

Using PaJMa to Enable Comparative Assessment of Health Care Processes within Canadian Neonatal Intensive Care Units

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Abstract

Critical care, and in particular the critical care of the premature or ill newborn infant is highly complex and requires healthcare professionals from many different areas. Research has shown that there is significant variation within care practice and outcomes within Canadian NICUs. This is due in part to the different healthcare roles function within the patient journey within individual NICUs and the use of dissimilar information and information technology solutions across NICUs. This paper presents case study based research demonstrating how the PaJMa modeling technique can explicitly capture role, information and information technology facts in a standard structured way to enable comparative assessment of health care processes. We demonstrate this through the high-level examination of three different Ontario neonatal intensive care units.

Keywords: Patient journey modeling; clinical practice; health care; quality improvement

Introduction

Neonatology is a complex field of medicine that involves a significant level of collaboration and organization in order to deliver efficient care. Infants in neonatal intensive care units (NICUs) stay for significantly longer than patients in other units on average, and as a result can produce vast amounts of patient data during their time in hospital[1], meaning that the unit requires a high level of organization and clarity within care processes. Patients can present with complicated and varied diagnoses, and as such there are a variety of different health care professions represented within neonatal intensive care units. The extended stay times and complicated diagnoses that

can exist within this area of care requires that care delivery processes be at optimal levels in order to create sustainable environments within units. Despite this requirement for optimized care delivery processes within neonatal intensive care, research has shown that there is significant variation within care practice and outcomes within Canadian NICUs [2]. Ontario currently operates under a universal health care program, however despite this fact there is currently no one standardized way of providing care or storing health information for neonates [2]. This means that there are no standard sets of documentation, no standardized role definition within the units, and utilization of technology varies between sites. These differences can make best care practices difficult to identify, which may be a barrier to delivering the highest level of care quality. In addition, patients are frequently transferred between NICUs as they are stepped up or down through the care process and a standardization of care delivery techniques has a potential to ensure a quality continuum of care for the patient.

Within these complex care settings, no one professional group can handle the care of a patient single-handedly and interprofessional collaboration is critical in the overall well-being of the patient. Interprofessional collaboration and specific role definition has a significant effect on the efficiency and quality of care provided to patients [3]. Adding to this complexity is the fact that intensive care unit healthcare providers frequently rotate on and off service requiring the team to constantly forge new professional relationships, creating potential difficulties within team communications and collaboration[4]. Over the past several decades, the role definition for nurse practitioners and other

physician assistants has seen increased responsibilities within some environments. However, in other environments the majority of this role remains the physicians[6].

Understanding the use of information and information technology by individual roles is an advantageous approach for the standardization of the implementation of care practices. When deficits in communication and information flow occur between various areas of patient care, patient safety outcomes are adversely affected[10].

The Patient Journey Modeling architecture (PaJMa) is a process flow modelling approach designed specifically for the nuances of patient journeys in healthcare [1]. That approach enables an assessment of current state health informatics capacity within the healthcare patient journey enabling explicit representation of healthcare roles within the patient journey and their use of information and information technology throughout the patient journey.

This paper presents case study based research demonstrating how the PaJMa modeling technique can explicitly capture role, information and information technology facts in a standard structured way to enable comparative assessment of health care processes. We demonstrate this through the high-level examination of three different Ontario neonatal intensive care units. This paper uses the “Investigations” process at each hospital in order to demonstrate the explicit representation of role, information and information technology facts within the PaJMa models and how this can lead to the comparative assessment to demonstrate potential establishment of best practice approaches.

The remainder of the paper is structured as follows: related research is reviewed in the next section, the methodologies of constructing the PaJMa models are then outlined, the models are presented, analyzed, discussed, and conclusions are drawn.

Literature Review

Significant research has been conducted on the impact of computerized physician ordering systems; this utilization of technology has been shown to have reduced medication errors, faster turn-around times, and decreased response time from external services such as radiology [8]. Furthermore, utilization of electronic prescribing has shown to decrease the number of adverse drug events that occur, thus improving patient safety outcomes [9].

