Effects of Decision Support Tools on Cardiac Telephone Consultation Process

by

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AUTHOR'S DECLARATION FOR ELECTRONIC SUBMISSION OF A THESIS

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The Nursing Coordinators (NCs) at the University of Ottawa Heart Institute (UOHI) fields phone calls from patients who have been discharged and are undergoing home care procedures at a daily basis. The project described in this thesis aims to provide tools for the Personal Digital Assistant (PDA) that the NCs can use during the phone calls. The Cognitive Work Analysis (CWA) and Ecological Interface Design (EID) approach are used to identify the information requirements to design the system. Major challenges of the telephone consultation process that are additionally identified by literature review and interviewing the NCs included visibility of patients, individual differences, and lack of standardized procedures. A combination of decision trees and visualization techniques is proposed to aid the process. Implementation of decision trees would help unload mental workload especially accesses to "knowledge in the head" as well as facilitate expert knowledge transfer to less experienced nurses. Visualization tools display integration of multiple-cues from patients in an abstract nature and can be accessed by users at any point of decision process.

Preliminary experiment with static images showed that visualization tools helped the decision makers more when the judgement tasks were more complex. The effects of different types of decision support on the cardiac nurses in simulated telephone consultation processes were examined. The system improved the performance of the decision makers and induced different types of strategic behaviours: a standardized checklist, OLDCAR, induced more through assessment, the decision algorithms induced efficient and more detailed recommendation, and the semantic network symptom map induced information gathering more relevant to diagnosis.

The research also explored methodologies to examine multi-layered decision process, where many decision makers with varying expertise are involved in modeling the strategic behaviours. This type of process can be applicable when the primary decision makers do not monitor the work domain, but can be alerted when something goes wrong.

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Table of Acronyms

ADS	Abstraction-Decomposition Space
AH	Abstraction Hierarchy
AIDL	Advanced Interface Design Lab
CARDIO	Cardiac Algorithm Research and Development In Operation
CHF	Congestive Heart Failure
CWA	Cognitive Work Analysis
DH	Decomposition Hierarchy
DSS	Decision Support System
DURESS	Dual Reservoir System Simulation
EID	Ecological Interface Design
ER	Emergency Room
FL	Fuzzy Logic
GA	Genetic Algorithm
HB	Heart Beat
HPI	History of Present Illness
ID3	Inductive Dichotomiser 3
MI	Myocardial Infarction
NC	Nursing Coordinator
NDM	Naturalistic Decision Making
NN	Neural Network
OLDCAR	Onset, Location, Duration, Characteristics, Associated Symptoms, Aggravating Factors, Relieving Factors (An acronym incorporated to the prototype)
OLDCART	Onset, Location, Duration, Characteristics, Associated Symptoms / Aggravating Factors, Relieving Factors, Treatment (An acronym taught as a checklist at some nursing schools)
PDA	Personal Digital Assistant
PPS	Post-Pericardiotomy Syndrome
RPD	Recognition-Primed Decision
SC	Soft Computing
SOB	Shortness of Breath

SRK	Skills, Rules, Knowledge
T3	Tungsten 3
TeleForm	Electronic TelePractice Documentation Record
UOHI	University of Ottawa Heart Institute
WDA	Work Domain Analysis

Chapter 1
Introduction

1.1 Overview

As the number of Canadians with heart disease increases and there is pressure for the length of hospital stays to be reduced, there is a need for cardiac care assessment and advice that cannot be fulfilled by homecare agencies or family physicians. Many patients wait several weeks before seeing their family physicians after they are discharged from the hospital. Consequently, the medical professionals offer telephone consultation services and frequently receive calls from patients for information inquiry or advice on complications that arise after being released from the hospital. Responding to the calls increases the workload for professionals and may interfere with the tasks they are performing before receiving the calls. In addition, handling patient calls must be conducted in a professional manner following up-to-date best practice guidelines and standardized protocols.

At the University of Ottawa Heart Institute (UOHI), the nursing coordinators (NCs) in the cardiology and cardiac surgery departments receive more than 1500 calls annually from patients requesting assistance (UOHI, 2004a). Besides providing suitable advice, the NCs also have to keep records of the phone interactions. The Cardiac Algorithm Research and Development in Operation (CARDIO) project aims to provide a mobile decision support system (DSS) to aid the NC's during phone calls including decision support and data collection capability on a Personal Digital Assistant (PDA) and data transfer to the UOHI's central database through desktop software (Figure 1-1). Electronic records can be viewed in a form or spreadsheet format so that more detailed information can be extracted from the records. The project was proposed in collaboration of the UOHI and Advanced Interface Design Lab (AIDL) at the University of Waterloo.

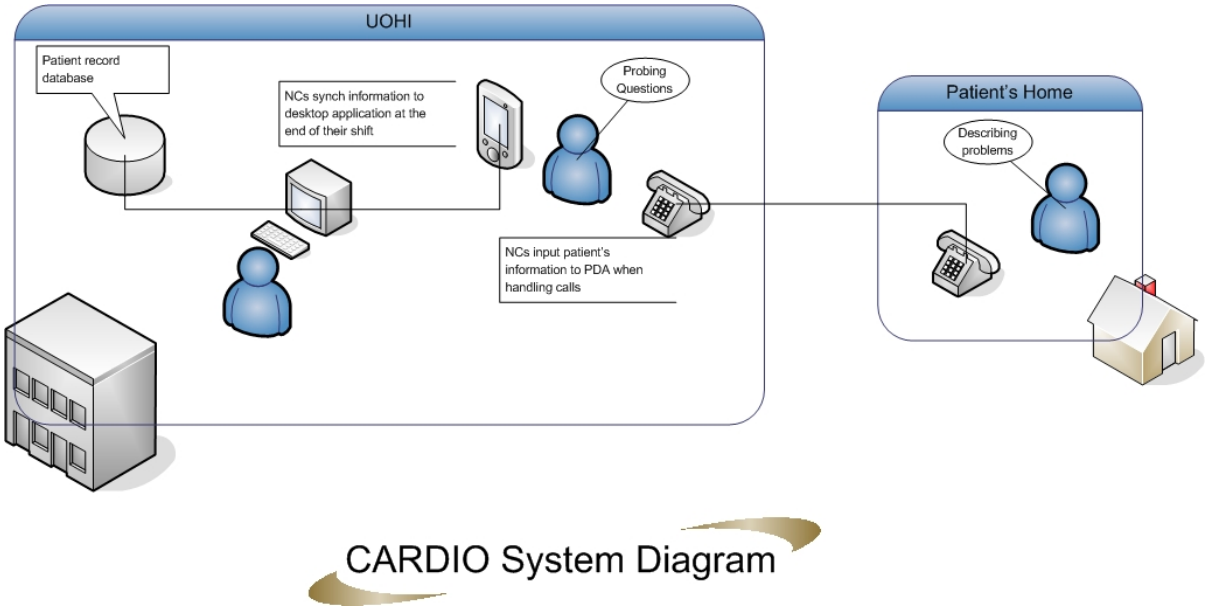


Figure 1-1: The system diagram for the CARDIO project.

1.2 Focus of Investigation

1.2.1 Decision Process Model for Telephone Consultation

In order to design an effective DSS, the first focus was placed on what needs to be supported. The telephone consultation processes at the UOHI involve complex interactions with patients. The DSS should essentially guide its users when generating questions and integrating information prior to forming conclusions and recommendations. Literature reviews in related fields and interviews with the NCs were conducted to understand their decision processes. Constructing appropriate models for the processes should help identify what part of the process needs to be supported to optimize the uses' cognitive work.

1.2.2 Effective Information Display

Key factors for an effective information display are what information is displayed and how it should be displayed. The Ecological Interface Design (EID) approach is used to identify the cognitive workload of intended users and thus reduce the demands. The Work Domain Analysis (WDA) was conducted, reviewed and refined throughout the modeling and design process. The EID approach has not been used in medical decision-making previously and it has the potential to facilitate expert decision-making processes in other fields.

1.2.3 How Information Display Influences the Users' Decision Process

The DSS is expected to influence the decision makers' behaviour in various ways. In addition to changes caused by the introduction of a PDA, the users' thought processes may be modified by the system. Given that there are multiple ways to support their telephone consultation processes, their behaviour can be affected differently when using different support. Extracting tool-behaviour relationships would be beneficial to provide consistent patient consultation. In addition, the DSS can be used as a training tool for novice users and these behavioural shaping effects should be more pronounced for novice decision makers than for experts.

1.3 Structure of this thesis

This thesis begins by giving background information in Chapter 2 followed by the interviews with the primary users, the NCs in Chapter 3. The process and results from the WDA, control task analysis and strategy analysis are described in Chapter 4, Chapter 5, and Chapter 6 respectively. The idea of knowledge extraction from quantitative data is introduced in Chapter 7. In Chapter 8, interface elements of the system are introduced. Two experiments are described in Chapter 9 and Chapter 11 while Chapter 10 spends some time describing the modifications of the design based on the result of the first experiment. Chapter 12 concludes this thesis with limitation, contributions and future work.

Chapter 2
Background

2.1 Telephone Consultation Practice at the UOHI

2.1.1 Resources at the UOHI

The UOHI serves more than 1.5 million residents from Eastern and Northern Ontario, and Western Quebec (UOHI, 2004b). It is the only specialized, teaching, and adult cardiac facility between Montréal and Kingston and it has the largest artificial heart program in Canada. There are eight NCs, eight cardiac surgeons and 33 cardiologists along with 116 beds offering specialized cardiac care. Cardiac life support areas consist of three operation rooms, a recovery room with six beds, and a surgical critical care unit with eight beds as well as other specialized lab units.

There are two major divisions at the UOHI: cardiac surgery and cardiology. The cardiac surgery division handles cases that involve surgery while the cardiology division provides service in all facets of cardiology from prevention to tertiary care.

Their patient care services are normally appointment-based, but patients that need to be seen by a cardiac specialist urgently can be referred to a reference centre by nurses. The UOHI's large coverage area and the limited number of specialists suggests that efficient handling of call-in patients is essential to maximize the resources, which in turn maximizes patient safety.

2.1.2 Telephone Consultation Practice at the UOHI

The UOHI receives 1500 calls annually from patients requesting help and advice. When a patient call is received, the call is directed to either the cardiology or the cardiac surgery division, and the NC from that division will be paged. The paged NC will then go to a nearby phone to receive the patient's call. It must be noted that there is only one NC in each department at a time.

When taking phone calls, the NCs use a flow sheet, called a *Telepractice Documentation Record*, but commonly referred as a "Callback sheet" by the NCs (included in Appendix A-1), to guide the question sequence as well as to log their conversations in an efficient manner. The sheet contains general information about the patient, such as name, phone number, and the name of their UOHI physician. It also contains a list of typical history items and chief complaints, with a checklist of dispositions.

Through appropriate questioning, the NCs identify the risk level of patients and match them to possible courses of action. For example, some patients are instructed to call 911 for emergency service while some others are advised to stay home with some caution and contact their family physicians or the UOHI on the following day. The NCs may also give homecare procedures for specific symptoms when appropriate. In such cases, the NCs may arrange a callback from a nurse, cardiologist, or cardiac surgeon. Additionally, the NCs can educate patients about precautionary measures against some of the symptoms and side effects, as well as how to manage them when they occur. There are homecare procedure instructions for patients, referred as *Discharge booklets* that the NCs can refer to when appropriate.

An important point to mention is the lack of a consistent or standardized protocols for telephone consultation in use at the UOHI. All NCs are qualified nurses with required educational background and extensive nursing experience in the field. Their expertise enables them to handle demanding phone calls while conducting their regular activities at the institution. Therefore, the NCs tend to follow algorithms based on their experience.

The following are some other findings:

a) The NCs move throughout the hospital and do not always have the flow sheet ready to receive calls (sometimes they use anything at hand).
b) The NCs often operate in a fairly noisy environment when talking to patients. Communication with patients therefore must be concise and effective.
c) The NCs may be in the middle of other processes while receiving calls. Therefore the cognitive workload of handling phone calls should be minimized to prevent degradation of other tasks.

There are also two important concerns regarding telephone handling during night shifts. One is that there is only one NC during after hours and weekends; therefore, the night shift NC is forced to handle all phone calls including the ones that may not fall within their specialized area. For example, an NC specialized in cardiology has to manage cardiac surgery patients if she is on a night shift. Thus, the system should support users who are not experts in the area. The other concern is that there are limited resources at the UOHI during night shifts compared to daytime shifts. The decisions on the urgency of patients' conditions then become even more critical.

As pointed out earlier, the calls are logged on flow sheets. Sometimes certain entries on the sheet are omitted due to time constraints or simply the inefficiency of the input procedure. The call records are transferred from the hand-written sheets to a database by contract workers. Those records include

inconsistent abbreviations and hand-written comments that are sometimes illegible. This data transfer procedure runs the risk of information loss and misinterpretation.

2.1.3 Nursing Profile

Nursing Profile is another form completed by the NCs at the UOHI. Nursing profiles are created when a patient is admitted to the UOHI (Appendix A-2). It contains a patients' demographic information as well as known issues including allergies and history of disease. The problem and admission purpose, which can be investigation, procedure, or surgery, are also included. Additional information is added when the patient is discharged. This form contains essential information of the latest UOHI visit of the patient.

Nursing profiles are filled on paper forms and filed and stored in the nursing station near the admission area in the institute. Although the information in the form is possibly useful, the limited accessibility to the forms makes it harder to utilize to aid their decision process.

2.1.4 Protocols Development at the UOHI

There are publicly available guidelines for effective telephone triage algorithms. Algorithms can be developed from expert knowledge based on the guidelines. For example, the UOHI developed a generic protocol for call handling (UOHI, 2003). The protocol utilizes the chief complaint as the starting point. The list of chief complaints is included in Table 2-1.

Table 2-1: Chief Complaints (Extracted from (UOHI, 2003))

Altered Level of Consciousness	Hypertension
Anxiety	Hypotension
Chest Pain	Leg Pain/Swelling
Cough	Neck Pain
Diabetes Mellitus Problems	Numbness and Tingling
Dizziness	Shortness of Breath
Fainting	Sleep Apnea
Fatigue	Weakness
Heartbeat, Rapid	Wheezing
Heartbeat, Slow	

It was designed to follow a path according to a patients' answers to mostly discrete (yes/no) questions. Consequently, the collective protocols are like decision trees. Some of the protocols are linked together to identify the best possible description of a patient's condition and to avoid missing critical information.

2.2 Judgement and Decision Making

2.2.1 Normative Approach

Normative approaches to decision making are sometimes referred to as rational choice research. Hastie lists four criteria for a rational choice (Hastie and Dawes, 2001: p. 18).

1. It is based on the decision maker's current assets. Assets include not only money, but physiological state, psychological capacities, social relationships and feelings.
2. It is based on the possible consequences of the choice.
3. When these consequences are uncertain, their likelihood is evaluated according to the basic rules of probability theory.
4. It is a choice that is adaptive within the constraints of those probabilities and the values or satisfactions associated with each of the possible consequences of the choice.

Examples of models used in rational normative approaches include expected utility, Bayesian theory and decision trees.

2.2.2 Descriptive Approach

In contrast to the normative approach, descriptive decision making, sometimes called naturalistic decision making (NDM), examines how decision makers actually make decisions in the real world. Their research showed that "naturalistic" decision makers use different processes and strategies from the traditional decision models (Zsambok, 1997). The researchers in NDM criticize the fact that the normative approaches compare the quality of decisions against abstract standards based on their models. The contextual factors that are omitted in a laboratory setting may contribute to the conclusion by providing better situation awareness.

The recognition-primed decision (RPD) model, proposed by Klein, is based on observations of experienced personnel in operational settings (Klein, 1989). In RPD, expert decision makers sense their environment and recognize patterns almost instantly. They claim that one component necessary for expertise is explicit and objective knowledge (Klein et al., 1989). This type of knowledge includes "*factual knowledge*, *if/then rules*, and *analytical procedures* (p 463)." "Tacit knowledge," which encompasses situation awareness and analogical reasoning, is pointed out as a second, and "*perceptual learning* and the development of a *perceptual-motor feel*" as a third aspect. In naturalistic decision making, heuristics are described as essential decision making strategies that cannot be explained by normative models (Patel et al., 2002).

2.2.3 Heuristics and Biases Approach

Heuristics and biases approach offers one interpretation of any observed gap between normative and descriptive analyses. The deviation from normative model can be explained as the results of heuristic approaches that individuals apply or cognitive processes when making decisions. Studies in *judgements and decision making* try to elucidate the mechanisms of heuristics in a hope of preventing errors and biases.

Although the research in normative decision revealed judgement biases as limitations of human information processing, most findings in them are from strictly controlled laboratory settings (Patel et al., 2002). It is arguable that experts can extract and integrate information in the experimental setting. For example, if an expert nurse is placed in a laboratory experiment with a piece of paper listing symptoms, the piece of paper is not likely to give her the same effect as a real patient.

2.3 Telephone Triage

National Council Canada (1997) defines telephone triage as the process of "prioritizing a client's health problems according to their urgency, educating and advising clients, and making safe, effective and appropriate dispositions by using the telephone" (p. 2). This process may include symptom assessment, counselling, home care advice, referral, and crisis intervention.

Wheeler defined four stages of the telephone triage process (Wheeler, 1993):

1. Assessment and data collection
2. Working diagnosis
3. Intervention
4. Evaluation

2.3.2 Assessment and data collection

Objectives of assessments are 1) to elicit data in sufficient quantity, quality and detail and 2) to establish a sequence of events relating to the presenting symptoms (Wheeler, 1993). The most important data, which should be recorded in detail, is the patient's history of present illness (HPI). Most patients calling the UOHI are patients who have had visited the institute before. It is desirable to have the patient's medical history accessible by the nurse. The current system does not support instant patient history retrieval. In the cases where the patient has no previous commitment with the UOHI, a new record should be started.

2.3.3 Working diagnosis

Telephone triage nurses, as regular nurses, have to make diagnoses from the analysis and synthesis of data. This process may employ the use of protocols, medical expertise and often, intuition as well (Wheeler, 2003). In fact, intuitive thinking, both cognitive and empathetic, is identified as a major component in a nurse's decision (Breslin and Dennison, 2002). Wheeler identified six categories of telephone triage nursing judgements:

a) whether a problem exists;
b) whether a potential problem exists;
c) whether the client is handling it well or needs help;
d) whether the problem needs to be studied further;
e) whether the problem sounds serious; and
f) whether the problem is urgent or emergent.

Obtaining answers to these questions essentially forms the basis of telephone triage. However, the nurse at this stage needs to be especially careful of forming a medical diagnosis beyond their capability or what their code of professional conduct permits.

2.3.4 Intervention

Based on the working diagnosis formed, the triage nurse may provide advice for treatment and medication (what and how) and directives about where and when treatment should take place.

2.3.5 Evaluation

The final stage of telephone triage is to educate the caller how to self-evaluate their symptoms. In most cases, the client performs the advice given to them after the phone conversation, and then evaluates the results. Either the client or the nurse may initiate a follow-up call.

2.4 Evidence-based Practice

Evidence-based medicine, which has emerged in the late 1980, utilizes research as a foundation for nursing practice (Shapiro and Driever, 2004). It is defined as "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients…. [it] means integrating individual clinical expertise with the best available external clinical evidence from systematic research" (Sackett et al., 1996: p71). By integrating the findings from the latest studies, physicians and nurses can complement the areas they have not experienced. There may be a completely new medication or procedure that is better than existing ones. For this reason, a medical

professionals needs to have the latest information to comprehend all the options so that s/he can take the best action.

Despite the apparent benefit of the practice, some medical professionals resist the emphasis on the evidence over personal experience (Grahame-Smith, 1995). The Straus and McAlister report based on multiple surveys and literature research regarding the criticisms of evidence-based practice (Straus and McAlister, 2000) points out that some of the criticisms were misperceptions rather than limitations of evidence-based medicine (Table 2-2). It should be emphasized that medical professionals understand that the evidence should be integrated with clinical expertise as opposed to deciding based on the evidence alone. As Straus and McAlister commented on most of the limitations, it is likely to take more time to improve the practice of evidence-based medicine.

Table 2-2: Commonly Cited Limitations and Misperceptions of Evidence-Based Medicine (Straus and McAlister, 2000)

Limitations
Universal to the practice of medicine
Shortage of coherent, consistent scientific evidence
Difficulties in applying evidence to the care of individual patients
Barriers to the practice of high-quality medicine
The need to develop new skills Limited time and resources
Paucity of evidence that evidence-based medicine "works"
Misperceptions
Evidence-based medicine denigrates clinical expertise
It ignores patients' values and preferences
It promotes a cookbook approach to medicine
It is simply a cost-cutting tool
It is limited to clinical research
It leads to therapeutic nihilism in the absence of evidence from randomized trials

2.5 Decision Making in Telephone Consultation

Decision making is an integral part of health care (Shapiro and Driever, 2004). Consciously or unconsciously physicians and nurses make numerous judgements throughout their shifts. For example, they have to decide what to observe, what to measure, or what to ask patients when examining or taking care of patients. Telephone consultation requires the nurses to make rapid and sound clinical judgements regarding the status of the patients, the situational context and their response to the presenting health problem. Moreover, such judgements are made under time pressure, with incomplete information in circumstances where no direct observation of the patient is possible,

and often in situations of crisis. This reasoning process involves a complex mixture of observation, critical thinking and data-gathering skills.

The complexity involved in the task therefore requires the nurses to be highly experienced and well trained (Breslin and Dennison, 2002). A nurse accumulates his or her expertise through repeated exposure to similar clinical situations which enables them to recognize patterns and quickly grasp the salient features of situations providing a cognitive shortcut to appropriate decisions. This particular ability of the nurse is often termed as 'intuitive thinking' by nurses themselves. Breslin and Dennison (2002) describes two types of intuitive thinking: cognitive thinking through which information is gathered quietly and quickly, and empathetic thinking that allows nurses to take action in the best interest of the patient.

Expertise is further associated with confidence, a critical component of the decision making process emphasized by many nurses in a study done by Hagbaghery et al. (2004). The nurses in this study believed that self-confidence provides them with the feeling of control and the ability to influence the situations, while a lack of self-confidence would cause them to feel weak and consequently avoid participating in the decision processes.

A potential concern of expert nurses making decisions on the grounds of experience and intuition alone is the possibility of selective and thus possibly biased attention to signs and symptoms present in the situation. The generated hypotheses from such cues are then used as the basis of subsequent information gathering in order to confirm which of these is the most probable. The use of intuition can occur where there is a lack of substantive knowledge (Edwards, 1998). Intuitions stemming from experiences can be wrong and affect a nurse's judgement.

The role of expertise and intuitions in decision-making is common to all nurses; however, recall that nurses during a telephone consultation lack the advantage of directly observing their patients. A common method for them to compensate for this lack of complete information is building a mental image of the patient and the contextual situation (Edwards, 1998). This kind of mental activity seems to form an integral part of nurses' assessment and diagnosis over the telephone; hence an effective design of a DSS for telephone consultation should take this factor into serious consideration.

Nurses with different levels of expertise may also receive specialized training and employ various types of decision support, including protocols and guidelines, to facilitate the nursing process to assess, diagnose, treat and evaluate. The DSS should therefore benefit the NCs, who are currently responsible for telephone consultation, and also allow other cardiac nurses with lesser experience to perform the task as well.

2.6 Human Information Processing

2.6.1 Skills, Rules and Knowledge Framework

The Skills, Rules, Knowledge (SRK) classification proposed by Rasmussen to reduce human errors has influenced the design and analysis of complex systems (Rasmussen, 1983, Sanderson and Harwood, 1988). The three levels in the SRK classification: skills, rules and knowledge levels, are illustrated in Figure 2-1. All three levels of cognitive control can exist at the same time in human information processing depending on the type of tasks. Study of the interaction and interference between different modes or levels of cognitive control are particularly important to understand and to minimize human errors (Rasmussen, 1986).

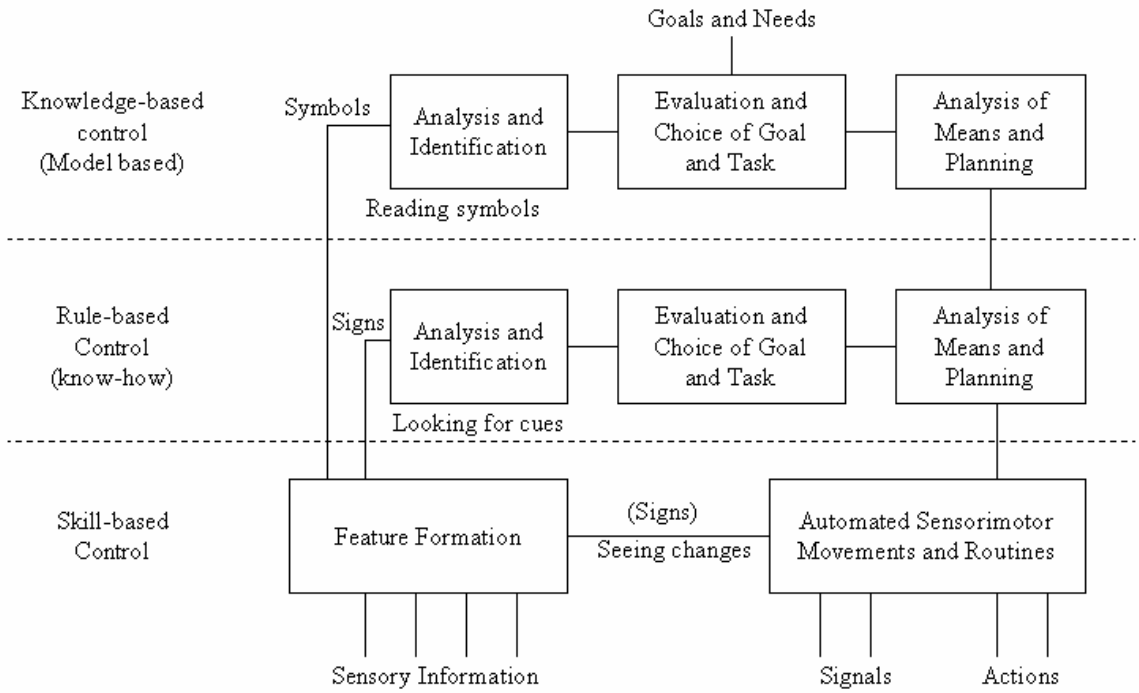


Figure 2-1: Levels of cognitive control of actions (Rasmussen, 1986).

A skill-based behaviour is characterized by sensorimotor behaviour, a type of behaviour that requires very little or no conscious control to react to the system status. In most skill-based control the performance is typically smooth, automated, and consists of highly integrated pattern behaviour (Rasmussen, 1986). For example, bicycle riding is considered as a skill-based behaviour, where very little attention is drawn to control a bicycle once you acquire the skills to ride it. This automaticity

frees up the actors' cognitive capacity, which can then be used to process more complex problems (Wickens and Hollands, 2000).

A rule-based behaviour, on the other hand, involves procedures or rules to select a course of action for a familiar situation (Rasmussen, 1986). The rules can be a set of instructions given by the supervisors or written in guidelines, as well as those acquired by the users by themselves. Decision makers do not have to know underlying principles to perform a rule-based control. For example, hospitals have highly proceduralized instructions for fire emergencies; thus one can follow the necessary steps to ensure the safety of patients and oneself without detailed knowledge of consequences.

A knowledge-based behaviour represents a more advanced level of reasoning by the operator (Wirstad, 1988). This type of control must be employed when the situation is novel and unexpected. Decision makers are required to know the principles and fundamental laws for the systems to perform more in-depth analysis. Since observers have to form explicit goals based on an analysis of the environment, their cognitive workload is typically greater than that of the other two controls.

2.6.2 SRK Behaviours in Telephone Consultation

Nursing practice involves a combination of the different levels of control. Some are skill-based behaviours that are highly automated, such as handling of equipment or classifying patients' records. However, managing patients' calls requires more careful data-gathering skills to form appropriate decisions. Observing the state of patients or acting directly on patients is not possible during a telephone consultation process. Therefore, skill-based behaviours are not a large part of patients' call handling at the UOHI.

Rule-based behaviour models are often efficient and convenient to establish protocols or algorithms since rule-based behaviour is dominant in proceduralized situations. Assuming that patient calls to the UOHI have some common characteristics to form patient groups, typical "if-then" relationships between the input information to the possible actions can be easily understood and utilized. In addition to established protocols, nurses often develop their own rules based on their experience.

Well-established algorithms help decision makers to make judgements on the familiar situations; however, in many real cases, the conditions of patients and environments do not fit into the description of available algorithms. In such cases, users are no longer able to use the protocols and have to switch to knowledge-based cognitive control. Although an expert NC can apply fundamental

cardiology principles to locate the problems, novices would require a well-structured integrative system that identifies the causal relationships within the subcomponents.

When algorithms do not apply in the real world situation, the NCs would take on a higher cognitive workload. Understanding of fundamentals in the work domain is necessary for users to maintain their level of situation awareness. An EID, which shows the relationship among the observable cues, should reduce mental workload in gathering essential information from the callers and integrating them to arrive at the best resolution.

2.7 Ecological Interface Design

The EID was developed to help operators of large systems make the best possible decisions when the systems or environment exhibit unexpected outcomes (Burns and Hajdukiewicz, 2004). The EID is often used to display systems that contain multidimensional quantitative data sets that relate to the goals of the work domain.

2.7.1 Cognitive Work Analysis

The cognitive work analysis (CWA) is a framework for work analysis based on the concept of behaviour-shaping constraints containing models of the work domain control tasks, strategies, social-organizational factors, and worker competencies in an integrated manner (Vicente, 1999).

As the first phase of CWA, the Work domain analysis (WDA) techniques, such as the decomposition hierarchy (DH) and abstraction hierarchy (AH) are used to examine the internal relationship of subcomponents of the domain thereby elucidating the intrinsic constraints of the work domain. The DH can repeatedly decompose a system until the sub-components are small enough to allow their goals and functionalities to be identified. The AH is used to illustrate the relationship between components in terms of means-and-ends through the WDA.

Once the constraints of the domain are examined, specific goals of operations and their associated requirements are analyzed by the *control task analysis* (Vicente, 1999.) Vicente emphasizes that control task analysis deals with "what needs to be done, not how or who (p. 183)." *Strategy analysis* following control task analysis investigates the "how" part. Expert operators have a range of strategies developed through experience or inherited from other operators. When solving problems, they may apply one or more strategies that are suitable for the situation while novices need to follow sequential procedures in manuals.

An interface design developed by combining and implementing the findings from the analyses leaves the operators more cognitive resources to deal with a problem if it arises by being able to more

easily monitor the current system status in relation to the constraints. If the same interface design is also compatible to the control tasks and expert strategies, it may induce expert behaviours from the novices.

Typically the main objects of the work domain are physical entities and the empirical studies demonstrated that the EID provides performance benefits over the conventional interface in physical domains. The EID was found to improve fault detection and diagnosis performance in tightly coupled, process control systems with mostly continuous variables (Chow, 2004).

2.7.2 EID in Medicine

The EID has been implemented in various complex systems such as aviation, network management and medical systems. Among medical applications, for example, a diabetes patient monitoring device was implemented on a PDA for self-monitoring of blood glucose level as well as other parameters that identify a patients' health condition (Thompson and Hickson, 2003, Thompson et al., 2003). Chow investigated the application of an EID to an ambulance dispatching system, which supports resource management in a loosely coupled system with mostly discrete variables (Chow, 2004). The results showed that an EID supports intentional systems and improves an operators' performance and reduces their cognitive workload.

2.7.3 EID in Telephone Consultation

While Chow's findings suggest potential benefits of EID implementation to the DSS at the UOHI, there are distinct differences between the two cases. First of all, the NCs at the UOHI have more knowledge about patients' conditions than ambulance dispatchers. The knowledge should then be retrieved from their memory and integrated with new information to form decisions. Unlike ambulance dispatchers, the NCs do not have resource displays, which show the availability of resources. The availability of each patient's resources depends on the geographical location of the patient, the time and the day; thus, they sometimes have to ask some questions to patients to ensure that the resource is accessible by the patient. Also the majority of calls to the UOHI are from currently or previously admitted patients. Consequently, integrative information gathering is needed. For example, nurses must combine the new information and previously known information while they talk to the patients on the phone. The NCs rely on their memory or paper-based patient records if they need to gather essential information. Dependence of the NCs on working and long-term memory is greater than ambulance dispatchers. Although immediate retrieval of patient records can be realized in the future, the amount of information that must be integrated for their decisions is still massive.

Finally, the NCs should be able to provide homecare procedures and advice to patients who are less critical, and arrange callbacks appropriate for them.

2.8 Soft Computing Approaches to Decision Support System Design

2.8.1 Soft Computing

Instead of generating the components of the DSS using expert knowledge, some software techniques can be used to extract relationships among a set of symptoms and circumstances and their corresponding outcomes. Karray and De Silva describe how "Fuzzy logic (FL), probability theory, neural networks (NN), and genetic algorithms (GAs) are cooperatively used in soft computing (SC) for knowledge representation and for mimicking the reasoning and decision-making processes of a human (Karray and De Silva, 2004: p38)." They also emphasize that SC aims to "approximate" the relationships of interests and has slightly different approaches from the conventional artificial intelligent systems, which typically uses symbolic representation. Table 2-3 summarizes the techniques.

Table 2-3: Techniques of Computational Intelligence (Karray and De Silva, 2004)

Technique	Characteristic	A popular analogy
Fuzzy logic	Uses fuzzy rules and approximate reasoning	Human knowledge
Neural networks	Network of massively connected nodes	Neuron structure in brain
Genetic algorithms	Derivative-free optimization	Biological evolution
Probability	Incorporates uncertainty in predicting future events	Random action of a human
Conventional AI	Symbolic processing of information	Symbolic languages

2.8.2 Validity of Soft Computing Approach for Decision Support System

DSS using SC methods have been evaluated in various fields including medical diagnosis (Mitra et al., 2002, Brameier and Banzhaf, 2001). The recent development of more sophisticated computer systems has realized large data storages and highly computationally expensive analyses. However, massive amount of data needs to be pre-processed before it becomes useful (Mitra et al., 2002). As more medical institutes use electronic measurement devices and patient record systems, the idea of extracting potentially useful information from stored data has drawn more attention from professionals.

Although humans are good at extracting information as patterns in their expertise, there are some known problems in their decision making process such as inappropriate heuristics and biases especially when they are dealing with multivariate information (Wickens and Hollands, 2000).

Traditional methods such as statistical analysis and plotting one variable against another may show local information, but may not be useful to improve over all quality of care. Integrating a large information space is very demanding to the human information processing system. Combined use of SC techniques such as FL and GAs would be beneficial because they can approximate human reasoning and aid automatic data-mining and visualization of complex data (Karray and De Silva, 2004). For example, FL can be used to express relationship among imprecise values while GA can be used to find near optimal solutions over large search space. Employing SC techniques at different stages of process, medical professionals would be able to obtain useful knowledge and visualize it in various forms such as decision trees, rules and procedures.

2.8.3 Telephone Consultation as a Fuzzy Communication System

Although there are successfully implemented DSS's in the medical domain (Mathmedics, 2005, Pepid, 2005), there exist a number of challenges unique to the nature of the UOHI's telephone consultation processes. As mentioned, one of the challenges of telephone consultation process is the lack of measurements or history of the patient's laboratory results while on the phone. For example, heart rate and blood pressure monitoring can provide some indication of malfunctioning of the cardiovascular system. If those basic physical measurements are available, it is easier for nurses to assess the severity of a patients' condition. The second challenge is that a patients' condition is not visible to the nurses. Their sensory inputs, such as vision and touch, are deprived and have to depend on the verbal reports by the patients or the patients' family.

The representation of the patients' conditions is typically expressed in descriptive terms such as "heart rate is fast" as opposed to numerical measurements as in "Temperature = 38 degree Celsius." In other words, patients defuzzify their discomfort with their own membership function and express it using descriptive terms (Figure 2-2). Sometimes they are advised to use scales to express the degree of discomfort, but these scales are also arbitrarily defined; therefore, making decisions based on the information may lead to interpretation errors. Both linguistic and numeric representations are crisp; however, when the information is evaluated by the receiver, linguistic information requires the same membership functions to be fuzzified correctly. As illustrated in Figure 2-3, if patient and nurse use different membership functions or scales for their information processing, decisions that are made will have higher risks of errors.

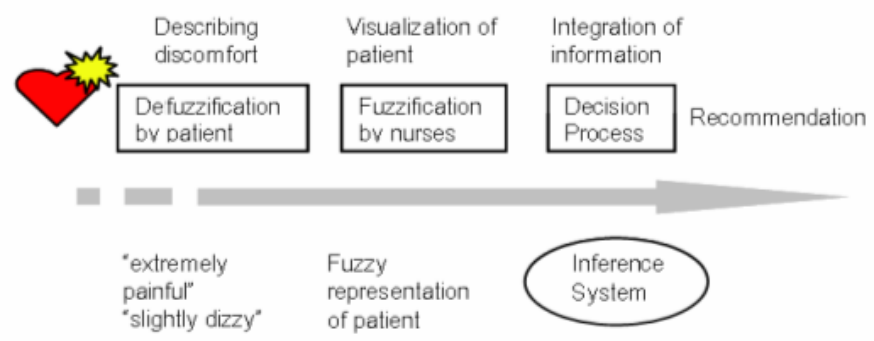


Figure 2-2: Fuzzy information relay.

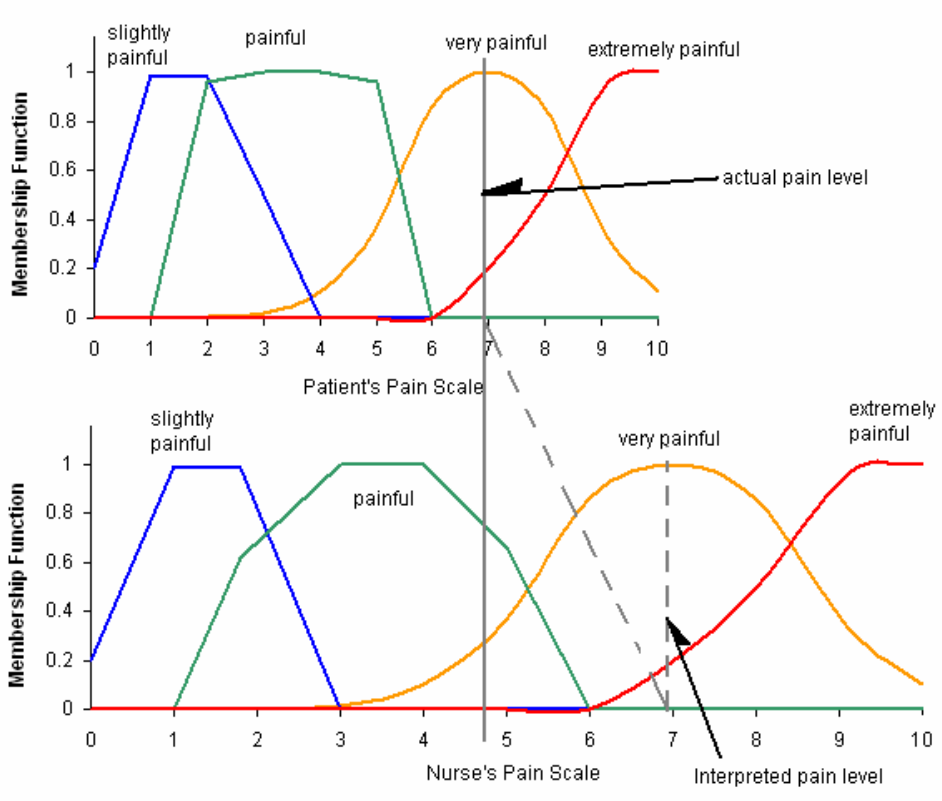


Figure 2-3: Illustration of fuzzy communication problem.

2.8.4 Use of Decision Trees as a Representation of Knowledge

The primary purpose of the proposed system is to assist cardiac nurses in consulting patients. Decision trees have been used to describe, classify, and generalize information contained in data in various fields (Murthy et al., 1994). There are a number of advantages and disadvantages in employing decision tree representations as the main decision support tool. The advantages are mostly

related to the usability of the tools while the disadvantages are mostly generation, tuning, and maintenance of good trees (Table 2-4). Despite the disadvantages, the benefits of having decision trees as the main tool appear to be more important. The visibility of a decision tree's structure and the familiarity of its form make it easy to use.

Table 2-4: Advantages and Disadvantages of Decision Tree Representation

Advantages
Decision trees are readily understandable by users.
Users' mental models of decision process are collection of sub-trees and sometimes they jump between two different sub-trees
Users can glance along other paths while travelling their own allowing parallel processing of observations
Disadvantages
Feature space can only be divided by an axis-parallel hyperplane at each decision point in conventional decision trees
Sensitive to training set
Hard to tune (prune) trees automatically

Chapter 3
Nursing Coordinator Interview

To understand better and gain insights into the current system employed at the UOHI, all eight NCs were interviewed using a set of questions that addresses major concerns in the system development. This chapter summarizes the interviews and discusses the implications of these findings on the design of the DSS.

3.1 Method

The questions were generated based on the knowledge gained through the literature reviews and the first-phase WDA (Chapter 4). In addition, the NCs were asked to submit a set of common telephone consultation scenarios (Appendix B). Some questions were generated based on the patterns observed in the scenarios. The interview questions were reviewed by nursing researchers, and were then categorized into three specific topics: algorithms, decision-making, and expert behaviour (Appendix C-1).

The interviews were conducted by a nursing researcher in her office at the UOHI. Each NC was invited to a separate interview to speak to the researcher directly and to the project members in the AIDL through speakerphone. Team members took turns leading the interview process by going through the question list. Additional questions were asked when it was appropriate to further elucidate the complex cognitive decision making process. Each interview lasted approximately ninety minutes and an NC also provided additional information after the interview.

3.2 Responses

The responses to the questions were recorded during the interviews at the both institutions and combined to generate complete documentation. The nursing professionals at the UOHI facilitated the interview process by mediating the conversation when specialized medical knowledge was required. The recorded responses are summarized in Appendix C-2.

3.2.1 Algorithms

Questions in this section are meant for understanding the approach and questioning sequences the NCs use when handling a patient's phone call.

First of all, seven out of the eight NCs acknowledged a significant difference between questioning cardiac surgery and cardiology patients. This finding reveals the need for the design to differentiate between the two categories at an early stage of decision making. For example, one should be looking for a changing pattern of pain if dealing with a cardiology patient, while seeking any post-pericardiotomy syndrome (PPS) or indication of infection for a newly discharged surgery patient. The only NC who recommended not distinguishing between the two types of patients reasoned that some valuable information is common to both. For example, a patient may have had angina, a stent and a bypass and thus is both a cardiology and surgery patient. Therefore, the design should include knowledge-based components that summarize the past procedures and allow the users to navigate between the algorithms for both types of patients for additional information at any given time.

Half of the NCs would assume complaints from a patient with recent surgery history to be related to the surgery. However, this does not mean that other possibilities should be ignored, several NCs pointed out the possible confusion between PPS and chronic pain or other flu symptoms. The NCs generally consent that such an assumption depends strongly on when the surgery took place. If the surgery was within two weeks, then most likely the condition is related to the surgery; if the surgery took place more than three months ago, then the possibility of the symptoms being a surgery related complication is much smaller. This time frame varies from patient to patient, especially with diabetics: infection for diabetics has no certain time frame. Therefore, a visualization of the patient's clinical pathway from their hospital record (e.g. nursing profile) would be beneficial.

The majority of the NCs found it useful to ask surgery patients to compare their pain before the operation and after the operation. This immediately provides an accurate feedback on whether it is a post-surgery problem or one that has to do with the original condition. This way, the NCs can generate a more suitable direction for their questions. Additionally, the NCs pointed out that since the patients themselves experience the pain or condition first hand, they can provide critical information about themselves when they are encouraged to compare it with their previous experience. The design should take this into consideration; a scale may be incorporated to allow the patient to rate or comment on their pain before and after the operation, and before and after being discharged from the hospital. Currently at the UOHI, patients are asked to rate their pain level from a scale of 0 to 10, with 10 being the worst. A discrete scale with 0.5 intervals was recommended by some of the NCs to improve precision of the rating.

Open-ended questions, such as "describe your pain," are commonly used at the early stages of the process. These questions are for discovering details that may be easily neglected by more straightforward questions; they serve as a checkpoint to prevent biases or false hypothesis. The basic

information that the NCs are looking for are similar: location, onset, intensity, frequency, relieving or aggravating factors, and symptoms that may be confused with flu symptoms. An NC mentioned that an acronym OLDCART, which stands for *onset, location, characteristics, associated symptoms/aggravating factors, relieving factors,* and *treatment*, helps to remind them to have a complete description of the chief complaints by asking these aspects.

Most of the NCs appear to observe the stamina of the patient by the way they breathe and talk. The tone of the patient also reveals the anxiety level of the patient and should be taken into consideration as well. Many NCs noted that it is helpful to talk to someone else, usually the spouse. These people are able to provide a more visually detailed description of the patient's condition. The DSS should generate notes and reminders at various points of the algorithm to remind the user of these alternative ways to make observations besides asking questions.

Finally, there are some special cases that may be difficult for an inexperienced nurse to decipher. For example, there are end-stage patients who are only concerned with pain management. The DSS may include a list of these possibilities if the user reaches the end of the algorithm without generating any significant possibilities of the situation.

3.2.2 Decision Making

Mental Model

All NCs reported to form a mental model to some degree while they are completing telephone consultation processes. The mental models may give rise to a hypothesis to guide the assessments by confirming or disconfirming possibilities. Therefore, the design should support the user in formulating a proper mental model. Since many NCs visualize the patient's condition, it would be helpful to have an iconic component that shows the location, size and severity of the symptom, if possible. The decision tree should be accurate in generating the most efficient path and provide feedback for the NCs to visually see where they are at in terms of the decision-making pathway.

It is important to note that the process of forming mental model varies among individuals and also different conditions the patient is experiencing. The majority of NCs form their mental images in the early stages of the consultation processes; however, they also mentioned that the images can be constantly updated with a new supply of information from the patient. One quite unique characteristic of the processes at the UOHI is that the NCs often know the patients very well. Especially in the surgery department, the nurses frequently receive calls from patients, who were just discharged from

the institute, and the complaints are typically related to the recent surgery. Therefore; rather than generating abstract mental models, the NCs update the image of the patient with the new complaints.

Medication

There are two types of calls associated with patients' medication: simple inquiries and problems. In the case of informational needs, easy access to the latest drug references should facilitate patient education on medication. Drug guides should be selected by the following criteria:

- All common/uncommon drug names, their classification, adverse effects and usage instruction (e.g. dosage, intake interval, things to avoid, etc.).
- Interaction effects among cardiac/non-cardiac medicines.
- Allergic reactions and/or any other known problems with specific patient condition (e.g. diabetic/weak kidney).

The latter cases, problems related to medication, would require asking a set of questions embedded in the decision trees. The criticality of typical side effects should be assessed along with their associated conditions to prioritize the order of appearance in the decision algorithms. Dosage levels and effectiveness of typical cardiac drugs should appear on the interface when necessary to make alarming conditions more salient. Finally, classifying the problems and providing a critical information list may be beneficial if the cases require consultation with the physicians.

Location

Implementation of the location of the patient in the DSS can be complex. This information may be valuable when making dispositional judgement. For example, when a NC reaches the conclusion of "Emergency Room (ER)", the system should list locational concerns: How far is the patient from the nearest ER? Does the patient have someone to drive him or her to the ER? Although NCs tend to know their patients' location when they receive a call, a reminder for locational concerns at the point of dispositional judgement might serve as an error prevention mechanism without distracting the flow of questions elsewhere. The decision makers should ask some questions related to the patient's location and providing alternative course of action if the first option is not likely to be available.

Callback Procedure

Most NCs appeared to prefer calling back the patients themselves. An NC mentioned that if she has to arrange an appointment with a physician for the patient passed from the previous shift NC, she would call the patient and ask questions herself to understand the problem better before contacting the

physician. Legibility of the forms and individual differences in procedures were observed as the main difficulties of the current callback procedure. When the information is passed along, some information may not be present in the callback sheet. Implementation of the new system would produce structured forms that can be transferred to the assigned NCs in a more efficient manner.

Nursing Profiles should be included as part of the system so that once the system is implemented on the PDA the forms can be transferred to the next shift's NC electronically. A desktop interface that monitors the patient records may be used to browse the required callback list for the next-shift at the NC change-over. A callback from a physician can be arranged in a similar manner. Both documents can be sent to physicians along with the callback request. It would be helpful to have an optional alarm reminder for callbacks, as well as a notification to update the system when the callback is completed.

Homecare Procedures

The homecare procedures at the UOHI are very structured and personalized through the patient discharge programs and a tailored exercise menu for the patients' particular needs. These programs educate patients before they are released home as a guideline on everyday activities. Some important part of the discharge booklets or standard procedures may be included in the DSS assessment section for the NCs to remind patients to consult the materials. For example, if a surgery patient experienced shortness of breath (SOB) by doing high activity tasks, the NCs can tell them to use the activity instructions on page 25 in the Surgery Discharge Booklet.

The UOHI also provide a "Heart Health Education" page on their website. If the patient or their family members are familiar with internet usage, a link to an appropriate webpage can be sent to the patients by email.

3.2.3 Expertise / Expert Behaviour

Experienced NCs gather more detailed information rather than making a haste decision. The initial information would enable the NCs to find an appropriate hypothesis and the direction of questioning sequence in the algorithm. They may continuously modify their hypothesis as new information is supplied by the caller along with the assessment process. The implementation of this flexibility might be very challenging; however, the challenge might be overcome if the risk factors of the patients are roughly determined by sets of observations based on the previously known relationships.

In addition, the NCs have developed some tests to discriminate conditions from the previous experiences. For example, a patient with PPS experiences a sharp discomfort in the chest, but the pain is relieved by leaning forward. These tests are effective methods in diagnostic judgements.

Sometimes, the UOHI receives atypical calls such as a call from an extremely emotional patient, or one with very unusual symptoms. With these types of call, it is important not to get distracted and to stay focused on the critical questions to seek the underlying reasons of the call. Vague patients can also be dealt with by structured and specific questions. The standardized algorithms in the new system would ensure the direction of the questions under stress and at the same time can help the NCs to observe the things that are unusual about the patients. By relying on a structured questioning sequence, less-experienced NCs can focus on extracting more subtle information such as the tone of the patient's voice and their willingness to follow advices.

3.3 Expectation of the New System

Although seven out of eight NCs are new to PDA systems, they have provided valuable suggestions and requests to the DSS design. Most of the NCs recognized the various advantages of recording all patient information in electronic format. Many NCs are anticipating that the use of PDA would allow them to store and assess information of patients, guidelines, and medications much more easily as they run around in the hospital. However, in order to support their decision-making processes, the validity of information should be assessed and the interface must be designed to accommodate the integration of a variety of information. This expansion of the system can be realized when the usability and usefulness of the system's features are assessed.

3.4 Summary

The interview with the NCs provided a great insight into the decision processes they are currently performing. Some notable findings are reiterated below.

1. The NCs use rules to eliminate or confirm possibilities.
2. There also are some tests that the NCs ask patients to attempt and the results can be used as the antecedent of their rules.
3. Many of above rules and tests have been developed individually.
4. There are some shared strategies that help the NCs to remember the important points when asking questions, such as OLDCART. (OLDCART is an acronym used by some nurses. It stands for Onset, Location, Duration, Characteristics, Aggravating Factor/Associated Symptoms, Relieving Factors, and Treatment.) It reminds them to collect information on a

patient's primary complaints.

Some NCs noted that they have tree like structures in their mind where you select a path depending on a patient's answers.

5. If the current strategy does not work, the NCs quickly switch the decision strategy.

Chapter 4
Work Domain Analysis

After literature reviews, the work domain of cardiac telephone consultation process was modeled using an abstraction-decomposition space (ADS). The objective of the WDA is to understand the interactions of the components in the system explicitly so that the interface can display the information. An ADS was used to extract information required for the interface.

There were two iterations of work domain analysis. The first iteration was performed before the NC interview described in Chapter 3, and the other performed after the interview and further research into medical information.

4.1 Boundary of the Work Domain

In order to assess work domain models, it is necessary to define the boundary of the cognitive systems that the DSS is aiming to support. Since what the system deals with are the patients' conditions and hospital resources, the boundary is drawn around the patients (Figure 4-1). In addition, all available means of intervention that the NCs use can be considered as part of the system. Such resources include medications and homecare procedures. All devices including the PDA are outside the boundary because these are not what nurses are trying to control.

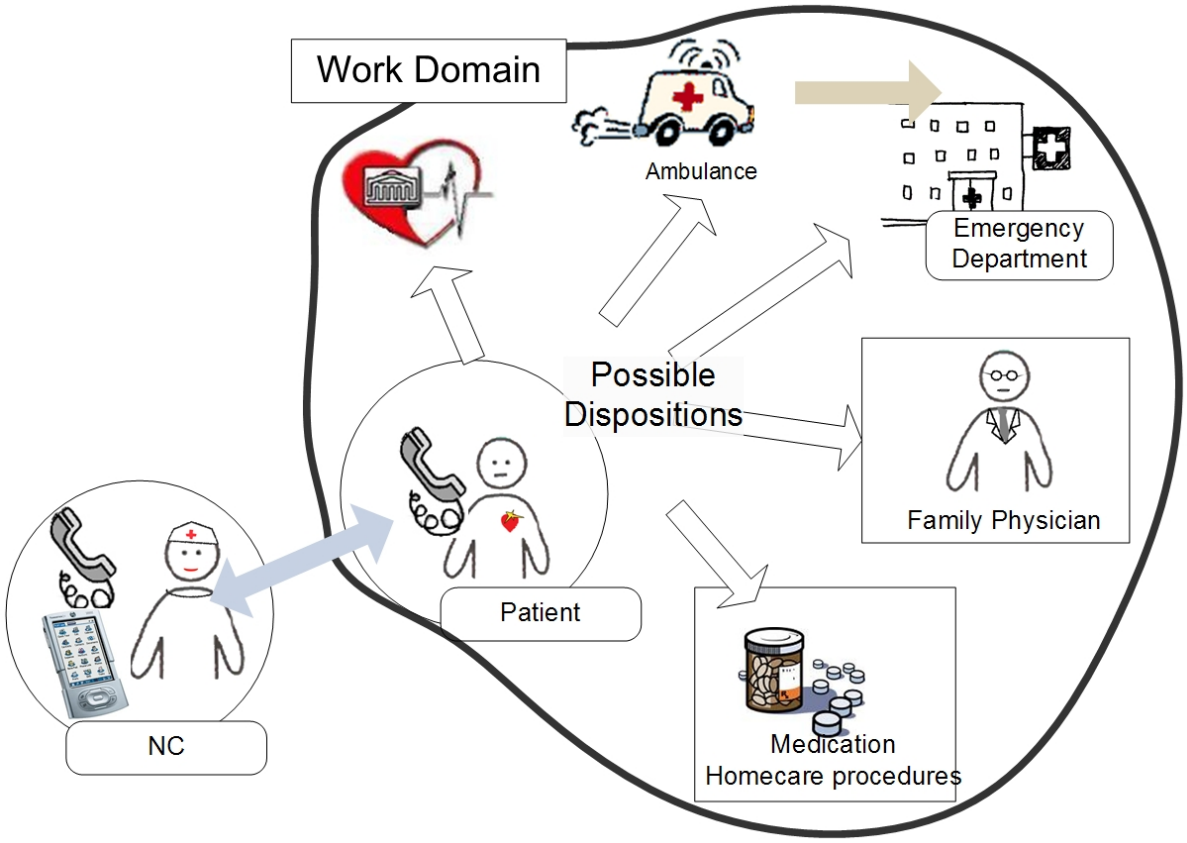


Figure 4-1: The system and its environment.

4.2 Goals and Purposes

The NCs' primary goal is to make appropriate assessments of a patients' condition and assign each to a suitable course of action in order to maintain or improve their medical condition. Taking into account the intensive workload and tight schedule of the NCs, the decision process needs to be optimized in all possible ways. Another important aspect of the system is to allocate resources efficiently due to the limited resources that many medical environments have, even though the UOHI is not concerned with this issue at the moment.

Secondary purposes of the system include logging of patient calls and storing medical history and disease history as part of the records. These practices can facilitate communication of patient conditions to the cardiologists and cardiac surgeons and for updating the algorithm on a regular basis. Good documentation may also relieve a nurse of legal responsibility in a lawsuit

Based on the literature review, the on-site visit at UOHI and the correspondences with nursing researchers, the focus was placed on the two major goals of the system. Two separate work domains

were proposed: the domain of potential risks and the domain of mitigating resources. The reason for having two separate domains is the fundamental difference in the natures of the two goals. The first one deals with a physical domain, namely the patient, while the latter involves an intentional system that envelops all resources. The two secondary purposes described are not considered in the WDA but may be considered at a later stage since they are minor and less complex.

4.3 The First Iteration

The AH was constructed in each domain with appropriate level of decomposition. Five levels of abstraction are described in the Table 4-1.

Table 4-1: Levels of the AH (Burns and Hajdukiewicz, 2004)

Means-end Links (levels)	Questions asked
Functional Purpose	What was the work domain designed to do?
Abstract Function	What are the underlying laws or principles?
General Function	What are the processes that are involved?
Physical Function	What equipment is involved and what is its capability?
Physical Form	What is the physical appearance and location of that equipment?

4.3.1 Domain of Patient Health

The domain of potential risks was identified as a major work domain of nurses since the ultimate goal of nursing practice is to maintain or improve patient health. Consequently, the primary objects of this domain are patients who consult with nurses at the UOHI on their medical condition.

This work domain is a physical system that contains complexly interacting biological components. Therefore, the DH was performed to decompose entire patient body to organs before the AH was carried out. The DH was carried out using a similar method as the tissue oxygenation study done by Sharp (Burns and Hajdukiewicz, 2004).

Decomposition ierarchy

Abstraction Hierarchy

	Body	Systems	Organs
Purposes	Maintain patients' health	Regulate circulatory and respiration systems	
Principles / Balances - Abstract Function	Balance oxygen and nutrition supply and demands	Oxygen and nutrition balances in respiratory, cadiovascular and metabolic system. Maintain blood flow (conservation of mass)	Oxygen and nutrition balances in heart, lungs, and blood vessels. Mass-in ↔ Mass-out
Processes - Generalized Function	Homeostatic processes	O2 CO2 and nutrition waste exchange	O2 CO2 and nutrition waste exchange at organ level
Physiology - Physical Function			Homeostatic response, blood pressure, blood flow, breath
Anatomy - Physical Form			Heart, lungs, neck legs arm

Figure 4-2: The ADS for the domain of potential risk.

Functional Purpose

At the highest level of abstraction, the goal of the system is to maximize individual patient health. While the telephone-nursing system aims to match patients to possible responses according to their level of urgency, the ultimate purpose remains to ensure the safety of the patients who call in. This overall goal encompasses functional purposes of the systems level, which is to maintain the balance in the physiological systems such as the circulatory and respiratory systems.

Principles/Balances

At this level, the domain of potential risks is concerned with probability judgement that governs the assessment of the likelihood of improvement or deterioration of the patient's health. Hence the principles of human physiology, medicine, and also physics are included in this level, which govern any flow of substances, whether it is water, nutrition or medication. The laws of physics include the laws of conservation of mass and energy. These laws and principles enable the decision makers to

understand and predict behaviour in complex systems at the *abstract* level. For example, if a patient reports swelling in their body parts, the fluid flaw input and output is not balanced.

There are guidelines and algorithms for nursing that the NCs can use when making the judgement; however, it is important to distinguish these from the above. The guidelines help decision makers select methods of consulting when appropriate. For example, a guideline might say, "when the patient is in acute distress, advise them to go to an ER." It describes a strategy an NC may take when a specific event happens, but it does not describe what is happening with the patient. This type of strategy manuals or algorithms comes into play at the different stages of cognitive work analysis, namely control and strategy analysis.

Processes

This level involves the physiological processes of cardiology and proper recovery from cardiac surgeries to maintain the balances. Processes of cardiology include controlled flow of oxygen and nutrition with blood (fluid) and exchange rates between carbon dioxide and waste at the cell level. These processes must be regulated in relation to each other to maintain the internal environment. An example of a process that ensures proper recovery following a surgery is the tissue regeneration process.

Physiological Functions

At this level of abstraction hierarchy, physiological functions that support the processes are included. A proper blood circulation control requires the pumping function of the heart and the flow control of valves etc. Other physiological functions include storage and transport functions.

Physiological functions of concern can be described in terms of the possible conditions which a patient may experience and from which the nurses may extract useful information. Based on the Telephone Monitoring Triage Protocol provided by UOHI (2003), these conditions include level of consciousness, anxiety, chest pain, cough, diabetes mellitus problems, dizziness, fainting, fatigue, irregular heartbeat, hypertension, hypotension, leg pain or swelling, neck pain, numbness and tingling, shortness of breath, sleep apnea, weakness, and wheezing.

Unlike manufacturing plant control, these functions are not typically visible to the decision makers in the medical domain. As listed in Table 4-2, linking observable states of patients to physiological function is necessary to understand the work domain.

Table 4-2: Links between Physiological Functions and Symptoms

Function	States or symptoms
Pumping of blood	Irregular or rapid heartbeat, hypertension, hypotension, dizziness
Blood Pressure	Irregular or rapid heartbeat, hypertension, hypotension, dizziness
Respiration	Cough, shortness of breath, wheezing, chest pain, fatigue, dizziness
Blood flow	Swelling of legs, chest pain, hypertension, hypotension, fatigue, dizziness
Tissue regeneration (healing)	Chest pain, fever, drainage from incision

Anatomy

At the lowest level of the abstraction hierarchy, the domain of potential risks describes the cardiac anatomy from which the physiological conditions of the previous level are based. This includes the physical forms of the heart, respiratory system, neck, legs, etc.

4.3.2 Domain of Mitigating Resources

Although resource availability is not particularly an issue at the UOHI, many medical environments that practice telephone triage or telephone medicine do find themselves resource restricted. Therefore, it is still important to analyze the domain of mitigating resources at this point.

This domain includes hospital resources such as the number of cardiac surgeons, cardiologists, and number of beds available. Emergency departments of general hospitals and family physicians are also included by this domain. NCs should be aware of the availability of their resources and maintain them at a manageable level while making decisions on the phone. For example, if the condition is not critical, the patient is encouraged to contact their family physicians for a physical examination.

Resource units were decomposed from the overall environment to the basic units of individual resources. As depicted in Figure 4-3, this decomposition addresses concerns of resources being external or internal, and whether they belong to cardiology or cardiac surgery divisions. Resource availability is directly associated with day and night shifts and their respective algorithms appeared to be quite different. However, the WDA reveals that the underlying principles remain the same; this suggests a consistent display with a night shift indicator alone may be sufficient to address the issue.

Decomposition Hierarchy

Abstraction Hierarchy

	Environment	Institution	Division	Individual Resources
Purposes	Maintenance of the resources of the environment	Coordination of external and internal (within UOHI) resources	Maintenance within division (cardiology vs. cardiac surgery)	Maximizing efficiency of individual resources
Principles - Abstract Function	Balance of overall resources	Balances of resources within the institution	Balances of resources within division	Balances of workload and schedule of individual resources
Processes - Generalized Function		Matching patients to the appropriate institution	Matching patients to the appropriate division	Matching patients to appropriate resources
Physical Function		Functions of facility and personnel available at the institution	Functions of facility and personnel available at each division	Functions of individual resources
Physical Form		Location and hours of the institutions	Locations and hours of each dividion	Location, identity, time schedule of individual resources

Figure 4-3: The ADS for the domain of mitigating resources.

Functional Purpose

At the highest level of abstraction, the goal of the domain of mitigating resources is to maintain the available resources at an appropriate level. Very often, the availability of a hospital resource is a limiting factor to patient care. The original reason for having a telephone triage or similar service is to be able to utilize medical resources efficiently. This also implies the need for the system to coordinate hospital resources and to keep track of the current resource allocation. For example, the NCs may be coordinating callbacks from the cardiac surgeons and the cardiologists to their corresponding patients, according to their knowledge of the availability of these cardiac professionals at different times.

Principles

The balancing of resources is the primary principle at this level. The nurse needs to coordinate the resources of the hospital and other medical care units, and at the same time provide adequate support and advice to patients. Allocating resources according to level of urgency is crucial here; patients with critical conditions should always be assigned to medical facilities with higher capabilities than

the patients with minor problems. In addition, principles of the triage process apply here to ensure professional practice of the nurse over the telephone.

Processes

This domain contains various processes: matching patients with appropriate medical care, such as directing them to family physicians, emergency departments of local hospitals, or the UOHI; arranging callbacks by nurses or physicians, and responding to inquiries such as providing homecare advices.

Physical functions

At this level of abstraction, the domain describes the facility and associated medical expertise of the UOHI, other local hospitals with emergency departments, family physicians' clinics, and documents and forms available for the telephone enquiry system.

Physical form

At the lowest level of abstraction, the physical description of the domain consists of location and identity of the patient, their family physicians, and other medical facilities available. Location and descriptions of documents and forms are also included in this level.

4.3.3 Information requirements and availability

EID has been implemented in various fields; however, most of the applications use observations that can be encoded into quantitative values. Such systems can be expressed with graphical displays to integrate multiple dimensions to facilitate data visualization. However, when dealing with the human body, direct measurements are not always available. Medical professionals combine external cues to estimate internal states and then decide whether further examinations are necessary (Table 4-2). Combining Figure 4-2 and Table 4-2 to map the observable cues that are used to assess the states of patients to the work domain allows the work domain space to be redrawn (Figure 4-4).

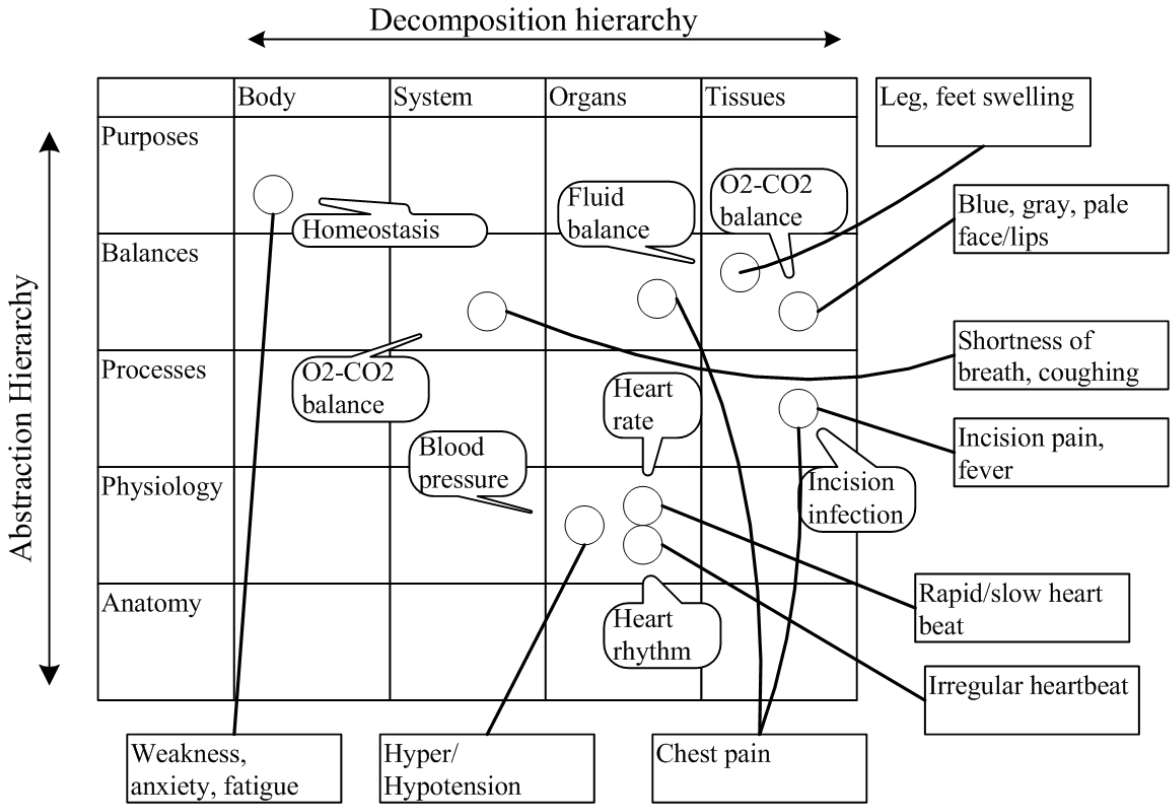


Figure 4-4: Mapping of observable cues to work domain model.

