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Research Article

To Study the X-Ray Services Provided in the OPD Complex of a Tertiary Care, Teaching and Research Institute of Northern India

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Abstract: Radiological imaging services are very important in the treatment of patients. X-ray is one of the important radiological imaging services. The discovery of the properties of X-rays gave medical sciences one of its most potent and vital diagnostic tools. Radiography was started in the year1895 after the discovery of X-rays and ever since, it has become an essential part of any hospital system. The aim was to study the X-ray services provided in the OPD complex of a tertiary care, teaching and research institute of Northern India. The objectives were (a) To study the existing workload and infrastructure of X-ray section of Ch. Ranbir Singh OPD complex, (b) To study one month work load of X-ray section located in Ch. Ranbir Singh OPD complex and (c) To study the one month expenditure of X-ray section located in Ch. Ranbir Singh OPD complex. An observational study was carried out at the X-ray wing to assess the organizational structure, study of existing equipments and items involved in the functioning of the X-ray wing. It included the retrospective analysis of the record for the period of January 2013 to May 2014 and calculation of expenditure incurred on running X-ray services in OPD complex. Total number of patient registered for X-rays as outdoor patients for health care services were studied for one month (19 June 2014 to 18 July 2014) and work load was assessed. In prospective study, it was revealed that during the study period the X-ray facility was used for 26 days and total 5312 patients had availed the X ray facility. Total 6174 number of four different sizes of X ray films were used and out of them maximum consumption (33%) was attributed to 10*12 X ray films. The retrospective study of the workload was carried out for 17 months (i.e. Jan 2013 to May 2014). It was revealed that total 69855 numbers of patients had undergone X ray examination in the seventeen months and total 83692 number of X ray films were used on these patients. Total capital cost incurred on establishing two X ray plants was Rs 1.15 crores. On the other hand the monthly recurrent expenditure involved on running the X ray unit was Rs 3.40 lacs. X-ray services are essential diagnostic services in the medical sciences. An X-ray is a safe and pain less procedure that is often used to provide images of inside the body. It is an effective way of looking at fractured bones such as a broken arm or wrist. The X-ray prescription should be used rationally and any waste full expenditure should be avoided. The cost incurred on single X- ray examination in our study was Rs 96/-.
Keywords: X-ray, Radiation, X-ray film

INTRODUCTION

Radiological imaging services are very important in the treatment of patients. X-ray is one of the important radiological imaging services. The discovery of the properties of X-rays gave medical sciences one of its most potent and vital diagnostic tools [1]. Radiography was started in the year1895 after the discovery of X-rays and ever since, it has become an essential part of any hospital system. X-ray imaging is one of the important radiological imaging services. An X-ray is a safe and pain less procedure that is often used to provide images of inside the body. It is an effective way of looking at fractured bones such as a broken arm or wrist. It is projected that around 30% to 50% of important treatment decisions are based on X-ray examinations [2]. World Health Organization has stated that basic X ray facilities are not accessible to two third of the world population regardless of the fact that majority of the diagnostic problems can be solved by using the fundamental X ray techniques. In a study [3]

it was stated that X- ray has been used for both diagnostic and therapeutic reasons, since its invention and the use of X- ray for medical reasons has continued to grow. It was stated that the X- ray or ionizing radiations are beneficial in providing comfort to the patients and in providing diagnostic and therapeutic effectiveness to the patients [2]. In today's time the radiological imaging's is the second fastest growing sector in hospital industry [4]. In a study, it was highlighted that the developing countries of the world relied on the traditional radiography techniques and they remain the core modality as compare to other imaging options [5].

