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Strengthening cardiac services in Faridabad District: A facility mapping exercise to explore implementation of a hub-and-spoke model

Md Asadullah[1], Ritvik Amarchand[1], Ambuj Roy[2], Rohit Bhatia[3], Rakesh Kumar[1] & Anand Krishnan[1]

[1]*Centre for Community Medicine, Departments of* [2]*Cardiology &* [3]*Neurology, All India Institute of Medical Sciences, New Delhi, India*

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***Background & objectives*: Improving access to acute cardiac care requires remodelling of existing health systems into a service delivery network with an anchor establishment (Hub) offering a full array of services, complemented by spoke establishments that offer limited services. We assessed the availability of cardiac services in the district of Faridabad in the northern State of Haryana, India and explored the feasibility and challenges of implementing a hub-and-spoke model.**

***Methods*: In 2019-2020, we listed all the facilities in private and public sectors in the study-district and mapped their geocoordinates with the help of QGIS (Quantum Geographic Information System) software version 3.20. After consent, we assessed the availability of specific cardiac care-related inputs (medicines, technologies and staff) using a checklist by enquiring from the hospital staff. Each facility was classified as L1 (No ECG) to L5 (cardiac catheterization) as per the national guidelines for the management of ST-elevation myocardial infarction (STEMI).**

***Results*: There were 109 health facilities (66% private) in the district, 1.6 cardiologists and 5.4 coronary care unit beds per 100,000 population (94% private). Only one district hospital running in a public-private partnership mode at the L5 level provided any cardiac services. Private facilities were providing a range of services with a considerable number of them functional at L5. The higher-level facilities were concentrated in the central and urban parts of the district. Only 46 per cent of the ambulances had oxygen cylinders and 14.7 per cent had defibrillators.**

***Interpretation & conclusions*: Implementation of a hub-and-spoke model for cardiac care in Faridabad district will require significant strengthening of public health services, development of a private-sector participation model, and strengthening of ambulance services.**

Key words Hub-and-spoke - cardiac - access - geospatial distribution - health system

In India, cardiovascular diseases account for 36.4 per cent of all deaths in the age groups of 30-69 years[1]. Ischaemic heart disease contributes to 61.4 per cent of total Disability Adjusted Life Years (DALYs) from cardiovascular diseases. The estimated number of cases of ischaemic heart disease in India increased from 10.2 million in 1990 to 23.8 million in 2016[2]. A study from 2017 estimated that of the 9.7 million deaths of all ages

occurring in India, 1.5 million were due to ischemic heart diseases and accounted for 9.6 per cent of the DALYs[3].

Around 2.5 million cardiovascular disease-related deaths could be avoided by well-run healthcare systems in low-middle income countries (LMICs)[4]. Inequities in access to cardiac care in LMICs have resulted in the recommendation of a well-functioning and accessible primary healthcare system that reliably delivers cost-effective therapy to people in need[5]. However, to meet these expectations, strengthening of the public health system is needed both in terms of infrastructure and human resources.

A study in Madhya Pradesh found that for every 100,000 people, there were around 2.5 ICU beds in the State and almost three-fourths of these beds were in the for-profit private sector; almost nine out of ten institutions were level 1 or level 2 facilities[6]. These point to geographic and financial barriers to care. Based on the data available from the Cardiological Society of India (CSI), it is estimated that an average of 1500 interventional cardiologists were working in 4185 cardiac catheterization laboratories in India with a population of 1.4 billion in 2020[7].

Between 2004 and 2012, the healthcare expenditure on CVDs had increased by 80 per cent in India, with a predominant role of private facilities[8]. Our earlier study from district Faridabad reported that only 10.8 per cent of those dying of acute cardiac event or stroke reached an appropriately equipped health facility within one hour with delays occurring in seeking care (38%); reaching a facility (20%) and in-hospital delay in 11 per cent of the deaths. Income and distance to the facility were identified as important reasons for reaching the facility after one hour[9].