In addition to the above variables, the NCs during telephone consultations should pay attention to auditory clues that suggests the states of patients, especially tone of voice. For example, if the NCs senses that patients are unusually anxious, they should weight the sensed information heavily rather than the one reported by the family when there is conflicting information. These types of information are sometimes subtle and easy to miss when the NCs are either mentally or physically occupied with other procedures.

Table 4-3 summarizes the information and measurement units as well as the range to extract information available for the interface. As seen in the table, most information is handled in binary format (i.e. yes/no questions) rather than using a continuous range. Although the telephone triage guideline encourages open-ended questions and avoids yes/no questions, due to time constraints, these direct questions are used more frequently. The fact that some variables are binary enables the system to treat them as simple binary rules and to include them in decision trees easily.

Table 4-3: Available Information during Phone Consultation

Level of abstraction	Variable	Measurement/Observation	Measurement Range
Purpose	Weakness, anxiety, fatigue	Tone of voice, speed of speech Patients' description	Discrete Scale (1, 2, 3, 4, 5) Sometimes linguistic scale (a bit/slightly, very, extremely)
Balances	Fluid balances	Leg pain/swelling, numbness and tingling	Binary (yes/no)
	O2/CO2 balance	Blue, grey, pale face/lips, SOB, coughing, dizziness	Binary (yes/no)
Process	Blood pressure (numerical or in comparison with patients' normal states)	(some patient has measuring device) Otherwise use dizziness, leg swelling or numbness for low BP	Numerical value (if there's device)
	Incision Infection	Fever and pain associated with incision.	Binary (yes/no)
	Effectiveness of medication	Patients' concern Type, name, dosage pattern of cardiac/non-cardiac medication Recommended dosage and frequency from Drug guide	Depending on the type of the medication. Should be adaptive to the medication. Possible use of commercial drug guide and the measurement range would be based on a particular medication
	Pain	Patients' description Comparison with "similar pain experienced before (pre-op/post-op)"	Scale (0 to 10 with 0.5 increment) 0 is no pain Comparative scale
Physiology	Heart rate	Patients' description Can be comparison with the normal condition	Rapid/Slow over a range Comparative scale with normal state
	Heart Rhythm	Patients' description	Binary (regular/irregular)

Most information the NCs use to make decisions is retrieved by a series of questions and "Knowledge in the head". Especially in the domain of mitigating resources, there is no quantitative information on how many facilities and individuals are occupied at a given time. Therefore, the NCs depend on their situation awareness of the resource availability in the institute. In addition, the available options for each patient differ depending on the location of the patients and who they are with as well as their physical condition.

4.4 The Second Iteration

The WDA was reviewed and reconstructed after the NC interviews, where new information about the work domain was revealed. The constitution of two domains remains roughly the same; however, some findings from further literature reviews and the interviews were incorporated into this iteration.

4.4.1 Domain of Patient Health

In the domain of patient health, the importance of patient activity level and medication was recognized during the interview process. These two components are actionable items in the patient health domain. Including these elements in the analysis, the work domain becomes controllable so that the decision makers can act on rather than monitoring a patient's condition. In this iteration, the focus of analysis is set to the patient's body itself including any actionable items that can be used to control the patient's health condition.

Functional Purpose

The main goal of this domain is unchanged: "Maintain and improve patient health." Cardiac patient heart functions are compromised when recovering from their heart conditions such as myocardial infarction (MI) or open-heart surgeries. The cardiac specialists develop treatment and rehabilitation plans that are specific to the patient so that these can complement the deficiency created by the heart condition. The nurses' focus therefore becomes to maintain the patients' cardiac workload within a manageable range and ensure proper recovery from the heart problem.

Principles / Balances

Homeostasis maintains internal equilibrium in a healthy human body. Although cardiac patients may have weak hearts, balances in their body must be kept within an acceptable range. The balances that are especially related to cardiac functions are those of energy, oxygen, and water (Figure 4-5).

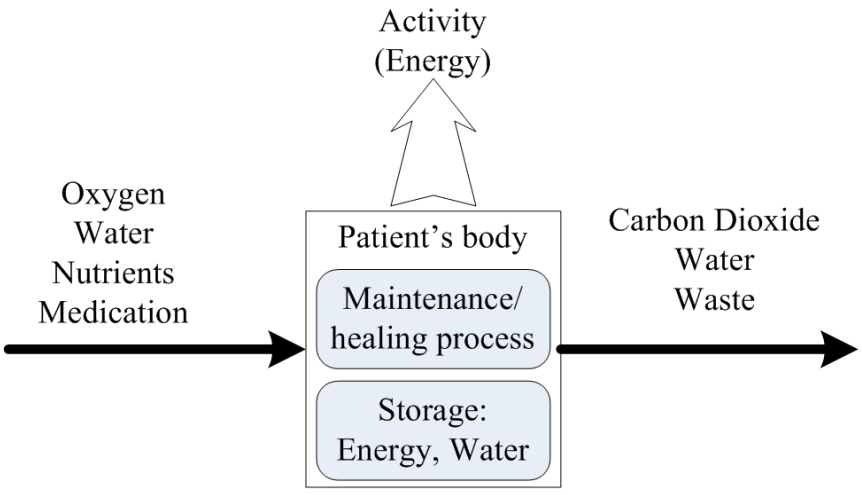


Figure 4-5: Balances in patient's body system.

Humans need energy for basal metabolism, metabolic response to food, and physical activities. Basal metabolism comprises a series of functions that are essential for life, such as cell function and replacement; and uninterrupted work of cardiac and respiratory muscles. In addition, the UOHI patients need extra energy to heal their surgical wounds or to overcome complications. Therefore, hearts need to supply oxygen and nutrients to the entire body to ensure proper functions of organs, tissues and cells.

In a hospital, patients are closely monitored to leverage the proportion of what a patient can handle and what needs to be aided. For example, after heart surgery, physicians may use a diuretic to remove excess fluids in the body because weak heart function often results in swollen legs and feet. Patient activities may be restricted so that the demand on the cardiovascular system remains at a manageable label.

When discharged from hospital, patients are instructed to follow personalized recovery plans so that proper recovery is ensured. Patients are often encouraged to perform mild exercises to gradually increase the workload of their heart, but to rest when experiencing discomfort. As they recover, patients may depend less on medication and do more activities and become able to maintain their health. Thus, it is important for nurses to know whether patients are taking their medications as instructed and following their rehabilitation plans.

Processes

This level involves processes of regular cardiac activities and recovery from surgeries or heart problems. These processes are necessary to maintain balances in body systems. Figure 4-6 shows the means-ends relationships at the whole body level.

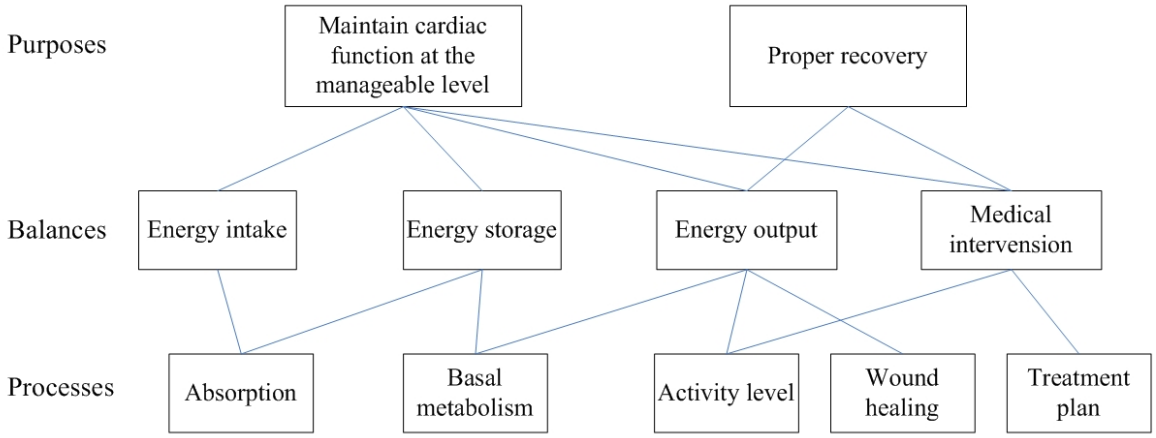


Figure 4-6: Means-ends links at whole body level.

The system can be examined further by breaking it down into sub-systems. In order to maintain energy balance, gas exchange, nutrition and waste removal must be balanced. In gas exchange illustrated in Figure 4-7, blood needs to be adequately oxygenated in the lungs and delivered to the heart and other body parts for energy generation. Carbon dioxide is removed from cells and collected in the lungs for removal from the body.

Food intake is a source of energy for human body systems. The nutritious part of food is absorbed through the membranes in the mouth, stomach, and intestines while the rest of it is secreted through the removal system. The absorbed nutrients are then broken down into sugar molecules at the liver to be carried in the blood to the entire body (Figure 4-8). In the figure, the flow of nutrients starts at the liver to be delivered to individual cells. At the cell level, energy is generated from oxygen, nutrients, and water. Waste material produced at the cell level is removed from the cells to the blood stream to be collected at the kidneys.

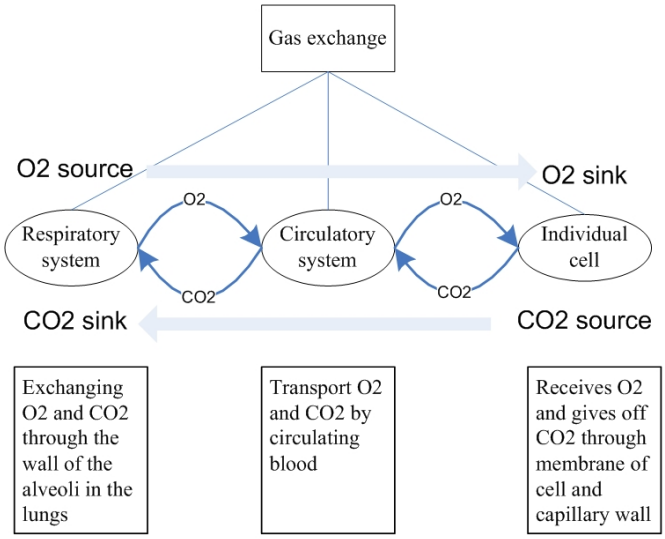


Figure 4-7: Means-ends links in gas exchange.

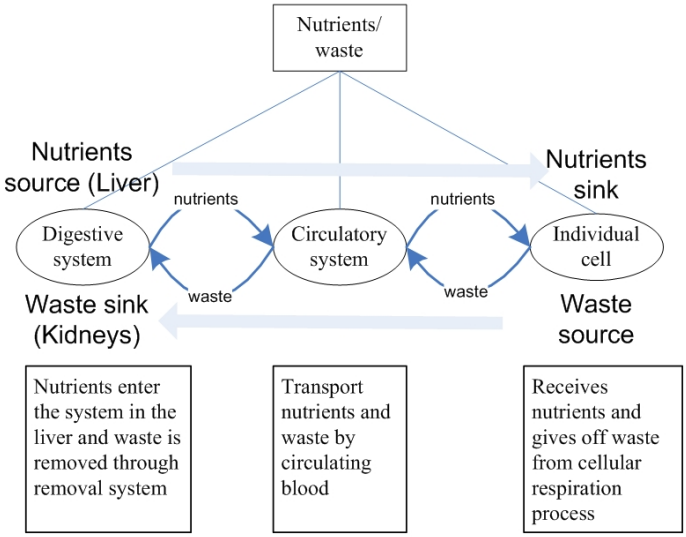


Figure 4-8: Means-ends links in nutrients and waste exchange.

Cellular respiration converts nutrients, oxygen and water to some usable energy. Unlike the oxygen intake-consumption balance, nutrient intake and consumption have a longer time lag because of the processing time. Consequently, body needs to store nutrients and control conversion and delivery of sugars. Nutrients intake and consumption need not to be balanced at a given time because of the storage capability. However, the amount of stored energy needs to be controlled because excess fat will require more energy to move and it may clog blood vessels.

Surgical wounds and damage from heart attack would follow a body's natural healing process. The process can be accelerated by appropriate dressing and medication. Nurses stress the importance of keeping the incisions clean and dry to avoid infection. A balanced diet and a stress-free life also facilitate the recovery.

Physiological Functions

The human body is complicated. Each organ or tissue may perform multiple functions for different purposes. The heart provides the driving force, like a pump, in a fluid flow system while blood vessels are like pipes with varying diameters and frictions. However, unlike pump-pipe systems, human physiological system does not allow direct observation or measurement easily.

At this level, medical treatments are included for this iteration. For example, surgical wounds are covered by protective dressings initially until a new layer of skin covers the incision. In this case, the dressing is serving the means to protect the underlying tissues in place of the skin. Various types of medications are used to aid compromised cardiac functions to maintain the body's internal

equilibrium (Table 4-4). Most of the medications in Table 4-4 are taken periodically to regulate the cardiac and related systems. According to the NCs, some patients stop taking their medications because they feel better. This typically results in an unbalanced internal environment. Therefore, it is important to ask patients if they are taking the medications during the assessment. Nitro-glycerine can be used to relieve angina pain temporarily by dilating blood vessels. However, if the pain appears to lead to ischemia, more permanent treatment is required.

Table 4-4: Cardiac drugs (Extracted from (UOHI, 2004b))

Type of Medication	How the Medication Works
Angiotensin-2- Receptor Blockers (ARBs)	Block an enzyme that causes blood vessels to narrow.
Angiotensin- Converting Enzyme (ACE) Inhibitors	Relax blood vessels and increase the supply of blood and oxygen to the heart.
Anticoagulants	Prevent harmful clots from forming in the blood vessels. Does not dissolve clots that have already formed, but may prevent them from getting larger.
Beta-Adrenergic Blocking Agents (Beta Blockers)	Affect the response to some nerve impulses in certain parts of the body. → Decrease the heart's need for blood and oxygen by reducing its workload. They also help the heart to beat more regularly.
Calcium Channel Blocking Agents	Relax blood vessels and increase the supply of blood and oxygen to the heart while reducing its workload.
Digitalis Medicines	Improve the strength and efficiency of the heart, or to control the rate and rhythm of the heartbeat.
Diuretics	Help reduce the amount of water in the body by increasing urine output.
Nitrates	Relax blood vessels and increasing the supply of blood and oxygen to the heart while reducing its workload.
Platelet Aggregation Inhibitors (antiplatelets)	Prevent dangerous blood clots from forming in the blood vessels.

Anatomy

At this level, the location, size, colour and shapes of components is included. The condition of incision may be described by its colour, smell, the amount of drainage, or whether it is swelling. These attributes of incision help nurses determine whether the patient's discomfort is caused by the incision or the heart itself. The change in discomfort in relation to body position also helps identify the internal condition. Nurses often ask if the discomfort is better when lying flat or sitting forward. Changing body position increases or decreases pressure in different part of the body that might be the cause of discomfort. For example, patients with cardiac tamponade often experiences SOB especially when flat because of the pressure caused by fluid accumulation in the pericardium.

4.4.2 Domain of Matching Resources

The main goal of this domain was slightly shifted because decision makers do not normally consider resource allocation during their telephone consultation. They are more concerned about matching an appropriate disposition to each patient. The domain is now called "domain of matching resources." In this domain the focus of the work is placed on matching the patient's needs and the capability of the resources within the constraints. Constraints are typically related to the availability of medical professionals in the proximity of the patients.

Decomposition Hierarchy ⟷

AH level	Institution	Individual
Functional Purpose	Protection of patients' health	Protection of individual health
Abstract Function	Good resource match	- Survival or Improvement of patients - appropriate resource match
Generalized Function		- Patient criticality - Interventions
Physical Function		- Patient condition - Capability of medication - Support capability (driving/ knowledge of CPR) - capability of ER, family doctor, general hospital etc..
Physical Form		- Patient location - Relative location of ER, family doctor, and general hospital - Availabilities of Car, ambulance, support, and medication

↕

Figure 4-9: The ADS for the domain of matching resources.

Functional Purpose

In this domain, the decision makers are dealing with a bigger work domain, which includes hospital resources and the availability of medical assistance in a patient's environment. Nevertheless, the underlying purpose of the domains is the same: maintain or improve the patient health.

Abstract Function

Forecasting patient's survival or improvement is difficult for the NCs because they can not see the patient directly. To aid the uncertainty, the criticality of a patient is communicated by using a timeline. Whether the patient needs to see a physician or they can wait until their next appointment depends on the type of discomfort they are experiencing. In addition to the criticality, the type of patient need affects the disposition judgement. The patient may need to make an appoint to have an x-ray taken even though he does not need to see a physician right away. Therefore, "time to intervention" and "type of help" is the means to achieve the overall purpose of the domain.

Generalized Function

At this level of hierarchy in this domain, means to achieve abstract function is needed. These may include the type of medical or paramedical services available. Some patients may need a specific examination to rule out other conditions while others may need over-the-counter medication for minor inflammation.

Physical function

Means to achieve the generalized functions are described in this level. The capability of individual resources can be described by using capacity, knowledge, and equipment to perform various medical services.

Physical form

The descriptions of the generalized functions are included in this level. It is important to know whether particular resources are available and how busy they are. It is also important to know the proximity of the services since the time to receive medical intervention directly impacts the survival and improvement of patients.

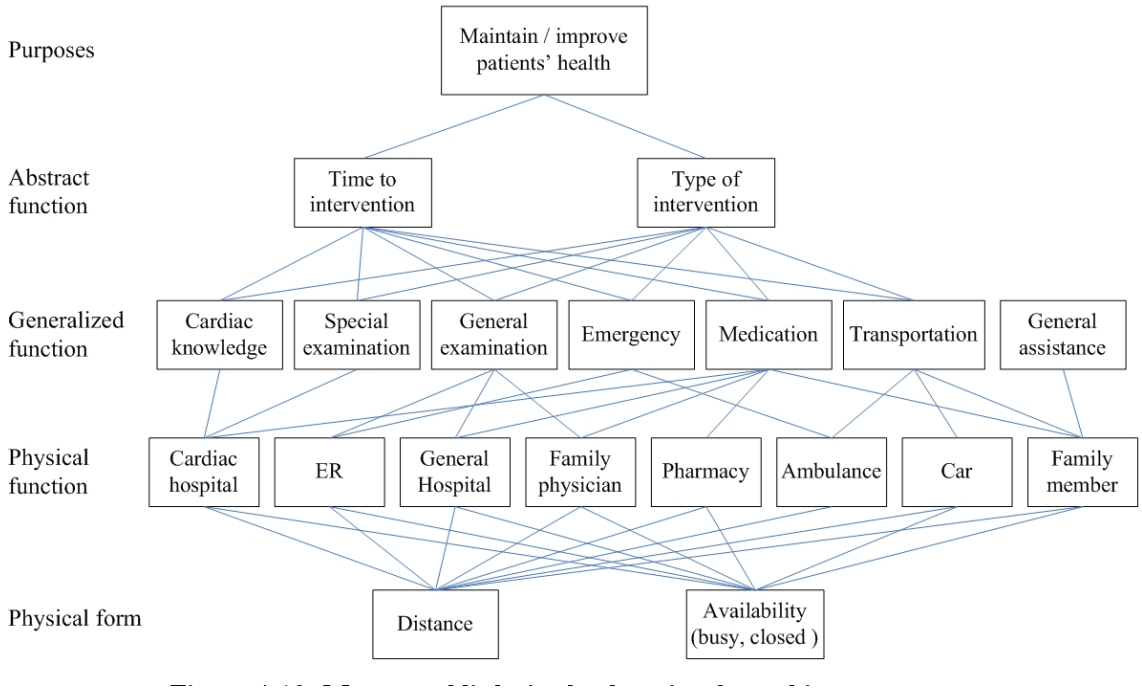


Figure 4-10: Means-end links in the domain of matching resources.

4.4.3 Information requirements and availability

During the first iteration of the WDA, the significance of matching the required information to the observable was recognized. Despite the limited information from what patients can report, the NCs utilize auditory cues such as breathing sounds, tone of voice, and memory of the patient in the hospital.

One NC mentioned the reliability of a patients' verbal report since some patients are naturally exaggerating while others may try to deal with discomfort on their own and report very little. As in process control, low reliability of sensor inputs needs to be aided by redundant information if available.

4.5 Summary

The WDA illustrated the relationships of components in the patient body and the environment. However, unlike any other EID displays, information would not be available unless the NCs recognize the importance of asking specific questions and a patient provides the information, or a patient voluntarily offers the information. Similarly the relationship of certain symptoms would not be useful if the users did not input the information. The consultation process starts with a patient

reporting their discomfort. Decision makers need to ask a minimum set of questions to understand the patient's conditions. Control task analysis and strategy analysis need to be performed to farther investigate suitable decision support for this process.

Chapter 5
Control Task Analysis

The previous chapter investigated the intrinsic constraints of the work domain. The results of a WDA showed the complexity of the work domain involving variables that are not readily observable. In this chapter, control tasks of the decision makers are analyzed, which deals with "what needs to be done" on a particular domain, but not "how" or "by whom."

5.1 Operating Mode

The operating modes of process control systems can include start-up, normal monitoring and shutting down (Vicente, 1999). In relation to that, a patient at the UOHI can be in pre-operation, hospitalized (post-operation), post-discharge recovery, or stable phases. Although the NCs monitor and consult the patients during the hospitalized phase, the presence of cardiologists, surgeons and various specialized equipment make the grain of analysis very different.

Another important aspect of this particular application is that there are two distinctive departments in the UOHI; the cardiology and the cardiac surgery. All NCs agreed that they use different approaches for surgery and cardiology patients, including the one who cautioned that surgery patients may develop cardiology problems after surgery. This aspect, however, has more relevance to strategy analysis, which is explored in next chapter, because it should not affect the work domain goals but it affects how to construct a questioning sequence. For example, an NC might heuristically ask about incision-related questions to a surgery patient at an early stage of consultation.

5.2 Control Tasks

Although the functional goals of the patient health domain are unchanged, the operational goals vary in different modes. In pre-operational phase, a patient is following instructions while waiting for surgery. The surgeon might prescribe medications to suppress some symptoms and instruct a patient to control their activities. During the operation, a team of medical professionals work collaboratively to achieve their surgical goals (e.g. repair a valve). The medical professionals' goals would shift after a successful surgery to ramp up the patient's cardiac functions to enable the patient to live without special medical equipment so that the patient can be discharged. Once the patients are discharged, they follow recovery programs to control the workload of the cardiac functions. Patients are encouraged to adjust their activity level depending on their physical condition because they recover or

respond to treatment plans on an individual basis. Patients may reach a stable stage where the goals are to maintain their health with some caution to their weakened cardiac functions.

5.3 Multiple Decision Maker Operation

Up until this point in the CWA, the decision maker of the domain has been assumed to be the NC alone. However, having completed the WDA and the interviews, it has become apparent that decisions during telephone consultation are made collaboratively between the NC and the patient. Depending on the situation, the family members of the patient, the cardiologist or surgeon may be consulted before forming dispositional judgement. In addition, when considering the management of the work domain, telephone consultation is only part of the decision process since the overall goals in a particular operational phase are typically set by a cardiologist or surgeon. For example, a surgeon may try to increase a patient's cardiac strength by reducing medication and increasing activity level gradually. Table 5-1 summarizes the goals and decisions makers in different operating modes. Patient's family physicians or a local hospital may be involved more if the patient lives far from the UOHI.

The work domain is primarily monitored by the patient excepting during surgeries. They follow their customized recovery program and adjust their activities when it is necessary. The recovery program may let a patient to do very little activity and gradually increase the workload of cardiac functions. The patient's spouse might advise them if their appearance becomes worse. When a problem arises, patients make a decision on where they should consult. According to the medical professionals at the UOHI, most calls are initiated by a patient or their spouse.

All NCs stressed the importance of patients voluntarily describing what is happening and how they feel. They are considered to be unmediated indications because the patients are the ones who experience the discomfort and the discomfort is directly related to the system status. This is similar to the reason why a nuclear plant control operator sends someone to take a look at a component (Vicente et al., 1996). Some information is not available remotely, so that the operators have to rely on the person who can see or feel what is happening. In the case of telephone consultation, very little information is spontaneously presented and the information is not usually organized.

Table 5-1: Goals and Decision Makers Involved in the System.

Operational Modes	Primary Goals	Primary Decision Maker	Secondary Decision Maker
Pre-operational	Suppress / control symptoms	Surgeon (plan) Patient/family (Monitor)	NCs (Teleconsultation)
Operation	Surgical goal (e.g. replace a valve)	Surgeon, Anaesthesiologist, Nurses	
Hospitalized (Post-operational)	Bring up the cardiac functions to the manageable level	Surgeon, Nurses	
Post discharge Recovery	Gradually increate activity level	Surgeon (plan) Patient/family (Monitor)	NCs (Teleconsultation) Surgeon & FP (scheduled visit)
Stable	Maintain the internal balance (monitor)	Patient/family (Monitor)	NCs (Teleconsultation) Surgeon & FP* (scheduled visit)

*FP = Family Physician

5.4 Decision Ladder

Rasmussen (1976) developed the decision ladder, shown in Figure 5-1, to represent information processing activities and subsequent states of knowledge. While novice decision makers may have to go through the ladder from the left bottom to the right bottom step by step, experts often develop shortcuts between the two sides of the ladder. Vicente (1999) shows the application of this modeling tool to control task analysis for a thermal-hydraulic process control microworld called DURESS (DUal REservoir System Simulation) II for start-up operation. The goals for the start-up operation are to bring up the flow rates and the temperature to a specified demand and the sequence of cognitive activities are also mapped on the ADS.

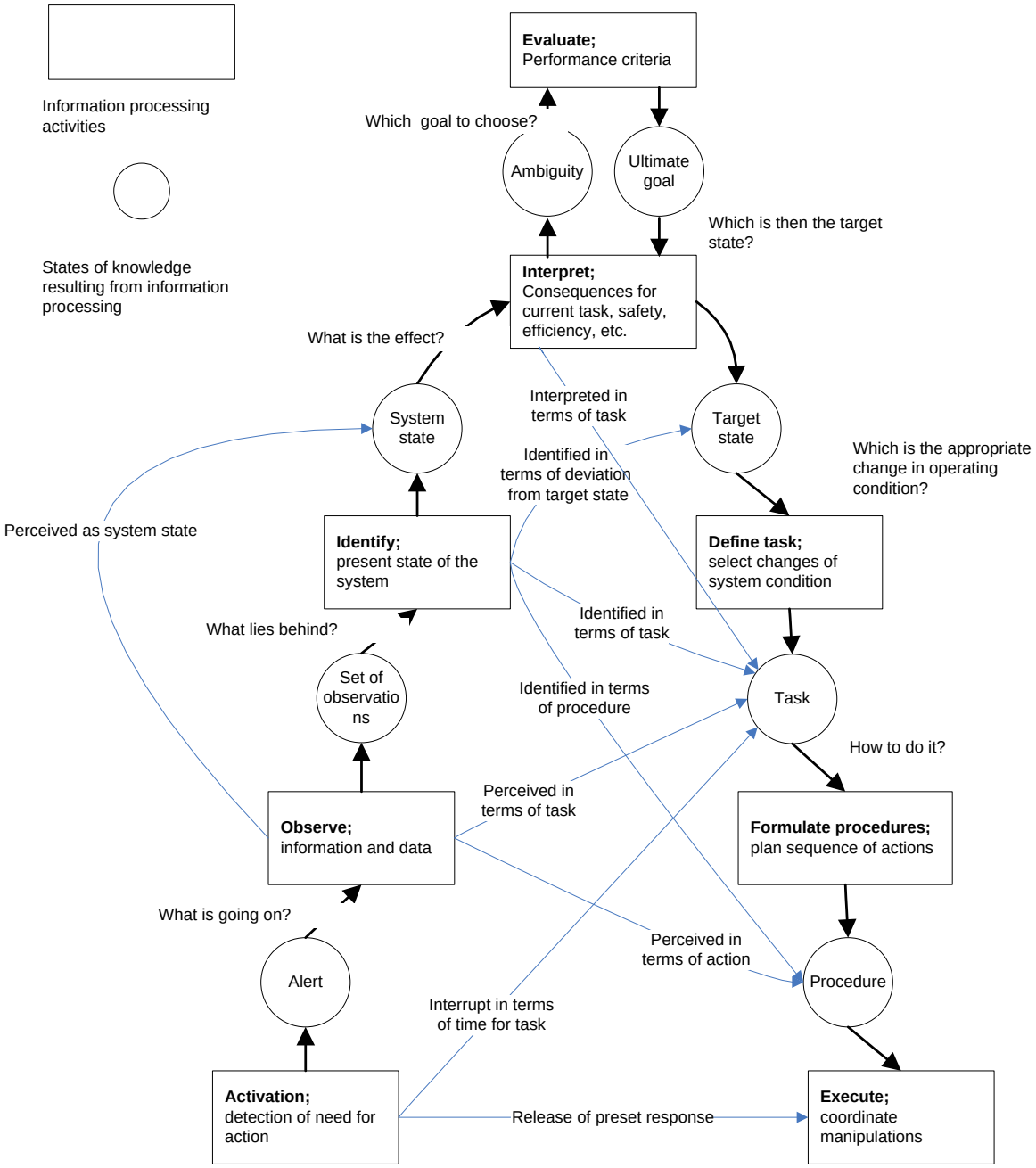


Figure 5-1: Decision ladder (Adapted from Rasmussen, 1976).

5.5 Implications to Telephone Consultation

There are distinctive differences between the NCs' work domain and DURESS II. First, the NCs are not usually monitoring the work domain. A patient may monitor his weight or blood pressure when instructed. However, most calls are made in response to physical discomfort or medication-related

questions rather than quantitative observation according to the phone consultation records from January 2, 2002 to December 12, 2003 (see Table 5-2 for the summary of patient calls). This indicates that the decision process is typically initiated reactively rather than by active monitoring. In addition to the reactive nature of the decision process activation, the difficulty of the task increases when the patient does not report the first indication, but waits until the discomfort gets worse. In such cases, the decision makers usually need to ask about the trajectory of the patient's condition to understand the trend as well as the current system state. Another difficulty comes from the nature of the medical system where there is varying time lag in the responses to an action onto the work domain. The time lag depends on individual differences as well as types of treatments. Lastly, telephone consultation process does not permit the NCs to observe their work domain directly. Information must be extracted serially by asking a question at a time. Therefore, the control tasks for this domain are very difficult to define compared to DURESS II.

Table 5-2: Summary of Patient Calls.

	Cardiology	Surgery
Physical Discomfort	262	829
Quantitative Alert	47	105
Medication Related	104	247
Informational Needs	35	154
Other	102	185

5.6 Mapping Decision Processes onto a Decision Ladder

A decision ladder can be used to map observations from field studies (Vicente, 1999). Although the observation is not available, the UOHI's decision process can be mapped on to a decision ladder based on the findings described in the earlier chapters. Figure 5-2 illustrates that of patients who are responsible for the bottom part of the decision process in the ladder. In relation to the ADS, they are more related to the physical levels. They sense their discomfort first hand and make decisions whether they should consult someone. Whether they make judgement themselves or procedures are given, the patients are typically the actors onto the work domain. Surgery patients may consult some guidelines in the discharge booklet for their decision support.

The decision ladder representation for the NCs is depicted in Figure 5-3. Their process is usually initiated by the alert (physical discomfort) reported by the patient. In the system, a patient can be viewed as a sensor that can process the task serially. The NC can ask the patient to look at something and report what they think they see. Each of the observations and descriptions has a varying level of

sensitivity; thus, the NCs need to adjust the sensed information. The NCs' difficulty can be concentrated on the information processing activity box labelled "Observe" before identifying the patient condition. The "Observe" box includes multiple strategies, which are investigated in the next chapter. Like patients, the NCs make decisions on whether they should consult with someone, refer the patient to someone, or give advice to the patient.

The last ladder included in Figure 5-4 is for the physicians. The NCs consult the physicians when the problem is complex or delicate, so the physicians are more likely to evaluate the system or choose to see the patient directly for more comprehensive examination.

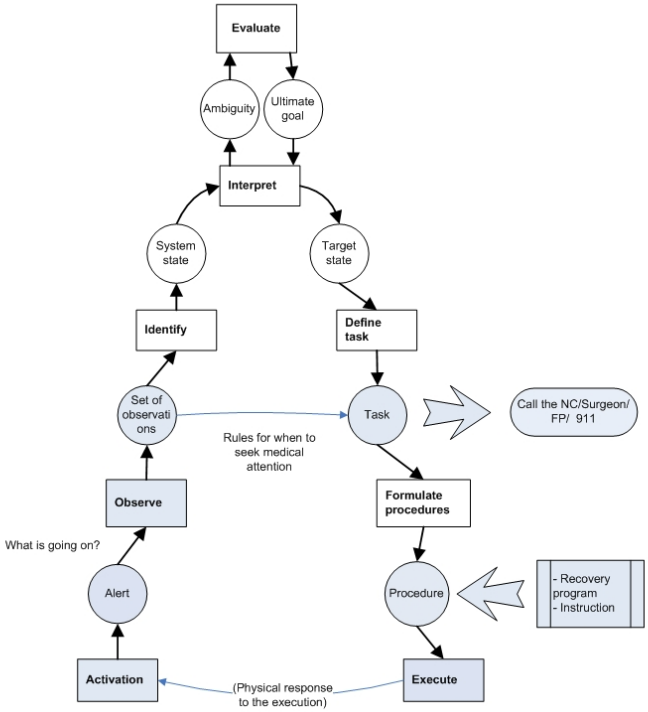


Figure 5-2: Decision process for a patient.

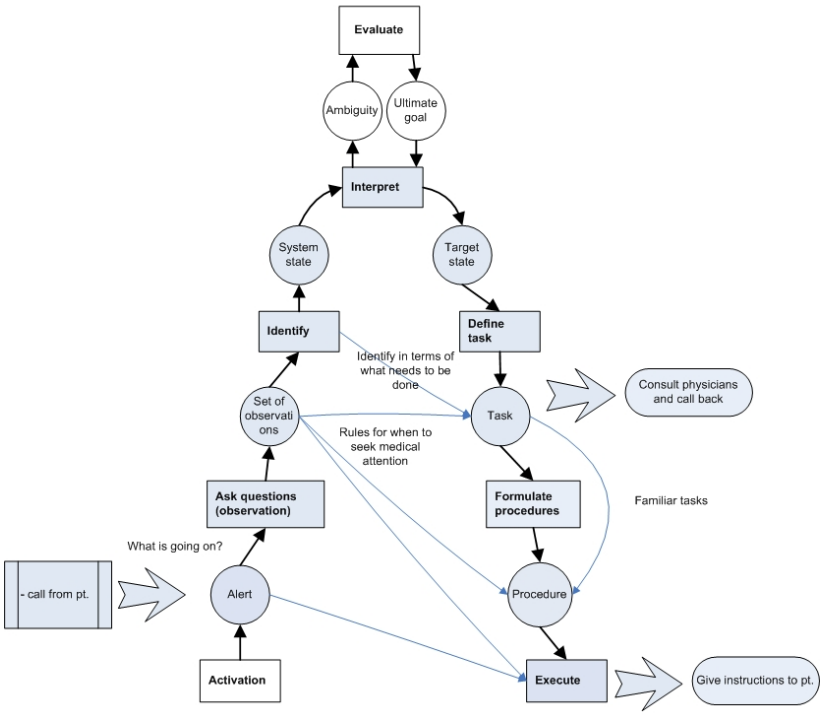


Figure 5-3: Decision process for an NC.

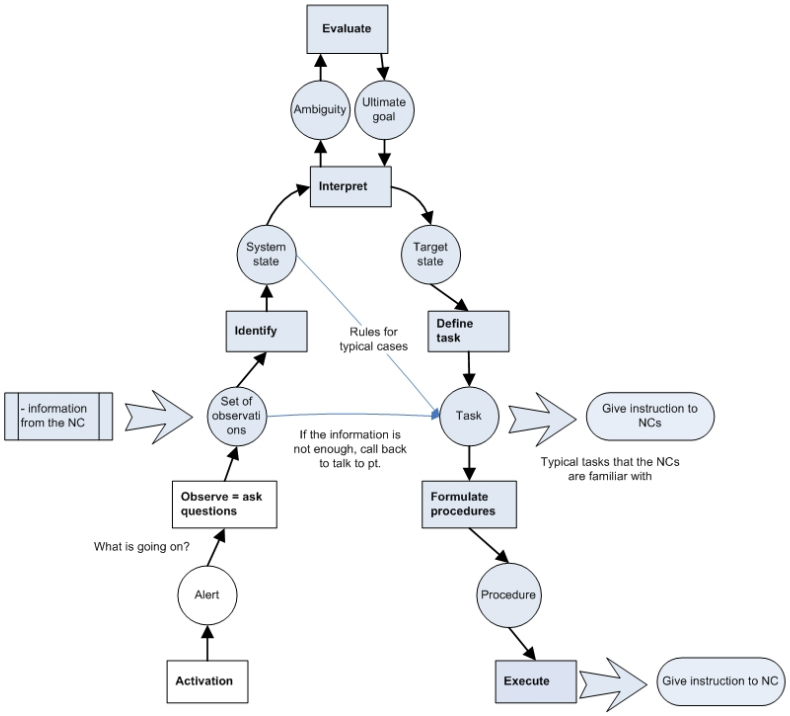


Figure 5-4: Decision process of a UOHI physician.

5.7 Summary

1. Investigation into the control task onto the work domain revealed very important characteristics of the decision process. Additional difficulties identified are;
   The reactive nature of the decision process rather than active monitoring,
2. The patient's asynchronous response to treatment,
3. Serial processing rather than parallel information processing,
4. Sensitivity of a patient observation to the physical discomfort, and
5. Reliability of the sensed information.

The information processing activity box labelled "Observe" would be subjected to strategy analysis which may involve other information processing activities such as "Identify" or "Interpret." The shortcuts between the two sides of the Decision Ladder should be supported by the DSS.

Chapter 6
Strategy Analysis

The NCs at the UOHI are experts in their field with a vast knowledge-base, which helps to overcome the complexity of the work domain and control tasks. The information processing activities labelled "Observe", "Identify", and "Interpret" appear iteratively in the telephone consultation because the NCs have to ask questions to the patient in serial fashion.

6.1 Type of strategies

Open-ended Questions

Open-ended questions such as "describe your discomfort" are often used to gather key information from the patient to gain a mental image of the patient. This is typically done at the beginning of the consultation process so that the decision maker does not form a biased hypothesis.

Standardized Question List

While open-ended questions are desired to prevent information gathering biases, they may not be sufficient to produce a clear mental model of a patient. Patients do not always know how to describe their conditions, so the NCs have to ask direct questions to get a full picture of the patient. Standardized question lists such as OLDCART remind them to ask certain types of questions and organize the information for integration. The comparisons and scales also help patients to describe their problems better.

Topological Search

When dealing with a surgery patient, NCs often start asking questions about characteristics of an incision, such as redness, swelling etc to look for signs of infection. Also, when a patient is experiencing pain in the chest, the NC might ask if they experience pain in other surrounding parts of the body because the propagation of the pain to left arm, shoulders and neck indicates possible ischemia.

Hypothesis and Testing

Many NCs mentioned that they form hypothesis at early stages of the consultation process and question the patient to confirm or disconfirm it. They mentioned that they form one or more hypotheses based on previous experience.

Ruling out Possibilities

This may be considered as a similar strategy to Hypothesis and Testing. However, this strategy appears in an earlier stage of the consultation process than Hypothesis and Testing. When NCs are not sure about patient conditions based on the information presented, they may ask some questions to rule out some possibilities before they form one or more hypotheses. For example, when a patient calls, the decision maker may want to rule out the possibility of flu or common cold, for which they can use over the counter medication to relieve the discomfort.

6.2 Scenario analysis

To investigate the decision process, the NCs were asked to submit typical telephone consultation scenarios. The typical scenarios are included in Appendix B. The items in the OLDCART acronyms were included excepting "T (treatment)" when a first attempt was made to categorize the type of questions. Other categories appear in Table 6-1 were added as the analysis progressed. Each scenario was examined using the categories listed in □ REF _Ref140337379 \h □□Table 6-1□ to see if there is any pattern in the sequence of questions.

Table 6-1: The List of Question Categories Used in the Analysis.

Category Label	Description
Open-ended question	Letting the patient describe things freely (i.e. describe the discomfort)
Onset	When the symptom started
Location	Where the symptom is
Duration	How long does the episode last
Characteristics	Size, frequency, comparison with the symptoms before the operation / before the discharge
Associated Symptoms	Secondary / tertiary symptoms
Aggravating Factors	Things or movement that make the condition worse.
Relieving Factors	Things or movement that make the condition better
Medication	Type, frequency, recent changes of medications
Activity Level	Things the patient was doing when the symptom started. Or the level of typical activities.
Availability of Help	Anyone who can help the patient in getting medication/driving them to the ER/FP/UOHI

Figure 6-1 shows the question sequence chart for a surgery patient experiencing chest pain submitted by Participant 1. She included a comment, “Once I have ruled out angina and PPS and infection … the next place I would go is to the pain management strategies.” In the chart, the question sequence starts from the bottom and moves upwards. This pattern was observed in other scenarios although there were some deviations. In this particular scenario, the primary complaint was chest pain so that more questions regarding describing this symptom were asked to gain the complete characteristics of the problem. This approach appears to be successful for ruling out certain conditions and also narrows down the specific problem the patient has.

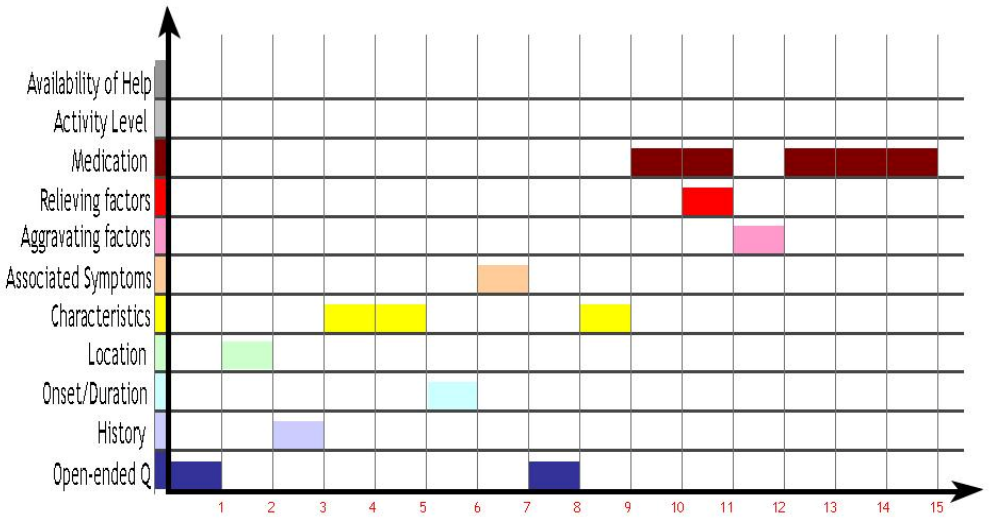


Figure 6-1: A Question sequence chart for patient with chest pain.

On the other hand, a chart for dizziness (Figure 6-2) has less focus on the bottom part of the chart. With a primary symptom like dizziness, fatigue, and sleep problems, the questions on associated symptoms appear to get more attention because the complaint is not localized. The decision makers are trying to find out which part of the body has problems by paying attention to other symptoms. In relation to the ADS, chest pain may be placed in the physiology abstraction level and at the organ or tissue decomposition level whereas dizziness may appear in a higher abstraction level and the largest decomposition level, the entire body. Therefore, the approaches for inquiry are affected by the type of primary complaint and its level of abstraction.

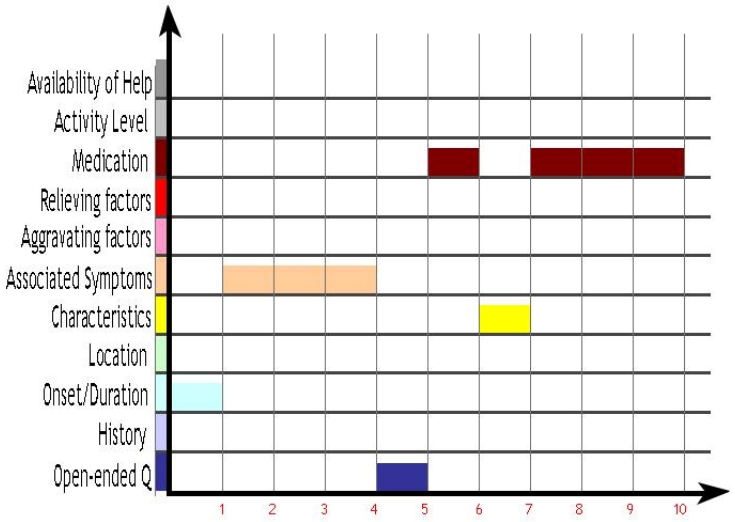


Figure 6-2: A Question sequence chart for a patient with dizziness.

Decision makers may use multiple strategies during telephone consultation. For example, if a surgery patient calls due to chest pain, the nurse may start with a topological search to see if it is related to the heart surgery and then move to standardized questions (OLDCAR) to gather enough information to form one or more hypotheses. If a hypothesis fails to pass some tests, the decision maker may choose a ruling-out approach to find another hypothesis. Many NCs described the process as "experience-based" or "intuitive" and it does not have one standard way. This may be explained by that fact that the NCs combine different strategies depending on the answers the patient provides. Therefore, the NCs react to a patients' response almost immediately and unconsciously select an appropriate strategy.

6.3 Decision algorithms

Algorithms that help the telephone consultation process were developed by a collaboration of medical professionals at the UOHI. In this context "Algorithm" is used to describe step-by-step guidelines for the NCs during telephone consultation. They can disagree with the paths or advice from the algorithm and deviate from them. The algorithms were constructed using decision tree representation because the representation has been used in medical practice, so the NCs can adapt the system with a reasonable learning curve. The decision algorithms were reviewed by the NCs and other clinicians and modified as was needed.

The decision algorithms were analyzed to understand how clinicians view a successful phone consultation process. The trees constructed by medical professionals contain more complex decision

sequences than simple binary questions found in typical decision trees. Figure 6-3 shows two types of decision trees: one mimicking trees proposed by a clinician group and the other that has been reorganized to form a binary tree. When analyzed carefully, it can be noted that it makes the decision of whether "the description sounds like X" before providing the detail in tree A. This shows the strong influence of hypothesis-and-testing strategies since they first select the possible conclusion and test the features later.

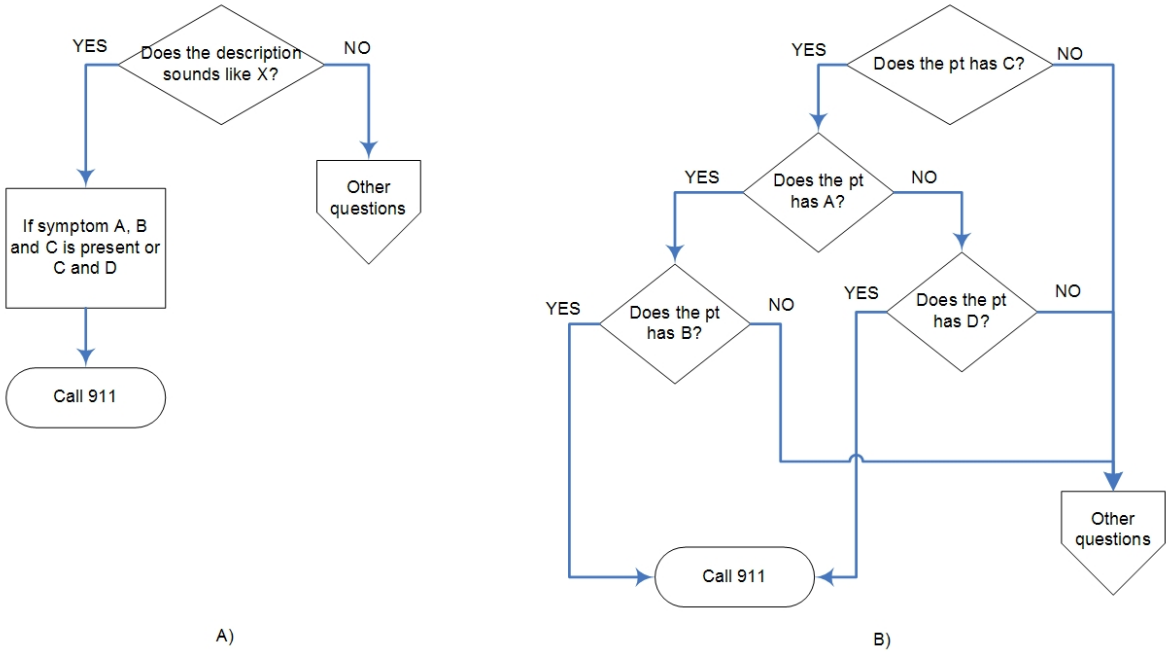


Figure 6-3: Two types of decision tree: A) Proposed by clinician group. B) Reorganized for binary decision tree.

Another interesting practice observed in the decision trees designed by clinicians was that a single cell may include a combination of multiple features as opposed to considering each feature one at a time. For example, "if symptom A, B and C are present or C and D, call 911" in Figure 6-3-A contains multiple items. When clinicians see the combination of information in a cell, it can be assumed to have meaningful association among the symptoms. This assumed association facilitates the abstraction of patient condition from a presented symptom set. On the contrary, when a multiple-feature decision cell is decomposed into single-feature decisions (as in Figure 6-3-B), this abstraction process is less likely to happen so that pieces of information remain unintegrated. Consequently it was not easy to tell what the underlying condition is.

Meaningful decision boxes in the algorithms appear to remind the users of the reasons for the particular set of questions rather than to make the users to ask questions serially and mechanically without clear context. In other words, the medical professionals appear to process the information as a cluster rather than dealing with them separately and they can become confused if the representation of the algorithm is not compatible to their mental procedures.

6.4 Summary

The following types of strategies are extracted from the interviews.

1. Open-ended Questions
2. Standardized Question List
3. Topological Search
4. Hypothesis and Testing
5. Ruling out Possibilities

Strategies were observed in the typical scenarios submitted by the NCs and the decision algorithms generated by the clinician group. Decision makers use multiple strategies to form decisions. It is important to represent the decision aid in the way that matches the mental procedures of the decision makers in order to support their cognitive activities.

Chapter 7
Knowledge Extraction from Data

In order to apply SC techniques to extract information and construct a DSS, suitable data format and algorithm combinations must be identified. Since the current system is paper based and the consultation procedure is not standardized, the data is not in the ideal condition. The attempt to extract decision trees by SC was not successful with the available data at the UOHI (Enomoto, 2005). This chapter describes a rough framework of automatic tree generation methods to address the capability of the approaches. Some of the attempt described here was submitted as a course requirement for SYDE 625.

7.1 Description of Data

1523 cardiac surgery and 552 cardiology phone consultation records from January 2, 2002 to December 12, 2003 were obtained from the UOHI for analysis. As discussed, the records are handwritten in the current practice. The information was typed into spreadsheets by a research assistant at the UOHI. When the data was transferred, numerical categories were assigned to checklist items such as patient history and presenting problems while any linguistic inputs such as comments and written notes were transferred in the summary columns as a chunk. For example, if "SOB" is checked as one of the problems for a cardiology patient, "SOB" is converted to "3". The data included the values that are described in Table 7-1. It should be noted that this dataset was not generated to extract causal information between the symptom sets and recommendations. The main purpose of the dataset was to transfer the record on the paper form to electronic format.

Table 7-1: Summary of the Telephone Consultation Record Data

	Cardiac Surgery		Cardiology	
	Data type	% of the data filled	Data type	% of the data filled
Date	Date of the call	100.00%	Date of the call	100.00%
Caller	$I \in [1,8]$	100.00%	$I \in [1,8]$	100.00%
History 1	$I \in [0,10]$	75.84%	$I \in [0,12]$	72.83%
History 2	$I \in [0,10]$	5.45%	$I \in [0,12]$	12.14%
Recent Procedure	N/A	-		7.61%
Operation				
Pre-op	$Bi \in \{0,1\}$	3.61%	N/A	-
OR Date	Date	47.14%	N/A	-
Post-op	$Bi \in \{0,1\}$	96.26%	N/A	-
Date of Discharge	Date	27.45%	N/A	-
Last Hospitalization				
Admission	Date	0.59%	Date	31.16%
Discharge	Date	0.00%	Date	12.32%
Length	Number of days	0.00%	Number of days	4.71%
Primary Problem	$I \in [0,28]$	99.80%	$I \in [0,23]$	99.64%
Secondary Problem	$I \in [0,28]$	38.15%	$I \in [0,23]$	34.60%
Tertiary Problem	$I \in [0,28]$	11.95%	$I \in [0,23]$	7.25%
Referral	$I \in [0,6]$	49.38%	$I \in [0,6]$	59.06%
Pt Agrees	$Bi \in \{0,1\}$	99.34%	$Bi \in \{0,1\}$	98.01%
Follow-up				
resolved	$Bi \in \{0,1\}$	98.29%	$Bi \in \{0,1\}$	98.01%
Informed Dr.	$Bi \in \{0,1\}$	16.94%	$Bi \in \{0,1\}$	13.59%
callback arranged	$Bi \in \{0,1\}$	7.75%	$Bi \in \{0,1\}$	8.51%
Summary	Text	98.29%	Text	99.82%

7.2 Data Manipulation

Conversion of the categorical representation of a patient history and presenting problem was attempted to create a binary representation of the data. This way, the each category in history and problem part would be treated as an attribute and the value for the attribute would be either 0 (absent) or 1 (present.) The distinction of the primary problem is still very important since the approach to a patient's problem would be very different depending on the main problem. For example, if a patient calls in to ask about medication concerns, the questions and recommendation would be mostly related to medication or known allergies.

Automatic information extraction from the summary columns was considered. Although the summary columns contain rich information related to patient condition, simple search and extract of a cardiac keyword was not successful because it contains conditional phrases and recommendation to possible future events. It was also attempted to extract words that describe some of the main problems. For example, the significance of "*extremely SOB"* and *"a bit SOB"* would be very different when the nurse made decisions; however, the main data set only shows that patient presented "SOB." Also problems with heart beat (HB) can be *"fast HB"* or *"irregular HB."* Some nurses use *"arrhythmia"* to describe the irregularity while others use *"palpitations."* Linguistic representation of quality of a particular attribute is very hard to quantize. "Extreme" and "slight" pain maybe comparable and can be replaced by an appropriate scale, but "burning" and "sharp" pain cannot be projected onto a one-dimensional space.

7.3 Design

SC techniques and tree generating algorithms were combined to form an intelligent system to generate decision trees from the given data. An important issue, which is unique to this application, is that the decision trees may not be balanced. When cardiac nurses are dealing with patients over the phone, one of the worst cases is that the patient collapses with MI – generally called heart attack. The condition is too risky and must be dealt with immediately. Therefore, the exit points (or leaves) for such conditions should be closer to the starting point, whereas the NCs like to listen to a good description of a patient's problem before making any recommendations if the conditions are not life-threatening.

The system included the following components:

1. Input feature selection by GA
2. Three different methods, i) fitness of active feature, ii) ID3, and iii) minimum local certainty, for splitting and stopping criteria
3. Cost Based classification criteria are used for i) and ii). (iii) has its own classification criteria
4. Cross-validation method to find a less noise-sensitive (training set sensitive) feature set

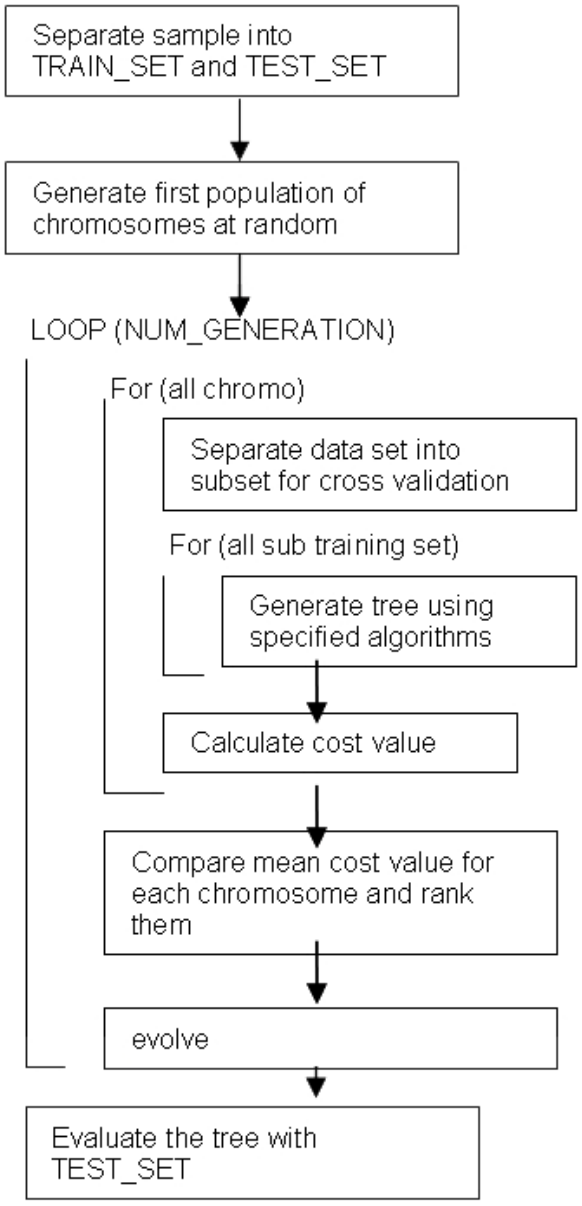


Figure 7-1: Flow chart of the system.

7.3.2 Feature Selection method

A binary GA was used to select features that are suitable for tree induction. A population size of twenty went through an evolution process for five generations. The initial population of chromosomes was randomly generated. The probability of each feature to be 'ON' (each gene to be '1') was set to

75% to keep moderate number of features to remain. After all five trees for cross-validation sets were evaluated, the chromosomes were then ranked in order of fitness. The fitness function for the selection was the mean value of cost-based error over five cross-validation sets. The best two chromosomes were selected as "*parents*" and underwent two crossover operations to reproduce. Two offsprings were produced by a single-point crossover while another set were produced by two-point crossover. Thus four offsprings were produced. The points of crossover were randomly selected. Among all chromosomes in the population, the worst half of the population were removed. A new set of randomly generated chromosomes filled the deficit of the population. All chromosomes excepting the parents were subjected to mutation with a mutation rate of 40%. Each gene on those selected to mutate flipped some digits of a rate of 1/length so that one gene in each chromosome would mutate on average.

7.3.3 Splitting and Stopping Criteria

Fitness of Active Feature

This method is especially designed for the phone consultation purpose. The major considerations for this application are reiterated here:

1. Not all questions are relevant for all patient conditions
2. Path for patients with higher risk should be shorter than other less severe cases
3. Patients with less severe cases are instructed to stay home; thus more information gathering would be necessary to give good consultation

This algorithm searches for the cases that are classified as the highest priority and looks for an attribute that can extract the cases. It is important that the algorithm only looks at the non-zero value of the attribute when the attribute is considered because of the first consideration listed above. The induced decision tree would be taller than most of the trees and likely to be unbalanced due to all three considerations.

ID3

ID3 (Inductive Dichotomiser 3) is an algorithm used to generate a decision tree. The algorithm calculates information gain using an entropy measure of the current set and the sets created after the split by a particular attribute. In the decision tree each node should be associated with the attribute which is most informative among the attributes not yet considered in the path from the root. In ID3 algorithm, entropy is used to measure how informative a node is.

Splitting criteria:

1. Consider all attributes in the data and count the entropy concerning the classification of the data for each attribute.
2. Compare and select an attribute with smallest entropy as a decision attribute.

Minimum Local Certainty Method

Yin et al (2004) proposed an effective algorithm to be used as a splitting and stopping criteria. This way, the tree remains as compact as it should while capturing most of the information content. They use minimal local certainty as the threshold to control the process of tree construction. They use a decision table to list the number of elements in each consistent set, where a consistent set is defined as a set having same value for every attribute including the outcome.

7.3.4 Cost-Based Error Calculation

As mentioned earlier, misclassification of the cases would not be uniformly penalized in the real world; therefore, simple calculation of error would not justify some of the errors. Applying cost based classification for this application is appropriate since some of the misclassifications may lead to a death while others might be calling a family physician for trivial conditions. This classification can be combined to other algorithms when assigning a class to a leaf node.

7.3.5 Cross Validation

The entire training set was randomly divided into five partitions. One of the sets would be selected for evaluation while the other four formed a training set. A decision tree is generated by each set and evaluated by the cost-based error. Because of the limited size of the data set, this method was incorporated to produce better coverage of the sample while avoiding over-fitting of the tree to a particular training set.

7.4 Results and Discussion

Because of the limited size of the data set, the experiment was repeated three times using different seeding of the pseudo-randomizing process for the initial chromosome setups. Only the cardiac surgery patient data was used for experiment due to the difficulty in extracting information from the summary column. Randomizing with the same seeding essentially produce some partitioning of datasets in the process. Table 7-2 summarizes the averaged results over the three randomized seedings.

Table 7-2: Summary of Results

	Method 1	Method 2	Method 3
# Feature	27.33	26.33	22.67*
Depth	19.33	13.00	7.33*
Training			
Classification Error	0.59458*	0.61118	0.64220
Cost	1279.67*	1319.33	1744.67
Average cost	1.67715*	1.72914	2.28659
Test			
Classification Error	0.70855	0.71030	0.64223*
Cost	397*	397.67	437.33
Average cost	2.07853*	2.08202	2.28970

Method 1: Split by active feature value, Method 2: ID3, Method 3: Split by Minimum local certainty. * indicates the best performance

7.4.1 Tree Size and Shape

Method 3, splitting by minimum local certainty, generated significantly smaller trees than the other two methods. Due to the level of confusion (or certainty) of the samples and the fact that the decision nodes did not always reduce the confusion, the algorithm tended to terminate the tree construction too early to produce reliable trees. Method 2 (ID3) produced moderately sized and balanced trees relative to the other trees. Both Method 1 and 3 produced unbalanced trees repeatedly. As for Method 1, it was intended to produce unbalance trees to prioritize severe patient conditions.

7.4.2 Classification Accuracy and Cost Performance

Method 1 and Method 2 performed comparably for classification accuracy and cost performance. Although the evolution of chromosomes was controlled by the cost performance, Method 3 suffered by cost performance since the frequency of 911 case and general physician case was not high. Therefore, the algorithm tended to ignore costly classes since these case were rare. The high classification error rate can be explained, again, by the level of confusion of the data set. If a tree is generated by dividing with all attribute nodes, more than 14% of leaf nodes of this tree would have multiple classes for cardiac surgery data. The need for better samples for a good tree generation is emphasized.

In addition, classification accuracy for each labelled data set was calculated to observe the effect caused by the difference in the occurrence of a particular class. Table 7-3 shows the percentage accuracy for each class data in the test set for three algorithms. As noted, the class frequency

distribution influenced method 3 significantly. If the data set was less noisy to train, the accuracy rate would have improved.

Table 7-3: Accuracy for Each Class

		Method 1		Method 2		Method 2	
	n	Correct	Accuracy	Correct	Accuracy	Correct	Accuracy
911	7	1	14.29%	1	14.29%	0	0.00%
ER	134	62	46.27%	57	42.54%	18	13.43%
GP	185	80	43.24%	91	49.19%	20	10.81%
UOHI	107	32	29.91%	21	19.63%	7	6.54%
ER if worse	47	7	14.89%	7	14.89%	1	2.13%
Pharmacy	12	7	58.33%	5	41.67%	0	0.00%
Home care	271	124	45.76%	86	31.73%	240	88.56%

7.4.3 Other issues

Out of all three trials and three methods the terminal node with "911" label was found only in Method 1 in the seed 2 and seed 20 case, and Method 2 in seed 20 case. The seed 2 case contained nine 911 cases while Seed 7 and 20 contained seven cases. In seed 2, Method 2 extracted the 911 path at the depth of 2, while Method 1 and Method 2 extracted the 911 path at the depth of 7 and 8 respectively. These results also suggested the importance of the number of sample cases and noise level control.

7.5 Summary

Although each method has its distinct advantages, classification by minimum local certainty is not suitable for noisy sample population. When applied to noisy medical data with distinct priority of importance, automatic generation of decision trees would become very challenging. Classification by active attribute value and misclassification penalty made use of expert knowledge, and the method performed slightly better in terms of cost. Size of the trees remained reasonable due to the GA-controlled input selection.

Noise level and the lack of some critical attributes impacted the classifiability of data. Linguistic degree terms such as "very", "extremely" should also be very important in terms of severity rating. As more attribute values would be available after the introduction of electronic patient recording system at the UOHI, this system should give better classification.

Decision tree generation and pruning by evolutionary techniques may not be best suited for this application at this moment. First of all, the data is very noisy while the search space of tree structure is huge. The noise and missing values make it impossible to learn the classification rules. For

example, there are more than two cases with exactly the same symptoms; however, these patients received different recommendations. Secondly, the values for the attributes are mostly binary, which does not communicate the fuzziness of the information. Evolutionary operations for tree generation should be explored to be effective while preserving the information content that has been gained over generations.

Lastly, the importance of expert knowledge in generating a good decision tree is re-emphasized. Data extraction from noisy data requires human judgments and understanding of medical and nursing principles. This system may be used to generate a good starting point for decision tree construction. A number of medical professionals at the UOHI spent many hours in meetings iteratively to generate, evaluate and refined the algorithms for the current system. If the system can generate the initial set of decision trees, the time commitment of experts might be reduced.

Chapter 8
Interface Design

This chapter describes various attempts in designing the interface of the DSS to reflect the findings from the CWA and the interviews to support the range of aspects for decision making. A desktop interface was also designed for the system, but it is outside the scope of this thesis.

8.1 Electronic Telepractice Documentation Record

The NCs use a paper form called a "Telepractice Documentation Record" (Appendix A). Because most NCs have not had exposure to handheld devices prior to this project, the team decided to implement the familiar form electronically and give the tool to the users while more decision support was developed. The NCs can then learn how to navigate the PDA and the tools using the basic forms. This should improve technology acceptance and also the users' perceived reliability because of the sense of control over the tool.

Through multiple reviews of the form, the team found that some items are never used and can be removed from the record. Two types of patients, cardiology and cardiac surgery, go through different items; therefore,

8.2 Decision Tree

The UOHI clinician group and the CARDIO team have generated decision algorithms in decision-tree format to help to handle typical consultation cases. To increase situation awareness, decision boxes are filled with different colours, which indicate the levels of criticality. As seen in Figure 8-1, the disposition "Call 911" box is filled with red indicating that the patient is in a critical situation, while the two oval terminating notes on the right are filled with green to indicate that the patient does not need immediate actions.

