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Radiology Section

A Comprehensive Approach Towards Quality and Safety in Diagnostic Imaging Services: Our Experience at a Rural Tertiary Health Care Center

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ABSTRACT

Introduction: An organization's transformation from implementation of small, distinct Quality Improvement (QI) efforts to complete incorporation of Quality Improvement Program (QIP) into its culture occurs through a process of churning the foundational elements over time.

Aim: To develop a quality culture across the employees, identify measurable indicators and various tools to impart effective quality care and develop a learning culture for continuous quality improvement in the field of imaging services.

Materials and Methods: To establish a QIP, the bare minimum requirement started with forming a quality committee. The committee identified the areas of improvement and ascertaining the core principle of Quality Management System (QMS) by having a Quality Manual, Standard Operating Procedures (SOP's), work-instructions, identification and monitoring of quality indicators and a training calendar. Appropriate tools like formatted daily registers, periodic check lists, run charts etc., were developed to collect the data followed by multiple PDSA cycles (Plan, Do, Study and Act) which helped identify the process bottlenecks, followed by implementing solutions and reanalysis.

Results: A total of 17 measurable key performance indicators were identified from the four major quality tasks namely Safety, Process Improvement, Professional Outcome and Satisfaction, to assess the performance measures and targets of QIP.

Conclusion: Diagnostic services should evaluate how to choose the most appropriate method and develop a comprehensive QIP to meet the needs of the staff and the end users, thus, creating a working environment, where people constitutes the intrinsic value in attaining the ultimate quality and safety.

Keywords: Continuous quality improvement, Diagnostic imaging, Key performance indicators, Quality improvement programme, Radiology

INTRODUCTION

In the era of rapid growth and technological advancements, imaging brings along with it, its own risks and hazards and therefore radiologist are presented with different challenges dealing with safety and health care monitoring [1]. It becomes of utmost importance to put patient and staff safety at the forefront and at the same time provide quality services.

Quality culture of a department in a health care organization is the epitome of its core values, guiding principles, attitude and a planned approach that altogether contribute to the daily chores.

It has to take into consideration, two elements of a very different nature, to be dealt in an entirely different manner which is technological (such as equipment, premises, documents, materials and tools) and social (the people and patients, composing the work place).

Failures, adverse events and errors can occur from any of the two constitutes, which needs to be controlled and prevented jointly.

The current study was part of an audit to a routine institutional practice, at Shree Krishna Hospital which is a 650 bedded rural tertiary care teaching hospital based in Karamsad, Gujarat, India, having five ICU's, cancer and cardiac centers. It offers services to the rural community and has been instrumental in adopting 90 villages. It has a physician led governance structure for managing patient care through functional groups based on four pillars of quality namely, Human Care Group, Rational Care Group, Efficient Care Group and Affordable Care Group. Policies developed by these groups are implemented by the Quality Improvement Group (QIG) under the overall guidance of the Board of Management which includes experts from other hospitals. In 2011, with involvement of the QIG, a new initiative was taken in developing a Quality Team for the department of Radiodiagnosis. The Quality Improvement (QI) activities commenced from 2011, however, a fully developed plan was implemented in 2013. The study period was from April 2013 to February 2017 for monitoring quality indicators.

MATERIALS AND METHODS

This was a qualitative research study with descriptive exploratory design, QMS audit of a Radiology Department from April 2013 to February 2017 and approved by the Institutional Ethics Committee.

The following steps included in the development of a QIP.

1. The Formation of the Quality Committee:

- **Chairman QIG:** An individual appointed by the Board of Management, to form a conduit between the management, clinical as well as non clinical departments.
- **Quality manager:** A radiologist, appointed by the QIG, organize and drive the ongoing work and team. Serves as the "key contact" responsible for coordinating communication on the progress of a QI project to the overall organization, staff and QIG. Aggregates and analyzes the monthly data and submits reports regularly.
- **Internal auditors:** Team of two radiologists trained by external agencies, responsible for training, educating and complying QI activities and further more participating in several hospital committees.

