What's next?

Cognitive Task Analysis of Emergency Physicians' Experience in Multi-Patient Environments

BY

TERESA MAN-YEE CHAN
H.B.Sc., University of Toronto, 2003
B.Ed., Ontario Institute for Studies in Education/University of Toronto, 2004
M.D., Western University, 2008

THESIS

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Defense Committee:

Matthew Lineberry, Chair and Advisor
Alan Schwartz
Jonathan Sherbino, McMaster University
Geoffrey Norman, McMaster University

“Good decisions come from experience,
and experience comes from bad decisions.”
- Unknown

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LIST OF ABBREVIATIONS

ACGME	Accreditation Council of Graduate Medical Education
ANOVA	Analysis of variance
CI	Confidence interval
CTA	Cognitive Task Analysis
CTAS	Canadian Triage Acuity Score
ED	Emergency Department
EM	Emergency Medicine
GUI	Graphical User Interface
ICC	Intra-class correlation coefficient
NASA-TLX	NASA Task Load Index
NDM	Naturalistic Decision Making
PGY	Postgraduate Year
RPD	Recognition-Primed Decisions

SUMMARY

Concurrent management of multiple ill patients is an important skill in emergency medicine, especially given increasing emergency department (ED) patient volumes. In this environment, rapid task prioritization is a critical skill. Regularly, emergency physicians are asked to concurrently manage multiple patients at once at any given point in their shifts, and often have to make time-sensitive decisions around the priorities across multiple patients.

The art and science of teaching the critical skill of task prioritization is not well described in the literature. Few studies have explored the cognition of physicians in multi-patient scenarios, and even fewer have examined how this affects their clinical decision-making.

We conducted a three-part, mixed-methods cognitive task analysis of attending and resident physicians' thinking about efficiency and task prioritization in multi-patient environments. The three components of this study included a critical incident interview, a cognitive task (prioritizing patients on a simulated tracker board), and a think aloud experiment of that same cognitive task.

This study was completed at multiple teaching hospitals associated with a major Canadian academic institution between March 2014 and September 2015. Ten attending physicians and ten residents engaged in all three parts of our study. In the first part they were asked via a critical incident interview to describe difficult prioritization scenarios, as well as the teaching and learning environments that result in the learning of this skillset.

In the second part, participants engaged in simulated prioritization exercises using a novel simulated tracker board interface. Participants were asked to view and interact with a tracker board with various simulated patients, and then prioritize these patients. Participants were asked to describe which patients they would see first, which they would see soon, for which they would initiate orders or tests, and which they deem could wait. Times to completion and interactions with this interface were recorded. We observed the effects on time to completion and task load as measured by a modified version of the NASA Task Load Index (modified NASA-TLX).

Finally, the participants were asked to think aloud while completing the prioritization exercise. This part allowed us to complete a modified protocol analysis and generate a new conceptual framework, which explains how physicians engage in task-prioritization processes within these multi-patient environments.

For the first part, there were three main themes that emerged from our interviews in our participant's descriptions of how they taught or learned the skill of task prioritization: 1) formal didactic teaching, 2) observation, and 3) *in situ* instruction (i.e. on-the-job teaching, informal coaching in the ED). Only one formal teaching strategy was named, and only by a single participant (i.e., formal teaching around the Canadian Triage Acuity Score). The bulk of teaching and learning strategies were more akin to coaching. They tended to be found within the *in situ* category (e.g., collaborative problem solving;

informal conversation with staff, i.e. think aloud, “running the board”, walk-around rounds). A minority of strategies included observation by learners (e.g., residents watching staff perform their duties) or by explicit role-modeling by attendings (e.g., faculty members asking residents to follow them around and observe how the job is done).

