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Factors Associated with Availability of X-ray Equipment in Public Hospitals: A Finding from Community Health Centres in Maharashtra, India

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Abstract

X-ray investigation is vital for patients seeking primary and emergency care for tuberculosis, pneumonia, trauma and other respiratory and abdominal diseases. This paper attempts to study factors associated with availability and functionality of x-ray equipment in public hospitals. Fourth round of District Level Household and Facility Survey (DLHS-4) data for Community Health Centres (CHCs) were used. We identified possible factors related to x-ray services and extracted available factors from DLHS-4 data which may influence the availability and functionality of x-ray units. These factors were grouped under three categories – geographical locations of CHC, physical resources available at CHC and patient workload of CHC. We have applied chi-square test to find out the association between CHC with/without x-ray unit and selected variables. Mean value and standard deviation were calculated for continuous variables. The study shows that 48.5 per cent CHCs with functional x-ray machine did not have X-ray technician to operate it. We found statistically significant relationship (p=<0.05%) between availability and functioning of x-ray unit and number of X-ray technicians in position, years since CHC functioning as 24x7, total number of beds, OT availability, number of OPD patients and number of cases referred for serious ailments from CHC. The study has been able to identify a set of key factors that are related to availability and functionality of an x-ray unit.

Keywords: X-ray, x-ray technician, First Referral Unit, physical infrastructure.

I. Background and rationale

Many a time, clinicians require objective evidence to support their clinical diagnosis or to decide on medical line of treatment in addition to presenting signs and symptoms. Medical diagnostic equipment is vital for provision of these objective evidences. Well-functioning health system ensures equitable access to these technologies. Properly balanced and managed health technology like diagnostic services lead to quality and efficient healthcare (WHO, 2007). Medical radiography (X-ray) and ultrasound are important basic diagnostic imaging equipment which covers 90 per cent of imaging needs of community (Maru et al., 2010). As per the WHO technical report on *The Hospital in Rural and Urban District*, First Referral Unit (FRU) should have at least basic diagnostic imaging 24 hours per day (WHO, 1992). X-ray is vital for patients seeking primary and emergency care for tuberculosis, pneumonia, trauma, and other respiratory and abdominal diseases. Non-availability of this service results in delay in treatment and increased transportation cost to an already marginalized patient population (Maru et al., 2010). Sometimes x-rays are used for screening of patients with minor ailments to rule out diseases like respiratory illness or fractures. Absence of x-ray services at FRU leads to increased workload of patients at higher centres who can be treated at FRU.

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Even though x-ray is an essential diagnostic service, very few studies from developing countries have discussed it. According to a study conducted by Filkins, almost 47 per cent of the x-ray units in developing country are non-functional (Filkins et al., 2015). A study conducted in Sri Lanka showed that in public hospitals only 40 per cent x-rays units were functional. However, in private hospitals more than 87 per cent of x-ray units were functional (Dasanayaka, 2006). According to a study done in India, public health facilities had a severe shortage of basic equipment. Available equipments were frequently non-functional. There was a huge gap between acquisition of equipment and its installation (Mahal, Varshney & Taman, 2006). X-ray is capital equipment with high operating cost in terms of skilled technician, electricity consumption and high consumable cost. Hence, it is important to look at this equipment in view of managing scarce resources optimally.

In India, health is a state subject. Curative care which includes hospitals and dispensaries are the state responsibility and itôs largely provided through the stateôs budget (Duggal, 2002). Under public health system, thirty bedded Community Health Centres (CHC) are assigned as a FRU to make modern health facilities accessible to rural population and to reduce overcrowding of District Hospitals (Planning Commission, India, 1999). CHCs provide specialty services like medicine, surgery, obstetrics and gynaecology, paediatrics, dental and AYUSH (Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy). Currently, public hospitals follow Indian Public Health Standards (IPHS) which state that x-ray is essential for all CHCs (Government of India. (2012). Many studies have been published on availability of equipment in public hospitals. But little has been known about availability and functioning of x-ray equipment in CHCs. Therefore, this paper attempts to study the geographical distribution of x-ray units. In addition, it aims to identify other physical resources available at CHCs which may be associated with availability and functionality of x-ray equipment. Lastly, we analyse patient workload of CHC as per availability and functionality of x-ray units.