When information flow is inefficient, patient safety can be adversely affected as patient records can be significantly different or missing [11]. In a 2001 case study of a hospital utilizing parallel electronic and

paper records, 13% of electronic documents and 1% of paper documents were missing from patient charts; furthermore, a large number of modifications that were made in the paper chart were not transferred over to the electronic records, contributing to inaccuracy in patient documents[11]. “Fit” of the information system within an organization is found to be a critical factor for successful use [12], and information flow must be flexible in order to support a variety of needs within an organization [13].

When facilities are poorly configured, patient care can be compromised through professional fatigue[14]; conversely, when environments are ergonomic and functional, health care providers are able to provide care easily and accurately[14]. A survey of Ontario intensive care units found that 46% of units surveyed believed their computer availability to be insufficient; it was found that “sufficiency” was generally found when there are 0.44 computers to every bed[15]. Research has shown that utilization of mobile computers allows for an increase in nurse proximity to patient rooms, which potentially would benefit patient outcomes as nurses spend approximately 15%-25% of their time charting[16].

In [18] Anderson and Aydin discuss how health care change can be modeled from multiple different perspectives based on: 1) social interaction; 2) system design; and 3) the computer system. Within the context of the research presented here, the social interaction can be defined through role definition. The system design describes information and information flow requirements throughout the patient journey and the computer system represents the information technology.

Various methods for patient journey modeling have been used for health care process analysis including UML, Lean, and PaJMa. PaJMa modeling is ideal for case studies such as the following as it was developed specifically for health care processes, and has been used in research to model processes in hospital units around the world [19,20]. The PaJMa modeling architecture is the only method that integrates the inclusion of hospital policies, clinical guidelines, and a more detailed representation of role definition, information, technology and the interface to access the information [21].

Methods

PaJMa is a structured process modeling approach for healthcare. Each layer within a PaJMa model independently contains information on activities in the patient’s journey, the health care roles involved in each activity, the way in which information is stored for each activity, and the technology utilized through the patient journey. Clinical guidelines, government

policy and patient needs layers can also be included. These individual horizontal layers are then read step-by-vertically from left to right, with each process step moving across the page[1].

Throughout this research, care processes at three Ontario NICUs were examined. The NICUs examined are level 3 NICUs in large urban hospitals; they are of similar size and patient demographic, therefore reasonable candidates for comparison.

The six specific scenarios that were modeled as part of the study were: Admissions, Investigations, Diagnosis, Treatment, Discharge, and Follow-up as per our Health Informatics Capacity Audit research[19,20]. To demonstrate this research we will focus on the “Investigations” scenario at the three case study hospital sites as this represented the scenario with the highest interprofessional interaction. The specific process steps within the investigation model were defined as the following:

1. Prescribe investigations
2. Order investigations from external departments
3. Check the status of investigation orders
4. Retrieve investigation results
5. Analyze investigation results
6. Store investigation results
7. Supervise investigation process

Upon determination and agreement of all participating neonatologists of these processes steps, the models could be populated using information from each NICU. The NICU of each hospital was toured, and notes were made on the health care processes. Comprehensive summaries of all aspects of information flow were transcribed into PaJMa models; this included the collection of paper documents, the list of books and any potential whiteboards utilized, as well as any electronic resources. All of these items were transcribed into information flow icons, and these were then examined and placed in the appropriate steps within the models based on existing knowledge of the processes. Role icons were also placed within the models based on existing knowledge; these initial preliminary models were based on observations and predictions of ideal practices.

Once preliminary models had been created, interviews were conducted to verify and correct the models. The representatives for many of the roles were available to describe their responsibilities and provide detail for other related roles. The roles interviewed varied between hospitals, and are as listed below (Table 1).

At each hospital, the interviews with the neonatologist served to provide a broad overview of care processes within each unit. All of the interviews

went into depth explaining daily tasks, work roles within the unit, and identification of information flow procedures and technological resources utilized. Each of these interviews took 30 to 45 minutes. Updates were made, and a final sign-off on all models was completed. Analysis then took place by examining each layer of the models in order to gain a deeper understanding of the role, information and information technology aspects. The PaJMa approach to colour-code by role, and to subsequently use the same colour codes for information and information technology use, enabled this information to be explicitly and easily represented within the model.