Addressing this problem, therefore, requires a remodelling of existing health systems which are still not geared for handling acute conditions, including ST-Elevation Myocardial Infarction (STEMI). This includes a hub-and-spoke model that arranges service delivery assets into a network consisting of an anchor establishment (Hub), which offers a full array of services, complemented by secondary establishments (Spokes), which offer more limited-service arrays. These spokes route patients needing more intensive services to the hub for treatment, through equipped and integrated ambulance services[10]. Based on the successful STEMI pilot carried out in Tamil Nadu[11], STEMI India, along with CSI and the Association of Physicians of India (API), through a consensus, developed a 'systems of care' protocol with a hub-and-spoke model for STEMI management across the country[12]. These have since been replicated in Goa[13], and the Government of India has added these in its guidelines for STEMI management[14]. While Hub hospitals are established preferably at State capital, super district administrative divisions or big-sized districts or group of districts, the spoke hospitals must be developed at district and Community Health Centres (CHCs) hospitals and then may be scaled up to Primary Health centres (PHCs). This should ensure that one can get access to a spoke hospital at least within 50–60 km of their residence.

The current study extends our enquiry into delays in acute cardiac care to mapping the cardiac services available in district Faridabad. We attempted to overlay the GOI-prescribed hub-and-spoke model on existing facilities and try to understand the opportunities and challenges of implementing the same.

Material & Methods

This cross-sectional study was carried out in Faridabad district of North Indian State of Haryana in 2019-2020. Ethical clearance was obtained from the Institutional Ethics Committee of the All India Institute of Medical Sciences (AIIMS), New Delhi.

Identification of health facilities: Written permission was obtained from the Deputy Commissioner and the Chief Medical Officer of the district to conduct this study. A list of medical facilities registered with the office of the district's Chief Medical Officer was supplemented with the list obtained from the National Health Mission (NHM) office. The list had information on name, address of the facility and types of services provided (*e.g.*, cardiac care, obstetric care, *etc*). These institutions were listed alphabetically, and each provided with a unique identification number. We then excluded facilities that did not offer in-patient care or offered only specialized care like maternity, paediatric, eye, otolaryngology, orthopaedic, dental or traditional medicine services. Any newly established institutions identified during the study were subsequently added to the list.

Service mapping: Facility authorities were approached by study personnel and provided information about the study and their written informed consent was taken for inclusion of their facility in the study. A facility mapping checklist developed through literature review and expert consultation was used for service

Table I. Description of the levels as per national guidelines for ST-Elevation Myocardial Infarction (STEMI) management

Level	Services available	Resource requirement		
		Human Resource	Technologies	Medicines
L1	No ECG, not capable of thrombolysis. Only suspect and refer	Any Medical officer	Pulse oximeter, BP apparatus	Nitroglycerine spray, morphine, aspirin, clopidogrel, atorvastatin, oxygen
L2	ECG facility and capable of thrombolysis on teleconsultation & refer	Medical Officer (MBBS doctor) ECG technician or staff nurse	Above and ECG machine (single channel)	Tenecteplase/Streptokinase, enoxaparin, ACE inhibitors, beta blockers
L3	ECG, thrombolysis capability and having emergency care with ICU/HDU setup	Facility with MBBS doctor & MD Medicine, ECG technician, staff nurse	ECG machine (12 channel) multiparameter monitor, routine biochemistry tests & serial cardiac enzymes (Troponin)	Tenecteplase/Streptokinase, enoxaparin, ACE inhibitors, beta blockers
L4	Coronary Care Unit	MD Medicine/ Cardiologist	CCU-related equipment	Tenecteplase/Streptokinase, enoxaparin, ACE inhibitors, beta blockers
L5	Cardiac Cath lab	Cardiologist	Cath lab related equipment	Tenecteplase/Streptokinase, enoxaparin, ACE inhibitors, beta blockers

Source: As ascertained from STEMI operational guidelines. ECG, electrocardiography; ICU, intensive care unit; BP, blood pressure; CCU, Coronary Care Unit; ACE, Angiotensin Converting Enzyme

mapping. The information was provided by the appropriate respondents of the facility. No checking or validation of the response was done. The checklist included information on available human resources, laboratory services, medicines, emergency services, ECG (electrocardiography) facility, thrombolysis, angiography, angioplasty and ambulance services. Each facility's GPS (Global Positioning System) coordinates were captured at the time of visit by using Google Maps.