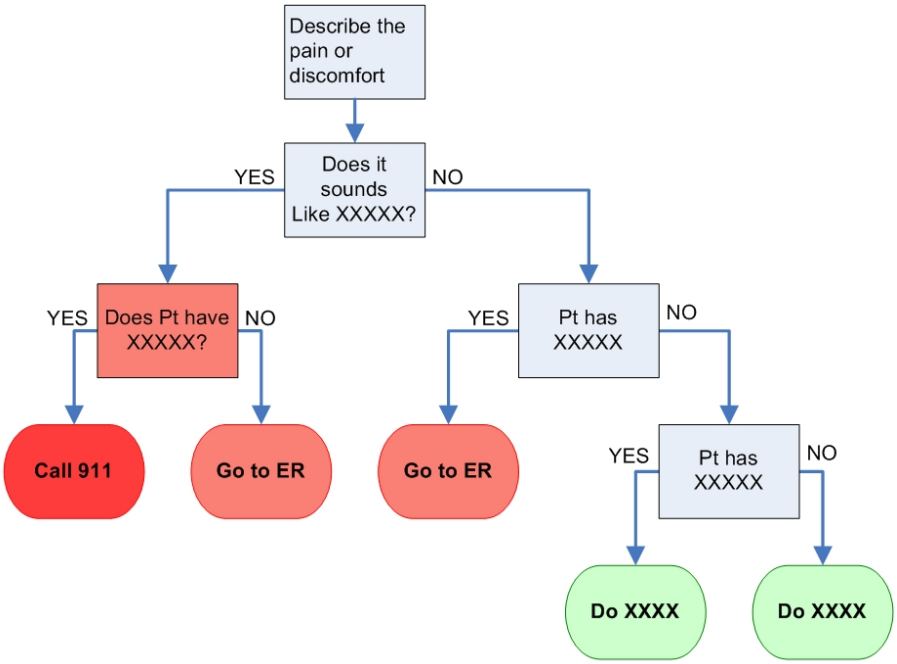


Figure 8-1: Colour scheme for decision tree.

One of the challenges of interface design for the PDA is the small display size. To fit decision algorithms in the display in a more efficient manner, trees can be rearranged like the one shown in REF _Ref141506134 \h Figure 8-2. This tree requires fewer scroll actions since the tree is packed in a shape similar to the PDA display (height: 8 cm, width: 5.3 cm). Notice that the arrows that run across the tree are always the "yes" option while the ones that go down are "no". This way, the users do not have to read the branch labels once they become used to the representation.

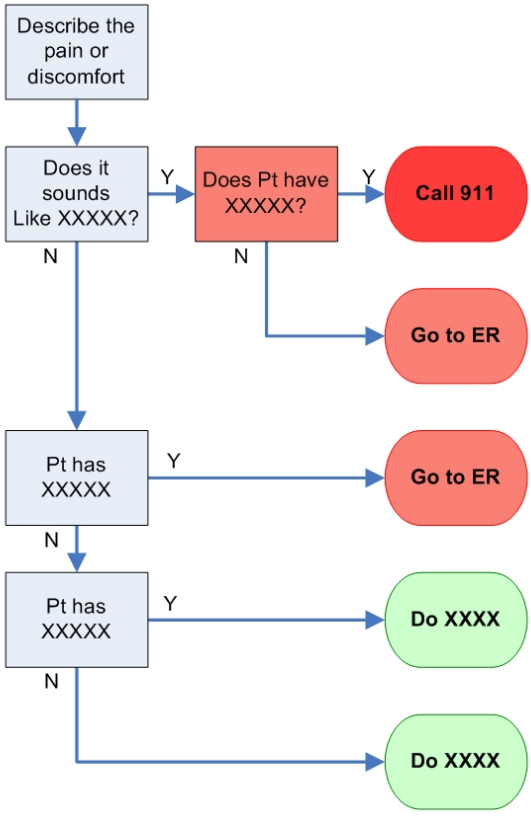


Figure 8-2: Decision tree rearranged to fit in PDA display.

In order to keep the user in the loop when they are navigating tools, the system should provide indicators that show where they are. It is important to show the context that surrounds the component and their relationships or make it easily accessible to maintain the users' situation awareness; however, due to the small display, it should only display selective information to avoid clutter. Additional features are included in the decision algorithms to increase usability and utility of the system. Table 8-1 summarizes some of the features that were proposed.

Table 8-1: Additional Features Proposed for the Decision Algorithms

Feature	Description
"i" icon	Provides additional information (definition, hints, characteristics, evidence)
Focus	The box that the user is currently on is highlighted.
Yes/No inputs	The path would be highlighted when the user input the information
Links to other algorithms	Provide flexibility to hop among different algorithms
Links to summary	Provide a quick summary of the information the users inputted
Data sharing	If the information is already entered previously (e.g. if the user already selected "fever" in the presenting problem list, it shows up highlighted in the tree.)

8.3 OLDCAR

An acronym, OLDCART, was suggested to generate a standardized question set. T was dropped from the set because some clinicians believe that "treatment (T)" is outside the scope of nursing practice. To facilitate the data recording process, a list of typical responses for each question is generated by the nursing researchers and reviewed by other clinicians. A simple list of items with checkboxes is used for each of the questions that allow multiple answers and a drop-down list is used for a question requiring the users to select only one answer. Users may have to enter free texts if they want to enter items not listed, but these lists would reduce the amount of writing or typing. All NCs are exposed to a moderate level of daily computing tasks; thus it is assumed that they are familiar with these input interface elements. Tapping on the screen directly with the stylus is similar to writing

Graphical elements are designed for some items in the OLDCAR that can be interpreted easier in graphical format. For example, the pain scale uses two bar charts, which indicate pain levels of "before discharge" and "current status", so that the difference can be seen instantly. Also the location of discomfort is mapped on a human-like figure (Figure 8-3). These graphical elements are intended to facilitate the recognition of the relationships of different variables and the recall of the integrated information when summarizing the entire information set.

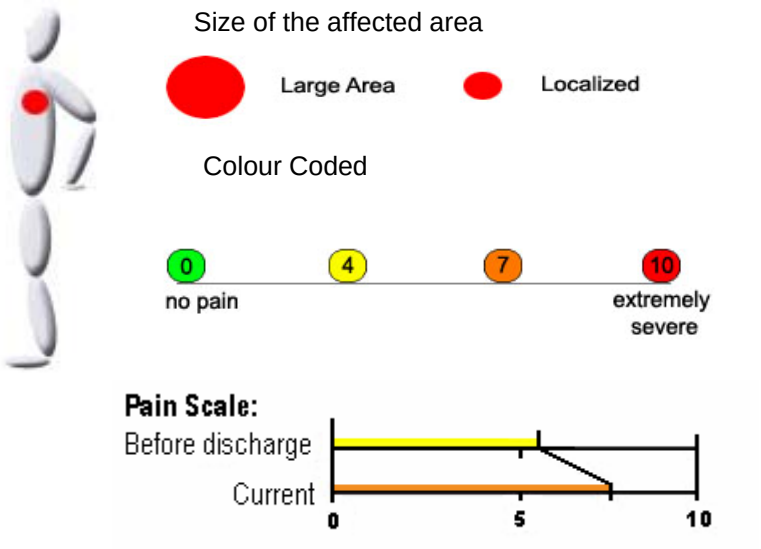


Figure 8-3: Graphical elements for OLDCAR checklists.

8.4 Call Management Sequence

Due to the reactive nature of the telephone consultation process, deciding on one particular consultation sequence is very challenging. However, general sequences were extracted from the previous analyses.

General Information

The UOHI collects basic information on the patient and caller for legal requirements. The "bunker" at the UOHI asks if the patient is a cardiology or surgery patient and also the name of the patient's cardiologist/surgeon when a patient calls. An NC said sometimes she knows how the particular doctor does things so it helps to make decisions and the information is useful if she needs to talk to the doctor later. As in the paper documentation record, general Information is placed at the beginning.

Describe Discomfort

The nurses typically ask the patient to describe the reason why they called. Like telephone triage principles, many NCs emphasized the importance of a patient's own description of the problem. It is ideal if the users can enter free text by voice-recording and the system is able to extract some information from it, but the implementation of such a system is challenging. A slightly easier way might be to provide drop-down lists for primary, secondary and tertiary problems and place a drawing pad for the user to leave extra notes. If information is selected by drop-down, it can be integrated into data-sharing. If a drawing pad is used, the system should show a shortcut to the notes during the consultation.

Critical Questions

Most of the NCs said that if they suspect MI, they ask the patient to hang up and call for an ambulance immediately. Therefore, critical questions should be placed at an early stage of consultation. According to the UOHI's guideline (UOHI, 2003), patients who are unconscious, have SOB at rest, or are experiencing chest pain not relieved by nitroglycerin, should seek immediate medical care.

History

Once the most critical conditions are ruled out, a patient's medical or surgical histories should be examined. This record helps the decision makers generate an appropriate patient image together with the patient's description. It is desirable to have an access to the patient's database from the PDA to

have a complete view of medial and nursing history; however, it is currently not possible at the UOHI.

OLDCAR

OLDCAR is used to ask standard questions related to the primary complaints to develop one or more hypotheses to explain a patient's condition.

Select appropriate algorithms

At this point, the users should be able to select an appropriate algorithm. Although, the users are able to move among different algorithms, it should be more efficient to have collected enough information to select an algorithm.

Summary

The users are able to view the summary of the data already entered in the system at any point during the consultation. Thus, it is easier to de-bias their hypothesis if the summary is used frequently.

Assessment

The NCs can add text notes on an assessment page by typing or using scribble as well as recording a voice message. This recorded voice can be played on the PDA and the desktop system. A voice-to-text conversion function was requested by the users, but it was not implemented due to time constraints on the prototype.

Disposition

The NCs give recommendation to the patient and arrange a callback if appropriate.

8.5 Navigation Elements

Since the tools will be used by both experts and novices, the navigation should be flexible enough to support different levels of support. The navigation and indicator bar (Figure 8-4) is designed so that the users can see where they are in the consultation sequence, and they can tap on the bar to jump to different pages. Small icons are placed next to the title bar so that the users know how to save and exit or navigate along the system.

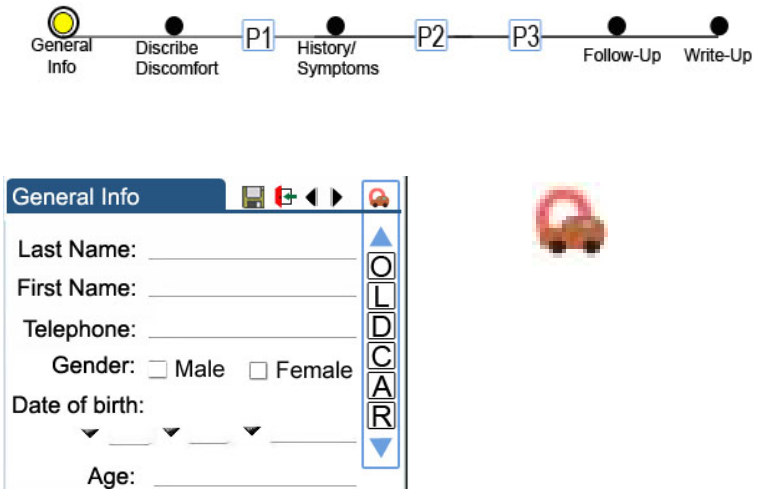


Figure 8-4: Navigation elements design.

8.6 Visualization Tools

There are cases where an algorithm may not apply. The novices would have difficulty in making sound decisions in these deviated cases. Therefore, the system should supply the basic principles when the algorithm fails. The challenge here is to find out what these principles are and how they can be incorporated in the design of the system. Many factors of expert decision making, such as intuition, which are highly associated with vast experiences, are difficult to quantify and describe explicitly. Forming a mental image of the patient and their condition, for example, was identified as a common method for telephone consultation. The question would be how a DSS can help in creating a mental model of a patient for novices.

While expert NCs use fundamental medical principles to process unexpected events, novices may not be able to retrieve such knowledge in the head. If the information presented by the decision support system were organized in an ecological way, the causal relationships among the components in their domain would become easier to detect. Providing multiple access points to the underlying fundamental principles allows novice nurses to recognize the connections.

Visualization of information that lies in a multidimensional space is difficult to achieve. Some of the components involved in the system are not physical entities, which makes it more difficult to design intuitive representation of the state of quality/quantity. Although some aspect of patient care is quantitative such that precise measurements can be obtained, the nature of telephone interaction prevents NCs from taking measurements such as heart rate or temperature during the conversation. As

a result, most of the variables are discrete (yes/no), graded (1, 2~ 10 scale), or qualitative. The interaction of a multidimensional decision space with mixed scales is difficult to visualize.

Three types of visualization tools were proposed. Each tool was designed to support different aspects of decision making.

8.6.1 Bar Symptom Map

The bar symptom map was designed to support prevalent strategies, "ruling out possibilities" and "hypothesis and testing." In this map, each bar, which comprises of multiple cells of symptoms, indicates a condition or a diagnostic label (Figure 8-5). This tool can show that the highlighted symptoms are present and not the ones that are crossed out. The major advantage of a bar map is the ease of understanding and navigation. Highlighting and crossing out is a very common memory aid people use. Also if used dynamically during the inquiry, the tool can provide a structured way to find an appropriate question at the time and reach the most probable diagnosis quickly because of the linear nature of display.

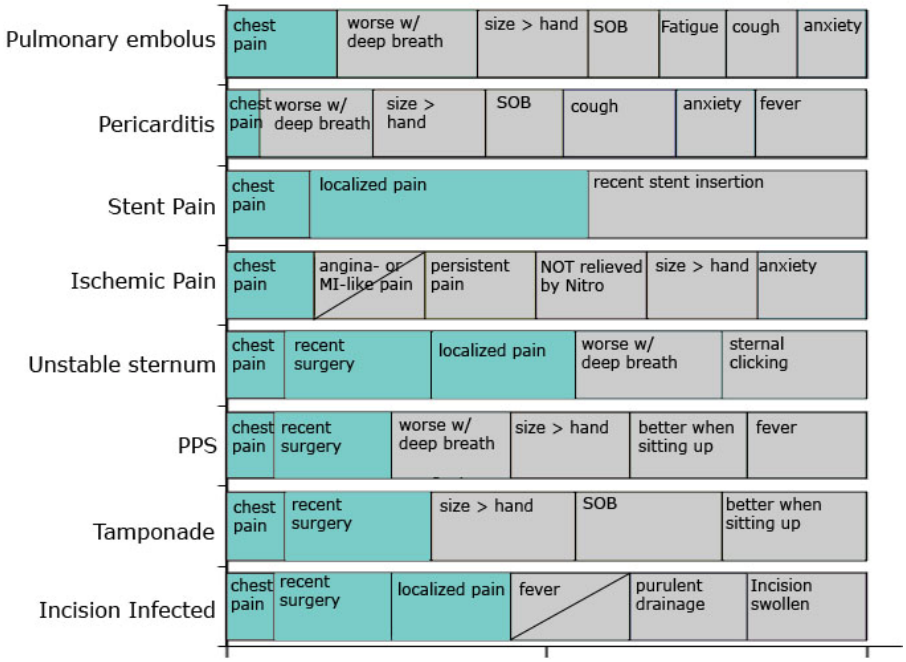


Figure 8-5: Bar symptom map.

8.6.2 Polar Symptom Map

The polar symptom map presents a set of symptoms in terms of problematic area. Each axis in the map indicates a symptom and as shown in Figure 8-6, axes of a polar star chart are arranged in such a

way that it forms a meaningful cluster. For example, Figure 8-6 shows that there is a large area highlighted around incision related symptoms; thus, the observers can hypothesize that the problem is incision related. This tool does not tell the diagnostic name of the condition a patient is experiencing, but shows you an abstract map of the patient condition so that the users can visualize what is happening. It can therefore be considered as a representation of lower levels of abstraction of the domain. One of the advantages of the polar map is that once users get used to the shapes of the map, the recognition of patient conditions become easier and quicker. When going through the decision algorithm, users can consult the map and reassess their hypothesis to make sure that they are following the right path.

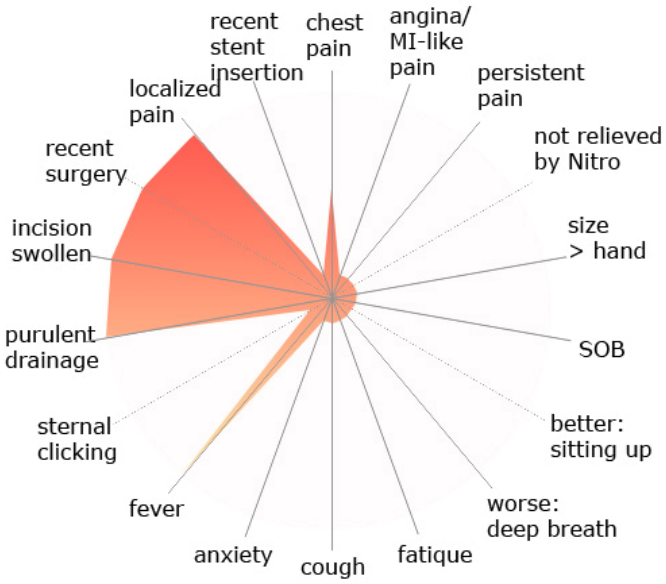


Figure 8-6: Polar symptom map.

8.6.3 Clock Symptom Map

The clock symptom map is intended to show the criticality of the patient condition. Like the polar symptom map, each axis indicates one symptom. The difference between the polar and clock maps is that the clock map's axes are arranged in order of criticality. Although it is difficult to define the criticality of a single symptom in relation to others, the axes shown (Figure 8-7) are arranged so that the users can identify critical conditions quicker than other issues. The arrangement of the criticality matches to conventional clock; the users start at the twelve o'clock with pain scale. Similar to the decision tree representation, colour is used to indicate the criticality as well. The clock starts off with

red at 1 o'clock, gradually turns into orange, yellow, and to green as the consultation proceeds. For example, Figure 8-7 has the area around 9 o'clock highlighted in green, which is at lower criticality level. The users can use the clock map to generate the questioning sequence or to check if any critical questions are missing. The clock map conveys more abstract information than other maps since it shows a patient's criticality rather than what is going on.

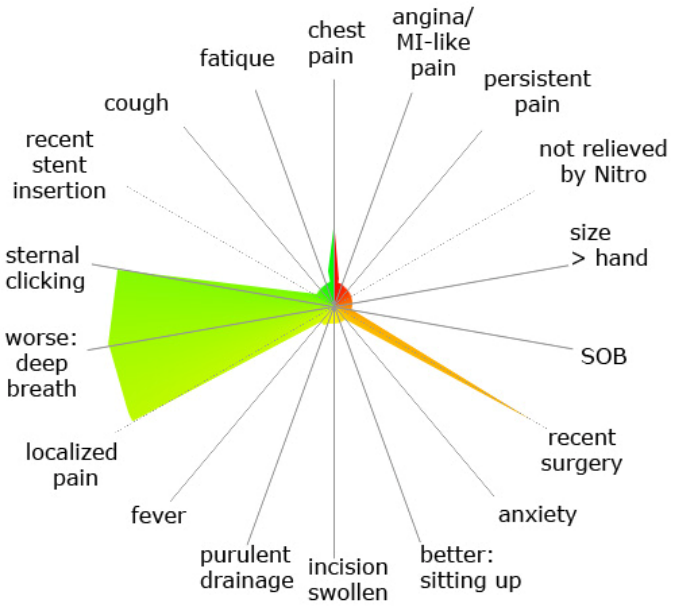


Figure 8-7: Clock symptom map.

8.7 Summary

The proposed interface elements were presented to the team and the users for review. Feedback was provided and some changes were made.

- The team did not want to separate critical questions from the other part of the algorithm.
- They thought the OLDCAR should be in the decision algorithm. Also "describe discomfort" question should be placed at the same point as OLDCAR. Thus, the users can ask open-ended questions first and if some information is missing, they can use the OLDCAR checklist to ask questions.
- The team preferred conventional tree representations over the compact modified trees (See Figure 8-2).

- They liked the human-like figure in OLDCAR checklist. They also would like to see the back, but they do not need head or bottoms.
- The lists for OLDCAR items were iteratively reviewed and modified.
- Top navigation bar was removed due to the small screen of the PDA, but would be incorporated in the desktop interface.
- The medical professionals are not certain if they can benefit from visualization tools.

The UOHI team requested to conduct a preliminary experiment to show the effects of the visualization tools before the tools are integrated into the system. The next chapter describes Experiment I.

Chapter 9
Experiment I

This chapter describes Experiment I and discusses the results of the study. All materials related to the study are included in Appendix D and the results are included in Appendix E.

9.1 Objectives

As described in the previous chapter, three types of information visualization tools were proposed to medical professionals at the UOHI. Unlike familiar decision trees and checklists, usage of abstract information representation is new in nursing practices; therefore, the effects of visualization tools are difficult to predict. The ultimate goal of visualization tools is to show a patient's symptom information space online, so that the users can be aided not only during the diagnostic phase, but also during the inquiry phase. However, Experiment I was designed as a preliminary experiment to demonstrate the advantages and disadvantages of tools using low-fidelity prototypes in a controlled laboratory setting prior to more advanced design and development.

Each of the three visualization tools is intended to support a different aspect of the decision process. The experiment compared the different visualization tools in terms of response time and accuracy of the judgements as well as the participants' response to post-experimental questionnaire.

9.2 Prototypes

Static images of the visualization tools were used for the evaluation. For each patient condition, a set of symptoms were generated and reviewed by experts. This represents the final set of information if the user asked an adequate number of questions. Images were drawn using Adobe Photoshop CS2 and converted to JPEG format.

9.3 Design

The study took a within-participant design to compare the performance of decision makers in four different display types, text list, bar symptom map, polar symptom map, and clock symptom map. Twelve patient models had been generated using the information from Medline Plus (National Library of Medicine, 2005); six cardiac patients ("Ischemia", "Cardiac Tamponade", "Incision Infected", "Stent Pain", "Unstable Sternum", "PPS") and six non-cardiac patients ("Allergies", "Asthma", "Food Poisoning", "Flu", "Mono", "Meningitis").

The experiment consisted two portions. Each participant performed tasks in common illness domain first followed by cardiac illness domain. Each portion was divided into four blocks where the four experimental conditions were assigned. Each block consisted of three patient models, which were pseudo-randomly selected from a pool of six models. The order of the experimental conditions and the patient models were counter-balanced across the experiment. Each participant was shown three stimuli in each display type and portion (3 x 4 x 2 = 24 trials in total)

Participants made a recommendation judgement, which required them to decide what to recommend to the patient to do (e.g. "Go to the ER", "Take Tylenol and rest"), and a diagnostic judgement, with which they had to select a most likely diagnostic label from a given list. Correct recommendation and diagnosis for each symptom set was defined so that each task had exactly one correct answer in the multiple-choice question. Response time to both judgment tasks were recorded as well as the percentage correctness of the judgements. The confidence level of each judgement was entered by participants by dividing a horizontal line labelled "Not confident at all" to "Very confident" at either end.

9.4 Method

9.4.1 Participants

Twelve undergraduate and one graduate student (eight males and five females) were recruited in the Waterloo and Toronto area. Five of them were in AHS/Human Biology, three of them have taken a second-year physiology course, but not in the area of study, and five of them took high school senior level biology.

9.4.2 Apparatus

Static images of patient symptom maps or a list of text (control group) were displayed on a laptop screen for eight seconds. The length of exposure was finalized based on the feedback from pilot study. A list of options for recommendation judgement was shown after the image disappeared. This method was used to limit the users to have a constant exposure to the stimuli and collect response time after the stimuli disappeared. A series of radio buttons were used so that the participants would not select more than one option. A horizontal line with confidence level labels was displayed after judgement options were chosen. When participants entered confidence level by clicking on the line and the OK button, options for diagnosis judgement were displayed. Confidence levels of diagnosis

judgement were asked in the same way as recommendation judgement. The whole experiment was implemented using Visual Basic 6.0.

9.4.3 Procedure

The participants were asked to read an information letter and signed a consent form at the beginning of the experiment. The experimenter gave a short introduction of the nurses' telephone consultation process and explained the tasks to the participant. A printed copy of each visualization tool was laid out in front of the participant while the experimenter described how the tools worked. All participants dealt with non-cardiac patients in the first half and cardiac patients in the latter half. At the beginning of each portion, a list of diagnostic labels with descriptions including associated symptoms was given to participants to study. Participants were given a few minutes to learn the list and completed a training session before the experimental trials.

At the end of the first session, the participants were given opportunity to take a break before the second portion. After the experimental session, participants filled a questionnaire to provide feedback. Participants were thanked, compensated and given a copy of informed consent form upon the completion of the experiment.

9.4.4 Training session

The training session consisted of eight trials; two trials in each visualization tool. The participants performed exactly the same tasks except that they were allowed to keep the training documents in front of them. Training was done on each session and the experimenter confirmed if the participants were comfortable before proceeding.

9.5 Pilot Study

Two pilot runs were conducted to optimize the stimulus-display duration and also to measure the total commitment time. The two pilots tried ten second and five second durations and both said that five second was too short. Ten seconds was too long to stay focused on the stimuli. Their attention shifted else where and ended up forgetting what the actual answer was.

9.6 Results

9.6.1 Difference in Background

To investigate possible expertise effects, the participants were divided into three groups; A: specialized in applied health science or human biology, B: have taken a second year physiology

course, and C: high school senior-level biology. There was no notable quantitative difference in performance and confidence response; however, it was observed that group B and C tend to try memorizing the symptom list while group A participants attempt to understand the patients' condition by asking extra medical questions.

9.6.2 Recommendation Judgement

Accuracy

Accuracy was calculated by dividing the number of correct answers by the number of trials. Over all accuracy was 0.6731 for the recommendation judgements. Significant interaction effects with type of patient models and tools were observed in a repeated measure ANOVA ($\alpha<0.05$). The bar map aided best in terms of accuracy with non-cardiac patient models (0.8205) while the polar map did best with cardiac patient models (0.7436). On the contrary, the polar map did the worst with non-cardiac and the clock map did the worst with cardiac models.

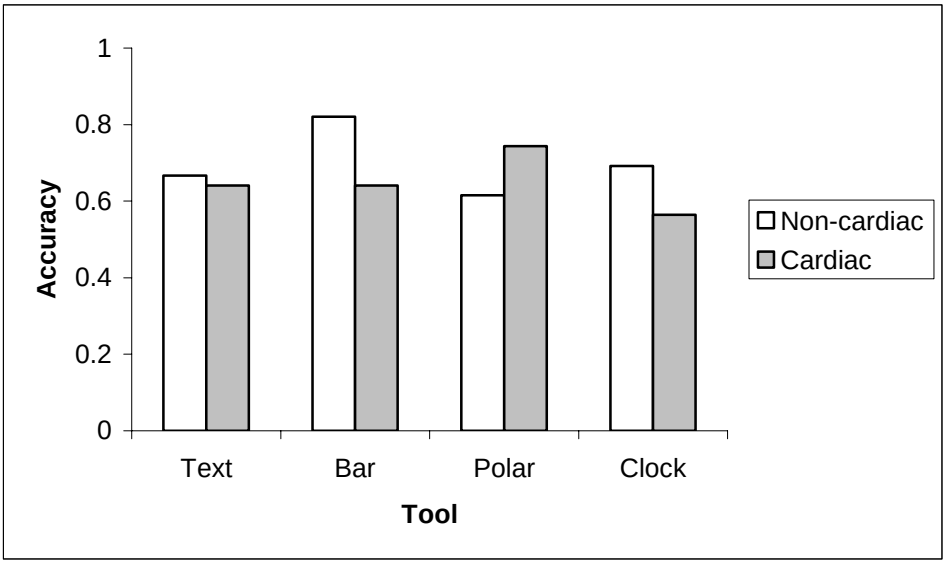


Figure 9-1: Accuracy of recommendation judgements.

Response Time

The response time was shortest with the bar map in non-cardiac domain (4387.7 milliseconds) and with the clock map in cardiac domain (4167.3 milliseconds). However, the effects were not significant on the response time.

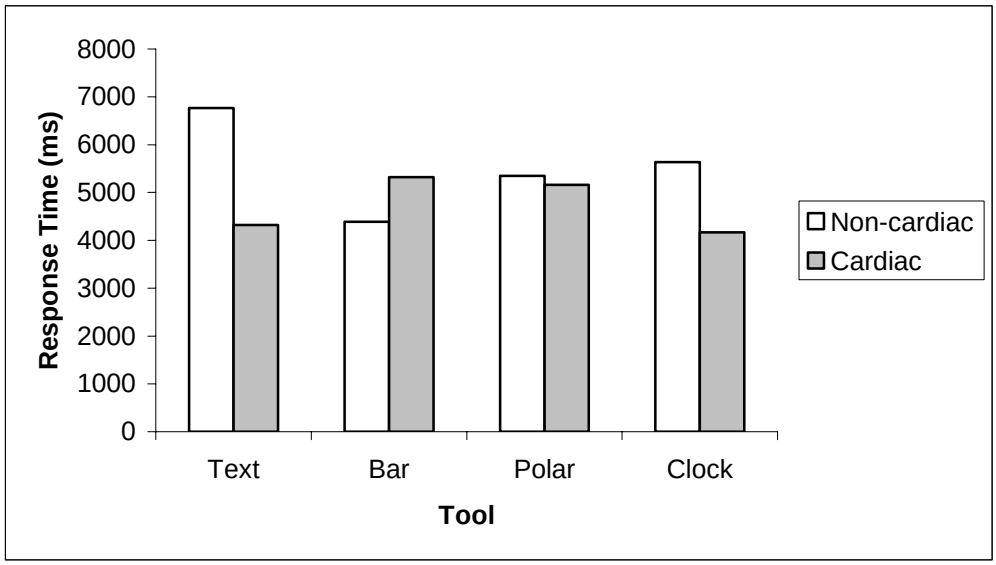


Figure 9-2: Response time of recommendation judgements.

Confidence Level

The effects of tool types were significant in the repeated-measure ANOVA (α <0.05). The participants were most confident with the bar symptom map and least confident with the clock symptom map.

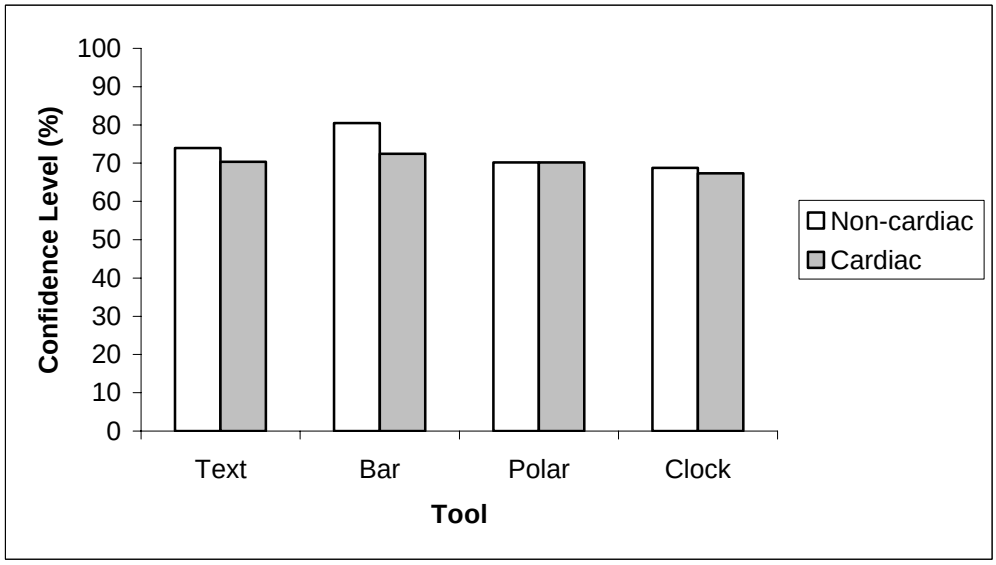


Figure 9-3: Confidence level of recommendation judgements.

9.6.3 Diagnostic Judgement

Accuracy

Over all accuracy was 0.7115 for the condition decision. A repeated measure ANOVA revealed a significant effect of tool types (α <0.001). This strong effect appears mainly due to the advantage of the bar symptoms map having diagnostic labels on it. The accuracy measure for bar map was 0.9231 for non-cardiac and 0.9744 for cardiac patient models.

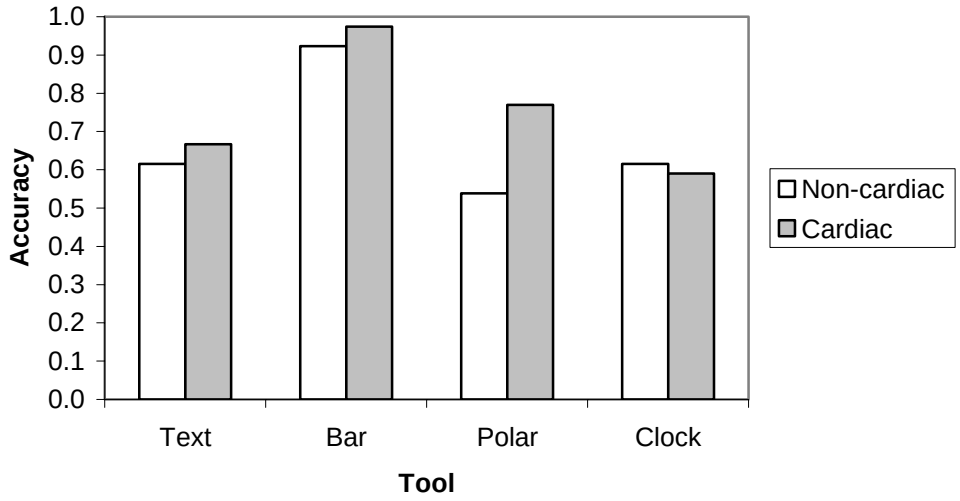


Figure 9-4: Accuracy of diagnostic judgements.

Response Time

The participant responded faster with the bar symptom map than with other tools although it did not reach a the significant level. Mean response time was 2505.0 milliseconds for bar while overall response time was 3770.6 milliseconds. On average, the non-cardiac problems took longer than the cardiac problems.

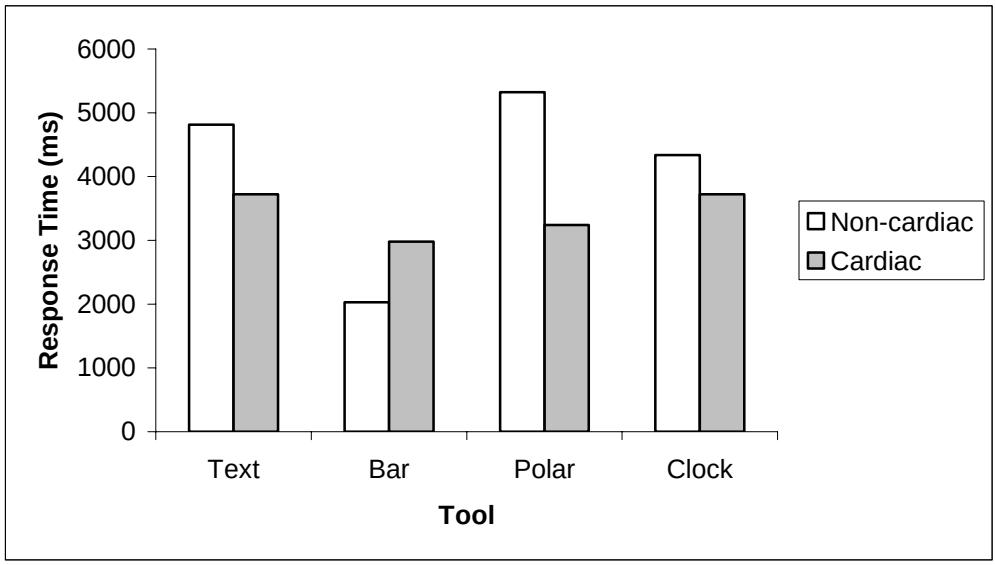


Figure 9-5: Response time for diagnostic judgements.

Confidence Level

The participants were significantly more confident when using the bar map for diagnostic tasks. On average the confidence level was 84.4% for the bar map in contrast to the clock map's 66.5%.

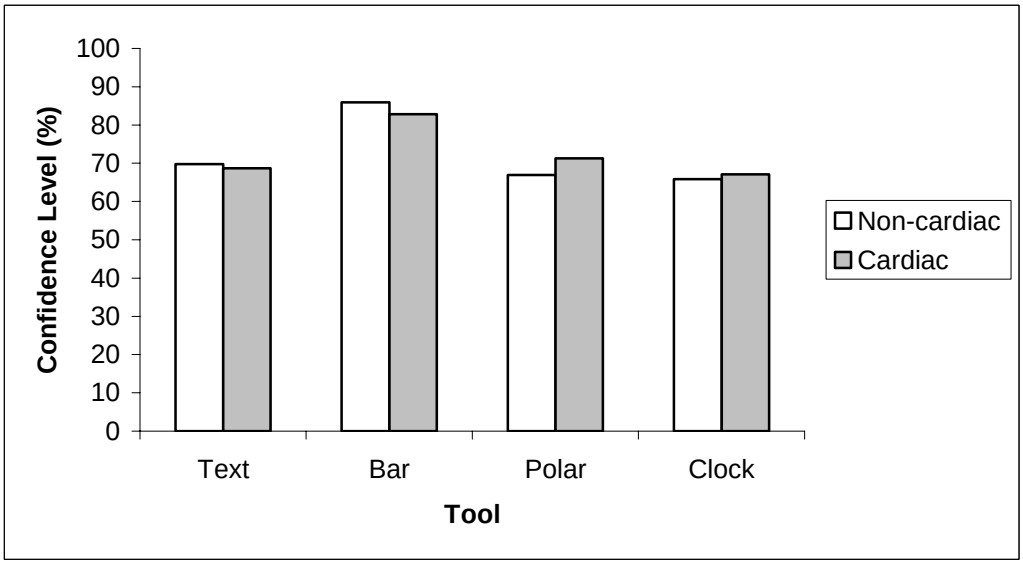


Figure 9-6: Confidence level of diagnostic judgements.

9.6.4 Post-experimental Questionnaire

All participants responded that visualization tools were useful when making judgements, and they thought they could perform better with more practice. For ease of decision making, the bar map was ranked easiest for diagnosis judgements while the clock map was ranked easiest for recommendation judgement.

Participants also provided positive and negative aspects of each visualization tool.

Positive aspects

- Bar: Easy to see the most likely conditions, makes the condition really obvious
- Polar: makes the most relevant symptoms more obvious to the user (eg. So it's easier to identify condition and not get distracted by potentially irrelevant symptoms)
- Clock: severity is obvious (angle, colour) so course of action is easier to choose

Negative aspects

- Text: does not show severity
- Bar: does not show severity. Some participants wanted the size of the cell to depend on how predictable the diagnosis is from a particular symptom.
- Polar and Clock: Time consuming to read all the symptoms in radial fashion rather than vertical or horizontal. If the symptoms were spread apart, it is difficult to gather information within eight seconds. On the other hand, it is easy if the symptom map is clustered. In addition, colour coding and axis arrangement take some time to get used to.

9.7 Discussion

9.7.1 Advantages of Visualization Tools

A clear mapping of diagnostic labels and sets of symptoms with the bar symptom map made diagnostic judgements straightforward. Participants did not have to remember the symptom lists, but they looked for a label with the most highlighted bar. When the diagnosis-recommendation mapping was relatively easy, participants were able to make a recommendation easily because they were confident about their diagnosis. Table 9-1 lists the advantages and disadvantages of all tools.

Table 9-1: Summary of Advantages and Disadvantages of the tools.

	Advantages	Disadvantages
Text	Simple, easy to implement. No design constraints (infinite number of conditions can be supported)	Does not show the seriousness/severity of patient's condition
Bar symptom map	Easy to understand and find a possible diagnoses if they are listed. Do not have to remember symptoms-diagnosis relationship Eye movement is linear	Only listed conditions are identifiable. Other conditions can be overlooked. (could be dangerous) If the bars are not completed, users can identify the possible questions from the list of bars
Polar symptom map	The clustering of symptoms helps users to identify the problem areas.	Arrangement of axes is hard (requires expert knowledge) Axis labels are hard to read (the labels must be short and easy to understand) If the symptoms are spread apart, it's hard to identify the problem.
Clock symptom map	The colour coded symptom axes helps to identify the patient's condition in order of severity. (can be identified online)	*same as the above

The polar map improved participant judgements with the cardiac patient profiles but the text and clock maps did not. However, the polar map was the worst performer with common illness patient profiles. The polar map appeared to be more useful when symptoms were concentrated in one segment of the map. In this case the map forms a larger and more distinct shape.

The clock condition scored higher accuracy with the non-cardiac patient models than that with cardiac patient models in both judgement tasks. Some of the cardiac patient models required decision makers to know the type of problems to correctly diagnose and recommend a course of action rather than the severity of the condition. For example, when a patient is experiencing an incision related problem, the patient is more likely to be referred to the UOHI rather than to a family doctor.

9.7.2 Difficulty Levels of Judgements

Some patient conditions are easier to make decisions than others. For example, late cardiac tamponade is a condition that is known to be very difficult to identify even by cardiac nurses because each of its symptoms appears in other conditions so that none of the symptoms serves as a strong contributor to judgements; consequently, decision makers have to integrate multiple cues to make accurate decisions. "Mono" and "flu" exhibited the same difficulty in the non-cardiac portion of the experiment.

In addition, some participants mentioned that when a list of symptoms is short and succinct, text lists were adequate to make a quick and accurate judgement rather than reading circular axes of the

polar or clock map; however, if problems were more complex, it became harder to remember each entry on the text list and integrate them. For example, “cough” and “fever” are easier to read than “feels better when sitting up”, or a list of three symptoms is easier to read than a list of eight symptoms.

Based on the overall accuracy, “cardiac tamponade”, “mono” and “flu” are classified as difficult and others are classified easy. Figure 9-7 and Figure 9-8 shows the comparison of the accuracy measurements in recommendation and diagnostic judgement respectively. The difference of the performance with text display between easy and difficult problems indicates that the text display is not sufficient for complex problem solving and additional visualization tools help the decision makers.

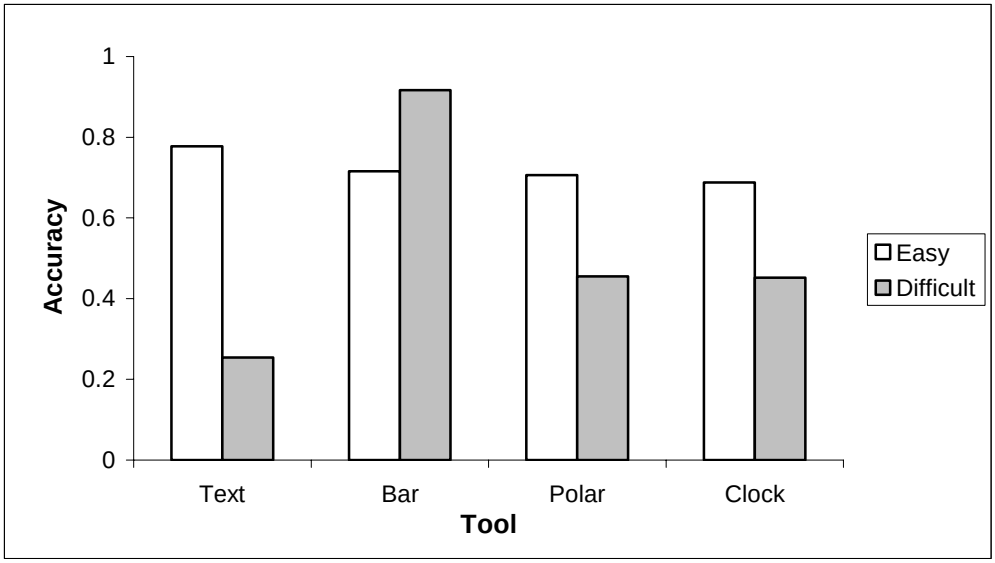


Figure 9-7: Accuracy of recommendation judgements against difficulty level.

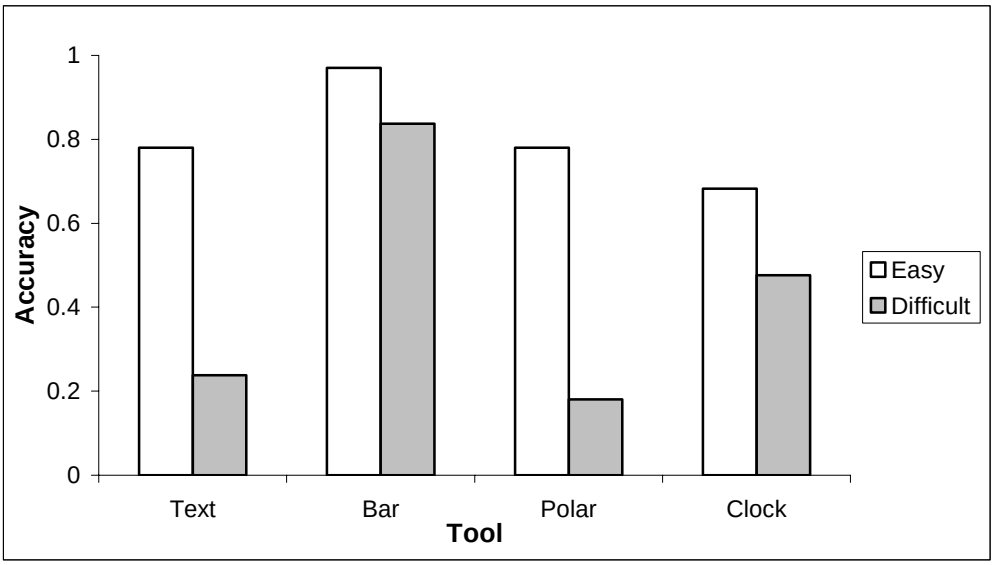


Figure 9-8: Accuracy of diagnostic judgements against difficulty level.

9.7.3 Polar versus Clock Map

The polar and clock symptom maps produced mixed performance results. Since the axes of the clock map are arranged in order of severity, it is easy to identify if a patient exhibits a severe condition. However, symptoms can be spread all over the map making it harder to observe them as a set. Thus it is more difficult to integrate the information set. On the other hand, the axes of the polar are designed to form meaningful groups if the condition of the patient is characterized by concentrated symptoms. The map forms a larger cluster indicating a problematic area and making it easier to make a judgement. This suggests that neither of them is superior for all conditions.

Although many participants stated that it was easy to judge severity of the symptoms using the clock map in the post-experimental questionnaire, the accuracy of the judgement in both the diagnosis and the recommendation tasks were the worst among all conditions on average. Since the response time on both tasks for the clock map was shorter than the polar map, the participants might have just looked at the highest severity point and did not spend time integrating other symptoms. For some cases, the strongest cue is enough to make correct recommendation judgements; however, others require integration of information. The polar symptom map was the least favourite, reported in the post-experimental questionnaire, by most participants; however, some participants preferred the polar and disliked the clock map. Considering that they only spent three trials on one particular tool in each patient domain, it may have been difficult to switch between the different tools. The similarity of the clock and polar maps in visual appearance may have added an additional layer of difficulty to an

already difficult task. Participants who found one tool especially useful appeared to look for patterns more eagerly with that tool than with the other ones. Performance suffered when they employed the wrong strategy.

9.7.4 Order Effects

To examine possible learning effects, participants were grouped in a same block sequence of visualization tools. There are four order groups and the orders are counter-balanced as in Table 9-2.

Table 9-2: Counter-balance Sheet

		Block #			
Order #	Participant #	1	2	3	4
1	1, 5, 21	Text	Bar	Polar	Clock
2	14, 18, 21=2	Bar	Clock	Text	Polar
3	7, 11, 15, 19	Polar	Text	Clock	Bar
4	4, 8, 24	Clock	Polar	Bar	Text

As shown in Figure 9-9 and Figure 9-10 no learning effects were observed. However, interference between the polar and clock symptom maps was observed. It was noticed that when the polar map was assigned to a participant right before the clock maps, they were less accurate with the clock map than with the polar, or vice versa. This was observed in all participants in order group 1 and 4 except one who indicated that he did not understand how the clock map worked.

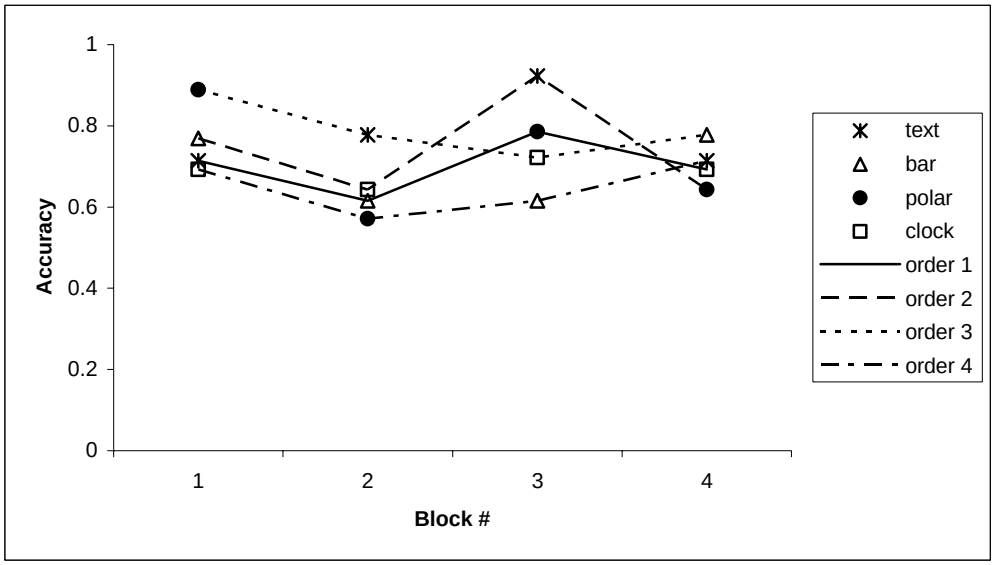


Figure 9-9: Accuracy of recommendation judgements separated by order groups.

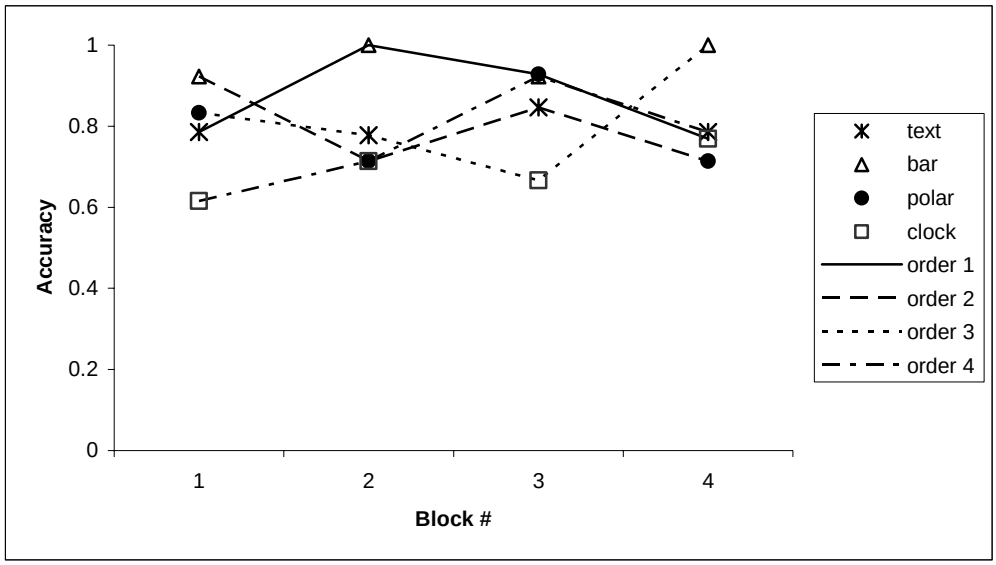


Figure 9-10: Accuracy of diagnostic judgements separated by order groups.

9.7.5 Confidence and Accuracy

Accuracy was plotted against confidence level. Each data point is the mean of individual participant's accuracy measurements. On average, participants were slightly over confident (71.7% confidence level for 0.673 accuracy in recommendation judgements and 72.3% confidence level for 0.715 accuracy in diagnostic judgements).

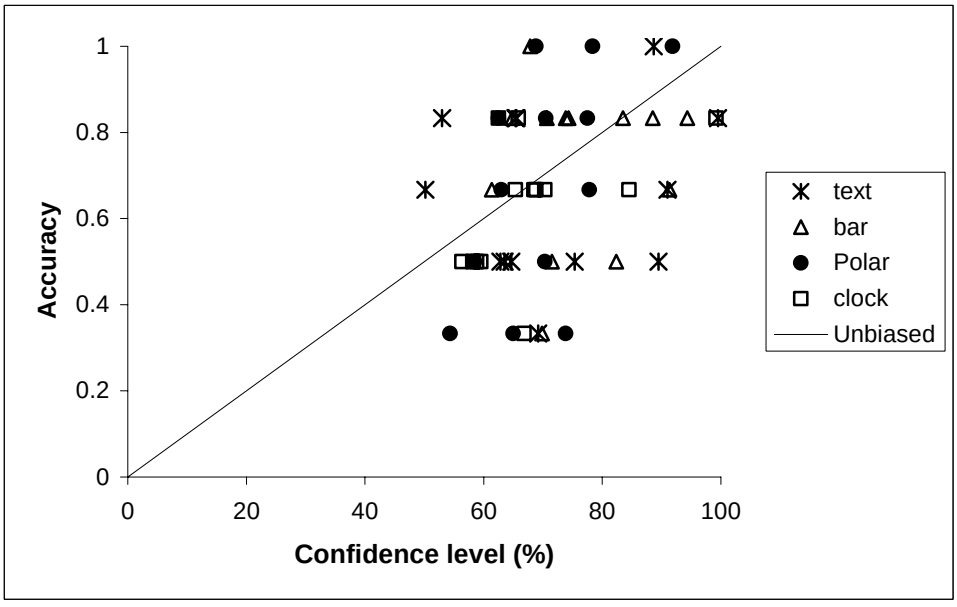


Figure 9-11: Accuracy plot over confidence level for recommendation judgements.

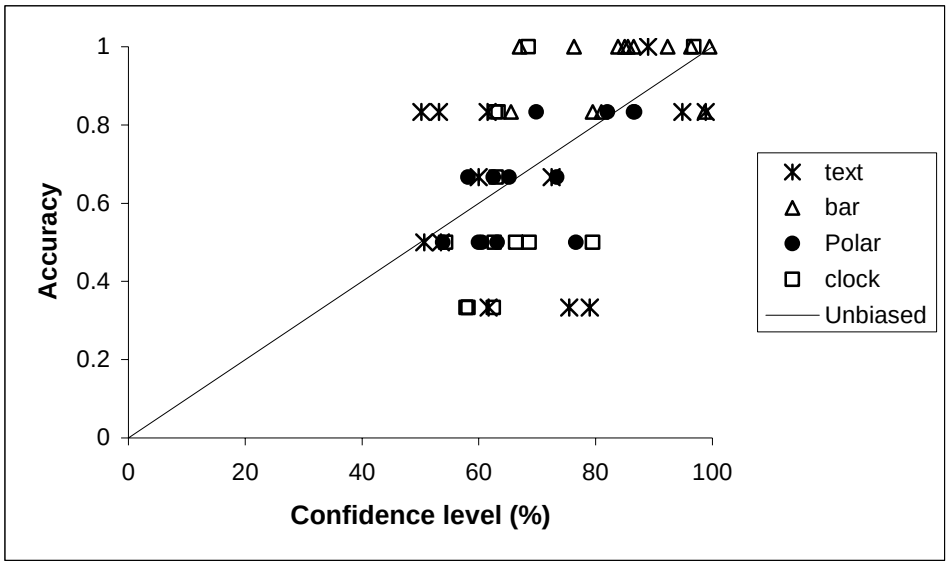


Figure 9-12: Accuracy plot over confidence level for diagnostic judgements.

9.8 Feedback from the UOHI Team

The visualization tools and experimental results were presented to the UOHI medical professional group to obtain feedback.

- The bar symptom map is very easy to understand and similar to what the nurses have in their minds especially highlighting and crossing-out operations.
- The polar and clock maps are interesting, but do not show the diagnostic labels.
- The concept of clock map might not be applicable for some cases because it is not possible to order the criticality of individual symptoms for all patient conditions.
- Reading the axes of the polar and clock maps is hard.
- It's not possible to list all possible conditions. Even if it was possible, it would be difficult to see them at once.

9.9 Summary

Each symptom map has different advantages and disadvantages and the performance of the decision varied depending on the type of problems they need to deal with. A visualization map that would integrate all three tools is needed to support the decision processes for various complex problems. The tool should help decision makers consider more options by drawing attention to the possible conditions based on the given symptoms

Chapter 10
New Design

Findings from Experiment I suggest that none of the three visualization tools maybe sufficient. The positive effects of visualization tools on the decision process were observed especially with the bar symptom maps. This chapter examines the shortcomings of the tools to develop a new visualization that can better aid the users.

10.1 What is Missing?

The three types of visualization tools studied in Chapter 9 were designed to achieve different functionalities; namely;

- The bar symptom map - to aid rule-based behaviour ("ruling out" and "hypothesis testing" strategies)
- The polar symptom map - to identify problematic area ("topological search" strategy)
- The clock symptom map - to assess the criticality of the patient condition

As pointed out previously one can consider the clock map as a tool to view the condition in a more abstract level because the criticality of the patient is directly associated with the patient survival and improvement. On the other hand, the polar symptom map shows information at lower levels of abstraction. Depending on the type of problem that a patient has, a nurse needs to jump around different levels of abstraction to understand what is happening in their work domain. Another piece of information that cannot be extracted from the work domain is diagnostic labels. Diagnostic labels can be considered as a conventional categorization of patient conditions, which a nurse learns from school and experience. Some diagnostic labels can be defined with a specific physical status of a patient or components (physical forms). The bar symptom map connects those symptoms to diagnostic labels. The NCs make decisions based on the information that contains all aspects. Therefore, none of the tools was sufficient for the users to make judgement for different kinds of patient conditions.

10.2 Integrated Visualization Tools

Expert decision makers should be able to hop among different supports during the consultation. Due to the small screen, displaying all three tools on one screen is not possible because the text would be too small or the screen would only show a small part of the tool at a time and users would need to scroll through the display. Therefore, designs of an integrated visualization tool, that encompass the three aspects, were explored and two alternatives are proposed.

10.2.1 Semantic Network Symptom Map

A new visualization tool was designed based on the semantic network concept. This map consists of symptom nodes and diagnostic labels and they are connected based on the principles of physiology and nursing practice. As in a semantic network, activation of one symptom node in this map influences neighbouring diagnostic labels. For example, the diagnostic label "ischemic pain" is connected to nine different symptom nodes and five of them are activated in Figure 10-1. The ratio of activated to non-activated nodes determines the activation level of the diagnostic nodes.

This symptom map shows linkages among different symptoms and conditions and decision makers would naturally shift their attention to more activated nodes. Although the entire symptom map does not fit on a PDA screen, the focus should be easily shifted to show the nodes of interest. The diagnostic labels are roughly divided into "cardiology" on the top-left, "surgery" on the top-right, and "non-cardiac problems" on the bottom of the map. This would create abstract spatial map in the users' mind when repeatedly used.

10.2.2 Modified Bar Symptom Map

The semantic network symptom map might not be accepted by nurses because of limited exposure to the concept. As an alternative, the bar symptom map was modified to have similar features as a semantic network. This modified bar map makes use of labelling and dynamic arrangement of the cells and uses the same colour scheme as the semantic network symptom map does. As more symptoms are activated, more focused diagnostic labels would be placed higher on the left column (Figure 10-2). The size of each cell is adjusted according to the level of focus as well. If users like to see less focused rows, they can select them by tapping on any of the cells. This collapsing capability should be useful for a PDA's small screen. Decision makers will be aware of other possible diagnoses, even though they might not be able to see the details.

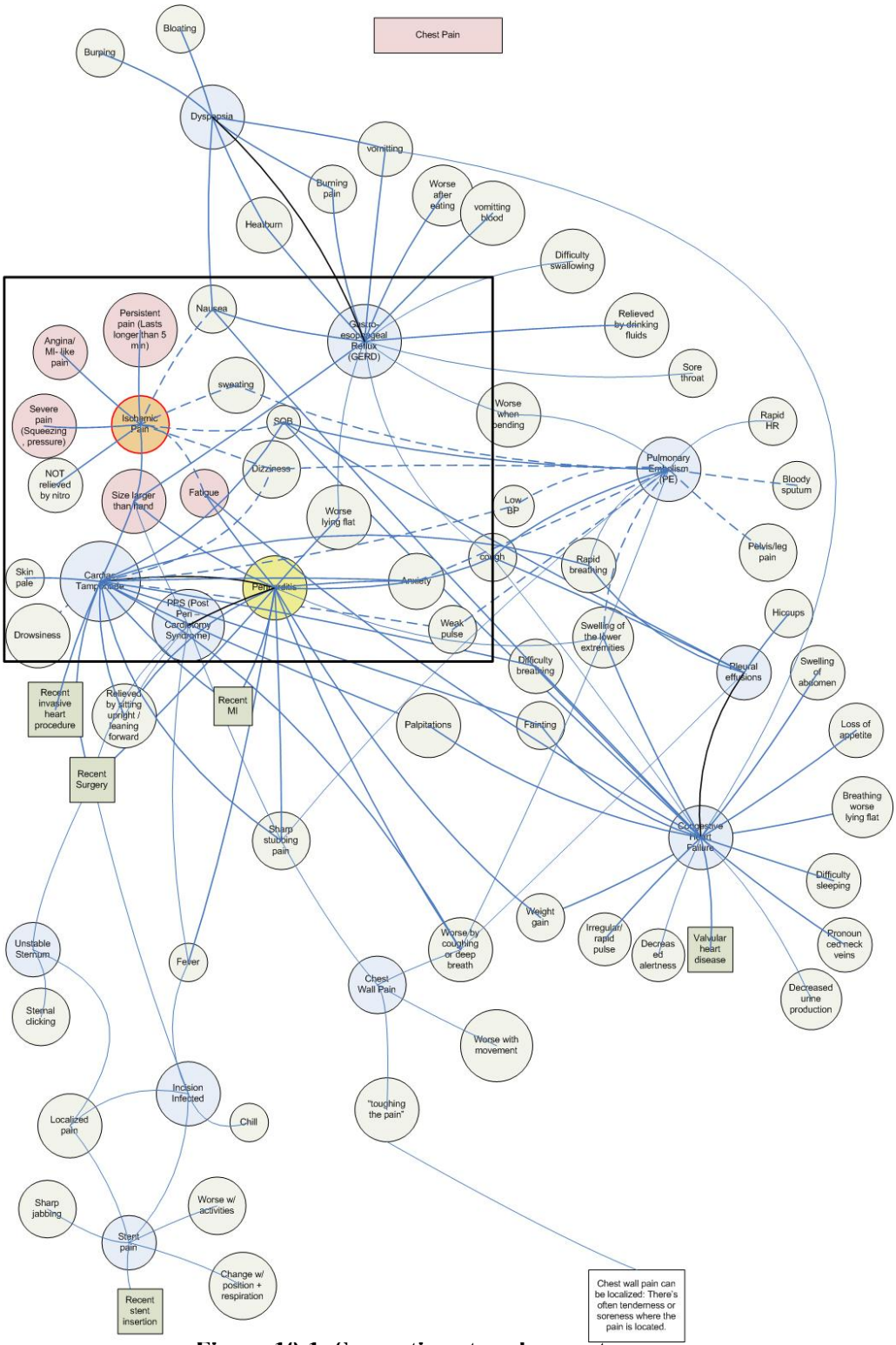


Figure 10-1: Semantic network symptom map.

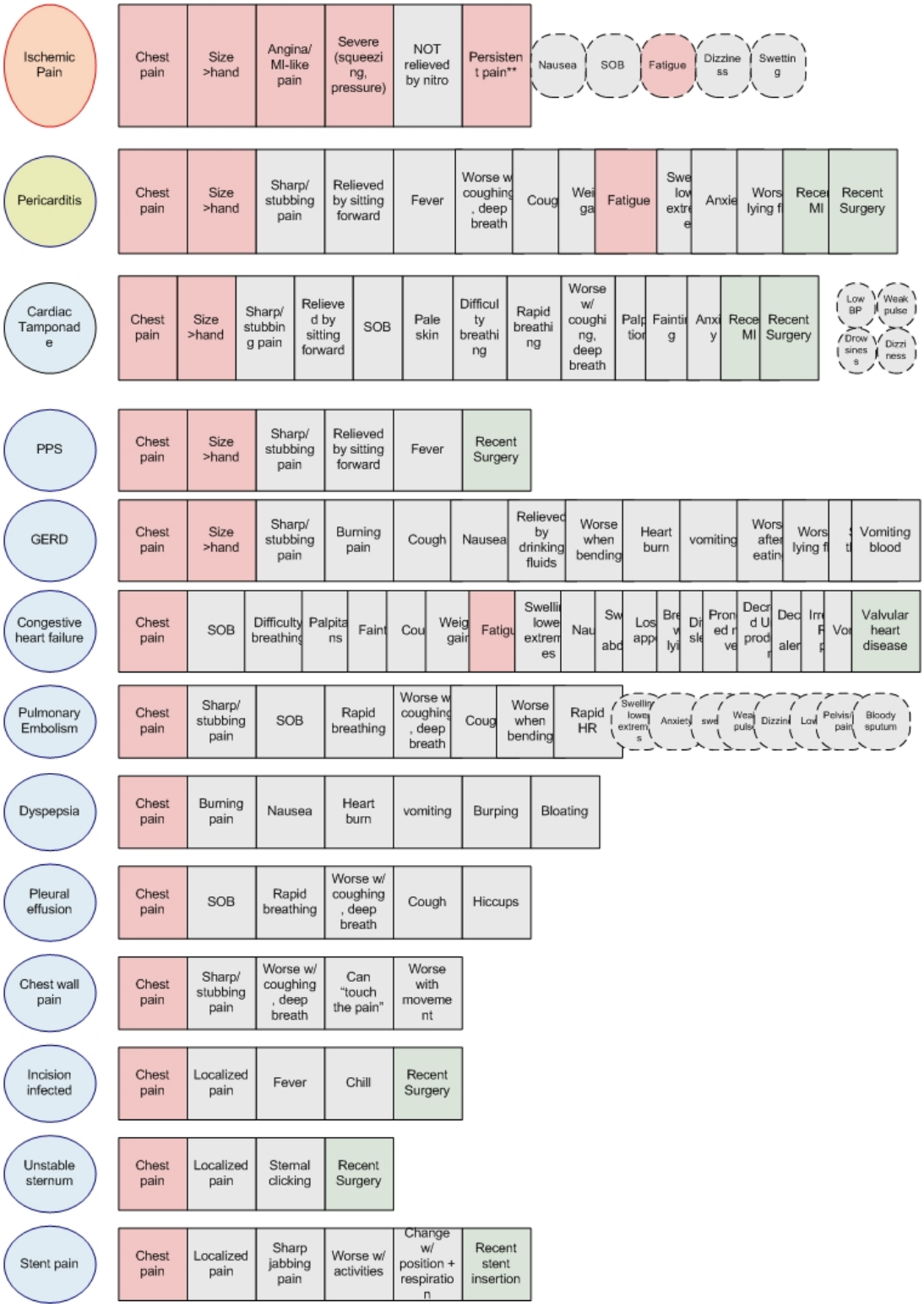


Figure 10-2: Modified bar symptom map.

10.2.3 Interface Elements for the Semantic Network Symptom Map

Although the acceptance level of the semantic network symptom map is questioned, the team decided to test how this tool aids the decision process. Interface elements for this tool were designed for the implementation on a PDA. When being programmed, basic capabilities of a decision tree tool were re-used for the new tool. For example, drawing and data collection routines were shared with the existing tool.

