Ergonomics

ISSN: 0014-0139 (Print) 1366-5847 (Online) Journal homepage: https://www.tandfonline.com/loi/terg20

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To cite this article: Maryam Ashoori, Catherine M. Burns, Barbara d'Entremont & Kathryn Momtahan (2014) Using team cognitive work analysis to reveal healthcare team interactions in a birthing unit, Ergonomics, 57:7, 973-986, DOI: 10.1080/00140139.2014.909949

To link to this article: https://doi.org/10.1080/00140139.2014.909949

Published online: 19 May 2014.

Ergonomics, 2014
Vol. 57, No. 7, 973–986, http://dx.doi.org/10.1080/00140139.2014.909949

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Using team cognitive work analysis to reveal healthcare team interactions in a birthing unit

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(*Received 3 April 2013; accepted 21 March 2014*)

Cognitive work analysis (CWA) as an analytical approach for examining complex sociotechnical systems has shown success in modelling the work of single operators. The CWA approach incorporates social and team interactions, but a more explicit analysis of team aspects can reveal more information for systems design. In this paper, Team CWA is explored to understand teamwork within a birthing unit at a hospital. Team CWA models are derived from theories and models of teamwork and leverage the existing CWA approaches to analyse team interactions. Team CWA is explained and contrasted with prior approaches to CWA. Team CWA does not replace CWA, but supplements traditional CWA to more easily reveal team information. As a result, Team CWA may be a useful approach to enhance CWA in complex environments where effective teamwork is required.

Practitioner Summary: This paper looks at ways of analysing cognitive work in healthcare teams. Team Cognitive Work Analysis, when used to supplement traditional Cognitive Work Analysis, revealed more team information than traditional Cognitive Work Analysis. Team Cognitive Work Analysis should be considered when studying teams.

Keywords: cognitive work analysis; teams; healthcare; nursing; task analysis

1. Introduction

Healthcare environments are known to be complex. Although human health is complicated, some of the complexity of healthcare comes from the diversity of expertise that is required to manage patient care effectively. Patients receive care from many different highly trained professionals, yet these are people who are trained in individual specialities, with particular conventions, information needs, and culture. While supporting technologies and software could be used to help unify across these differences and enable better teamwork, in many cases that has not occurred. Understanding teamwork and team member needs is important when introducing effective technologies into healthcare (Custer et al. 2012).

Cognitive work analysis (CWA) has been explored as one method to understand the nature of work in healthcare (Jiancaro, Jamieson, and Mihailidis 2013). CWA evolved from the nuclear power domain (Vicente 1999) as an approach to understand how people work in complex environments involving technology and helps people make better and quicker decisions. Momtahan and Burns (2004) described some early work applying CWA to healthcare. More recently, Momtahan and Burns explored CWA in cardiac care nursing for the design of a telephone triage system (Momtahan et al. 2007). Other researchers have used CWA to analyse patient falls (Lopez et al. 2010), workflow decision tools (Effken et al. 2008; Effken, Brewer et al. 2011), paediatric medicine teams (Lin and Gennari 2011; Custer et al. 2012), and medication management (Pingenot, Shanteau, and Sengstacke 2009). While CWA has clearly been useful in healthcare, people work in teams more than individually in this domain. For this reason, we explored a modified CWA that focuses on team interactions in a healthcare domain. The objective of this work was to investigate the usefulness of a team-oriented CWA (hence called Team CWA), comparing the benefits of this approach to a traditional CWA approach.

The first question must be what can be gained from a Team CWA approach? The CWA approach (Vicente 1999) recommends five levels of analysis: (1) work domain analysis (WDA), (2) control task analysis (ConTA), (3) strategy analysis (StA), (4) social organisational analysis, and (5) worker competency analysis (WCA). Although this approach allows room for social and team interactions in the fourth level of analysis, the original CWA literature (Vicente 1999) left this particular level largely unspecified. In recent works, as people have tried to develop social organisational analyses for their work domains, a wide variety of different approaches have been used. For example, Hajdukiewicz et al. (2001) modelled work domain regions to show where individuals needed to collaborate, Durugbo (2012) explored how to use CWA for enhancing collaboration in organisations, Naikar, Moylan, and Pearce (2006) modelled team activity, Jenkins, Stanton, Salmon, et al. (2008) and Jenkins, Stanton, Walker, et al. (2008) used a range of different models, and Stanton et al. (2013) took a highly integrated approach. It became apparent in reviewing this work that a single model for social organisational analysis may not exist or may not be appropriate. Indeed, social organisational interactions have a

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complexity of their own, in some ways mirroring the complexity of the technical work domain itself. Social organisations have constraints, social tasks, social strategies, and competencies. For this reason, we have proposed that analysts examine social influences throughout the whole CWA (Ashoori and Burns 2013), rather than isolating them into a separate phase of the CWA. We suggest that this provides a more integrated and richer approach, reflecting the sociotechnical nature of these systems in greater balance.

It should be noted that social network analysis also provides a useful approach for analysing team interactions, particularly when looking at social structures. This approach has been used successfully in healthcare (Effken, Carley et al. 2011; Effken, Gephart, and Carley 2013) and used in conjunction with CWA before (Euerby and Burns 2014). Social network analysis can reveal structure and show the role of key participants in facilitating the network. The approach can also provide useful metrics for comparing different organisations or observing organisational change. In this work, however, we have focused on looking at more detailed and less structured team interactions.

In a team CWA, each level closely follows Vicente's terminology and concepts for CWA (Vicente 1999) as the most commonly used formulation of CWA and more commonly used in the recent literature. However, Team CWA (Ashoori and Burns 2010) deliberately aims to identify teamwork constraints in the four different levels: (1) Team Work Domain Analysis (Team WDA), (2) Team Control Task Analysis (Team ConTA), (3) Team Strategy Analysis (Team StA), and (4) Team Competencies Analysis (Team CA). While teamwork constraints can still be identified using traditional CWA, Team CWA provides some useful perspectives that may make the identification of these requirements easier. Other authors have taken a similar approach, notably Naikar (2013), whose development of the contextual activity template (CAT) and use of CWA in teams inspired our further exploration of tools to improve the understanding of teamwork in CWA. This work is meant to complement such work, building a richer set of tools for CWA.