For the prioritization exercises, we manipulated tracker boards to vary along three factors we anticipated may affect the degree of agreement across different participants’ prioritization decisions and their time to completion: number of patients with similar acuity, number of patients with similar presentations, and number of extraneous patients (i.e. patients already cared for by other physicians). None of the manipulated factors discernably affected novices differentially when compared to experts. There were no specific trends in expert vs. novice agreement within the various conditions as measured by the intraclass correlation statistics for the various tracker boards. There were significant main effects of our three experimental conditions within these simulated tracker boards on the participants’ completion time for scenarios: Increasing the number of patients with similar presentation led to longer time to completion ($F(2,17)=35.6$, $p<0.001$; means = 20 seconds with 0 patients with similar presentations, 5 seconds with 2 patients with similar presentations; 20 seconds with 4 patients with similar presentations). Increasing the number of patients with similar acuity led to a decreased time to completion with two similar acuity patients, but then a much higher mean time to completion with four similar acuity patients ($F(2,17)= 18.8$, $p<0.001$, quadratic relationship). Increasing the number of extraneous patients led to increased time to completion of the prioritization task ($F(2,17)=11.2$, $p=0.001$, linear relationship). The experimental design only permitted examining two-way interactions while holding the third factor constant at zero each time.

The think aloud processes revealed a unified, overall process used by almost all participants. The cognitive task of patient prioritization consisted of three components (Figure 10): 1) viewing the entire board to determine an overall strategy, 2) creating an archetype (a functional ED-context based illness script) from patient-care information available in an initial chart (i.e. vitals, brief clinical history), and 3) creating a relativistic prioritization list.

Using a mixed methods study, we generated a cognitive analysis of how physicians perceive multi-patient environments and engage in rapid task-prioritization. This will inform development of didactic and clinical educational materials.

1. INTRODUCTION

In the busy environment of the emergency department (ED), task prioritization is an essential skill for practicing emergency physicians. The aim of this project was to model experts' thought processes for task prioritization in the ED and highlight key foundational principles from which to develop strategies for emergency medicine (EM) residents to learn this important skill.

1.1 Background and context

ED crowding is steadily increasing in the Western world and its negative impact on patient care is well documented.[1–5] In response to ED crowding, triage scores[6,7], disaster management systems[8], and administrative staffing strategies[3] have to ensure smooth operations and flow Emergency physicians have adopted digital interfaces known as tracker boards to organize patient data.[9] These tracker boards include patient data such as Name, Age, Location, and Chief Complaint and often link to electronic medical records (EMRs).[9] Generally, these solutions have arisen around logistical and workplace-based requirements to ensure smooth ED operations and flow.

Understanding clinical decision-making within real-life contexts is of great importance for EM physicians and teachers. Acknowledging the effect of real world stressors[1–5] on decision-making in the multi-patient ED context is important for understanding the expertise of the practicing emergency physician (EP).[10–12] The same patient with the same demographics and chief complaint on two different days may be prioritized differently simply due to other patients within the same ED. The EP needs to make decisions about priorities multiple times over the course of

each and every shift – often between very sick patients – and therefore making them an ideal group to study expertise in medical task- and patient- prioritization.

The challenges of ED crowding on EM training are not well studied, but have the potential to be quite significant. EM trainees not only require strong clinical skills but, under these increasingly difficult environmental conditions, must also eventually learn ED management skills (such as task prioritization, time management, coordination of teams, and negotiation skills) to ensure safe and effective patient flow. Hence, training programs must teach these important managerial and leadership skills to ensure trainees are successful, competent EPs when they begin independent practice. Both major medical education frameworks in North America (CanMEDS and Accreditation Council of Graduate Medical Education [ACGME] competencies) prominently feature competencies associated with effectively working within systems (e.g. ACGME's Systems Based Practice, CanMEDS Leader and Manager roles).[13–15] Our literature review revealed a burgeoning body of work that focuses on contextualized decision-making for EPs.[12,16–20] Other fields have examined the same problem from various lenses: The engineers have used a human factors engineering lens, examining processes, detailing work-flow processes.[12,17] Some literature takes a business management approach[19] and still other studies take more of an epidemiological approach to the problem.[18]

When considering decision-making in realistic (or *naturalistic*) environments we must, of course, consider the work of Gary Klein in the area of Naturalistic Decision Making. Gary Klein's model of macrocognition as an underlying conceptual framework.[21,22] Klein has previously described two main phenomena that occur when experienced practitioners engage in thinking about their

work: 1) functions (including naturalistic decision-making, sense-making, planning, adaption, problem detection, and coordination) and 2) processes (maintaining common ground, developing mental models, mental simulation & story-building, managing uncertainty and risk, identifying leverage points, and managing attention).[21,22]

