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Case Report

Improving patient flow in diagnostic imaging: a case report

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ABSTRACT

Introduction: This case study focuses on Erie Shores Healthcare, a small Canadian hospital with a busy emergency department (ED) who acts as the sole provider of outpatient diagnostic imaging (DI) services to the community. The hospital is experiencing bottlenecks when balancing outpatient diagnostic procedures with inpatient and urgent ED requests in the X-Ray department, creating the need for increased overtime and missed breaks, as well as frustrations amongst patients, staff and physicians.

Case and Outcomes: To alleviate these issues and improve patient flow, this case study aims to identify options for increasing efficiency, improving adaptive workflow and decreasing wait times during peak hours in X-Ray.

Discussion: After a literature review, key components were narrowed down to include the following Lean Methods: floor plan evaluation with spaghetti diagrams, collection of benchmarking data from similar Canadian sites, and a real-time Client Flow Analysis. The potential benefits of Technologist Assistants (TA) and DI-dedicated porters are also explored.

Conclusion: Lean methodology is an effective way to evaluate and improve patient flow in DI. Healthcare organizations should take advantage of key redevelopment projects and technological advancements to maximize their departmental efficiency.

RÉSUMÉ

Cette étude de cas porte sur Erie Shores Healthcare, un petit hôpital canadien avec un service d'urgence (SU) très occupé qui est également le seul fournisseur de services d'imagerie diagnostique pour patients ambulatoires dans la collectivité. Le service de radiographie de l'hôpital est confronté à des goulots d'étranglement dans la recherche de l'équilibre entre les procédures de diagnostic pour les patients ambulatoires, les demandes pour les patients hospitalisés et les demandes urgentes du SU, ce qui nécessite le recours aux heures supplémentaires et la perte des pauses, suscitant la frustration chez les patients, le personnel et les médecins. Pour atténuer ces problèmes et améliorer le flux des patients, cette étude de cas visait à recenser des options permettant d'augmenter l'efficacité, d'améliorer le flux de travail adaptatif et diminuer le temps d'attente durant les périodes de pointe en ID, notamment pour les patients ambulatoires qui se présentent sans rendez-vous. Après une revue documentaire, les éléments clés ont été sélectionnés en retenant les aspects suivants de la méthode LEAN: évaluation du plan d'étage avec un diagramme spaghetti, collecte de données de référence à partir de sites canadiens similaires et analyse du débit en temps réel dans le service de radiographie d'Erie Shores. Les auteurs explorent également les avantages potentiels du recours aux assistants en radiographie et à des porteurs réservés en ID sont également explorés.

Keywords: Diagnostic imaging; Radiology; Radiological technology; Patient flow; Wait times; Process improvement

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Introduction

With increasing technological sophistication and diagnostic accuracy, diagnostic imaging (DI) has progressively moved to the forefront of providing efficient and comprehensive care. In particular, X-ray imaging can play a vital role anywhere from rapidly evaluating acute injuries to diagnosing and staging a variety of disease. However, having access to X-Ray imaging in a timely fashion is pivotal to ensuring prompt diagnosis, suitable intervention and optimal patient outcomes.[1] Additionally, in emergency department (ED) and inpatient settings, delays in access to X-Ray and DI is associated with increased length of stay and ED overcrowding.[2] Therefore, it is imperative for hospital administration to closely monitor and evaluate wait times and access to essential services such as X-Ray imaging. The focus of this case study will be Erie Shores Healthcare, a Canadian hospital with a busy ED who acts as the sole provider of outpatient DI services to the community, also known as a community hospital[3]. Currently, outpatient Ultrasound, Computed Tomography (CT), Nuclear Medicine and Mammography procedures at Erie Shores are scheduled, however, X-Rays are offered on a walk-in basis. Unfortunately, this hospital is experiencing bottlenecks when balancing outpatient diagnostic procedures with inpatient and urgent ED requests in the X-Ray department. This is creating the need for increased overtime and missed breaks, as well as frustrations amongst patients, staff and physicians.

To alleviate these issues and improve patient flow at Erie Shores, this case study aims to identify options for increasing efficiency, improving adaptive workflow and decreasing wait times during peak hours in DI, and walk-in X-Ray in particular. Key components of this case study include a literature review, floor plan evaluation, collection of benchmarking data from similar Canadian sites and a real-time Client Flow Analysis within the Erie Shores X-Ray department. This case study was considered program evaluation and thus, did not require ethics approval.

Literature review

At the commencement of this project, a literature review was conducted to gain a better understanding of existing and prominent patient flow techniques and strategies. A combination of PubMed, CINAHL and Google Scholar were used to search the literature for relevant articles. Limited results were yielded from utilizing too many terms while searching the literature. The search terms were then reduced to ''patient flow'' and ''diagnostic imaging''. After targeting any article that combined the terms ''patient flow'' with ''diagnostic imaging'', 14 useful articles were retrieved.[1,2,4–15] Reviewing the literature provided a wealth of knowledge and a multitude of frameworks for analysing and improving patient flow. Additionally, several gaps in the literature were identified, including the possible benefit(s) of utilizing personnel such as Technologist Assistants (TA) or DI-dedicated porters. Upon completion of the literature review, it was found that LEAN practices coupled with LEAN tools such as spaghetti diagrams, benchmarking and value stream mapping were the most popular. Therefore, a LEAN approach was used to aid in the evaluation of patient flow at Erie Shores. From a health administration perspective, LEAN methodology focuses on the elimination of waste and improvements in operational efficiency to enhance the value of the service being provided.[7]

The three most common LEAN tools identified in the literature were targeted to complete this case study: spaghetti diagrams, benchmarking and value stream mapping. With the goal of waste elimination and improved efficiency, spaghetti diagrams are used to help track the movement of a person or product through an environment or, in this case, a department.[4] The second LEAN tool is benchmarking, where sites that are similar in size or workflow are contacted to gain a better understanding of standards of care.[7] Finally, value steam mapping is used to produce a visual of how a process within an organization is completed, allowing any non-value adding activities to be identified and ideally, removed.[7] In this case study, a Client Flow Analysis was developed and intended to be used for the purposes of value stream mapping. However, due to unforeseen circumstances surrounding the Covid-19 pandemic, the Client Flow Analysis, and thus the value steam mapping portion of this case study could not be completed.