The most obvious question, in understanding this approach, would be that of using a multi-layered analysis, rather than simply considering these ideas within the context of the social-organisational analysis already included in the approach of CWA. The core of this argument is that when work is distributed across multiple people, the cognitive work is affected at many different levels. CWA is a multi-layered analysis moving from the structural constraints in the work domain, to cognitive strategies and competencies. Teamwork as well could be understood in its relation to work domain structure, task distribution, and communication, strategies, coordination, and effectiveness. It is part of our suggestion here that the structure of CWA in its abstract intention continues to be useful to develop a multi-dimensional view of teamwork. In the end, however, it is a moot point whether these analyses presented here should be grouped under the single phase of social-organisational analysis. It is more important that in seeking to understand the richness of team cognitive work, analysts reflect on the implications for the distribution of structure, control tasks, and the unique cognitive strategies and competencies that should be supported in teamwork. In this regard, we continue to find that the structure of CWA yet again gives a rich framework for thought.

CWA (Vicente 1999) is intended to be a formative approach. A formative approach attempts to break the task-artefact cycle by identifying constraints that hold true regardless of actors or the specific instantiation of a particular design. This particular work is not driven by an explicit design problem, but rather from a need to understand teams better using the CWA approach. At this stage of exploring Team CWA, it was more useful to use CWA descriptively, in order to achieve more explanatory power. However, in the types and categories of information and constraints identified, the approaches suggested in Team CWA remain formative. In this paper, we present a modified CWA, Team CWA, (Ashoori and Burns 2013) and show its use in the context of a caesarean section (C-section) surgical team in a birthing unit. We discuss the Team CWA method then develop the Team CWA models for the birthing unit. Finally, we discuss the advantages that are seen by taking a Team CWA approach over a traditional CWA approach.

2. Method

The Team CWA phases are described, followed by the observations that were performed.

2.1 *Team Cognitive Work Analysis*

As discussed above, we have chosen to examine teamwork along the same abstract structure of CWA. We began by looking at how the work domain and structural constraints were distributed across team members, and then looked at the distribution of control tasks. Finally, we looked at strategies and competencies particular to effective teamwork.

2.1.1 *Team Work Domain Analysis*

Team WDA looks at the distribution of work domain structure across a team. Team members may or may not have shared processes, components, or objectives. By knowing which parts of the work domain are shared, and which are not, you can determine what views different team members have and, if elements are shared, include the relevant team member's requirements in any planned computer interface design. Some of the previous work using WDA for establishing collaborative work requirements have examined joint work domain models (Burns et al. 2009), trajectories (Rasmussen, Pejtersen, and Schmidt 1990; Burns and Vicente 1995), responsibility maps (Hajdukiewicz et al. 2001), and the intentional WDA incorporating values or soft constraints (Burns, Bryant, and Chalmers 2005). Our Team WDA takes the same approach as in this prior work, starting with a traditional WDA and then examining how the team uses the work domain through areas of overlapping or directly mapping interactions in tables.

2.1.2 Team Control Task Analysis

ConTA, the second phase of the CWA framework, examines the constraints on what needs to be done, identifying timing, decision-making processes, and expert shortcuts. Vicente (1999) described ConTA as an analysis to address what needs to be done, independently of how or by whom. Extending this to teamwork situations, however, it becomes very useful to add layers to the original analysis that do identify who does what tasks and how tasks are shared. The collaborative nature of the control tasks in a team considerably affects the control tasks for individuals and the role each individual plays in a team. There has been previous work extending ConTA for establishing collaborative work requirements. Rasmussen, Pejtersen, and Goodstein (1994) used the decision ladder as a tool for modelling control task requirements across multiple parties, using chained ladders. Naikar, Moylan, and Pearce (2006) suggested a new formative representation for ConTA (CAT) to represent activity in work systems that are characterised by both work situations and work functions. They argued that work functions for an individual could be different for various situations, which can lead to different interaction patterns in various collaboration situations. The CAT is a helpful model when work functions change over different situations (e.g. typical care-giving process and an emergency situation). Variations of the CAT include the colour-coded CAT of Jenkins, Stanton, Salmon, et al. (2008) and the team-view CAT (Ashoori and Burns 2011). Chained ladders are a good representation to show how different parties interact on a single control task. The CAT is a good representation to show how individuals are involved in multiple control tasks. In our prior work, we have proposed a third visualisation, the decision wheel (Ashoori and Burns 2013). The decision wheel, like the collaboration table (Ashoori and Burns 2011) is aimed at showing interactions in larger teams. The decision wheel can also be used to explore synchronous and asynchronous collaboration (Ashoori and Burns 2010).

2.1.3 Team Strategy Analysis

Many of the previous attempts at using CWA for strategies analysis have focused on an examination of information flow maps (IFMs) for modelling a descriptive characterisation of strategies for single operators (e.g. Vicente 1999; Ahlstrom 2005). Team StA looks at how teams coordinate, form, or regroup to handle different tasks. The requirements for different teams under different situations, and the contexts that trigger those needs, are of great interest in this analysis. For a Team StA we suggest that IFMs be studied to examine tasks under different team configurations and that team coordination and structure be explicitly defined.

2.1.4 Team Competency Analysis

The overall objective of Team CA is to allow the determination of a series of desirable competencies that operators must possess in order to effectively work in a team. This is different from the functional competencies typically identified in CWA (e.g. Rasmussen 1983; Vicente 1999; Kilgore and St-Cyr 2006). Traditionally, authors developing the WCA have used Rasmussen's (1983) Skill-Rule-Knowledge (SRK)-based behaviour distinction. It should be noted that while the SRK was developed to describe the cognitive modes of control that are active when an operator is working, in the WCA phase of CWA the SRK distinction has typically been used to identify knowledge, training, capabilities, and expertise (e.g. Sanderson et al. 1999). This descriptive approach provides a precursor to developing the cognitive mode support that would be provided in the design phase of Ecological Interface Design (Burns and Hajdukiewicz 2004; Rasmussen, Pejtersen, and Schmidt 1990). The approach taken here is consistent with previous approaches of using the WCA to identify knowledge, capabilities, and expertise; however, in this case the focus returns to examining the additional competencies that are a precursor for effective team interaction (e.g. Belbin 1981). In Team CA, we consolidate both approaches to analyse operator competencies with respect to (1) functional competencies and (2) social competencies. While functional competencies look at the cognitive skills of individuals, such as problem solving or analytical reasoning, social competencies focus on interpersonal skills required for effective teamwork. Team CWA adds to CWA by looking at social skills as well as functional skills, acknowledging that the person with the right communication or leadership abilities is important to helping a team to be effective.