In today's time the number of X ray investigations has increased enormously without much significance or contribution to the treatment modalities. This increase in prescription of X- rays examinations may perhaps be under the patient's pressure or due to money making culture of few of the corporate hospitals. This point was also highlighted in a study [6] conducted in United Kingdom on patient pressure and perceived medical need for undergoing investigation in which the physicians understood that the half of the investigations were either required to some extent or were not required at all. In few other studies [7,8] it was concluded that to a great extent the increase in demand of X-ray was needless and wasteful and the number of radiological investigations prescribed to the patients was much more than what is actually required for diagnostic purposes. Further in a study [9] the health workers, patients and authorities had shown the concern towards the preventable use of medical X-rays and to the related radiation hazards. The X-ray is a type of radiation, exposure to high level of radiation can be harmful. Therefore proper precaution should be adopted during working in X-ray room, because the primary radiation is absorbed by the photographic plate but secondary radiation may causes damage to the tissue. However, the X-ray used for medical purposes are safe because the dose of radiation is very small.

Here we study PT. B.D.SHARMA, PGIMS, Rohtak which is a tertiary care teaching and research hospital of North India. The institute provides health services in almost all the specialty and super-specialty services. The outdoor patients are seen in Ch. Ranbir Singh OPD complex. The radiology wing of OPD complex is having X-ray unit at ground floor with two X-ray machine and two processing units. Keeping in view the work load of orthopedic patients and their conditions the hospital administration has decided to do only orthopedics patient's X-ray in OPD block and rest all others X-ray are done at main radiography department. Therefore, a study is planned to analyze the infrastructure, workload and other aspects of X- ray section of Ch. Ranbir Singh OPD complex.

Process mapping at X-ray wing of OPD complex

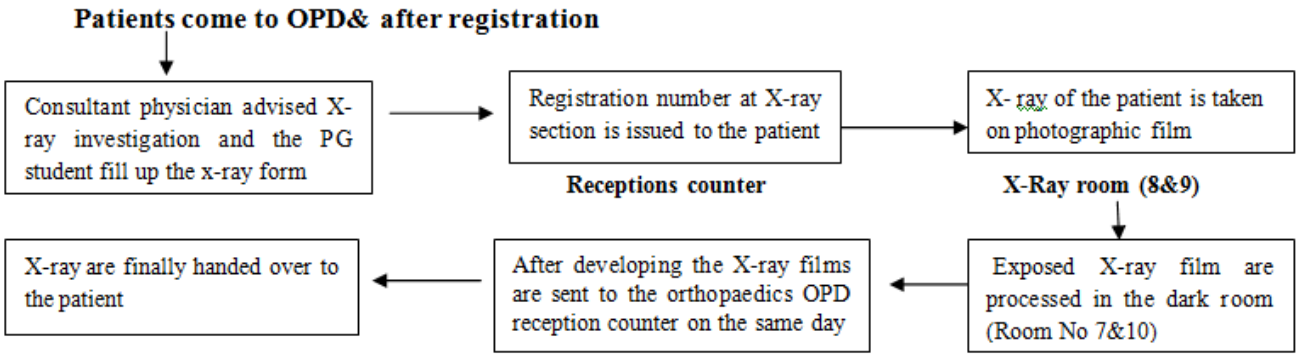


Fig. 1: Process mapping at X-ray wing of OPD complex

Aim

To study the X-ray services provided in the OPD complex of a tertiary care, teaching and research institute of Northern India.

Objectives

- To study the existing workload and infrastructure of X-ray section of Ch. Ranbir Singh OPD complex.
- To study one month work load of X-ray section located in Ch. Ranbir Singh OPD complex.
- To study the one month expenditure of X-ray section located in Ch. Ranbir Singh OPD complex.

METHODOLOGY

Keeping in view the above aim and objectives the following methodology was adopted.

Observational study

An observational study was carried out at the X-ray wing to assess the organizational structure, study of existing equipments and items involved in the functioning of the X-ray wing.

Retrospective study

- Retrospective analysis of the record for the period of January 2013 to May 2014.
- Calculation of expenditure incurred on running X-ray services in OPD complex.

Prospective study

Total no. of patient registered for X-rays as outdoor patients for health care services were studied for one month (19 June 2014 to 18 July 2014) and work load was assessed.