Spaghetti diagrams and floorplan evaluation

For this case study, spaghetti diagrams were overlaid on both the current department design (Fig. 1) and the proposed department design (Fig. 2) to track how reconfiguration improved work- and patient flow. The imaging process was tracked from the moment an outpatient enters the department for registration (at the DI Clerk desk) until they are taken into an X-Ray room for their exam.

This is a crucial time to evaluate the work- and patient flow at Erie Shores, as the hospital is about to undergo a redevelopment project where the X-Ray department will be redesigned. Fig. 1 demonstrates the original redevelopment floor plan for the X-Ray department with a spaghetti diagram overlaid to track both patient (purple) and technologist (red) movement. Fig. 2 demonstrates the proposed configuration of the X-Ray department, again with a spaghetti diagram overlaid to track patient and technologist movement, as well as the introduction and movement of a Clerk or TA (blue) to assist with patient flow.

With patient movement shown in purple and technologist movement shown in red, it is easy to appreciate that in Fig. 1, the technologists do most of the walking as they retrieve the patient from the waiting room that is far removed from the exam rooms to first instruct the patient on how to get changed. After changing, the patient is then retrieved by the technologist from the far waiting room again before proceeding to the exam room. A key thing to note here is that this X-Ray department does not assign patients to specific exam rooms upon registration. When this model is used, studies

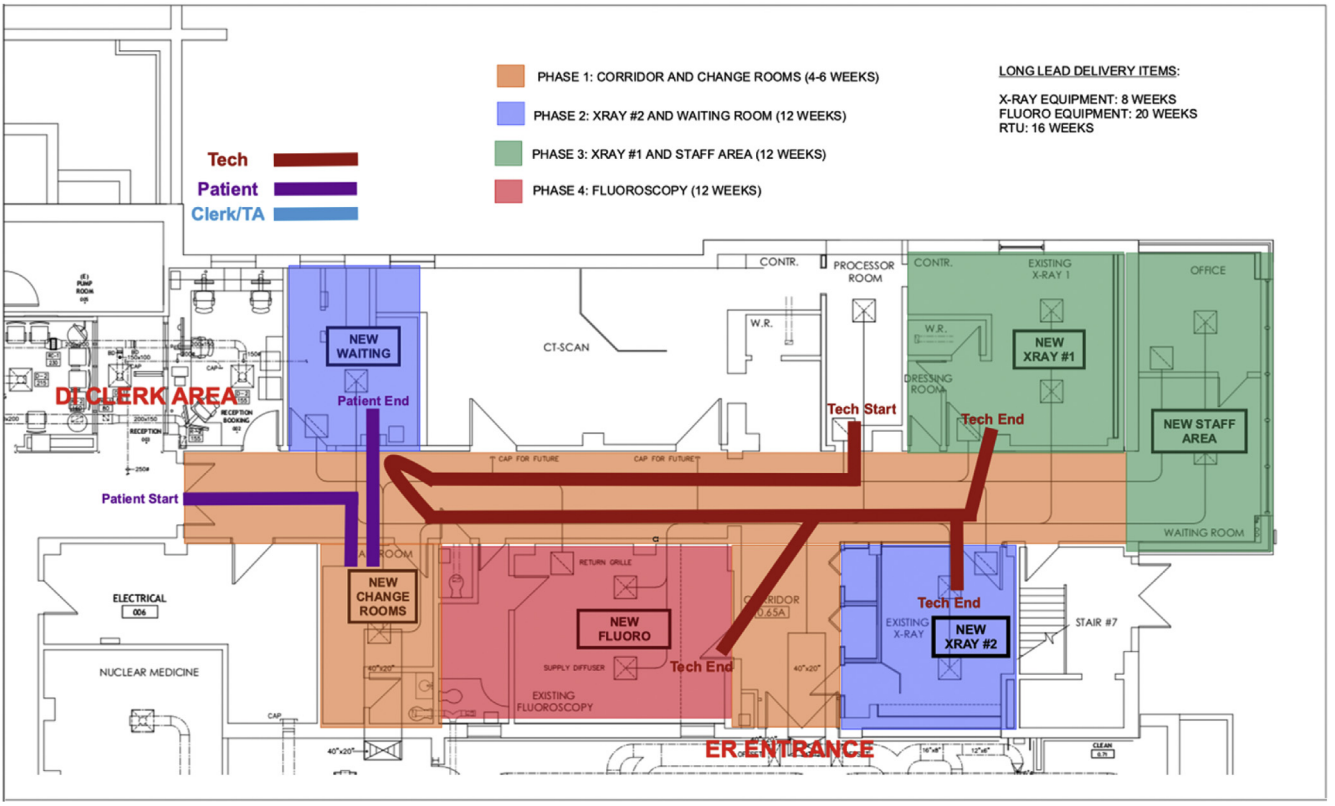

Fig. 1. Original Floorplan with Spaghetti Diagram Displaying Outpatient Patient Flow at Erie Shores Healthcare. Floorplan compliments of Erie Shores Healthcare.

have found that performance is poorest when patients must sit in one large waiting room that is far removed from the exam areas.[4,10] Instead, these studies have shown that small waiting rooms should be placed just outside of each exam room or a large waiting room should be relocated as close as possible to the exam rooms. Thus, there exists an opportunity for improved patient flow here by moving the waiting room closer to the exam rooms and utilizing the DI Clerks or a TA to instruct patients on how to properly change for their exam and direct them to the waiting area once changed.