- **Sectional in-charges:** One radiologist for each modality to oversee the functions and QI activities.
- **Quality executive/Data specialist:** A representative from the QIG appointed by the QIG, who is well-versed with QI concepts and tools, analyzes data using appropriate QI tools.
- **Office assistant:** An individual elected by the Department of Radiodiagnosis, who carries out the data-entry function at each functional level.
- **Operations person:** An individual from hospital Infection team to manage the infection control audits. The infection-control nurse to oversee the infection control practices. Individuals from Hospital Information System, Biomedical Department, Purchase Department, Projects Department, to monitor down time and maintenance of the equipment and systems.

2. Generation of manuals and the Standard Operating Procedures (SOP) followed by identification of the Radiology Specific Key Performance Indicators (KPI): Radiation Safety, Quality Manual and SOPs were drawn for all the modalities. As mentioned by Johnson CD et al., four main quality tasks were addressed as depicted in [Table/Fig-1] and the measurable KPI affecting the service delivery were identified [2]. Atomic Energy Regulatory Board (AERB) guidelines [3] for radiation protection were followed which constituted appointing certified radiation safety officers (level I and III) for regular audits and compliance with regulatory boards, radiation safety committee to oversee the safety policies and enlist the procedures for radiation safety including As Low As Reasonably Achievable (ALARA) principle.

1. Safety	2. Process Improvement	3. Professional Outcome	4. Satisfaction
Radiation safety	Appropriateness	Peer review	Patient satisfaction
Infection control	Waiting time	Procedural outcomes	Client satisfaction
Contrast media safety	Defined standard protocol and monitor the deviation.	Success rate	Employee satisfaction
Patient and employee safety	Repeat procedure	Critical alert TAT*	Student satisfaction

[Table/Fig-1]: Areas addressing quality care under major quality tasks.
TAT*: Turn around Time

Dose reduction techniques were followed and radiation doses at the end of scan were recorded for each patient. Paediatric patients and women of child bearing age and pregnant females were offered a change in modality whenever applicable; however, if imaging necessary in life threatening situations, it was done after weighing benefit versus risk equation with appropriate shielding.

Monitoring and periodic records for employees involved in radiation zones were maintained using Thermo Luminescent Dosimeter (TLD) badges. Proper handling and periodic checks for adequacy of lead apron and other shields were observed.

American College of Radiology (ACR) guidelines [4] for contrast media safety were followed with a pre-contrast safety checklist incorporated in the consent forms as a part of safe practices.

Checklist and consent forms for image guided procedures and screening for MR imaging was mandatory to identify patients at potential risk before imaging.

3. Cultivation: This included educating and training the staff at workplace by the quality manager and internal auditors who were trained by QIG and external agency (National accreditation Board of Health care), utilizing innovative methods like hands on training, demonstrations, power point presentations, mock drills and brain storming activities to make the training more acceptable and easily absorbable. After the initial session on orientation, various training programmes as tabulated in [Table/Fig-2] were launched followed by post training evaluation.

S.No	Staff Training Programme
1.	Vision, Mission, Core purpose, Values
2.	Care of Vulnerable Patients
3.	Adverse events reporting
4.	Employee rights and responsibilities
5.	Employee grievance handling mechanism
6.	Policy on sexual harassment
7.	Patient rights and responsibilities
8.	Code red, code blue and code pink
9.	Methods for dose reduction in computed tomography
10.	Radiation safety and hazards
11.	MRI safety measures
12.	Needle stick injuries
13.	Infection Control Practices (Spill Management, Equipment Cleaning and Hand-washing)
14.	Fire and Disaster management
15.	Committee Against Sexual Harassment (CASH)
16.	Adverse Drug Reaction and Adverse Drug Events
17.	Complaint Handling Mechanism
18.	Incident Reporting Mechanism

[Table/Fig-2]: List of training programmes for the staff.

4. Stimulation and ensuring compliance: Training need assessment sheet was generated to keep the ongoing check on new and existing recruits at periodic intervals and reviewed annually. The training need assessment sheet helped to identify the individual/groups required to be re-trained. To ensure compliance we followed the dictum "Anything which can't be recorded, cannot be measured" [5]. Appropriate tools like formatted daily registers, periodic check lists, run charts etc., were developed to collect the data followed by multiple PDSA cycles [6].
5. Identifying the culprits and root cause analysis: The collected data were periodically analyzed to identify the bottlenecks followed by root cause analysis and solutions to rectify the problems.
6. Re-analysis of the rectified parameters and the continuing cycle. The final step was to reanalyze the data and continue with the same process again.