II. Data and methods

We have selected the fourth round of DLHS-4 data as it is the only data related to public health infrastructure facility available in public domain. Since 1998-99 every four years, the Ministry of Health and Family Welfare conducts nationwide DLHS survey in India. Key objective of the DLHS was to give district level data related to reproductive and child health (Government of India, 2012a). It is a cross sectional survey. DLHS-4 (2012-13) was conducted in 20 non- Empowered Action Group (EAG) states and six union territories. The sampling design was multi-stage stratified systematic sampling. DLHS-4 surveyed, 249 CHCs catering to selected Primary Sampling Units (PSUs) of the survey during January to October 2013.

Health facility questionnaires designed for CHCs included information about human resources, services and infrastructure available at these facilities. In this questionnaire, in Section VI on investigation facility, questions were asked regarding availability and functionality of x-ray facilities. Here x-ray facility available and functional means only physical availability and functionality of x-ray equipment. During analysis, the CHCs were categorized as CHCs with functional x-ray equipment, CHCs with non-functional x-ray equipment and CHCs without x-ray equipment. Possible factors which may influence the availability and functionality of x-ray services were identified based on a review of the literature and which could be extracted from available DLHS-4 data. These factors were grouped under three categories ï geographical location of CHC, resources available at CHC and patient workload of CHC. Certain variables like population covered, the distance between CHC and District Hospital/Sub-Divisional Hospital (DH/SDH), distance between CHC and farthest Sub-Centre (SC) village, number of Primary Health Centres (PHCs) covered, functioning as 24 x 7, since when x-ray technician is not in a position, etc., were converted in a categorical variable. As it was secondary data, the study had a limitation in selecting the variables.

Chi-square test was used to find out the association between CHC with/without x-ray unit and selected variables. The mean value and standard deviation were calculated for continuous variables.

Study Site

This study is based on CHCs in Maharashtra, the second most populous state of India. Its population was 112.4 million in 2011. It is a highly urbanized state (42.5 per cent) (Directorate of Economics and Statistics, 2016). It has a history of progressive reforms and industrial development. It has been in the forefront in healthcare development. In 1960s it decentralized primary healthcare administration through Zilla Parishads. In 1980s, it was one of the first states to upgrade older PHCs as Rural Hospitals (RHs)/CHCs under Minimum Needs Programme to expand rural health infrastructure (Duggal, Dilip & Raymus, 2005).

Maharashtra contributes about 40 per cent of Indian tax revenue (Krishnamacharai, 2016). It spents 3.7 per cent of total budget on health and family welfare as against 7-8 per cent mandated by National Health Policy, 2002 (Yashwantrao Chavan Academy of Development Administration, 2014). However, its healthcare indicators are not at par of its financial/economic development indicators. It will be interesting to see the status of availability of x-ray equipment in an economically progressive state.

III. Results

Geographical location of CHCs

To describe geographical factors associated with availability and functionality of x-ray equipment, information about location of CHC (rural/urban), population covered by CHC (Ò30000, 30001-120000 and Ó120001), distance between CHC and DH/SDH (Ò25 km, 26-50 km, 51-75 km and Ó76 km), distance of CHC from farthest SC village ((Ò20 km, 21-40 km, 41-60 km and Ó61 km) and number of PHCs covered by CHC (4 or 5) were used. Table 1 presents factors related to the location of CHC.

Out of total CHCs, two-thirds of CHCs were in rural areas. Rural CHCs reported a higher percentage of non-availability of x-ray equipment. But the functionality was more among the available x-ray equipment in rural areas (68 per cent). This finding is in contrast with the popular belief that equipment in rural areas is less functional. Average population served per CHCs was 47,977. Looking at the fact, there is a concern about the survey respondent's knowledge about the meaning of population covered as population norm followed in India for setting up a CHC is one per 120,000 population in plain areas and one per 80,000 population in difficult/tribal or hilly areas ("Infrastructure," 2016). Considering the norms for setting up CHCs and population of Maharashtra during 2012, there was a shortfall of 184 CHCs in Maharashtra (Statistics Division, MoHFW, India, 2013). Hence, the findings of the population covered may be actual population served by that hospital. The table suggests that the functional x-ray equipments were more in CHCs catering to higher population.