In the proposed department design in Fig. 2, the waiting room has been moved closer to the exam rooms which has resulted in a large decrease in technologist movement (red). The changing process now flows more naturally, as all patients are directed to the nearby changing area by the Clerk/TA when they check-in at the clerk desk. After changing, patients proceed down the hall to the large waiting room near the exam rooms. Moving the waiting room to this location also solves the front-line staff's complaint that the current waiting room is too small for the busy department. Additionally, moving X-Ray #2 to the larger location in Fig. 2 maximizes patient flow by solving the department's current issue of being unable to image stretcher patients in the second X-Ray room due to space limitations.

A final important change to the floor plan is the changing areas. Currently, Erie Shores uses fully drywalled change rooms. After changing, each patient keeps their belongings in the change room and locks the door, preventing another patient from entering that room to get changed until the initial patient has completed their X-Ray exam and is released. In Fig. 2, changing stalls with lockers are proposed. Switching to change stalls instead of change rooms may be a cost-effective alternative that allows more space for additional areas to change and/or lockers to be installed. In this way, upon changing, a patient can place all their belongings in a locker while their X-Ray exam is being carried out, allowing other patients to continue to use the changing stalls and improve patient flow. An example of four changing stalls with lockers is demonstrated in Fig. 3.

Client flow analysis

Value steam mapping was intended to be completed via a popular operations management technique in the literature called the "Gemba walk", where a staff or manager observes a process first-hand, from beginning to end, to explicitly understand its steps.[11] For this project, a Client Flow Analysis was to be conducted as a "Gemba walk" by the hospital's Patient and Family Advisory Council (PAFAC), who covers the domains that include patient voice at Erie Shores. However, due to unforeseen circumstances, the Client Flow Analysis could not be conducted. Fig. 4 demonstrates the Client Flow Analysis template that was developed for this project, aimed to capture how much time a walk-in patient spends at each step of the X-Ray imaging process, as well as patient