Table 1 – Summary Table of Individuals Interviewed by Hospital Location

Hospital	Professionals Interviewed
Hospital A	Neonatologist Staff nurse Respiratory therapist Transitional care coordinator
Hospital B	Neonatologist Informatician Staff nurse Ward clerk
Hospital C	Neonatologist Neonatal nurse practitioner

Results

In this section we present the results of our comparative assessment of the Health Care Investigations process from three Ontario Level III NICUs. Differences were found relating to three major categories of care within each unit: role definition, information flow, and technological resource utilization. Figure 1, Figure 2, and Figure 3 present the PaJMa models for the Investigations scenario from each NICU.

First consider role definition, each unit utilizes a reasonably large amount of interprofessional care in delivering care within this portion of the patient journey. As previously discussed, interdisciplinary teams are critical, but the composition and organization of these teams varies throughout each NICU. Examining the roles documented in the PaJMa models for all three hospitals, it becomes apparent that a neonatologist, fellow, resident, and neonatal nurse practitioner are standard throughout the “Investigations” process. However, by examining the practices individually, differences can be noted. At “Hospital A”, the neonatologist, resident, fellow, and neonatal nurse practitioner are present in the majority of steps; they prescribe and order the

investigations, retrieve and analyze the results, and supervise the entire process. In some of these stages they are joined by a respiratory therapist and nurse; results are retrieved by any of these six individuals, and are analyzed by these professionals as a team.

However, in some stages, the neonatologist, resident, fellow, and neonatal nurse practitioner are not present. For example, the respiratory therapist, nurse, or transitional care coordinator are involved in checking the status of investigation orders, and the nurse, information clerk, or laboratory will store the investigation results. These tasks do not necessarily require the advanced skills of the doctors and nurse practitioners, and therefore are not generally in the

scope of their role definition; these tasks can be reliably delegated to other members of the team.

This practice differs from that of “Hospital B”. The PaJMa model for this hospital indicates the presence of the neonatologist, fellow, resident, and nurse practitioner in all steps of the “Investigations” process; they are joined by a nurse, respiratory therapist, and ward clerk for many of these steps, but are still involved in processes that do not necessarily require their advanced training. This indicates a lesser degree of role specification and definition at “Hospital B” where the majority of tasks are completed as a physician-driven team, and specific responsibilities may be less well differentiated.