2.2 Observations

In total, 31 hours of observations were conducted in the birthing unit at a 1000-bed tertiary care hospital. The research protocol was reviewed and received ethics approval from both the University of Waterloo and the Research Ethics Board of the hospital where the observations occurred. The observations included observing each patient from her admission to the birthing unit to the time that she is recovered and leaves the unit. The interactions within the C-section surgical team were analysed because of the tight team coordination required of this team. These teams consist of several smaller teams, such as the anaesthesia team, the nursing team, the paediatric team, and the obstetrical team. The teams are used to working with each other and are formed for the 45- to 90-minute surgical events. Team member expertise ranged from novice to expert.

3. Results

From the observations, team CWA models were developed. These are discussed in order from Team WDA, Team ConTA, Team Strategies, and Team Competencies.

3.1 Team Work Domain Analysis

A WDA reveals constraints at different levels of abstraction in the work domain. The key difference in a Team WDA is that we look at who is influenced by which constraints and what constraints are shared. The Team WDA in Figure 1 shows the domain constraints for the birthing unit, distributed across five key stakeholders. The WDA components and connections remained the same in the Team WDA; however, the Team WDA can explore the WDA further by examining the distribution of components across different stakeholders. In particular, at the physical form level several functional objects are identified. Although these elements are described as objects for the sake of space in the figure, they should be recognised as functional objects with associated capabilities and constraints. For example, various surgical tools have different capabilities and limitations that influence their function. Some of these are constrained by their physical form aspects (e.g. size, material) and some by their nature of the object (e.g. scissors vs. scalpels will have different cutting capabilities). These influence higher levels of the functional hierarchy by playing a role during surgery, as well as the coordination of the

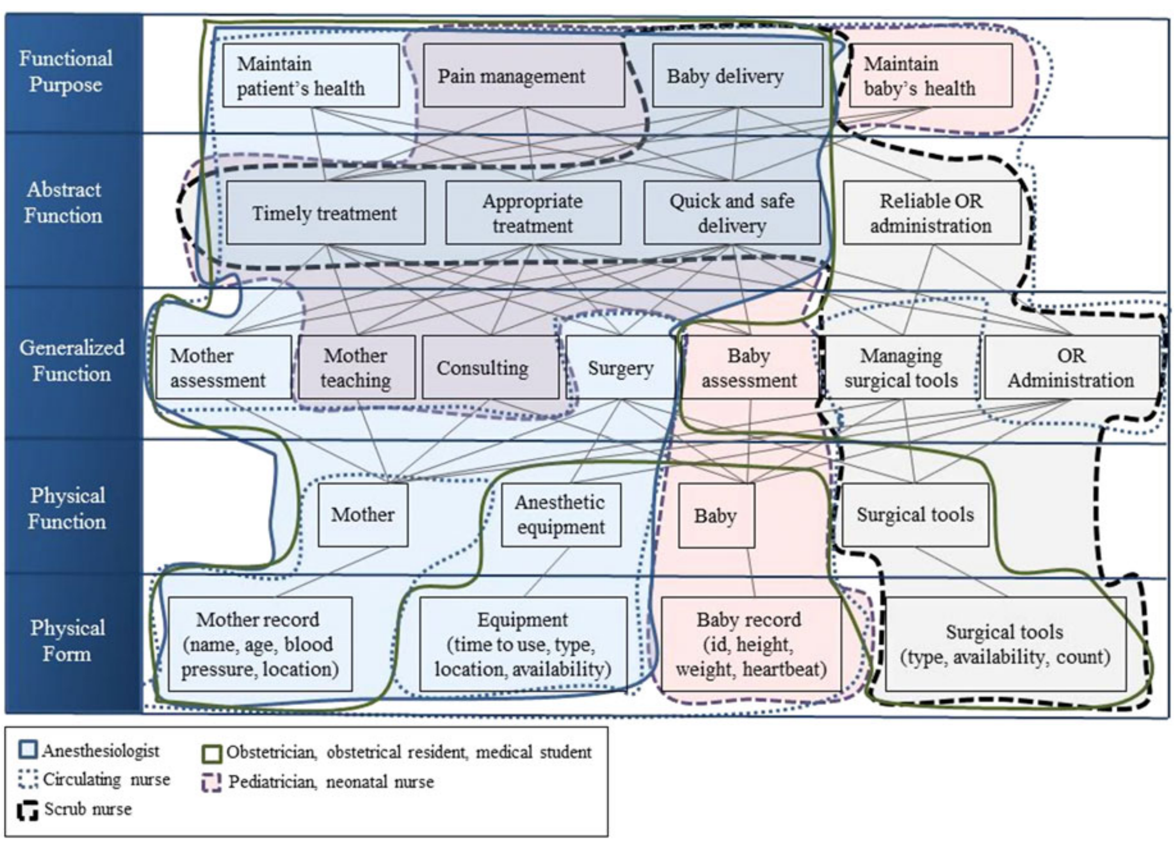

Figure 1. Team work domain analysis.

Table 1. Comparison of team WDA and WDA.