One recent study by Schubert et al. (2013) examined macrocognitive processes and differences between expert EPs and novices with regard to their cognitive work in the ED.[16] The framework of study used by Schubert et al., however, was still heavily influenced by previous physician-cognition work and emphasized the decision-making around single patients.[16] Schubert and her colleagues did allude to key differences between experts and novices in the way that they perceived patient care was the result of their ability to anticipate problems, approximate time-spent with various actions (e.g. procedures) and handle complexity (e.g. patients with complex conditions). The findings of Schubert et al.'s findings focused on sense-making for diagnostic reasoning of the expert EPs versus the novices, noting that the novices tend to rely more heavily on objective measures (e.g. lab tests) when making decisions versus the expert EPs whom use 'big picture' processes with a fair degree of cognitive elasticity when making decisions.[16] Their findings aligned with previous work by Sklar et al. (1991) which showed that experienced clinicians demonstrated the use of a flexible strategy of testing in order to arrive at a diagnosis.[20] While the work by Schubert et al. (2013) does elucidate some patterns in expert EP decision-making that are disparate from novices, the study's ambitious exploration of all cognitive tasks in the ED provide only a glimpse at differences between the two groups with regards to decision-making in a multi-patient environment. From their work, we know that expert EPs tend to be more intimately aware of the ED's function within a larger health system.[16] EPs are also more

focused on through-put, supervising learners, and applying their medical knowledge.[16] Novices tend to be more focused on the specific patient care activities (e.g. charting, patient interview, workup, consultation/discharge processes), and not on the over-arching processes that EPs consider.[16] Based on their work, it is unclear as to whether these differences are due to disparities between the roles that these groups are expected to play in the ED. Are the EPs more likely to think about overarching concepts such as patient throughput (or ED flow) and teaching learners simply because it is their job within the current system? Are interns are more preoccupied with the specific logistics of carrying out their patient care duties? If tasked with the same responsibilities as an attending EP, would the interns think differently? These questions have yet to be addressed in the present literature.

1.2 A Selective Review of Literature on Cognition and Decision-Making within the Healthcare Setting

In this thesis, we explored EPs' and residents' thinking processes within multi-patient environments to determine how they conceptualize task- and patient-prioritization activities in these contexts. In exploring these tasks, we aimed to create models that allow for further development of training methods that can enhance and augment the learning that a novice might undertake to become competent in handling these complex scenarios. However, before engaging in these activities, it is important to consider the present literature on cognition and decision-making within the healthcare setting.

1.2.1 Physician Cognition

Previous literature in physician cognition has mainly emphasized clinical reasoning or decision-making as it pertains to a single patient.[11,23–25] There have been many laboratory or *ex vivo* studies that helped to advance theories and understanding of decision-making outside of the clinical environment, some of which have studied EP decision-making.[12,16,20] Recently, decision-making studies have involved some element of concept of System 1 and System 2 thinking.[26,27]This concept dichotomizes two types of thought: System 1, which hinges on intuition and heuristics to arrive at answers in an efficient manner; and System 2, which is slower, more deliberate and logic-driven.[28] However, this decision-making paradigm has mainly been applied to single cases of diagnostic reasoning[29], and has not explored how reasoning is altered in complex scenarios involving multiple patients.[30]

Meanwhile, recently procedural decision-making literature (e.g. cognitive research in surgical research) has been informed by Moulton's '*slowing down when you should'* framework.[31–33] Moulton's explores how experienced surgeons handle reasoning within the complex environment of the operating room. In her studies, Moulton describes four main phenomena (stopping, removing distractions, focusing more intently, and fine-tuning) that explain how surgeons transition from routine to more effortful thinking, mostly in scenarios where difficulties or problems are arising. Within the field of surgery, Moulton's work represents an important approach, as it uses a naturalistic, situated approach for examining the complexity of intra-operative decision-making. However, this framework does not clarify how physicians handle complex situations with multiple patients.