RESULTS

Details of Infrastructure

The X- Ray wing of the OPD complex is situated at the ground floor of the OPD complex. There are two X ray units with two processing units. Total four different kinds of X- ray films are used for the different kinds of X- ray investigations. There are two radiographers and other staff posted in the X-Ray wing (Table 1).

Table 1: Details of infrastructure & staff posted at X- ray wing

Availability of equipments		
Sl. No.	**Name of Equipment**	**Quantity**
1	Plain automatic X-Ray machine having capacity of 800 MA and 125 KV with X-ray tube	2
2	X-ray table (according adjustable according to the requirement)	2
3	Standing X-Ray stand (for taking X-Ray of shoulder and neck)	2
4	Controller of X-Ray machine behind the protective wall of lead	2
5	Automatic X Ray film processor (Big & Small)	1+1 =2
6	Stabilizer (Big)	01
7	Stabilizer (Small)	02
Availability of X-ray films		
Sl. No.	**Size of X Ray Film**	**Quantity**
1	14inches*14 inches	**Adequate Stock**
2	12inches*15 inches	
3	10inches*12 inches	
4	8inches*10 inches	
Staff position		
Sl. No.	**Designation**	**Number of Staff**
1	Radiographer	3
2	DRA(dark room assistant)	2
3	House keeping	3
4	Security	1

Work load of the X- Ray wing

Prospective Study

One month prospective study from (19 June 2014 to 18 July 2014) was carried out to find out the patient load on the X- Ray wing and to find out the consumption of different kinds of X ray films. It was revealed that during the study period the X -ray facility was used for 26 days and total 5312 patients availed the X- ray facility. Total 6147 number of four different sizes of X ray films were used and out of them maximum consumption (33%) was attributed to 10*12 X ray films (Table 2).

Retrospective Study

Retrospective study of the work load was carried out for 17 months (i.e. Jan 2013 to May 2014). It was revealed that total 69755 numbers of patients had undergone X–ray examination in the seventeen months and total 83692 number of X-ray films were used on these patients (Table 3).

Table 2: Day wise detail of workload of X-ray wing (19th June 2014 to 18th July 2014)

Date	Total patient	Total film consume	Sizes of film			
			14*14	12*15	10*12	8*10
19/6/14	308	362	84	26	152	100
20/6/14	192	230	130	-	-	100
21/6/14	82	95	48	-	-	47
22/6/14	**Holiday**					
23/6/14	213	256	149	5		102
24/6/14	154	187	24	52	34	77
25/6/14	159	191	13	80	35	63
26/6/14	386	410	37	138	105	130
27/6/14	197	223	7	66	95	55
28/6/14	203	234	13	91	83	47
29/6/14	**Holiday**					
30/6/14	316	370		118	152	100
1/7/14	193	247		87	98	62
2/7/14	153	176		60	64	52
3 /7/14	286	321		107	140	74
4/7/14	189	211		68	100	43
5/7/14	165	201		81	78	42
6/7/14	**Holiday**					
7/7/14	247	275	22	79	98	76
8/7/14	201	213		72	75	46
9/7/14	204	228	26	81	84	37
10/7/14	257	295	33	98	109	55
11/7/14	191	209	29	71	71	38
12/7/14	137	177	19	60	72	26
13/7/14	**Holiday**					
14/7/14	269	291	27	91	113	60
15/7/14	159	197	16	63	81	37
16/7/14	122	153	18	38	71	26
17/7/14	198	237	26	70	90	51
18/7/14	131	158	19	49	57	33
Total (26)	5312	6147	760 (12.36%)	1751 (28.48%)	2057 (33.47%)	1579 (25.6%)

Table 3: Month wise detail of workload of X-ray department (Jan 2013 to May 2014)