Comparison factors	Team WDA	WDA
Functional purpose level	Shared purposes: Maintaining mother's health is the shared purpose between the obstetrical team, the anaesthesiologist, and the circulating nurse. Maintaining baby's health is the shared purpose between the paediatric team and the circulating nurses. Pain management is shared by everyone except the scrub nurse as the scrub nurse is only responsible for managing surgical tools in the operating room (OR). Everyone on the team contributes to baby delivery.	Purposes: Maintaining mother's health Maintaining baby's health Pain management Baby delivery
Abstract function level	Shared values, priorities, and principles: Reliable OR administration is the shared value between the nursing team. Everyone on the surgical team is expected to contribute in a timely treatment, appropriate treatment, and quick and safe delivery.	Values, priorities, and principles: Timely treatment Appropriate treatment Reliable OR administration Quick and safe delivery
Generalised function level	Shared processes: Mother assessment is the shared process between the obstetrical team, anaesthesiologist, and the circulating nurses. Surgery is the shared process between the obstetrical team, the anaesthesiologist, and the scrub nurse. Baby assessment is the shared process between the paediatric team and the circulating nurses. Managing surgical tools is an individual process performed by the scrub nurse. OR administration is the shared process in the nursing team.	Processes: Mother assessment Surgery Baby assessment Managing surgical tools OR administration
Physical function level	Team WDA examines how the functionality of the boundary objects would affect the teamwork. The boundary objects in our scenario are the mother and the baby, and the surgical tools. The patient's attributes and behaviours (e.g. a calm mother, a normal blood pressure, a baby in distress) can influence the coordination of the surgery. Attributes of the surgical tools will affect how they are used by the team. Various surgical tools have different capabilities and limitations that influence their function. Some of these are constrained by their physical form aspects (e.g. size, material) and some by the nature of the object (e.g. scissors vs. scalpels will have different cutting capabilities). These influence higher levels of the functional hierarchy by playing a role in surgery, as well as the coordination of the surgery (e.g. management of surgical tools). The anaesthetic equipment is not shared among the surgical team, but the functionality of the equipment during the surgery might affect the coordination of the surgery (e.g. How long it takes for the mother to be anaesthetised).	WDA examines the functionality of the physical work domain resources: Patient Surgical tools Anaesthetic equipment

surgery (e.g. management of surgical tools). From this analysis we can see that while many values and purposes are shared, there are potential conflicts when functional objects must be shared and processes must be coordinated. Since a Team WDA figure can be difficult to read, the Team WDA was supplemented using tables to identify the relationships created at each level of abstraction. In Table 1, we summarise the key differences noted from the Team WDA that may be helpful above and beyond the traditional WDA.

3.2 Team Control Task Analysis

Team ConTA can reveal information flow between team members during key tasks, making it one of the most practical analyses in a Team CWA. We examined different control tasks in various routine situations and built the decision ladders (Rasmussen, Pejtersen, and Goodstein 1994) to analyse what needs to be done for each task. For example, Figure 2 (left) shows the decision ladders for newborn evaluation in a routine situation. The paediatric team and circulating nurses contribute to this control task. Steps are numbered for simplicity. The shaded boxes show the decision ladder elements that are activated in the situation. The baby's arrival (Step 1 in the figure) is a signal for the paediatric team to immediately start the assessment process (Step 2). The outcome of this activity is a set of measured data (Step 3). Based on the collected information, the paediatric team identifies whether the baby is healthy or needs special care (Step 4). In a routine situation, when the baby is healthy, the paediatric team knows that they need to document the results of the baby assessment (Step 5), they formulate the procedure to complete the assessment (Step 6) and identify the sequence of actions to perform (Step 7). After that, the paediatric team and the circulating nurses are ready to implement the actions (Step 8). The ladders in Figure 2 are typical of a traditional ConTA. In an emergency situation, there is no direct link between the state identification and the list of tasks. Figure 2 (right) shows the decision ladder in the case of an emergency. By using this approach, one can clearly see that the emergency situation takes the team from routine procedures and requires the team to diagnose a more complex situation and evaluate available options, all while under time stress. While this is useful, it can also be useful to explore the roles and actions of the various team members involved in the tasks.

Team ConTA improves on the decision ladder by showing interactions between team members through the decision wheels (Figure 3). Each wheel shows a team with each team member comprising a portion of the wheel. The decision ladder of each team member is drawn within the slices and the connections between the ladders represent the interactions between team members. Synchronous and asynchronous activities are highlighted as well as communication flows between the teams and team members. Links are numbered for simplicity. Similar to Figure 2, the typical decision ladder, once the baby has arrived, the paediatric team starts the initial observation to make sure the baby is healthy (Link 1). The circulating nurses help to complete the baby assessment (Link 3). The circulating nurses share the observation task with each other (Link 4) and then they plan the sequence of actions to complete that task (Link 5). After completing the observation, one of the circulating nurses, Circ1, updates the paediatrician with the requested information (Link 6) and the paediatric team