RESULTS

A total of 17 measurable Key Perfomance Indicators (KPI) as in [Table/Fig-3] were identified and a dedicated quality indicator sheet was drawn every month.

Safety

a. Radiation exposure parameters were tabulated for patients and staff members. A pregnant radiographer was offered change in workplace during the pregnancy tenure as decided by the radiation safety committee. Biannual lead shield's safety checks by CT scannogram and aprons showing cracks were replaced.

b. Procedure-related safety: Reporting of needle stick and ergonomic injuries were highly variable and dependent on individual reporting. There were only 15 injuries reported including all cadres across the department, out of which 7 were mechanical, 4 were ergonomic, 3 had needle stick injuries and 1 reported of having infective splash over face. Strict adherence to the guidelines laid down by ACR [4], for usage of contrast media was advocated, but it was observed that labelling for used bottles of contrast media were overlooked and therefore periodic audits and repeated staff awareness was accentuated.

Sr. No	Measurable Quality Indicators Assessed
1	Operational Data (Financial year wise)
2	TLD* monitoring
3	Repeat exams (Positional, System and Patient Movement)
4	Reporting errors
5	Contrast Media Reaction
6	Adverse event/ Needle stick/Ergonomic injuries monitoring
7	TAT† (From registration to report dispatch)
8	TAT† Intimation of Critical Alerts
9	Clinico-Radiological and Radio-pathological correlation
10	Internal Peer Review
11	External Quality Assessment system
12	Breakdown and Downtime of Equipments
13	Dose calculations for CT procedures for vulnerable patients (Paediatric patient)
14	Patient Feedback and Satisfaction
15	Doctor (Client) Feedback Satisfaction
16	Employee Feedback Satisfaction
17	Student Feedback Satisfaction

[Table/Fig-3]: Measurable key performance indicators as a part of quality improvement programme.
TLD*: Thermoluminescent dosimeter, TAT†: Turn around time

c. Infection control practices: Though staff was trained for importance of hand hygiene, barricade methods while imaging infective patients, as well as for trash and spillage management, hand hygiene was found to be an area of concern after the annual audit. A staff nurse trained in infection control policies was assigned the task of daily supervision and hand hygiene display charts were placed in each service area. Daily check sheets were found to be the best method for the daily assessment of the trash management areas.

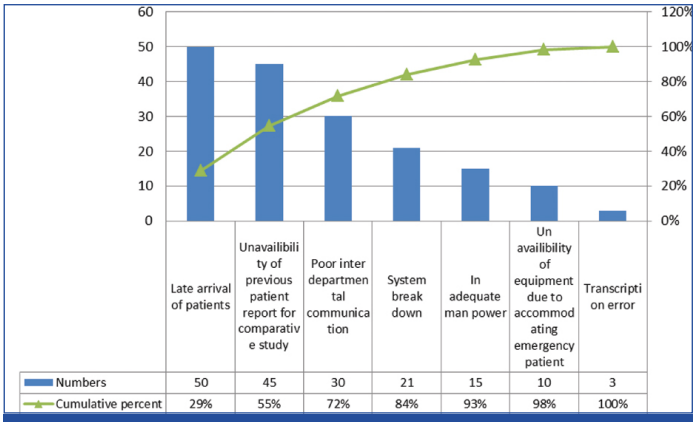
d. Consent form and patient care: Appropriate identification and consent involved with imaging and invasive procedures was observed to be followed adequately. Precontrast screening forms were found to be useful in identifying at risk patients and records for minor and major contrast induced reactions in patients were monitored. Very few number of patients had developed contrast induced reactions, mostly minor reactions like chills and rigors.