DHs/SDHs serve as next referral centre for CHCs. It was important to look at the distance between CHC and its next referral centre. In the absence of a functional x-ray unit, patients have to travel further distance to a higher level centre or private facility. As the distance between CHCs and DHs/SDHs increases, the functionality and availability of x-ray equipment increases too. This indicates that the administration has provided x-ray equipment to CHCs in remote areas which is a good practice. The survey data did not permit us to assess the quality of the communication links between the habitations and the CHCs. In the absence of such information, it was assumed that the accessibility to CHCs with functional x-ray unit is directly related to the distance from the next referral unit and accessibility to CHCs without x-ray unit is inversely related to the distance from next referral unit.

Table 1: Geographical location of CHCs

Factor Category	CHCs with functional x-ray equipment (n=165)	CHCs with non-functional x-ray equipment (n=21)	CHCs with no x-ray equipment (n=63)	Total (n=249)	Chi-Square	p-value
	n (%)	n (%)	n (%)	n (%)		
Location of CHC						
Rural	114 (67.86%)	10 (5.95%)	44 (26.19%)	168	4.129	0.127
Urban	51 (62.96%)	11 (13.58%)	19 (23.46%)	81		
Population Covered by CHC						
≤30000	79 (65.83%)	11 (9.17%)	30 (25.00%)	120		
30001-120000	74 (65.49%)	10 (8.85%)	29 (25.66%)	113	1.658	0.798
Ó120001	12 (75.00%)	0 (0%)	4 (25.00%)	16		
Mean (SD)	49144.18 (48054.88)	41700.09 (34120.59)	47012.94 (46391.44)	47977.13 (46513.52)		
Distance between CHC and DH/SDH						
Ò25 km	28 (52.83%)	5 (9.43%)	20 (37.74%)	53		
26-50 km	62 (67.39%)	7 (7.61%)	23 (25.00%)	92	9.362	0.154
51-75 km	51 (75.00%)	7 (10.29%)	10 (14.71%)	68		
Ó76 km	24 (66.67%)	2 (5.56%)	10 (27.78%)	36		
Mean (SD)	53.52 (30.68)	45.95 (23.82)	45.03 (25.68)	50.73 (29.12)		
Distance of CHC from the farthest SHC village						
Ò20 km	43 (60.56%)	9 (12.68%)	19 (26.76%)	71		
21-40 km	49 (70.00%)	4 (5.71%)	17 (24.29%)	70	3.272	0.774
41-60 km	49 (68.06%)	6 (8.33%)	17 (23.61%)	72		
Ó61 km	24 (66.67%)	2 (5.56%)	10 (27.78%)	36		
Mean (SD)	39.62 (27.51)	29.86 (25.13)	39.21 (25.49)	38.69 (26.85)		
No. of PHC catered by CHC						
Ò4	101 (63.13%)	13 (8.13%)	46 (28.75%)	160	2.821	0.244
Ó5	64 (71.91%)	8 (8.99%)	17 (19.10%)	89		
Mean (SD)	4.3 (2.2)	3.9 (2.2)	3.8 (2.6)	4.1 (2.3)		

To understand catchment area of the CHCs, we analysed the distance between the furthest SC village and CHC. The mean distances between SDHs/DHs and CHCs with functional x-ray equipment, non-functional x-ray equipment and without x-ray equipment was 39.62 km, 29.86 km and 38.69 km respectively. CHCs without functional x-ray equipment where patients from farther villages were reported (more than 40 km away) should ensure x-ray availability at the earliest.

Resources available at CHCs

The context is described through these variables: Availability of x-ray technicians (yes/no), since how long x-ray technician is not in position (<2years, 2-8 years and >8 years), CHC designated as FRU (yes/no), since when CHC started functioning as 24 x 7 (24 x 7 facility absent, Ò10 years, 11-20 years and Ó 21 years), emergency room/casualty room available with CHC (yes/no), and availability of functional ventilator (yes/no). Table 2 shows that around half of the CHCs with functional x-ray equipment did not have an x-ray technician to operate it. IPHS guidelines state that one x-ray technician is essential in each CHCs. The absence of an x-ray technician leads to non-utilization of available resources (i.e., x-ray equipment and space it occupies). The percentage of non-functional x-ray equipment is almost double in CHCs without an x-ray technician. It indicates that x-ray technicians may ensure functionality of the equipment. In half of the CHCs with functional x-ray equipment, an x-ray technician was not available for more than eight years. As an x-ray technician plays a crucial role in the maintenance of an x-ray unit, it indicates that maintenance of these x-ray units might be at stake.