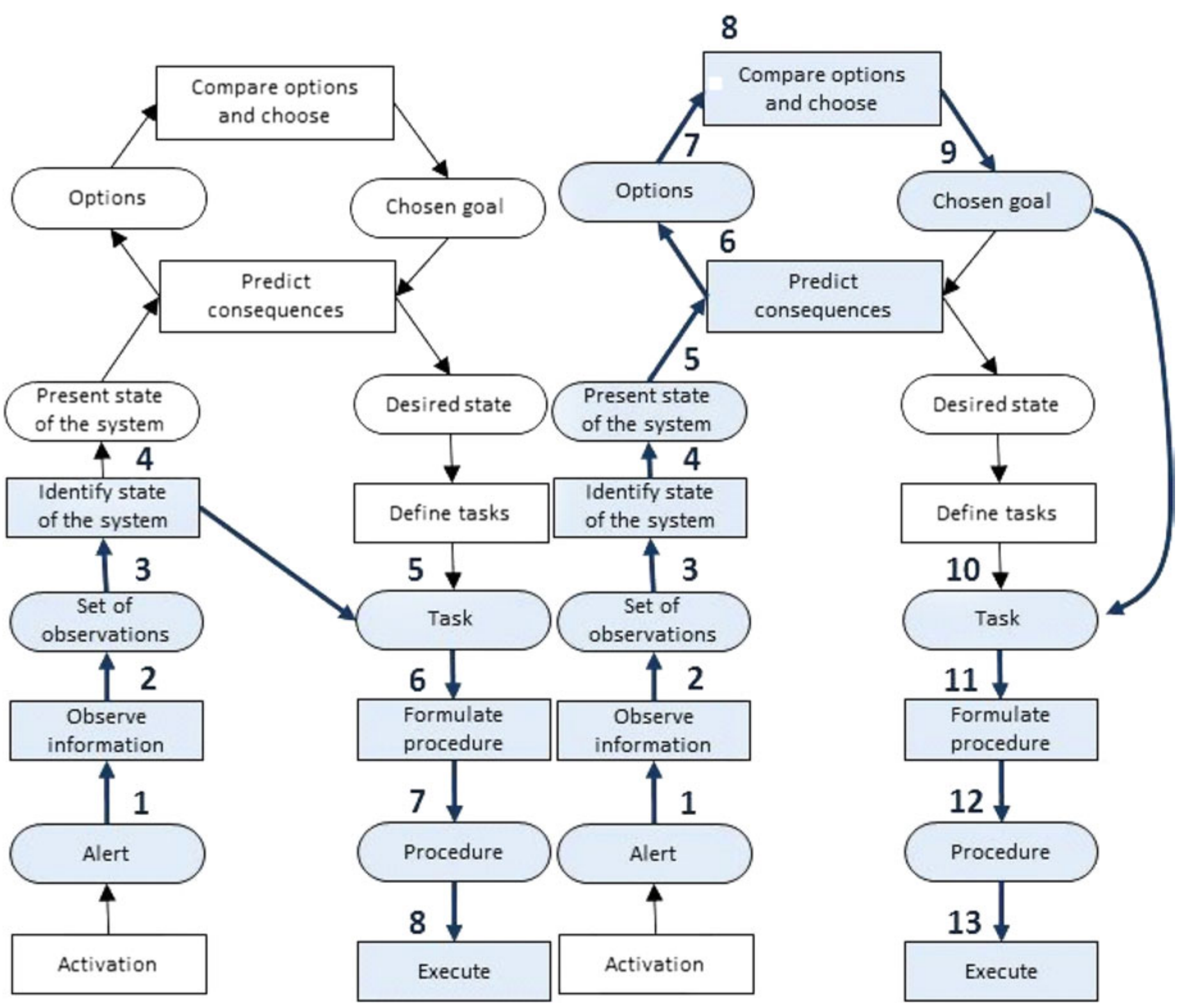

Figure 2. Decision ladder for newborn evaluation in a routine situation (left) and in an emergency (right).

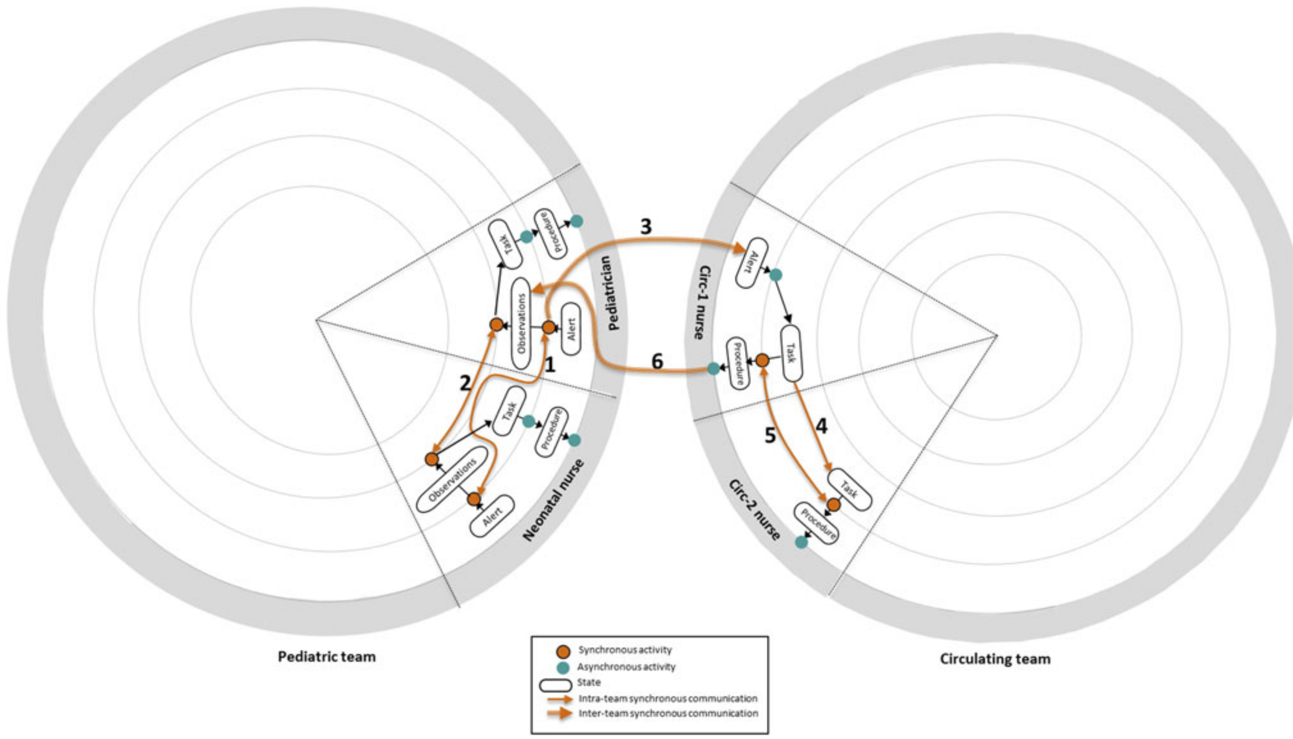

Figure 3. Decision wheel analysis.

decides if the baby needs special care (Link 2). The decision wheel allows individual decision ladders to be displayed, showing team member roles. The wheels show the decision steps taken by teams as a unit. Interactions between individuals and teams can be shown. The overall depiction of teamwork is much richer than in a decision ladder alone. In contrast to other approaches with multiple decision ladders, the decision wheel is more scalable.