Process Improvement Group

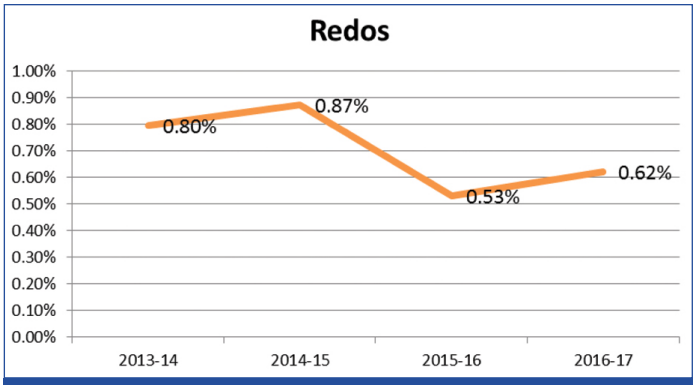
a. Justification of referrals: Many unsatisfactory patterns of referrals were observed. The patients showed a resistance in acceptance for the change in modality offered due to cost constraints and referring physician's acceptance.

b. Average waiting time for patients from the time of appointment to the initiation of imaging was observed to be uncontrolled. Quantitative evaluation of various factors contributing to delay was as shown in [Table/Fig-4]. As a step towards rectifying the problem, separate time slots were made for OPD and IPD patients. Front desk scripting was enhanced including patient information on importance of pre-procedure requisites and any previous imaging details.

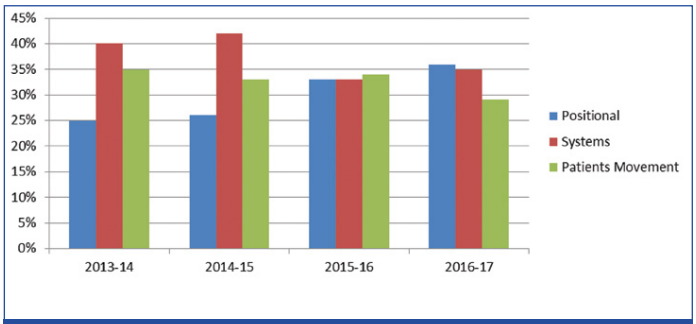
c. Repeat imaging was more commonly observed in conventional radiography. [Table/Fig-5] shows the average percentages of Redo's in conventional radiography. As shown in [Table/Fig-6], increase in number of system errors from 2013-2015 were related to timeworn cassettes and CR system leading to image artifacts and filming issues. However, in due course of time the cassettes and CR machine were updated. In 2015-2017 a percentage increase in 9% (positional) was noted. Being a teaching hospital, having new apprentices, students and residents for imaging–technology lead to increase in the positional Redo's. It was also observed that the positional errors were more encountered in the post implant patients of orthopaedic department and most of them were taken by trainees and new recruits in the period, hence the radiographers were trained to comply with rational practices.



[Table/Fig-4]: Pareto analysis for factors contributing to increased waiting time.



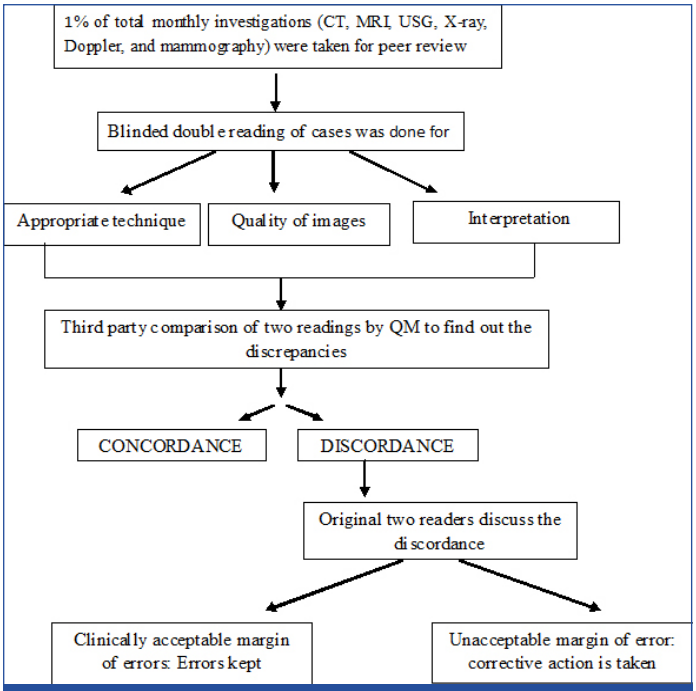
[Table/Fig-5]: Average percentage of repeat imaging (Redo's) in radiography.