Classification of facilities: Based on the availability of resources, each participating institution was classified as L1 to L5 as per the national guidelines for management of ST-Elevated Myocardial Infarction[14]. These are summarized in Table I.

Statistical analysis: The data were entered in an Excel sheet and stored in a password-protected computer at AIIMS, New Delhi with access limited to data analyzers and study investigators. The STATA statistical software version 15.0 (StataCorp LLC, TX, USA) was used for data analyses. The proportion of facilities with different resources/facilities was estimated separately for the private and public sectors. To assess adequacy, we estimated the number of beds and cardiologist per 100,000 population taking the population of the district to be 21 lakhs[15] and comparing with existing norms or other studies. The distribution of L1 to L5 facilities in the public and private sectors was plotted on the district map using their geocoordinates with the help of QGIS software version 3.20 (Free Software Foundation Inc., Boston, USA).

Results

Out of the total 236 health facilities identified in the district, 96 were excluded for various reasons (Fig. 1). Four hospitals were identified during the survey totalling to 144 eligible health facilities for mapping of services. We covered 109 health facilities (37 public including 2 Employees State Insurance Corporation hospitals and 72 private) with five refusals and 30 facilities had either closed or could not be located (Fig. 1).

The availability and distribution of different resources needed for the provision of cardiac care services in the district are shown in Table II. There were a total of 34 cardiologists and 13 cardiothoracic surgeons in the district, and except two cardiologists, all were in private sector. There were 529 and 114 intensive and coronary care unit beds, respectively in the district with less than 10 per cent being in the public sector. This came to 1.6 cardiologist and 5.4 coronary care unit beds per 100,000 population in the district. The district hospital was providing angioplasty facility in the public sector, while eight hospitals were doing so in the private sector. Even in the existing medical