While the decision wheels are a good representation to show how different parties interact on a single control task, the CAT (Naikar et al. 2003) is a good representation to show how individuals are involved in multiple control tasks, or work together on tasks in various situations. For these reasons, we consider the CAT to be another useful representation for exploring team cognitive work. Figure 4 shows the modified CAT for the surgical team. Work situations are shown

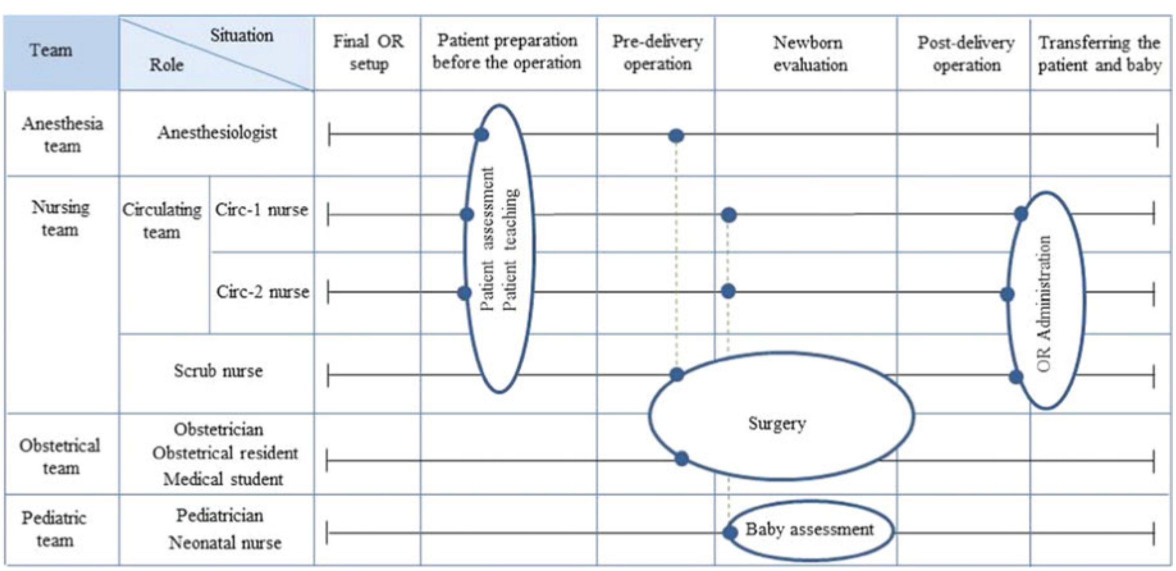

Figure 4. The contextual activity template for the surgical team.

along the horizontal axis and roles and responsibilities are shown along the vertical axis. The ovals indicate the teamwork functions and the small solid circles attached to the teamwork functions indicate the surgical team members that contribute to that function. The extended CAT can be used to identify the team functions at each situation. For example, in the newborn evaluation situation, two team functions can be identified: (1) baby assessment, which is a shared function between the paediatric team and the circulating nurses; and (2) surgery, which is the shared function between the obstetrical team, the anaesthesiologist, and the scrub nurse. Figure 4 shows a summary of the work functions for the C-section surgery and represents how individuals are involved in multiple control tasks considering various situations.

Team ConTA can show the various task steps in different control tasks, where complexities lie, and through the decision wheels, how teams coordinate their activities, and timing to accomplish joint tasks. In Table 2, we show how the Team ConTA can add to the traditional ConTA.

3.3 Team Strategy Analysis

StA identifies different options that can be triggered by different situational factors. An StA may look at different task pathways that may occur (Burns, Enomoto, and Momtahan 2008), different functional configurations of the work domain that could be utilised (the operating configurations of DURESS as discussed in Vicente (1999)), or, in the case of teams, different team configurations. For the Team StA, we built an IFM to examine routine and emergency situations in a paediatric case as there are distinctly different task pathways in these two situations. This is shown in Figure 5.

We also looked at team configurations in the routine and emergency situations. In Figure 6 we have shown the coordinative structure under routine situations, and below in emergency situations. In the emergency situation, there is tighter coordination and stronger central coordination through the emergency paediatric team leader.

In Table 3, we compare the Team StA to the StA.

3.4 Competency Analysis

In a traditional CWA, the SRK framework is used to assess the competencies that each worker should possess (Vicente 1999). A Team CWA supplements this by examining the social competencies that are equally as important in having an effective team. Table 4 presents the SRK inventory and Table 5 presents the social competencies.

In Table 6, we show how WCA can be supplemented.

4. Discussion

As an additional perspective on CWA, Team CWA offers promise for revealing team-related information that is important in complex team situations in healthcare. There are several key benefits obtained by performing a Team CWA.

4.1 Identification of boundary objects

By looking at which team members use which parts of the work domain, it can quickly be seen if team members must share the same object. These ‘boundary objects’ require careful attention in design as different users, from different professions, will be using these objects. These objects also require careful coordination so that they are available to the right person at the right time. A *boundary object* is a concept from Activity Theory (Star and Grisemer 1989; Bodker 1991) that describes an artefact that moves between different communities. Boundary objects often present unique design challenges in that they must be designed to be compatible in different activity systems and in collaborative work environments, for different team members, or for different teams entirely (Broberg, Andersen, and Seim 2011). Deeper in the concept of boundary objects is the notion that the object itself interacts with the community boundaries to reduce or reinforce that boundary (Lee 2005). Clearly in this sense, identifying boundary objects in the work domain has an influence on teamwork itself. While Team WDA can also be used to identify the boundary objects and the shared elements of the information space, Team ConTA can be used to identify the distribution of workflow to different team members.

4.2 Recognition of shared values and purposes

When teams collaborate and have pressing individual goals, it can be difficult to keep focused on the overall picture. Reinforcing shared values and purposes can be a helpful way to keep a team working together.

Table 2. Comparison of team ConTA to ConTA.