[Table/Fig-6]: Percentages of causative factors from the total Redo's for repeat radiography.

Professional Outcome

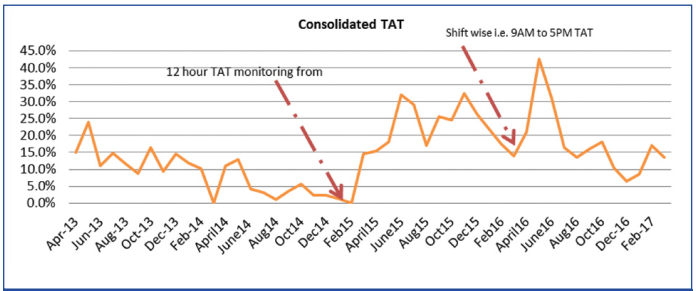
a. Internal and external peer review was done by the in-house radiologists and radiologists of other centres who have a memorandum of understanding. One percent of the total monthly workload for each modality in the scope of services including radiography, mammography, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasonography (USG) and Doppler, which consisted a total of 983 cases recorded in monthly sheets from the period of 2013 to 2016, were taken up for blinded peer review and further categorized as concordant (98%) and discordant (2%) according to the diagnostic accuracy, quality of images and appropriateness of the technique. The results of discordant imaging findings were observed in 16 cases (2%) which were further classified as clinically significant (observed in only 2 cases) and non-significant (observed in 14 cases) and the procedure followed as mentioned in [Table/Fig-7]. Only the two cases in which clinically unacceptable margin of error was observed, the errors



[Table/Fig-7]: Flow chart showing internal and external peer review procedure.

were conveyed to the treating physician and for the other one and the errors were conveyed to the concerned radiologist.

b. Turn Around Time (TAT) of reports was found to be an important parameter in radiologist's performance evaluation as it helped in accommodating more imaging procedures and reflected an overall increase in workload. With continuous evaluation of various factors affecting TAT, physician's demand and departmental consensus we have reduced the TAT from 24 hours to 12 hours followed by commitment towards reporting in the next shift of morning and evening working hours as depicted in [Table/Fig-8].



[Table/Fig-8]: Line chart diagram showing consolidated Turn Around Time (TAT) for both CT and MRI from April, 2014 to Jan, 2017. Arrows indicate the revision of timings.

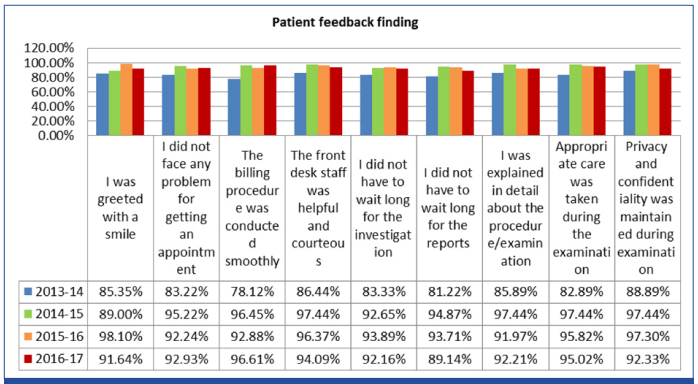
c. Radiopathological and Clinicoradiological correlation was done taking few random cases every month, constituting five percent of the total monthly workload to strengthen professional accuracy.

d. Reporting errors after generation of reports were properly evaluated categorizing clerical errors and errors probably affecting/not affecting the clinical outcome. It was observed that most of the errors in reports were related to transcription errors.