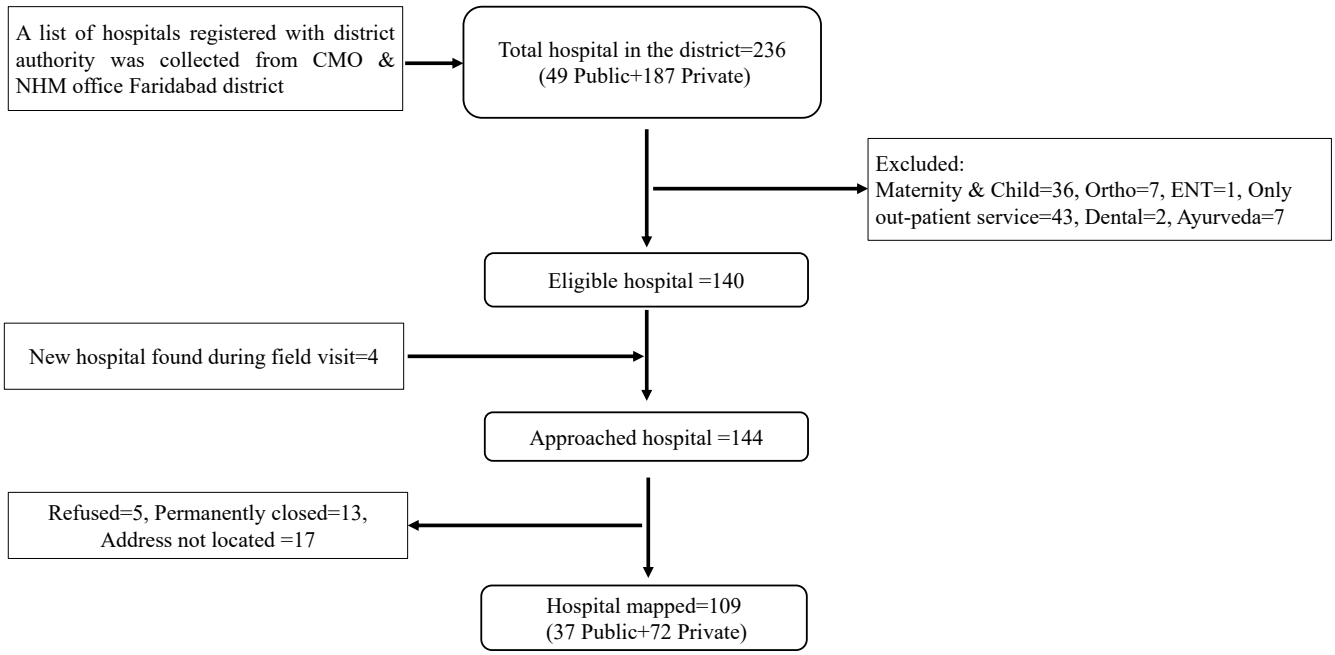

Fig. 1. Flow chart of recruitment of hospitals and the mapping exercise. CMO, chief medical officer; NHM, national health mission; ENT, ear, nose & throat.

college, L5 facility was not being provided. The single public and six private facilities were providing this service round-the-clock.

Diagnostic facilities including ECG (9 facilities) and point-of-care tests were poorly available in the public sector, but available in most of private sector facilities. Thrombolytic agents, the first line of therapy for STEMI, were available in none of the public sector facilities and only in 10 out of 72 private facilities. Only 13 (18%) private facilities were covered under the government's Ayushman Bharat - Pradhan Mantri Jan Arogya Yojana (AB-PMJAY) scheme of health insurance. The ambulances in most of these facilities also lacked basic requirements for cardiac resuscitation such as oxygen cylinder (46%) or defibrillators (14.7%).

Results of the assessment of the current service provision is shown in Table III. Only one public facility at the district level (in a public-private partnership mode) was providing L5 STEMI-related services. Private facilities were providing a range of services with a substantial number functional at L5. Figure 2 depicts the geographical distribution of facilities, which were currently providing any kind of cardiac services as envisaged under the government guidelines. It shows heavier concentration in the central part of the district, which was urban with very poor rural penetration.

To develop a cardiac care plan for the district, we assessed the potential for each site to provide cardiac care by training or provision of additional medicines without addition of human resources or equipment. For example, all PHCs and HWCs could serve as potential L1 facilities as they do not need any ECG or MBBS doctor. The sub-district hospital at Ballabgarh could serve as L3 facility and the CHCs as L2 facility with the necessary strengthening. This is also applicable to the private sector, and we could potentially expand the network of facilities providing STEMI services. This would alter the geographical distribution of facilities as shown in Figure 3 and could greatly enhance the access to STEMI services, especially if arranged in a hub-and-spoke model. However, the centrally concentrated facilities are a challenge for this to ensure that cases from rural areas can access optimum and timely therapy.

Discussion

This study describes the availability of health facilities to provide care for STEMI in the public as well as private sector in the district of Faridabad. Our study shows major private–public and rural-urban differentials in the provision and availability of STEMI care. Establishment of a hub-and-spoke model of care will need that these issues are addressed adequately. Most public health facilities can be strengthened to

Table II. Availability of cardiac care resource and services in district Faridabad

Particular	Public	Private	Total
	n=37	n=72	n=109, (%)
Human resources (Number)			
Cardiologist	2	32	34
Cardio-thoracic surgeon	0	13	13
Critical care (Number of beds)			
Intensive Care Unit	45	484	529
Coronary Care Unit	6	108	114
Cardiac care services (Y/N)			
Thrombolysis	0	17	17 (15.6)
Angiography	1	8	9 (8.25)
Angioplasty	1	8	9 (8.25)
Coronary artery bypass graft	0	7	7 (6.4)
Investigations (Y/N)			
Electrolyte	4	54	58 (53.2)
ABG analysis	2	36	38 (34.9)
PT-INR	3	51	54 (49.5)
Troponin T	2	47	49 (44.9)
Creatine kinase (CK-MB)	2	44	46 (42.2)
Natriuretic peptide tests (NT-PRO BNP)	0	19	19 (17.4)
ECG	9	65	74 (67.9)
Echocardiography	2	31	33 (30.3)
CT-Scan	2	14	16 (14.7)
Cardiac Catheterization Lab	1	10	11 (10.1)
Medicine availability (Y/N)			
Aspirin	37	59	96 (88.1)
Atorvastatin	33	56	89 (81.6)
Clopidogrel	27	50	77 (70.6)
Beta blocker	36	56	92 (84.4)
ACE inhibiter	16	52	68 (62.4)
Heparin	7	43	50 (45.9)
Nitroglycerine	12	55	67 (61.4)
Thrombolytic agent	0	10	10 (9.1)
Health insurance acceptance (Y/N)			
Private	NA	53	53 (48.6)
Public (PMJAY)	37	13	50 (45.9)
Presence in ambulance			
Defibrillator	2	14	16 (14.7)
Oxygen cylinder	8	42	50 (45.9)
Cardiac monitor	3	28	31 (28.4)
ECG machine	3	28	31 (28.4)