Symptom Nodes

Both symptom and diagnostic nodes can be "in focus" by one tap. When a node is in focus, it gets centred in the display and a thick square is placed around. A symptom node can be activated if the patient has the symptom (Figure 10-3). If a user taps on an activated (yes) node, it will then be crossed out indicating the symptom is not present. Users can toggle the three states by tapping through so that they can make corrections if they make mistakes.

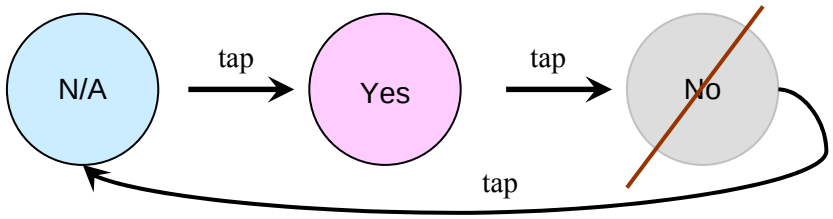


Figure 10-3: Three states of a symptom node.

Diagnostic Nodes

Each diagnostic node is connected to the related symptoms and changes colour accordingly to its activation level. Figure 10-4 shows a diagnostic node and the colour scheme that is used to encode the activation level. Although the colour bar is not provided explicitly in the tool, it would be intuitive enough for users to learn the colour scheme. The information icons are placed on the diagnostic node to provide definitions and other information as in the decision algorithms. When the tool is loaded, the node at the highest criticality (i.e. ischemic pain) would be centred to remind the users to ask important questions.

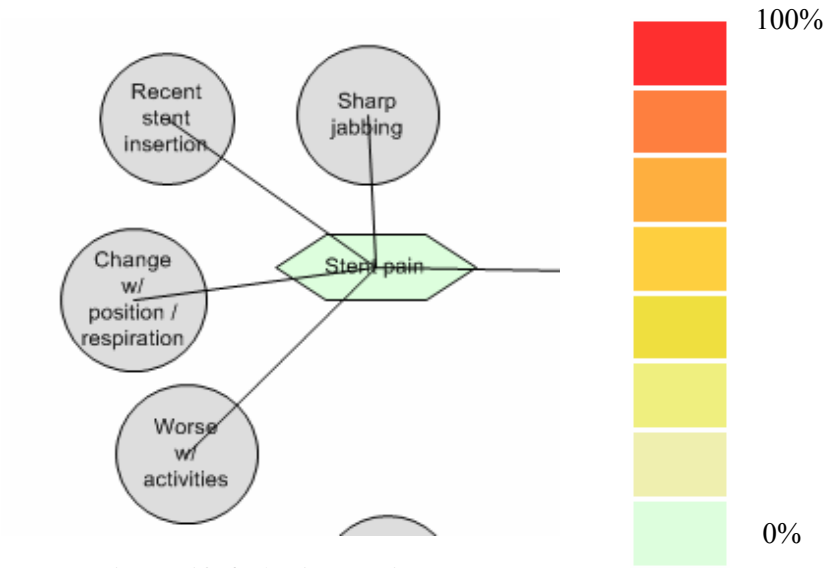


Figure 10-4: A diagnostic node and the colour scheme.

Indicator/Navigation Bar

A navigation aid is added to the map to mitigate the disadvantages of the small display. As in Figure 10-5, the indicator/navigation bar is placed on the right side of the display. While the focus of the tool moves around the network map, the indicator remains at the same place. The indicator lists all the diagnostic labels that are in the map and each cell has the corresponding colour to the diagnostic label. When the user taps on the indicator bar, the corresponding diagnostic label would be centred. For example, cardiac tamponade (abbreviated as "Tamp") in Figure 10-5 has the highest activation level, in which the user is usually interested. This indicator/navigation bar provides means to hop between highly activated diagnostic labels to examine the surrounding symptoms.

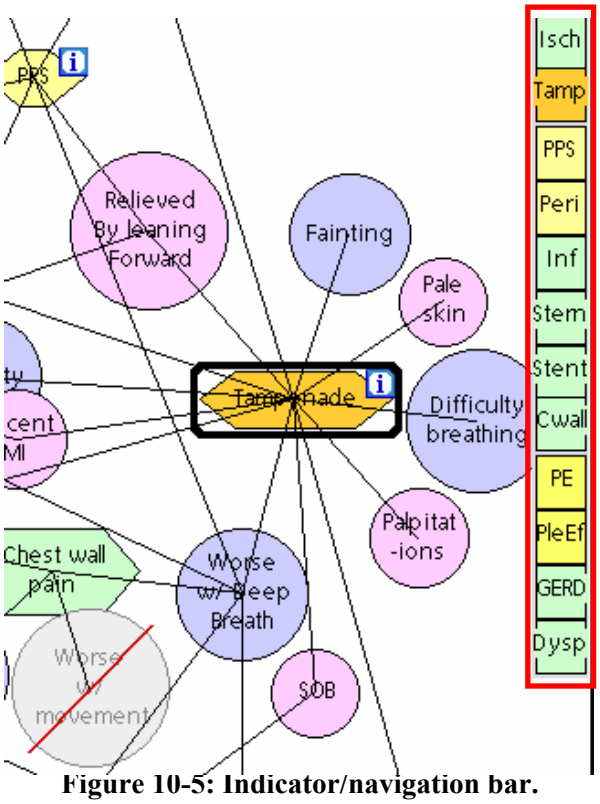


Figure 10-5: Indicator/navigation bar.

10.3 Discussion

Both the ecological visualization tools proposed have interesting dynamic capabilities. Users would be easily guided by the dynamic movement of focus throughout the inquiry process until the users feel comfortable to make a judgement. Having context around their focus, they can be reminded of other possibilities and they can decide whether they should ask additional questions. Based on the interviews and analyses, it appears that the mental process of the NCs is close to the dynamic linking of these symptom maps. Although they might not visualize the linkage explicitly, the natural shifts of hypotheses as questioning progresses indicate that there are multiple possibilities from the hypothesis in focus rather than a binary decision tree. While the expert may be aware of context, the novice may not know if there are other possibilities. Although visualization tools were designed as additional features to decision algorithms, they might support user's decision processes sufficiently alone.

The decision algorithms and the semantic network symptom maps aid decision makers in different ways. It is therefore expected that users would behave differently if they understand and use the tool's features. The semantic network symptom map is selected to test against decision algorithms and the OLDCAR checklist. The OLDCAR checklist was added to the comparison because it aids a different

type of decision process. These three decision supports were combined with the electronic TelePractice Documentation Record (TeleForm) on the PDA. The next chapter describes Experiment II to examine the effects of different decision support on the telephone consultation process using simulated telephone consultation processes in a laboratory setting.

Chapter 11
Experiment II

The experiment described in this chapter investigated the effects of decision support tools on cardiac nurse decision processes during telephone consultation. While the performance measurements were important, this study also focused on the strategies participants employed with respect to the type of decision support tool available. Decision support was implemented on a PDA.

The results of this experiment can be used to select a desired type of decision support tool when the users know what strategies need to be supported for particular tasks. Based on the known benefits, the tools can also be used as training tools to reinforce specific behaviours. In addition, the tools can be arranged in the DSS in such a way that the user would benefit most. A strategy study of this kind had not been done in the past; thus, it would benefit the theoretical development of the EID process. Documents that are used for the experiment are included in Appendix F.

11.1 Hypothesis

It was hypothesized that a particular decision support tool induces decision strategies that are compatible to the tool; thus the behaviour of the participants can be classified. All four experimental groups contained the basic forms to collect patient history, presented problems, and a disposition page. These were considered to be minimum support since the current paper-based form includes similar categories.

Group 1: TeleForm only

This group acted as a control group in this experiment. The participants in this group were expected to ask questions freely. Therefore, individual variability of question sequence or recommendation would be the highest compared to the other groups. They were expected to ask more open-ended questions and anticipate the patient to provide descriptions before deciding on a strategy.

Group 2: TeleForm and the OLDCAR

The participants in this group were expected to spend more time on obtaining a full description of the primary complaints. The integration of the information might be difficult and it might not lead to a recommendation. They were might navigate back and forth within or between the OLDCAR and TeleForm during the consultation resulting in varying sequences of questioning

Group 3: TeleForm and the decision algorithms

This group was expected to show the most consistency in the consultation process and question set. Although some questions might be added, questions that are not on the decision algorithm were less likely to be asked. Since the tool provides recommendation and advises at the terminating boxes, this group were expected to have higher accuracy in recommendation judgements. The participants were more likely to arrive at their decision fairly quickly and efficiently. There were three decision algorithms for patients with chest pain: "Possible Ischemic Pain", "Incision Healing Well", and "Incision Not Healing Well." The participants were expected to choose an appropriate algorithm from the set after asking a few questions at the beginning.

Group 4: TeleForm and the semantic network symptom map

The participants have freedom to choose the order of questions on the symptom map; thus the question sequences were likely to exhibit more flexibility. The questions were expected to be more relevant to diagnosing the patient condition and questions might be more selective. It was expected that the participants in this group might have some difficulties in understanding of the concept. Slow loading and refreshing of the network map was expected to add more difficulty to the users.

In this chapter, experimental conditions, group 1, 2, 3, and 4 are referred as "Form", "OLDCAR", "Tree", and "Network" respectively for readability.

11.2 Design

The experiment had a between-participants design with four conditions using the above decision support tool prototypes. The form condition served as a control and was considered to possess minimal support. Participants interacted with an assigned tool while talking to a medical professional acting as a patient over the phone. Four representative patient models, "ischemic pain", "cardiac tamponade", "PPS", "stent pain", were used for the simulation. The patient models were selected to cover different levels of criticality and different types of patient (see Table 11-1). Participants used the DSS to guide their consultation processes; however, they were not instructed to ask particular questions to their patients. At the end of each call, they made decisions on a possible diagnosis and recommended a course of action to the patient.

Table 11-1: Four Patient Models

	Cardiology	Cardiac Surgery
Urgent	Ischemic Pain	Cardiac Tamponade
Non-urgent	Stent Pain	PPS

11.3 Method

Empirical data collection was conducted at the UOHI. Participants' interaction with the tool was recorded by the embedded logging system on the PDA. Since the primary purpose of the study was to evaluate the tool by examining strategies, the "Patient Info" page was pre-filled by the experimenter and the participants were not required to fill "Summary", "Assessment", and "Advice & Counselling" pages to minimize the participants' time commitment. The conversation between the participant and the mock patient was recorded through microphones. The experimenter sat in the same room during the calls and recorded any notable observations.

11.3.1 Participants

Sixteen cardiac nurses were recruited at the UOHI. The NCs were excluded from this recruitment because of their established individual strategies. All participants were females and all had normal or corrected-to-normal vision. Their exposure to electronic devices was pre-sampled so that the participants were balanced across experimental conditions as much as possible. Five participants participated in the Somoza' baseline study (Somoza, 2006), and the others were recruited by word of mouth. All participants were recruited from the same pool of cardiology and surgery nurses as Somoza's study, and there was no notable difference between the two participant groups.

11.3.2 Apparatus and Stimuli

The DSS ran on the PDA, Tungsten 3 (T3), and was controlled by the participants with the stylus, the hard buttons, and/or the participants' thumbs. They were advised to keep T3's extendable field at the maximum position. The participants made their entries using check boxes, dropdown lists, and toggle buttons. The participants used a numbered entry form on a piece of paper to record the entry when any field required writing, and entered the corresponding number in the filed on the DSS. They were not allowed to make any notes excepting the paper entry specified above. There was no required field on the tools so that the participants were not forced to follow certain paths.

11.3.3 Procedure

The participants filled out a pre-experimental questionnaire prior to the experiment. They were seated comfortably with a speaker phone and the PDA. Each participant read the information letter and

signed the informed consent form. The experimenter answered any questions regarding the general design of the experiment. The participants went through a power point tutorial on how to use the system and completed a practice session with the experimenter before the experimental calls. The practice session included a walk through of a chest cold scenario and interaction with the tool while generating questions. Note that interaction with mock patients over the phone was not practiced. In each experimental patient model, the participants were instructed to ask as many questions as they liked until they felt comfortable to make their judgement within a time limit of ten minutes. The participants gave recommendation to patients and ended the call. They were informed that they were not required to fill every field in the DSS.

The participants received four experimental phone calls from the mock patient and interacted with the DSS. After completion of each trial, they filled a short post-trial question set. They were also asked to complete post-experiment questionnaire after all four call simulations. The participants were debriefed, offered a copy of the consent form and thanked for their participation.

11.3.4 Time Involvement

A maximum of ninety-minutes of commitment was approximated for the entire experiment including training and debriefing, but not including the pre-experimental questionnaire. The participants were told that each simulated consultation was limited to ten minutes, but no one exceeded the time limit before they arrived at their recommendation. The time involvement varied depending on the type of tools the participants used as well as individual differences.

11.4 Pilot Study

Four students at the University of Waterloo volunteered to do pilot studies. Since they did not have cardiac knowledge, only the tree and network groups were tested. These two tools were considered to possess enough support for the novices to make decisions. The complexity of the form and OLDCAR conditions is low; thus they were expected to have much less difficulties. The pilot study was mainly used to measure the participants' commitment time and level of stress they experienced. The first two participants went through the experiment with the experimenter in front of them and interacted with the tool. Both the participants provided feedback on the training slides to improve the understanding of the system before the experiment.

The other two participants for the pilot study completed exact procedures as the actual experimental procedures. The participant in the tree condition completed all calls very quickly. Because she did not have prior exposure to cardiac knowledge, she was forced to go through the decision trees step by step. On the other hand, the participant in the network condition felt that she

needed to ask many questions to feel comfortable with her decisions. In the semantic network symptom map, each diagnostic label is connected to typical symptoms; however, the patient does not have to have all symptoms to be diagnosed for a particular condition. Therefore, the users have to make judgement on how much information they need to make decisions based on their cardiac and/or nursing knowledge.

11.5 Results and Analysis

The conversation between the participant and mock patient was transcribed by the experimenter and sent to the nursing researchers to be assessed the quality of the consultation. For strategy analysis, each question was categorized into question types (open-ended, directed-multiple answers, binary) and also the categories of OLDCAR. The results were compared among experimental conditions. The documents related to the questionnaire response and experimental analysis are included in Appendix G

11.5.1 Participants Demographics

The pre-experimental questionnaire indicated that some of them are specialized in one of the two departments of cardiac care although many responded that they work in both areas (Figure 11-1). During the experiment, a few of those participants voiced their frustration of not being familiar with some conditions. However, those with less experience appeared to follow the tool's advice more than more experienced nurses. For example, participant 17 repeatedly said that she did not know surgery patients, but completed the consultation quite successfully using the decision algorithm in the PPS simulated call. She commented that the tool was particularly helpful for cardiac surgery patients.

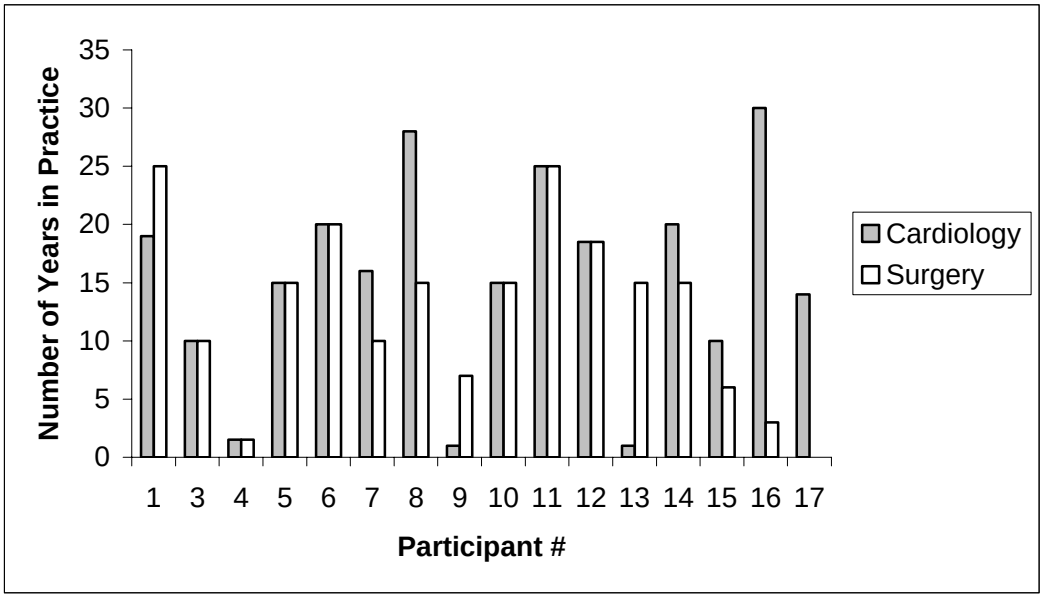


Figure 11-1: Number of years in practice in cardiac care.

Exposure to electronic devices was also asked. Majority of the participants were familiar with everyday computing. The usage of mobile devices and the comfort level with PDA devices varied in response. Some gave ten (Everyday) while some others gave zero (never) to the mobile device usage. Regardless of the level of prior exposure to technology, many participants commented that they would perform well with the tool once they become familiar with it.

11.5.2 Effectiveness Rating

The transcribed conversations were scored by two nursing researchers. The effective rating system was developed by the two researchers at the UOHI and used to score Somoza's (2006) results. The rating was reviewed by a number of medical professionals at the UOHI. It was informed that there have been a few minor revisions since Somoza's study to improve the scoring system. An effective rating was defined for each of the four patient models and consisted of a list of questions that were considered to be essential to diagnose and make recommendation to a patient in the condition. Each effective rating scheme consists of five categories; "establishing context", "quality of assessment", "quality of recommendation", "correctness of diagnosis", and "severity assessment." The effective rating schemes and the scores are included in Appendix G-3. The focus of the scoring scheme varied depending on the patient model, and one or two points were awarded to the questions accordingly to the importance.

Establishing Context

The scores for "establishing context" measured whether the participant gathered important background information about the patient in order to proceed with their assessment. The questions may vary depending on the patient models. All tool groups did better (Average achievement for Form: 89.1%, OLDCAR: 88.1%, Tree: 86.3%, Network: 88.8%) in this category compared to the baseline research done by Somoza (2006) (Average achievement: 70.1%). The repeated measure ANOVA revealed significant difference between the results from the baseline and this study ($\alpha < 0.05$), but not among the four experimental groups. Note that Somoza's baseline research used a similar protocol with no decision support in conducting the experiment. In addition, the participants in her research were provided a piece of paper and a pen as aids.

The positive effects of the tools over the baseline study indicate that the history page on the TeleForm could have acted as a reminder to learn relevant history. Although some participants skipped the page at the beginning, some remembered to come back to fill the page during the conversation.

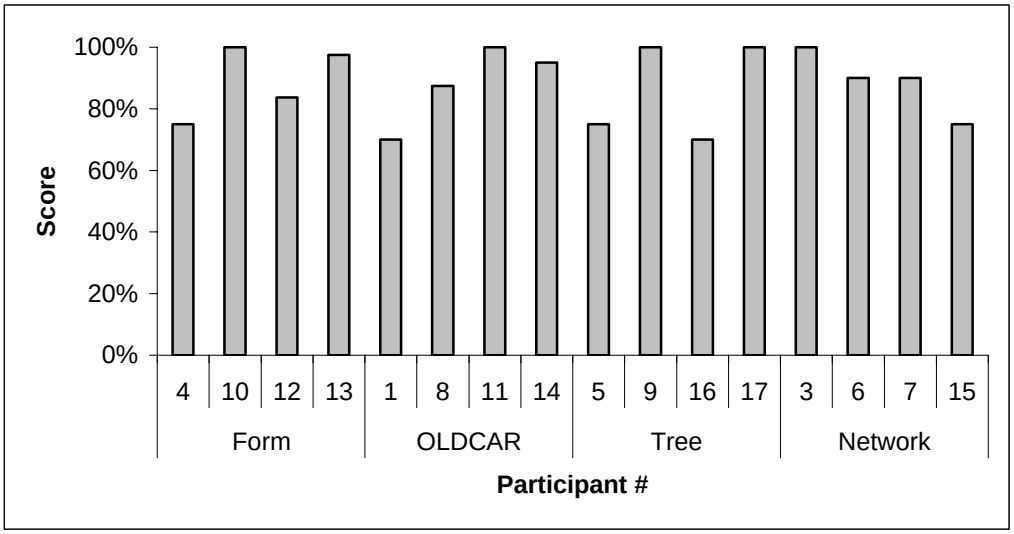


Figure 11-2: Scores for establishing context.

Quality of Assessment

The scores for the quality of assessment are defined by the importance of a particular question to make an accurate judgement. Excepting the form group, the tools improved the quality of assessment (Form: 34.6%, OLDCAR: 55.3%, Tree: 39.8% and Network: 41.0%) compared to the baseline study (Somoza, 2006: Average score: 37.5%). The participants in OLDCAR group did significantly better

than all other tool groups ($\alpha<0.05$). All the criteria listed in the scoring sheet are considered to be essential to understand the patient conditions. Thus the scoring criteria are more compatible to knowledge-based behaviour than rule-based behaviour. Among all tool groups, OLDCAR aids to gather the most information related to the patient's conditions while decision algorithms and symptom maps provide ways to shortcut the process. For this reason, this knowledge-based scoring system might not be suitable to evaluate expert behaviour especially when they are dealing with fairly representative patient conditions.

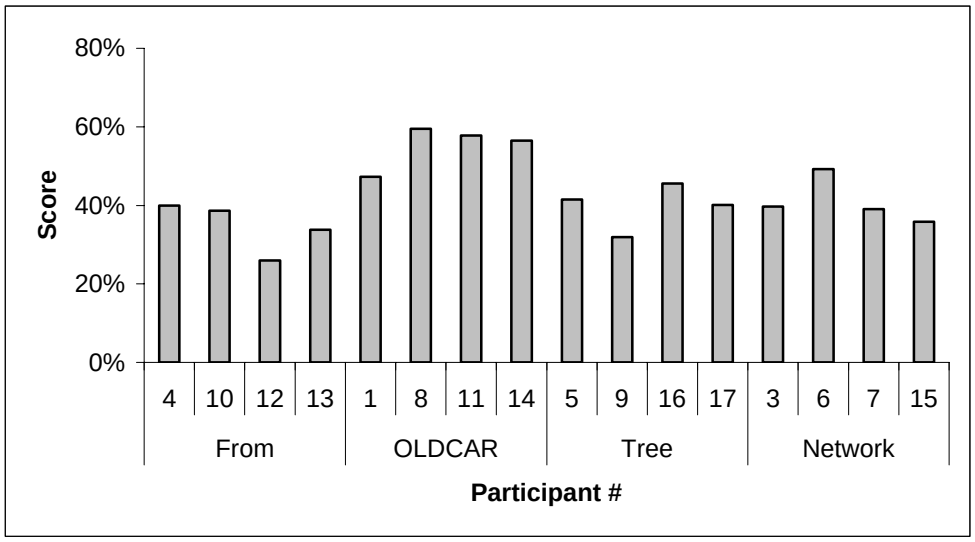


Figure 11-3: Scores for the quality of assessment.

Quality of Recommendation

Quality of recommendation was evaluated by the recommended course of action. In the case they advised the patient to perform homecare procedure, the decision makers must ensure that the patient does not have allergies or provide additional precautious advice in case the condition gets worse. Figure 11-4 shows individual scores on the quality of recommendation. On average, all groups performed better than Somoza's (2006) baseline test (Form: 38.0%, OLDCAR: 31.3%, Tree: 55.1%, Network: 32.5%, and Baseline: 30.4%). The tree group performed consistently better than other tool groups across different patient models (see Figure 11-5). Because of the individual variability and the small sample size, the difference in the effects did not reach the significant level. As seen in the figure, it is more difficult to give a high quality recommendation for non-urgent conditions because non-urgent patients require more caution than those to be sent to urgent care institutions for their increased uncertainty of the trajectory. The reminders placed in the decision algorithms helped the

participants in the tree condition to ensure the safety of the patient when recommending. For example, one participant did not read the terminating nodes for PPS before ending the call and agreed that she should have asked allergy related questions before recommending certain medications. To further enforce patient safety, various reminders can be placed on the disposition page additionally.

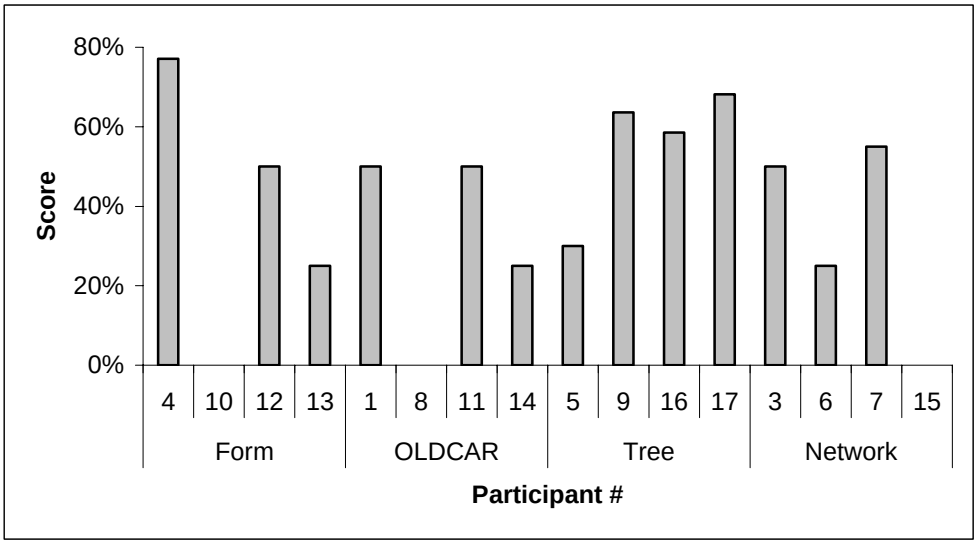


Figure 11-4: Scores for the quality of recommendation.

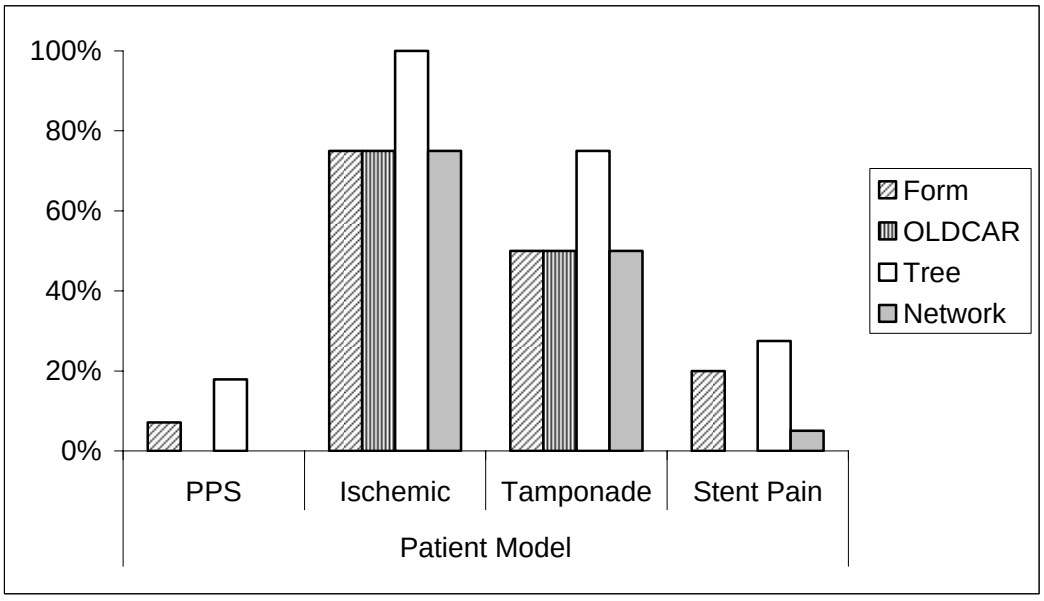


Figure 11-5: Scores of the quality of recommendation by patient models.

Correctness of Diagnosis

The participants provided a possible diagnosis for each patient model. The answers were assessed by the two nursing researchers. Figure 11-6 shows the individual correctness of conclusions. On average, all tool groups did better than Somoza's (2006) baseline condition (Form: 56.3%, OLDCAR: 46.9%, Tree: 53.1%, Network: 62.5%, and Baseline: 39.6%). The network participants performed better than other groups because of the symptom-diagnosis mapping, but the difference did not reach to the significant level. Among high scoring participants, participant 1, 4 and 9 participated in Somoza's study; therefore, there might have been learning effects by the exposure to the phone consultation process. Figure 11-7 shows the data arranged in terms of the patient models. Cardiac tamponade is the hardest to diagnose among others and this was consistent with Somoza's study. Congestive heart failure (CHF) has many symptoms common to cardiac tamponade and it is more prevalent. Therefore, many participants hypothesized the condition being heart failure and could not eliminate the possibility.

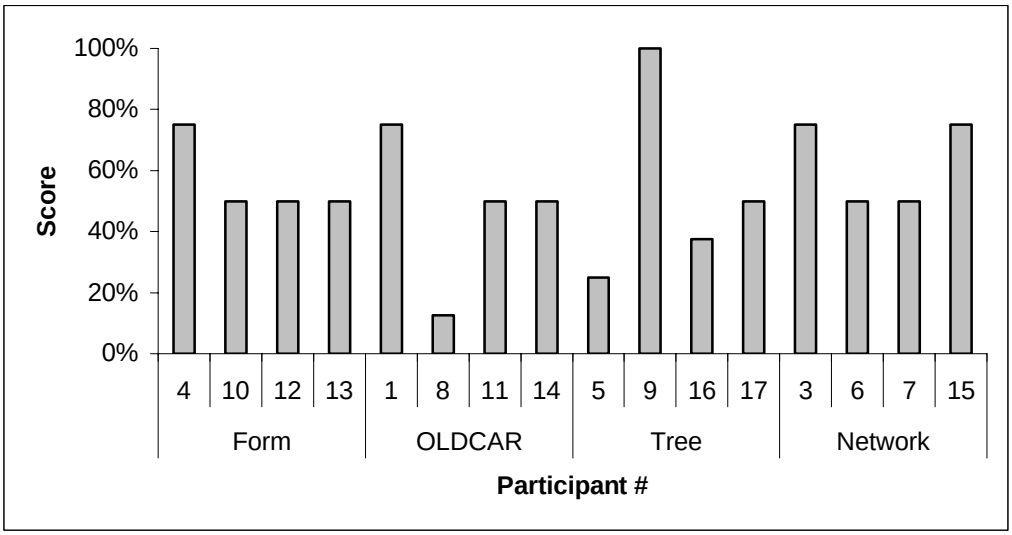


Figure 11-6: Correctness of conclusion.

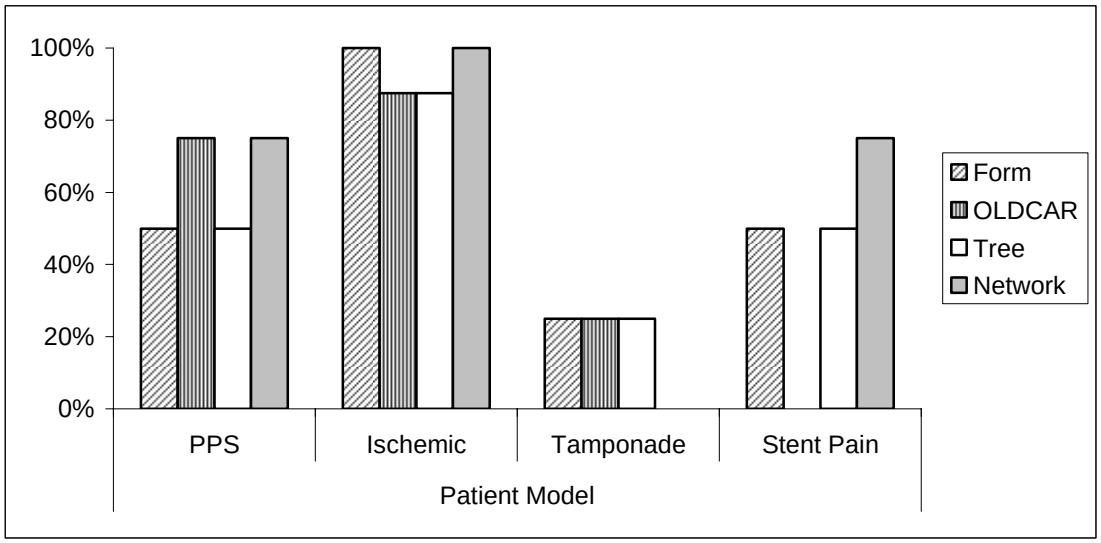


Figure 11-7: Correctness of conclusion by patient model.

Severity Assessment

Since the decision maker's primary goals are to assign adequate support to a patient's condition to improve or maintain patient health, it is important to assess the severity of the condition. Knowing that the patient condition is urgent or non-urgent immediately changes the consultation strategies. For example, if a nurse recognizes that the patient is experiencing ischemic pain, she would stop questioning and tell the patient to call 911 immediately, while if she learns that the patient is not in an acute condition, she might spend more time to understand the situation. For this score, the nursing researchers read the transcribed conversation and judged if the decision makers correctly assessed the acuity of the patient condition.

All tool groups assessed severity better than Somoza's (2006) baseline research (Form: 87.5%, OLDCAR: 75.0%, Tree: 93.8, Network: 68.8% and Baseline: 59.4%). The tree group assessed the severity significantly more accurate than the baseline (α <0.05), which can be explained by the detailed support on the recommendation boxes. The form group also scored high in this assessment. The participants in the form condition depended on their own experience and intuition and focused more on their own hypothesis. On the contrary, the tree and network conditions required the participants to navigate through relatively longer paths; thus, some lost track of what they had asked and repeated some questions. Since they struggled to find information on the tool along the decision process, their cognitive resources were divided rather than aided. Familiarity to the particular tools would be necessary for the users to utilize the tools more efficiently.

When compared among different patient models, cardiac tamponade was assessed more poorly than others. A participant said that it was not easy to detect the urgency because the fake patient did not sound short of breath. Although she was told and understood that it was not a real patient, she stressed the importance of the auditory cues.

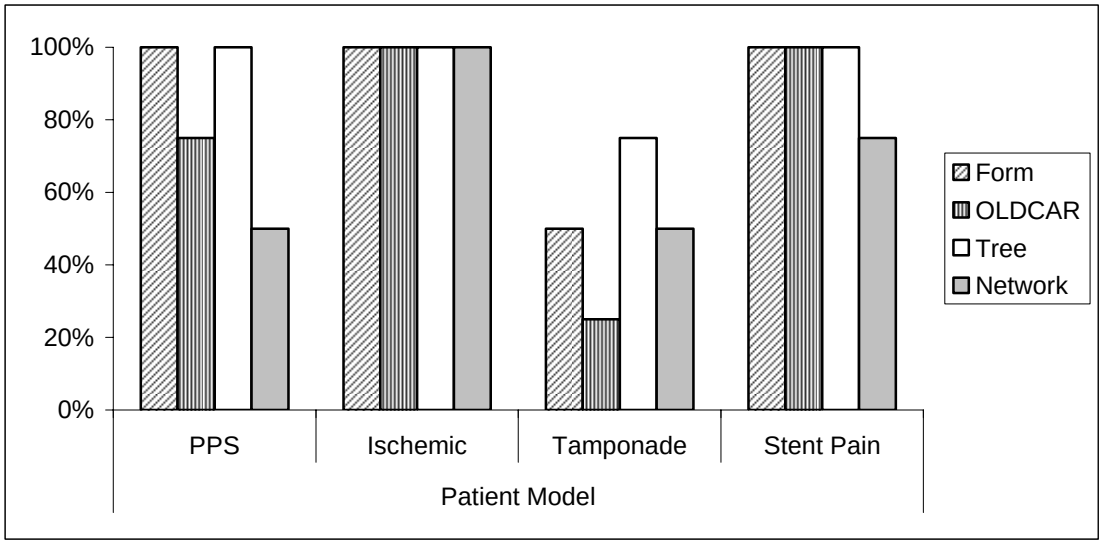


Figure 11-8: Severity assessment score by patient model.

Summary

On average, all tool groups did better than the baseline study (Somoza, 2006). The summary of the efficiency scores is included in Table 11-2. Due to the small sample size and individual differences, most differences in the effects did not achieve statistical significance.

Table 11-2: Summary of Efficiency Score

	Baseline	Tool #				
		Form	OLDCAR	Tree	Network	Tool average
Context	0.701	0.891	0.881	0.863	0.888	0.880
Assessment	0.375	0.346	0.553*	0.398	0.410	0.426
Conclusion	0.396	0.563	0.469	0.531	0.625	0.547
Recommendation	0.304	0.380	0.313	0.551	0.325	0.392
Severity Assessment	0.594	0.875	0.750	0.938*	0.688	0.813

* significant results

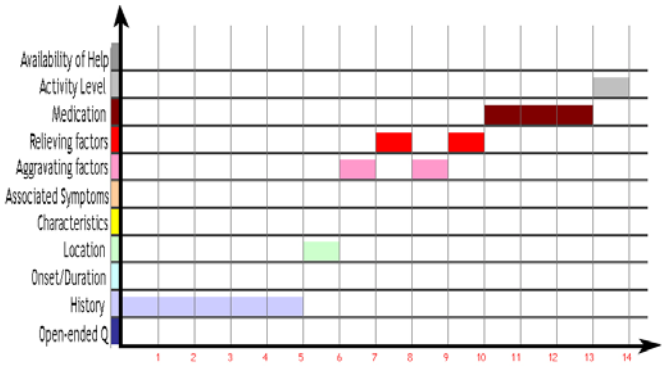
11.5.3 Question Sequence Analysis

The consultation process was categorized using the method described in Chapter 6. After all questions were categorized, essential questions that were used for the effectiveness scoring were marked. The question sequence was then analyzed with the particular support used during the call so that the entry point of the additional support was identified. Lastly, the questions sequences were charted. This subsection first describes the characteristics of the consultation process in each tool group.

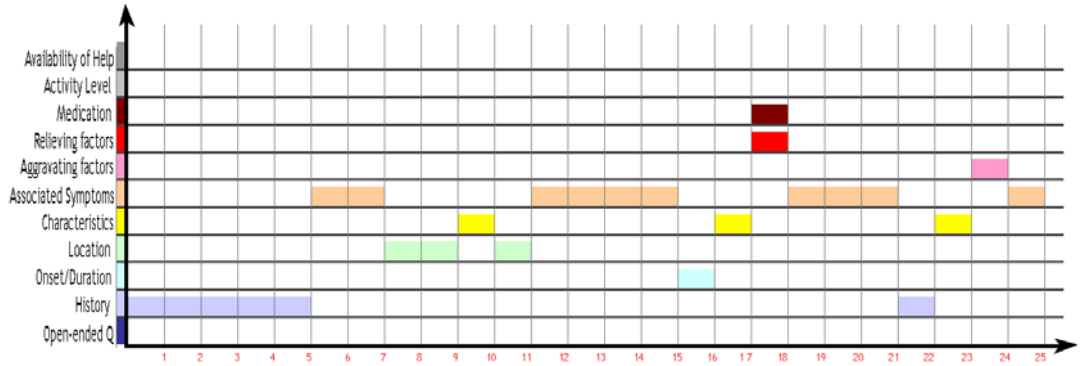
Group 1: TeleForm

The participants in this group showed variability. A successful consultation pattern in this group appeared to be "experience-based." Most participants who diagnosed the patient correctly finished the consultation quickly. They formed a hypothesis at the very early stage and used the hypothesis-and-testing or ruling-out strategies to quickly eliminate other possibilities. Since some patient models that were used for this experiment were common, they were relatively easy to hypothesize if the relevant context was extracted at the beginning. For example, the ischemic pain patient model had a cardiologist visit with a chest pain which had not been diagnosed and she had been on the list for an angiogram. Although there were many other possible conditions, the first condition the nurse has to check is if the patient is experiencing ischemic pain because it may lead to a heart attack. On the other hand, cases like cardiac tamponade are rare; therefore, it is difficult to generate a possible hypothesis without a reminder.

When examining the question sequence chart, early hypothesis-testing consultations showed short monotonic lines while unstructured sequences were likely to result in incorrect judgements. Figure 11-9 shows two types of question sequence with the PPS patient model. Chart a) was extracted from a successfully diagnosed trial. The participant spent five questions on the history and ruled out incision problems with question 6. It appears that the participants already had PPS as her hypothesis at that point so that she asked aggravating or relieving factor questions to test her hypothesis. On the contrary, chart b) shows a less structured sequence which did not lead to a definite diagnosis.



a) Monotonic question sequence in a correct diagnosis.



b) Unstructured question sequence in an unsure judgement.

Figure 11-9: Question sequence charts with PPS patient model.

The participants in the form condition referred patients to medical services in all consultation processes excepting one. They appeared that they were not sure about the patient conditions and added that the patient should get checked out to be sure. It is important to emphasize again that the nurses are not trained to diagnose or prescribe any medications for patients. They appeared to be more comfortable with referring patients to medical services rather than instructing them to perform homecare procedures.

Group 2: TeleForm + OLDCAR

Participants in this group spent more time consulting with the patient than participants in the form condition. Participants were having difficulty remembering to go to the OLDCAR checklist from the presenting problem list. Due to the broadness of the list, some participants added more specific questions in between. This appeared to make them focus on problem solving rather than information gathering. Some participants used OLDCAR before they went to the presenting problem list and it

seemed to work better because a similar symptom list appears in the "associated symptoms" under OLDCAR.

Although no learning effect was prominent in terms of accuracy or effectiveness, the participants in this group seemed to be learning the type of questions that are listed in OLDCAR. As the experiment progressed, some participants asked OLDCAR questions before went to the pages. They appeared that it was easier to find the list as the experiment progressed. Participants also learned from mistakes. For example, participant 1 skipped the history section and started asking more detailed questions during the stent pain patient call. She realized that she needed to know the context in the later stage and went back to the history page. The information she gathered before the context gathering seemed to be less integrated. At the end of the call, she commented "History is important," and she remembered to go to the history pages during the subsequent trials.

Integration of information appeared to be the problem of this group since the summary feature was not available during the experiment so that they had to browse through multiple pages to see all the symptoms that the patient had. Because of the missing feature, participants often asked the same questions during the call. This was observed more so during the call where participants asked about every item in the list. In such cases, the process became mechanical and the participants appeared to concentrate on checking the list off rather than understanding the problem. For example, a participant placed a check mark even though the patient answered "no" to the question. She said "oh, I checked off because I asked that question." This can easily be a source of error because when the information appears on the summary pages, it would appear without context and it would be less likely that the decision makers remember all the answers. It might be more helpful to have two check boxes or toggle fields for each item so that they can select "yes" or "no" or unselected to avoid confusion.

Group 3: TeleForm + Decision Algorithm (Tree)

All four participants in Tree condition appeared to be comfortable with the decision algorithms as well as history and presenting problem list. There was varying dependence on the algorithms among the participants. For example, participant 17 is a cardiology nurse so that she had no experience dealing with surgery patients before the experiment. She depended on the tool completely during the PPS (surgery: non-urgent) patient call and ended the consultation successfully; however, when choosing an algorithm for cardiac tamponade (surgery: urgent), she selected "possible ischemic pain" algorithm and did not know how to deal with the symptoms presented. Other participants extracted more information at "describe the discomfort" and followed the trees more freely.

Many participants had difficulty selecting an appropriate algorithm for surgery patients. For the PPS patient model, participant 17 was the only one who chose the correct algorithm, “Incision Healing Well.” Participant 5 selected “Incision Not Healing Well” and the other two selected “Possible Ischemic Pain.” As for the cardiac tamponade patient model, participant 5 stopped and told the facilitator that she could not choose one. The facilitator suggested “Incision Healing Well” algorithm because the participant already said that the incision appeared to be fine. The participant thought that because the patient was having problems, she should not choose “healing well.” This interpretation explained her selection of “Incision Not Healing Well” for the PPS patient although the patient said that the incision was fine.

It was intended that if the patient says that their incision appears to be not healing well, “Incision Not Healing Well” should be selected, and if otherwise, “Incision Healing Well” should be selected. During the iterative revisions of the decision algorithms, combining all the chest pain algorithms was suggested. However, each tree was decided to remain simple so that it is easy to understand and manipulate. The selection of trees did not appear to be an issue among the NCs during the feedback processes.

The question sequence chart consisted of three parts, history, presenting problem list, and the decision algorithm part. Participants skipped presenting problems sometimes and spent more time on the algorithms. The sequence remained relatively unchanged across different trials unless the participant could not make conclusions in the algorithm and started asking her own questions. Figure 11-10 shows a sequence of Participant 17 with the PPS patient model. First part was spent for the history, questions 7 to 9 were about the incision in order to select the algorithms. The rest of the questions were mostly compatible with the decision algorithm.

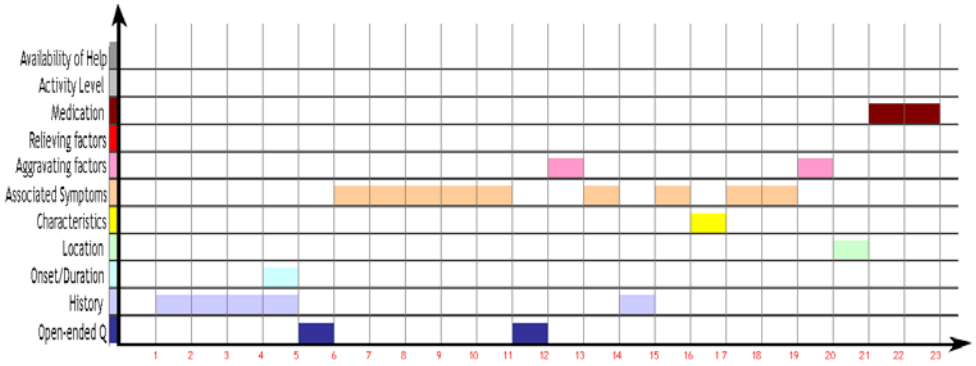


Figure 11-10: Question sequence chart of Participant 17 with the PPS patient model.

Group 4: TeleForm + Semantic Network Symptom Map (Network)

Participants in this group asked more questions than the participants in the tree group. The participants were interested in looking at the entire trees to select the next questions rather than concentrating on the context of the current focus. This may be improved once they know the map and understand how each node is connected to others. The question sequence map appeared random since the participants had more freedom to choose their own question sequence. History, characteristics, aggravating factors, and relieving factors were all included as symptom nodes. Thus they may be asking if patient had taken nitroglycerin before asking how severe the pain was.

During the cardiac tamponade patient calls, an interesting behaviour was observed. One participant who thought the patient was experiencing CHF, persistently looked for a diagnosis label for it even though they picked up and asked about some symptoms that are connected to the cardiac tamponade label. According to the nursing professionals, the difference between cardiac tamponade and CHF is that cardiac tamponade patients do not have swelling lower limbs. Because of the varying degree of swelling, it is very difficult to tell without an X-ray result that shows the fluid collected around their heart. Although cardiac tamponade is much less common than CHF, the decision makers should consider both diagnoses when making recommendations. The CHF diagnostic node was removed from the symptom map because it was not associated to chest pain. However, inclusion of the node would give more context to the decision focus and remind users to see the differences between the two diagnostic labels.

Unlike the decision algorithms, which covers typical calls and assigns to a single disposition, this network map connects each diagnostic node to multiple symptoms. Because each patient shows different symptom sets, the map would not be a perfect match even though the focus is on the right diagnosis node. This created slight confusion in the cardiac tamponade patient model because this condition can have many symptoms or very few. The network connectors should encode the strength of contribution so that the users can make judgements on which symptoms are strong predictors of a particular diagnosis. Because of the lack of expertise, the linkages are not adjusted with respect to the strength of the symptom to the diagnosis for this experiment.

11.5.4 Notable Observations

Flexibility of the process

The NCs, who are going to be the primary users for the system, and the nursing researchers emphasized that the tool needs to be flexible enough to support different types of processes. However, many of the participants modified their consultation process by learning from mistakes. For example,

if a nurse skipped history and arrived at a wrong decision, she tended to be more careful getting into history pages on the next trial. Since the participants for this experiment were all novice decision makers for telephone consultation, it was expected the participants to be more adaptive to the tools than the NCs. It appeared that it was easier to learn the tools if the user learned from her own mistakes rather than to be told by someone beforehand. Simulated telephone call trials like this experiment can be a valuable experience for novices to learn the process.

The Scope of Telephone Consultation

The participants appeared to be uncomfortable with homecare instructions in general. For the two non-urgent patients, the participants should recommend anti-inflammatory medications such as ibuprofen or Advil and monitor. As seen in Table 11-3, only the participants in the tree condition gave the correct recommendations. It is important to reiterate here that none of the participants practice telephone consultation as part of their job and they do not prescribe any medications. Therefore, displaying sets of detailed recommendations with precautions give the novice ideas of the scope of their decision problems. Additional "what-if" advice may also give patients more information so that they would know where to go or call if the condition happens. One participant who made the correct judgement in the form group had participated in two studies, the baseline and medium-fidelity prototype experiments by Somoza (2006). Thus she might have remembered or been reminded by the similar symptom patterns of the patients.

Table 11-3: Number of the Correct Recommendation Judgements with Non-urgent Patients

	PPS	Stent Pain
Form	0	1
OLDCAR	0	0
Tree	3	4
Network	0	0

Trajectory of the Patient Condition

Another interesting observation was the importance of timelines. Figure 11-11 shows a) the timelines with recognized milestones before the experiment and b) after the experiment. Before the experiment, the medical history taking was centred on "what was done" and "when it was done" on the DSS since that was on the original paper form. According to the nursing researchers, if a surgery patient develops pain shortly after a surgery, the problem is most likely related to the surgery. In addition to the "when" and "what" questions, extra questions were asked to extract the assessment of the patient at important milestones, so that they can understand the trajectory of the patient condition, rather than

snap shots of the conditions. Pinning down the conditions of a patient at a given time, decision makers connect the dots to find the trajectory of a patient's condition.

Some nurses asked whether the operation was successful (With no problems after the operation? Did the surgeon tell you that you might have pain afterwards?) Many asked if they have already seen family doctors for post-surgery check-ups. In the conversation, one mentioned that it will be important to communicate with the patient's family physician on what surgery/ procedures were done and what stages they are in. A participant suggested the "patient" bring her discharge booklet to her family physician so that she can communicate better. In a way, the nurses are using the family physician as another layer of the entire decision process so that the patient can get closely monitored.

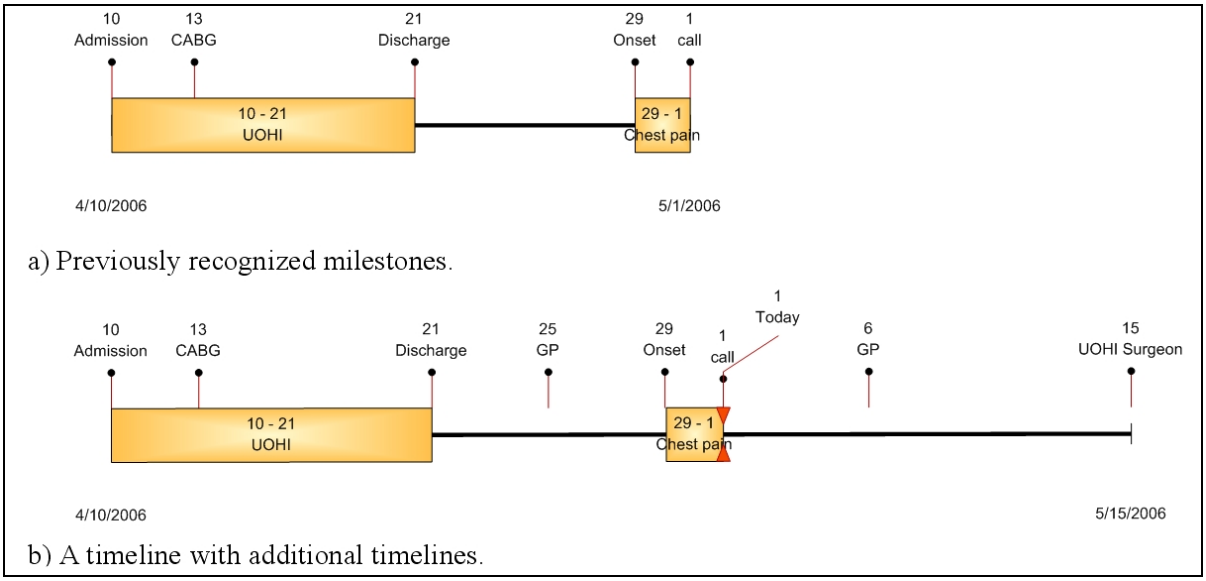


Figure 11-11: Comparison of milestones of a patient condition.

The timeline b) has the future part which can include scheduled doctor visits so that the nurses can reassess the patient's urgency and change the appointment date if the patient needs medical attention earlier than that. By providing the future timeline, the nurses can be better able to envision the risk or uncertainty level of the patient before making a recommendation judgement. The future part of the timeline was only subjected to questioning when a patient is not in an acute condition. In sum, the past trajectory of the patient was used for problem solving while the future uncertainty trajectory appeared to be used for the recommendation part.

The importance of time factors was also seen in the fact that the nurses often communicated the severity of the condition using a time frame. For example, "See your family physician within 24 hours," or "if you can't get an appointment this afternoon, please call us back so I can arrange one of

our residents to assess you" or "I don't think you should be rushing to hospital or anything." Since the diagnosis judgement is not their regular practice, it might have created unnecessary stress to the participants. A possible solution may be to ask the type of intervention or additional examination with reason and the time line. Figure 11-12 shows an idea to tie the problem solving mechanism together.

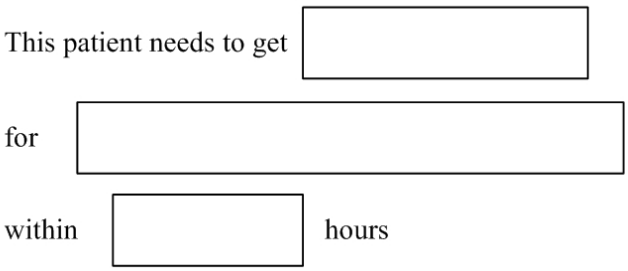


Figure 11-12: Possible prompt for recommendation.

Missing is What drives Consultation Processes

It was also observed that not all participants form a diagnosis during the call. Some participants ended their calls successfully and looked still unsure about what the patient has. Their behaviour can be explained better with detection of missing pieces. If the nurse recognizes that the patient needs to be assessed using medical devices right away, she would send the patient to the emergency department. However, if the nurse wants to see if an anti-inflammatory medication suppresses the chest pain, she would ask the patient to try the medication and arrange a call back to see the effects of it.

The nurse's problem solving appears to be like putting pieces of a puzzle together to complete a picture. In fact many participants stressed the importance of the summary page so that they can see all the information they collected on one page. Since she does not have access to physical measurements, the picture might appear blurry around one spot or it might be missing a chunk of pieces. They seemed to gather as many pieces as possible during the consultation and examined them. For the missing pieces, the decision makers need to assess the risk and decide whether the patients should be sent to a medical facility where they have direct access to intervention.

Transition Traps

Participants often got trapped at a decision support path. For example, some participants spent a long time on the history and presenting problem pages. Although knowing the patient's primary complaint is important, it is not efficient to ask about each item on the tray. This was also observed in navigation of the decision algorithms. Participants were stuck in one algorithm once they chose it even though they were told that they can move to another algorithm.

The decision path for the telephone consultation needs to be reassessed and rearranged. For example, the presenting problem list maybe changed to drop-down lists to select only one or two primary problems. Hyperlinks among decision algorithms might be useful to make the users aware of the options.

11.5.5 Post-trial Questionnaire Response

Various questions regarding a particular patient call were asked at the end of each trial. Most questions were answered by dividing a line marked “strongly agree” and “strongly disagree” at the either end. The dividing point was measured and translated into a ten-point scale for analysis.

Confidence and Performance

All participants gave their confidence level of their recommendation and diagnosis for each phone call. The data was averaged in each tool group and patient model and plotted (recommendation judgement: Figure 11-13 and diagnostic judgement: Figure 11-14). The participants were over-confident for recommendation judgements on average. This can be due to the poor performance with PPS and stent pain patient models. As mentioned, recommendations for homecare procedure require more care and an individual nurse might have a different severity assessment over these conditions. The nurses who participated in this experiment were trained to take care of in-patients and they are not used to giving any direction without directly observing the patient condition.

All data points in the lower right region in Figure 11-13 belong to PPS and stent pain patient model simulations. The confidence and performance was unbiased for ischemic pain and cardiac tamponade in recommendation judgements.

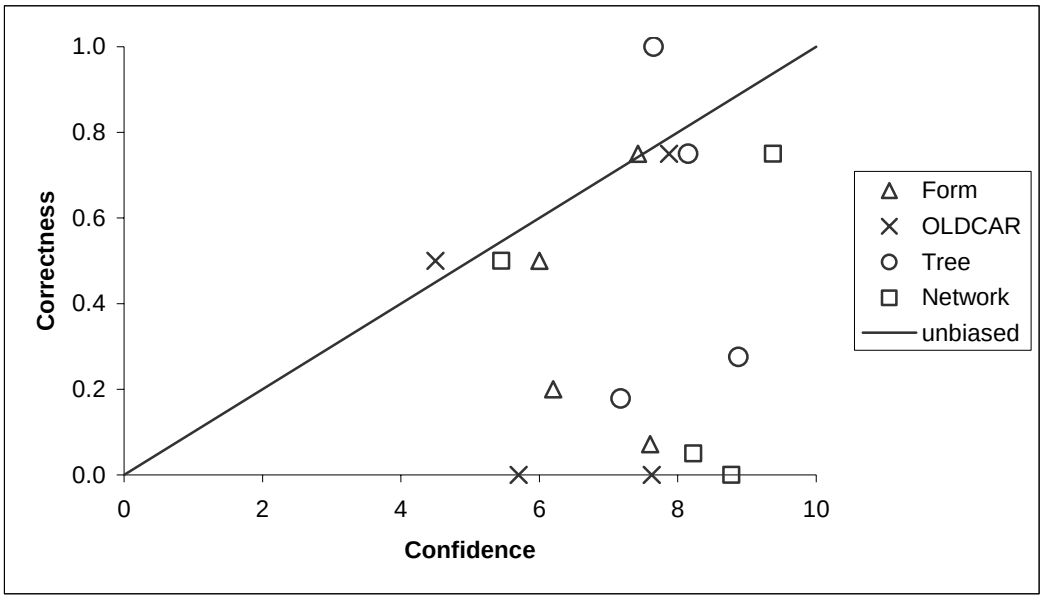


Figure 11-13: Correctness of recommendation versus confidence.

On the other hand, participants were almost unbiased for diagnostic judgement (see Figure 11-14). The confidence level for cardiac tamponade was lowest and the performance was the lowest as well. Some of the participants who provided the diagnosis as heart failure placed their confidence higher than others resulting a slightly higher confidence. There was no significant difference between the tools.

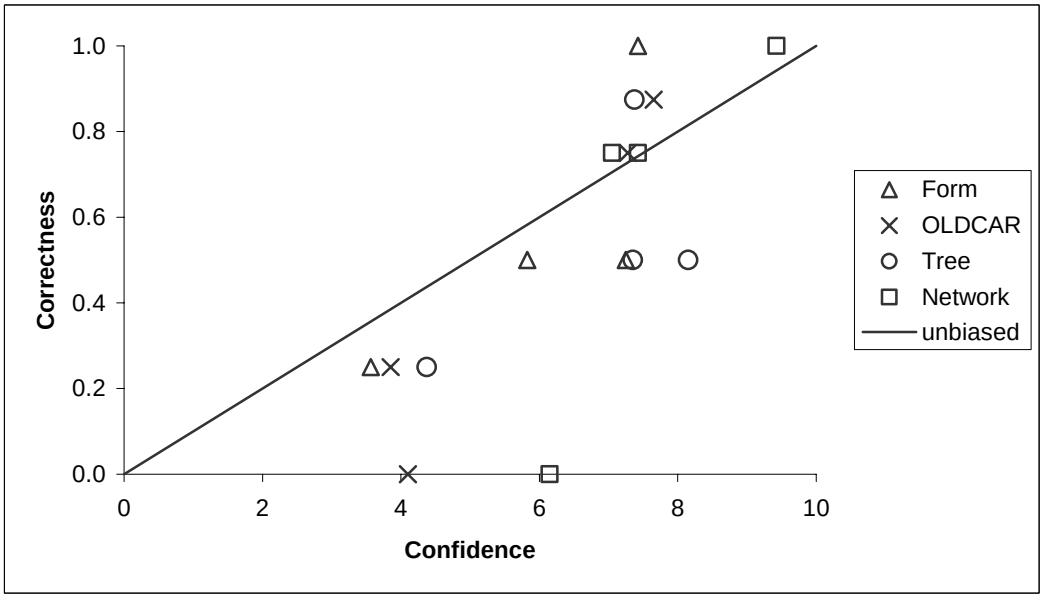


Figure 11-14: Correctness of diagnostic judgement versus confidence.

Ease of Decision Making

Along with confidence ease of making decisions on the recommendation and diagnosis was asked after each trial. Mean scores for recommendation was 6.92 and diagnosis was 5.99 (scores are out of 10). No significant difference in the responses among different tools was observed by one-way ANOVA. The scores for the cardiac tamponade patient model both in recommendation and diagnosis suffered (recommendation: 5.60, diagnosis: 3.91), and it can be explained by the complexity of the patient condition. It is interesting to note that the ease scores are the highest with the network condition on both recommendation and diagnosis.

Helpfulness in Generating Questions

Participants using decision algorithm thought that the tool helped them to generate a question sequence (mean score: 7.41 out of 10). They found the reminders for medication usage or some tests to assess a particular condition such as pleural pain useful when consulting patients. Many participants added more questions in between to make sure that they understood the problem rather than depending on the tool. The scores were averaged to 6.51; thus, most participants accepted moderate benefits of the decision tool in generating questions.

Helpfulness in Considering More Possibilities

Participants were asked if the tools helped them to consider more possibilities than they normally think of. Although participants provided positive response to some trials, they commented that they already knew what the patient is having on some trials. The scores are averaged out to be 5.86 overall; however, ischemic pain patient model appeared to be quite obvious to the participants, so that the participants arrived to the decision without aids (average score for ischemic pain: 4.87).

Helpfulness in Diagnosis

Participants were asked if the tool was helpful in making diagnostic judgement. Overall score was 5.17 for this question. As above, some commented that they arrived at their conclusion using their experience without tools.

Helpfulness in Recommendation

The tree group is the only condition, which suggests recommended course of action and associated cautions. As expected, the helpfulness scores for recommendation of this group was highest (7.84) among other tool groups (overall average: 5.46).

Correlation

Correctness, confidence, and ease of judgement rating were positively correlated with each other. Confidence and ease of judgements were strongly correlated (Pearson coefficient > 0.5) in both judgement tasks while correlation among correctness of diagnosis and other ratings were moderate (0.30 < Pearson coefficient < 0.49). Correctness of recommendation exhibited weak correlation with other ratings. Ratings regarding the helpfulness of the tools showed moderate to strong correlation. This can be interpreted as individual differences in adaptation of the tools or personality difference in rating. Some might be more easily adapted or satisfied with new technology while others might have negative responses.

11.5.6 Post-experimental Questionnaire Response

Upon completion of four simulated telephone consultations, all participants filled a post-experimental questionnaire. The results and the summary of the questionnaire appear in Appendix G-8.

Overall Experience

Majority of the participants responded positively to all three categories of overall experience. Figure 11-15 shows that Form has the highest rating and Network has the lowest. Considering the limited amount of training and the complexity of the semantic network symptom map, the overall experience is expected to improve when given sufficient time. Because the semantic network symptom map had response delay due to memory optimization problem, the network participants experienced time loss when navigating the tool.

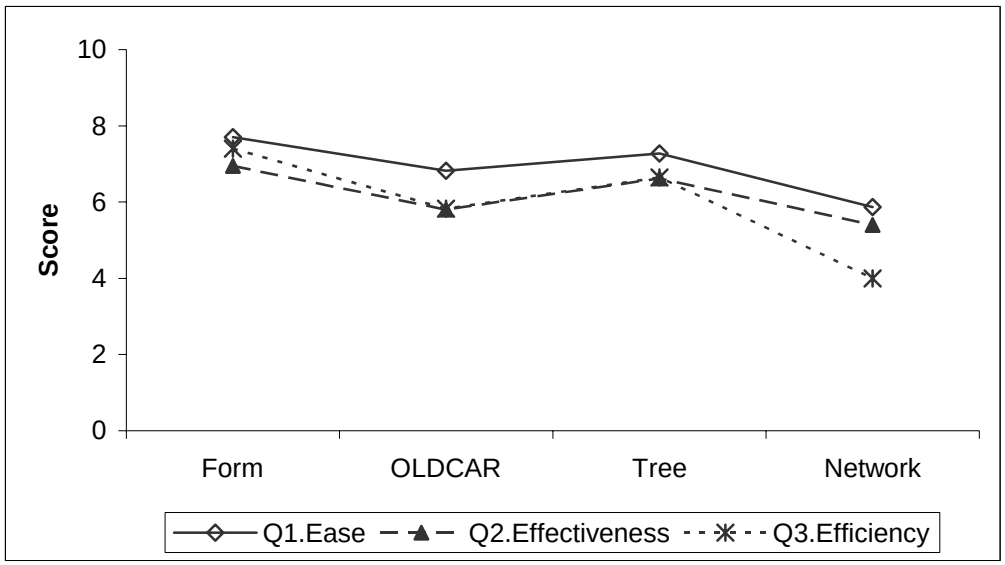


Figure 11-15: Overall experience rating.

Participants also compared their confidence against the judgements without decision support. Majority answered they are equally or more confident with decision support. Higher confidence in the tree group suggests the effectiveness of providing hints at the terminating boxes. The users appreciated the details of the instruction associated with calling an ambulance or taking ibuprofen.

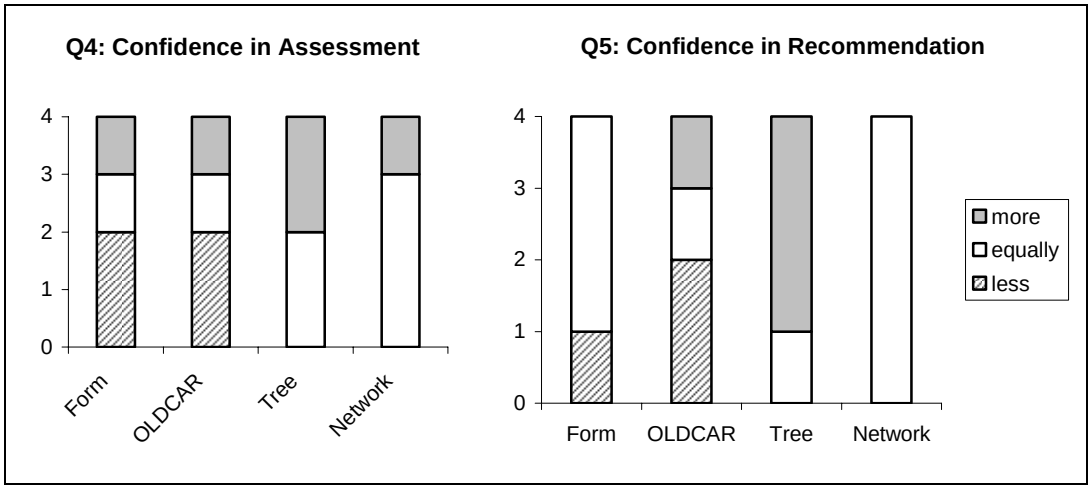


Figure 11-16: Comparative confidence in judgements.

PDA Use

Most people reported that they were comfortable with the tools during the experiment. However, some noted their concern of using the PDA with a handset because they had a speaker phone and comfortably seated in front of a desk, which they can rest their PDA or put down their stylus while using their thumbs at the experiment.