Satisfaction

Feedback questionnaire was prepared in a way to identify the end user preferences for each group.

a. Patient satisfaction: The data was collected on daily basis by the front desk staff from patients availing services at imaging centre. An average of 40 feedbacks were collected weekly to study the satisfaction parameters. Front desk's unfriendly greetings, issues in billing procedures, waiting longer for reports and waiting for imaging were the areas of immediate concern as shown in [Table/Fig-9]. Immediate corrective action included training of the front desk staff on behavioral



	I was greeted with a smile	I did not face any problem for getting an appointment	The billing procedure was conducted smoothly	The front desk staff was helpful and courteous	I did not have to wait long for the investigation	I did not have to wait long for the reports	I was explained in detail about the procedure/examination	Appropriate care was taken during the examination	Privacy and confidentiality was maintained during examination
2013-14	85.35%	83.22%	78.12%	86.44%	83.33%	81.22%	85.89%	82.89%	88.89%
2014-15	89.00%	95.22%	96.45%	97.44%	92.65%	94.87%	97.44%	97.44%	97.44%
2015-16	98.10%	92.24%	92.88%	96.37%	93.89%	93.71%	91.97%	95.82%	97.30%
2016-17	91.64%	92.93%	96.61%	94.09%	92.16%	89.14%	92.21%	95.02%	92.33%

[Table/Fig-9]: Bar diagram compiling data from questionnaires for patient satisfaction of respective years.

and communication skills as well as enhancing the front desk scripting to properly instruct patients for total time taken for pre, para and post procedures. Early time slots were allocated for patients coming from long distances with early dispatch of reports. Front desk's unfriendly greetings were again an area of concern in the year 2016-17. Analysis revealed the causative factors being the new untrained recruits as well as front desk staff accommodating to new change in time shifts and recent technology advances in hospital information systems. The training needs were thus assessed and accentuated. Dissatisfaction for waiting longer for reports was also observed in 2016-17 which reflected in the TAT graph [Table/Fig-8] as well which was due to commitment towards change in the TAT from 12 hours to shift wise reporting, as a step towards enhancing the professional outcome.

Vulnerable group of patient's e.g., elderly, paediatric age group and diabetics were given a priority for early morning appointments. Time slots for indoor and outdoor patients were identified to provide easy accommodation for each subset.

b. Physician satisfaction: Physician's feedback form was designed and given to almost all in-house doctors referring cases to imaging centre. The data was collected biannually. Ease of availability of appointments and intimation of critical alerts as well as routine imaging were the areas of concern. As corrective action, all the critical alerts and cases done in emergencies were immediately informed to the treating physicians on completion of the study. Necessary changes were made at reception area to provide an easy access and a system to inform provisional findings immediately after the imaging was done for non- urgent cases. To accommodate more appointments the timings of OPD and IPD patients were defined with all efforts taken to reduce the pre-imaging waiting times e.g., transfer of indoor patients on appointed time and fulfillment of preimaging checklist.

c. Employee satisfaction survey: All the employees underwent a departmental customized annual satisfaction survey. Respectful and a blame free friendly working environment, timely trainings for new techniques and reduced radiation hazards were considerable preferences. Training on radiation safety, patients and employee's rights and responsibilities, infection control safe practices, awareness of the staff regarding grievance handling and sexual harassment committee were accentuated.

d. In student satisfaction survey: All the postgraduate students, an average of 12 students were surveyed annually. Case based learning and friendly working environment were the areas of concern which were addressed in the teaching curriculum.

DISCUSSION

Recent advances in imaging and the incursion into a digital era, the role of radiologists have evolved from being just an image interpreter to be omniscient, thus necessitating being vigilant in all the aspects including health care delivery, statutory advocacy, patient and staff safety, professional maturity and information technology [7].

Many safe practices are mandatory by regulatory boards; however there are many others which are often overlooked, e.g., dose reduction techniques in CT, labeling the contrast used bottles, hand hygiene, reporting of work related injuries etc.

Rising concerns of radiation risk of diagnostic imaging, prompted to lay down adequate departmental policies and insist the physicians to send referrals to centers strictly adhering and following dose reduction techniques. Though benefits of medical imaging most of the times outweigh the relatively small excess cancer risk, however, for certain subsets of patients e.g., paediatric, radiation risk should be of greater concern to the clinician [8].