Month	Total patients	Total films consumed	No. of different Sizes of films consumed		
			12*15	10*12	8*10
January	1978	2311	637	956	718
February	4102	4947	1641	2147	1159
March	4238	5035	1545	2137	1353
April	3661	4276	1347	1851	1078
May	5326	6408	2244	3280	884
June	4333	5233	1861	2304	1068
July	4145	5329	1722	2254	1353
August	3336	4041	1391	1528	1122
September	2698	3180	989	1254	937
October	4029	4718	1769	1742	1207
November	2062	2389	772	950	667
December	3188	3610	1160	1491	959
Total	43096	51477	17078 (33.17)	21894 (42.53%)	12505 (24.30%)

Year 2014

Month	Total patient	Total film consumed	Sizes of film			
			14*14	12*15	10*12	8*10
January	4696	5572		1842	2271	1459
February	4530	5230		1965	2043	1235
March	5861	6839		2236	2616	1987
April	5713	6842	468	2148	2518	1708
May	5859	7719	804	2556	2681	1678
Total	26659	32215	1272 (3.95%)	10747 (33.37%)	12129 (37.60%)	8067 (25.05%)
Grand Total	69755	83692	1272 (1.5%)	27825 (33.24%)	34023 (40.65%)	20572 (24.58%)

Table 4: Detail of expenditure incurred on X- ray services of OPD complex in one month (i.e. 19th June 2014 to 18th July 2014)

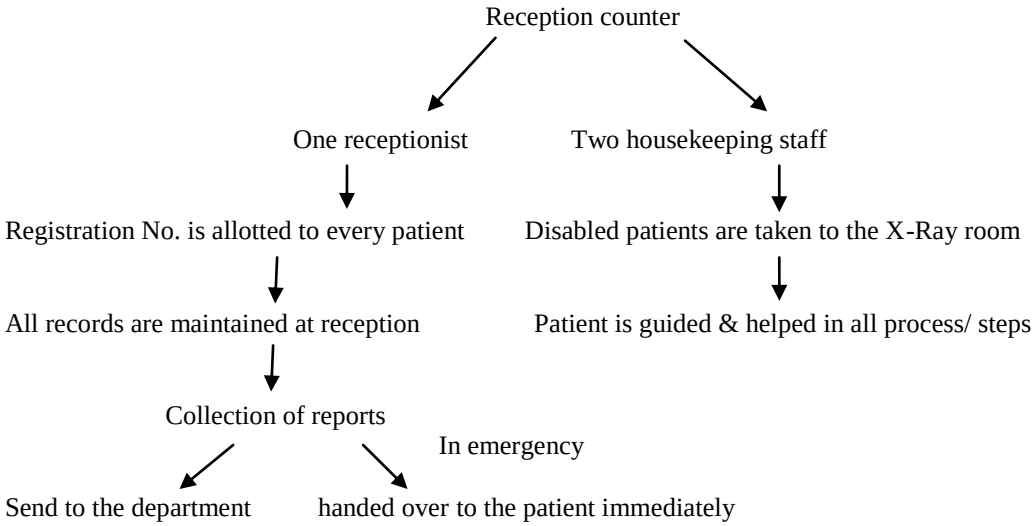
Head	Total monthly Cost (In Rs)	Total annual Cost (In Rs)	Remarks
Building	1979.17	23750	Tentative average life of building is 80 years
Equipment	53154.25	637851	Tentative average life of the equipments is 15 years
Consumable item	162878	1954536	X-ray film + solution
Staff Salary	177400	2128800	
Annual Maintenance Cost (AMC) of two X ray machine's processor units	5802	42654+26966 = 69620	AMC Charges of Big processor unit for the period 1/6/14 to 31/5/15 = Rs 37962/- + 12.36% tax extra AMC Charges of Small processor unit for the period 1/6/14 to 31/5/15 = Rs 24000/- + 12.36% tax extra
Electricity cost	-	-	The electricity cost is not calculated because there is no separate electricity meter for the X ray wing.
Total Cost	401213.42	4814557	-

Details of expenditure incurred on X-ray services

Total capital cost incurred on establishing this X- ray wing was Rs 1.15 crores and on the other hand the monthly recurrent expenditure involved on running the X-ray unit was Rs 3.40 lacs.

