

Institutional Ethical Committee

O/o Civil Surgeon-Ambala

#Old Civil Hospital, Ambala City. Email: sukhpreet36_dhs@hry.gov.in

Memo No:- 1093 Dated:- 16.11.2022

From:	To:
Dr Sukhpreet Singh **Chairman, Institutional Ethical Committee** **Civil Surgeon Office, Ambala** **Haryana, 134003**	*Dr. Kuldeep Singh, Civil Surgeon Ambala* *Principal Investigator* *Civil Surgeon Office, Ambala* *Haryana, 134003* *Dr. Sukhpreet Singh, ASMO* *Co-Principal Investigator* *Civil Surgeon Office, Ambala* *Haryana, 134003* *Dr Hitesh Verma, ASMO* *Co-Principal Investigator* *Civil Surgeon Office, Ambala* *Haryana, 134003*

Subject: Ethical Clearance Approval for the Research Project titled "Assessment of a complete implementation of a comprehensive cardiac system of care for Detection and Management of Cardiovascular Diseases in Ambala."

Dear Dr. Kuldeep Singh, Dr. Sukhpreet Singh and Dr Hitesh Verma

We are pleased to inform you that the Institutional Ethical Committee of Civil Surgeon, Ambala has reviewed your research project titled "*Assessment of a complete implementation of a comprehensive cardiac system of care for Detection and Management of Cardiovascular Diseases in Ambala.*" After careful consideration, we are granting ethical clearance for your project based on the presented proposal.

Your project's major objectives, which include the evaluation of the effectiveness and accuracy of the technology-aided ECG machine in detecting cardiovascular diseases and determining the potential impact of this technology on improving the timely detection and referral of cardiovascular disease cases, align with the principles of ethical research and patient welfare.

We would like to commend your commitment to adhering to ethical guidelines, including ensuring participant privacy, obtaining informed consent, and conducting the study with due diligence and scientific rigor. It is with great confidence that we grant approval for your research to proceed as outlined in your proposal.

Please note that you are expected to adhere to all ethical principles and guidelines throughout the project's execution, as stated in your proposal and our previous discussions. Any deviations from the approved methodology, unforeseen ethical issues, or changes in the project must be reported to the Ethical Committee immediately.

We appreciate your dedication to conducting research that contributes to the advancement of healthcare and the well-being of the population in Ambala. If you have any questions or require further clarification, please do not hesitate to contact us.

Congratulations on receiving ethical clearance, and we wish you every success in your research endeavors.

Sincerely,

16/11/2022

Dr Sukhpreet Singh,
Chairman, IEC
Civil Surgeon, Ambala

Dr. SUKHPREET SINGH
Chairman,
Institutional Ethical Committee
Civil Surgeon, Ambala (Haryana)

Appendix-5: **ECG Lead Chart for IEC purpose**