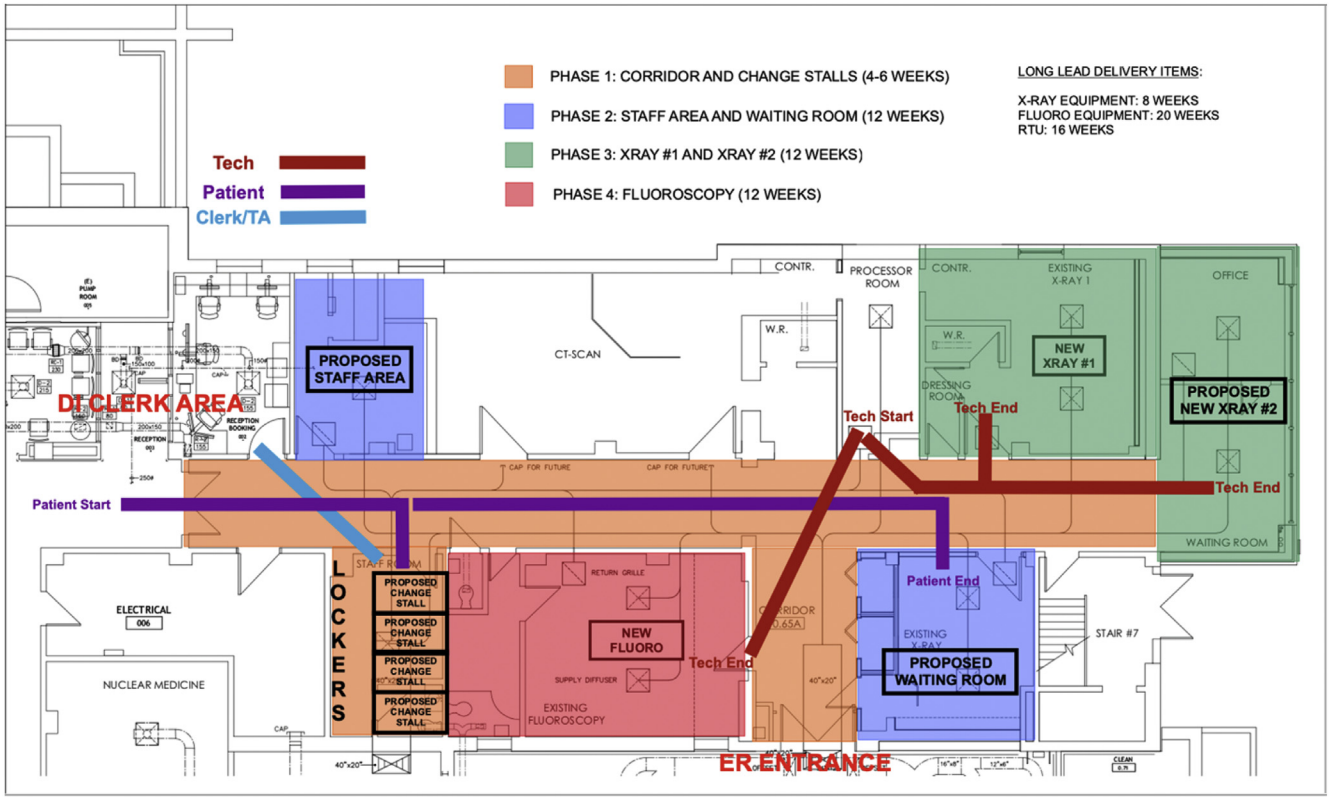

Fig. 2. Proposed Floorplan with Spaghetti Diagram Displaying Improved Patient Flow at Erie Shores Healthcare. Floorplan compliments of Erie Shores Healthcare.

feelings and experiences along the way. To keep data collection accurate and avoid rounding errors during time recordings, a delegate from the PAFAC would have followed the patient and completed the form on their behalf. From this, a LEAN value stream map would have been created to identify (and potentially remove) any ''non-value-adding steps'' in the current process.[11]

Benchmarking data from similar canadian sites

As discussed, benchmarking for the purposes of LEAN involves contacting sites that are similar in size or workflow to gain a better understanding of standards of care.[7] Since Erie Shores Healthcare is a community hospital (small local hospital) with no nearby out-patient imaging centres to defer patient bulges to, these two factors were considered most important when creating targets for benchmarking. A total of 10 sites across Canada were contacted for benchmarking and program evaluation via telephone. Provinces reached included Ontario, New Brunswick, Prince Edward Island, Nova Scotia and Newfoundland. The Atlantic provinces were selected because out-patient imaging centres are quite uncommon in these areas and the hospitals are similar in size to Erie Shores. Since Erie Shores is in Ontario, a few similar hospitals near Erie Shores were also targeted.

A strategic list of interview questions were formulated by the author prior to benchmarking. Based on findings from the literature review, there were three primary goals to achieve through the benchmarking process: 1) to bridge gaps in the literature surrounding the possible benefit of personnel such as TAs or DI-dedicated porters, 2) gain a better understanding of what strategies Canadian community hospitals have adopted to improve patient flow and alleviate bulges in demand in DI, and 3) identify the standard model for X-Ray workflow and compare it to Erie Shores. The author contacted each site by telephone. The X-Ray or DI front-line manager or director were targeted for interviews.

Table 1 outlines the interview topics (top row) and the findings from the benchmarking interviews. Site #11 is Erie Shores Healthcare. As expected, like Erie Shores, the majority of sampled hospitals offer X-Ray imaging to out-patients on a walk-in basis from Monday to Friday and do not have a dedicated X-Ray unit in their ED. Additionally, almost all hospitals utilize 8-h shifts for their technologists and stagger breaks and meal times to prevent exam rooms from being ''shut down'' during these periods due to inadequate staff. This means that Erie Shores' current model for X-Ray fits well with the sampled standard. However, some interesting data can be pulled from Table 1 around TAs, type of equipment, DI-dedicated porters, wait times displayed, strategies for bulges and recent changes for patient flow.

TAs and DI-dedicated porters

Current gaps in the literature exist surrounding the use of personnel such as TAs and DI-dedicated porters. A TA can

Fig. 3. Lockers with Change Stalls to Improve Patient Flow. Images compliments of QEII Health Sciences Centre (Halifax, Nova Scotia).

improve patient flow by undertaking duties to allow the technologist to focus on imaging. Common TA duties include: greeting patients, instructing patients on how to change into gowns, guiding patients to correct waiting areas, ensuring proper exam preparation is followed, completing exam paperwork, and developing cassettes, depending on the age of equipment. Of the two hospitals (Site #1 and #2, Table 1) that currently utilize a TA, both support the culture that throughout the day, technologists should only be performing technologist duties and believe that TAs help improve department flow and efficiency. There was one site (Site #8, Table 1) who acknowledged the benefit a TA has on patient flow but was not able to obtain funding for the position. Interestingly, there was one site (Site #10, Table 1) who has recently lost their TA position due to budget constraints. This site acknowledges that losing their TA has added stress to technologists, as they have had to absorb all the TA duties. This site also believes that losing their TA has contributed to increased burnout and decreased morale amongst the staff. Since the technologists at Erie Shores are currently experiencing burnout and missed breaks, adding a full- or part-time TA position may prove beneficial. As proposed in Fig. 2, the TA may become an integral part of efficient workflow. Having the TA change and direct patients to the waiting room will prevent unnecessary technologist movement through the department (less red in the spaghetti diagram).

However, hiring a full- or part-time TA position means increased personnel costs. In Ontario, this cost can be estimated at (($24/hour x (37.5 h/week x 52 weeks)) x 26% benefits) $58,968/year for a full-time TA or (($24/hour x (18.75 h/week x 52 weeks)) x 26% benefits) $29,484/year for a part-time TA (part time recommendation would be 4-h days at peak times, five days a week). A creative solution to this issue could be to utilize the already existing DI Clerks to perform some TA duties. Like many hospitals across Canada, Erie Shores is preparing to launch an electronic medical record platform (in this case, CERNER) that will be able to accomplish many of the existing Clerk duties. This will free up some or much of the Clerk's time to perform TA duties such as changing and directing out-patients, as well as potentially organizing and ordering ED and inpatients. As shown in Fig. 2, with the changing area being so close to the DI Clerk desk, having Clerks change and direct patients will require minimal Clerk movement (blue in spaghetti diagram).