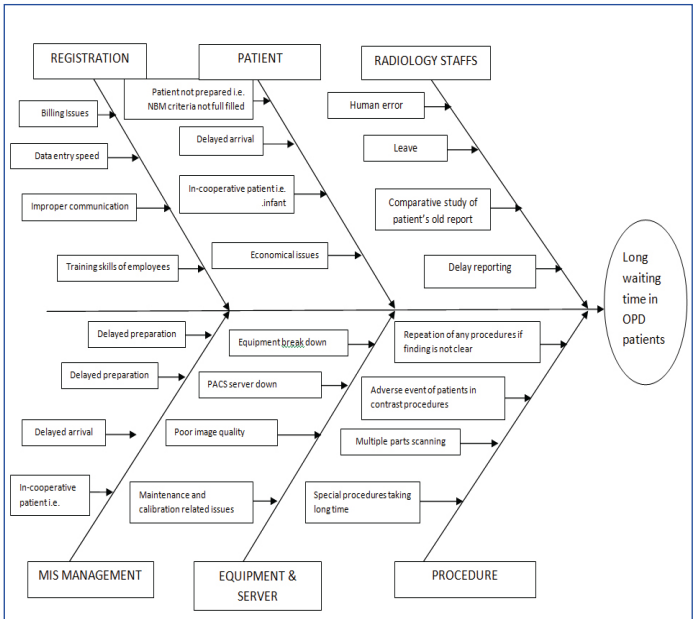
We also observed as mentioned by Siewert B et al., that the gizmos for a comprehensive safety program includes observational safety audits and an adequate safety reporting tool for employees to track the safe practices [9].

We had contrast induced minor reactions more commonly as compared to major reactions in our patients. The same trend was observed by Cochran ST et al., in their study [10]. However, post-procedural patient care in such cases was found to be important in accentuating patient satisfaction.

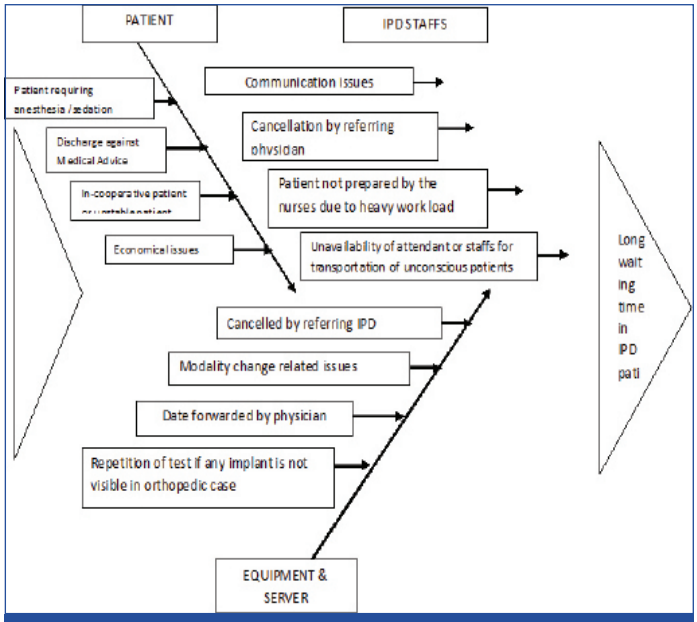
As mentioned by Mathur P, hand-washing practices continue to remain unacceptably low, rarely exceeding 40 percent [11]. Most common factor stated by many was forgetfulness and therefore hand hygiene charts at each service area were displayed.

It was observed that least attention was paid to justification of referrals as it was never seen as a problem. Many countries have set guidelines made to promote good medical practice; at the same time use an appropriate investigation and contribute in reducing the radiation burden [12]. It was wise to follow the guidelines and set our own to collectively provide diagnostic, therapeutic, health and economic benefits not only to the patient but also to the diagnostic services.

Increasing demand for diagnostic services has led to increased volumes and at the same time contributing to increase waiting times. [Table/Fig-10,11] show the fishbone of reasons contributing towards increased waiting times. As it was in the study of Weissman BV, we



[Table/Fig-10]: Fish bone diagram showing reasons behind long waiting time in case of OPD patients



[Table/Fig-11]: Fish bone diagram showing reasons behind long waiting time in case of IPD patients.

too found that with a clear understanding of the patient through-put, standardizing scheduling times, automating scheduling processes, revising optimal protocols and examination timing, decreasing radiologist time to protocol orders and developing service standards, we streamlined steps for a patient enroute to diagnostic imaging and expedited the process, however achieving the golden TAT still remains challenging [13].