Comparison factors	Team ConTA	ConTA
Operating modes/ situations	Operating mode/situation: Final OR set-up Patient preparation before the operation Pre-delivery operation Newborn evaluation Post-delivery operation Patient transfer to the recovery room	Operating mode/situation: Final OR set-up Patient preparation before the operation Pre-delivery operation Newborn evaluation Post-delivery operation Patient transfer to the recovery room
Control tasks/ information-processing activities	Control tasks for the newborn evaluation mode: Surgery Baby assessment Information-activity processing for the patient assessment (routine situation): Collecting the required information for the baby assessment. The paediatric team and both circulating nurses contribute to this activity. Identifying whether the baby needs special care. The paediatric team is responsible for performing this activity. Formulating a list of steps for documenting the baby's health parameters. The paediatric team is responsible for performing this activity. Completing the actions, such as filling out the forms.	Control tasks for the newborn evaluation mode: Surgery Baby assessment Information-activity processing for the patient assessment (routine situation): Collecting the required information for the baby assessment Identifying whether the baby needs special care Formulating a list of steps for documenting the baby's health parameters Completing the actions, such as filling out the forms
Work functions	Team functions at the final OR set-up situation: In this situation, the scrub nurse manages the surgical tools and the circulating nurse checks the OR equipment. All the work functions in this situation are individual work functions. Team functions at the patient preparation situation: Patient assessment is the shared function between the obstetrical team, the anaesthesiologist, and the circulating nurses. Patient teaching is the shared function between the anaesthesiologist and the circulating nurses. Managing surgical tools is the individual work function for the scrub nurse. Team functions at the pre-delivery operation situation: Surgery is the shared function between the anaesthesiol ogist, the obstetrical team, and the scrub nurse Managing surgical tools is the individual work function for the scrub nurse. Team functions at the newborn evaluation situation: Baby assessment is shared between the paediatric team and the circulating nurses. Surgery is the shared function between the obstetrical team, the anaesthesiologist, and the obstetrical team and the scrub nurse. Managing surgical tools is the individual work function for the scrub nurse. Team functions at the post-delivery operation situation: Surgery is the shared function between the obstetrical team, the anaesthesiologist, and the scrub nurse. Managing surgical tools is the individual work function for the scrub nurse. Team functions at the patient transfer situation: Managing surgical tools is the individual work function for the scrub nurse. The rest of the team help to transfer the patient to the recovery room. Operation is done at this point.	Work functions at the final OR set-up: Managing surgical tools Work functions at the patient preparation situation: Patient teaching Patient assessment Managing surgical tools Work functions at the pre-delivery operation situation: Surgery Managing surgical tools Work functions at the new-born evaluation situation: Surgery Managing surgical tools Baby assessment Work functions at the post-delivery operation situation: Surgery Managing surgical tools Work functions at the patient transfer situation: Managing surgical tools

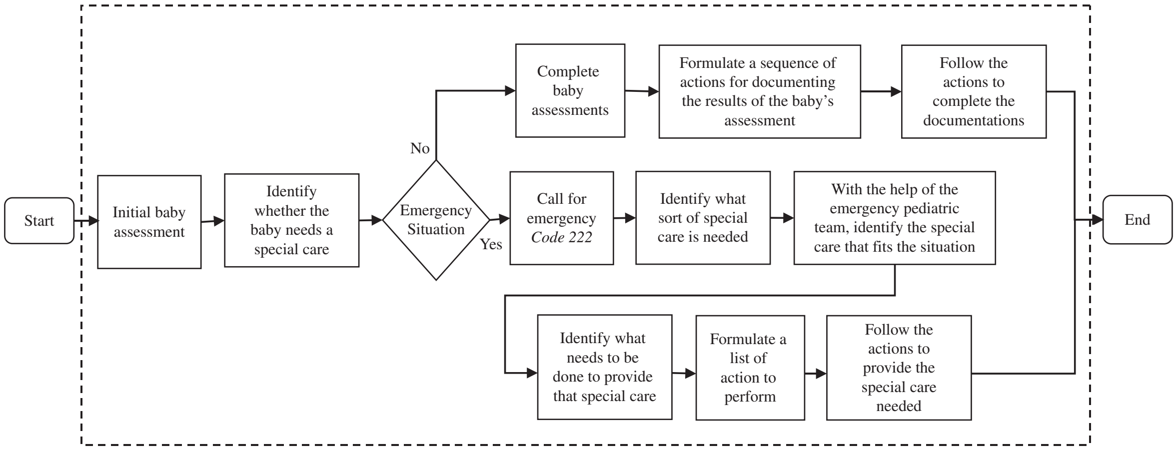

Figure 5. Information flow map for routine and emergency situations.

4.3 Identification of synchronous and asynchronous activity

The decision wheel allows the team's actions on a task to be mapped explicitly to each team member. When team members work together, good coordination is needed. However, by identifying when asynchronous tasks occur, communication needs and record-keeping requirements may be noted.

4.4 Recognition that team structures change

As the work context changes, team structures change, as seen in the StA presented here. This is clearly seen in routine and emergency situations, but could be seen in other situations as well. For example, busy periods versus quiet periods, day shifts versus night shifts. Designing for a 'team' means recognising that the composition of that team may flex and change.

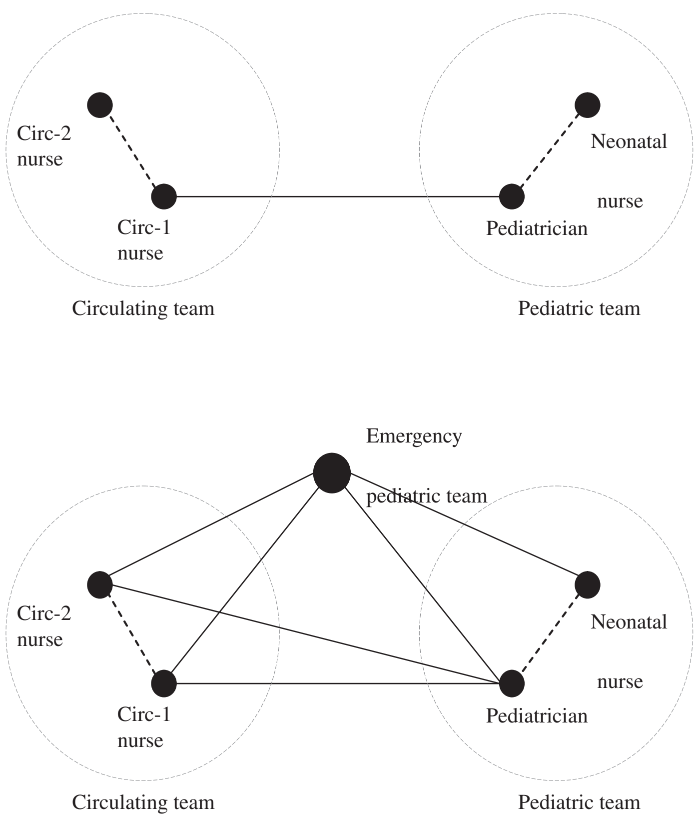

Figure 6. Coordination structures in routine situations (above) and emergencies (below).