Usability

Participants answered various questions related to the usability of the DSS. All ratings were positive despite the known problems. Most participants stressed that the tool was not difficult to learn and should become easy to use once they are properly trained. Some mentioned the treatment options, possible diagnosis list to aid each tool's deficiency. Since intended DSS includes all tools, most of the participants' concerns should not be an issue. However, when combining the tools, the flexibility of the navigation and integration capability should be tested for the utility and usability.

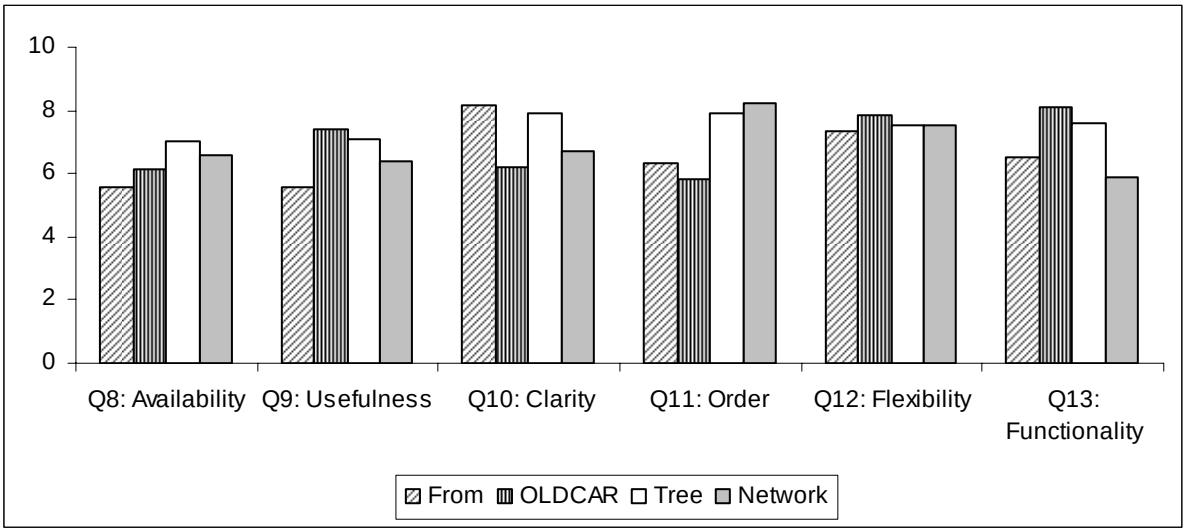


Figure 11-17: Usability of the DSS.

Participants selected multiple benefits of the tool from a list (Figure 11-18). The majority appreciated the tool as a reminder, question guide, and training. Some other benefits such as communication might become more

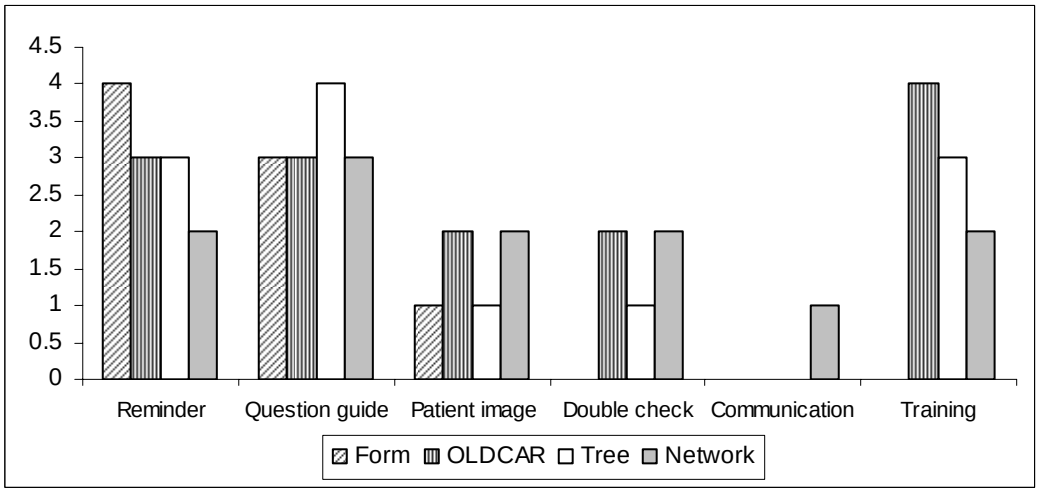


Figure 11-18: Recognized benefits of the DSS.

Training Issues

Many participants thought that it was easy to learn the DSS. Most of them agreed that the training was sufficient for this experiment, although they mentioned that they can use the tool better if they have more exposure to it.

Overall Satisfaction and Comments

Most participants responded very positively for overall satisfaction. Some participants like the basic functionality of TeleForm in terms of record keeping with drop-downs and checklists. Some mentioned that the tool is easy to understand and use while others who used the network map said the map was complicated. Many mentioned the small fonts and the difficulty to see the entire tree or maps because of the small screen. The participants suggested including specific questions to rule-out some conditions, or more context in recommending a course of action.

11.6 Summary

The participants in all tool groups performed better than the participants in the baseline study conducted by Somoza (2006). The effectiveness scores supported the intended benefits of three additional tools to the forms: the OLDCAR checklist for effective assessments, the decision algorithms for the quality of recommendation, and the symptom map for the correctness of diagnosis. These tools are complementally so that they can aid one another's deficiency. It is also possible that to classify the type of problems the patient has so that the appropriate tools are selected. For example, non-urgent patients benefited from the detailed recommendation and precaution notes in the decision algorithms rather than the diagnosis names in the semantic network symptom map. On the other hand, the semantic network map can be used to compare two or more conditions that are semantically close. The symptom map can be improved if more data are available to extract the numerical evidence of the varying level contributing factors or additional cases to add alerts to the users to consider more options.

The participants in the form group exhibited individual difference in the decision strategies. Some used more structure while others used an intuition-based approach. The OLDCAR group had good coverage of the primary complaints, but the sequence of questioning varied. Some participants voiced every item as if she was checking inventory whereas some others extracted important questions so that they did not have to ask many questions. The more mechanical they asked questions, the less integrated the information seemed to get. Decision algorithms provided great support for recommendation judgements especially with non-urgent condition, where the nurses passed on the precautions and advice. The network condition showed benefit in diagnosis judgement. Because the summary page was not available for this experiment, many participants had a hard time to integrate the information.

Timeline of the patient conditions was recognized as more important and it had different meaning to it than it was originally thought. Whether the patient had seen their surgeons or family physicians

between the discharge date and the phone call provided significant information for their decision making. The nurses appeared to reduce the uncertainty from the timeline so that they were able to roughly approximate the time frame where the patient's condition went wrong. Knowing the time frame, the nurses estimated the severity of the patient thus appropriate matches was made.

A majority of the participants gave positive feedback about the DSS. Many mentioned that they would perform better if enough training and practice was done ahead of time. Since the patient models used were fairly representative of the type of patient they receive at the UOHI, some participants made jugements without using the tools. Such nurses liked to ask questions freely; however, since they did not know where to put some items, they had to navigate through the tool to look for the particular items. If the tool did not match with the users' mental models, the integration of information appeared to be poor.

Chapter 12
Conclusion

12.1 Limitation

12.1.1 Experimental Design

One of the major limitations of the study was the experimental design. The experiment tested four tools using between-participant design. The observations and the questionnaire responses were taken repeatedly using four patient models that were counter-balanced across the participants. Because of a learning curve, participants who dealt more difficult patient models on the first call appeared to be more frustrated. It could have been more effective, if the order of the patient models were in order of increasing difficulty. The four patient models were representative of UOHI's patients. More patient models should be included to examine the behaviour of the users when they deal with less familiar patient calls.

Also the validity of the simulated phone calls needs to be assessed. First of all, the decision makers during real telephone consultation always use auditory inputs. Thus having a fake patient reporting about her conditions might skew experimental results. Nurses knew that they were not talking to a patient and appeared to be more comfortable asking questions especially when the participants and the mock patient were acquainted. This might have contributed to individual differences. In addition, the number of participants in each tool group was only four and it is difficult to observe statistically valid effects.

12.1.2 Training Issues

Due to busy schedule of cardiac nurses, the maximum time commitment for an experiment at the UOHI was restricted to an hour and half. Thus, the participants spent just enough time to understand the functionalities that were needed to perform the task. Although the training was designed to focus on only the part the users needed to know, it was not easy to learn the tool fully during the practice. Especially the decision trees and network require users to visualize the context to maximize benefits. Users appeared to be more stressed to talk to patients over the phone rather than talking to them directly; therefore simulated training maybe needed to give sufficient confidence with the task.

12.1.3 Software Issues

Integration of the tools to TeleForm had some problems. For example, one of the quick access icons for the decision algorithms was inactive. Although the participants were warned that the particular one does not work, they were confused that if they made a mistake. During the simulation, the experimenter assisted with technical difficulties as much as possible to smooth out system deficiencies. However, some participants held their tools in such a way that the experimenter cannot see the screen making it difficult to provide timely advice. Also some functions, such as summary pages, were not usable at the time of the experiment.

For the participants in the tree and network conditions, the navigation of the decision trees and the semantic network map was not at the desired level. Due to the drawing routines, the reaction of the system to the user input was slow. Especially the initial loading of the network took a few seconds. Participants appeared frustrated with the time loss since this broke the conversation flow with the patient.

12.1.4 Usability Issues

Most participants were comfortable with the PDA device. None had problems in controlling the device with stylus, hard buttons, and their finger tips. Because the experiment used speaker phone, the usability of tools with handset should be tested. Some participants said that the fonts on the decision algorithms and the network are small. The balance between font size and display limitation should also be investigated. Finally, a formal usability testing should be conducted once all known issues are addressed.

12.1.5 Comparison with the Baseline study

The baseline study conducted by Somoza (2006) was used to compare efficiency scores and performance. There were however some differences in the way that the studies were conducted. The focus of the baseline study was to compare results with the prototype evaluation, which focuses on the usability and efficiency of the tool. For this reason, the mock patient was answering freely to the questions and the facilitator did not assist participants with their technical difficulties unless it was essential. However, this project focused on the sequences of questions and the strategies used. The mock patient was requested not to give out any more information than she was asked throughout the consultation process so that the participants needed to ask questions if they wanted to have the information. Any technical problems were assisted by the experimenter to ease the experience.

12.2 Theoretical contributions

CWA and EID was used to analyze the cardiac specialized nurse's telephone consultation process to develop a decision support for them. The NCs' phone consultation processes were modelled using the CWA and interviews to extract the essential information. A multi-layer decision ladder analysis was performed when examining the strategies. This analytical process split the collaborative decision process into different sets. This multi-layer cognitive process was interpreted as the levels of abstraction with doctors being the highest abstraction and patients being the lowest.

Using a low-fidelity and a high-fidelity prototype, two experiments were conducted to examine the effects of the decision support tools. The strategies that the nurses use were analyzed using multiple information sources such as the NC's typical scenarios and interview results.

The qualitative analysis suggested that time-frame or timeline analysis may be useful in the situation similar to the UOHI's decision process. Decision makers do not actively observe their work domain regularly but are being alerted by someone or automated system when needed to diagnose or find solution to it. Explicit analytical procedure at an early stage of the modeling process might lead to a better understanding and development of the work domain and thus better interface design.

12.3 Practical contributions

A DSS was designed and implemented by the collaborative effort. The DSS was well accepted by the floor nurses as well as the NCs. The tool was built flexible enough so that information can be added or deleted at any time. This allows the researchers and the nurses to work together to bring the evidence to the point of care.

12.4 Future work

Removing Traps

Possible traps were identified on the history, presenting problem, or within decision algorithms. History may need more information space to remind users to ask if patients had any problems during surgery or at discharge. A question to ask if the patient has visited their family doctor might be useful as well. It would be ideal if one calendar or timeline can list all the items in the figure.

The presenting problem can be removed from TeleForm; however, a list like "Primary Problem", "Secondary Problem" can be added at the very beginning of the consultation process possibly on the first page where they typically select cardiology or surgery patient. Possible ischemic question should then be asked before the system gets into the history pages. When a patient is experiencing a possible heart attack other details are not helpful. The flow goes to the history pages and OLDCAR pages.

Once users are done with OLDCAR should be able to select a tree from the list or reduce the number of options so that it becomes more obvious which is best suited.

Provide More Evidence

The system requires frequent updates of the information to provide evidence to the point of care. Once a large set of data is extracted from the PDA, decision algorithms or symptom maps can be developed using the data. Decision algorithm can then be evaluated by medical professionals. This would be beneficial for some medical institutions with special needs. They can extract evidence from their own data. More tips and tests for the decision processes should be added to train novices or remind more experienced users. A list of homecare procedures and associated precautions can be added to the dispositional page so that users will be prompted to ask certain questions.

Full Usability Assessment

The usability of the system needs to be assessed fully using a wide range of experience. For usability assessment, all tools should be provided and integration of the tools should be assessed. To obtain more a large test population to examine portability, the tools can be implemented outside a cardiac care hospital. The expansion of patient domain would assess tool flexibility.

Test the Analytical process

The analytical tools used in this project need to be tested in other work domain to see if they are generalizable. Layered-decision making may be found in a domain with multiple decision makers with varying levels of expertise. In this type of systems, communication between the different layers is one of the key factors of decision making. Decision makers at the higher level of hierarchy needs to analyze the known issues to hypothesize the states of missing pieces. Layered-decision making and timeline analysis are closely related and examining the approaches in more details to find out the categories of the application might be very interesting.

Bibliography

1. Brameier, M. and Banzhaf, W. (2001). "A comparison of linear genetic programming and neural networks in medical data mining," *IEEE Transaction on Evolutional Computing,* 5(1): 17-26.
2. Breslin B. and Dennison, J. (2002). "The development of telephone triage: historical, professional and personal perspectives." *Journal of Orthopaedic Nursing*. Vol. 6, 191-197.
3. Burns, C.M. and Hajdukiewicz, J.R. (2004). *Ecological Interface Design*, Boca Raton: CRC Press.
4. Chow, R.W.Y. (2004). *Generalizing Ecological Interface Design to Support Emergency Ambulance Dispatching*, PhD Thesis, the University of Toronto, the Graduate Department of Mechanical and Industrial Engineering.
5. Edwards, B. (1998). "Seeing is believing--picture building: a key component of telephone triage," *Journal of Clinical Nursing*, 7(1): 51-57.
6. Enomoto, Y. (2005). Induction of Decision Trees by Soft Computing for Cardiac Phone Consultation, a report submitted in partial fulfillment of the requirements for SYDE 625, the Department of Systems Design Engineering, the University of Waterloo.
7. Grahame-Smith, D. (1995). "Evidence based medicine: Socratic dissent," *British Medical Journal,* 310:1126-7.
8. Hagbaghery, M.A., Salsali, M., and Ahmadi, F. (2004). "The factors facilitating and inhibiting effective clinical decision-making in nursing: a qualitative study." *BMC Nursing*, 3:2.
9. Hastie, R. and Dawes, R.M. (2001). *Rational Choice in an Uncertain World: the Psychology of Judgment and Decision Making*, Sage Publications, Thousand Oaks, California.
10. Karray, F.O. and De Silva, D. (2004). *Soft Computing and Intelligent Systems Design: Theory, tools and application*, Harlow, England: Addison Wesley.
11. Klein, G.A. (1989) "Recognition-primed decisions," in *Advances in Man-Machine Systems Research*, Vol. 5, W. Rouse, Ed. Greenwich, CT: JAI Press.
12. Klein, G.A., Calderwood, R., and MacGregor, D. (1989). "Critical Decision Method for Eliciting Knowledge," *IEEE Transactions on Systems, Man and Cybernetics,* 19(3): 462-472.

13. Mathmedics, "http://www.mathemedics.com/", Accessed in May, 2005.
Mitra, S., Pal, S.K., and Mitra, P. (2002). “Data mining in soft computing framework: A survey,” *IEEE Trans. Neural Networks*, 13(1): 3-14.

14. Murthy, S.K., Kasif, S., and Salzberg, S. (1994). “A system for induction of oblique decision trees,” *J. Artificial Intelligence Research*, 2: 1-32.

15. National Council Canada (1997). Telenursing: A Challenge to Regulation. National Council Position Paper.

16. National Library of Medicine, Medline Plus, http://medlineplus.gov/, Accessed in June, 2005.

17. Patel, V.L., Kaufman, D.A., and Arocha, J.F. (2002). “Emerging paradigms of cognition and medical decision making,” *Journal of Biomedical Informatics* 35:52–75.

18. Pepid LLC, http://www.pepid.com/, Accessed in June, 2005.

19. Rasmussen, J. (1976). Outlines of a hybrid model of the process plant operator. In Sheridan, T.B. and Johannsen, G. (Eds.), *Monitoring behavior and supervisory control* (pp. 371-382). New York: Plenum.

20. Rasmussen, J. (1983). Skills, rules, knowledge; signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on Systems, Man and Cybernetics*, 13: 257-266.

21. Rasmussen, J. (1985). The role of hierarchical knowledge representation in decision making and system management. *IEEE Transactions on Systems, Man, and Cybernetics,* 15(2): 234-243.

22. Rasmussen, J. (1986). *Information processing and human-machine interaction: An approach to cognitive engineering*, New York: North Holland.

23. Sanderson, P.M. and Harwood, K. (1988). The skills, rule and knowledge classification: a discussion of its emergence and nature, in Goodstein, L.P., Andersen, H.B. and Olsen, S.E. (eds), *Tasks, Errors and Mental Models* (London: Taylor & Francis), 21-34.

24. Sackett, D.L., Rosenberg, W.M.C., Gray, J.A.M., Haynes, R.B., and Richardson, W.S. (1996). “Evidence based medicine: what it is and what it isn't: It's about integrating individual clinical expertise and the best external evidence”, (editorial) *British Medical Journal*, 312: 71-72.

25. Shapiro, S.E. and Driever, M.J. (2004). "Clinical decision rules as tools for evidence-based nursing." *Western Journal of Nursing Research*, 8: 930-937.

26. Straus, S.E. and McAlister, F.A. (2000). “Evidence-based medicine: a commentary on common criticisms,” *Canadian Medical Association Journal,* 163(3): 837-841.

27. The University of Ottawa Heart Institute (2003). *Telephone Monitoring Triage Protocol*. Internal Document.

28. The University of Ottawa Heart Institute. (2004a). *Using Personal Digital Assistants and Patient Care Algorithm to Improve Access to Cardiac Care Best Practices*: Project proposal. Internal Document.

29. The University of Ottawa Heart Institute (2004b). Retrived from <http://www.ottawaheart.ca/UOHI/> accessed November 30, 2004.

30. The University of Ottawa Heart Institute (????). *Surgery Discharge Booklet*.

31. Thompson, L.K. and Hickson, J.C.L. (2003).*Project Update: Mobile Information Displays for Diabetes Management*, Report Submitted for a Partial Fulfillment of the Requirements for SYDE 462, the University of Waterloo, the Department of Systems Design Engineering.

32. Thompson, L.K., Hickson, J.C.L., and Burns, C.M. (2003). A Work Domain Analysis for Diabetes Management, In *Proceedings of the Human Factors and Ergonomics Society 47th Annual Meeting 2003*, 1516-1520.

33. Vicente, L.J., Burns, C.M., Mumaw, R.J., and Roth, E.M. (1996). How do operators monitor a nuclear power plant? A field study. In *Proceedings of the 1996 American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies* 1127-1134.

34. Vicente, K.J. (1999). *Cognitive Work Analysis: Toward Safe, Productive, and Healthy Computer-Based Work*. Mahwah, NJ: Erlbaum and Associates.

35. Wheeler, S.Q (1993). Telephone Triage: Theory, Practice, and Protocol Development Albany, NY: Delmar Publishers Inc.

36. Wickens, C.D. and Hollands, J.G. (2000). *Engineering psychology and human performance* (3rd ed.). Upper Saddle River, NJ: Prentice-Hall.

37. Wirstad, J. (1988). On knowledge structures for process operators. In Goodstein, L.P., Andersen, H.B. and Olsen, S.E. (Eds.), *Tasks, Errors, and Mental Models* (pp.50-69). London: Taylor and Francis.

38. Yin, D.S., Wang, G.Y., and Wu, Y. (2004). “A self-learning algorithm for decision tree pre-pruning,” in *Proc. 3rd Int. Conf. Machine Learning and Cybern.,* 4: 2140-2145.

39. Zsambok, C.E. (1997). Naturalistic decision making: where are we now? In Zsambok, C.E. and Klein, G.A. (Eds.). *Naturalistic decision making* (pp. 3-16). Mahwah, NJ: Erlbaum.

Appendix A
The UOHI Forms

A-1 Telepractice Documentation Record

TELEPRACTICE DOCUMENTATION RECORD			
Patient / Family / Public Initiated Nurse / Allied Health Initiated		Spoke with: Patient Family / Friend Public RN	
Mode of Communication Phone Fax Email		Name of OHI Cardiologist or Surgeon	
Date	Time		
Caller Last Name	Caller Telephone	Relationship to Patient	
Caller First Name			
Patient Last Name	Patient Telephone	Patient DOB (ymd)	Patient Gender Male Female
Patient First Name			

Cardiac Surgery Patient	Cardiology Patient
CABG Valve Replacenment - Aortic Mitral Valve Repair - Aortic Mitral Transplant Other Pre-op Date of OR_____ Post-op Date of Surgery _____ Date of Disch_____	Unstable Angina MI CHF Arrhythmia Recent Procedure Cath PCI EP study Date of Procedure _____

Date last hospitalization (ymd):

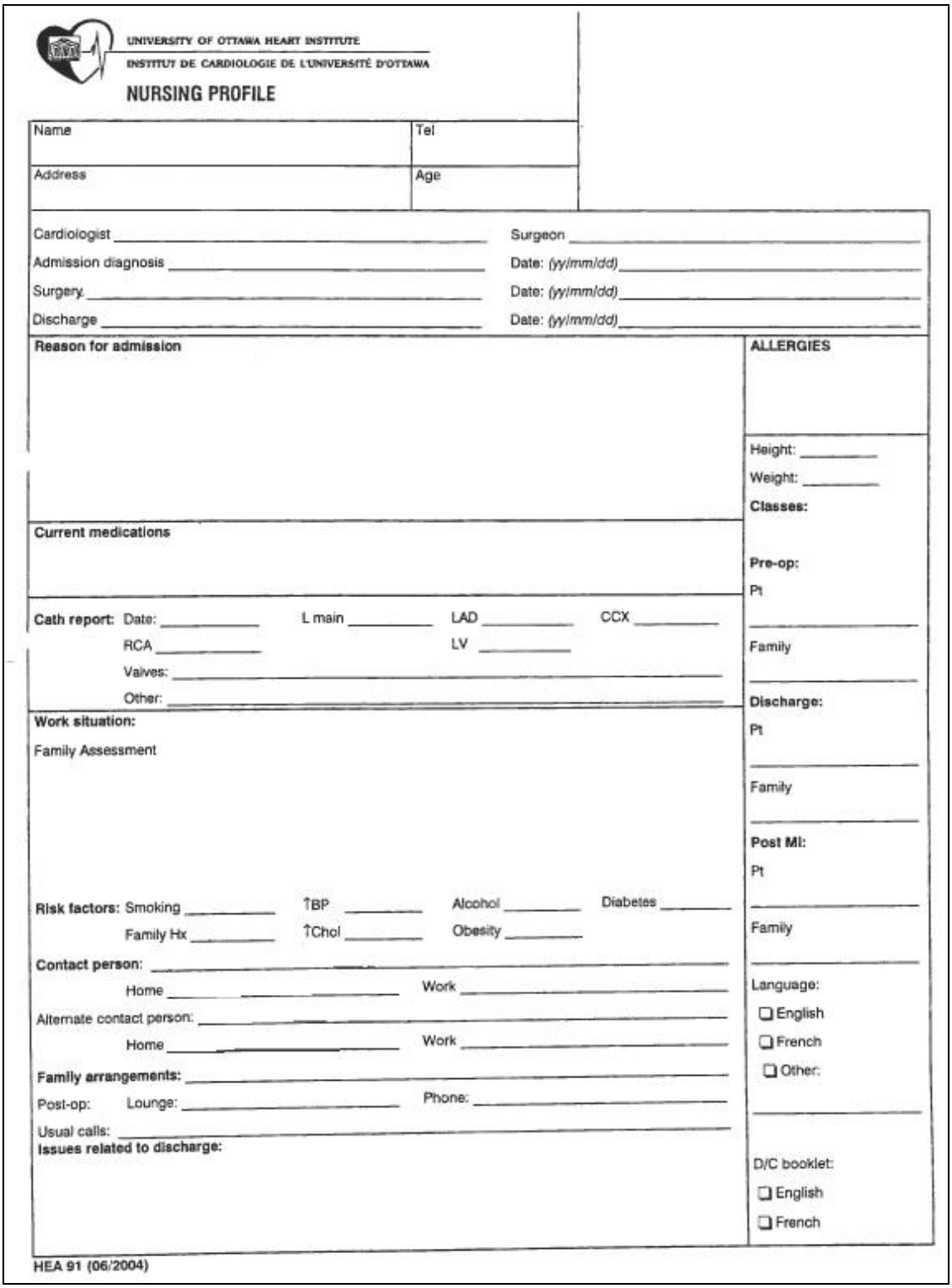
Medication	Pain	Sleep Problems	Constipation	
Changing S & S	Fatigue	SOB	Anxiety	Other
Complication	Information Needs	Appetite	Coping Problems	

Assessment

Advice / Counseling

Disposition of Call	Follow-up Summary
Referral to: ER Family Physician See at OHI	Resolved Informed OHI Physician
Patient agrees with plan of care Yes No	Call Back Arranged for: Date and Time

A-2 Nursing Profile



UNIVERSITY OF OTTAWA HEART INSTITUTE
INSTITUT DE CARDIOLOGIE DE L'UNIVERSITÉ D'OTTAWA

NURSING PROFILE

Name	Tel
Address	Age

Cardiologist _____ Surgeon _____

Admission diagnosis _____ Date: (yy/mm/dd) _____

Surgery _____ Date: (yy/mm/dd) _____

Discharge _____ Date: (yy/mm/dd) _____

Reason for admission

ALLERGIES

Height: _____

Weight: _____

Classes:

Pre-op:

Pt

_____

Family

_____

Discharge:

Pt

_____

Family

_____

Post MI:

Pt

_____

Family

_____

Language:

☐ English

☐ French

☐ Other:

_____

D/C booklet:

☐ English

☐ French

Current medications

Cath report: Date: _____ L main _____ LAD _____ CCX _____

RCA _____ LV _____

Valves: _____

Other: _____

Work situation:

Family Assessment

Risk factors: Smoking _____ ↑BP _____ Alcohol _____ Diabetes _____

Family Hx _____ ↑Chol _____ Obesity _____

Contact person: _____

Home _____ Work _____

Alternate contact person: _____

Home _____ Work _____

Family arrangements: _____

Post-op: Lounge: _____ Phone: _____

Usual calls: _____

Issues related to discharge:

HEA 91 (06/2004)

Appendix B

Call Scenarios Submitted by NCs

B-1 Call Scenario Template

Patient complaint/concern:

You say

They say

You say

They say

You say

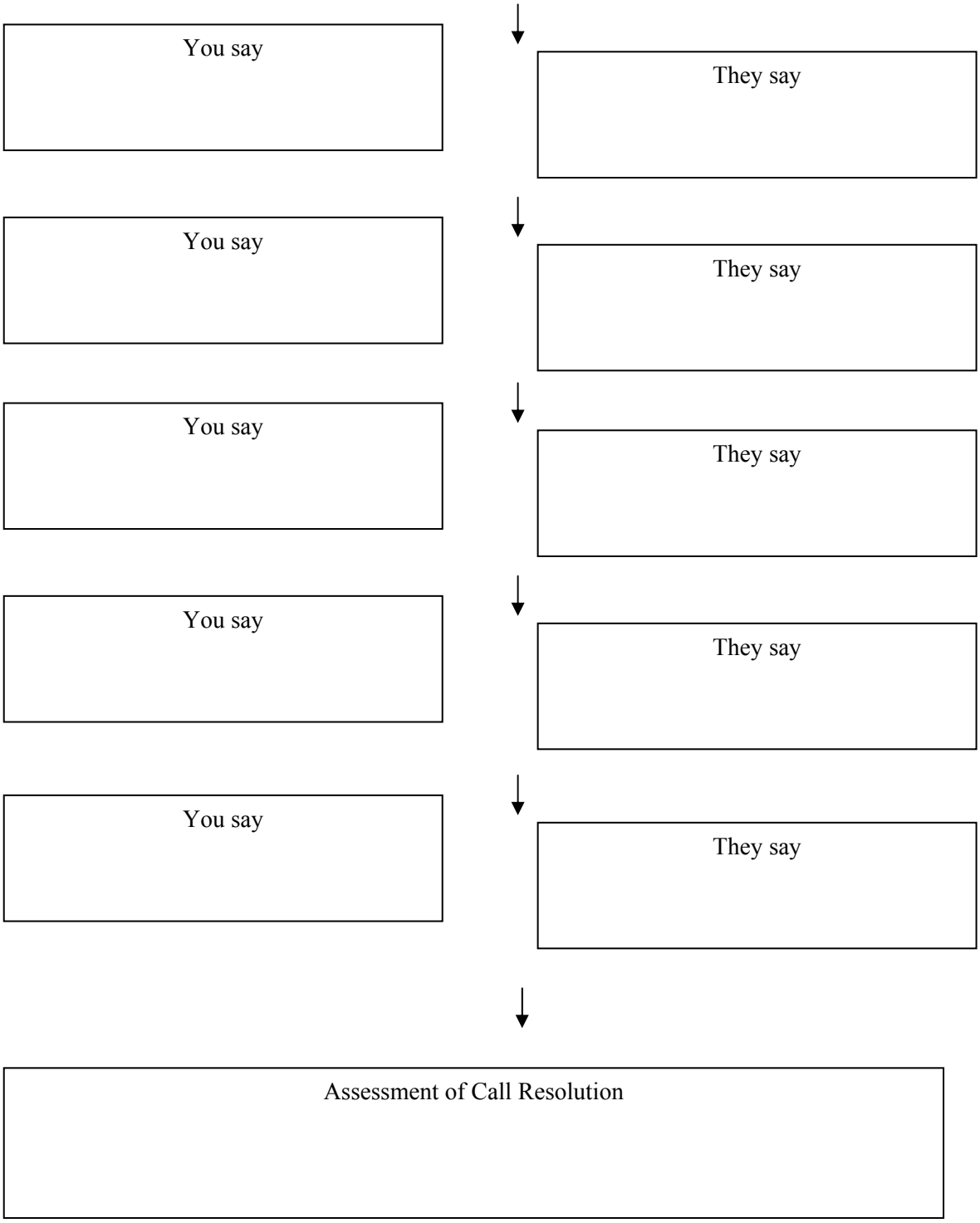
They say

You say

They say

You say

They say


You say
They say
You say
They say
You say
They say
You say
They say
You say
They say
Assessment of Call Resolution

B-2 Typical Scenarios for Cardiology Patients

Patient complaint/concern: Pain

55-yr-old female with unstable angina requiring repeated stents to RCA x2, LAD x2, Cx x 1 - also known to have 60% LAD lesion not stented. Most recent stent last week. Discharged home to <city in Northern Ontario>. Called to discuss 2 episodes of chest pain since leaving hospital. Wants to know that to do.

Submitted by: ID#02

	NC says	**Patient Says**
X	Hello <name>, nursing coordinator speaking.	My name is <name> and I had a stent put in last Tuesday - was discharged Wed to Intern's Residence then flew home Thursday. Friday I had angina again and I can't believe this.
1	Mrs <name>, could you describe for me exactly the sensation that you had?	Well, it seems to me to be the same pain. It started when I began to go through the week of mail and that had accumulated. When I stopped doing that, it seemed to go away and I did try Nitro
2	How long did the episode last?	Less than 10 minutes - about 5 minutes I think
3	It lasted 5 minutes and was relieved totally with the nitro?	Yes - Nitro fixed it but it happened again the next day.
4	The 2nd episode occurred with activity also?	yes - similar activity and now I'm afraid to do anything.
5	What have you been doing since you got home?	Not very much
6	Have you been able to get up and around and do things for yourself?	Yes, I have.
7	Have these activities resulted in any discomfort?	No. I've been okay, but I've been trying to take it easy. Now I don't know what to do.
8	Right now, today, you have had no pain, is that right?	Yes, so far today, I've been fine.
X	Well, I think you should carry on and try to increase your activity tolerance slowly. Use your Nitro if you need to. Report episodes of pain to the cardiologist in <city in Northern Ont>. Go the ER for an ECG if the pain lasts longer than 10 minutes.	I don't want another angiogram!
X	That may not be necessary at the time, but it is important to have an ECG to help determine if your discomfort is caused by your heart.	do you think the stent is blocked?
X	I can't be 100% sure but usually if a stent blocks this early then the pain is not easily	No, both times Nitro did the trick. It's just that I was hoping that the problem was solved.

	controlled with Nitro and you would need to return to the ER - but this has not been the case	Now I'm thinking that maybe I need a bypass.
X	I think it's too soon to draw that conclusion Mrs <name>. What were you told about your earlier stents?	They are all open and working fine. That's why I can't understand why I'm having chest pain.
X	Sometimes there is a degree of irritation, like inflammation after a stent procedure that resolves with time. I think you need to monitor yourself a little longer while increasing your activity by walking 10 minutes at a time, 2-3 times a day and see if this discomfort returns. If not, then I think you can feel more comfortable about taking on more knowing that the arteries are delivering a good blood supply.	So you think it's okay for me to start a little exercise? This won't cause more discomfort?
X	I think you should start increase your walking activity and if the exercise causes discomfort, then you will need to be re-assessed by your cardiologist in <city in Northern Ont>.	That makes sense. Is it so good to talk to somebody who knows. I'm so confident with the HI, but you are so far away.
X	Yes, but you can call us anytime and will no doubt be referred again if there is a need. But for now, I think you should taka few days to get going and see the cardiologist in <city in Northern Ont> for follow-up.	Thank you so much. I feel better just by talking to you. Sorry for bothering you.

Seems unlikely that the patient is experiencing occlusion of the most recent stent since it has only been a week since the procedure. However, this is not impossible and it could even be that one of the other stents has blocked. Working against the theory that the chest pain was due to blocking of a stent is that the pain goes away with Nitro. Likely that these two particular chest pain episodes could be due to inflammation from PCI.

Patient complaint/concern: Dizziness

Angioplasty 3 days ago and since then he feels dizzy each time he stands up. Is this normal?

Submitted by: ID# 02

	NC says	**Patient Says**
X	Mr. X, This is Nursing Coordinator calling from the HI. I understand you have a question?	Yes, thanks for calling back. I had my angioplasty on Friday and ever since, I feel dizzy when I get up. Is this normal?
1	Does this occur just when you stand up, or at other times?	Only when I first get up
2	Did the doctor give you new medication after angioplasty?	Yes the only new one is Plarix (?)

3	Are you taking other medications?	Yes, Vasotine(?), C…xa(?), clonagapam(?) Crestor, Metoprolol & ECASA.
4	None of these have changed - no increase in dose since being here?	No, I've taken these same pills for a long time and 6in patch(?) also but last night I dint' put it on and then I had pain when I was lying down so at 0400 hrs, I put it on.
5	After your procedure, did the doctor mention anything about your other arteries?	He told me that they are all blocked and are too brittle to do bypass.
6	Okay. Tell me about the chest pain.	I get it when I lie down, only on the left side.
7	Does it feel like the discomfort that you had before angioplasty?	Not exactly. It's more confined(?) and if I touch my chest I can feel it.
8	This sounds like some inflammation or stretch from your stent. It will get better with time and you can take a mild pain pill like Tylenol if you have some.	Yes, Ok. I'll do that.
9	Now about the dizziness. How long has it last each time?	About 5 sec. then it's gone, but sometimes I think I might fall.
10	I think this is related to sudden movement because your B.P. is trying to adjust. Try to move your legs a bit before standing and get up slowly. Has it changed any since Saturday since you had nothing to eat and better to drink during the 24 hours around (?) angioplasty. your B.P. is a little lower. This will improve I think.	Yes, it's a little better today.
11	Then the next few hours, drink a large glass of water this evening and see if this helps.	Thank you so much. It makes sense what you say. I feel better now that I talked you.
12	When do you see your doctor again?	I see Dr. Quixxxx Dec 17.
13	That's good If you have any concern before then, don't' hesitate to call again	Thanks very much. Bye now.

Patient complaint/concern: Heart Rate

Submitted by: ID# 03

	NC says	**Patient Says**
X		My heart rate is irregular and fast. I was sleeping and wake up to this fast HR.
1	Did you have this problem in the hospital after Surgery?	Yes, I did.
2	What did they say it was?	Fibrillation I think.
3	Arial Fibrillation.	Yes.

4	What did they do to control the heart rate?	started a medication.
5	How do you feel right now, other than the fast heart rate?	I'm short of breath and a little dizzy.
6	Where do you live?	In Alexandria
7	Because you are not feeling well, I suggest you call an ambulance to take you to the hospital	I can get there faster if I take my car. If I wait for an ambulance, it will take forever.
8	I do not recommend that you get up and walk around because you will stress your heart out more and feel even worse than you do right now. Is there someone else there with you?	Yes.
9	May I speak to them?	OK
10	Hello, How does he/she look?	Not very good. He is SOB.
11	I want you to call an ambulance as soon as you are done talking with me and let them know it is a heart arrhythmia. Tell them he/she is not feeling well. Do not drive them because if something happens in the car you will not be able to help them.	okay
12	If he/she passed out while you are waiting for the ambulance you may need to start CPR. Do you know how to do that?	NO
13	Call 911 back and let them know he/she is now unconscious and ask for CPR instructions.	OK
14	If you have any problems you can call us back. Call the ambulance now.	OK
15	After all is taken care of, call the surgeons office and let them know what happened	OK

If patients are SOB at rest and are symptomatic, it is safer to call an ambulance.

Patient complaint/concern: Groin

Submitted by: ID# 03

	NC says	**Patient Says**
X	Hello, this is the nursing coordinator. How can I help you?	I have noticed a swelling in my groin where I had my test.
1	Do you mean the puncture site where they put the catheter in?	Yes
2	Is it worse than when you were in the hospital?	I don't know. I never noticed it when I was in the hospital.

3	How big is the swelling or lump?	about 2 inches in width and 4 inches in length
4	Is it hard, or soft?	It is soft.
5	What colour is it?	It is blue and spreads down into my thigh
6	When you put your hand on it, do you feel a pulsation there?	NO, I can't feel anything.
7	Is there anything else that you have noticed?	no
8	Are you on any blood thinners other than ASA or Plavix	NO
9	there can be bruising that shows up a little late	OK
10	You do not need to see someone tonight unless there is increase in swelling , you can feel it pulsating or you have increased pain. You should see your doctor in the AM and get him/her to assess it.	I will not be able to get an apointment to my doctor tomorrow.
11	Is there a clinic you can go to?	Yes
12	Try your GP first and if that doesn't work, then go to the clinic nearest to you	OK
13	I will leave a message with the cardiologist who did your angiogram.	OK, thank you.

If groin was pulsatile or leaking, he/she would have been advised to go to CIVIC ER as vascular Sx works out of Ottawa Hospital

Patient complaint/concern: Sleep problem

I can't sleep - I wake up and I have to sit up so I can breath. I sat in my chair until 4 am this morning.

Submitted by: ID# 04

	NC says	**Patient Says**
1	Are you short of breath now?	Not too bad. It's okay as long as I'm sitting. If I go to do something.
2	Are you able to do your walks and exercises?	Yes, but I have to rest.
3	What medicine are you taking?	Colace, metoprolol, gly xxxx? Tylenol
4	Were you on a water pill in the hospital ?	Yes, but they didn’t' give it to me when I left 3 days ago.
5	Are your feet and ankles swollen?	a bit
6	More than when you left hospital?	I think so
7	I will speak with the doctor about putting you on a water pill and call you back. What is your pharmacy number?	<<phone number >>
8	I want you to weigh yourself every morning	

	after you've been to the BR - just with your pyjamas, OK. Keep track of your weight and call back if your weight is going up, If you are more SOB or cannot sleep lying down.

Spoke with resident - lasix and slow R(?) called in to pharmacy

Patient complaint/concern: Speech problem

I don't have air to speak

Submitted by: ID# 04

	NC says	Patient Says
1	When did this start?	Today
2	Were you able to do your walks and exercises?	Yes, I did them this morning
3	Are you SOB?	No, if I'm sitting and not talking or doing anything, it's okay
4	Everyone should be able to talk comfortably. You need to be seen. Someone needs to listen to your lungs and do a CxR. Do you live in Ottawa?	Yes
5	Is there someone to drive you here in the next little while?	Yes
6	I'm going to bring you to the reference centre - it is located xxxxx	OK, I'll call my son.

Pt. seen CxR done >> Pleural effusion - patient admitted

Patient complaint/concern: Weakness

Submitted by: ID# 04

	NC says	Patient Says
1	How long have you been feeling weak?	3 days
2	Are you dizzy or light headed?	This morning, when I got up, it's not so bad now.
3	Are you dizzy whenever you change position?	a little bit
4	Do you have any abdominal pain?	No
5	Have you vomited?	NO
6	Are your bowel movement normal colour?	Yes
7	Do you feel a change in your heart rate-is your heart racing?	No
8	Have you had any chills or sweats?	Yes sometimes
9	Do you have a fever	No.. I don't know .. Maybe

10	Do you have a thermometer?	No
11	What does your chest or leg incision look like?	My chest incision is leaking ever since I left hospital
12	Has the drainage increased since you left hospital?	Yes it just keeps coming out, especially the last 3 days
13	What colour is the drainage?	It was clear-now it is thicker
14	Is there an open area?	My wife says there is a small hall.
15	Is the incision red or tender?	it is a little red but just a bit sore.
16	What are you doing for your incision?	Nothing-do you want me to use some gauge?
17	It is important to keep your incision clean and dry but because the drainage has increased and you are feeling weak, you need to be seen. Do you life in the Ottawa area?	Yes
18	I'm going to arrange for you to be seen in our reference centre. When do you think you can get here?	I'm calling my son. Should take about 45 min.

Pt. seen -admitted with sternal wound infection

Patient complaint/concern: Groin

Sore groin post angiogram

Submitted by: ID# 05

	NC says	**Patient Says**
X	How can I help you?	I had my angio 3 days ago with Dr. xxxx and now my groin is very sore.
1	Has your groin swollen, is there a lump below the incision?	No but there is bruising from my groin down to mid thigh
2	Post cath bruising can extend to the knee & become very discoloured - purple, blue & yellow	So I can expect bruising
3	Yes. Is the puncture site open or oozy? Due to manipulation of the catheter, some discomfort is expected, too.	Everything appears normal its just the soreness.

Since there is no swelling or bleeding and the xxx to your leg is normal. I would suggest Tylenol two tablets q4h prn. But also monitor groin and leg for change in colour, sensation, temp and swelling in the groin. If pain is not resolved or anything worsens, go to ER.

Patient complaint/concern: Chest Pain.

Submitted by: ID# 06

	NC says	Patient Says

	Hello, Nursing co-ordinator speaking can I help you?	I am having chest pain.
1	Have you experienced chest pain before, and/or a "heart attack"?	Yes. I have had a small heart attack 2 weeks ago and I had chest pain. I had angioplasty.
2	Is the chest pain you are experiencing the same as other episodes of angina or are you having symptoms similar to your heart attack?	Yes, the chest pain is similar not exactly the same as when I had my heart attack.
3	Describe pain from 0-10 in intensity. Is pain radiating to arms/back/neck/jaw? Do you have palpitations/shortness of breath/nausea/vomiting or light-headedness/ diahporesis	pain is 7-10 with severe diaphoresis and radiating down arms. Pain ongoing for 20 min.
4	Sit down or lie down. Have you taken Nitro spray? Call 911	No.
5	Take your Nitro Spray x3 5 minutes apart. It may not relieve pain/symptoms, but it will not case any problem	I'm going to call 911 now.

Patient complaint/concern: Dizziness

Submitted by: ID# 08

	NC says	**Patient Says**
1	When did it start? And did you have any chest discomfort or numbness in arm?	No, no pain or numbness. Today at lunch time, after my exercise, when standing up.
2		
3	Did you have weakness fainting or sweating?	Felt very weak at first but okay when lying down.
4	Did you lose consciousness and how do you feel now?	No longer feeling faint. No, I didn’t' lose consciousness
5		
6	Did you start any new medication and are you eating and drinking well?	Yes. I started a new medication after the doctor visit and I have some nausea, so I'm not drinking.
7		
8	Did you check your heart rate or blood pressure when you were feeling dizzy?	yes, My BP was 90/50 HR 51
9	Is your new medication to slow your heart rate; and is it called a Beta blocker?	Yes, the doctor said it would slow my heart reate and lower my blood pressure.
10	Do you take all your pills in the morning and what are they?	Yes, I take all pills with breakfast except my cholestrol pill.

11		
12	do you check your pulse before you take your pills?	No, I don't know how but I could use my monitor.
13	Try to check your pulse before taking your morning pills to slow your heart, Instruct to try XXX Radial Pulse x15sec and ???? Beta Blocker until Pulse >55 x4	I will also try to learn how to take my pulse before my morning pills
14	Do you take a pill for blook pressure or ACE Inhibitor in the morning?	Yes I take all the pills at one once XXXXXXX ACE Inhibitor.
15	Check with your doctor Try to take ACE Inhibitor at night. If your heart rate and BP are low, check again before taking Beta Blocker in the morning	I will check my heart rate before morning pills
16	How streneous is your exercise that you do?	Oh, I can go on walking when I feel good except today I feel faint.
17	Slow down on your exercise. Ensure you feel good before increasing activity and drink adequate fluids	Yes, I will dlow down on with my walking and make sure I drink adequate fluids.
18	If this dizziness ?????? Notify your doctor immediatedlyin in case he has to adjust your medication. OR let your cardiologist know of this	OK, thank you. I will let my family doctor know.
19	If you are weak dizzy and faint that it not going away, go to the nearest ER by ambulance or someone to drive you.	

B-3 Typical Scenarios for Surgery Patients

Patient complaint/concern: Shortness of breath

Submitted by: ID# 01

	NC says	Patient Says
1	Tell me about your SOB. When did it start?	Tuesday
2	How long have you been SOB?	About 2 days
3	Is your breathing worse than when you left the hospital?	Yes
4	When do you get SOB? All the time, or just with exercise?	Both
5	Are you able to do anything at all?	No, I'm too short of breath
6	How many pillows do you use at night to sleep?	I can't lay down, I sleep or try to in my lazy boy
7	Do you have any swelling in your legs/ankles?	Yes
8	More or less swelling than when you left the hospital?	the same
9	Were you taking any medicines like water pills before you came to the hospital?	yes
10	Are you taking any of these right now?	no, they didn't give me any
11	Do you think you can get in a car with your family member to go to ER?	if yes --> bring them in if no, 911 to ER

SOB interventions are variable. This patient I would have sent to ER. How they got there would really depend on them. IF they felt they could go by car fine, but if not, then 911. If the SOB was on exertion, questions and intervention would be quite different. ie. what degree of exertion is necessary for patient to become SOB? diuretic, pre-op. In some instances, surgeons would give them a couple of days of diuretics with provision to check in on progress and if no better come in here. Other surgeons would want to see them first, get an x-ray and then put them on diuretics.

Patient complaint/concern: Pain

Submitted by: ID# 01

	NC says	Patient Says
1	Tell me about your pain	Pain in chest as dull aching tight
2	Did you have any CP/Angina before your OR?	Yes
3	If this pain you are experiencing like the pain you had before your operation?	Yes, I think so
4	Did your surgeon say you might still have a bit of angina/CP after your operation?	Yes
5	Take a nitro. If the pain does not go away with one nitro, go to the hospital	right

1. If the surgeon told the patient the revascularization was incomplete and they may still have

angina, I would direct them to take nitro. If it works, ok. Monitor response, if not, go to hospital.

2. If they don't' have nitro at home, go to hospital

3. If they have not been told this, then -- early in the course of recovery, it maybe graft blockage and need urgent attention. If much later, then still need to get seen, but may send them to cardiologist if 1 nitro relieves it. If need more, go anyway.

Patient complaint/concern: Pain

Submitted by: ID# 01

	NC says	Patient Says
1	Tell me about your pain	Sharp, in neck, back, shoulder
2	Did you have any chest pain/ angina before your OR?	yes
3	Is this pain similar to that?	no
4	Is this pain like the pain you had after surgery?	A little, not really
5	When did the pain start?	Day before yesterday?
6	You have had this pain about 2 days?	Yes
7	You described the pain as sharp, in the neck and shoulder. Is there anything else you want to tell me about the pain?	No
8	What makes the pain worse?	Taking a deep breath
9	What makes it better?	nothing
10	What have you done to treat your pain?	Took some pills
11	How much medicine did you take?	3 or 4 tylenol extra strength, but it didn't help.
12	Tell me again, you have more pain when you take a deep breath	Yes, it feels like a knife in my chest
13	How is your breathing	a little tight, but not bad
14	I would like you to try something - lean forward from the waist and take a deep breath. Tell me how you feel	OK, I can take a deep breath and it doesn't hurt
15	Tell me the names of the medicines you are taking (want to make sure not on coumadin or any anti-inflammatory meds)	….. (patient says and none of them are problematic)
16	Have you ever had any problems with your stomach	no
17	Any allergies	no

This is fairly representative of PPS post op. Seen in 10% and more post op patients. Recommend using some ibuprophen for a day or so and if no better, call back

Patient complaint/concern: Pain

Submitted by: ID# 01

	NC says	Patient Says

1	Tell me about your pain	My chest hurts
2	Where does it hurt?	In my incision and my shoulders
3	Did you have chest pain or angina before your operation?	Yes
4	Is this pain similar?	NO
5	Is this pain like the pain you had in the hospital after your operation?	sort of
6	How long have you had this pain?	Since I got home from the hospital 3 days ago
7	Is your incision causing you any problems? (R/O Infection)	No
8	Tell me more about your pain	My chest hurts
9	Describe your pain, ie. Dull, sharp, aching, spreading anywhere…..	Dull and aching all the time
10	What have you done to treat the pain	I took some tylenol
11	Did the tylenol help?	Yeah, little
12	What makes the pain worse?	It's always there
13	How much tylenol have you used?	3-4 extra strength tablets a day
14	Do you have any narcotic prescribed for you before you left the hospital?	Yeah, but I don't want to get addicted
15	Tell me what you have been prescribed	Tylenol#3
16	You wont' get addicted from the tylenol we gave you, you might get constipated though. What I would suggest you try is take the tylenol #3 in the morning and evening and during the day take a couple of doses of extra strength tylenol. Never more than a total of 8 tablets a day of tylenol. I would like you to do that for 24 hours and call me back in the morning to let me know how things are going. Your doctor sent you home with stool softeners so take them as well while you are using the tylenol with codeine. Is that okay with you?	I'll try

This is the third group of pain complaints reported post op. Once I have rules out angina and PPS and infection (that's the reason for the added text boxes), the next place I would go is to the pain management strategies.

Patient complaint/concern: Constipation

Submitted by: ID# 03

	NC says	**Patient Says**
X	Hello, you are speaking with the nursing coordinator. How can I help you?	I am having problem going to the washroom

1	When was the last time you had a bowel movement?	since about 5 days now
2	Are you able to pass gas by your rectum?	Yes
3	Are you nauseated?	NO
4	Are you eating and drinking okay?	Yes
5	Are you eating enough fibre, fresh fruit & vegetables?	Yes
6	Are you taking Tylenol #3 -> they can be very constipating	Yes
7	Do you have nay milk of magnesia at home?	No, but I can go and get some
8	Do you have any kidney problems?	No
9	Take some daily as directed on the bottle until you have a BM	OK
10	If at any time you start to throw up, go to your doctor	OK
11	Do not wait longer than 3 days before you have a BM	OK
12	Make sure you are eating enough figre to keep your regular- try some bean	OK
13	Call us back if you are still having problems	OK, thank you

Patient complaint/concern: Cough

Submitted by: ID# 04

	NC says	**Patient Says**
1	Are you shrot of breath?	No, it is just this cough
2	Are you able to do your walks and exercises?	Yes.
3	Are you short of breath when you lie down at night?	No, I use 2 pillows, but I cough
4	Is there increased swelling of your feet or ankles?	No
5	What medicine are you taking?	Metoprolol 25 mil BID, Altase 2.5 mg QHS, Lasix, Slow k, colace, tylenol #3, but I don't take it. I just use regualr tylenol.
6	Were you on altace before surgery?	No.
7	I will speak with the doctor about the altace and call you back. Try keeping a glass of ice water or ice chaps nearby to keep your throat moist.	
8	Beause of all the coughing, watch your incision carefully. What does your incision	looks okay

	look like now?	
9	Do you hear a click when you cough?	No
10	If you start to hear a click or if your incision becomes more red, tender, or any drainage, call back.	OK
11	If you are SOB or unable to lie down to sleep or the cough worsens call back. I will speak with the doctor and call you back.	

Speak with surgeon, altace D/C

Appendix C

Nursing Coordinator Interview Materials

C-1 Question Set

1) Algorithms

1. Is there a major difference between cardiology and cardiac surgery patients when you go through pain (or any other) scenario? (i.e. any special question sequence for surgery patients?)

2. For cardiac surgery patients, do you always (or almost always) assume that the complaints have to do with the recent surgery? Would you as likely to consider other possibilities (e.g. a new condition on its own) the same time?

3. We see some NCs comparing "pain before the operation" or "pain after the operation". Is it simply asking if it's improving or worsening, or is there any significance? (especially related to the type of operation?)

4. When asking open-ended questions, (e.g. "describe your pain") what type of information are you looking for in general?

    a. Do most patients provide you those answers? Or you have to redirect questions to gather more relevant information?

    b. Have there been cases when you received unexpected answers (to open-ended question) that led to better assessment.

5. When you ask symptoms do you typically ask (onset/duration/frequency/condition)

    a. When did it start?

    b. What is the duration?

    c. How often?

    d. Or is it symptom dependent? (Can you give examples)

    e. When you ask symptoms do you typically ask (onset/duration/frequency/condition)

    f. As related to the previous question, do you assess the severity level of symptoms by mostly frequency and duration? Are there any other cues you look for in a patient's response (e.g. particular description of a certain symptom, tone, etc)?

2) Decision Making
(mental model)

6. When you are asking questions about the patient's condition, at what point would you formulate a **mental model of the problem** in your mind, if any at all? If you do form a **mental model of the problem** in your mind, do you ask questions to confirm your hypothesis or do you continue on following a standardized question set?

(medication)

7. For medication, is it more important to know how much they consumed? Or how much at a time and how often?

8. Would it be useful to have a drug reference? Or cumbersome?

9. When (if ever) and within what range would you make recommendations about changes in drugs (dosage, use of pain killers, etc.)

(location)

10. Does the location of patients influence the decision? (i.e.: if the patient is not close to a hospital, would you advise them to call ambulance.)

(call back)

11. When you assign call-backs what is the factors you consider? For example, what makes you to decide how many hours later the call-back should be / who should be calling?

12. Are there a standard set of questions that you ask when you call back?

13. When calling back what is the most important information to know?

    a. What makes for an easy-to-follow call back record?

    b. What can be hard about this job?

(home care)

14. Do the specific homecare instructions given to the patient (e.g. exercise or increase patient's activity) follow closely to standardized procedures or more by experience?

    a. Do you give those homecare instructions directly on the phone or do you redirect the patients to recorded message / website / patient education booklets?

3) Expertise/expert behaviour

15. What makes a patient call-in difficult? What are the characteristics of the "difficult caller"? Are there strategies for handling this?

16. Similarly, what is the ideal call-in? What does this patient (or caregiver do) that makes it easier?

17. Have you had any experience training others to handle calls? (or advising new nurse coordinators?)

    a. What are the challenges that new or learning NCs have with handling calls? What are the "trademarks" of an experienced NC in this task, how do you recognize one?

18. Do you have any particular strategies that you have developed to

    a. Help you triage the call-ins quickly

b. Fill in the call back forms efficiently so that you have the key info when you do the call back

19. Can you think of a call that was unusual? (what was it?) And what strategies did you use for understanding/triaging this patient?

C-2 Summary of Results

1) Algorithms

Q 1:
Is there a major difference between cardiology and cardiac surgery patients when you go through pain (or any other) scenario? (i.e. any special question sequence for surgery patients?)

- Yes: 7/8
  - C – looking for changes in pain and associating pattern (frequency, intensity or duration).
    - Is it angina pain or MI (Myocardial Infarction – heart attack)?
    - Pericardial – does it hurt more with a deep breath?
    - 1 NC said C patient with pain usually need to be sent to the hospital
  - CS – compare with the angina pain before their surgery, is it worse than when they left the hospital
    - PPS (post-peri-cardiotomy syndrome): pain in their back, shoulder and neck. May have a low grade fever.
    - Distinguish between pleuritic pain and PPS:
      - PPS pain – High lateral pain. Pain is acute and severe.
      - Pleural effusion – Low lateral pain. Pain is sharp, usually worse with a deep breath. Often described by patients as a 'catching pain' (common question to ask patient if the pain "Catches your breath?")
    - Infection for incisional pain: "Does it hurt more if you touch it?"
    - When was the surgery? When was the patient discharged?
- No: 1/8
  - Always start with name, date of birth, physician's name, what did we take care of you for?
  - Patient may have had angina, a stent and a bypass –> they are both a C/CS patient.

Patient could have been post-op for 2, 3, or 4 yrs.

Q2:

For cardiac surgery patients, do you always (or almost always) assume that the complaints have to do with the recent surgery? Would you be as likely to consider other possibilities (e.g. a new condition on its own) the same time?

- Yes (almost always assume the complaints are related to the recent surgery): 4/8
  - Calls from surgery patients are usually related to surgery.
  - 1 NC stressed time – within 3 months for surgery related pain; within 1 month could be incisional; if within 1 week then usually incisional.
  - 2 NCs – infection has no time frame, especially for diabetics.
- No: 3/8
  - Consider chronic pain that resembles PPS.
  - Patients may call about non-cardiac issues, including flu symptoms.
  - Some conditions involve both C and CS.
  - Though NCs answered no to this question, they still appear to consider CS symptoms along the way.
- Depends: 1/8 – 1 NC said it depends on how long it has been since the surgery.
  - If within 2 weeks of surgery then it has to do with surgery;
  - If calling after 3 years of surgery, then likely to be something else.

Q 3:

We see some NCs comparing "pain before the operation" or "pain after the operation". Is it simply asking if it's improving or worsening, or is there any significance? (especially related to the type of operation?)

- 6/8 NCs mentioned that they are looking for clues/causes by finding out whether or not it felt like the angina or MI pain the patient had previously, the pain related to incision, something new.
- 1/8 NC is concerned with comparison to the pain the patient had at the hospital; she is interested in how the pain affects the patient's activity.
- 1/8 nurse does not ask this question.
- 3 NCs indicated that this question was asked after patient describing their pain first. Sometimes this information came from their description.
- 1 NC provided an example:

Comparison of Attributes Between Cardiology and Cardiac Surgery Patient

	Cardiology Patient	Cardiac Surgery Patient
Type of pain	Constant	May be intermittent or constant
Severity of pain	Severe	May be mild, moderate or severe
What helps?	Unlikely to be relieved by rest and/or Nitro	May be relieved by rest and/or Nitro

Q 4:

When asking open-ended questions, (e.g. "describe your discomfort") what type of information are you looking for in general?

- 4/8 NCs immediately look for:
  - Location/onset/intensity/frequency
  - What relieves/aggravates it?
  - Does it hurt at rest? Does it hurt when taking a deep breath (2/4)
- 3/8 NCs look for a sense of direction for asking questions (type of pain, etc)
  - then get into more specific information (location, onset, etc)
- 1/8 NC looks for problems that the patient hasn't described before from answering the NC's previous questions. The same NC is concerned with general symptoms such as infection, high temperature, breathing, and if they have chills.
- 2/8 NCs observe patients' stamina from how they talk (e.g. how they breathe)

Q 4a:

Do most patients provide you those answers? Or you have to redirect questions to gather more relevant information?

- Yes: 2/7
- No: 5/7
  - Get spouse on the phone
  - Have to cue them
  - 1 NC OLDCART it
- Depends: 1/8

- Sometimes have to ask, for example, how they feel since they left the hospital

Q 4b:

Have there been cases when you received unexpected answers (to open-ended question) that led to better assessment.

- Yes: 6/8
  - Ask "tell me more" questions after a brief statement of pain from patient.
  - Other symptoms mentioned that aren't expected to be associated with the primary symptom (e.g. chest pain + dizzy => 'arrhythmia'? instead of MI
  - Patients sometimes don't call about the most important symptoms
  - Patient complained of gastric symptoms (diarrhoea) but ended up with it in his wound as the diarrhoea was caused by C Diff (Clostridium difficile). It is important for patients to learn (in classes) about infection, how to avoid them, and how to self-screen for fever.
- No: 2/8 - 1 of these 2 NCs simply started with direct questions

Q 5:

When you ask symptoms do you typically ask (onset/duration/frequency/condition)
a. When did it start?
b. What is the duration?
c. How often

- Yes: 8/8 (including questions a to c)
- Additional information: (6/8)
  - What relieves/aggravates it?
  - Is it new/typical?
  - Is the patient taking medicine? If yes, does it help?
  - What procedure did the patient have?
- For CS patient, there are questions related to the incision
- 1 NC said OLDCART for everything

Q5d:

Or is it symptom dependent? (Can you give examples?)

- Yes: 5/7
  - e.g. some questions are not appropriate for sleep problems, constipation, etc.
  - Special cases such as end-stage patients. Then you are looking for change in pain pattern.

Q 5f:

As related to the previous question, do you assess the severity level of symptoms by mostly frequency and duration?

- Yes: 1/8
- Depends: 3/8, depends on C or CS
- Did not comment directly (4/8)
  - C – frequency is more important in chronic pain

Are there any other cues you look for in a patient's response (e.g. particular description of a certain symptom, tone, etc)?

- 4/8 NCs- rate pain on scale 1-10
  - Worse/same as pain in the hospital (rate for both)
  - RNAO has a mnemonic for pain assessment
  - 1 NC stated that an 8 on this scale would definitely send the patient to Emergency Room (ER).
- 3/7 NCs – is the patient taking medication for pain? Does it help?
- 3/8 NCs - listen for breathing/SOB (shortness of breath), grunting, huffing and puffing, moaning, etc.
- 4/8 NCs - tone of voice / anxiety
- 2/7 NCs - Information from other people in the background, often the spouse.
- 1 NC – Are patients coherent? Are they able to answer the questions?
- 1 NC – Do they have blurred vision?
- 1 NC - Dyspnea scale. How many pillows do they need to go to sleep? How far can they walk without getting SOB? Can they dress themselves without getting SOB?

2) Decision Making

(mental model)

Q 6:

When you are asking questions about the patient's condition, at what point would you formulate a mental model of the problem in your mind, if any at all? If you do form a mental model of the problem in your mind, do you ask questions to confirm your hypothesis or do you continue on following a standardized question set?

- 8/8 NCs - formulate a mental model to some degree
  - 6/8 within a short time (a couple questions)
  - 1/8 – mental model can be formed at any given time during the conversation, keeps changing
  - 1/8 – when figure out how the pain is occurring and what aggravates/relieves it.
  - 3 NCs mentioned visually picturing patient and their problem – often know/met the patient
  - Hypothesis/direction of questions is set by these mental models. Mental model changes when new information found.
    - 1 NC stressed the need to have several possibilities in mind.
    - Similar response by another NC: model used to rule out major problems.
  - Charts, discharge records are useful here to picture patient's condition.

(Medication)

Q 8:

For medication, is it more important to know how much (total quantity) they consumed? Or how much (dose) at a time and how often (frequency)?

- Yes to all: (3/8)
  - How much and how often (pain killer dosage) (1/8)
  - Important to know the name /type (specific kind of) medication they are on. (2/8)

- if they have their bottles, ask them to read

- if they call for SOB → are they on diuretic (the kind/how long it was ordered i.e. time period or perpetual)

if they call for dizziness → are they on ACE inhibitor/beta-blocker & what time of the day they are taking (if they are taking both at the same time recommend to take them separate time – dizziness is side effect)

- Depends (2/8)
  - Yes for surgical pain (dose & frequency) Nitro etc..
  - For cardiology patient amount is usually not an issue (unless they took more than the regular amount)
  - If incisional pain, → important to clarify the medication with patients (kind/usage)
- Other things: (4/8)
  - If they are taking it /Are they able to take them (without throwing up)
  - Effectiveness / if it was working fine and now it doesn't --> problem
  - Give patients more information on meds (types of meds, side effects, simple facts about interaction)
  - Diet
  - Bowel movement (Frequency, Colour)
  - Some pharmacies advice elderly patients → need to talk to physician and call back
  - Coumadin: Have they had their blood pressure taken?
  - Weight gain (2/3 lbs) in the last 2 weeks and feet swollen → ask physician if he wants to increase Lasix and call back
  - Refer to nursing profile
  - if they have kidney problem
  - On dialysis?
  - Did they use an anti-inflammatory in the hospital?
  - How strong is their heart?
  - When did they take pain-killer? / Was there enough time for the medication to react?

Q 9:

Would it be useful to have a drug reference? Or cumbersome?

- Yes - useful (7/8)
  - Information on non-cardiac drugs: their classification (generic/trade names), side effects (adverse effects) and interaction effects with cardiac drugs
    - e.g. for arthritic, cold, flu, etc., commonly asked ones include anti-histamines, anti-arthritic drugs like Vioxx and Celebrex
  - Sometimes patients are on a drug with different brand name than the usual ones (use CPS – 3 NCs)
  - Refer to pharmacist – 2 NC
  - List of common drugs: Metropolol, Amiodorone, Altace.
  - Allergies, Penicillin, codeine and sulfa drug allergies.
- Depends (1/8) – refer to pharmacists might be best as NCs are always busy

Q 10:

When (if ever) and within what range would you make recommendations about changes in drugs (dosage, use of pain killers, etc.)

- Generally don't recommend change without asking physician (4/8)
- Sometimes (2/8)
- Frequently (2/8)

- Tell patient to hold a drug while checking with the physician (6/8)
  - BP drop, low heart rate, high INR
  - Frequently patients have problems with coumadin (bleeding) or metropolol (fatigue) diaphoretic
  - May get an order for a diuretic from the resident to call into the patient's local pharmacy.
  - If the patients are taking maximum dosage (pain killer)
- Recommend how to take medication (when to take it) (3/8)
- Recommend over-the-counter drugs (7/8)
  - kidney problem, stomach ulcer (anti-inflammatory)
  - constipation (plain Tylenol or take Tylenol 3 at bedtime)
  - pain – Tylenol/extra strength Tylenol
- Sometimes recommend patients to see family physician (2/8)
  - bring book and tell your physician about the condition.
  - Problem with beta-blocker or ACE
- Advice CS patient to keep taking their medication if they have stopped too early
- Help guide the patient with their prescribed Lasix titration
- Give advice to patients to deal with problems without changing medication
  - Gum bleeding – if serious go to ER, if not change to soft tooth brush)
  - Change the amount of exercise

(location)

Q 11:

Does the location of patients influence the decision? (i.e.: if the patient is not close to a hospital, would you advice them to call ambulance.)

- Yes (8/8)
  - Availability of doctor (community dependent)
  - If not available→ send them to ER (sometimes ER doesn't understand and call UOHI)
  - Proximity to UOHI (send patients in day shifts, 2 exam rooms in reference centre for drop-ins)
  - If coming into UOHI is not possible
    - → go to General Physician (GP) and show page 12 of their discharge book
    - → ER (SOB, draining wound UTI)
  - Assess the timeline (urgent, few hrs, within 8 hrs etc.) to see doctors and find possible solution
  - 911, ER (if someone can drive), UOHI, advice over phone
  - If not cardiac related, sending UOHI would delay the emergency care → ER is better choice
  - Distance from the nearest ambulance dispatch and the patients condition is very important factor to tell them call 911 or ask someone to drive to ER. (if the patient has a cardiac arrest in a car with a driver they can't do anything to help the patient)

Ask if someone can come to stay with the patient when he/she is taking nitro.