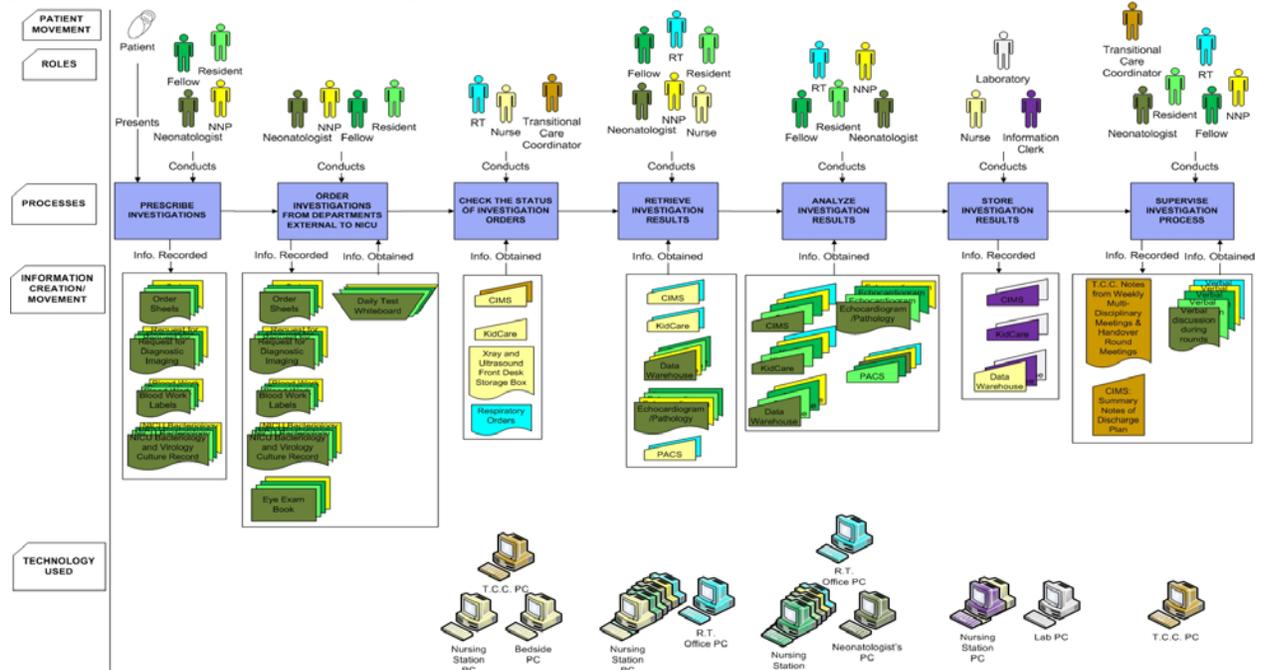


Figure 1- Investigations Process at Hospital A

The practices at “Hospital C” differ significantly in respect to role definition; they utilize a large number of the interdisciplinary team members in most steps of the “Investigations” process. In addition to the neonatologist, fellow, resident, and nurse practitioner’s involvement, they are joined by a nurse, respiratory therapist, dietician, and pharmacist for many of the steps indicating a wide and diverse interprofessional team approach to supporting patient care. This expansion of the dietician and pharmacist roles is unique to “Hospital C”; at Hospitals A and B they are focused expertise, and do not play as large a role in the patient’s overall journey.

The second difference identified using the PaJMa model is in the “Information creation/movement” layer. This layer focuses on the information flow

within the NICUs. The three hospitals vary quite widely in their methods of information flow. “Hospital A” uses a variety of electronic resources. Tests are ordered using general order sheets, and results are returned through one of two different electronic records (EHR). Test results may be stored in either EHR depending on the case. The hospital also has a data warehouse where some information can be stored, and utilizes PACS (electronic picture archiving and communication systems) to retrieve high-quality image results such as x-rays. Some information is not online but rather stored on whiteboards (such as the “Daily Test Whiteboard”) or in paper form such as in hand-written notes from multidisciplinary meetings and in generalized paper order forms, but the majority of information is strictly online within the patient’s chart.