Alder A in his review of forty-nine studies reported repeat/reject film ranging from 3% to 15% however, we observed a lower rate of rejects [14]. It was commonly observed that there was more number of repeats in conventional radiography as it was operator dependent and the positional errors were observed due to trainees involved in the radiography as was the same scenario in the study by Acharya S et al., [15].

Many ways already exist to measure the professional formal recognition of competence including educational prerequisites, medical licensure; however, it may not encourage dedication to professional excellence and commitment towards continuous learning.

Peer review is an important parameter in a radiologist's performance evaluation [16]. We observed that a just culture and a positive attitude to learn from one's own mistakes provide a gateway for self-improvement [16,17].

The increasing demand for the fast and furious TAT for imaging modalities by private centers cannot be ignored, as it also impacts the professional competency of their counterparts in academic medical centres. The golden TAT number is one hour for many stand alone centres and they hold an advantage in reaching that threshold and going even lower because reading reports is their only focus [18]. The scenario for academic medical centers continuously thriving for quality improvement is much different as we also have to consider teaching and other academic responsibilities and at the same time generate timely communications, be it for a critical alert or aiding in further management of a patient.

TAT not only depends on individual knowledge but also on type of imaging and the disease being interpreted. We also found factors like speedy transcription of reports, use of structured formats, speedy filming, compiling the clinical details and previous comparative studies to be useful as was the case with study of Seltzer SE [19]. However, it should not be used as a sole qualitative measure but rather a tool for performance evaluation which keeps one more disciplined and organized.

Evaluating the reporting errors is also considered an important parameter in professional outcome. Berlin L [20] has quoted a daily radiologist error rate averaging from 3%–5% and a retrospective error rate among radiologic studies averaging 30%. Though we could not perform a dedicated survey, rather documented the errors as informed by individuals or brought to notice by staff and referring physicians, it was observed that there was an average of 10 to 15 reporting errors per month, most of which were clerical errors. Kim YM et al., published a classification system for radiological errors into various categories like under reading, faulty reasoning, satisfaction of search or report etc., which is beyond the scope of our study [21]. Brady AP has suggested many contributing factors and strategies in his article to avoid errors/discrepancies in radiology considering them inevitable but avoidable [22]. We intend to improvise the error reporting tool as a scope of further safety practices.

We believe that it is through the just culture we would be able to provide our work environment to be less error prone and more error tolerant [23]. As mentioned by Pinto A et al., that identification and reduction of diagnostic error not only helps to reduce mortality and morbidity, but also affects the cost and length of hospital stay [24].

As described by Hoe J et al., it is important to identify different types of customer and their needs, followed by identification of the KPI's pertaining to their satisfaction [25]. We also prepared a questionnaire in a way to identify the end user preferences.

We identified determinants of patient satisfaction either dependent or in-dependent and compared the magnitude of each on overall patient satisfaction. It was found similar to the study of Al-Abri R [26], that interpersonal skills in terms of courtesy e.g., greeting with a smile, maintaining respect and dignity along with patient information and communication skills, were more alluring than other technical skills like clinical competency and hospital equipment's.

Physician satisfaction survey was similar to that of Mozumdar BC et al., with referring physicians more concerned with the ease of availability of appointments and a prompt intimation not only for critical alerts but also as a part of routine cases [27].

It was a greater challenge for the residents and faculty members as both need to work together for service and educational obligations without compromising patient care [28].

LIMITATION

There were few limitations in our study like bias involved in peer review. Though there was a systematic format in place, human nature bias regarding peer goodwill might not have been completely removed. The staff though was trained for measures involving personal radiation safety, ALARA principles, justification of referrals and methods for minimizing investigational radiation doses to patients, periodic audits for investigational doses for each patient were beyond our scope. Since it was a large scale project and several variables were taken into account, it is difficult to point out which single variable would have contributed more towards overall performance improvement.

CONCLUSION

Thus, developing and maintaining the quality and safety culture across the work place requires commitment of all the staff and deliberate management of the change process which we have achieved over a period of time by strictly adhering to the quality principles and meticulous implementation of various guidelines. We are now miles ahead from where we began and aim to strive for constant improvement in providing quality health care.

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