There are similar findings for DI-dedicated porters. Two (Site #1 and #5, Table 1) of the sampled hospitals utilize DI-dedicated porters and acknowledge their value to patient flow and maintaining efficiency. Again, similarly to TAs, there is one hospital (Site #8, Table 1) actively trying to create funding for a DI-dedicated porter and one hospital (Site #7, Table 1) who has recently lost their DI-dedicated porter position. Interestingly, in the site that lost the position, there has been an observed increase in wait times for ED and inpatients. Several sites also expressed their frustrations with how inadequate porter staff negatively effects DI patient flow and wait times in their hospitals. This finding is further supported by Kruskal et al[7]; who note that patient transport is an area where waste commonly occurs in radiology departments. Currently, porters are an issue to patient flow at Erie Shores, with only one porter for the entire hospital. With multiple hospitals confirming the benefit of a DI-dedicated porter and one hospital seeing the negative effect first-hand of losing this position, adding a second general porter or a DI-dedicated porter at Erie Shores should be considered as an option to improve patient flow, as well as ED and inpatient wait times. Again, with a similar pay-scale to TAs, hiring another full-time porter (whether DI-dedicated or not) would increase personnel cost at an estimated (($24/hour x (37.5 h/week x 52 weeks)) x 26% benefits) $58,968/year.

Type of equipment

For equipment, there was found to be a mix between digital and computed radiography (CR) amongst sampled hospitals. Worth noting is that all hospitals that switched from CR to digital found an increase in efficiency and perceived decrease in wait times. This is likely because digital machines require less steps to complete image acquisition than CR machines, improving efficiency and workflow. This finding is supported in a study by Oh et al[1]; who recommends switching from CR to digital machines to reduce overall procedure times. This is important for Erie Shores, as the hospital is about to switch from CR to digital X-Ray machines during

Client Flow Analysis

Patient: Please feel free to use the box below to describe any feelings/thoughts about your experience in X-Ray today

BELOW IS FOR OFFICE USE ONLY

1. Patient Number.....
2. Type of Exam.....
3. X-Ray Room.....
4. Patient Type (circle one).....Walk-In.....ER.....In-Patient
5. Patient Travelling (circle one).....Ambulatory.....Wheelchair.....Stretcher
6. Time of Arrival.....(_____:_____) Hour (_____:_____) Min
7. Service Time

	Initial of Staff	Time Service Started (hh:mm)		Time Service Completed (hh:mm)	Total Contact Time (hh:mm)
Main Registration			Until		
DI Clerk Desk			Until		
Patient Change			Until		
X-Ray Exam			Until		
Transporter **(if ER/in-patient)**			Until		

Fig. 4. Client flow analysis example.

their redevelopment project. After these new machines are installed, like the benchmarked hospitals, Erie Shores should see a natural improvement in the efficiency of workflow.

Displaying wait times to patients

There was also a mix between whether wait times were displayed to out-patients in the department. Of the hospitals that displayed wait times (Site #1 and #8, Table 1), both hospitals utilized whiteboards in the waiting areas to regularly update patients on their expected wait. During bulges in demand, one hospital (Site #8, Table 1) allows registration staff to notify the patient of their expected wait while registering, giving patients the option of coming back during historically less busy days/times if they choose. Studies have shown that

Table 1
Data Collection from 10 Benchmarking Telephone Interviews.

Site	Out-patient model	Out-patient hours of operation	Days	Dedicated ER unit	Shifts (in hours)	On call	Stagger breaks	TA	Number of XR rooms	Digital or CR	Waiting room model	Dedicated DI porter	Dedicated ER porter	Community centre option	Reqs flagged for discharge	Critical indicators, Targets collected	Wait times displayed	Strategies for bulges	Recent changes for patient flow
1	Walk-Ins	0730–1730	M-F	Y(1)	4, 8, 12	N/A	Y	Y	5(1 FL)	Mix	Small	Y (1)	Y (2)	N	Y	N	Y	Casual called in for 4 h shift over Lunch time	Waiting rooms broken into small areas outside of each exam room
2	Booked	0800–1600	M-F	N	8	2400–0800	Y	Y	4 (1 FL, 1 chest)		Small	-	-	N	-	N	-	-	-
3	Walk-Ins[a]	0900–1600	M-F	N	8 and 12	2000–0645	Y	N	7 (2 FL, 1 chest)	Mix	Small	N	N	Y (limited)	Y	N	N	-	Now book out-patient exams with prep from 0700 to 0900
4	Walk-Ins	0730–1530	M-F	N	8	2330–0800	Y	N	2(1 FL)	Digital	Large	N	N	N	-	N	-	Techs work 2 to a room, created culture where efficiency is high priority	All new equipment (digital), switched from booked to walk-ins which has resulted in busier periods around lunch time
5	Walk-Ins	0600–1800	M-F	Y (1)	8	N/A	Y	N	5(1 FL, 1 ER, 1 Clinic)	–	Large	Y (2)	N	N	-	N	-	Techs will go to clinic or ER units and image walk-ins	New dedicated Clinic and ER units have shown improvements on wait times
6	Walk-Ins	0800–1600	M-F	N	8	N/A	Y	N	3(1 FL)	Digital	Large	N	N	N	N	N	N	-	Moved reception areas closer to DI, kiosks for check-in at hospital entrance so there is less to do at registration desk
7	Walk-Ins	0800–1530	M-F	N	8 and 12	N/A	Y	N	5 (2 FL, 1 Clinic)	Digital	Small	N (but use to have)	N	N	-	Y,N	-	Techs work through lunches (must be pre-approved) or, more commonly, casual called in for 4 h shift over lunch time	Utilizing a number system for registration, since moving to digital, less rooms but same number of staff as during CR times so lots of staff available to increase flow when needed, loss of DI porter has increased wait times for in-patients and ER
8	Walk-Ins[b]	0700–1600	M–F[c]	N	8	N/A	Y	N (denied funding)	4(1 FL)	Digital	Large	N (trying to get budget for one)	N	Y	-	Y,N	Y	Double up on techs during clinic days, O.R. tech assists on floor when not needed in O.R., charge tech will come onto floor, registration will tell patient their expected wait time and give them an option to come back another day, students perform TA duties such as changing patients, etc.	New ER is attached to DI, added a Saturday shift from 0900 to 1600 for walk-ins to accommodate working population, hospital uses a LEAN model where staff feedback is taken seriously, new digital equipment has made imaging more efficient, added second tech to overnight shift because single tech found workload overwhelming