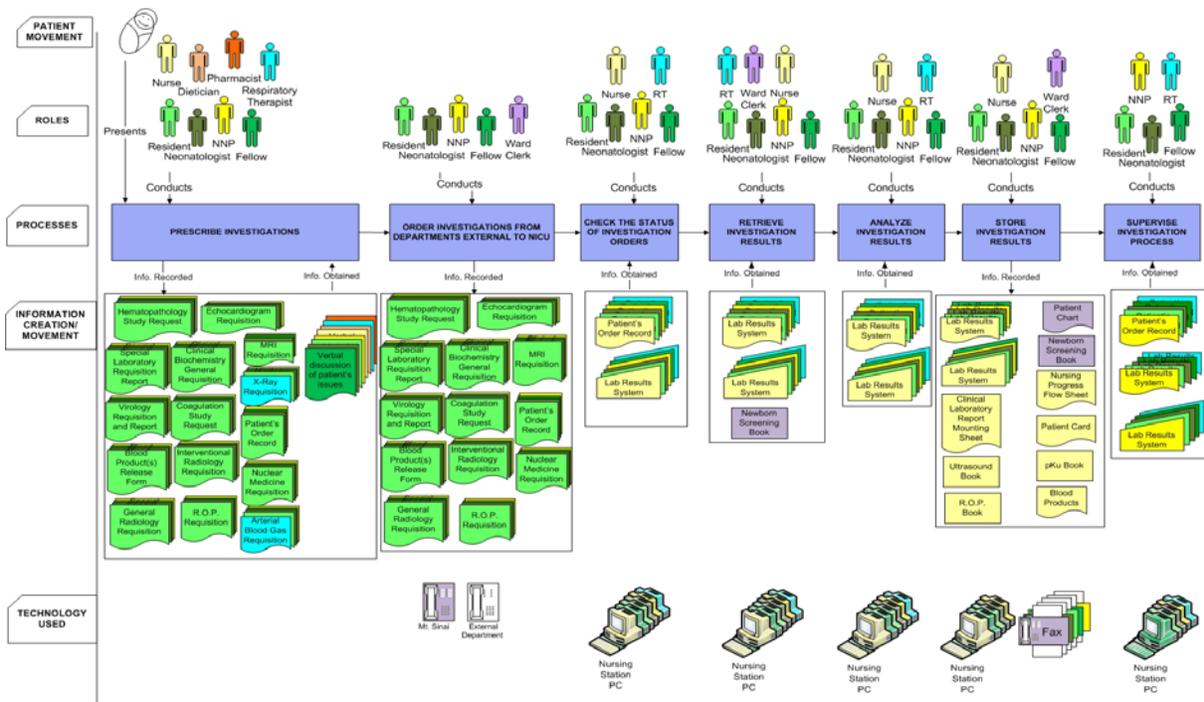


Figure 2- Investigations Process at Hospital B

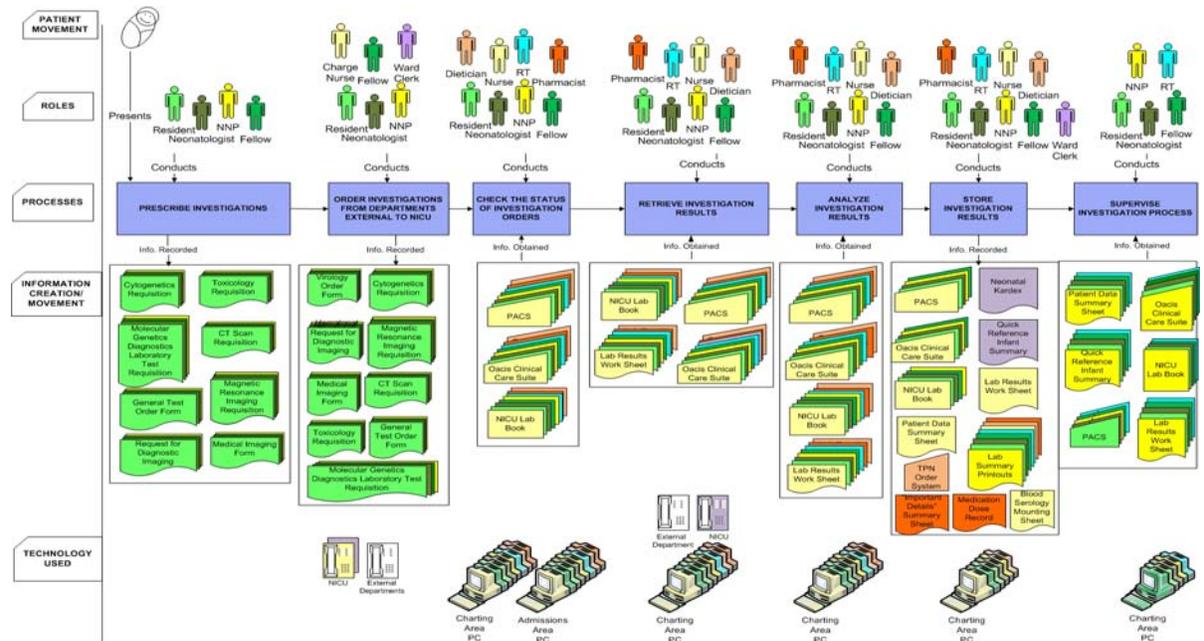


Figure 3- Investigations Process at Hospital C

This differs from “Hospital B” as they run a parallel electronic and paper charting system. Similarly to “Hospital A”, investigations are prescribed using paper forms; however, “Hospital B” does not use a generic form but has a wide variety of specific order forms for each separate investigation. These lab

results are later made available in an electronic resource titled the “Lab Results System”. However, since the patient’s chart is paper-based, these results are then printed and as such exist in corresponding paper and electronic formats. A paper record of the patient’s orders is kept, and several different books are utilized to track the tests completed such as the “Ultrasound Book”, “Retinopathy of Prematurity