Table 2: Resources available at CHCs

Factor Category	CHCs with functional x-ray equipment (n=165)	CHCs with non-functional x-ray equipment (n=21)	CHCs with no x-ray equipment (n=63)	Total (n=249)	Chi-square	p-value
	n (%)	n (%)	n (%)	n		
Availability of X-ray technician						
Yes	85 (91.40%)	5 (5.38%)	3 (3.23%)	93	44.38	<0.001*
No	80 (51.28%)	16 (10.26%)	60 (38.46%)	156		
Since how long x-ray technician is not in position at CHC#						
Ò2 years	7 (63.64%)	1 (9.09%)	3 (27.27%)	11	3.053	0.549
2-8 years	3 (37.50%)	0 (0%)	5 (62.50%)	8		
Ó8years	68 (51.52%)	14 (10.61%)	50 (37.88%)	132		
Total	78 (51.66%)	15 (9.93%)	58 (38.41%)	151		
CHC designated as FRU						
Yes	130 (69.52%)	16 (8.56%)	41 (21.93%)	187	4.596	0.1
No	35 (56.45%)	5 (8.06%)	22 (35.48%)	62		
Since when CHC started functioning as 24 X 7						
Ó21 years	39 (84.78%)	4 (8.70%)	3 (6.52%)	46	17.891	0.007*
11-20 years	48 (73.85%)	4 (6.15%)	13 (20.00%)	65		
Ò10 years	37 (55.22%)	8 (11.94%)	22 (32.84%)	67		
24x7 facility absent	41 (57.75%)	5 (7.04%)	25 (35.21%)	71		
The Emergency Room / Casualty room available in the CHC						
Yes	144 (68.90%)	16 (7.66%)	49 (23.44%)	209	4.069	0.131
No	21 (52.50%)	5 (12.50%)	14 (35.00%)	40		
OT availability						
Yes	163 (68.78%)	20 (8.44%)	54 (22.78%)	237	16.988	<0.001*
No	2 (16.67%)	1 (8.33%)	9 (75.00%)	12		
Availability of functional ventilator						
Yes	63 (75.90%)	6 (7.23%)	14 (16.87%)	83	5.786	0.216
No	102 (61.45%)	15 (9.04%)	49 (29.52%)	166		

Note: # for 5 CHCs data were not available; * statistically significant at <0.05 p value

Around one-third of CHCs designated as FRU did not have a functional x-ray unit. The availability of functional x-ray equipment was more in CHCs designated as FRU. The non-availability of an x-ray unit is inversely proportionate to the year since CHC was functioning at 24x7. Older the provision of 24x7 services, more the chances of availability of an x-ray unit. The findings indicate that there is a statistically significant relationship between the availability and functioning of an x-ray unit and years since CHC are functioning at 24x7 (p=0.007) and availability of Operation Theatre (p = 0.0002).

The patient workload of CHCs

The context was described through these variables: OPD registration in last month (Ò1500, 1501-3000 and Ó3001), IPD admissions in last month (Ò150 and Ó151), patients referred to CHCs in last month (Ò20 and Ó21) and patients referred from CHCs in last month (Ò20 and Ó21). Table 3 shows patient workload at CHCs. In one month, on an average, 2,607 OPD and 260 IPD patients were served in CHCs with a functional x-ray unit compared with 2,300 OPD and 232 IPD patients in CHCs with a non-functional x-ray unit and 2,074 OPD and 235 IPD patients in CHC without an x-ray unit. So the workload of OPD patients was the highest in CHCs with functional x-ray equipment. Similarly, IPD admission and serious cases referred from/to CHCs were the highest in CHCs with functional x-ray equipment and lowest in CHCs without x-ray equipment. A significant relationship was found between CHCs with an x-ray unit and some cases referred for serious ailments from CHC (p = 0.015) by applying the Chi-Square test.