(Callback Procedure)

Q 12:

When you assign call-backs what are the factors you consider? For example, what makes you decide how many hours later the call-back should be / who should be calling?

When?

- Usually call back myself during my shift (5/8)
  - Consult with physician and call back to patients.
- Ask patient to call back if the intervention doesn't work or the condition gets worse (6/8)
- Usually call back within 30 min (eg. BP drop)

Night/evening shifts:

- Sometimes a day NC arranges appointment and calls back the patient

Reason of Callback:

- If the patient (or family members) was anxious
  - Give specific time to call back so they can be reassured. (next day)
- If patients appear to have infection developing
- When I feel that the patient might not follow the advice
  - This kind of knowledge was gained when the patient was at the UOHI
  - Social level, tone (of interest)
  - Sometimes you have access to previous information on the patient

When ask physicians to call the patient back

- incisional infection not getting better (leave surgeon a note)
- sometimes ask patients to call physician if they don't get called
- there's no feedback from physicians regarding whether or not they called the patient back

a. How is the information transferred between the shifts?

- Review callback sheet at change-over (patients name, their physician, issue, NC's expectation to next shift NC, phone number, DOB)
- When taking notes at callback use the original (addendum below a line) or fill a new form and staple together
- Leave the callback sheet with a little note (post-it) and the surgeon's name
- Sometimes handwriting that is hard to read.
- One of the NCs uses a lot of cryptic words and acronyms but you get used to it. --> Standardizing these would help.

Will go and check the chart if it's available. Looking at general health, white blood cell count.

b. What information you like to get from the bunker?

- From the bunker, you get patients name, physician's name, last admission, what they were here for (e.g. procedure/OR)
- Don't need anything from bunker

c. Are there a standard set of questions that you ask when you call back?

- No: 1/2→ use the original callback sheet
- Yes: 1/2
  - Ask if they took the recommended action.
  - Ask about the effect of intervention (medication etc.)
  - Is the condition improved/worsen?

d. When calling back what is the most important information to know? (1/1)

- The primary physician
- The physician's agreement to the plan (clinic visit / change of medication etc.)
- The physician's planned course of action
- Is the patient experiencing a side-effect to their medication?

e. Do you look up nursing profile?

- Not often (1/2): Usually remember the patients since the condition of the patients is critical
- Yes (1/2): for SOB, check meds (types and how long they are on)
  - Other information on the patient can be obtained from it (special notes etc…)

(home care)

Q 12:

Do the specific homecare instructions given to the patient (e.g. exercise or increase patient's activity) follow closely to standardized procedures or more by experience?

- Standardized (7/8)
  - Exercise program, wound care
  - Discharge booklet
  - Physio class/discharge class

  Cardiology is more liberal
- Combined with experience (2/8)
- Review strategies to help them sleep (1/8) – caffeine, nap time etc..
- Things to check if they are not following their discharge program at home
  1. don't want to? – psychological
  2. can't do?
  3. depressed?
  4. other things.
  5. physiologically impossible <-- more serious
- If they can't do their exercise program
  → something physiologically wrong or they're depressed.

Q 13:

Do you give those homecare instructions directly on the phone or do you redirect the patients to recorded message / website / patient education booklets?

- Booklet (7/7) – discharge book/patient education booklet/post-procedure sheets
  - (direct patients to certain page, explain about program)
- Tailored exercise program
- Others (2/7)
  - Recorded message/website
  - Local walking program
  - Cardiac rehab, nutrition class

3) Expertise / Expert Behaviour

Q 14:

What makes a patient call-in difficult? What are the characteristics of the "difficult caller"? Are there strategies for handling this?

- Screaming, demanding, upset, angry (2/8)
  - Tell them to call back when they are calm, and hang up.
  - Try to calm them down
- Vagueness of symptoms (6/8) especially elderly (1/8)
  - Takes long time to extract what is going on (often the calls are from patients' family)
  - Ask pointed questions (2/8)
  - Ask them to rephrase if it's still vague (1)
  - Take time to listen to them (1)
- Language Barriers
  - Ask to speak slower or get someone else
- Needy patients
  - Vague → sometimes refer to physicians
  - Sometimes patients just want to talk to someone
- Does not want to follow advice (e.g. They have work to do rather than going to ER)

Q 15:

Similarly, what is the ideal call-in? What does this patient (or caregiver do) that makes it easier?

- Specific information /clarification call (5/8)
- Good communicator/describer. (1/8)
- In control, knows the details of their history (2/8)
- Well-informed about condition/meds (3/8)

Q 16:

Have you had any experience training others to handle calls? (or advising new nurse coordinators?)

Experience training/orienting

- Yes (7/8)
- No (1/8)

a. What are the challenges that new or learning NCs have with handling calls?

- They jump to conclusions too fast (less than with 3 questions)
- Teach them first listen until you get a reasonable story (make difference if they check off information)
- They should keep the major dx uppermost in their minds (MI, HF, pulmonary embolus)
- They may need to learn specific questions (they might forget)
- New NCs need to learn how to figure out what their next questions should be.
- Since there is no standard algorithm, it comes from your experience.
- Learning anticipation of what calls would be like
- Need to take down basic info. - Patients get annoyed by providing basic info again after telling the bunker.
- "Experience vs. theory" -> "have you ever had …xxx?" these symptoms may be associating with different possibilities. Try to eliminate chronic pain, recent surgery, flu/cold.
- Sometimes you have to give advice covering two different possibilities.
- Need to know how to prioritize tasks in emergency situations.
- Advise them on what to say (limits), HI policy.
- A new NC that's only worked in one place – can they distinguish something that's life and death from something that can wait?
- Needs to know where her resources are and how they're going to get them.
- Dealing with the stress of picking up life-threatening call

b. What are the "trademarks" of an experienced NC in this task, how do you recognize one?

- An open mind and a good sense of humour
- I've been surprised by some of the interventions other NCs have given patients. If the night NC leaves me a message to arrange for a physician to see a patient, I call the patient back to re-assess and to get more information that might be missing.
- A more experienced NC collects more detail first. They probe quietly. They realize the patient is already upset.
- An experienced NC writes the facts and is faster at handling calls.
- As an experienced NC, you sort of know what's going to happen for a lot of the post-op patients.
- Ask the right questions/or the right 'next' questions (prompting)
- You gain confidence and know that difference between the patients who need to go to the ER and those that can be seen in clinic or by their GPs.

Q 17:

Do you have any particular strategies that you have developed to

a. Help get through calls a little faster?

- There's no strategy (2/8)
- Focusing on the point to extract the reason of the call (6/8)
  - OLDCART (1)

- Keep own pace and make a list on a paper (1)
- Use callback sheet to ask specific questions (1)

b. Fill in the call back forms efficiently so that you have the key info when you do the call back?

- Writing:
  - Fast
  - Point form (meds, symptoms)
  - Short forms (individual variation→ better if it's standardized)
  - Talking and writing at the same time helps
- Skip:
  - DOB (3/6)
  - Age (if they don't volunteer)
  - Repetition
- When calling back
  - Use the original form to fill the new one
  - Add a new page attached to the old one (do not create a new page)
- Have patient's profile to get info (when I'm not sure)

Q 18:

Can you think of a call that was unusual? (what was it?) And what strategies did you use for understanding/triaging this patient?

CASE A: An aortic valve patient (44, F)
had an aortic valve done ½ year ago
after OLDCART → she says that symptom is going on a couple of weeks.
I hang up and told her that I call back
Checked chart/nursing profile
After calling back twice, I told her to go to ER
Turned out that the scar tissue supporting her artery was kinked → surgery

Strategy:
Not making the decision at the end of call → hang up and go back to the call again.
Usually tell patients that I'm consulting with Dr. so that they know that I'm working on the case.

CASE B: Related to dentists and the person is looking for information
eg on preventative antibiotic use for cardiac patients

CASE C: The wife of a patient called in and said, "He's not picking up".
I asked, "What do you mean"?. The wife said, "He's not doing his walks". It turns out that the patient had developed a cough. I asked what meds he was on and if the cough was associated with SOB.
If a patient has a dry cough and is on Captopril, I would call the resident. If the patient had a cough and was not on Captopril, I would leave a note on the call in the surgeon's office.

Strategy:
You use different strategies when patients are dealing with stress or anxiety; you have to set aside 15-20 min to devote to that type of phone call.

CASE D: Get calls that are not cardiac related and unusual
(e.g. woman with acute schizophrenic episode).

CASE E: Compartment syndrome where they harvest the radial arteries.
The patient gets swelling, tightness, colour changes in their limb and have movement and sensation changes. These patients need to be seen. An inexperienced nurse may just tell them to elevate the limb.

CASE F: A lady called and she was upset with her job – they let her go on disability. She felt she was in that position because her physician wouldn't give her extended leave. She wanted to know if there was something she could take so her heart wouldn't burst (from the stress). This call took about an hour.

Strategy:
Try to calm her down

CASE G: A woman called after she had a fight with her daughter and she was having angina. I called her down and told her to call her family doctor the next day.

CASE H: I had a patient call and say that every time they went to the bathroom, they passed out. I was thinking they were having vasovagal episodes but I asked them if they were diabetic and when they said "yes", I asked them how their sugars were and they said they had been fine. I asked the patient to take their blood sugar and it was high. It turns out they were having an MI post-CABG.

CASE I: I had a husband call to say his wife was nauseated and that she wasn't eating but I heard her moaning in the background. I asked him if he could drive her to the hospital but he said she couldn't even walk 2 steps so I told him to call an ambulance. She was having a late cardiac tamponade.

4) Expectation to the new system (asked at the end of the interview)

- Patient Information:
  - Using the PDAs to input the Nursing Profiles that are filled in on all cardiac surgery patients and cardiology patients that to through CCU or are CCU patients in Reference Centre would give us easy access to pertinent information on these patients.
  - Having list of patients to follow-up on in a group would be useful
  - Activities expectation for patients (on a time line)
  - Diet information – what they can eat, alcohol consumption, etc
  - Preload patient demographic information, info on past surgery as much as possible.
- Algorithm
  - Having a summary of what's going on as one is going through the algorithm
  - Separating basic info for advanced users and more detailed info for novices (navigation wise) – flexibility to jump around.
  - Need to see algorithm visually
  - Generate assessment report (such as callback sheet information)
- Useful discrimination questions
  - Use of "key phrases" in the algorithm, e.g. "stabbing/squeezing" pain
  - Stent pain - Pulmonary edema – include the proper way of assessing

- Guidelines for homecare:
  - Could put the care map on the PDA.
  - Should be able to do 18 stairs when they leave.
  - Canada Food Guide.
  - How quickly they can drive or fly.
- Features:
  - Alarms for reminders to call patients back would be useful.
  - Personal signature, eliminate writing NC's name.
- Technical Concern:
  - Narrative entry will take longer than writing down on a paper.

Appendix D

Experimental Documents for Experiment I

D-1 Recruitment Poster

Department of Systems Design Engineering
University of Waterloo

PARTICIPANTS NEEDED FOR RESEARCH IN HUMAN FACTORS ENGINEERING

We are looking for volunteers to take part in a study of

Using Personal Digital Assistants and Patient Care Algorithms to Improve Access to Cardiac Care Best Practices

As a participant in this study, you would be asked to perform

- a short performance task (such as deciding on the disposition of a patient's call) on a personal computer
- usability evaluation of graphical display elements

Some prior experience in health care/human physiology is desirable to participate in this study.

Your participation would involve 1 single session, which is approximately one hour. In appreciation for your time, you will receive

$10.00

For more information or to volunteer for this study, please contact:

Yukari Enomoto

Advanced Interface Design Lab

Systems Design Engineering

@

519-888-4904 or Email: yenomoto@engmail.uwaterloo.ca

This study has been reviewed by, and received ethics clearance through, the Office of Research Ethics, University of Waterloo (ORE # 11940.)

D-2 Consent Form

INFORMATION SHEET AND CONSENT
for
USABILITY TEST PARTICIPANTS

Using Personal Digital Assistants and Patient Care Algorithms to Improve Access to Cardiac Care Best Practices

PRIMARY INVESTIGATORS:
Dr. Kathryn Momtahan, RN, PhD
Dr. Catherine Burns, PhD, PEng
CO-INVESTIGATORS:
Ms. Heather Sherrard, RN, BScN, MHA
Dr. Thierry Mesana, MD, PhD, FECTS, FRCS(C)
Dr. Marino Labinaz, MD, FRCP(C)

STUDY COORDINATOR:
Yukari Enomoto

Please read this Information Sheet and Consent Form carefully and ask as many questions as you like before deciding whether to participate.

INTRODUCTION

We are conducting a study funded by the Ontario Ministry of Health and Long-Term Care to develop and test patient care algorithms on personal digital assistants (PDAs) to support telephone consultations to cardiac patients, using best practices. The goal of the project is to develop a tool that can support primary care healthcare practitioners such as family physicians and nurses working in family medicine clinics when they receive calls from cardiac patients. The study will run from November, 2004 to the end of March, 2006, a period of 17 months. The purpose of the usability testing that you will be participating in is to determine usability problems with the prototype design of this tool before the nursing coordinators at the University of Ottawa Heart Institute test them on live calls with patients.

PROCEDURE

You will be given cardiac and non-cardiac and then you will be given a set of visual stimuli and tasks related to fielding the calls. The usability testing session will last for approximately one hour.

RISKS and DISCOMFORTS of PARTICIPATION

There are no anticipated risks or discomforts involved in this study.

BENEFITS OF PARTICIPATION

Although there may be no direct benefits of this study to you, it is hoped that the end result will be that the usability of the prototype software for use by the nursing coordinators will be improved.

COMPENSATION/RENUMERATION

There will be monetary compensation, $10.00, for participating this experiment.

CONFIDENTIALITY

All records will be kept confidential. Any documentation and interviews will be reviewed by the Investigators and may be reviewed by representatives from the Ontario Ministry of Health, or representatives of the Heart Institute Research Ethics Board under the supervision of the Investigators or their staff. You will not be identified in any publications by name or initials. All data sheets will have your number only on them and they will be kept in a locked office at Advanced Interface Design Lab.

TERMINATION OF THE STUDY

Your participation is voluntary, and you may elect to refuse to participate or to discontinue participation at any time.

ETHICS

This project has been reviewed by, and received ethics clearance through, the Office of Research Ethics (ORE # 11940.) In the event you have any comments or concerns resulting from your participation in this study, please contact Dr. Susan Sykes at 519-888-4567, Ext. 6005.

PARTICIPATION

Participation in research is completely voluntary.

You are free to choose whether to participate in this study or not. If you choose to participate, you may choose to withdraw your consent at any time. You are also free to refuse to answer any questions that you may be asked because of your participation in this study.

CONSENT TO PARTICIPATE IN RESEARCH

I understand that I am being asked to participate in a research study on using personal digital assistants and patient care algorithms to improve access to cardiac care best practices. By giving my consent, I am authorizing Advanced Interface Design Lab and the University of Ottawa Heart

Institute to review my data for the purposes of this study. I am also agreeing to be interviewed for the purposes of this study.

I have read and understood this Information Sheet and Consent Form. All of my questions at this time have been answered to my satisfaction. If I have any further questions about this study, I may contact the Study coordinator, Yukari Enomoto at (519) 888-4904.

I will receive a signed copy of this Consent Form and the attached Information Sheet.

I voluntarily agree to participate in this study.

Name _____

Signature _____

Date _____

Signature of person obtaining Consent _____

Investigator / Co-Investigator's Signature _____

D-3 Experimental Script

Thank you very much for participating in this study.

The goal of this project is to evaluate the visualization methods of the conditions a call-in patient is experiencing. The results of our evaluation will be summarized and integrated into the design of decision support system for cardiac nurses. The system would help nurses to provide better care to cardiac patients.

I would like you to read through the information sheet and consent form and sign the consent form. Please ask me any questions before you sign the form.

<< Give them information sheet and consent form >>

As you have read in the form you can stop any time during the experiment.

Please imagine you are a nurse talking to a patient on the phone. And your task is to make recommendation to the patient and select possible conditions from a list. The task would be performed in two domains; first, common illness and second cardiac conditions.

You will be seeing sets of symptoms in 4 different representations.

<< Show the display description >>

Text, Bar, Polar and Clock displays (pointing to each figure). Please take a moment to read the descriptions and ask any questions. Please keep in mind that you will not have this sheet during the experimental trials.

<< Give them 1 minute to go over the display.>>

Before we start common illness section, I'd like you to look at common illness symptom list. I'll give you 2 minutes to go over the list. Please ask any questions. Please note that your questions will not be answered and you will not have this sheet during the trials. << If they want more time... let them know that you can keep the sheets during the practice>>

<< Set up the experimental software when the participant is going over the sheet. Enter year and discipline of the study and age, exposure to cardiac care / telephone consultation>>

You will have 4 trials for training. You can keep the information sheets with you during this practice. Please adjust your chairs and position of the computer so that you are comfortable. You can ask any questions during the practice.
<< Make sure that they don't spend too much time on practice session >>

<< Watch the subject to see if they are responding to the questions in reasonable time. If they are taking too long, please remind them that this experiment is not testing your ability to remember the list. We are interested in the difference between the different >>

<< After the practice…>> From here, it would be the actual trials, please press okay when you are ready to continue. Please keeping in mind that we are interested in the accuracy and response time, so please answer the questions as quickly and accurately as possible.

<< Don't forget to take away the info sheets!!!>>

After you finish, you will need different sets of symptoms. Please let me know when you finished common illness part of the experiment.

<< When it's done >> Please take a moment to look at the symptom list for cardiac illnesses. I'll give you 2 minutes to do so.

You can go over practice session as you did last time. You can keep the sheet with you during the practice, but not in the real experiment. Please ask any questions before the experimental session starts.
<< Make sure that they don't spend too much time on practice session >>

<< Don't forget to take away the info sheets!!!>>

<< After the participants are done >>
Thank you. Please fill out the both side of this questionnaire and let me know when you are done. Ask me if you have any questions.

<< Make a photo copy of consent form and give it with $10 for compensation. Ask them to sign the receipt.>>

Thank you very much for participating to this study.

D-4 Pre-experimental Questionnaire

Participant ID:

Display Order:

- Order 1
- Order 2
- Order 3
- Order 4

Demographic Information

Age:

Gender:

- Male
- Female

Current term:

Field of study:

- AHS
- KIN
- BIO
- Other

Exposure to cardiac care

1. A doctor or nurse in cardiac care
2. A doctor or nurse in another field
3. Studying in medical school
4. Studying in nursing school
5. University level physiology
6. University senior level physiology
7. High school level physiology
8. Am/was a patient in cardiac care

Exposure to phone consultation (Telehealth etc...)

1. Never used it
2. Used it a few times
3. Frequent user
4. Studied about it before
5. Worked in phone consultation environment

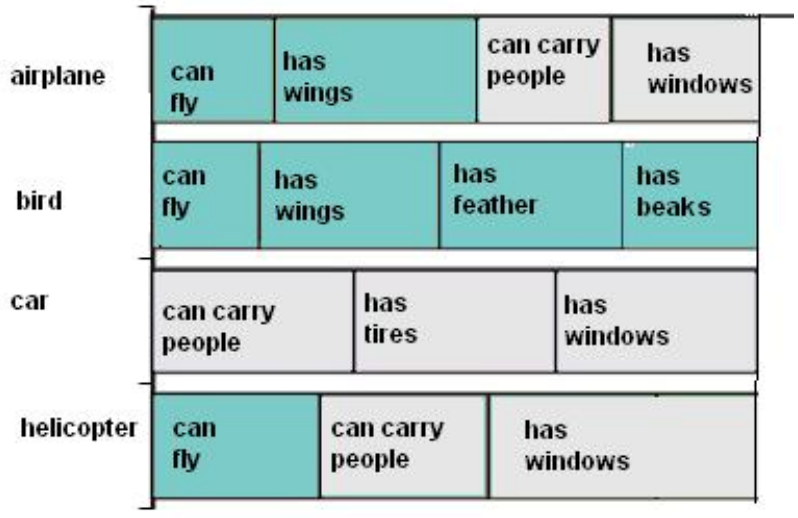
D-5 Training Material: Visualization Tools

As a participant in this research, you will be asked to view the 4 different types of displays. Each display uses a different method to show a patient's symptom information.

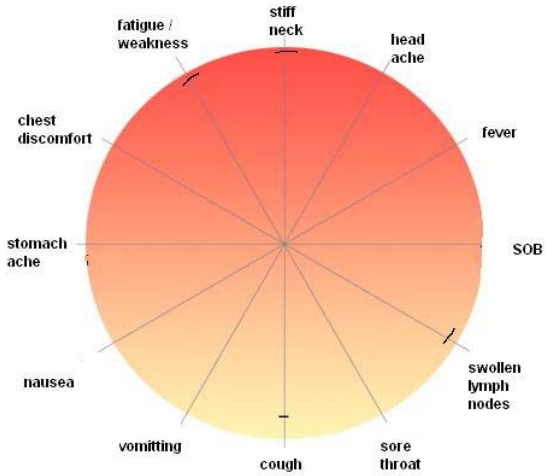
1. Text display: Symptoms of a patient are presented as a list of text.

Cough
High fever
Sever Headache

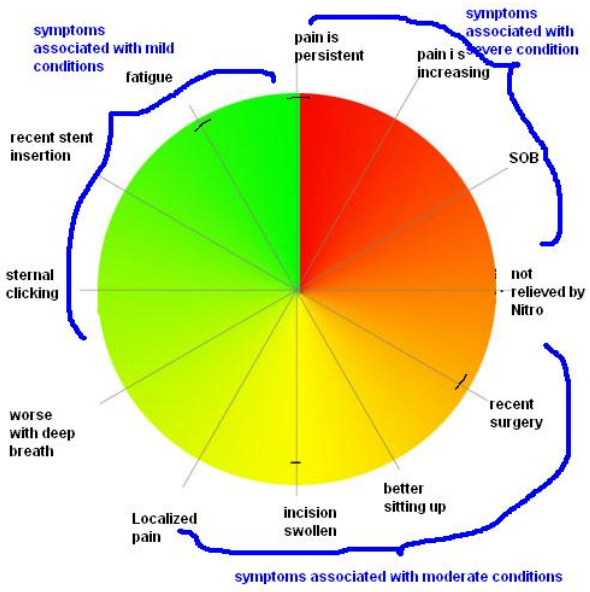
2. Bar Symptom map: Bar charts for multiple conditions would be displayed with labels. Each bar contains only relevant conditions and patient's symptoms will be highlighted



3. Polar symptom map: Symptoms are arranged on the axis of a polar graph. The symptoms are grouped in a logical way such that related symptoms are grouped together.



4. Clock symptom map: Nurses typically ask questions in order of severity. The symptoms are arranged around the clock in such a way that symptoms related to severe conditions are plotted along the early hours, those that represent moderately severe conditions are plotted around 3-9:00, and the rest would be filled with those that represent less severe condition.



D-6 Training Material: Cardiac Illness Patient Models

	Description	Symptoms	Recommendation
Ischemic Pain	Pain caused by decrease in the blood supply to the heart caused by constriction or obstruction of the blood vessels.	Chest pain (8 out of 10)* Angina- and MI-like pain Persistent pain Area larger than hand Not relieved by Nitro Anxiety	Call 911
Tamponade	Cardiac tamponade is the compression of the heart caused by blood or fluid accumulation in the space between the muscle and the outer covering sac of the heart.	Chest pain(4 out of 10)* Area larger than hand Better when sitting up Shortness of breath Recent Surgery	Go to Emergency
Incision Infection	The incision created during a recent surgery has become infected.	Chest pain (4 out of 10)* Localized pain Fever Incision swollen Purulent drainage Recent surgery	Nurse will consult with physician and call the patient back
Unstable sternum	A wound complication that may occur after open-heart surgery.	Chest pain (4 out of 10)* Localized pain Worse with deep breath Sternal clicking Recent surgery	Nurse will consult with physician and call the patient back
PPS	Post-pericardiotomy syndrome is a febrile illness in patients who have undergone surgery that involves opening the pericardium (outer covering sac of the heart).	Chest pain (4 out of 10)* Area larger than hand Better when sitting up Worse with deep breath Fever Recent surgery	Nurse will consult with physician and call the patient back

Pulmonary embolus	Pulmonary embolus is a blockage of an artery in the lungs by fat, air, tumour tissue, or blood clot.	Chest pain (8 out of 10)* Area larger than hand Mild shortness of breath Worse with deep breath Mild anxiety Mild fatigue Mild cough	See family physician
Stent Pain	Coronary stent insertion is used to open up a blocked coronary artery. After implantation, the coronary stent remains to hold the artery open.	Chest pain (3 out of 10)* Localized pain Recent stent insertion	Take Tylenol and call back if it doesn't work
Pericarditis	Inflammation of the pericardium.	Chest pain (3 out of 10)* Area larger than hand Fever Worse with deep breath Cough Anxiety	Take Tylenol and call back if it doesn't work

* Based on a 10 point pain scale

D-7 Training Material: Non-cardiac Patient Models

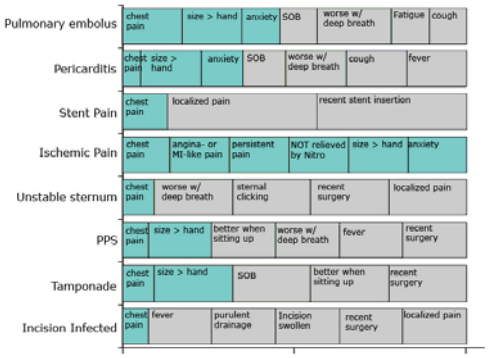
	Description	Symptoms	Recommendation
Allergies	An abnormally high sensitivity to certain substances, such as pollens.	Shortness of breath Itchy eyes Slight difficulty in breathing Vomiting Wheezing Nausea Rash Sneezing	Go to emergency
Meningitis	Inflammation of the meninges of the brain and the spinal cord, most often caused by a bacterial or viral infection.	Nausea Severe headache Fever Vomiting Photophobia Stiff neck	Go to emergency
Asthma	A chronic respiratory disease characterized by wheezing.	Wheezing Shortness of breath Difficulty in breathing Cough Chest discomfort	Go to emergency
Strep Throat	An infection of the throat, often epidemic, caused by hemolytic streptococci.	Fever Swollen lymph nodes Nausea Rash Mild headache Sore throat	See family physician
Mono	Infectious mononucleosis is an acute infectious disease associated with Epstein-Barr virus.	Swollen lymph nodes Fever Fatigue Rash Sore throat	See family physician
Food Poisoning	An acute, often severe gastrointestinal disorder caused by eating food contaminated with bacteria.	Vomiting Abdominal pain Nausea Diarrhoea Fever	See family physician

Flu	An acute highly contagious virus disease that is caused by various strains of orthomyxoviruses	Headache Fever Chest discomfort Fatigue/weakness Diarrhoea Sore throat Sneezing Cough Stuffy nose	Take over-the-counter medications
Cold	A viral infection characterized by inflammation of the mucous membranes lining the upper respiratory passages. (i.e. the common cold)	Mild chest discomfort Sore throat Slight swollen lymph nodes Slight wheezing Slight fatigue/weakness Stuffy nose Sneezing cough Mild shortness of breath	Take over-the-counter medications

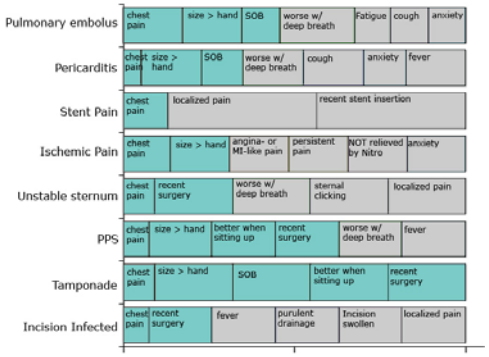
D-8 Stimuli

a) Cardiac Illness – The Bar Symptom Map

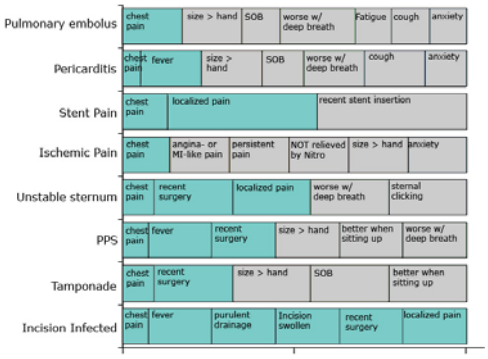
Ischemic Pain



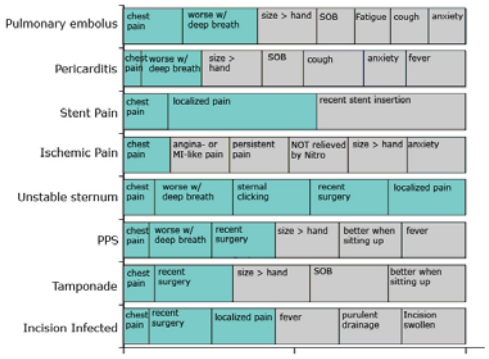
Tamponade



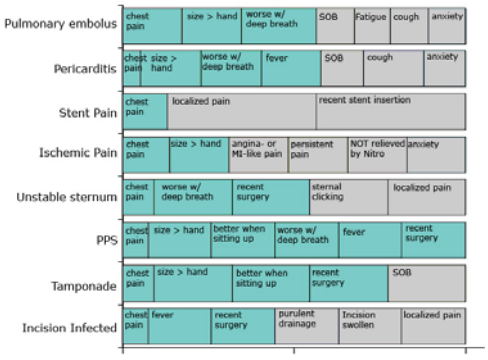
Incision Infection



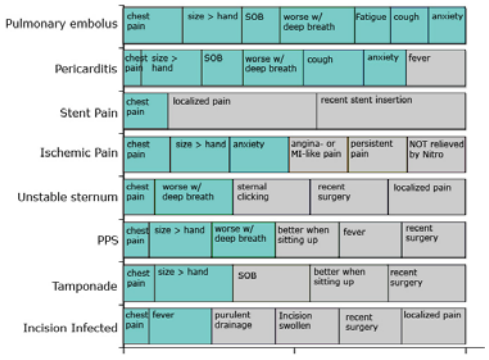
Unstable sternum



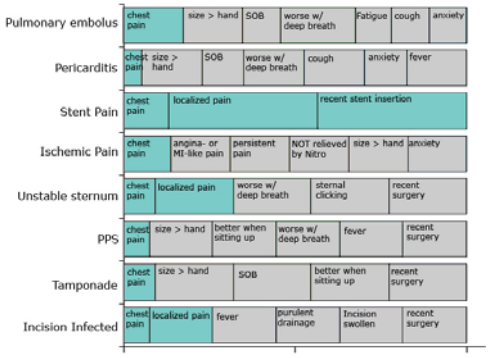
PPS



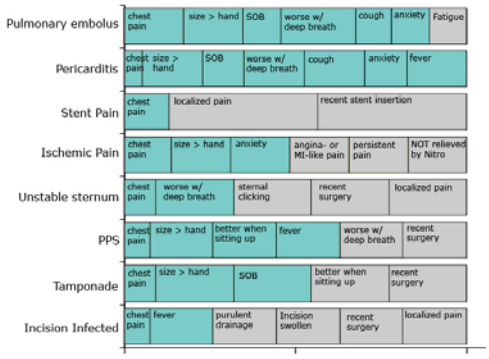
Pulmonary embolus



Stent Pain

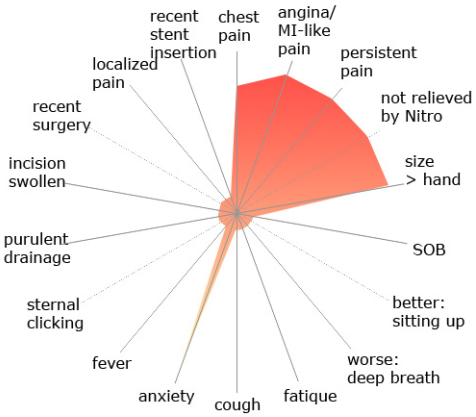


Pericarditis

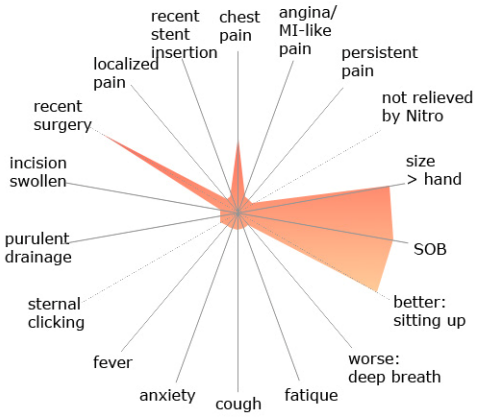


b) Cardiac Illness – The Polar Symptom Map

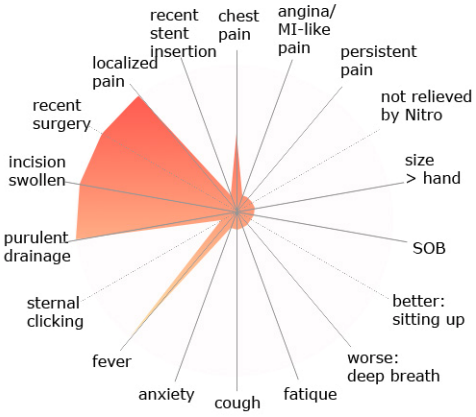
Ischemic Pain



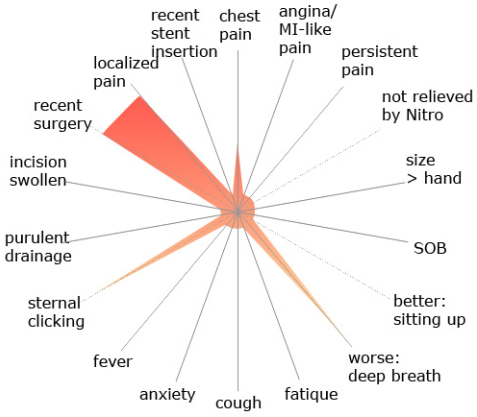
Tamponade



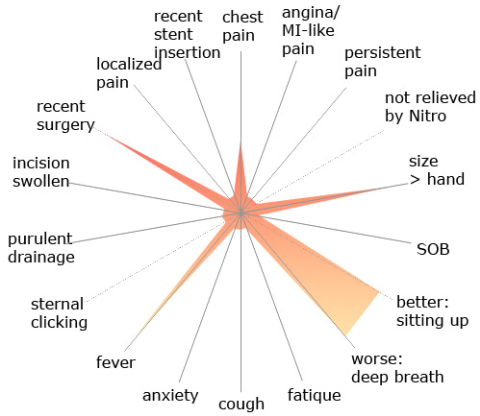
Incision Infection



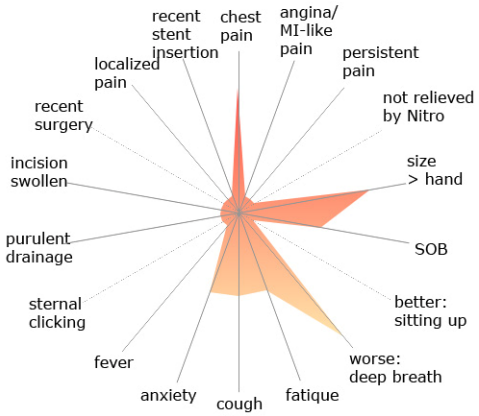
Unstable sternum



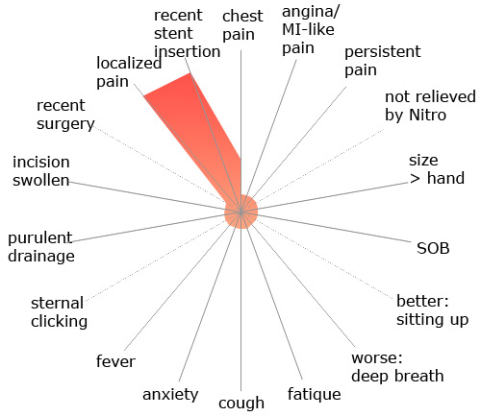
PPS



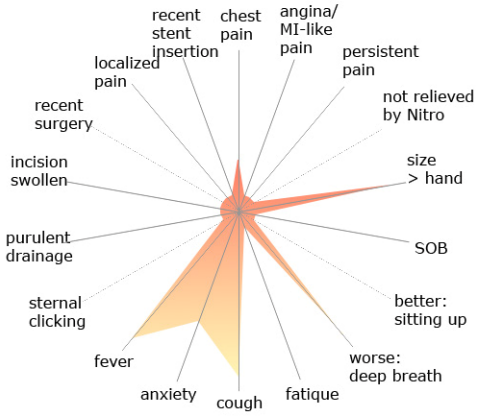
Pulmonary embolus



Stent Pain

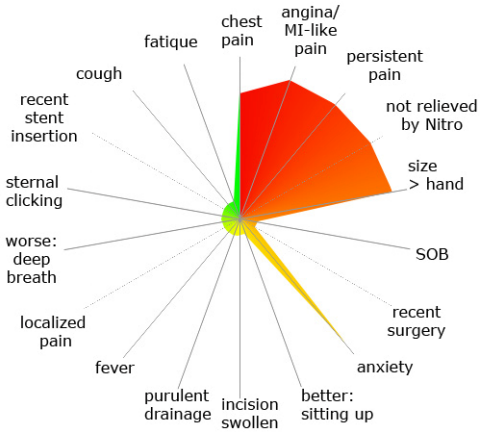


Pericarditis

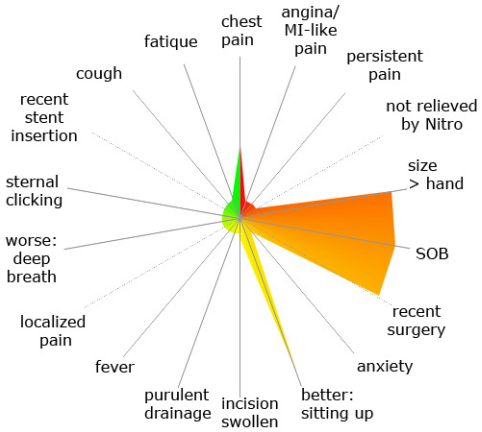


c) Cardiac Illness – The Clock Symptom Map

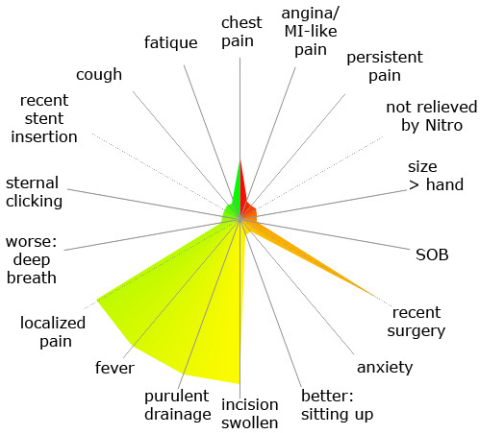
Ischemic Pain



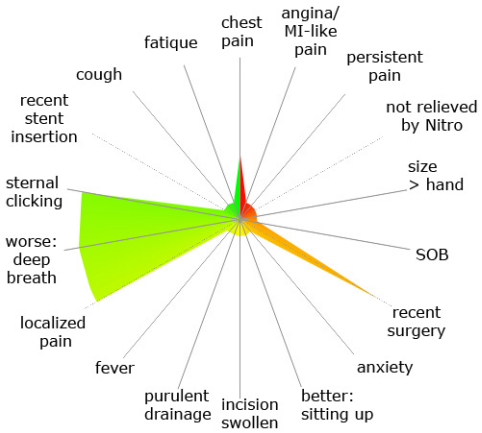
Tamponade



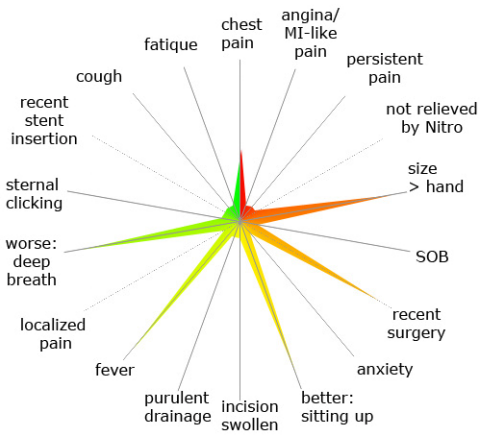
Incision Infection



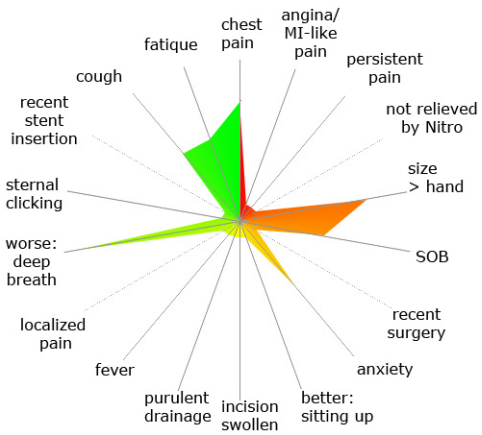
Unstable sternum



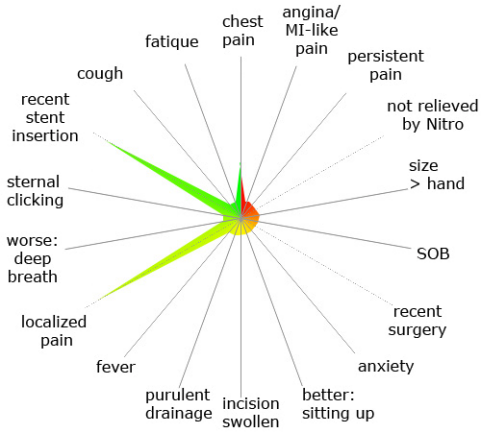
PPS



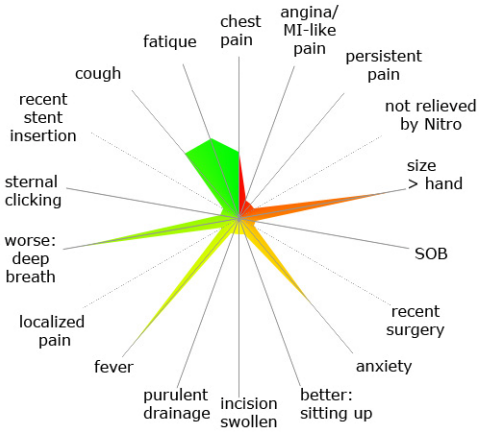
Pulmonary embolus



Stent Pain

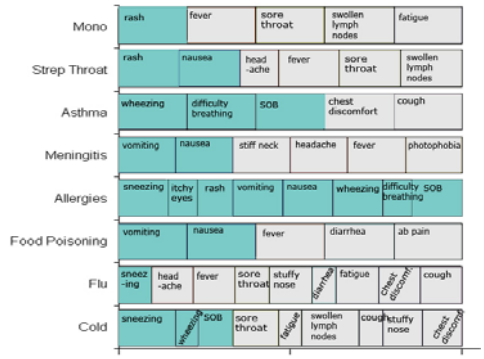


Pericarditis

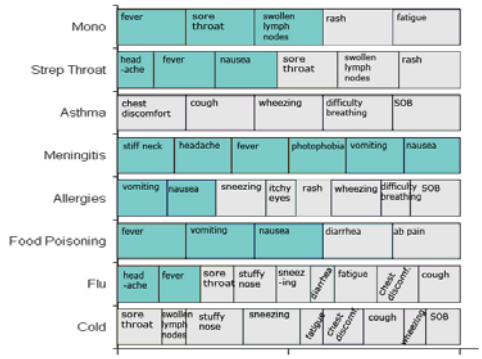


d) Non-Cardiac Illness – The Bar Symptom Map

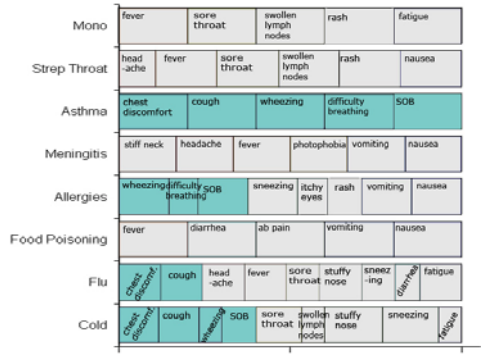
Allergies



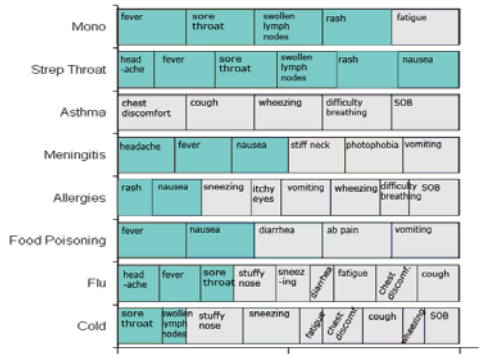
Meningitis



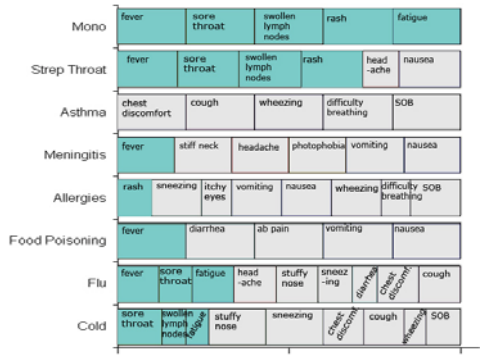
Asthma



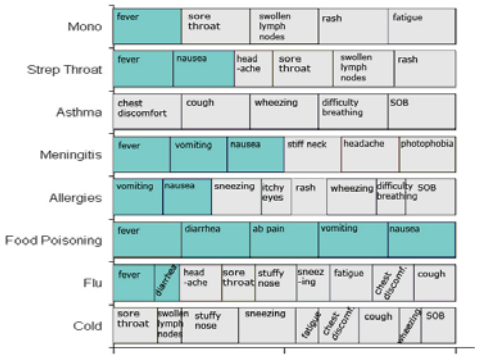
Strep Throat



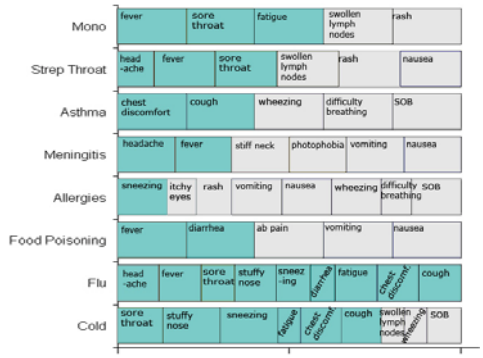
Mono



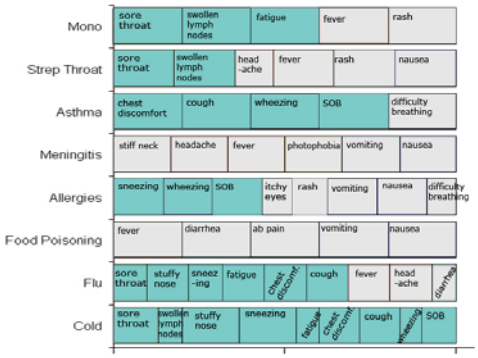
Food Poisoning



Flu

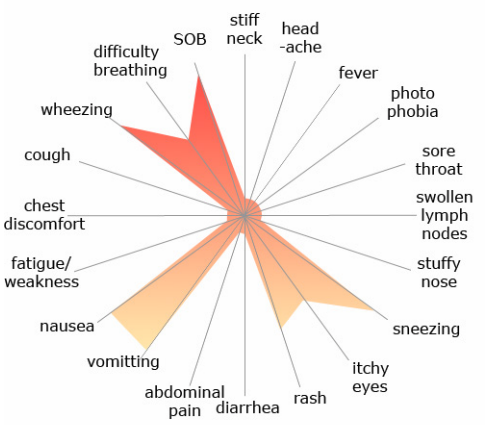


Cold

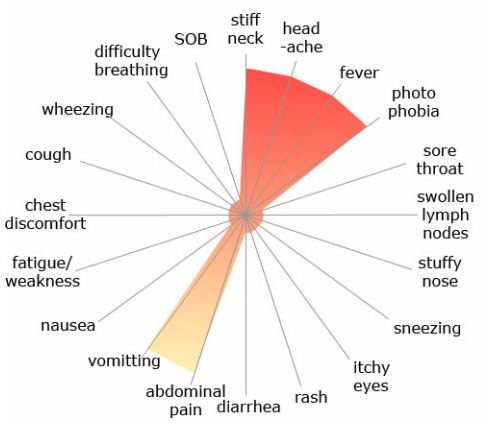


e) Non-Cardiac Illness – The Polar Symptom Map

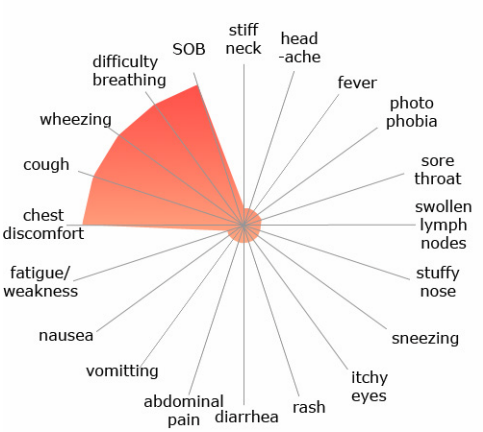
Allergies



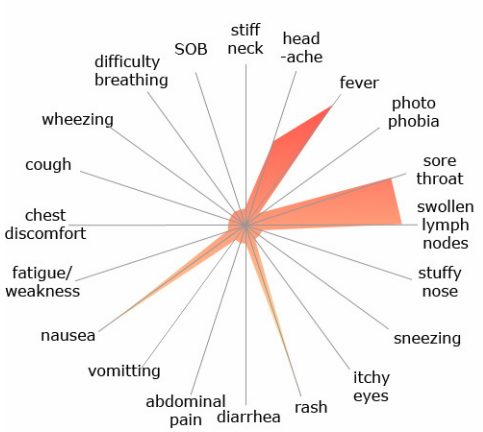
Meningitis



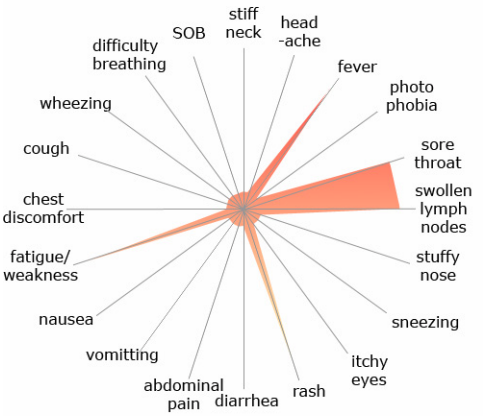
Asthma



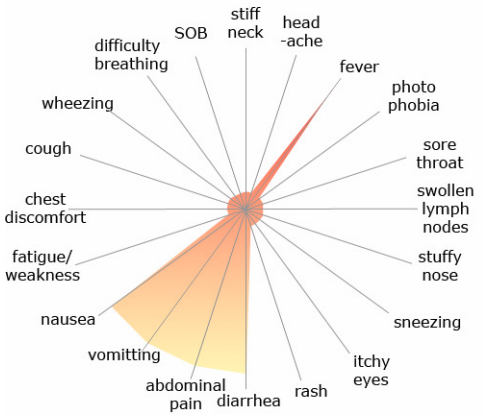
Strep Throat



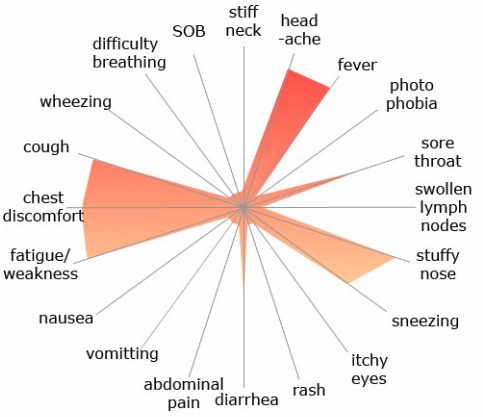
Mono



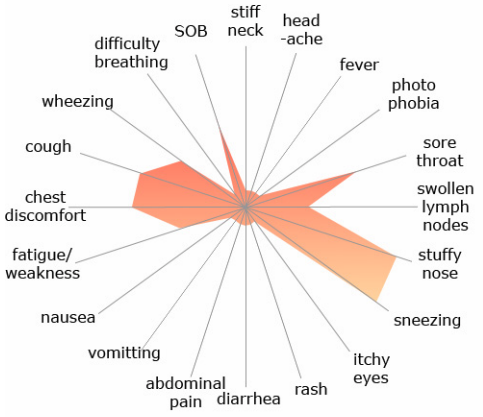
Food Poisoning



Flu

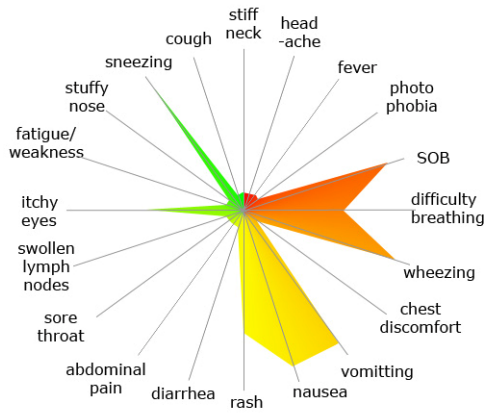


Cold

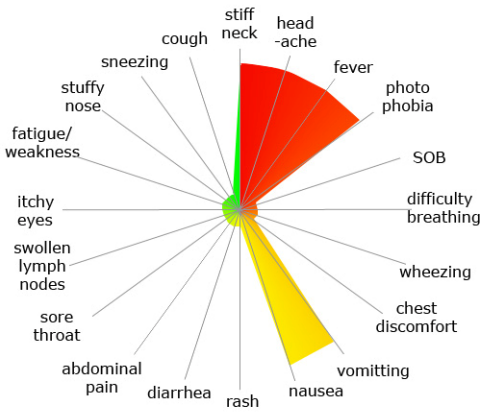


f) Non-Cardiac Illness – The Clock Symptom Map

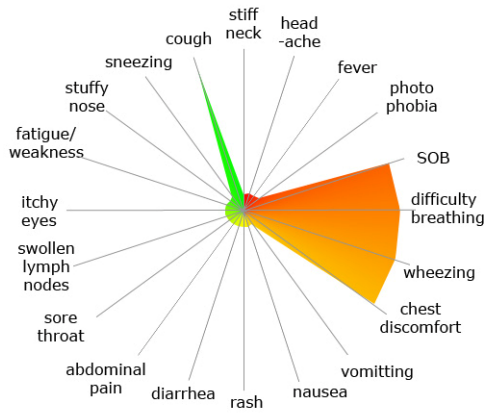
Allergies



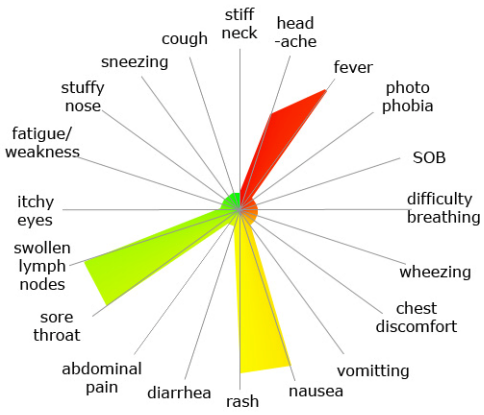
Meningitis



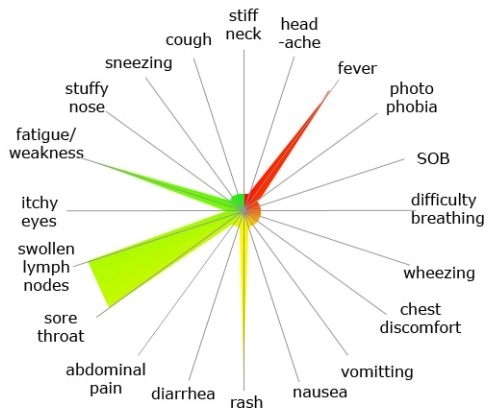
Asthma



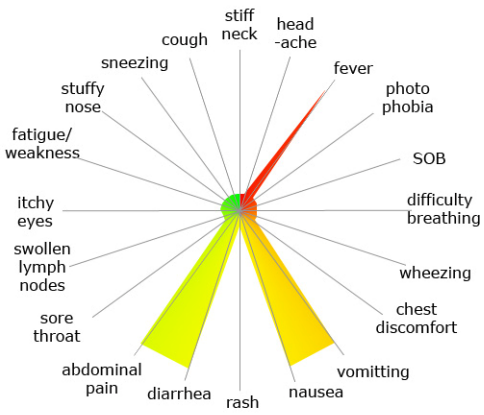
Strep Throat



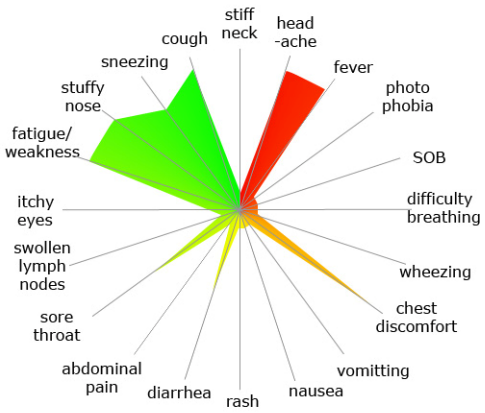
Mono



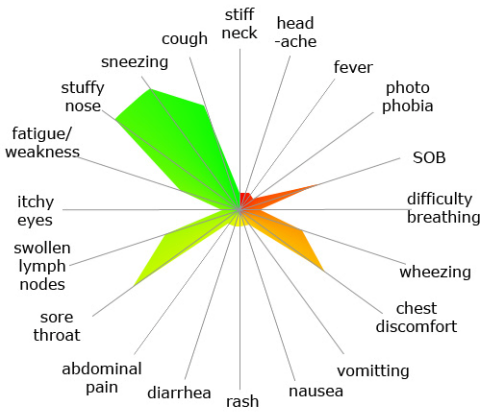
Food Poisoning



Flu


stiff neck
head -ache
cough
fever
sneezing
photo phobia
stuffy nose
fatigue/ weakness
SOB
itchy eyes
difficulty breathing
swollen lymph nodes
wheezing
chest discomfort
sore throat
abdominal pain
vomitting
diarrhea
rash
nausea

Cold


stiff neck
head -ache
cough
fever
sneezing
photo phobia
stuffy nose
fatigue/ weakness
SOB
itchy eyes
difficulty breathing
swollen lymph nodes
wheezing
chest discomfort
sore throat
abdominal pain
vomitting
diarrhea
rash
nausea

D-9 Post-experimental Questionnaire

For questions 1 to 6, circle the most appropriate answer in terms of the whole experiment.

1. How confident are you with your recommendations? (Overall)

Not at all confident		Neutral		Very confident
1	**2**	**3**	**4**	**5**

2. How difficult was it to decide the recommendations? (Overall)

Very difficult		Neutral		Very easy
1	**2**	**3**	**4**	**5**

3. How confident are you with your possible diagnoses? (Overall)

Not at all confident		Neutral		Very confident
1	**2**	**3**	**4**	**5**

4. How difficult was it to decide the diagnoses? (Overall)

Very difficult		Neutral		Very easy
1	**2**	**3**	**4**	**5**

5. How comfortable were you making decisions? (Overall)

Not at all comfortable		Neutral		Very comfortable
1	**2**	**3**	**4**	**5**

6. Do you think having graphical displays of the symptoms would help your decisions?

Yes
No

7. Which of the displays made it easiest to identify the condition of a patient?
(Please rank 1 to 4 from easiest to most difficult.)

__ Text Display
__ Bar Symptom Map
__ Polar Symptom Map
__ Clock Symptom Map

8. Why was the display you chose better than others?

9. Which of the displays made it easiest to see the severity the patient's condition?
(Please rank 1 to 4 from easiest to most difficult.)

__ Text Display
__ Bar Symptom Map
__ Polar Symptom Map
__ Clock Symptom Map

10. Why was the display you chose better than others?

11. Is there any confusion between display 3 and 4? (Polar vs. clock) Please explain.

12. Did you find any part of any graphical display confusing? Please explain.

13. Please list the most negative aspects of the displays. (Please add the display type beside your comments. i.e. Polar Symptom Map – labelling was confusing)

14. Please list the most positive aspects of the displays. (Please add the display type beside your comments.)

15. Do you think you would be able to utilize the graphical displays better after more practice?

Yes
No

16. Please give us any other suggestions or comments you may have.

Thank you very much for your participation.

Appendix E

Response and Results of Experiment I

E-1 Pre-experimental Questionnaire Response

ID	Gender	Age	Major	Year	Handed -ness	Exposure to cardiac care	Exposure to phone consultat-ion	Date	Time
1	M	24	Other	3	R	B	1	Tue, Aug 9	11:00 AM
4	M	19	BIO	2	R	C	2	Tue, Sept 7	3:32 AM
5	M	21	BIO	3	R	A	1	Sun, Aug 21	11:00 AM
7	F	20	Other	2	R	C	1	Sun, Aug 21	5:10 PM
8	M	20	Other	3	R	B	1	Tue, Aug 9	11:00 AM
11	M	18	BIO	2	R	C	1	Mon, Aug 29	2:20 AM
14	F	18	BIO	2	R	C	1	Thur, Aug 25	12:41 PM
15	F	23	BIO	4	R	B	1	Sat, Aug 13	3:30 PM
18	M	18	KIN	2	R	A	1	Wed, Aug 24	8:30 PM
19	F	21	KIN	3	R	A	1	Tue, Sept 6	4:40 PM
21	F	19	Other	2	R	C	1	Mon, Aug 29	1:02 AM
22	M	25	KIN	MA HS*	R	A	2	Thur, Aug, 18	11:00 AM
24	M	24	BIO	4	R	A	1	Tue, Sept 6	11:30 AM

* Masters of Applied Health Science

NOTES:
1. Exposure to cardiac care (human physiology)

   A: Specialized in Biology or Kinesiology
   B: Not specialized, but has taken university level physiology
   C: High school level biology
2. Exposure to phone consultation

   1: Never used it
   2: Used it a few times

E-2 Performance Data

				Recommendation			Diagnosis		
ID	Patient Type	Tool	Block	Accuracy (%)	RT (ms)	Confidence (%)	Accuracy (%)	RT (ms)	Confidence (%)
1	0	1	1	66.67	15956.33	58.33	100.00	10488.33	50.33
1	0	2	2	66.67	4326.33	91.67	100.00	2153.00	87.67
1	0	3	3	33.33	11657.00	52.67	33.33	13476.00	46.33
1	0	4	4	66.67	12418.00	70.00	100.00	1752.33	63.33
1	1	1	1	33.33	6803.00	67.33	66.67	14324.33	56.00
1	1	2	2	33.33	7124.00	73.00	100.00	1495.33	83.33
1	1	3	3	33.33	8101.67	56.00	66.67	4119.00	74.67
1	1	4	4	66.67	5301.33	67.00	66.67	3665.33	62.33
4	0	1	4	33.33	4009.33	74.00	66.67	3071.00	69.67
4	0	2	3	66.67	2249.67	78.00	100.00	1689.33	81.00
4	0	3	2	0.00	2480.33	72.33	100.00	2574.00	73.67
4	0	4	1	66.67	2633.33	53.33	33.33	6709.67	63.00
4	1	1	4	66.67	1876.33	76.67	66.67	2881.00	75.33
4	1	2	3	33.33	4416.67	65.00	66.67	2734.00	78.00
4	1	3	2	66.67	3805.67	57.67	33.33	2991.33	56.67
4	1	4	1	100.00	3348.00	78.33	66.67	3194.67	74.33
5	0	1	1	66.67	1869.67	90.67	33.33	4332.67	77.00
5	0	2	2	66.67	4119.33	97.33	100.00	1785.67	96.33
5	0	3	3	66.67	2717.00	71.00	66.67	1128.67	71.67
5	0	4	4	66.67	4770.67	79.33	66.67	3044.00	65.67
5	1	1	1	33.33	1225.33	88.33	33.33	1956.00	81.00
5	1	2	2	66.67	2506.67	85.33	100.00	1027.67	88.33
5	1	3	3	66.67	1359.33	84.67	100.00	1322.00	92.33
5	1	4	4	0.00	3672.00	54.33	0.00	1602.33	50.00
7	0	1	2	66.67	6958.67	68.33	66.67	2015.67	72.33
7	0	2	4	100.00	6875.00	70.33	100.00	1187.00	77.33
7	0	3	1	66.67	4343.67	66.33	66.67	8869.67	64.67
7	0	4	3	66.67	2593.33	73.67	66.67	2083.33	70.33
7	1	1	2	100.00	6343.67	62.33	100.00	4089.00	50.67
7	1	2	4	100.00	9973.67	65.33	100.00	1359.67	90.33
7	1	3	1	66.67	4317.67	59.67	66.67	3604.33	51.67
7	1	4	3	66.67	4432.00	57.00	66.67	4275.67	55.67
8	0	1	4	66.67	1880.33	97.67	66.67	4359.67	98.33
8	0	2	3	100.00	9495.00	74.00	66.67	1823.00	93.67
8	0	3	2	33.33	10932.33	49.33	33.33	11187.33	34.33
8	0	4	1	66.67	4453.33	90.33	33.33	6625.00	83.33
8	1	1	4	66.67	5395.33	84.33	100.00	2370.00	91.33
8	1	2	3	66.67	6708.33	73.67	100.00	2046.67	99.00
8	1	3	2	33.33	2437.33	98.33	66.67	2072.67	85.67
8	1	4	1	66.67	4833.33	78.67	33.33	4578.33	75.67

				Recommendation			Diagnosis		
ID	Patient Type	Tool	Block	Accuracy (%)	RT (ms)	Confidence (%)	Accuracy (%)	RT (ms)	Confidence (%)
11	0	1	2	66.67	3024.00	50.00	0.00	2977.33	50.33
11	0	2	4	100.00	2113.33	83.33	100.00	2103.00	91.33
11	0	3	1	100.00	1759.33	66.00	33.33	2767.67	50.00
11	0	4	3	33.33	3345.00	49.67	33.33	2954.33	50.00
11	1	1	2	66.67	2336.33	50.33	100.00	1569.33	51.00
11	1	2	4	66.67	2176.33	58.00	100.00	1341.67	78.67
11	1	3	1	66.67	4443.33	59.00	66.67	1589.00	57.67
11	1	4	3	66.67	2210.00	66.67	33.33	1425.67	66.33
14	0	1	3	33.33	8485.67	67.33	33.33	12121.00	52.67
14	0	2	1	100.00	5702.00	65.00	100.00	3101.00	81.67
14	0	3	4	33.33	4803.67	59.00	33.33	12000.67	62.67
14	0	4	2	66.67	5902.00	60.33	33.33	7931.33	53.33
14	1	1	3	66.67	6409.33	62.00	33.33	2793.67	70.67
14	1	2	1	33.33	14848.00	57.67	100.00	3671.67	71.00
14	1	3	4	66.67	11750.33	58.00	100.00	8846.00	62.33
14	1	4	2	33.33	7380.67	58.67	66.67	11577.00	55.33
15	0	1	2	33.33	8151.00	74.33	33.33	1896.00	82.00
15	0	2	4	0.00	3145.67	67.33	100.00	1343.67	65.33
15	0	3	1	66.67	5286.33	88.00	66.67	4713.33	76.67
15	0	4	3	66.67	3255.33	74.00	33.33	3297.00	63.00
15	1	1	2	33.33	7693.00	64.00	33.33	1452.67	69.00
15	1	2	4	66.67	4156.33	72.33	100.00	1708.00	68.67
15	1	3	1	100.00	2510.33	67.00	66.67	1880.33	70.00
15	1	4	3	66.67	3682.00	66.67	66.67	2047.00	69.67
18	0	1	3	66.67	20616.33	68.67	33.33	9597.33	53.00
18	0	2	1	100.00	3184.33	91.67	66.67	1595.67	91.67
18	0	3	4	33.33	2296.33	75.00	33.33	3942.00	69.67
18	0	4	2	100.00	17759.00	50.00	100.00	8732.67	53.67
18	1	1	3	100.00	3021.33	62.33	100.00	3004.67	67.00
18	1	2	1	66.67	7027.00	57.00	100.00	7434.00	70.33
18	1	3	4	66.67	10828.67	65.67	66.67	2527.33	56.67
18	1	4	2	66.67	5551.33	75.00	100.00	4346.33	83.33
19	0	1	2	100.00	1371.67	99.00	100.00	1709.33	97.33
19	0	2	4	66.67	3171.00	87.67	66.67	1499.33	99.33
19	0	3	1	100.00	2714.00	69.00	66.67	1595.67	74.33
19	0	4	3	66.67	1234.67	78.67	100.00	4092.67	69.67
19	1	1	2	100.00	1766.33	78.33	100.00	1605.67	80.67
19	1	2	4	100.00	2250.00	89.33	100.00	1138.00	98.00
19	1	3	1	100.00	3291.67	87.67	100.00	1228.67	99.00
19	1	4	3	66.67	2326.67	59.00	66.67	1041.67	57.00

				Recommendation			Diagnosis		
ID	Patient Type	Tool	Block	Accuracy (%)	RT (ms)	Confidence (%)	Accuracy (%)	RT (ms)	Confidence (%)
21	0	1	1	100.00	1816.00	99.67	100.00	2316.33	99.67
21	0	2	2	100.00	2834.00	96.67	100.00	2353.33	99.33
21	0	3	3	100.00	12237.33	91.67	66.67	3311.00	88.33
21	0	4	4	100.00	2473.67	99.67	100.00	2293.33	98.00
21	1	1	1	66.67	3085.00	99.33	66.67	3204.67	98.00
21	1	2	2	66.67	2590.33	92.00	100.00	2714.00	99.67
21	1	3	3	100.00	8759.00	92.00	100.00	5488.00	84.67
21	1	4	4	66.67	2156.00	98.67	100.00	3361.00	95.67
22	0	1	3	100.00	7312.00	53.33	100.00	1968.67	50.00
22	0	2	1	100.00	5458.33	62.67	66.67	3510.33	58.33
22	0	3	4	100.00	3838.67	79.00	66.67	1453.33	78.67
22	0	4	2	66.67	8156.00	58.33	66.67	1875.00	70.00
22	1	1	3	66.67	5239.33	52.67	66.67	2458.33	50.33
22	1	2	1	66.67	3239.67	67.00	100.00	2839.00	72.67
22	1	3	4	100.00	2812.33	58.67	100.00	1770.67	61.00
22	1	4	2	33.33	4338.33	54.33	33.33	3182.67	55.33
24	0	1	4	66.67	6516.00	60.00	66.67	5692.00	55.00
24	0	2	3	100.00	4366.67	80.67	100.00	2216.67	94.00
24	0	3	2	66.67	4503.33	73.00	33.33	2160.00	79.00
24	0	4	1	66.67	4272.67	56.33	0.00	4964.33	53.33
24	1	1	4	33.33	4987.33	67.00	33.33	6696.33	52.00
24	1	2	3	66.67	2179.67	86.33	100.00	9260.33	79.00
24	1	3	2	100.00	2667.33	68.00	66.67	4696.67	74.33
24	1	4	1	33.33	4943.33	61.33	66.67	4092.33	71.67

Patient Model

0: Non-cardiac patient models

1: Cardiac patient models.