Reception Services

A separate reception counter is available for the patients coming for X-rays in the X-ray section of Ch. Ranbir Singh OPD complex, for taking the queries of the patients and guiding them about the whole procedure.



Data analysis and interpretation

Table 5: Correlations

		Total patient	Total film consume
Total patient	Pearson Correlation	1	1.000**
	Sig. (2-tailed)		.000
	N	27	27
Total film consume	Pearson Correlation	1.000**	1
	Sig. (2-tailed)	.000	
	N	27	27
** Correlation is significant at the 0.01 level (2-tailed).			

The correlations give the values of the specified correlation tests, in this case, Pearson's r. Each row of the table corresponds to one of the variables. Each column also corresponds to one of the variables. This correlation must always be 1.0. Likewise the cell at the middle row of the middle column represents the correlation of rather stay at home. It too, must always be 1.0. The cell at middle row and right column (or equivalently, the bottom row at the middle column) is more interesting. This cell represents the correlation of films and patients. There are three numbers in these cells. The top number is the correlation coefficient. The correlation coefficient in this example is 1.000. The middle number is the significance of this correlation; in this case, it is .000. (The significance basically tells us whether we would expect a correlation that was this large purely due to chance factors and not due to an actual relation. In this case, it is improbable that we would get an r this big if there was not a relation between the variables.) The bottom number, 27 is the number of observations that were used to calculate the correlation coefficient.

Table 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	13.258
a. Predictors: (Constant), Total patient				

This table provides the R and R^2 values. The R value represents the simple correlation and is 1.000 (the "R" Column), which indicates a high degree of correlation. The R^2 value (the "R Square" column) indicates how much of the total variation in the dependent variable, Total films, can be explained by the independent variable, Total patients. The next table is the ANOVA table, which reports how well the **regression equation** fits the data (i.e., predicts the dependent variable) and is shown below:

Table 7: ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33765779.790	1	33765779.790	192103.829	.000[b]
	Residual	4394.210	25	175.768		
	Total	33770174.000	26			
a. Dependent Variable: Total film consume						
b. Predictors: (Constant), Total patient						

This table indicates that the regression model predicts the dependent variable significantly well. Look at the "Regression" row and go to the "Sig." column. This indicates the statistical significance of the regression model that was run. Here, $p < 0.0005$, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).

The Coefficients table provides us with the necessary information to predict films from patients, as well as determine whether income contributes statistically significantly to the model (by looking at the "Sig." column). Furthermore, we can use the values in the "B" column under the "Unstandardized Coefficients" column, as shown below:

Table 8: Coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.197	2.755		.072	.943
	Total patient	1.157	.003	1.000	438.297	.000
a. Dependent Variable: Total film consume						

An analysis of the residuals does not reveal any departure from normality. It also suggests a constant and independent variance for the error term. There are potential problems with observations at the extremes of total patient and these should be investigated further.

In conclusion, the ability to predict total films from total patients is reduced by the lack of precision in predictive probability. Other variables should be explored in lieu of or in combination with total patient to improve the predictability of total films used.