1.2.2 Nursing Literature

Few studies have examined EP thinking and planning within complex ED environments.[12,20,34] However, the nursing literature has examined the effects of multi-task prioritization demands on nurses' task performance. Moreover, their work is quite interesting as they are able to examine what occurs when

nurses of different experience levels engage in similar tasks. Findings from the nursing literature have shown that when experts and novices do the same job, there are differences in how they handle complexity.[35] Ebright et al. describe adaptive strategies such as 'stacking,' which allow expert nurses to fluidly reorganize and reprioritize tasks when interrupted.[36] Stacking can be described as parallelized 'to-do' lists, allowing a nurse to simultaneously initiate work on multiple task streams.[37] Stacking is essentially a macrocognitive system that allows for rapid re-planning and adaptive responses to changes in a complex work environment.[37]

It seems these macrocognitive systems may be, by themselves, insufficient in explaining effective task prioritization. In an examination of advanced beginner, competent, and expert nurses, Burger et al. found that for experts to function well, "…experience is necessary to develop the cognitive skills to prioritize the multiple demands on their time and attention."[35] Advanced beginners in their study were found to prioritize in a linear way (i.e. they did one thing at a time) whereas competent nurses employed stacking to make it possible to initiate parallel processes, making them more efficient. Expert nurses were found to be so fluid in their task-switching, it seemed as though phenomena that would be seen by others as interruptions (e.g. helping a colleague when asked) were seamlessly integrated into their workflows because of their ability to see the big picture, anticipate needs, and even return their focus away from tasks and focus on the patients at the center of it all. The ability of the expert nurses in being able to see and anticipate aspects of care allowed them to efficiently perform their patient-care tasks.

1.2.3 Disaster Triage

Disaster triage is an area where there are well defined triage protocols to reduce decision-making time by simplifying assessments to the very core elements required to deal with mass casualty events.[38–42] Such research is important for helping to label a mass number of patients, but does not help to clarify how best to prioritize patients or patient-care tasks once patients have been labeled. Within EM, there has been substantial research exploring the nursing role in triaging patients in non-disaster scenarios[43–55] and a few studies examining triage by physicians.[56–58] These studies have examined various scoring systems or triage practices for sorting though some basic level of priority to guide practitioners and allow them to determine the severity illness for a single patient by triaging them into various acuity levels. However, this literature does very little to examine what occurs when you have multiple patients of the same acuity level.

The triage and disaster literature are unable to inform us with regards to relative comparisons between patients beyond helping to label acuity and severity of illness. This is useful when there are multiple patients at various degrees of illness (i.e. one patient with Triage level 1, one at Triage level 2, and one at Triage level 3), but this literature stops short of providing insights on how doctors or trainees think when considering multiple patients simultaneously, all of whom are of similar acuity level or similar presentation.

1.2.4 Relevant Literature and Frameworks from Non-Healthcare Fields.

Economists, ethicists, and psychologists have explored decision-making through various lenses, sometimes intersecting with healthcare to examine physician decision-making.[59–61] These bodies of work often take into account the values of various practitioners and how they affect the decision-making between patients.[62–66] Others have sought to streamline prioritization processes

of patients with similar presentations (such as elective surgery wait lists)[67,68] or elucidate value differences between groups of people working within healthcare.[60]

Within psychology, some of the earliest work on expert decision-making was conducted by De Groot et al., which examined the cognition of chess masters.[69] De Groot's work helped us better understand the way that experts organize data into 'chunks', or familiar constellations of items that might interact with one another (e.g. prototypical configurations of chess pieces). Subsequent scientists in this field theorized that it is the recognition of these chunks that allow chess masters to make better moves. One could argue that the term 'stacking' from the nursing literature is simply a manifestation of this 'chunking' phenomenon: A grouping of related tasks that are seen within a certain constellation, thereby allowing experts to decrease cognitive load and free up their working memory to better handle new data, like an interruption that forces them to integrate in new tasks into a work-flow. This may also explain some of the recalled phenomena described by the expert EPs in the work by Schubert et al. (2013), wherein the EPs within the study were far more able to maintain a birds eye in describing their cognitive tasks, whereas novice interns were more focused on the specific patient-care related sub-tasks.[16]