PMJAY, *Pradhan Mantri Jan Arogya Yojana;* NA, not available

perform to their potential as there is availability of human resources and equipment, and can be used to develop a hub-and-spoke model of STEMI care. Only the district hospital had facilities for angiography, angioplasty and Coronary Care Unit (CCU) beds, that too outsourced to a private provider.

Unlike our study, the study from Kerala showed that 69.84 per cent of the population resided within half-an-hour travel distance from a percutaneous coronary intervention (PCI)-capable hospital[16]. The estimated travel time were derived using historical traffic data from Google navigation systems[16]. Of the 432 acute care hospitals in Kerala, 258 hospitals were offering thrombolytic services for STEMI and 104 had cardiac catheterization facility. Only 10 PCI-capable hospitals were in the public sector and 93 PCI-capable hospitals in the private sector with one being non-functional[16]. In Madhya Pradesh, 85 (75%) of ICUs were in private for-profit sector with an average availability of 2.5 beds per 100,000 population[6]. In South Africa, it was found that districts with preponderance of rural settings had among the lowest densities of health facilities providing cardiac care[17]. This predominant role of the private sector and lack of access in rural areas have been documented in earlier studies as well.

A positive feature of the Faridabad district is the high number of hospitals that are PCI capable, though in the private sector, that can be roped in for STEMI care management. Faridabad district faces limited access to thrombolysis services as public and most private L3 hospitals refrain from thrombolysis due to low confidence and perceived lack of support if something goes wrong. Hub-and-spoke model implementation could enhance confidence and promote service provision in the district.

It is evident in the ICMR STEMI ACT model initiated in eight districts of seven States, with CHCs, Civil hospitals, District hospitals as spoke and tertiary care facilities with cardiac services as a hub that health system-based intervention like capacity building and tele-ECG support had significantly improved the timely thrombolytic therapy rate in STEMI patients in spoke hospitals. The National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases including Stroke (NPCDCS) STEMI guidelines are adapting to include this model[18,19].

The medical college can be strengthened to serve a L5 facility. The challenge, therefore, is in developing the spokes (S1 and S2) and ensuring geographical

Table III. Distribution of functional and potential health facilities that can provide the services recommended by the Ministry of Health guidelines on STEMI

Level of Facility (Expected functionality)	Public			Private		
	Number	Currently providing services	Potential for delivering services	Number	Currently providing services	Potential for delivering services
L1 (suspect and refer)	28	Nil	28	7	7	Nil
L2 (ECG, telemedicine, loading dose and refer)	7	Nil	7	35	3	32
L3 (Thrombolysis capable ICU or high dependency unit)	1	Nil	1	20	4	16
L4 (Thrombolysis capable Coronary care unit)	Nil	Nil	Nil	Nil	Nil	Nil
L5 (Cardiac catheterization)	1	1	Nil	10	8	2