(*continued on next page*)

Table 1 (*continued*)

Site	Out-patient model	Out-patient hours of operation	Days	Dedicated ER unit	Shifts (in hours)	On call	Stagger breaks	TA	Number of XR rooms	Digital or CR	Waiting room model	Dedicated DI porter	Dedicated ER porter	Community centre option	Reqs flagged for discharge	Critical indicators, Targets collected	Wait times displayed	Strategies for bulges	Recent changes for patient flow
9	Booked[d]	0800–1600[e]	M-F	N	8	2100–0800	N (shut down for lunch)	N	1 (FL and gen capabilities)	CR	Large	N	N	N	-	N	N	Numerous multi-modality techs so sonographer or mgmt. will go to floor to do XR, if out-patient wait time is > 2 weeks, department will temporarily extend hours	E-referrals and online wait times arc on horizon
10	Walk-Ins	0700–1800	M-F	N	8	N/A	Y	N (position just cut)	4(1 FL)	CR	Large	N	N	Y (2)	Unsure	N	Unsure	Lots of cross training between XR and CT so CT tech can float to XR when needed, charge tech ensures breaks/lunches being staggered at appropriate times to maximize flow, students perform TA duties such as changing patients, etc.	Loss of TA has causcd increased stress for techs as they have had to absorb TA duties which has increased burnout and decreased morale, improved privacy during the registration process
11	Walk-Ins	0800–1800	M-F	N	8	0100–0600	Y	N	3(1 FL)	CR	Large	N	N	N	N	Y	N	Techs will assign all short exams to one room and more complcx exams to another room to complete as many short exams as efficiently as possible	-

"-" means question was not answered during interview.

FL = fluoroscopy.

[a] Majority are walk-ins but some out-patient exams with prep are booked between 0700 and 0900.

[b] Any exams that require prep or take longer than 30 min are booked.

[c] Added walk-in shift on Saturdays from 0900 to 1600.

[d] All out-patient X-Rays are booked but won't turn a walk-in away.

[e] Out-patient walk-ins accepted from 0800 to 1600 but 0900-1000 blocked off for ER/in-patients only (no out-patients imaged during that hour).

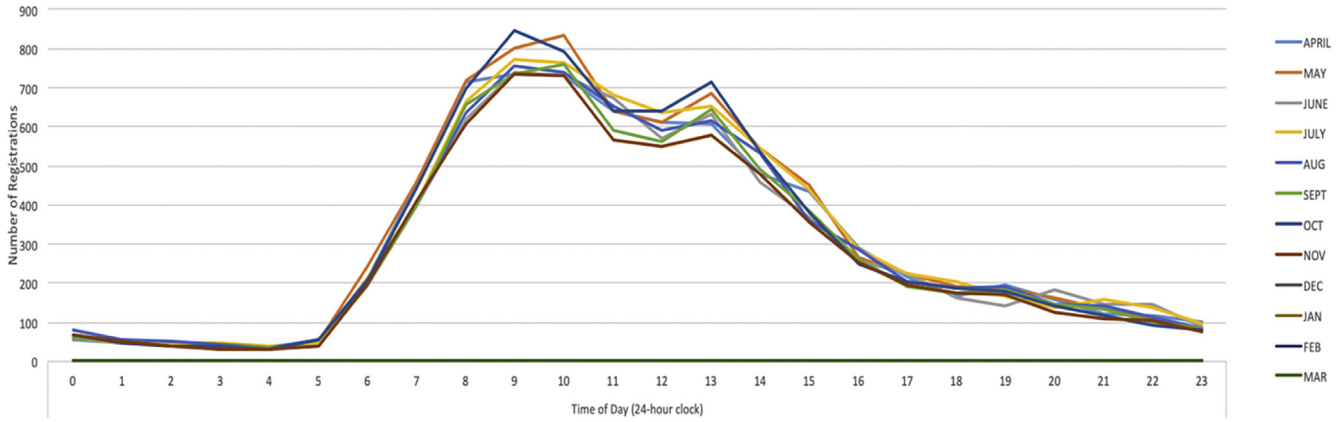

Fig. 5. DI registration peak times (outpatients and ED combined).

displaying or voicing wait times to patients at front desks or waiting areas improves their satisfaction and lessens their anxiety.[11,13] This is thought to be achieved by allowing the patient to feel a sense of control over the process and alleviating much of the negative emotional response to waiting. Displaying wait times on TVs or whiteboards and/or via reception staff may be an easy and cost-effective way for Erie Shores to improve the *perception* of patient wait times. Additionally, Loving et al[11] found a patient's perception of waiting is improved by utilizing aesthetically pleasing paint colours and updated furniture in waiting areas, as well as displaying (in hard copy or on TV screens) educational material that patients can read while waiting.