E-3 Summary of Results

Summary of Recommendation Judgement Results

Data	Domain	Text	Bar	Polar	Clock	Mean
Accuracy	Non-cardiac	0.6667	0.8205*	0.6154	0.6923	0.6987
	Cardiac	0.6410	0.6410	0.7436*	0.5641	0.6474
	Mean	0.6538	0.7308*	0.6795	0.6282	0.6731
RT (ms)	Non-cardiac	6766.7	4387.7*	5351.5	5635.9	5535.5
	Cardiac	4321.7	5322.8	5160.4	4167.3*	4743.0
	Mean	5544.2	4855.3*	5255.9	4901.6	5139.2
Confidence (%)	Non-cardiac	73.949	80.487*	70.179	68.744	73.340
	Cardiac	70.385	72.462*	70.179	67.359	70.096
	Mean	72.167	76.474*	70.179	68.051	71.718

Summary of Diagnostic Judgement Results

Data	Domain	Text	Bar	Polar	Clock	Mean
Accuracy	Non-cardiac	0.6154	0.9231*	0.5385	0.6154	0.6731
	Cardiac	0.6667	0.9744*	0.7692	0.5897	0.7500
	Mean	0.6410	0.9487*	0.6538	0.6026	0.7115
RT (ms)	Non-cardiac	4811.2	2027.8*	5321.5	4335.0	4123.9
	Cardiac	3723.5	2982.3*	3241.2	3722.3	3417.3
	Mean	4267.3	2505.0*	4281.4	4028.6	3770.6
Confidence (%)	Non-cardiac	69.820	85.923*	66.923	65.897	72.141
	Cardiac	68.692	82.846*	71.282	67.103	72.481
	Mean	69.256	84.385*	69.103	66.500	72.311

Accuracy of disposition judgment (averaged in order groups)

	Non Cardiac				Cardiac				Mean
Order	Text	Bar	Polar	Clock	Text	Bar	Polar	Clock	
1	0.500	0.429	0.750	0.571	1.000	0.833	0.833	0.833	0.563
2	1.000	0.571	0.875	0.500	0.833	1.000	0.333	0.833	0.737
3	0.800	0.900	0.900	0.800	0.750	0.625	0.875	0.625	0.850
4	0.625	0.429	0.750	0.714	0.833	0.833	0.333	0.667	0.630
Mean	0.727	0.613	0.824	0.656	0.846	0.808	0.615	0.731	0.705

Response time for disposition judgment (averaged in order groups)

	Non-Cardiac				Cardiac				Mean
Order	Polar	Bar	Polar	Clock	Text	Bar	Clock	Text	
1	6073.3	3759.9	8870.4	6554.1	3704.4	4073.7	3709.8	6547.3	5411.6
2	8463.8	4781.6	3646.2	10605.7	4890.0	8371.6	5756.8	12138.0	7331.7
3	3640.8	3826.3	3525.8	2607.1	4534.8	4639.1	3162.7	4876.3	3851.6
4	2970.1	5370.4	5972.0	3786.4	4086.3	4434.9	4374.9	4135.2	4391.3
Mean	5160.3	4387.7	5351.5	5635.9	4321.7	5322.8	4167.3	6766.7	5139.3

E-4 ANOVA Tables

Tests of Within-Subjects Effects for Accuracy of Recommendation Judgements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pt_type	.048	1	.048	.814	.390
pt_type * Order	.294	3	.098	1.652	.246
Error(pt_type)	.534	9	.059		
tool	.141	3	.047	.927	.441
tool * Order	.716	9	.080	1.563	.177
Error(tool)	1.374	27	.051		
pt_type * tool	.421	3	.140	3.547	.028
pt_type * tool * Order	.475	9	.053	1.333	.267
Error(pt_type*tool)	1.069	27	.040		

Tests of Within-Subjects Effects for Response Time of Recommendation Judgements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pt_type	19926006.793	1	19926006.793	1.857	.206
pt_type * Order	18793653.877	3	6264551.292	.584	.641
Error(pt_type)	96585374.631	9	10731708.292		
tool	7773667.836	3	2591222.612	.282	.838
tool * Order	75277847.116	9	8364205.235	.910	.531
Error(tool)	248296395.757	27	9196162.806		
pt_type * tool	47192643.996	3	15730881.332	2.144	.118
pt_type * tool * Order	144314488.067	9	16034943.119	2.186	.056
Error(pt_type*tool)	198070380.101	27	7335940.004		

Tests of Within-Subjects Effects for Confidence Level of Recommendation Judgements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pt_type	226.957	1	226.957	19.410	.002
pt_type * Order	338.662	3	112.887	9.655	.004
Error(pt_type)	105.234	9	11.693		
tool	1007.566	3	335.855	3.005	.048
tool * Order	560.842	9	62.316	.557	.819
Error(tool)	3018.089	27	111.781		
pt_type * tool	271.525	3	90.508	.625	.605
pt_type * tool * Order	603.916	9	67.102	.464	.886
Error(pt_type*tool)	3908.137	27	144.746		

Tests of Within-Subjects Effects for Accuracy of Diagnostic Judgements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pt_type	.158	1	.158	4.103	.073
pt_type * Order	.239	3	.080	2.068	.175
Error(pt_type)	.347	9	.039		
tool	1.903	3	.634	8.662	.000
tool * Order	.217	9	.024	.330	.957
Error(tool)	1.977	27	.073		
pt_type * tool	.243	3	.081	1.411	.261
pt_type * tool * Order	.532	9	.059	1.031	.442
Error(pt_type*tool)	1.547	27	.057		

Tests of Within-Subjects Effects for Response Time of Diagnostic Judgements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pt_type	12322344.987	1	12322344.987	2.387	.157
pt_type * Order	2345817.726	3	781939.242	.151	.926
Error(pt_type)	46466415.965	9	5162935.107		
tool	58350588.957	3	19450196.319	2.555	.076
tool * Order	54554399.612	9	6061599.957	.796	.623
Error(tool)	205561455.129	27	7613387.227		
pt_type * tool	32786125.660	3	10928708.553	2.158	.116
pt_type * tool * Order	49637822.458	9	5515313.606	1.089	.403
Error(pt_type*tool)	136746617.460	27	5064689.536		

Tests of Within-Subjects Effects for Confidence Level of Diagnostic Judgements

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pt_type	8.513	1	8.513	.162	.696
pt_type * Order	117.787	3	39.262	.749	.550
Error(pt_type)	471.913	9	52.435		
tool	5028.715	3	1676.238	8.371	.000
tool * Order	505.874	9	56.208	.281	.974
Error(tool)	5406.313	27	200.234		
pt_type * tool	204.540	3	68.180	.507	.681
pt_type * tool * Order	1152.682	9	128.076	.952	.499
Error(pt_type*tool)	3631.306	27	134.493		

E-5 Post-experimental Questionnaire Response

1~5. Overall rates of confidence and difficulties when making decisions on both disposition and diagnoses are answered by all participants. On average recommendation judgments were slightly more difficult than diagnosis judgments. (rated from 1 to 5)

	Average	Standard Deviation
Confidence with recommendations*	3.27	0.86
Difficulty with recommendation decision**	2.65	1.11
Confidence with diagnoses*	3.02	1.01
Difficulty with diagnoses**	2.98	1.04
How comfortable to make decision***	3.48	0.87

*1 not at all confident~ 5 very confident
** 1 very difficult ~ 5 very easy
*** 1 not comfortable at all ~ 5 very comfortable

6. Q: Do you think visualization tools were useful when making judgment?

All participants answer "yes" to the question.

7. Bar symptom map was ranked the easiest when making condition judgments by 11 out of 12 participants.

8. Participants noted the advantage of Bar map being "easy to see", "has the name of condition already", "do not have to think", "clear."

9. Clock symptom map was marked as the easiest tool to make recommendation judgment by 9 out of 12 participants. 3 participants answered that polar map was the easiest.

10. Participants noted advantages of angles and colour being severity information for advantages of clock map. Others noted the advantages of polar map being that it draws attention to particular area (the axes are arranged to form meaningful group rather than severity) so that it is easy to identify the problem.

11. A half of participants noted that polar and clock display caused confusion. One particularly said that when the highlighted area is narrow, it is hard to tell the colour so that it is not apparent if you are

looking at the polar or clock symptom map. A few participants noted that polar map indicates severity, which is not true.

12. Mostly related to #11.

13. Negative aspects:

Text: does not show severity

Bar: does not show severity. The size of each cell does not make sense (it was % contribution to the diagnosis)

Polar & Clock: Time consuming to read all the symptoms in radial fashion rather than vertical/horizontal. It is not easy if the symptoms were spread apart within 8 seconds. (If it's clustered, it's easy). Colour coding and axes take long time to get used to.

14. Positive aspects:

Bar: Easy to see most likely conditions, makes the condition really obvious

Polar: makes the most relevant symptoms more obvious to the user (e.g. It's easier to identify condition and not get distracted by potentially irrelevant symptoms).

Clock: severity is obvious (angle, colour) so course of action's easier to choose

15. All participants noted that after more practice they can utilize the graphical displays better.

16. Recommendation and comments:

- If bar map is used, the list of bar should automatically arranged in order of relevance.

Appendix F

Experimental Documents for Experiment II

F-1 Information Letter

Participant's Letter of Information

Effects of Decision Support Tools on Cardiac Telephone Consultation Process

Project title: Using Personal Digital Assistants and Patient Care Algorithms to Improve Access to Cardiac Care Best Practices

The purpose of this study is to evaluate the performance of cardiac nurses in handling patients' calls using Patient Care Algorithms on Personal Digital Assistants (PDAs).

As a participant in this research, you will be asked to answer four phone calls from mock patients. You will be navigating a decision support system (DSS) on PDA while answering the calls and entering information gained through your conversation with the patients. At the end of each call you will make recommendation to the mock patient. After each call, you will be asked to give a feedback related to the process. You will also be asked fill questionnaires related to the system and PDA experience.

It is important that you know that the people you are talking on the phone are not patients so that you are not jeopardizing their health. They are trained nurses who are following well-defined patient models. Also it should be emphasized that we are not evaluating your performance, but we are evaluating how well our system support the decision process you are going through.

There will be a single session lasting approximately an hour and half including a training session at the beginning of the experiment. None of the tasks involved in this experiment would be stressful to you.

Under all circumstances your data will be kept anonymous. If at any time, even after the experiment is complete, you would like your own raw data (data logs, test sheets, questionnaires, and audio logs) returned to you, please let us know and we will return it to you. Otherwise, your data will be retained indefinitely. Raw data (data logs, test sheets, questionnaire, and audio logs) will be retained in a safe storage in Advanced Interface Design Laboratory at the University of Waterloo.

It should also be emphasized that you should **not** discuss this experiment with any of the other participants during the study. After the study is finished and results are maintained, you are more than welcome to discuss it with us or other participants.

If you have any questions or concerns, please contact:

Yukari Carrie Enomoto
Student Investigator
Department of Systems Design Engineering
University of Waterloo
E-Mail: yenomoto@engmail.uwaterloo.ca
(519) 888-4904

Professor Catherine Burns
Principal Investigator
Department of Systems Design Engineering, DC 2607
E-mail: c4burns@engmail.uwaterloo.ca
(519) 888-4567 x3903

This study has been reviewed and received ethics clearance through the Office of Research Ethics (ORE) at the University of Waterloo (ORE # 11940.) Participants who have concerns or questions about their involvement in the project may contact the Director, ORE at 519-888-4567 x 6005.

Thank you for your participation in this study.

F-2 Consent Form

INFORMATION SHEET AND CONSENT

for

USABILITY TEST PARTICIPANTS

UOHI-05-150, ORE #11940

Using Personal Digital Assistants and Patient Care Algorithms to Improve Access to Cardiac Care Best Practices

Principal Investigators:	Dr. Kathryn Momtahan, RN, PhD	(613) 798-5555, ext.13575
	Dr. Catherine Burns, PhD, PEng	(519) 888-4567, ext.3903
Co-Investigators:	Ms. Heather Sherrard, RN, BScN, MHA	(613) 798-5555, ext 14826
	Dr. Thierry Mesana, MD, PhD, FECTS, FRCS(C)	(613) 798-5555, ext.14220
	Dr. Marino Labinaz, MD, FRCP(C)	(613) 798-5555, ext.15427
Masters Student Investigator:	Ms. Yukari Enomoto	(613) 798-5555, ext.13575
Study Coordinator:	Dr. Kathryn Momtahan, RN, PhD	(613) 798-5555, ext.13575

Please read this Information Sheet and Consent Form carefully and ask as many questions as you like before deciding whether to participate.

INTRODUCTION

This experiment is being conducted by Ms. Enomoto for her Master's thesis in the Systems Design Engineering Department at the University of Waterloo, supervised by Dr. Catherine Burns at the University of Waterloo and Dr. Kathryn Momtahan at the University of Ottawa Heart Institute. The experiment is designed to investigate the effect of decision support tools on the consultation process. As a participant in this research, you will be asked to answer four phone calls from mock patients.

PROCEDURE

You will be navigating a decision support system (DSS) on a PDA while answering the calls from a mock patient and entering information gained through your conversation with the patients. At the end of each call you will be asked to make a judgment regarding the nature of the problem and a recommended course of action. We will be audio taping the session in order to do our data analysis. You will also be asked to fill in questionnaires related to the system and PDA experience.

It should also be emphasized that you should **not** discuss this experiment with any of the other participants during the study. After the study is finished and results calculated, you are more than welcome to discuss it with us or other participants.

RISKS and DISCOMFORTS of PARTICIPATION

There are no anticipated risks or discomforts involved in this study.

BENEFITS OF PARTICIPATION

Although there may be no direct benefits of this study to you, it is hoped that the end result will be that the usability of the prototype software for use by the nursing coordinators to manage calls from cardiac patients will be improved.

COMPENSATION/RENUMERATION

There is no personal monetary compensation to being in the study. Parking fees will be reimbursed.

CONFIDENTIALITY

All records will be kept confidential. Any documentation and interviews will be reviewed by the Investigators, both at the Ottawa Heart Institute and at the University of Waterloo, and may be reviewed by representatives from the Ontario Ministry of Health, or representatives of the Research Ethics Boards at the Ottawa Heart Institute and at the University of Waterloo under the supervision of the Investigators or their staff. You will not be identified in any publications by name or initials. All data sheets will have your number only on them and they will be kept in a locked office at the University of Waterloo and at the Heart Institute. Data will be stored for a period of 8 years.

ETHICS

This study has been approved by the Human Research Ethics Board of the University of Ottawa Heart Institute and has been reviewed and cleared through the University of Waterloo, Office of Research Ethics. These two institutional ethics review structures consider the ethical aspects of all research projects using human subjects being conducted by researchers in their institutions. If you wish, you may talk to the Chair of the Human Research Ethics Board at the University of Ottawa Heart Institute through the Secretariat at (613) 761-4417 or contact the University of Waterloo, Office of Research Ethics at (519) 888-4567, ext. 7163.

VOLUNTARY PARTICIPATION **Participation in research is completely voluntary.**

You are free to choose whether to participate in this study or not. If you choose to participate, you may choose to withdraw your consent at any time. If you are a Heart Institute employee, this will not affect your employment at the Heart Institute in any way. You are also free to refuse to answer any questions that you may be asked because of your participation in this study.

CONSENT TO PARTICIPATE IN RESEARCH

I understand that I am being asked to participate in a research study on using personal digital assistants and patient care algorithms to improve access to cardiac care best practices. By giving my consent, I am authorizing the University of Ottawa Heart Institute to review my data for the purposes of this study. I am also agreeing to be interviewed for the purposes of this study.

I have read and understood this Information Sheet and Consent Form. All of my questions at this time have been answered to my satisfaction. If I have any further questions about this study, I may contact the Principal Investigator Dr. Kathryn Momtahan at (613) 798-5555, x 13575.

I will receive a signed copy of this Consent Form and the attached Information Sheet.

I voluntarily agree to participate in this study.

Name _____

Signature _____

Date _____

Signature of person obtaining Consent _____

Investigator / Co-Investigator's Signature _____

F-3 Pre-experiment Questionnaire

Participant #:

1. Gender: ☐ Male ☐ Female

2. Age:
□ <25 □ 25-34 □ 35-44 □ 45-54 □ 55-65 □ >65

3. Number of years in practice with **Cardiology Patients**: _____

4. Number of years in practice with **Cardiac Surgery Patients**: _____

5. Number of years in practice as a **Cardiac nurse**: _____

6. Number of years in practice as a nurse: _____

7. I have participated Ms. Kirsten Somoza's Experiment: ☐ Yes ☐ No

If you participated in Ms Somoza's Experiment, please indicate how many sessions you participated in:
☐ Baseline Session Only
☐ Both Baseline Session and Tablet PDA Session

Please read each statement and divide the horizontal line provided below

8. I am familiar with everyday computing activities (e.g. word processing or email).

Strongly Disagree ——————|—————— Strongly Agree

9. How often do you use mobile devices, *excluding* laptop computers and cellphones? (E.g. Palm Pilot, Windows CE device, RIM Blackberry)?

Never ——————|—————— Every Day

10. I am comfortable with personal digital assistants (PDAs).

Strongly Disagree ——————|—————— Strongly Agree

F-4 Experimental Script

1. Introduction
Thank you very much for participating in this experiment. The purpose of this experiment is to evaluate our decision support system prototype that is designed for cardiac telephone consultation. The results of our evaluation will be summarized and integrated into the future development of the decision support system.

2. Informed Consent Form
I would like you to read through the information sheet and consent form and sign the consent form. Please ask me any questions before you sign.
<< Give them information sheet and consent form >>
As you just read in the information sheet, you can withdraw from this study any time during the experiment. You will be asked to fill a questionnaire before and after the experiment. You will also be asked to provide feedback on each trial.

3. Introducing T3 and DSS
This is the PDA you will be using throughout this experiment.
<< Show how to use stylus and hard buttons >>
We ask you to keep the slider at the open position for the entire experiment.
<<Open the slider if it's not already open>>
You will not be writing on PDA today since it takes some time to get used to graffiti, but I like you to insert numbers in the field on PDA by using numerical pad (show how to bring numerical pad) and write down the entry on this paper. (Appendix A: Entry Sheet) Patient information such as names and phone numbers will be pre-filled so your writing will be the minimum to none.
Please go through a tutorial slides. Ask any questions.
<< The experimenter opens a slide show that displays screenshots of the system as participants go through the program so that they can check the sequence of action >>
<< The experimenter answers any questions that participants ask.>>

4. Introducing Experiment
You will be going through 4 experimental calls from mock patients. You will receive a call from the bunker first, and she will provide you the patient's name, phone number and the UOHI physician's name, which is already filled on your DSS beforehand so you don't have to do anything for the first 3 pages. The bunker will connect you to the patient when you tell them that you are ready.

We encourage you to use the system as much as you can; however, you are not obligated to use or fill all fields on the decision support tool. That means that you do not have to ask all the possible questions that are suggested on the system. Whether you like to use it or not is up to you. Also, this system is **NOT** making decisions for your patient. You will be the one who is making decisions using this tool. We like you to try to work through any difficulties related to decision process on your own during each call, but if you need any technical assistance, you can let me know. **Your phone consultation process will be limited to 10 minutes, so at the end of the call, you will have to make some recommendation.** If you need to consult with physicians, you will tell your patients so. At the end of each call, I will ask you to provide us feedback on the trial.

Please remember that we are not testing how well you handle each call, but we are evaluating how well our decision support system helps the process. These calls you are receiving are not from real patients, but simulations that follow realistic patient models.

We will be recording the conversations during the call.

7. Experimental call
We will start the first experimental call when you are ready.

<< Let the bunker know when the participant is ready >>
<< After the participants are done, give her post scenario question set>>
Please answer the questions on the sheet and provide any feedback you have for this call.
<< Repeat this for all calls >>

8. Post-experimental Questionnaire
Please fill out this questionnaire for overall evaluation of your experience with the system. Please ask any questions
<< They complete the questionnaire >>
<< While they are filling out the questionnaire, make photocopy of the information sheet and consent form for the participant >>

9. Thank participants
Thank you very much. This is a copy of the information sheet. You can contact me or my supervisors at this contact (point out the contact info on the information sheet) if you have any questions or concerns regarding this study. Please do not discuss about this experiment with anyone until the study is complete.

Thank you very much for your time to help us evaluate our system.

F-5 Patient Models

PPS - Surgery Pt. (Non-urgent)

Name	Kelly Yardley	
Surgeon	Dr. Mac	
Initial Complaints		I was told to call if I was having any pain in my chest.
Open ended Q	Tell me about your pain	It's sharp and in my neck, back and shoulder. It's more of a sharp discomfort.
History	What	Bypass surgery
(surgery)	When	12 days ago
	Did you have a valve surgery?	No.
(discharge)	When	4 days ago
	Were you to expect any chest pain after Sx?	No. had good results.
	Were you told that you would have some pain?	Yes.
	Any heart problems or anything before?	Yes.
	Have you had a heart attack before?	No.
	Have you had angina before?	Yes.
	When you went home, were you having chest pain?	No.
Incision	How does it look like?	Looks good
	How are your incisions	Fine
	Redness	No
	Swelling	No
	Drainage	Yes
	What does drainage look like?	Light yellow
	How much drainage?	Not a lot. It just makes little stains on my nightie.
	Where is the drainage coming from?	Bottom of incision
	IS the drainage thick	No. It's more see-through
	Look clean?	Yes.
Comparison	Chest pain/angina before your operation?	Yes.
	Is this pain similar to that?	No.
	Is this pain like the pain you had after surgery?	A little, but not really.
	How was MI pain like?	Burning middle of Chest
	Is the pain new to you?	Yes.
	You never had this type of pain before	No.
OLDCAR		
(Onset)	When did it start?	2 days ago
(Location)	Where is this pain?	chest, back and shoulder
	Is it near the incision line?	No.
	Is it off the side little bit?	Yeah yeah.
	Does it go down to your arm?	No.
(Duration)		constant
(Characteristi	Is it always there?	Always there.

cs)	Pain scale (0-10)	About 3
	Is it muscular?	No
	What type of pain?	Sharp
	Does it get worse at a time?	No.
	Is that getting progressively worse?	No.
	Would you say that the pain is really bad?	No. I would say it's only 2 or 3
(Associated Symptoms)		None
	Are you well otherwise?	Yes.
	How is your breathing?	A little tight, but not bad.
	Angina	No
	Cough	No
	Fever/temperature	Maybe a little bit warm. Slightly. (37.8)
	Is there any swelling	No
	Problem with sleeping?	I'm not sleeping that well
	Nausea	No
	Weakness/ dizziness	No
	Sweating	No.
	Vomiting	No.
	Short of breath?	I'm not keen on taking deep breath so… I tend to be a bit more short of breath
	Chills	No
	When you move, do you hear clicking?	No.
	Are you coughing up anything?	No.
	Your heart beating faster than usual?	No.
(Aggravating factors)	Something to make it worse?	taking a deep breath
	Does it hurt when you hold your breath	Yes.
	Lay Flat	Same
	Are you able to lay flat?	Yes.
	Lifting hurt more	No.
	It doesn't change when you do activities?	Sometimes. It can get little worse when I move a little bit
	Does it hurt more with movement?	Yes.
	Does it hurt more if you bend over?	No. It actually feels better.
(Relieving factors)	Is there anything to make you feel better?	Nothing
	Try sitting forward and take a deep breath	Feel better
	Have you tried changing positions using pillows to change position?	I've done a little bit.
Activity level	Lifting anything recently?	No.
	What started that?	It came on all by itself
	How did it start	Did nothing
Medication	Have you done (taken) anything to treat your pain?	Tylenol Extra Strength but it didn't help.
	How much did you take?	Two.
	Tell me the names of the medicines you are taking.	Metropolol, Captopril and Aspirin.
	How much Aspirin do you take a day?	81 mg.
	Are you on Coumadin?	No.

	Are you taking Tylenol with Codeine	No.
	When did you last take Tylenol	2 hrs ago
	How often are you taking it [Tylenol]?	q4h
	Have you taken any NTG	No.
	Do you take Advil?	No.
	NTG patch on?	Used it before the Sx
	Metropol	50 mg in am
	Have you tried any Advil or Ibuprofen or something like that?	No.
Known conditions	Kidney problems?	No.
	Any bleeding problems like stomach ulcers?	No.
	Diabetic?	No.
Future appointment	When are you to see the Dr?	In 6 weeks
Availability of help	Is there someone with you	Husband
	Do you have a GP?	Yes.
	Is the [family physician's] office open?	Yes
Location of the patient	When can you get here	½ hr

Ischemic Pain - Cardiology Pt. (Urgent)

Name	Laura Mason	
Surgeon	Dr. Mann	
Initial Complaints		My husband is making me call, but I'm having this pain in my chest.
Open ended Q	Can you be more specific?	My chest is sore.
History	Have you had this pain before?	Yeah, it's the same kind of pain that I got sent to the cardiologist
	Have you been diagnosed with Unstable Angina?	I went to see the cardiologist, but he didn't tell me exactly.
	What did the cardiologist say?	He said I was going to have an angio
		I am on the list of angiogram
	When did you see the cardiologist?	Last week
	Have you had a heart attack before?	No.
	Have you been hospitalized for chest pain?	No.
	Have you had a heart failure?	No.
	Have you had an angiogram or heart catheterization?	No.
	Have you had a stent put in?	No.
	Have you had any electro physiology studies?	No.
	Did you ever go into the hospital for chest pain?	I saw the cardiologist last week.
	Why did you see the cardiologist?	For this type of discomfort.
	When is your angiogram?	They were going to call.
	Did you have any testing done?	No.
Comparison	Is the pain new?	I had it before, but never this bad.

	Is this pain similar to that?	I only had it when I exercise before
OLDCAR		
(Onset)	When did it start?	About 1/2 hour ago
(Location)	Where is it?	All across chest, and radiates to left arm
(Duration)		Constant
(Characteristics)	What type of pain?	Sore, burning.
	Pain scale (0-10)	6
	What does the pain feel like	Burning
	Has it gotten worse?	Yes.
	Is it severe?	Yes.
	Does it come and go?	No.
(Associated Symptoms)	Dizzy?	No.
	Sweating?	Yes.
	Nausea	Yes.
	Short of breath	Yes.
	Anxious	Yes.
	Have you had any stomach problem?	No.
(Aggravating factors)	Does anything make it worse?	Can's say.
	Is it worse with anything that you are doing?	Oh... If I start to do anything, it seems to get worse.
(Relieving factors)	Is there anything that helps?	No.
Activity level	Is it brought on by anything?	It came on all by itself.
	What were you doing when it's come on	Watching TV
Medication	Have you taken any NTG	Yes.
	Does NTG help?	It helped a little bit, but the pain didn't go away.
	How many NTG did you have?	Three
	When did you take the last NTG	1/2 hour ago.
	Are you on any medication?	ASA
Availability of help	Is there someone with you	My husband
	Can someone drive you?	Yes.

Cardiac Tamponade – Surgery Pt. (Urgent)

Name	Judy Shaw	
Surgeon	Dr. Ray	
Initial Complaints		I'm not feeling well and I've got this pressure in my chest
History (surgery)	What	Bypass surgery
	When	8 days ago
	Did you have a valve surgery?	No.
	How many grafts?	Two.
(discharge)	When	2 days ago
	Did you have this discomfort during your admission with us?	No.
	Did you have any pain when you were in	No.

	the hospital?	
	Was it the same when you were in the hospital?	No.
	Have you had a heart attack before?	No.
	Prior to the surgery were you having a lot of angina?	Not a lot.
Incision	How does it look like?	It looks okay.
	How are your incisions	Fine
	Redness	No.
	Swelling	No.
	Drainage	A little bit
	What colour is the drainage?	Sort of clear yellowish colour
	How much drainage?	
	Where is the drainage coming from?	
	Did you have a leg incision? Or did we use arm?	I have a leg incision
	And that looks okay?	Yes.
Comparison	Chest pain/angina before your operation?	Totally different
	Is this pain similar to that [angina]?	Much different.
	How was your angina pain like?	It was more of a pain. Burning.
	Have you had this pressure before?	No.
OLDCAR		
(Onset)	When did it start?	Yesterday
(Location)	Where is this pressure?	In my chest. Around my chest
	Is it like a band?	Not like it's sitting on my chest… pressure around my left side of my chest...
	Does it radiate anywhere?	No.
	Between your shoulder blades?	No.
	Is it along your incision line?	No.
(Duration)	How long does this pressure last for?	It's always there
(Characteristics)	Is it always there?	
	Scale (0-10)	Can't say... [exception: 4 (to Par ID 11)]
	Has it changed at all?	No. not really
(Associated Symptoms)	Are you well otherwise?	I'm feeling a bit fatigued
	Fatigue	Yes.
	How is your breathing?	I'm little bit short of breath. Especially when I am flat.
	Cough	When I lie down.
	Fever/temperature	No.
	Are you feeling dizzy when you stand?	Yes.
	Is the dizziness little bit or it's pretty significant.	It's pretty significant.
	Do you feel weak?	Very weak when I stand up
	Short of breath?	When I lie flat
	Does that make you short of breath to just get out of bed and walk?	No.
	When you move, do you hear clicking?	No.
	Are you coughing up any sputum at all?	No.
	Have you had a recent cold runny nose?	No.
	Are you feeling tired more than usual?	Yes.
	Any swelling in your ankles?	No.

	Are your feet swollen?	No.
	runny nose, sore throat	No.
	Are you pale looking?	My husband thinks I'm a bit pale.
	No other discomfort anywhere else	No.
	Have you being able to eat?	No.
	It's pretty upsetting?	Yes.
	Acute distress	No.
(Aggravating factors)	Lay Flat	Yes.
	Does taking a deep breath making it worse?	No. (Sometimes yes? ID11)
	Does it hurt more with movement?	No
	Does it hurt more if you press on it?	No
(Relieving factors)	Is there anything to make you feel better?	When I sit up it relieves the pressure a bit. But feels dizzy when I do that.
	When you sleep you do need 1, 2, or 3 pillows?	I have to sleep with 2 or 3 pillows.
	Does it go away with rest? Lying down?	No. when I lie down, it gets pretty short of breath.
Activity level	Is it with exertion?	No.
	What started that?	Nothing... Just noticed.
Medication	Did we start you on any new medication after your surgery? Any blood pressure medicine?	No.
	Are you on any cardiac medications?	No.
	Do you have any fluid restrictions?	No.
	Are you weighing yourself?	No change in weights.
	Are you on water pills?	No.
	Are you on Lasix?	No.
	Have you taken any NTG	Yes.
	Did NTG help?	No.
Future appointment	Are you due to see your physician at any time soon?	Not any time soon.
	Do you have an appointment with the surgeon?	Not soon.
	When is your next appointment	3 weeks
Availability of help	Is there someone with you	My husband

Stent Pain – Cardiology Pt. (Non-urgent)

Name	Danielle Charter	
Surgeon	Dr. Lee	
Initial Complaints		I'm having this discomfort in my chest.
History	What	2 stents
(Procedure)	When	2 days ago.
(discharge)	When	The same day.
	Have you had a heart attack before?	No
	Have you had angina before?	Yes.
	When were you diagnosed as unstable angina?	In January
	Were you admitted to the hospital for that?	Yes.

	Did you have any intervention done?	I had angiogram then.
Comparison	Is it the kind of pain you've been having before?	No.
	Is this pain similar to angina?	No.
	Is this pain like the pain you had when the stents get in?	No.
	What is the previous angina pain like?	More of burning.
OLDCAR		
(Onset)	When did it start?	Yes.
(Location)	Where is this pain?	in the chest
	And it's across all of your chest...	No.
	Is it localized?	Yes.
	Can you put your finger on it?	I can put my finger on it.
	Where is it in your chest?	Left side.
(Duration)	How long you had it for?	Since yesterday
(Characteristics)	What's the chest pain feel like?	It's more of an ache.
	Would you say that the pain is severe?	No.
	Pain scale (0-10)	about 3
	It's a constant pain is it?	Yes.
(Associated Symptoms)	Are you well otherwise?	Yes.
	Do you have any other symptoms?	No.
	Cough	NO.
	Fever/temperature	No.
	Weakness/ dizziness	No.
	Short of breath?	No.
	Chills	No.
	Are you coughing up any sputum?	No.
	Tired	No.
	Constipated	No.
	Are you in distress?	No.
(Aggravating factors)	Does it hurt more when you take a deep breath?	No.
	Does it hurt when you touch?	No.
(Relieving factors)	Is there anything to make you feel better?	No.
Activity level	Lifting anything recently?	No.
Medication	Have you done (taken) anything to treat your pain?	I tried the Nitro-glycerine but that didn't help at all.
	Have you had any medication?	I had Tylenol, but that didn't help.
	Have you taken any NTG	Yes. I did, but it did nothing.
	Have you tried any Advil or Ibuprofen or something like that?	No.

F-6 Post-trial Questionnaire

Participant #:
Trial #:

Please answer following questions regarding the patient calls you received. Please read each statement and indicate how strongly you agree or disagree with the statement by placing a mark on the line scale. The midpoint of the line indicates neither agreement nor disagreement. **From question 6 to 9,** please provide your comments on your response. Thank you very much!

1. Please name the possible diagnosis for the patient.

2. I am confident with my possible diagnosis above.

Strongly Disagree ——————|—————— Strongly Agree

3. It was easy to decide the diagnosis.

Strongly Disagree ——————|—————— Strongly Agree

4. I am confident with the recommendation I gave to the patient during the phone call.

Strongly Disagree ——————|—————— Strongly Agree

5. It was easy to decide the recommendation to the patient.

Strongly Disagree ——————|—————— Strongly Agree

6. The decision support tool helped me **to generate questions to patient**. (Please provide a comment on your answer)

Strongly Disagree ——|—— Strongly Agree

Comments:

7. The decision support tool helped me **to consider possibilities** that might have been overlooked without the tool. (Please provide a comment on your answer)

Strongly Disagree ——|—— Strongly Agree

Comments:

8. The decision support tool helped me make **diagnostic decision**? (Please provide a comment on your answer)

Strongly Disagree ——|—— Strongly Agree

Comments:

9. The decision support tool helped me make **recommendation to patient**? (Please provide a comment on your answer)

Strongly Disagree ——|—— Strongly Agree

Comments:

F-7 Post-experimental Questionnaire

Participant #:

This questionnaire gives you an opportunity to provide us feedback on our decision support system. Please read each statement and indicate how strongly you agree or disagree with the statement by placing a mark on the line scale where. When checklists are provided please check off the boxes.

<<Overall experience >>

1. I am satisfied with how **easy** it is to use this system.

Strongly Disagree	——————|——————	Strongly Agree

2. The decision support tool helped me complete the consultations **effectively**.

Strongly Disagree	——————|——————	Strongly Agree

3. The decision support tool helped me complete the consultations **efficiently**.

Strongly Disagree	——————|——————	Strongly Agree

4. I felt (please check one)
   - ☐ more
   - ☐ equally
   - ☐ less

   confident in my assessment with this system than without it.

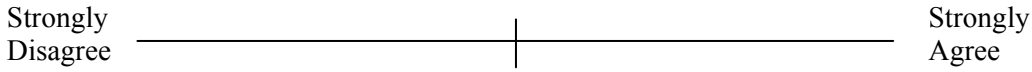
5. I felt (please check one)
   - ☐ more
   - ☐ equally
   - ☐ less

   confident in my advice with this system than without it.

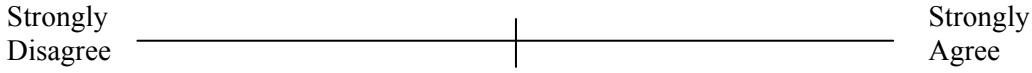
Comments:

<< PDA use >>

6. I felt comfortable using the stylus to interact with the screen.



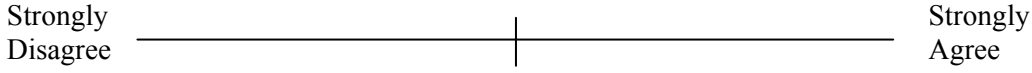
7. I felt comfortable using the system while talking on the phone.



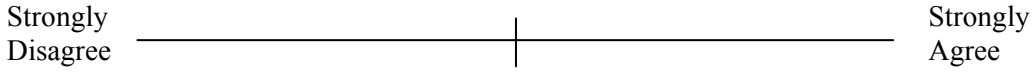
Comments:

<< Decision support tool >>

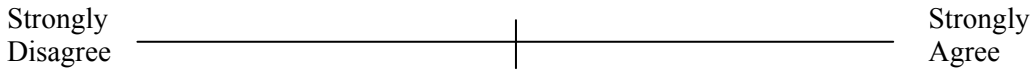
8. It was easy to find the information I needed.



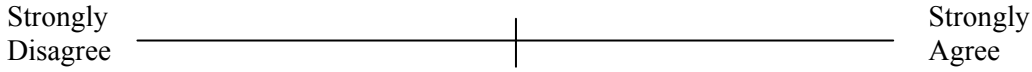
9. The information on the system was **useful** to me in completing the phone consultations.



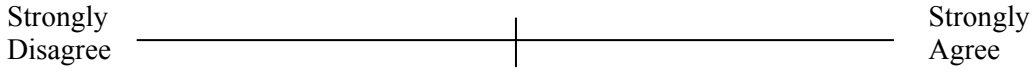
10. The organization of information on the screens was **clear**.



11. **The order** of the screens made sense.



12. I like the **flexibility** of the navigation (easy access via icons etc...)



13. This system has all the functions and capabilities I expected it to have.

Strongly Disagree ——————————————— Strongly Agree

14. This system is useful for (please check **all that apply**)
    - ☐ **Reminder** to consider more possibilities than people normally think of
    - ☐ **Guide for question sequence** to generate most efficient path
    - ☐ **Create better image of patients** in mind
    - ☐ **Double check** your knowledge with the most current evidence
    - ☐ **Communicate** with physicians/other medical professionals easier
    - ☐ **Training tool** for telephone consultation
    - ☐ Other (Please specify)

Comments:

<< Training issues >>

15. It was easy to learn to use this system.

Strongly Disagree ——————————————— Strongly Agree

16. The training at the beginning of the session was sufficient for me to know how to complete my tasks.

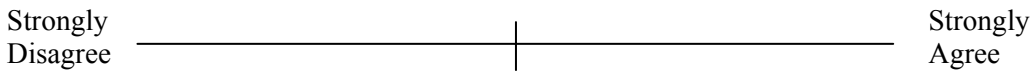
Strongly Disagree ——————————————— Strongly Agree

17. I believe I could become productive quickly using this system.

Strongly Disagree ——————————————— Strongly Agree

Comments:

18. Overall, I am satisfied with this system.



Comments:

19. Please describe what you liked best about this system.

20. Please comment on parts of this system you feel could be improved.

21. Please provide any other suggestions to the system.

Appendix G

Response and Results of Experiment II

G-1 Participant Demographic Data

			Experience with (in yrs)				Somoza's Study		Experience with Electronics		
	Gender	Age	Cardiology Pt	Surgery Pt	Cardiac Nursing	Nursing	R1	R1&R2	Computing	Mobile devices	PDA
1	F	4	19	25	25	27	Y	-	10	7.5	7.5
3	F	3	10	10	11	15	-	-	10	10	0
4	F	2	1.5	1.5	1.5	6	Y	Y	9.5	0.5	0.5
5	F	3	15	15	15	22	-	-	5.5	0	0.5
6	F	3	20	20	20	23	Y	Y	9.5	1	6
7	F	4	16	10	16	31	Y	Y	8	0	5
8	F	4	28	15	28	28	-	-	8	0	0
9	F	3	1	7	8	21	Y	Y	7.5	0	2
10	F	3	15	15	15	16	-	-	10	10	10
11	F	4	25	25	25	25	-	-	7.2	0	0
12	F	3	18.5	18.5	18.5	20.5	-	-	8	7.5	0.5
13	F	5	1	15	15	30	-	-	0.5	0	0
14	F	4	20	15	20	20	-	-	6	5	5
15	F	3	10	6	10	14	-	-	5	2	0
16	F	5	30	3	31	32	-	-	6	6	6
17	F	4	14	0	14	26	-	-	7	0.5	1

G-2 Participant Assignment

		Patient model number*			
Participant	Experimental condition	Block 1	Block 2	Block 3	Block 4
1	2	2	4	1	3
3	4	3	1	4	2
4	1	3	1	4	2
5	3	2	4	1	3
6	4	4	3	2	1
7	4	2	4	1	3
8	2	3	1	4	2
9	3	3	1	4	2
10	1	1	2	3	4
11	2	4	3	2	1
12	1	2	4	1	3
13	1	4	3	2	1
14	2	1	2	3	4
15	4	1	2	3	4
16	3	4	3	2	1
17	3	1	2	3	4

*Patient model number
1: PPS, 2: Ischemic Pain, 3: Cardiac Tamponade, 4: Stent Pain

G-3 Effectiveness Rating

a) Results for PPS

Tool Group		1. Form				2. OLDCAR				3. Tree				4. Network			
Participant		4	10	12	13	1	8	11	14	5	9	16	17	3	6	7	15
Establishes Context	5	2	5	4	5	4	5	5	4	5	5	5	5	5	4	3	5
What was done	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
When it was done	2	0	2	2	2	2	2	2	1	2	2	2	2	2	2	0	2
When discharged from hospital	1	0	1	0	1	0	1	1	1	1	1	1	1	1	0	1	1
Conducts Assessment	26.5	7	6	8.5	11.5	8	13	13.5	8.5	11	5	15.5	12.5	11	11	9	15.5
Onset (2 days ago)	2	0	0	2	2	0	2	0	2	2	0	2	2	0	2	0	0
Location (neck, back and shoulder)	2	1.5	2	0	2	0	2	2	0	0	0	2	2	2	2	0	2
Duration (constant)	2	0	0	0	2	0	2	2	2	0	0	2	0	2	0	0	0
Characteristics - any	1	1	0	0.5	1	1	1	1	0.5	1	1	1	1	1	1	1	1
R/O cold symptoms (runny nose, sore throat)	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
R/O flu symptoms (general aching)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Characteristics - asks pt if the pain they have now is like their angina pain or different from their angina pain	2	0	0	2	0	0	2	2	0	2	0	2	0	2	0	2	2
Characteristics - asks pt if the pain they have now is like the pain they had after surgery	1	0	0	1	0.5	0	0	0	0	0	0	0	0	0	0	1	0
Extra half point for use of pain scale	0.5	0.5	0	0	0	0	0.5	0.5	0	0	0	0.5	0.5	0	0	0	0.5
No sternal clicking	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Associated symptoms (fever)	2	0	0	2	0	2	0	2	2	2	0	2	2	0	2	2	2
Aggravating factors (taking a deep breath)	2	1	2	0	2	2	2	2	1	2	2	2	2	2	2	2	2
Relieving factors																	
- Nitro doesn't help	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1
- nothing (e.g. ask about rest etc.)	1	1	1	0	0	1	0.5	0	0	0	0	0	0	0	0	0	1
- get them to try sitting forward and take a deep breath; this should feel better	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Asks them what the physician told them to expect regarding their angina or the success of the surgery	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Extra point for asking about incision	1	1	0	1	1	1	0	1	0	1	1	1	1	0	0	1	1
Asks pt if they are taking any pain medication	1	1	1	0	1	1	1	1	0	0	1	0	1	1	0	0	1
Asks pt what medications they are on	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conclusion	1	0	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1
Possible PPS	1	0	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1
Recommends Appropriate Action	7	2	0	0	0	0	0	0	0	0	1	1	3	0	0	0	0
Asks the pt if they have any drug allergies	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Could try Tylenol or Ibuprofen (Advil) - 1 mark and call back if they don't get any relief from it - 1 mark	2	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0
Extra point if they suggest Ibuprofen and ask if pt is on ASA and dosage, hx kidney problems or hx bleeding (i.e. gastric ulcers)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Will talk with surgeon and call back	2	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Severity assessment	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1
They were able to differentiate between level	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	0	1

of care required (urgent vs. non-urgent; in this case, non-urgent)																		
Total score	40.5	12	13	13.5	18.5	14	19	19.5	14.5	17	13	23.5	21.5	17	17	12	22.5	

b) Results for Ischemic Pain

Tool Group		1. Form				2. OLDCAR				3. Tree				4. Network			
Participant		4	10	12	13	1	8	11	14	5	9	16	17	3	6	7	15
Establishes Context	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1
Asks questions to further understand context	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1
Conducts Assessment	18.5	8	6.5	4.5	3	9.5	11.5	11.5	12	5	7	5	9	5	8.5	7.5	5
Onset	1	0	1	0	1	1	1	1	1	1	0	0	1	1	1	0	0
Location (additional info on location-radiating 1mark, large area- 1 mark)	2	1	1	0	0	1	1	1	1.5	1	0	1	2	0	1	0	0
Duration	1	0	0	0	0	1	1	1	1	1	0	0	1	1	1	1	1
Characteristics - any	1	1	0	0	0	1	1	1	1	0	1	0	1	0	1	1	0
Characteristics																	
R/O cold symptoms (runny nose, sore throat)	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
R/O flu symptoms (general aching)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Characteristics - asks pt if the pain they have now is like their angina pain or different from their angina pain	2	2	0	2	0	2	2	2	2	0	2	0	2	0	0	2	2
Extra half point for use of pain scale	0.5	0	0.5	0.5	0	0.5	0.5	0.5	0.5	0	0	0	0	0	0.5	0	0
Associated symptoms (i.e. nausea and/or SOB and/or sweaty)	2	2	2	2	0	2	2	2	2	0	2	0	0	0	2	0.5	0
Aggravating factors	1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0
Relieving factors																	
- not relieved by rest	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
- not relieved by Nitro	2	2	2	0	2	0	2	2	2	2	2	2	2	2	2	2	2
Asks pt what medications they are on	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asks the opinion of whoever is with the pt how the patient looks	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conclusion	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Ischemic pain	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Recommends Appropriate Action	2	2	0	2	2	2	0	2	2	2	2	2	2	2	2	2	0
Call 911	2	2	0	2	2	2	0	2	2	2	2	2	2	2	2	2	0
Severity assessment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
They were able to differentiate between level of care required (urgent vs. non-urgent; in this case, urgent)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total Score	23.5	13	9.5	9.5	8	13.5	14.5	16.5	17	9	12	10	14	10	13.5	12.5	8

c) Cardiac Tamponade

Tool Group		1. Form				2. OLDCAR				3. Tree				4. Network			
Participant		4	10	12	13	1	8	11	14	5	9	16	17	3	6	7	15
Establishes Context	5	3	5	4	4.5	5	5	5	5	5	5	4	5	5	4	5	5
What was done	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

When it was done	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
When discharged from hospital	1	1	1	0	0.5	1	1	1	1	1	1	0	1	1	0	1	1
Conducts Assessment	23	9.5	12	6	9.5	13	13	11.5	14.5	7.75	8.5	9.5	8	9	11	10	3.5
Onset	1	1	0	0	1	1	1	1	1	1	0	1	1	0	1	0	0
Location (chest)	1	1	1	0	1	1	1	1	1	1	0.5	0.5	1	1	1	0	0
Duration	1	0	1	0	1	0	1	1	1	0.75	1	0	1	0	1	0	0
Characteristics - asks pt if the pain they have now is like their angina pain or different from their angina pain	2	0	2	0	2	2	2	2	2	0	2	2	2	2	2	2	0
Characteristics - asks pt if the pain they have now is like the pain they had after surgery	1	0	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0
Characteristics: R/O cold symptoms (runny nose, sore throat)	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
R/O flu symptoms (general aching)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No sternal clicking	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1
Aggravating factors (SOB when lying flat)	2	1	1	1	1.5	2	1	1	2	1	1	1	0	2	1	2	1
Relieving factors (sitting up)	2	0	2	0	0	2	2	0	2	0	0	0	0	0	2	2	0.5
Relieving Factors - Nitro doesn't relieve it	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
Relieving Factors - other	1	0	0	0	0	0	0	0.5	0	0	0	1	0	0	0	0	0
Dizziness	2	2	2	2	0	2	0	0	0	0	0	2	0	2	0	2	0
Lethargic/ tired/weakness	1	0.5	0	1	0	1	1	1	1	0	1	0	0	0	1	1	0
Extra point for asking about incision	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1
Asks pt if they are taking any pain medication	1	0	1	1	1	0	0	1	0	0	1	0	1	0	0	0	0
Asks pt what medications they are on	2	2	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0
Asks questions to rule out heart failure	1	1	1	0	1	0	0	1	0.5	1	0	1	0	0	1	1	0
Conclusion	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Possible cardiac tamponade	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Recommends Appropriate Action	2	2	0	2	0	2	0	2	0	0	2	2	2	2	0	2	0
Go to ER or Call 911	2	2	0	2	0	2	0	2	0	0	2	2	2	2	0	2	0
Severity assessment	1	1	0	1	0	1	0	0	0	0	1	1	1	1	0	1	0
They were able to differentiate between level of care required (urgent vs. non-urgent; in this case, urgent)	1	1	0	1	0	1	0	0	0	0	1	1	1	1	0	1	0
Total Score	32	16.5	17	13	14	22	18	18.5	19.5	12.7 5	17.5	16.5	16	17	15	18	8.5

d) Stent Pain

Tool Group		1. Form				2. OLDCAR				3. Tree				4. Network			
Participant		4	10	12	13	1	8	11	14	5	9	16	17	3	6	7	15
Establishes Context	2	2	2	1.5	2	2	1	2	2	2	2	0	2	2	2	2	0
Patient recently had stents inserted	2	2	2	1.5	2	2	1	2	2	2	2	0	2	2	2	2	0
Conducts Assessment	23.5	11.5	10.5	5	8	12	16.5	16	15.5	15	8	13	7	12	14.5	9	10
Onset (yesterday)	2	2	0	0	2	2	2	2	2	2	0	2	0	0	2	0	0
Duration (constant)	2	2	0	0	0	2	2	2	2	2	0	2	0	2	2	0	0
Characteristics (localized)	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2
R/O cold symptoms (runny nose, sore throat)	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
R/O flu symptoms (general aching)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Characteristics - asks pt if the pain they have	2	0	2	2	2	2	2	2	2	2	0	1	2	2	2	2	2

now is like their angina pain or different from their angina pain																	
Extra half point for use of pain scale	0.5	0.5	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0.5	0	0
Associated symptoms (none, feels well otherwise)	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Aggravating factors (none)	2	0	0	0	0	0	2	2	2	2	2	2	0	2	2	0	2
Relieving factors (none)	2	2	2	0	0	2	2	2	2	2	2	2	0	2	2	2	2
Asks them what the physician told them to expect regarding their angina or the success of the procedure	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Asks pt if they are taking any pain medication	1	1	1	0	0	0	1	1	1	1	0	0	1	0	0	1	0
Asks pt what medications they are on	2	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Asks pt if they're taking their Plavix	2	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conclusion	1	1	0	1	0	0	0	0	0	0	1	0	1	1	0	1	1
Possible stent pain	1	1	0	1	0	0	0	0	0	0	1	0	1	1	0	1	1
Recommends Appropriate Action	5	4	0	0	0	0	0	0	0	1	2	1	1.5	0	0	1	0
Asks the pt if they have any drug allergies	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Could try Tylenol or Ibuprofen (Advil) - 1 mark and call back if they don't get any relief from it - 1 mark	2	2	0	0	0	0	0	0	0	1	2	1	1.5	0	0	1	0
Extra point if they suggest Ibuprofen and ask if pt is on ASA and dosage, hx kidney problems or hx bleeding (i.e. gastric ulcers)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Severity assessment	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
They were able to differentiate between level of care required (urgent vs. non-urgent; in this case, non-urgent)	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
Total Score	32.5	19.5	13.5	8.5	11	15	18.5	19	18.5	19	14	15	12.5	15	17.5	14	12

G-4 Summary of Scores

Establishing Context

	Patient Models				
Tool	PPS	Ischemic	Tamponade	Stent Pain	Mean
Baseline	57.50%	91.67%	58.33%	72.92%	70.10%
Form	80.00%	100.00%	82.50%	93.75%	89.06%
OLDCAR	90.00%	75.00%	100.00%	87.50%	88.13%
Tree	100.00%	75.00%	95.00%	75.00%	86.25%
Network	85.00%	100.00%	95.00%	75.00%	88.75%
Mean	75.36%	89.29%	78.21%	78.57%	80.36%

Quality of Assessment

	Patient Models				
	PPS	Ischemic	Tamponade	Stent Pain	Mean
Baseline	37.97%	35.14%	32.43%	44.50%	37.51%
Form	31.13%	29.73%	40.22%	37.23%	34.58%
OLDCAR	40.57%	60.14%	56.52%	63.83%	55.26%
Tree	41.51%	35.14%	36.68%	45.74%	39.77%
Network	43.87%	35.14%	36.41%	48.40%	40.96%
Mean	38.71%	37.93%	38.16%	46.96%	40.44%

Correctness of Conclusion

	Patient Models				
	PPS	Ischemic	Tamponade	Stent Pain	Mean
Baseline	33.33%	91.67%	4.17%	29.17%	39.58%
Form	50.00%	100.00%	25.00%	50.00%	56.25%
OLDCAR	75.00%	87.50%	25.00%	0.00%	46.88%
Tree	50.00%	87.50%	25.00%	50.00%	53.13%
Network	75.00%	100.00%	0.00%	75.00%	62.50%
Mean	50.00%	92.86%	12.50%	37.50%	48.21%

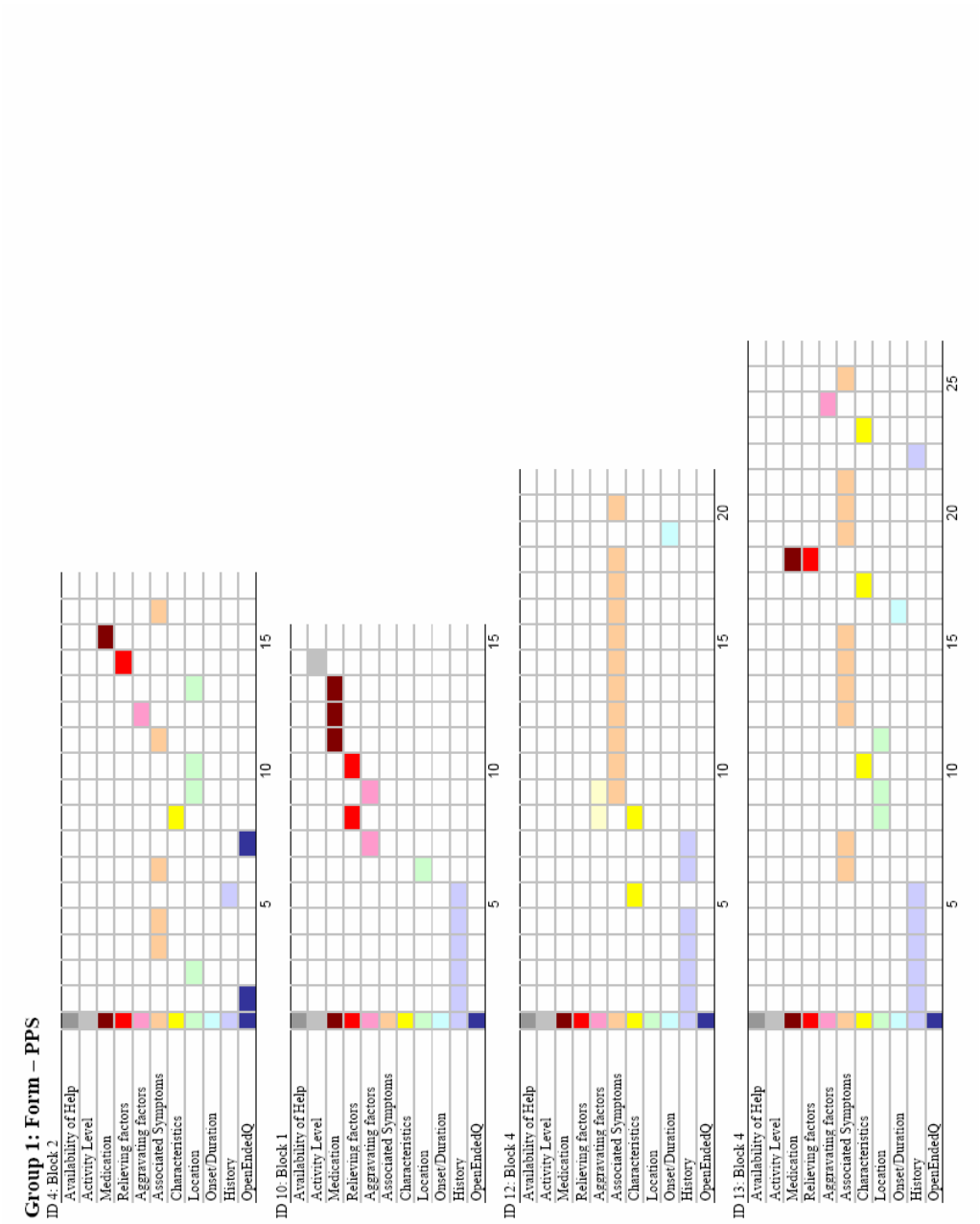
Quality of Recommendation

	Patient Models				
	PPS	Ischemic	Tamponade	Stent Pain	Mean
Baseline	10.12%	41.67%	50.00%	20.00%	30.45%
Form	7.14%	75.00%	50.00%	20.00%	38.04%
OLDCAR	0.00%	75.00%	50.00%	0.00%	31.25%
Tree	17.86%	100.00%	75.00%	27.50%	55.09%
Network	0.00%	75.00%	50.00%	5.00%	32.50%
Mean	7.91%	64.29%	53.57%	16.07%	35.46%

Severity Assessment

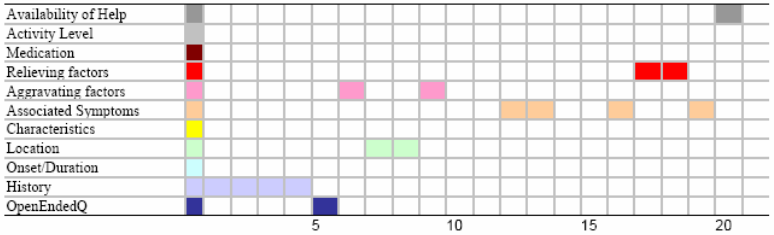
	Patient Models				
	PPS	Ischemic	Tamponade	Stent Pain	Mean
Baseline	50.00%	83.33%	66.67%	37.50%	59.38%
Form	100.00%	100.00%	50.00%	100.00%	87.50%
OLDCAR	75.00%	100.00%	25.00%	100.00%	75.00%
Tree	100.00%	100.00%	75.00%	100.00%	93.75%
Network	50.00%	100.00%	50.00%	75.00%	68.75%
Mean	67.86%	92.86%	57.14%	69.64%	71.88%

G-5 Question Sequence Chart

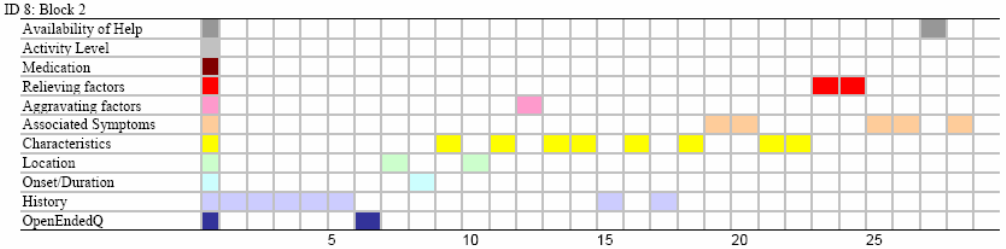


Group 2: OLDCAR – PPS

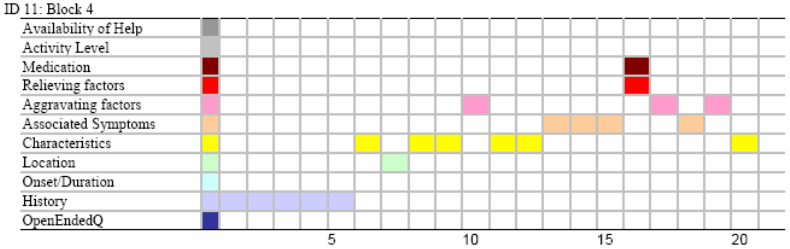
ID 1: Block 3



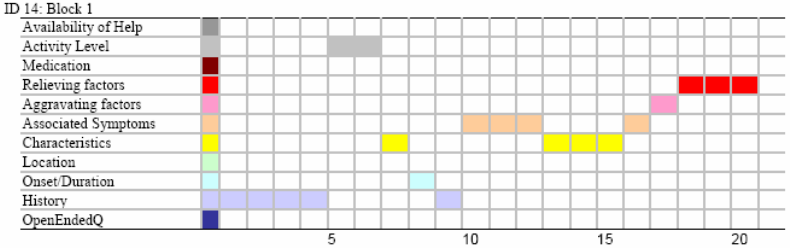
ID 8: Block 2



ID 11: Block 4

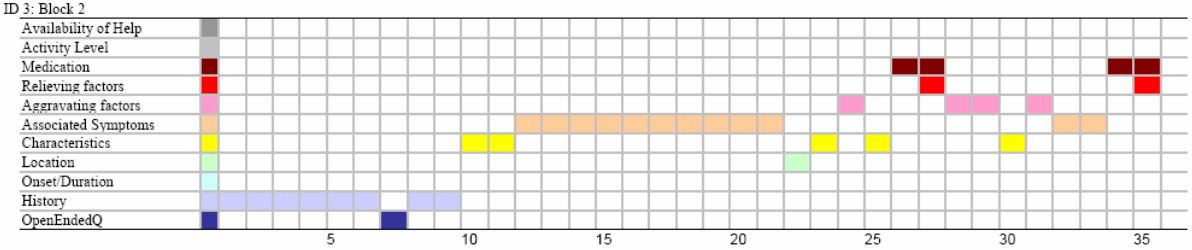


ID 14: Block 1

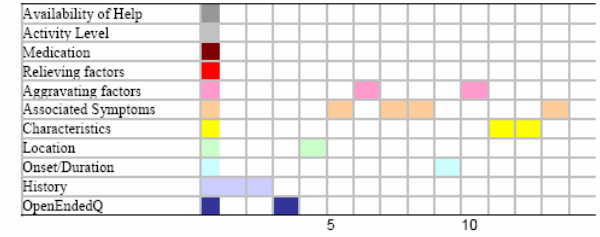


Group 4: Network – PPS

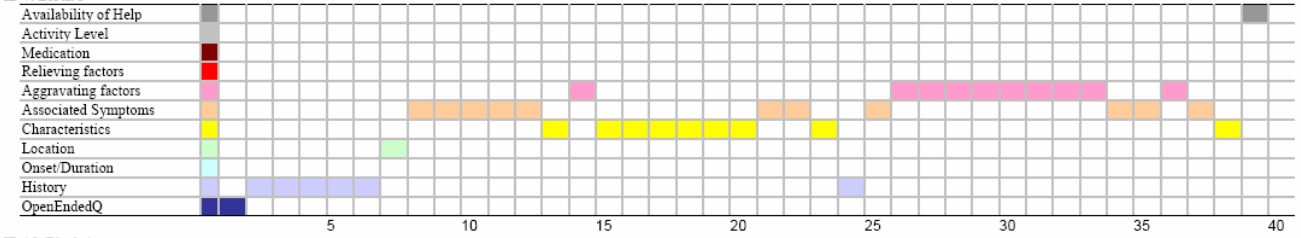
ID 3: Block 2



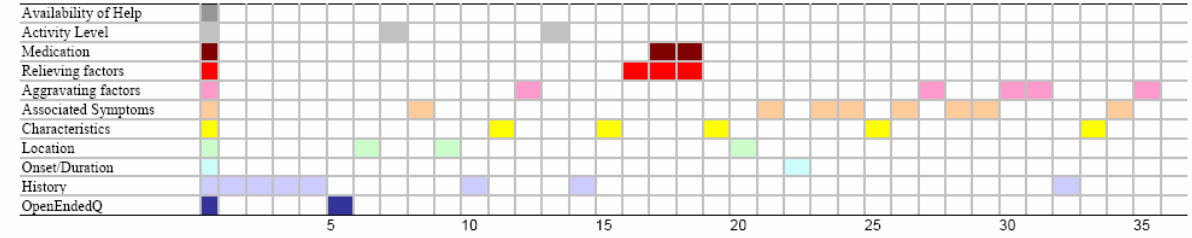
ID 6: Block 4



ID 7: Block 3

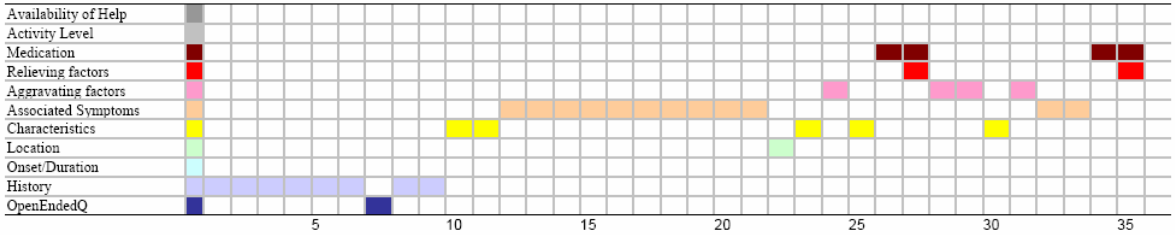


ID 15: Block 1



Group 4: Network – PPS

ID 3: Block 2



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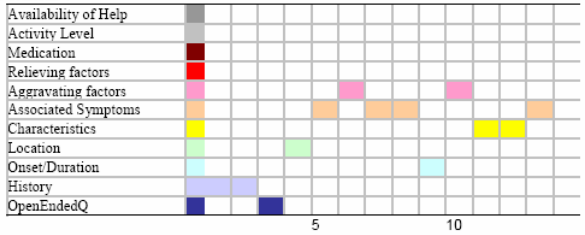