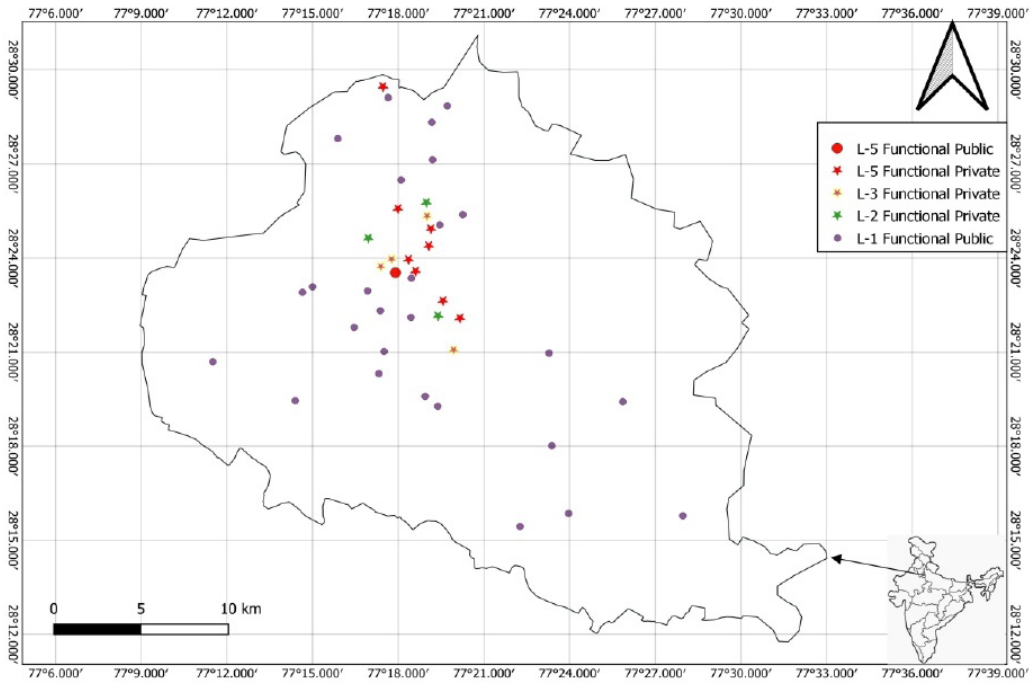

Fig. 2. Health facilities currently providing different levels of care as envisaged under the ministry guidelines. Map generated using QGIS software version 3.20 (Free Software Foundation Inc., Boston, USA).

spread. Another strength is that the road network is good and a national highway goes right through it around which the large hospitals are situated like veins of a leaf. This ensures that at least one L5 facility can be reached within 2 hours.

Evidence suggests that any STEMI care model in India should be able to improve the rate of fibrinolysis and reduce the time from symptom onset to first medical contact (FMC), and treatment. Ensuring the performance of ECGs at the point of FMC, will enable their prompt interpretation followed by initiation of bolus fibrinolytic therapy and subsequent transportation to the hub hospital[20]. Such hub-and-spoke based implementation plan by the STEMI India for STEMI care[21] is of critical importance.

In contrast with patients in the urban setting, individuals requiring care in rural areas, with suspected long transportation times to PCI-capable hospitals, should utilize the thrombolysis-first strategy with thrombolysis therapy, followed by catheterization and PCI, if indicated. With the strengthening of the public sector, this type of service delivery is certainly mobilizable through the government sector. Existing public L2 facilities can immediately be made functional