Recognition primed decisions (RPDs) are conceptually related to both the dual process theory (System 1 and System 2 thinking) and the cognitive load reduction through processes (e.g. chunking or stacking). The model of RPDs emerges from the field of naturalistic decision-making (NDM). It suggests that humans can be primed to react upon a specific set of cues via repeated cue-response associations.[21] Through repeated exposures, the connections between a certain cue and a particular response are strengthened. RPDs are inherently System 1 driven and

yet System 2 responsive, in that they require little-to-no deliberate processes to be triggered but then can lead into more systematic thinking.[21] Research in RPDs suggests that priming and preparing individuals with various scenarios may augment real-life performance of similar tasks by helping to train automatic processes which may then go on to prompt more specific, reasoned responses.[21] If System 1 and System 2 processes drive their thinking concurrently, then keeping the RPD model in mind may better explain when each of these systems are at play and how they can be harnessed by teachers to augment trainee performance. It is our contention that the RPD model is a key framework for EM teachers to understand and use to guide their design of training programs for inexperienced practitioners for routine-yet-challenging decisions in naturalistic settings. While clinical exposure and practice is important, it may not be practical to provide the amount of exposure needed to allow residents to connect certain cues to certain responses.[16] Understanding the value of experience and how it intersects with building better decision-making abilities may allow us to harness simulated scenarios to create training programs to expose learners to more cue-response pairs and thereby accelerate the development of appropriate RPDs.

There is promising work being done in the field of disaster triage where such training has been found potentially useful.[38,40,41] Of course, as we addressed earlier, this form of triage is limited by its lack of context and simply acts as a label to help sort patients into different levels of acuity. Harnessing the power of RPD, one could imagine applying similar teaching strategies to subsequently begin training EM practitioners not just to recognize and diagnose a level of the acuity of the patient, but rather to recognize patterns of groups of patients and how best to respond to these.

To summarize, these previous frameworks do not clarify what occurs when there are multiple patients being encountered, and how the information from multiple sources is then assembled into more complex decisions. To date there has been little dedicated EM research focusing on the cognitive science of naturalistic, managerial decision-making. Studies to date have employed qualitative or mixed methods designs to explore the complexity and richness of decision-making in naturalistic contexts.[42]

1.3 Relevance to the Field

The findings from this study will be relevant to both the fields of medical education broadly, and emergency medicine in particular. Understanding the specific macrocognitive processes and functions that EPs and trainee EPs use to navigate multi-patient environments will be of use in both assisting teachers to become more explicit in their thinking and approach to this skill, but also in helping learners to conceptualize how their teachers are thinking. If there are differences between expert and novice thinking around the performance of the same skill, then it will be important to elucidate these differences to better understand the gap between where the learners are beginning and what their faculty members are thinking about the same process.

We hope that by examining their thinking in multiple ways, we might construct a model that informs how these doctors actually think about multi-patient environments. By comparing these groups our aim was to identify common heuristics that these populations use to prioritize patients and/or tasks. We also hope to detect mismatches behind experts' stated heuristics and the actual approaches they use to sort through and prioritize patients or tasks.

It will also be important to discern the differences between each of the phases of our cognitive task analysis. Each of the three planned phases of this project is meant to clarify a different aspect of the cognitive processes of our participants (explicit, tacit, and experienced).

We hope that by making explicit processes that have previously been accepted as tacit, we might be able to better prepare learners to engage in this type of decision-making. Moreover, understanding these processes may allow educators to create better simulations for training. If there are tacit patterns in their thinking, perhaps we can harness the processes of RPD to train System 1 via repeated exposure to expedite learning of this cognitive skill. Moreover, if these scenarios were to be used for training purposes, we must first determine the range of behaviors exhibited by experts in order to guide scoring of the answers by trainees.

1.4 Summary

With increasing pressures being placed on emergency physicians in the decision-making contexts of the ED, elucidating the core skill of task prioritization is of paramount importance. Better understanding the cognitive task and processing required to prioritize multiple patients at once has great promise for assisting physicians to better understanding cognitive gaps, which may be a source of patient-safety breaches. The use of naturalistic decision-making frameworks may be very useful in better understanding how to incorporate new methods by which to train learners to better accomplish this task. Utilizing a cognitive task analysis with mixed investigatory modalities will be the best way to understand this complex process of task prioritization in multi-patient environments.