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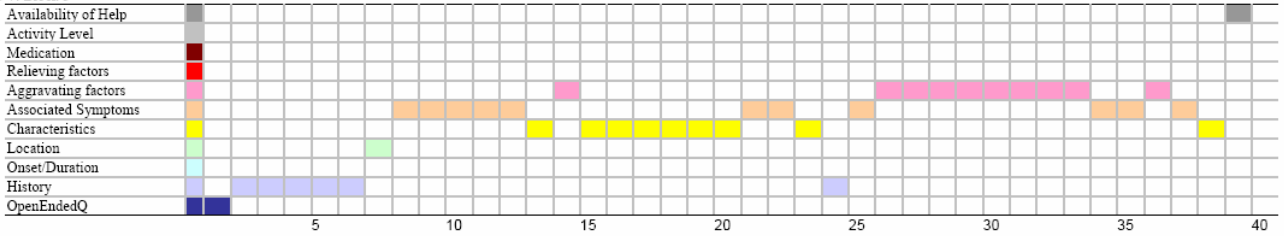

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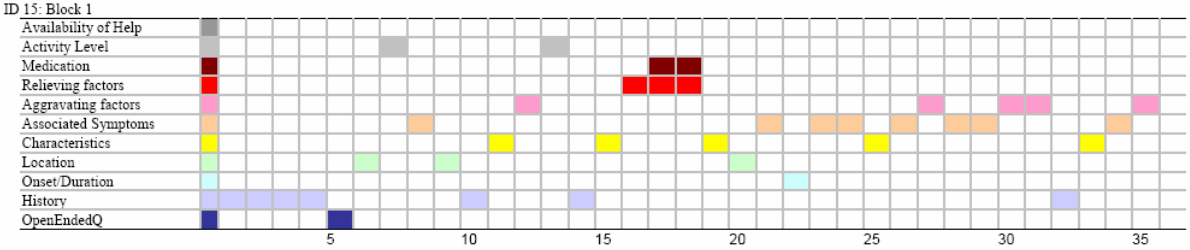
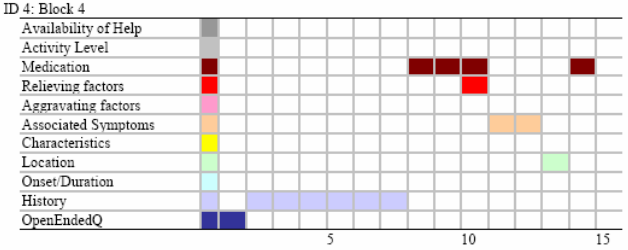
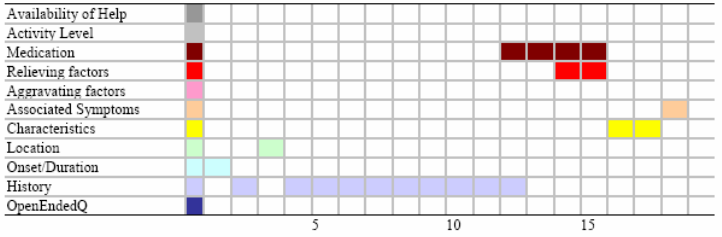


Group 1: Form – Ischemic Pain

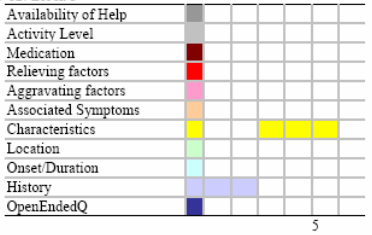
ID 4: Block 4



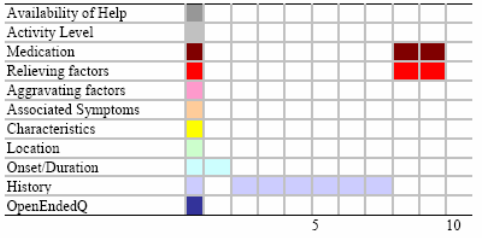
ID 10: Block 2



ID 12: Block 3

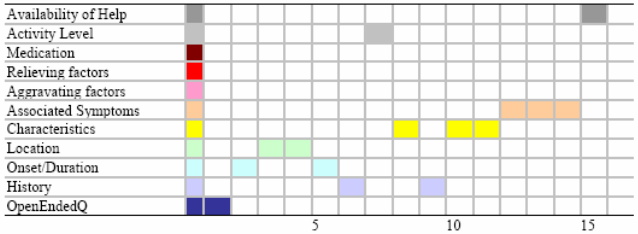


ID 13: Block 3



Group 2: OLDCAR – Ischemic Pain

ID 1: Block 1



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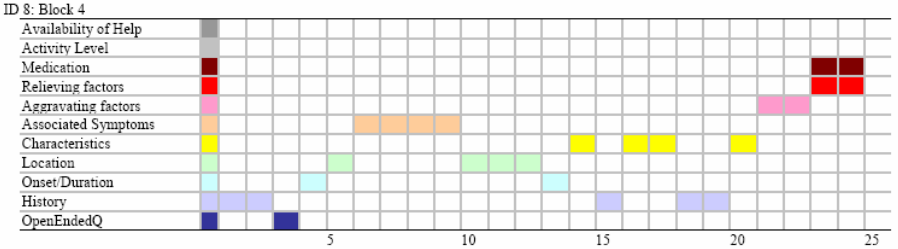

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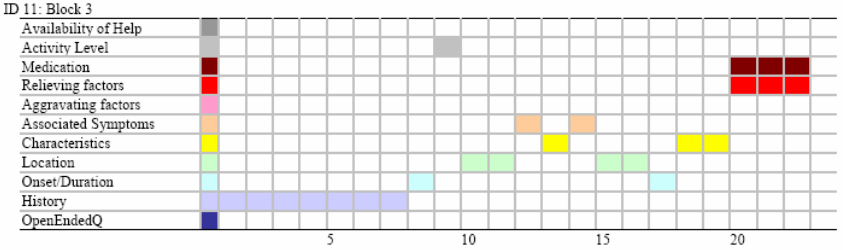
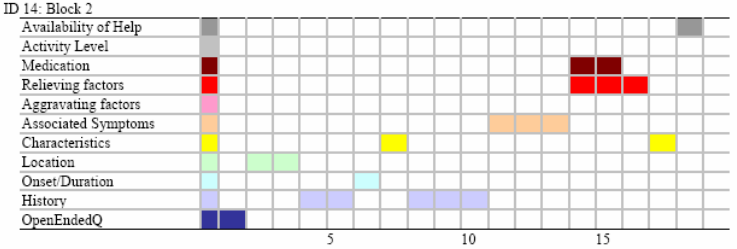
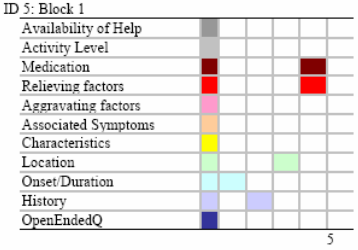


ID 14: Block 2

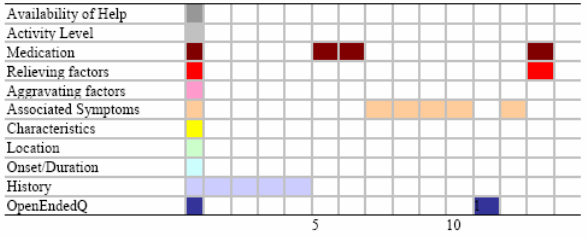


Group 3: Tree – Ischemic Pain

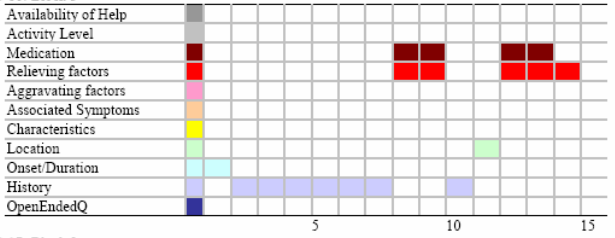
ID 5: Block 1



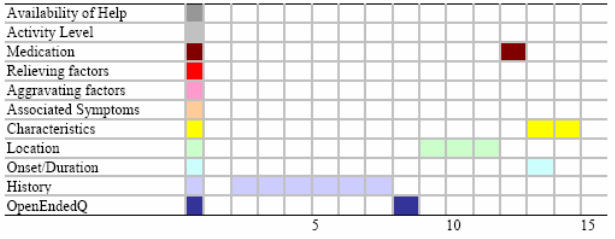
ID 9: Block 4



ID 16: Block 3

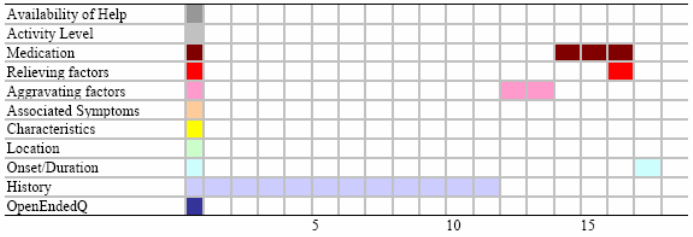


ID 17: Block 2

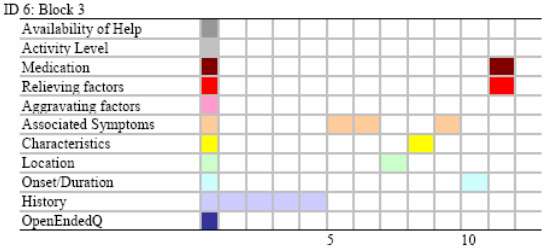


Group 4: Network – Ischemic Pain

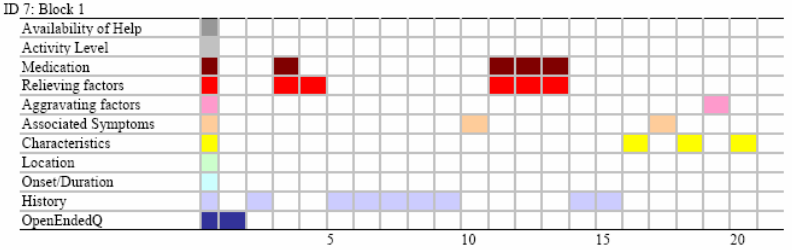
ID 3: Block 4



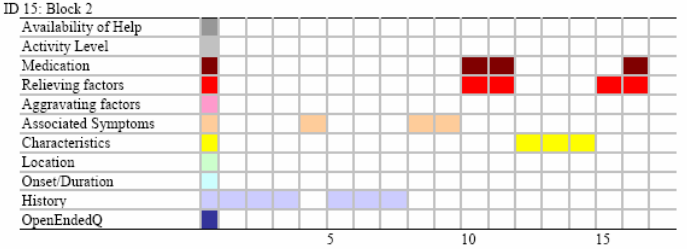
ID 6: Block 3



ID 7: Block 1

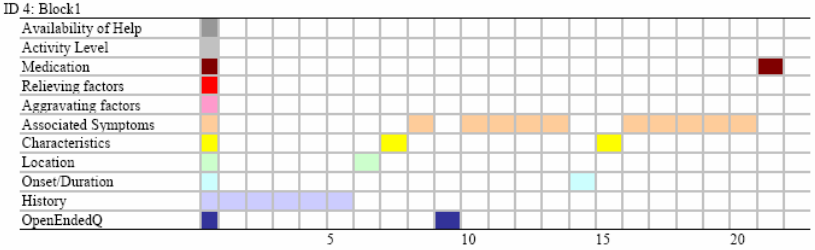


ID 15: Block 2

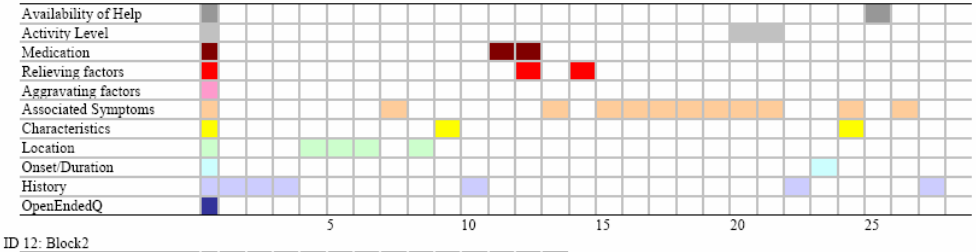


Group 1: Form – Cardiac Tamponade

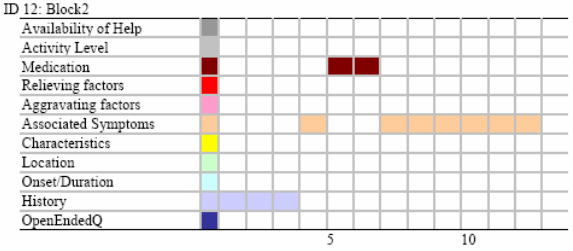
ID 4: Block1



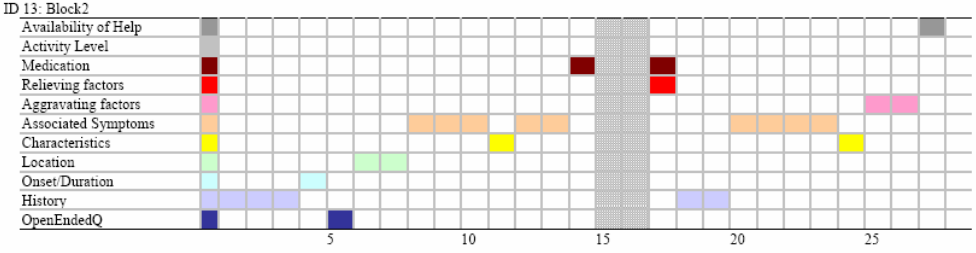
ID 10: Block3



ID 12: Block2

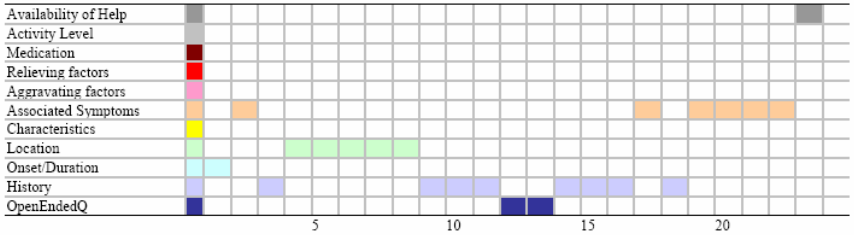


ID 13: Block2

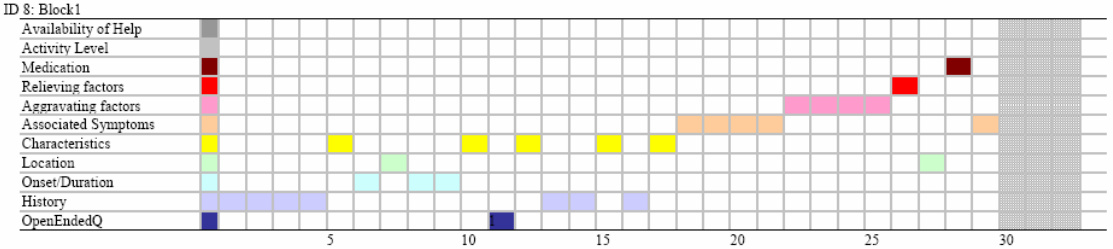


Group 2: OLDCAR – Cardiac Tamponade

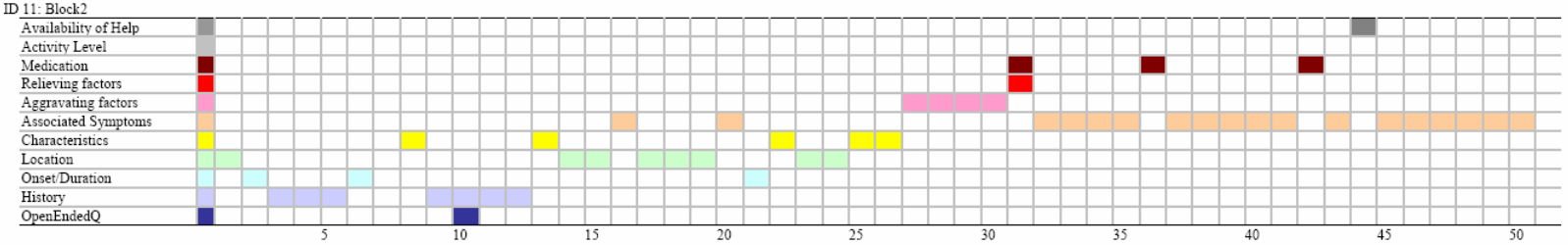
ID 1: Block 4



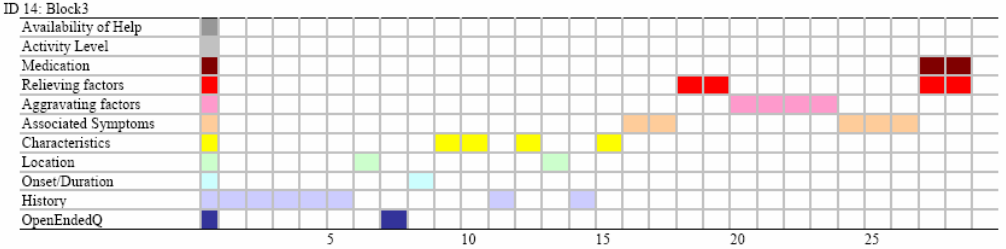
ID 8: Block1



ID 11: Block2

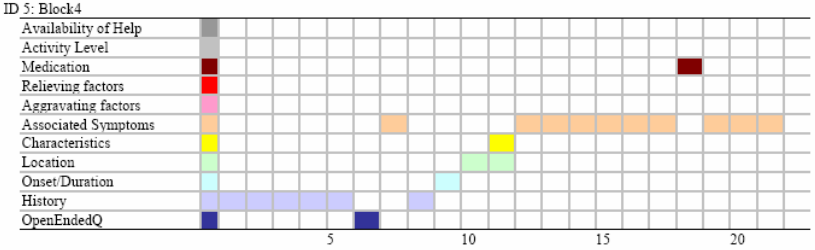


ID 14: Block3

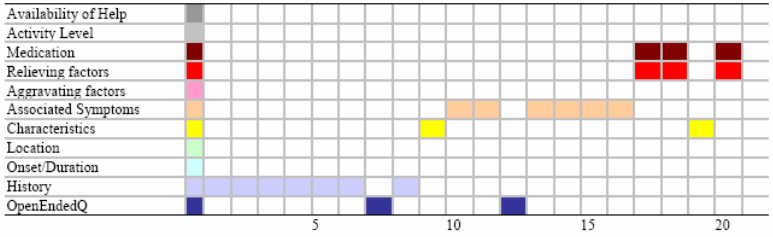


Group 3: Tree – Cardiac Tamponade

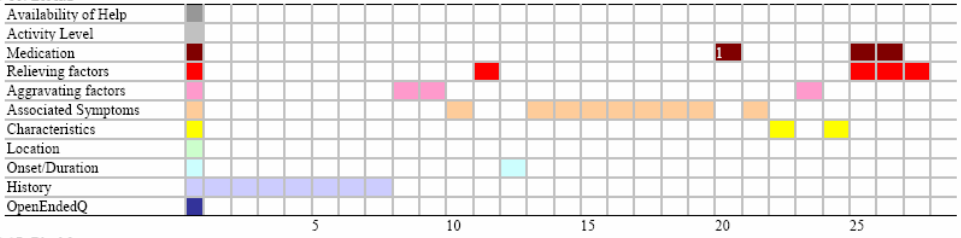
ID 5: Block4



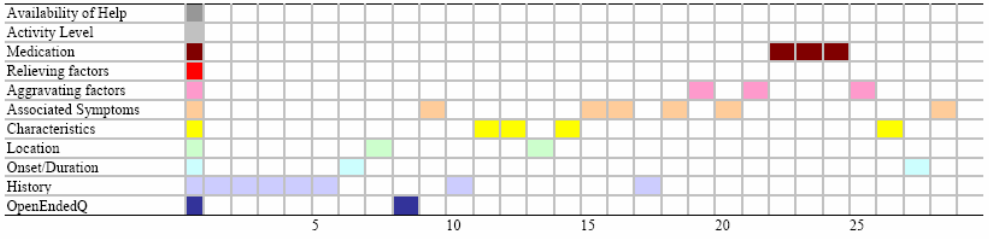
ID 9: Block1



ID 16: Block2

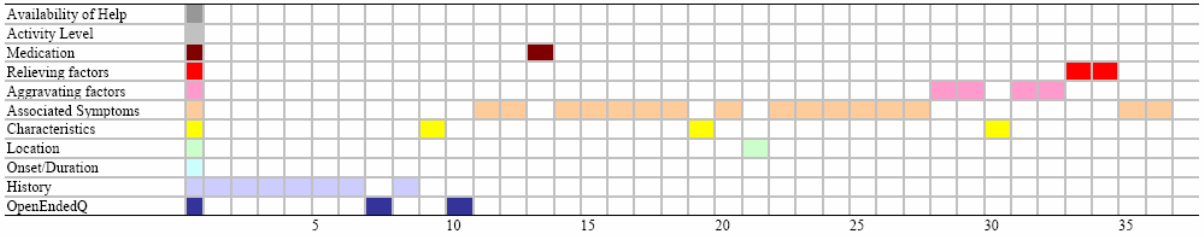


ID 17: Block3

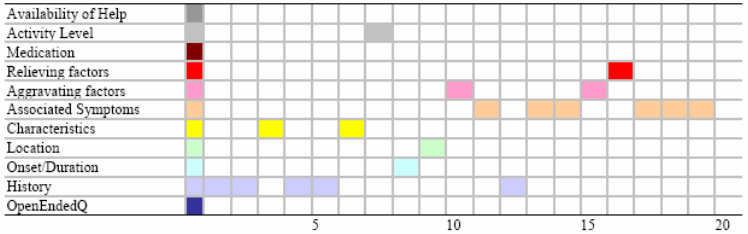


Group 4: Network – Cardiac Tamponade

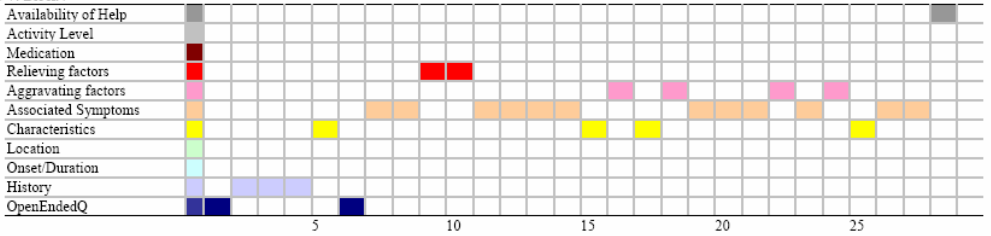
ID 3: Block1



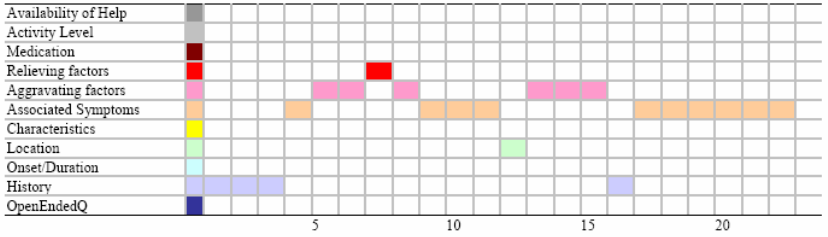
ID 6: Block2



ID 7: Block4

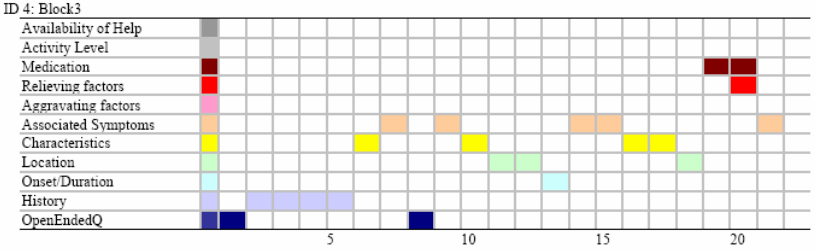


ID 15: Block3

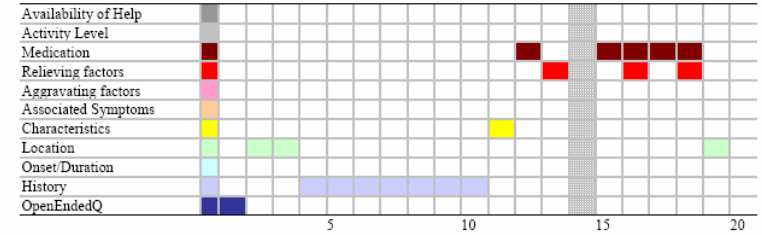


Group 1: Form – Stent Pain

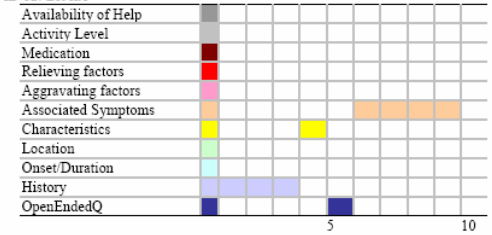
ID 4: Block3



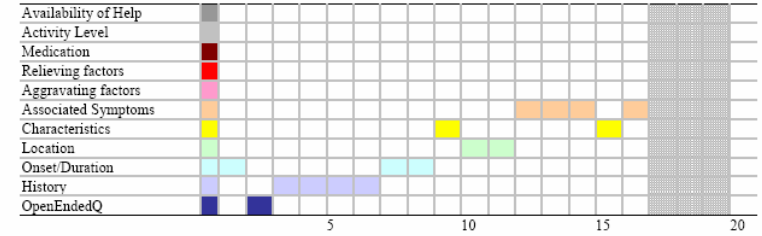
ID 10: Block4



ID 12: Block1

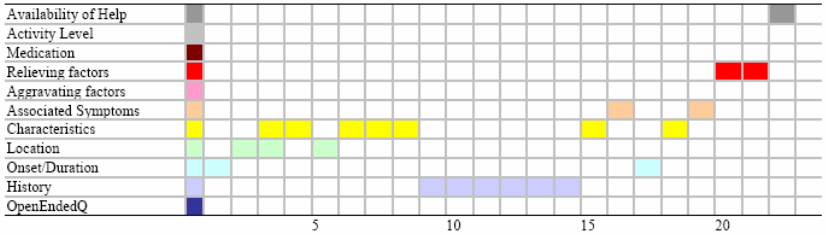


ID 13: Block1

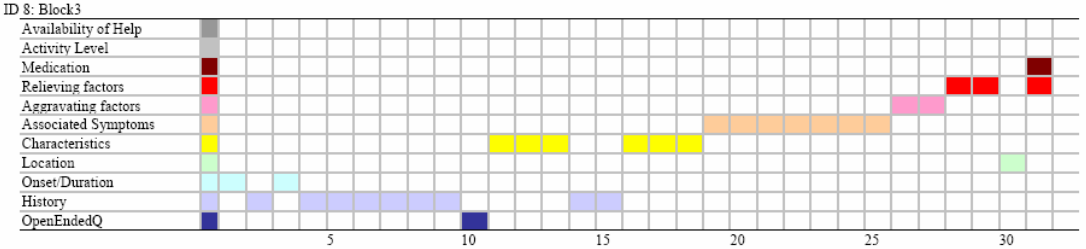


Group 2: OLDCAR – Stent Pain

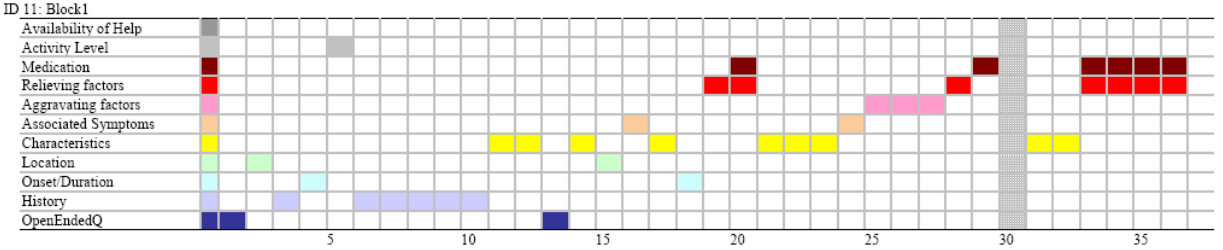
ID 1: Block2



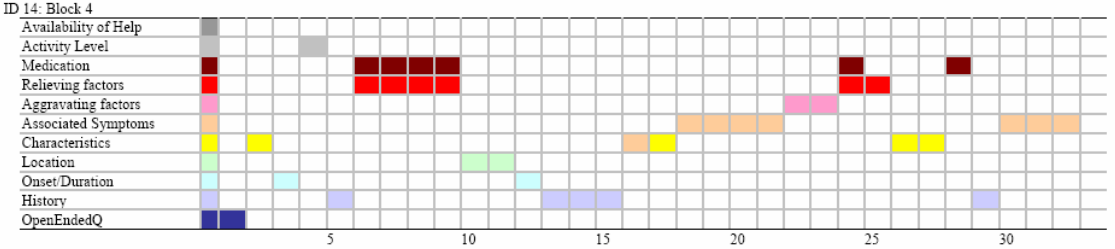
ID 8: Block3



ID 11: Block1

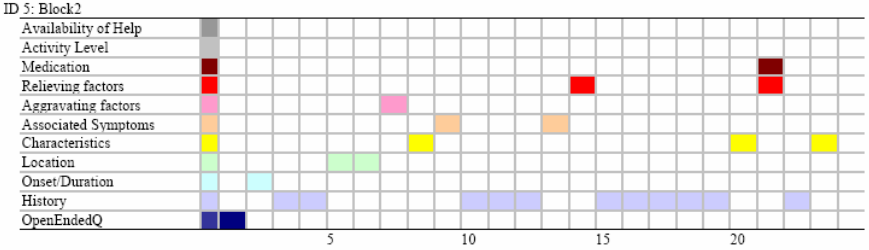


ID 14: Block 4

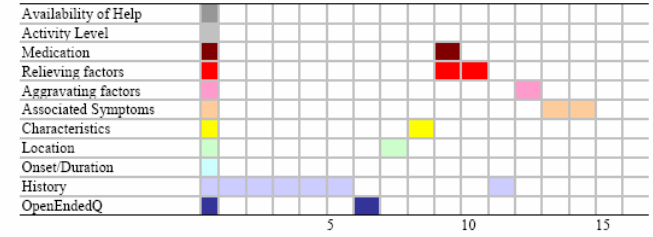


Group 3: Tree – Stent Pain

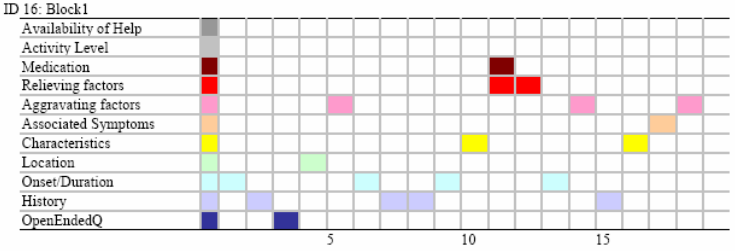
ID 5: Block2



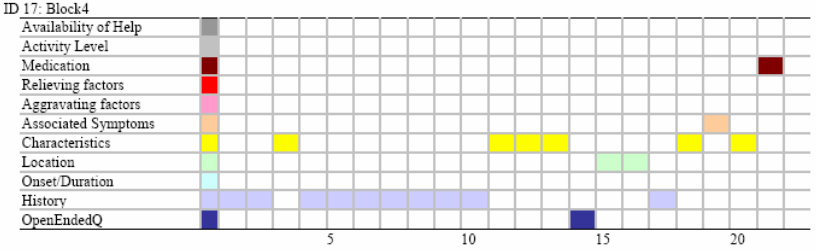
ID 9: Block3



ID 16: Block1

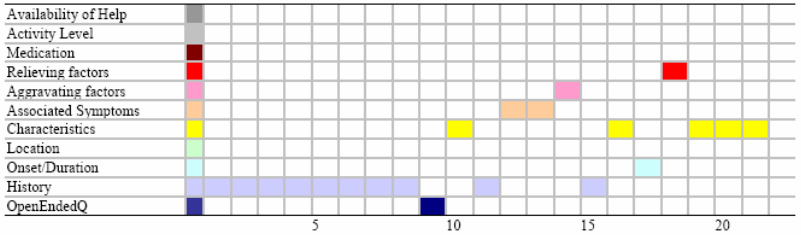


ID 17: Block4

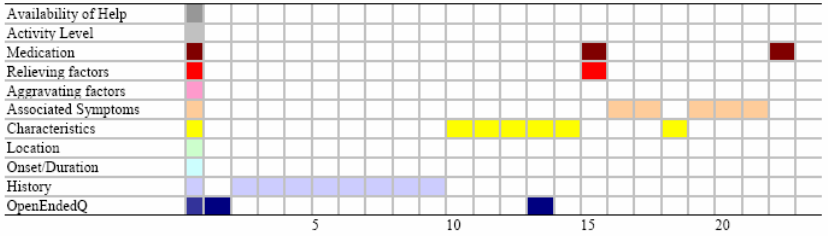


Group 4: Network – Stent Pain

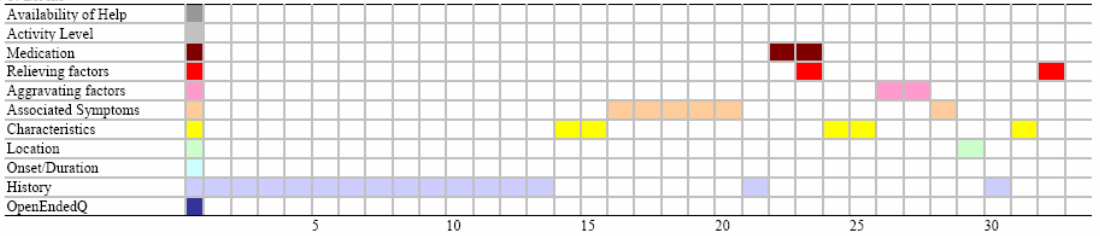
ID 6: Block1



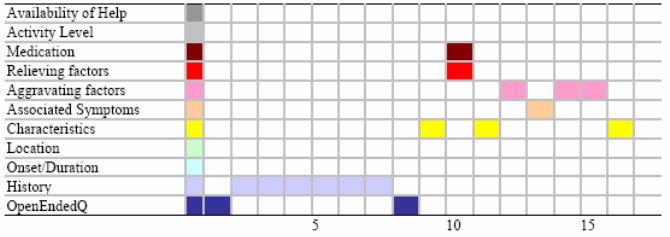
ID 7: Block2



ID 3: Block3



ID 15: Block4



G-6 Post-trial Questionnaire Response

a) Question 1 ~ 5

					Diagnosis			Recommendation		
ID	Tool	Model	Trial	1. Diagnosis response	correct	2. conf	3. ease	quality	4. conf	5. ease
1	2	1	3	Post pericardiotomy syndrome	1	6.5	6.7	0	6.9	7
1	2	2	1	Possible MI	1	6.6	6.5	1	6.4	6.2
1	2	3	4	Post op Tamponade	1	6.3	5.7	1	5.5	6.1
1	2	4	2	Muscular ache, not like angina	0	7.5	7.3	0	7.5	7
3	4	1	2	Pericarditis	1	7.5	9.5	0	9.6	9.4
3	4	2	4	Increased Angina Possible MI / Ischemica	1	9.9	9.9	1	9.9	9.7
3	4	3	1	Increased HR + SOB + Chest pain + achy cerdia (?) related to HR.	0	8.1	2.6	1	8.8	9.9
3	4	4	3	Post stent pain	1	5.7	2	0	7.4	8
4	1	1	2	Pain management issue	0	3	1.9	0.286	4.1	2.3
4	1	2	4	Possible MI	1	8.8	9.1	1	9.2	9.2
4	1	3	1	Possible cardiac Tamponade	1	2.5	1	1	6.3	5.1
4	1	4	3	Spasm at stent site	1	5.9	5.1	0.8	6.6	6.5
5	3	1	3	Post sternotomy syndrome	0	7.7	2.1	0	9.2	4.6
5	3	2	1	ACS, aortic dissection	1	10	10	1	10	10
5	3	3	4	SOB -> pleural effusion, CHF	0	1	0.2	0	9.7	0.7
5	3	4	2	Muscular or chest wall inflammation or pericarditis.	0	10	5.5	0.2	9.8	5.5
6	4	1	4	Post cardiotomy syndrome or Pericarditis	1	8.3	8.4	0	8.1	8.4
6	4	2	3	ACS	1	9.8	9.6	1	9.7	9.7
6	4	3	2	CHF	0	5.8	5.5	0	5.5	5.6
6	4	4	1	Atypical chest pain	0	8.9	7.9	0	7.6	8.8
7	4	1	3	Failure? Pul embol? Chest wall pain?	0	5	1.8	0	7.6	7.7
7	4	2	1	Having MI	1	8.7	9	1	8.9	5.8
7	4	3	4	Failure.	0	8.3	5	1	5	6.8
7	4	4	2	Post stent discomfort	1	8.6	8.2	0.2	8.5	8.6
8	2	1	2	Post surgery Resp Problem? Pneumonia	0	4.3	4.3	0	6	5.3
8	2	2	4	Unstable Angina	1	7.4	7.2	0	8.6	8.1
8	2	3	1	Sternal discomfort due to Surgery	0	3.7	4.5	0	5.2	5.2
8	2	4	3	Chest discomfort - cause unknown	0	5.5	5.5	0	5.5	5.9
9	3	1	2	Pleuritic/Muscular pain post op	1	8.1	8.4	0.143	8.5	8.8
9	3	2	4	Possible Ischemic pain? Heart burn? Muscular.	1	4.1	1.9	1	5.5	3.9
9	3	3	1	Possible ischemic chest pain, ? CAB Graft blocked ?, tamponade	1	6.5	3.5	1	6.3	6.8
9	3	4	3	stents implantation discomfort	1	5.5	8.4	0.4	8.5	8.4

					Diagnosis			Recommendation		
ID	Tool	Model	Trial	1. Diagnosis response	correct	2. conf	3. ease	quality	4. conf	5. ease
10	1	1	1	PPS: post pericardiotomy Syndrome	1	9	9.4	0	9.4	9.2
10	1	2	2	Chest pain -> ACS -> ? MI	1	7.1	7.1	0	7.4	7.4
10	1	3	3	? PPS, Muscular pain? PE?	0	----	1.4	0	2.4	5
10	1	4	4	Angina	0	5.8	5.6	0	6.6	6.7
11	2	1	4	Pericarditis Post-op	1	9.7	9.8	0	9.6	10
11	2	2	3	Unstable Angina - Possible MI	1	9.3	9.2	1	8.9	9.7
11	2	3	2	Pericarditis	0	4.4	5	1	6	7.1
11	2	4	1	Possible GI reflux	0	2.7	2.5	0	5	5
12	1	1	3	Angina or MI	0	9.5	9.2	0	9.3	9.4
12	1	2	1	Could be a "stretching" pain pts sometimes get after a PCI	1	5	4.3	1	4.2	4.1
12	1	3	4	CHF or incisional mending, healing of incision	0	0.9	6	1	8.1	1.7
12	1	4	2	CHF, incisional pain	1	8	5	0	4.1	3.6
13	1	1	4	muscular discomfort, PPS	1	7.5	7.5	0	7.6	7.5
13	1	2	3	Angina / MI	1	8.8	9.1	1	8.9	9.1
13	1	3	2	PPS	0	7.3	7.3	0	7.2	7.4
13	1	4	1	Muscle strain	0	3.6	5	0	7.5	7.5
14	2	1	1	Pericarditis	1	8.6	7.6	0	8	8.3
14	2	2	2	Unstable angina - possibly starting MI	1	7.3	6.8	1	7.6	7.6
14	2	3	3	? Possibility of chest infection (but no fever) doesn't sound like angina	0	1	1.3	0	1.3	2.1
14	2	4	4	?	0	0.7	1.2	0	4.8	0.7
15	4	1	1	Pericarditis	1	8.9	8.4	0	9.8	9.5
15	4	2	2	Ischemic pain	1	9.3	9.1	0	9	9.3
15	4	3	3	? Related to OR	0	2.4	4.5	0	2.5	1.8
15	4	4	4	Post stent pain	1	5	3.4	0	9.4	9
16	3	1	4	Pericarditis	1	7.3	6.9	0.143	6.8	6.7
16	3	2	3	Unstable angina	1	6.5	6.1	1	6.2	6.5
16	3	3	2	CHF R/O Pericardial effusion	0	6.2	6.3	1	10	9.9
16	3	4	1	non ischemic pain pullea muscle	0	8.8	8.8	0.2	8.9	8.8
17	3	1	1	Post op pain	0	6.3	6	0.429	4.2	5.8
17	3	2	2	ACS possible MI	1	8.9	8.5	1	8.9	8.9
17	3	3	3	Pneumonia - ? Post op pain.	0	3.8	2.8	1	6.6	8.4
17	3	4	4	Stent inflammation	1	8.3	8.3	0.3	8.3	8.4

b) Question 6 ~ 9

ID	Model	6. Generating Questions		7. Consider more possibilities		8. Helped Diagnosis		9. Helped recommendation	
		rate	comments	rate	comments	rate	comments	rate	comments
1	1	7.7		8		5.8	My experience	6.1	
1	2	7.4	Allowed me to see questions to ask	6.1		0	Not with this call. I used my experience	5.6	
1	3	7.3	Reminded me. More comfortable.	6.8		6.9		6.8	
1	4	8		9.1		5		5	
3	1	2.6		7.5		5.1		0.4	
3	2	0.1		0		0.2	CP not reduced by NTG + Increased cardiac activity pt known cardiac problems	0.3	No. it was more instinct + experience.
3	3	7.3		6.4		0.9		2.5	
3	4	9		8.2		0		7.1	
4	1	4.4		4.6		4.6		5.3	
4	2	1.4		0.9		0.6		0.5	
4	3	0.6		0.5		0.6		0.6	
4	4	3.3		2.6		2.6		2.2	
5	1	5.4	i.e. discharge, fever, chills	9.2	Did surgeon use internal mammary arteries to do CABG	4.8	I still don't know what is the problem with the patient.	9.8	Help me to advise pt to see Dr. within 24 hours.
5	2	---	The prompt for using NTG is good	4.9	Not really, I decided quickly that she needed to go to the ER	9.4	Yes, if chest pain persist after 3 NTG -> 911	---	Yes, in the case of MI -> AA chewable.
5	3	8.7	Chills, fever, discharge, SOB...	----	I don’t' remember the decision tree	8.1	Because of SOB--> prompt you for an intervention.	8.4	I knew that the patient wasn't in acute distress, but SOB after Sx is not good therefore needed to be seen or if pt's get worse -> go to ER
5	4	5.3	The PDA screen is small, so sometimes, you don’t' see all the info at once	8.3	Help you to make a quick decision in terms of call 911 or not.	10	Helped me to decide that it was not a critical call. I.e. no SOB, pain not radiating...	9.8	I felt confident that the patient wasn't having an acute event and therefore, could use Ibuprofen at home and see if there was any improvement of symptoms.
6	1	6.4		6.6		---	My diagnosis was made without the support tool. But I did open up PPS to confirm my diagnosis.	0.4	The decision support tool did not help me make any recommendations. The recommendation was put forward based on my previous experiences.
6	2	7.7	Tool was easier to use this time.	3.7	I didn’t look at any other possibilities	3.8	No. I decided on my own that she was ACS	4.4	Again I knew with ACS she needed to call 911.

ID	Model	6. Generating Questions		7. Consider more possibilities		8. Helped Diagnosis		9. Helped recommendation	
		rate	comments	rate	comments	rate	comments	rate	comments
6	3	3.6		0.4	My diagnosis was made without the decision tool. The decision tool did not include CHF.	0.9		0.8	
6	4	5.4	In this case I didn't feel the decision support tool helped. My decision was guided by my own gut feeling	5.5		5.4		5.3	
7	1	8.9		8.7	Chest pain is vague - helps direct questions and consider different options on origin.	5	It didn't direct me to a real diagnosis. It wasn't' exactly chest wall pain or ischemic. Perhaps because the chest pain type was vague.	8.1	
7	2	8.5		8.8	Having the type of chest pain they were, it was ischemic	8.4		5	It helped if my decision to send the Pt to hospital by calling 911.
7	3	7.6	Just the different reasons a person could have chest pain post op as well as shortness of breath.	7.5		5	I felt it wasn't specific enough for shortness of breath. I couldn't' find an algorithm square that would take me to Heart failure.	6.8	It helps to navigate in asking the right questions then to decide whether you should continue on that direction of questions or try alternate ones.
7	4	7.8	accessing the stent algorithm helped point me in the right direction	8.6	Just with chest pain it can be so vague and you don't want to overlook ischemic pain.	9	Just to direct me to post stent pain.	8.7	
8	1	5.3		5.2	This is Case #2 and focused it easier somewhat to find cues	5.3		6.3	
8	2	6.9	Summary pt does not provide all retrieved descriptions (told it will be changed for live use)	5	It suggests many questions to ask	5.6	Not sure.	5	Not sure.
8	3	5		5		3.2		1.4	Strongly feel my opinion is based on lack of knowledge of device and screens.
8	4	6.8		5	It had some windows of information that had cues more than surgical pt.	5.9		6.2	
9	1	9	i.e. Take deep breath	7.2		9.2		9.3	NSAID--> GP
9	2	7	Provided options	4.5	could have been non-cardiac	7.6	Decisions available	7.7	choice available on PDA
9	3	9.7	So no options are forgotten	6.7	Usually ER. Dr next day are suggestions.	6.3	Gave "info" options	6.7	Usual options provided by PDA

ID	Model	6. Generating Questions		7. Consider more possibilities		8. Helped Diagnosis		9. Helped recommendation	
		rate	comments	rate	comments	rate	comments	rate	comments
9	4	8.4	i.e. Pleural pain assessment	8.5		9	Info re pain post stent helpful	9.5	recommendation -> chose one stated in PDA
10	1	1.5	There were no general pain questions so difficult to navigate	4.8		4.9		5	Too busy trying to record c/o of patients not in list so did not have a chance to use tool to assist in diagnosis.
10	2	5.7		5.4		5.3		4.9	
10	3	7.1		6.6		0.8		4.8	
10	4	6.6		4		3.6		5.1	
11	1	9.8		5		5		9.1	
11	2	9.9		4.7	Not really because I already knew what the diagnosis was.	4.4		9.5	
11	3	7.3		7.2		6.2		7.9	
11	4	5.5		5.5		5		5	
12	1	2.8		9		8.5		7.6	
12	2	7.5		8.8		2.5		7.3	
12	3	9.8		9.2		8.9		1.6	
12	4	9.1		8.7		7.8		8.2	
13	1	5		5		5		5	
13	2	5		5		5		5	
13	3	7.7	The list of problems did help to ask questions	5		7.4		0.5	Patient's answers helped me make recommendations.
13	4	8.9		8.7		8	I did not look at all the screens while speaking with patient	8.9	I knew from patient's answers what to recommend.
14	1	5.4		5.7		5.7		5	
14	2	7.6		5		6.8		7.9	
14	3	6.5		2		---		---	
14	4	2.3		4.7		2.9		3.2	
15	1	6.6		2.8		7.6		8.7	
15	2	6.8		3.4	I know cardiology fairly well, so the tool almost interferes	6.6	Seeing the colour change, makes the decision more supportive	1	It did not help.
15	3	8.9		9.7		4.7		0.7	
15	4	7.6		5.4		1.8		0.8	
16	1	7.5		7.1		6.5		6.3	
16	2	7.2	No.	3	No. Pt is on the waiting list for angio. It was felt she should be seen.	2.8	No	10	I should have asked how far away she was to the hospital.
16	3	5.7	Having difficulty bringing up algorithm	2.1	Would need more time to work with PDA	2.5		1.9	If patient having trouble breathing and requires 3 pillows to sleep, I would want them to be assessed.

ID	Model	6. Generating Questions		7. Consider more possibilities		8. Helped Diagnosis		9. Helped recommendation	
		rate	comments	rate	comments	rate	comments	rate	comments
16	4	---	Yes, but I probably would like to ask more questions	----			Yes.	6.7	I would add if condition changes or pain changes increase in intensity she becomes SOB she should seek medical attention. But again... I would have preferred to have more time with PDA first
17	1	8.2		8.1		7.9		8	
17	2	8.6		8.8		8.9		9.1	
17	3	6.8	needed tool to guide where to go and what to ask	----	wasn't sure what to the pt to do	2.9	still unsure of a diagram	6.6	Would probably recommended going to ER no matter what if I was unsure.
17	4	6.2	Fairly compatible with knowledge base so knew what questions I wanted to ask but tried to follow algorithms	7.1	Always good to have after uses.	5.5	Fairly comfortable with my decision with a wizard.	----	Had more confidence in what to say with algorithm.

G-7 Summary of Post-trial Questionnaire Response

Q2: Confidence of Diagnostic Judgement

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	7.250	7.425	3.567	5.825	6.180
	StdDev	2.958	1.804	3.331	1.797	2.668
OLDCAR	Mean	7.275	7.650	3.850	4.100	5.719
	StdDev	2.387	1.156	2.195	3.002	2.728
Tree	Mean	7.350	7.375	4.375	8.150	6.813
	StdDev	0.772	2.627	2.554	1.905	2.399
Network	Mean	7.425	9.425	6.150	7.050	7.513
	StdDev	1.715	0.550	2.745	1.987	2.116
Total Mean		7.325	7.969	4.547	6.281	6.562
Total StdDev		1.898	1.768	2.592	2.525	2.520

Q3: Ease of Diagnostic Judgement

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	7.000	7.400	3.925	5.175	5.875
	StdDev	3.505	2.272	3.195	0.287	2.766
OLDCAR	Mean	7.100	7.425	4.125	4.125	5.694
	StdDev	2.276	1.218	1.947	2.779	2.505
Tree	Mean	5.850	6.625	3.200	7.750	5.856
	StdDev	2.689	3.536	2.507	1.515	2.943
Network	Mean	7.025	9.400	4.400	5.375	6.550
	StdDev	3.522	0.424	1.268	3.144	2.940
Total Mean		6.744	7.713	3.913	5.606	5.994
Total StdDev		2.776	2.233	2.142	2.423	2.747

Q4: Confidence of Recommendation Judgement

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	7.600	7.425	6.000	6.200	6.806
	StdDev	2.475	2.290	2.510	1.463	2.122
OLDCAR	Mean	7.625	7.875	4.500	5.700	6.425
	StdDev	1.550	1.130	2.159	1.236	2.011
Tree	Mean	7.175	7.650	8.150	8.875	7.963
	StdDev	2.225	2.146	1.971	0.665	1.788
Network	Mean	8.775	9.375	5.450	8.225	7.956
	StdDev	1.090	0.499	2.590	0.918	2.051
Total Mean		7.794	8.081	6.025	7.250	7.288
Total StdDev		1.819	1.702	2.495	1.698	2.068

Q5: Ease of Recommendation Judgement

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	7.100	7.450	4.800	6.075	6.356
	StdDev	3.312	2.381	2.345	1.706	2.478
OLDCAR	Mean	7.650	7.900	5.125	4.650	6.331
	StdDev	1.991	1.445	2.161	2.757	2.434
Tree	Mean	6.475	7.325	6.450	7.775	7.006
	StdDev	1.773	2.711	4.037	1.528	2.483
Network	Mean	8.750	8.625	6.025	8.600	8.000
	StdDev	0.858	1.893	3.349	0.432	2.129
Total Mean		7.494	7.825	5.600	6.775	6.923
Total StdDev		2.123	2.003	2.830	2.258	2.427

Q6: Helpful Generating Questions

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	3.425	4.900	6.300	6.975	5.400
	StdDev	1.584	2.560	3.972	2.700	2.900
OLDCAR	Mean	7.050	7.950	6.525	5.650	6.794
	StdDev	2.142	1.333	1.084	2.456	1.859
Tree	Mean	7.525	7.600	7.725	6.633	7.407
	StdDev	1.544	0.872	1.808	1.595	1.412
Network	Mean	6.125	5.775	6.850	7.450	6.550
	StdDev	2.609	3.847	2.275	1.500	2.501
Total Mean		6.031	6.487	6.850	6.680	6.510
Total StdDev		2.438	2.609	2.322	2.049	2.326

Q7: Helpful Considering More Possibilities

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	5.850	5.025	5.325	6.000	5.550
	StdDev	2.106	3.236	3.653	3.170	2.797
OLDCAR	Mean	5.975	5.200	5.250	6.075	5.625
	StdDev	1.382	0.616	2.369	2.043	1.609
Tree	Mean	7.900	5.300	4.400	7.967	6.577
	StdDev	0.976	2.473	3.253	0.757	2.268
Network	Mean	6.400	3.975	6.000	6.925	5.825
	StdDev	2.550	3.628	3.977	1.711	3.002
Total Mean		6.531	4.875	5.364	6.660	5.861
Total StdDev		1.863	2.515	3.018	2.089	2.457

Q8: Helpful in Diagnosis

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	5.750	3.350	4.425	5.500	4.756
	StdDev	1.841	2.222	4.345	2.802	2.825
OLDCAR	Mean	5.450	4.200	5.433	4.700	4.913
	StdDev	0.370	2.966	1.966	1.273	1.764
Tree	Mean	7.100	7.175	4.950	8.167	6.760
	StdDev	1.889	3.014	2.705	2.363	2.553
Network	Mean	5.900	4.750	2.875	4.050	4.293
	StdDev	1.473	3.575	2.284	3.991	2.964
Total Mean		6.060	4.869	4.353	5.433	5.174
Total StdDev		1.509	3.046	2.874	2.923	2.679

Q9: Helpful in Recommendation

		Patient Model				
Tool	Data	PPS	Ischemic	Tamponade	Stent	Grand Total
Form	Mean	5.725	4.425	1.875	6.100	4.531
	StdDev	1.258	2.842	2.012	3.080	2.749
OLDCAR	Mean	6.625	7.000	5.367	4.850	6.000
	StdDev	1.746	2.083	3.479	1.237	2.122
Tree	Mean	8.350	8.933	5.900	8.667	7.843
	StdDev	1.563	1.159	2.792	1.710	2.166
Network	Mean	4.400	2.675	2.700	5.475	3.813
	StdDev	4.625	2.368	2.855	3.412	3.296
Total Mean		6.275	5.547	3.867	6.113	5.464
Total StdDev		2.809	3.135	3.033	2.691	3.004

Correlations among Judgement Rating

		Diagnosis			Recommendation		
		correct	confidence	ease	correct	confidence	ease
Diagnosis	correct	1	.449(**)	.470(**)	.261(*)	.343(**)	.409(**)
	confidence	.449(**)	1	.785(**)	0.092	.616(**)	.770(**)
	ease	.470(**)	.785(**)	1	0.090	.589(**)	.692(**)
Recommendation	correct	.261(*)	0.092	0.090	1	0.095	0.134
	confidence	.343(**)	.616(**)	.589(**)	0.095	1	.678(**)
	ease	.409(**)	.770(**)	.692(**)	0.134	.678(**)	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation among Question 6~9

	Q6	Q7	Q8	Q9
Q6	1	.569(**)	.409(**)	.486(**)
Q7	.569(**)	1	.513(**)	.449(**)
Q8	.409(**)	.513(**)	1	.508(**)
Q9	.486(**)	.449(**)	.508(**)	1

G-8 Post-experimental Questionnaire Response

a) Question 1~13

		Question												
ID	Tool	1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	6.7	7.8	5	equally	equally	9.4	9.4	4.6	6	6.1	6	6.7	7.8
3	4	7.2	5	2.7	equally	equally	10	7.6	7.5	7.6	9.9	9.8	7.3	7.6
4	1	7.7	8.1	7	less	less	9.4	9.5	3	3.1	8.8	8.1	6.1	5.2
5	3	5.7	6.7	5.7	equally	more	6.4	2.8	5.3	5.3	8.8	9.1	8.5	7.3
6	4	3.3	3.8	3.6	equally	equally	9.6	4	4.5	4.4	2.3	6.6	5.3	2.6
7	4	---	6.7	---	equally	equally	8.5	7.5	5	7.1	----	8.8	7.6	----
8	2	4.2	4.4	4.4	less	less	7.5	7.2	5.7	6.2	6.6	2	7.3	7.2
9	3	9.8	8.6	9	more	more	10	10	10	10	10	9.5	9.9	9.8
10	1	6.3	5.9	6	less	equally	9.2	1.1	4.9	5.1	6.1	6.1	5.9	6.9
11	2	9.4	9	8.9	more	more	9.9	9.9	9.2	9.3	9.1	9.4	9.6	9.8
12	1	8.8	8.8	8.9	more	equally	9.1	9.4	9	9.2	9.4	5.7	9.1	8.5
13	1	8	5	7.7	equally	equally	8.3	5	5.5	5	8.3	5.4	8.3	5.5
14	2	7	2	5	less	less	8.7	0.2	5	8	3	---	---	7.6
15	4	7.1	6.1	5.7	more	equally	10	10	9.3	6.4	7.9	7.6	10	7.4
16	3	5.5	4.5	4.2	equally	equally	5.5	5.5	5.6	5.5	5.4	5.3	5.4	5.7
17	3	8.1	6.7	7.7	more	more	8.2	7.9	7.3	7.5	7.5	7.8	6.3	7.5

b) Questions 14~18

	14 (check all that apply)									
ID	reminder	question guide	patient image	double check	communicate	training	15	16	17	18
1		1	1	1		1	4.4	3.6	5	6.2
3		1		1	1		10	9.9	9.9	7.7
4	1						8.3	7.8	5.4	5.2
5	1	1				1	3	0.8	7.1	5.7
6	1			1			6	8.8	9.1	3.8
7	1	1	1			1	7.3	7.3	8.1	5.1
8	1			1		1	7.9	7.3	7.4	6.1
9	1	1	1			1	8.9	9.4	9.8	9.7
10	1	1					9.6	9.3	6.1	5.2
11	1	1	1			1	9.8	9.8	9.9	8.4
12	1	1	1				9.5	9.5	9.9	9.9
13	1	1					8.5	8.6	5	6
14	1	1				1	8.3	8.2	7.6	6.2
15		1	1			1	9.6	9.7	9.5	7.4
16		1					3.6	4.1	9.6	5.8
17	1	1		1		1	7.7	7.8	7.8	7.7

c) Comments

Overall Experience

ID 4: I pay so much attention to the system and looking for info, I lose track of what the pt has said and the best course of action.
ID 7: It is easy until the algorithm (question 1), I really love the names, age, and calendar of when their surgery was. The list of symptoms. It maybe a learning curve but I wanted a better list of symptoms I have been a cardiac nurse for many years. So when I am asking questions my mind is trying to fit the answers into possible diagnosis. I.e. with the surgery patient that was short of breath and was worse laying flat. Maybe more arrhythmia or heart failure direction would be helpful.
ID 8: At this stage, and lack of use has bearing on ease of data entry.
ID 9: Of course ease of the tool would come with time.
ID 10: I found myself scrolling back and forth during the call, rather than focusing my attention on the caller and doing a thorough assessment - a lot like chewing gums and walking somewhat difficult to do both at the same time.
ID 16: I feel more time needs to be spent on using PDA. It does not appear to be difficult, but more time spent would have made me more comfortable using it.
ID 17: Mostly with surgery patients due to my knowledge of them.

PDA Use

ID 1: With hands free phone was okay.
ID 6: I would prefer to take notes to review and come to conclusion that way.
ID 7: I just felt slow.
ID 9: again familiarity of the tool would increase speed while on phone
ID 16: Felt I was slow in getting to the area or field
ID 17: Not sure how easy would be without a hands free phone.

Decision Support Tool

ID 1: Need few more minutes with it. By 4th call (it) was more comfortable.
ID 6: Should have recommendation for treatment.
ID 7: I would like to have more. If I chose a symptom and it took me to an algorithm. That algorithm was hard to navigate. I was looking for symptoms to lead me to ischemia for example. That is why I would like to be directed when I chose a symptom from the list. .... Again I think this is a great system with lots of potential. I just found that it was hard for me to go from the symptoms to algorithm when the info from the patient was vague.
ID 9: Although because of knowledge of cardiac assessment I asked my own questions and got a little "lost" with the flow of the questions on the machine.

Training Issue

ID 4: with practice and as I become comfortable with the system.
ID 16: With more training I do not feel it would be difficult to learn.

Satisfaction

ID 16: again, if I were more familiar, I would like it.

d) Question 19~21

Q 19: Please describe what you liked best about this system

ID 1: Easy navigation after 3rd call

ID 3: Record keeping, easy navigation
ID 4: Easy way to log info. Pt information is at finger tips.
ID 5: Once you figure out what is the problem, it does guide you in asking appropriate questions.
ID 6: No. I prefer to use this in conjunction with taking notes.
ID 7: There are certain parts I really like. I like the patient info page and doctor. The list of symptoms - could be a few more added such as irregular heart beat. Shortness of breath can be better isolated.
ID 8: Ease of use
ID 9: Straight forward decision trees
ID 10: It is a user friendly system which flows well.
ID 11: The format of questions done well.
ID 12: System was user friendly. Very efficient system helped me remember what to ask.
ID 13: Good to use as guide to ask appropriate questions.
ID 14: Checklist of suggestions to ask
ID 15: It is very easy to use
ID 16: Screen clear
ID 17: Liked the way the algorithms were set up.

Q20: Please comment on parts of this system you feel could be improved

ID 3: The network circle. Difficult to navigate small and complicated. Colours are good.
ID 4: the recording feature for advice given and relevant info.
ID 5: The screen is small and therefore it is difficult to see all the info on the screen.
ID 8: 1st screen should not be "History" as 1st pt describing symptoms and this information should be captured, it is key.
ID 9: can't think of any.
ID 10: It is something that one has to get used to
ID 11: Adding a section for other medications patients may use.
ID 14: Less complicated: (calendar dates -> add checklist like 2 days ago... Etc...)
ID 15: The CP graph is very confusing
ID 16: Font could be larger.

Q21: Please provide any other suggestions to the system.

ID 3: Maybe have more symptoms in the presenting problem section. I would probably be better with scoring system.
ID 5: I thought that it was difficult to record the information and keep talking at the same time. I lost my train of thought few times. Overall the project has merits.
ID 6: Need recommendations (i.e. if diagnosis is CHF-pt needs to come to hospital and receive Lasix)
ID 7: 1) need something more specific that can isolate vague symptoms, 2) That there would be a short cut from the symptoms to the algorithm. For example irregular heart rate shortness of breath edema-> would point you to failure -> something like that.
ID 8: The Summary page should have all the description retrieved, itemized on the page- I was not able to see all the information I retrieved to make assessments.
ID 10: A way to document all the info generated from the caller specific pain issues in particular.

G-9 Summary of Post-experimental Questionnaire Response

Overall Experience

		Form	OLDCAR	Tree	Network	Grand Total
Q1	Mean	7.700	6.825	7.275	5.867	6.987
	StdDev	1.042	2.127	2.056	2.223	1.805
Q2	Mean	6.950	5.800	6.625	5.400	6.194
	StdDev	1.794	3.196	1.676	1.278	1.996
Q3	Mean	7.400	5.825	6.650	4.000	6.100
	StdDev	1.219	2.069	2.124	1.539	2.019

Confidence in Assessment Compared to Judgement without Tool

	Form	OLDCAR	Tree	Network	Grand Total
less	2	2			4
equally	1	1	2	3	7
more	1	1	2	1	5

Confidence in Recommendation Compared to Judgement without Tool

	Form	OLDCAR	Tree	Network	Grand Total
less	1	2			3
equally	3	1	1	4	9
more		1	3		4

PDA Use

		Form	OLDCAR	Tree	Network	Grand Total
Q6	Mean	9.000	8.875	7.525	9.525	8.731
	StdDev	0.483	1.040	1.996	0.709	1.319
Q7	Mean	6.250	6.675	6.550	7.275	6.688
	StdDev	4.024	4.473	3.103	2.470	3.246

Decision Support Tool

		Form	OLDCAR	Tree	Network	Grand Total
Q8	Mean	5.600	6.125	7.050	6.575	6.338
	StdDev	2.505	2.100	2.155	2.241	2.092
Q9	Mean	5.600	7.375	7.075	6.375	6.606
	StdDev	2.570	1.567	2.188	1.406	1.915
Q10	Mean	8.150	6.200	7.925	6.700	7.280
	StdDev	1.439	2.505	1.969	3.940	2.361
Q11	Mean	6.325	5.800	7.925	8.200	7.147
	StdDev	1.218	3.704	1.895	1.395	2.130
Q12	Mean	7.350	7.867	7.525	7.550	7.553

	StdDev	1.595	1.531	2.050	1.926	1.615
Q13	Mean	6.525	8.100	7.575	5.867	7.093
	StdDev	1.511	1.160	1.688	2.831	1.818

Possible Benefits of Tools

	Form	OLDCAR	Tree	Network	Grand Total
reminder	4	3	3	2	12
question guide	3	3	4	3	13
patient image	1	2	1	2	6
double check		2	1	2	5
communicate				1	1
training		4	3	2	9

Training Issues

		Form	OLDCAR	Tree	Network	Grand Total
Q15	Mean	8.975	7.600	5.800	8.225	7.650
	StdDev	0.670	2.285	2.938	1.902	2.248
Q16	Mean	8.800	7.225	5.525	8.925	7.619
	StdDev	0.770	2.629	3.853	1.184	2.605
Q17	Mean	6.600	7.475	8.575	9.150	7.950
	StdDev	2.246	2.002	1.333	0.772	1.822

Satisfaction

	Data	Form	OLDCAR	Tree	Network	Grand Total
Q18	Mean	6.575	6.725	7.225	6.000	6.631
	StdDev	2.249	1.118	1.889	1.871	1.697