Strategies to alleviate bulges in demand

Some interesting learning points can be pulled from the strategies hospitals utilize to alleviate bulges in demand and recent changes for patient flow. First, to ease bulges, two sites (Site #1 and #7, Table 1) call-in or schedule a casual or part-time technologist for a 4-h shift over the busiest period (typically, 1000–1400). These sites have observed that utilizing a float technologist over busy periods allows full-time staff to take their breaks without feeling pressured to skip meals to image patients, thus reducing or preventing burnout. Fig. 5, developed by the hospital's analyst, demonstrates historical registrations per hour at Erie Shores (Monday-Friday).

From Fig. 5, it is easy to appreciate the peak hours in the department. Erie Shores currently has several part-time and casual technologists in their pool. With peaks at 0900 and 1300, Erie Shores may want to consider having some part-time technologists work Monday to Friday, 0900–1300 or 1000–1400, rather than their current model of 8-h shifts, two or three days a week. Site #1 employs this model and noted that many part-time technologists appreciate the predictable schedule of working 4-h shifts Monday to Friday, which creates a better work-life balance.

Last, benchmarking revealed that two sites assign Radiological Technology (X-Ray) students to TA duties during busy times (Site #8 and #10, Table 1). Sites that utilize this strategy noted that having an X-Ray student change patients and confirm their personal information during peaks improves flow in their department. Some sites note that this is especially good for X-Ray students who are new in their clinical placement, as it allows the student to orientate themselves to the department, feel a sense of purpose during hectic situations, and improve their patient communication skills. As Erie Shores accepts one student a year in their X-Ray department, this may be an alternative to improve patient flow during peak periods if hiring a TA or utilizing the DI Clerk for TA duties is not an option. However, this will only be available through May to September each year, while the hospital is actively training students.

Additional strategies in improving patient flow

Additional strategies that Erie Shores could consider to improve patient flow for inpatients include creating a section on requisitions to indicate whether the X-Ray exam is needed for patient discharge. Although not extensively discussed during the benchmarking interviews, some sites did indicate that their requisitions are specially marked when the exam is required before the patient can be released from hospital. Erie Shores currently utilizes a model where each day, the Director of DI attends face-to-face Bed Meetings to discuss what exams are required for discharge. However, these daily meetings seem to be an inefficient use of Director resources and time. By creating an area on the requisition to indicate when an exam is required for discharge, the Bed Meetings may only be required in special circumstances. Creating requisitions with a checkbox that allows physicians to mark for discharge immediately allows staff to prioritize patients upon receiving requisitions. This will permit staff to better plan their day and may help improve bed turnover in the hospital.

Measures that Erie Shores Healthcare may also consider are moving to accurate exam start/stop times and the impact of CERNER, once implemented. To maintain efficiency, technologists at Erie Shores do not currently accurately track at what time the X-Ray exam is started and at what time it is completed. Instead, after the exam is completed, the technologist hits "start", immediately followed by "stop" on the system