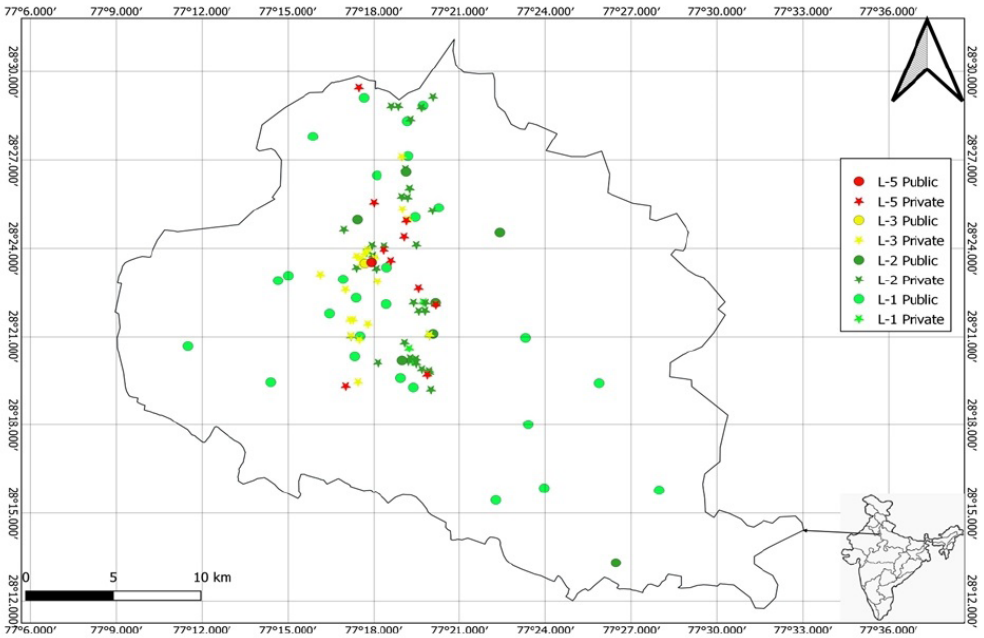

Fig. 3. Distribution of all public and private health facilities in Faridabad district with potential for cardiac services. Map generated using QGIS software version 3.20 (Free Software Foundation Inc., Boston, USA).

by using telemedicine with the district hospital for ECG reading and training on providing thrombolysis. Some L1 facilities can also be easily upgraded to L2 level by making ECG machines available and linking them *via* tele-medicine for quicker diagnosis along with ensuring availability of essential medicines. Use of tele-electrocardiography support for primary care physicians has also been shown to reduce the treatment time in acute coronary syndromes[22].

While public sector strengthening is critical, it should be noted that engagement with the private sector may be needed to bear the burden of treating acute coronary syndromes in a district at least initially. One year data from the National Intervention Council in India showed that "out of 30 lakhs expected STEMI cases in India, 12 lakhs underwent thrombolysis and only 57,512 patients received primary PCI"[23]. While the Tamil Nadu (TN) model[11] has an extensive involvement of private sector hospitals, the Goa model[13] is largely public sector based. Guidelines developed by NITI Aayog to provide health services in district hospitals for the provision of prevention and treatment services of non-communicable diseases (NCDs) related to cardiac, oncology and pulmonary services in Tier 2 & 3 cities encourage working through Public Private Partnership (PPP)[24]. Even under the NPCDCS, many district hospitals are running cardiac care units (as in Faridabad). However, the experience of such efforts has not been fully evaluated. Another issue that comes up with the involvement of the private sector is the financial protection for those with an acute illness. Studies have shown that "uninsured CAD patients in India are younger with more risk factors, more likely to have multivessel disease and coronary stenting compared to those with government or private insurance"[25]. A study from Kerala found that the mean cost of acute myocardial infarction management was US $480.4 (US $112.5–$1733), largely driven by in-hospital expenditures[26]. Financial constraints and concerns of overtreatment in the private sector were among the important barriers to timely treatment initiation[9]. This calls for an integration of insurance schemes like Ayushman Bharat, which are an integral part of STEMI care as used in the TN model.

The present study also noted that ambulance services in these facilities were poor. Currently in the district, the free centralized ambulance services are mainly provided for obstetric and neonatal emergencies. There is a dire need to expand such services to include acute cardiac syndromes. Another area requiring attention is the monitoring and oversight of all intervention components under STEMI. Salve *et al*[13] have described the implementation of the Government of Goa STEMI programme and found it functioning

effectively due to its emphasis on the importance of regular monitoring. Over or under diagnosis and treatment affect quality of care, cost and outcome. Adequate and transparent audit and quality control assessment of all hub-and-spoke facilities, irrespective of their being private or public, should therefore be built into the system. Sufficient generation of awareness to promote judicious care-seeking, strengthening ambulance services and involving peripheral medical practitioners to reduce delays are other requirements for hub-and-spoke models to be successful[27].

In conclusion, we believe that adequate access to acute cardiac care is an important goal that district health systems should aim to achieve in near future and it can serve as a template for other acute conditions. This will require strengthening and training of the public health systems, active engagement of private sector as needed and coordination of hospitals, insurance schemes and ambulance services to provide optimum STEMI care.

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For correspondence: Dr Anand Krishnan, Centre for Community Medicine, All India Institute of Medical Sciences, New Delhi 110 029, India
e-mail: anand.drk@gmail.com