Table 3: Patient workload of CHCs

Factor Category	Available & functional (n=165)	Available & non-functional (n =21)	Not Available (n=63)	Total (n= 249)	Chi-square	p-value
	n (%)	n (%)	n (%)	n		
OPD registration in last month						
Ò1500	29 (54.72%)	5 (9.43%)	19 (35.85%)	53		
1501-3000	82 (65.60%)	10 (8.00%)	33 (26.40%)	125	7.283	0.122
Ó3001	54 (76.06%)	6 (8.45%)	11 (15.49%)	71		
Mean (SD)	2606.65 (1333.84)	2299.90 (798.55)	2073.97 (1084.70)	2446.01 (1255.48)		
IPD admissions in last month						
Ò150	68 (60.71%)	8 (7.14%)	36 (32.14%)	112	5.115	0.078
Ó151	97 (70.80%)	13 (9.49%)	27 (19.71%)	137		
Mean (SD)	259.98 (427.64)	232.19 (200.26)	235.14 (407.66)	251.35 (407.26)		
Patients referred to CHCs in last month						
Ò20	107 (63.69%)	17 (10.12%)	44 (26.19%)	168	2.417	0.299
Ó21	58 (71.60%)	4 (4.94%)	19 (23.46%)	81		
Mean (SD)	27.39 (59.38)	9.33 (14.12)	17.35 (31.77)	23.33 (51.35)		
Patients referred from CHCs in last month						
Ò20	84 (60.43%)	10 (7.19%)	45 (32.37%)	139	8.14	0.015*
Ó21	81 (73.64%)	11 (10.00%)	18 (16.36%)	110		
Mean (SD)	29.79 (31.39)	25.52 (20.50)	19.16 (29.31)	26.74		

* statistically significant at <0.05 p value

IV. Conclusion and recommendations

India contributes 21 per cent in global tuberculosis cases. There are also rising injury and accidents cases across rural as well as urban areas. Hence, x-ray service is essential for the diagnosis of smear negative tuberculosis, fractures and other general health issues at CHC (The Planning Commission, 2011). For the vast majority of people, the access to healthcare services is determined primarily by the availability (and the quality of delivery) of public health institutions. It is especially true of the majority of the rural people for whom alternatives to public health services hardly exist. Though in Indian public health system CHCs are considered as FRUs, many CHCs do not have functional x-ray units. This could be because óGuidelines for Operationalizing FRU' did not mention availability x-ray services as essential criteria (Maternal Health Division, Department of Family Welfare, 2004). The Guidelines of FRU are focused towards maternal and child health (MCH) and neglect other spheres of health and illness. Even health statistics available about health infrastructure are more related to MCH services. As the CHCs are required to deliver specialized healthcare services, especially for the rural population, without suitable diagnostic and investigation facilities this goal may not be realized.

There is a mismatch between availability of x-ray technicians and availability of x-ray units which leads to sub-optimal utilization of the resources. The overall productivity of CHCs will improve if this mismatch is corrected as an x-ray technician also does preventive maintenance.

Apparently the requisite number of x-ray units in CHCs as per norms are not yet made available. Perhaps, it is also not possible to meet these norms for CHCs in the near future as the supply gap is large and resources are limited. Since resources are scarce, a set of criteria must be evolved for optimal use of available x-ray units by proper planning of human resources. This issue has assumed added importance because of the observations of the authors. More number of x-ray units without a proper human resource planning has adversely affected implementation, delivery systems and hence the performance of the basic imaging services in the social sector. The existence of vacancies could be due to non-availability of qualified x-ray technicians, transfer/retirement and resource constraints of the State Governments.

It is necessary to know the factors that influence the availability of x-ray units in CHCs to identify criteria for their optimal use. An attempt was made in this paper to determine such factors through analysis of available data. It has been able to locate a set of critical factors that are related to availability and functionality of x-ray units. These factors in the case of an x-ray can be grouped into (i) location-related, (ii) infrastructure-related and (iii) workload of CHCs. This analysis brings out that internal factors like 24x7 services, availability of x-ray technicians, availability of OT and severe cases referred from CHC have a bearing on the availability and functionality of an x-ray unit. The analysis also brings out that the availability of an x-ray technician is the most important determinant for the provision of x-ray services. It is hoped that the findings of the study will be useful for planning/implementing agencies in introducing the necessary corrective steps for improving the basic imaging services delivery system.

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