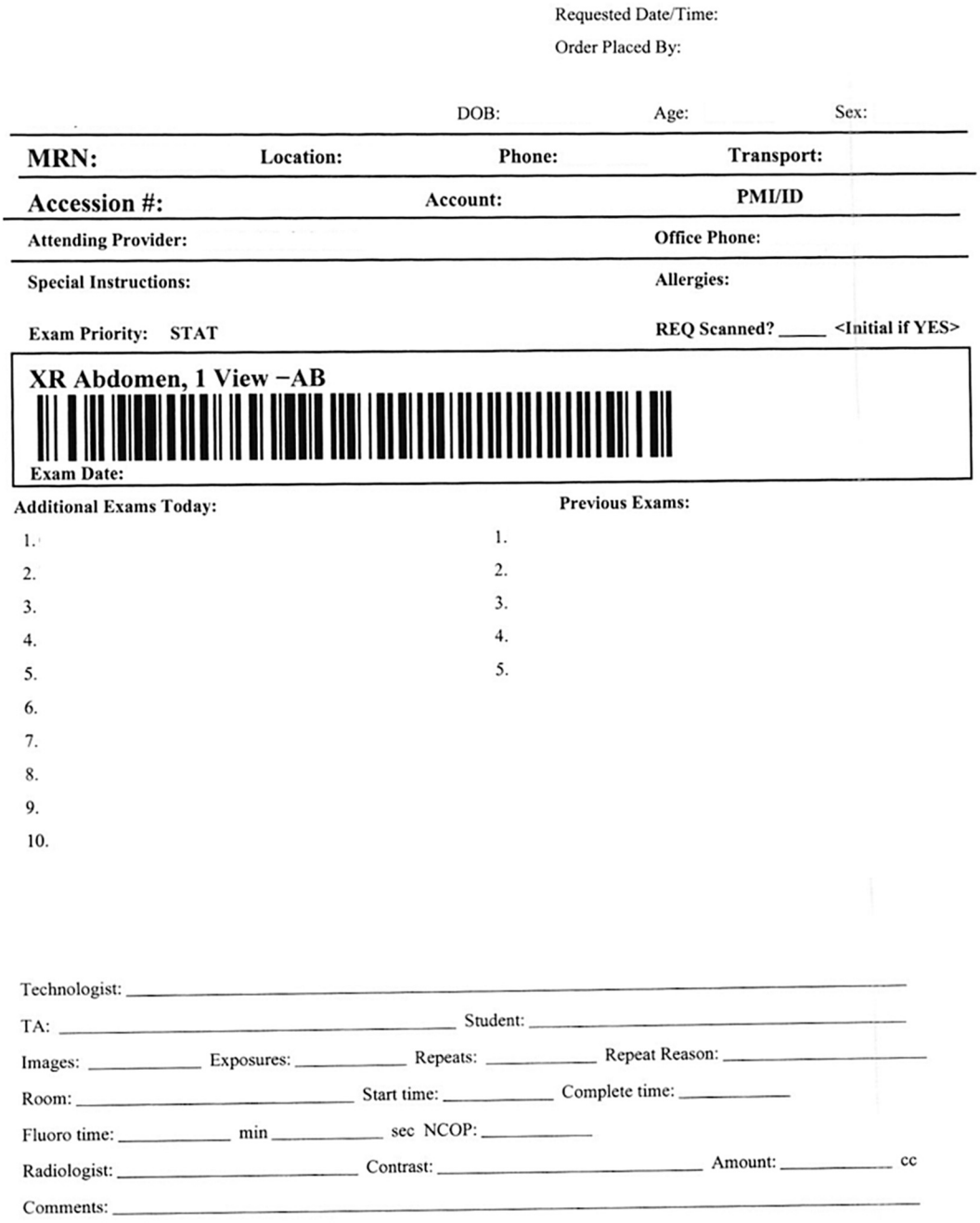
Requested Date/Time:
Order Placed By:
DOB: Age: Sex:
MRN: Location: Phone: Transport:
Accession #: Account: PMI/ID
Attending Provider: Office Phone:
Special Instructions: Allergies:
Exam Priority: STAT REQ Scanned? _____ <Initial if YES>
XR Abdomen, 1 View –AB
Exam Date:
Additional Exams Today:
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
Previous Exams:
1.
2.
3.
4.
5.
Technologist: _____
TA: _____ Student: _____
Images: _____ Exposures: _____ Repeats: _____ Repeat Reason: _____
Room: _____ Start time: _____ Complete time: _____
Fluoro time: _____ min _____ sec NCOP: _____
Radiologist: _____ Contrast: _____ Amount: _____ cc
Comments: _____

Fig. 6. Automated visit printout example. Compliments of QEII Health Sciences Centre (Halifax, NS).

computer so that all exams appear to take zero minutes. Inadequate time was stated as the reason why this approach is used. However, switching to accurate exam start/stop times can be a good measure of productivity and has been used to create evidence to support funding for additional equipment at some of the benchmarked hospitals. It is proposed that the ''start'' time is the time that the technologist first brings the patient into the exam room and the ''stop'' time is the time that the patient leaves the exam room, once the images have been deemed diagnostic. To prevent a cumbersome start/stop process for technologists, it is recommended that accurate exam start/stop times are first hand-recorded on the requisition, which can later be inputted into the computer when there is more time. Alternatively, some sites utilize an Automated Visit Printout for each patient with designated areas for exam start/stop times to be recorded by the technologist and then inputted in the computer system later by any staff. Additional data can be capture on this document, such as ''Number of Repeats'' and ''Repeat Reason'', which can be consolidated, assessed and trended across exams for quality control and

quality improvement purposes. Fig. 6 demonstrates an example of one site's Automated Visit Printout.

A final aspect to be recognized is the impact of electronic platforms such as CERNER on critical indicators or targets, once implemented. Currently at Erie Shores, target data is not collected uniformly across all modalities. For areas outside of X-Ray such as CT, Ultrasound, and Nuclear Medicine, requisitions for ED and inpatients are faxed directly to the DI department and time-stamped once the DI Clerk enters it into the system. The DI Clerk may then choose to enter it into this system as soon as it is received or wait a period, possibly until the next morning, to enter it. Once entered, this is the official start of the "wait time" for the patient to receive their test. However, X-Rays are entered into an online system by the referring ward at the time that the X-Ray requisition is first created by the referring physician. For X-Rays only, this is the official start of the "wait time" for the patient to receive their test. This skews the data, making X-Ray wait times for ED and inpatients look artificially longer than wait times for other modalities. When creating multi-modality targets in DI, it is important for hospital administrators to ensure that all modalities are measured in the same manner. At Erie Shores, once CERNER is launched, all requisitions will be entered into the online system at the time the requisition is created by the referring physician, regardless of modality. This will create a more uniform collection of critical indicators across all of DI and prevents artificial wait time inflation in some areas due to unintentional human interference.

Conclusion

Patient flow and wait times in DI are pivotal to efficient and adequate patient care, as well as optimal bed turnover in Canada. This case study aimed to identify options for increasing efficiency, improving adaptive workflow and decreasing wait times during peak hours in DI, and walk-in X-Ray in particular. Although Erie Shores was the target of this case study, other hospitals can benefit from the recommendations provided. Two of the most important aspects for maximizing patient flow in DI are departmental design and personnel. It is important for organizations to keep patient flow in mind and take advantage of key redevelopment and restructuring projects. Additionally, adequate personnel and the scheduling of these personnel can improve not only vital aspects of flow such as efficiency and wait times but also mental and emotional health priorities of staff, such as burnout and work-life balance. Last, as technology continues to develop, aspects such as standardized electronic platforms, exam data collection and digital equipment should be capitalized on for optimal flow and target analysis.

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