Table 3. Comparison of Team StA to StA.

Comparison factor	Team StA	StA
Coordination strategies	Coordination structure for the newborn assessment at the newborn evaluation situation: Routine situation: Paediatric team: autocratic structure Circulating nurses: autocratic structure In emergency: Paediatric team: autocratic structure Circulating nurses: autocratic structure Considering the paediatrician as the team lead, the whole team can be examined as an autocratic structure Considering the emergency paediatric team and connections with every other team member, it is a distributed structure	None
Operational strategies (emergency)	Team structure: Paediatric team: Paediatrician Neonatal resident Emergency paediatric team Circulating team: Circ1 nurse Circ2 nurse Expertise level: Novice to experienced paediatricians, novice to experienced nurses Duration: Very quick Category of actions: Initial baby assessment by the paediatric team The paediatric team identifies whether the baby needs special care The paediatrician calls for emergency Code 222 The paediatrician and the emergency paediatric crew identify what sort of special care is needed The emergency paediatric team identifies the best special care that fits the situation The emergency paediatric team decides what needs to be done to provide that special care The emergency paediatric team formulates a list of actions to perform The emergency paediatric team follows the actions to provide the special care needed	Procedure: In case of an emergency, all of the on-call emergency paediatric team members are expected to be present in the OR within two minutes. The paediatric team should identify the reason for the emergency call and, then, identify a set of options to deal with the situation. With the help of the emergency paediatric team, the paediatrician compares the options and decides about the required special care for the baby.
Operational strategies (routine)	Team Structure: Paediatric team: Paediatrician Neonatal resident Circulating team: Circ1 nurse Circ2 nurse Expertise level: Experienced or novice paediatrician Novice to experienced nurses Duration: Around 10 minutes Category of actions: Initial baby assessment Identify whether the baby needs special care The circulating nurses finish the baby assessments and update the paediatric team with the results The paediatric team identifies that the OR forms should be filled with the results of the baby assessment The paediatric team fills in the OR forms and leaves the OR	Procedure: Once the baby is born, the paediatric team starts the initial observation to make sure the baby is healthy. In some cases, the paediatrician may ask the circulating nurses available in the OR to complete some baby assessments. Once the measurement is done, one of the circulating nurses updates the paediatrician with the collected data. Then, the paediatric team decides on the sequence of actions to finish the process.

Table 4. SRK inventory for the team.

Team member	Skill-based behaviour	Rule-based behaviour	Knowledge-based behaviour
Paediatric team: Paediatrician Neonatal nurse	An experienced paediatric team should be able to quickly identify the emergency situations and if the baby requires special care	The paediatric team should be able to look up information available in the OR such as care algorithms	Once the required information is collected, the paediatric team should be able to analyse supplementary information and make a decision about the criticality of the situation
Circulating team: Circ1 nurse Circ2 nurse	The experienced nurses should be aware of the set of measurements required for baby assessment in the OR	The circulating team should be able to look up information such as care algorithms to determine equipment and other resources required	The circulating team should be able to identify a list of signs and symptoms to observe

Table 5. Social competencies required for the team members.

Team member	Functional role	Team role	Social skills required (Belbin 1981)	Functional skills required
Paediatric team	Paediatrician	Coordinator Specialist	Single-minded, self-starting, dedicated to provide knowledge and skills in rare supply. Confident, a good chairperson, should be able to clarify goals, promote decision-making, and delegate well.	Specialised, four or five years of residency after graduation from medical school is required.
	Neonatal nurse	Team-worker	Cooperative, perceptive, and good interpersonal skills. Should be able to listen, build, and avert friction, while being assertive in their role.	Expert nurse with specialty training in neonatal nursing.
Circulating nurse	Circulating nurse 1	Coordinator	Confident, a good chairperson, should be able to clarify goals, promote decision-making, and delegate well.	The trained nurse who has passed the training period required for participating in a C-section surgery.
	Circulating nurse 2	Team-worker	Cooperative, perceptive and good interpersonal skills. Should be able to listen, build, and avert friction, while being assertive in their role.	The trained nurse who has passed the training period required for participating in a C-section surgery.

4.5 Identification of Team Strategies

The value added by Team Strategies lies in understanding different ways to carry out shared tasks. While operational strategies focus on different ways of performing control tasks, coordination strategies examine coordination structures and the processes underlying coordination.

4.6 Identification of Social Competencies

Merely looking at functional competencies will not result in an effective team. In an effective team some members must be leaders, some must take direction well, some must be fluent communicators.

5. Conclusion

While CWA is showing promise as a method for understanding work in healthcare situations, using CWA with an explicit team perspective can reveal additional constraints relevant to teamwork. The intention of this work is not to create a new CWA, per se, but rather to suggest that CWA remains relevant in team situations and the existing framework can be usefully interpreted to understand cognitive work in teams. In particular, we have demonstrated the Team CWA approach in the context of work models for a birthing unit.

Table 6. Comparison of team CA and WCA.

Comparison factor	Team CA	WCA
Functional competencies	Similar to a basic WCA	Function roles: Paediatrician Neonatal nurse Circ1 nurse Circ2 nurse Functional skills: The SRK behaviours are examined within the SRK inventory in Table 5
Social competencies	Team roles for the baby assessment: Paediatrician: coordinator, specialist Neonatal nurse: team worker Circ1 nurse: coordinator Circ2 nurse: team worker Social skills: Specialist: single-minded, self-starting, dedicated to provide knowledge and skills in rare supply. Team worker: cooperative, perceptive, and diplomatic. Should be able to listen, build, and avert friction. Coordinator: confident, a good chairperson, should be able to clarify goals, promote decision-making, and delegate well.	None

Acknowledgements

The authors thank the nursing leaders of the birthing unit for coordinating and smoothing the data collection process, and the study participants.

Funding

The authors thank the Natural Sciences and Engineering Research Council of Canada (NSERC) for supporting this work through an NSERC Discovery Accelerator Supplement 132995.

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