Book”, and “pKu Book”. “Hospital C” is quite different from both A and B as it mainly utilizes paper charts for the patient and many members of the interprofessional team use their own unique charts. Order forms are similar to “Hospital B” as they are paper-based and specific to each test. “Hospital C” does have an EHR, but this is mainly used for storage of results by the neonatologist, fellow, resident and neonatal nurse practitioner; it is not a comprehensive patient record and information is not documented within it by all members of the healthcare team. Instead, the lab results are received in paper form by members of the team (the “Lab Results Work Sheets”), and stored independently. Dieticians have their own EHR, the “TPN Order System” that allows them to document patient nutritional information. Pharmacists as well as nurses also have their own independent patient charts, and have unique forms on which their profession alone records their information. Some resources such as PACS are shared between the entire team; however the majority of patient data is kept in separate, unique patient charts, and is shared through the extensive interdisciplinary collaboration at this site. Should hospitals B and C make the decision to implement comprehensive EHR and ordering systems, “Hospital A” may be an important point of reference. The information flow methods used in each unit help to facilitate the role definition within the healthcare teams. For example, “Hospital A” uses a variety of electronic resources that ensure that each professional is able to access the most up-to-date patient information simultaneously; as a result, the team at “Hospital A” is able to operate more independently than that of B or C, as previously discussed. Since “Hospital B” uses a single paper-based patient chart, information cannot be accessed simultaneously, and the unit relies more heavily on the physician-driven team. “Hospital C” must also work closely as they independently record information in separate charts.

By examining the “Technology used” layer of the PaJMa models, it is noted that the third way in which differences of practice between hospitals can occur is through the utilization of technological resources. “Hospital A” contains a number of different computer icons - six in total. These computers are located in various places throughout the unit; in the neonatologist’s office, the respiratory therapist’s office, the transitional care coordinator’s office, the nursing station, at the bedside, and in the lab. This is reasonable for “Hospital A” as it relies heavily on electronic charting. Within “Hospital B”, the majority of computer use occurs at the main nursing station, or at nursing stations throughout the unit. These centralized locations allow the infants to be monitored while charting is occurring. “Hospital C”

has communal computers located in a “charting area”; these are not directly within the unit, but rather in an area immediately beside. These computers, like the ones at “Hospital B”, are shared between different members of the interdisciplinary team. This sharing of resources between multiple different professionals is reflective of the information flow practices at each of these units; the majority of health information is stored in paper form and as a result the units are less reliant on computers. The models for these two hospitals also note the use of telephones within the “Investigations” process; telephone calls are made to external units when ordering tests at either hospital, and also when retrieving results at “Hospital C”. The PaJMa model for “Hospital B” indicates use of a fax machine. Neither of these technologies is seen in the process at “Hospital A”; this is likely due to the unit’s use of computer technologies, as these processes can be supported through the use of electronic ordering systems. Best practices in regards to technology utilization in hospitals must correspond with other practices within the NICU; teams that rely more heavily on computerized communications and charting will require a greater number of technological resources. Issues arise when a mismatch occurs between technological needs and physical technological resources.

Conclusions

This paper has presented case study based research demonstrating how the PaJMa modeling technique can explicitly capture role, information and information technology facts in a standard structured way to enable comparative assessment of health care processes. We demonstrated this through the high-level examination of the Investigations scenario within the patient journeys of three different Ontario neonatal intensive care units. PaJMa explicitly represents information on role definition, information flow, and the use of technology within the units. This information can be utilized by healthcare practitioners, informaticians, or management and administration in order to identify best practices.

This research is part of a larger research initiative which is currently being carried out across all NICUs across Canada. Opportunities exist to continue our research into using PaJMa as a change management tool to support the communications of changes in role, information, or information technology use that may result from the completion of this audit.

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