DISCUSSION

X-Ray services are one of the essential diagnostic services. The diagnosis and treatment modality of the patients depends to a larger extent on the X-Ray diagnostic services**.** In Ch. Ranbir Singh OPD complex there was a separate dedicated X-Ray facilities for the patients taking treatment in Orthopedics department. The detailed study was carried out in this section and it was found that this section is fully equipped with the requisite machinery and equipments required for X-ray wing. There were two fully functional automatic X- Ray machines with processing units for doing the X-Ray of patients coming from orthopedics department. The X-Rays of patients of other specialties and super specialties are carried out in the main Radiology department of the institute. The work load of these two X-ray units was studied by both retrospective and prospective studies. The month wise retrospective study was carried out for the period of Jan 2013 to May 2014.It was found that during this period a total of 69755 numbers of patents had utilized the X-ray services. While on the other hand the day wise prospective work load analysis was carried out for the period of 19th June to 18th July 2014 and it was found that total 5312 number of patients were benefited from the X- Ray services. Further, when the workload of two Corresponding six months were compared with each other (i.e. Jan- June 2013 with Jan- June 2014), it was found that the number of patients had increased by around 11% to 13% in the year 2014. To corroborate this finding the total consumption of X-Ray films were also compared for the same corresponding durations and it was found that the consumption of X- ray films was also increased by around 26 % in the year 2014. The more increase in the consumption of X ray films than the increase in number of patients may be explained by the fact that many patients must have been prescribed more than one X- ray view or X- ray of more than one site by the orthopedician. The increase in number of patients in year 2014 as compared to previous year was difficult to explain. Therefore, to gain more insight into this deviation the total number of OPD patients of all specialties and super specialties were compared for the same duration and it was revealed that the number of OPD patients had increased to the same extent in year 2014 as compared to the previous year. The finding was discussed with staff posted at X-ray section and in Orthopedics OPD and it was informed that Government of Haryana has implemented Mukhyamantri Mufat Illaz Yojana w.e.f 1st January 2014 in the institute and under this scheme more free facilities are being provided to the patients coming to the institute, therefore the increase in utilization of X ray services in year 2014 can be attributed to this welfare scheme of the Government of Haryana. Similarly when the consumption of different sizes of X-ray films of the year 2013 and 2014 were compared with each other it was found that in year 2013 three sizes of X-ray films were used and since April 2014 four different sizes of X ray films were used (i.e. 14*14 inches size was also included). On detailed analysis of these films, it was revealed that the utilization of 14*14 inches X ray films had resulted in proportional decreased utilization of only one size of X-ray film (i.e.10*12) and the utilization of other films remained unaffected.

The total expenditure incurred (i.e. Capital + Recurrent) on the X-ray service was analyzed in the study. It was found out that around Rs 1.15 crores was one time capital expenditure on the installation of two X-ray plants and the monthly recurrent expenditure involved on running the X-ray unit was Rs3.40lacs. The expenditure on human resource was around 52% of the total recurrent expenditure. Further, in few other studies on hospital costing, it was concluded that human resource constitutes the majority of hospital operating cost [10-13]. On an average the life of building is around 80 years and life of X ray unit is around 15 years. Therefore, the proportionate expenditure (both capital + recurrent) incurred per month on X- ray services was around Rs 401213/-. The average number of patients/ month coming to X ray section is around 4170. Therefore the tentative cost per X-ray investigation is Rs 96/-.Thus the institute is spending around Rs 96/- on each X-ray investigation carried out in Ch. Ranbir Singh OPD complex. However the cost of a single chest X-ray was found to be MYR 5.65 (USD 1.75) in a study conducted in the Malaysia [14].

The strength of our study is that the detailed work load analysis and detailed study on the cost incurred on the X- ray section of OPD complex was carried out. The limitation of our study is that the analysis of safety feature as per guidelines of regulatory agencies was not carried out, as it was not within the scope of this study. This study throws light on the basic aspects of X ray section viz. workload, costing etc. and some other study may be planned for analyzing the safety aspects of X-ray section vis a vis guidelines provided by the regulatory authorities (eg. BARC/AERB etc.).

CONCLUSION

X-ray services are essential diagnostic services in the medical sciences. An X-ray is a safe and pain less procedure that is often used to provide images of inside the body. It is an effective way of looking at fractured bones such as a broken arm or wrist. The X-ray prescription should be used rationally and any waste full expenditure should be avoided. The ability to predict total films from total patients is reduced by the lack of precision in predictive probability. Other variables should be explored in lieu of or in combination with total patient to improve the predictability of total films used. The cost incurred on single X- ray examination in our study was Rs 96/-.

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