2. METHODOLOGICAL CONSIDERATIONS

Decision-making studies in medicine stem from experimental traditions, ranging from quantitative to qualitative.[22] Medical decision-making studies have used very quantitative approaches - tying in rigorous methodologies of experimental manipulation to isolate key phenomena.[41,60,68,70] The nursing literature, which has emphasized and studied task prioritization, has utilized 'Think Aloud' and qualitative descriptive approaches to better understand the prioritization phenomenon. [36,37,71–73] This section will discuss the specific methodological considerations considered by our team when designing our series of studies.

2.1 Cognitive Task Analysis

The ideas behind NDM and RPD suggest that if we are able to make explicit the heuristics and cognition behind task prioritization then we may be able to design better tools to assist learners with developing task prioritization skills by designing experiences that allow them to link various situational cues to certain responses. Cognitive Task Analysis (CTA) is a useful technique for clarifying thinking processes of individuals.[22] There has been extensive work done by NDM researchers using CTA techniques.[22] CTA is a process that allows researchers to systematically examine the thinking of their subjects. Crandall, Klein & Hoffman describe CTA as having three components: 1) knowledge elicitation, 2) data analysis, and 3) knowledge representation.[40] CTA predominantly provides a framework to task cognition, which allows us to accomplish the goal of understanding and representing the thinking of participants. As such, CTA borrows techniques from a number of different scientific traditions including both qualitative and quantitative methodologies.

Knowledge elicitation is a phase when researchers attempt to gather information about

participants' existing cognitive processes. Some techniques will involve the knowledge of the participants, asking them simply to explain their thinking. Data collection techniques in CTA studies can range from qualitative methods, such as interviews and think aloud, to more psychometrically-driven approaches such as Likert scales and Q-sorts.[22] In general, knowledge elicitation phase aims to help investigators understand how participants think about a given topic. As such, it might include interviews to determine explicit metacognitive processes that participants may recognize, or think alouds where they are asked to just tell a researcher about their thinking as they pursue a task. Other techniques might try to elicit non-explicit knowledge or behaviours via observation of a task or an experimental design. The data analysis phase seeks to take data gathered from the various aspects of the knowledge elicitation phase to better understand the thinking of the study participants. Finally, a CTA process ends with knowledge representation wherein investigators take the data collected to assemble this into a sensible representation of the cognitive processes that have been observed or inferred.

We used a CTA framework to organize this thesis. The bulk of this work will incorporate aspects of Knowledge Elicitation and Data analysis in hopes of being able to create a naturalistic knowledge representation of task prioritization within the emergency department setting. Bearing in mind the explanatory nature of the NDM paradigm, this conceptual framework (and its related theories), are well suited for characterizing EP and trainee decision-making involving multiple patients and tasks in the context of emergency department.

In this study, we used three techniques - critical incident interviewing, a sorting exercise experiment, and think aloud - to examine the cognition of both experts and novices around this

skill of task prioritization. The aim was to elucidate EP and residents' reported heuristics and strategies, the tacit heuristics and strategies that we observe as investigators, and also the heuristics and strategies that become apparent to them only while doing the task. Our team believed that each of the different knowledge elicitation techniques (interviewing, sorting exercise experiment, think aloud) might reveal a different component of the physician's cognition. We anticipated that explicit strategies and heuristics would be revealed in the interview. Meanwhile, the sorting exercise experiments might reveal more tacit heuristics and strategies not noted previously. Moreover, the sorting exercise experiments incorporated intentional manipulations of conditions to probe particular decision-making processes. Specifically, we manipulated the number of patients on the tracker board, thereby potentially increasing apparent cognitive load; the number of patients of similar acuity, which may force decision-making within a triage class; and the number of patients with similar presentation or incorrect prior triaging, which may challenge participants' ability to recognize to adapt their decision-making processes. Finally, we designed a think aloud phase at the end of the exercise to hopefully elicit the actual thinking processes used during the sorting exercise, revealing strategies and heuristics that participants may use consciously during an exercise requiring them to prioritize tasks and patients in a multi-patient scenario.

2.2 Sample Size Considerations

This study is largely an exploratory study on the expertise of task prioritization and therefore sample size approximations for quantitative measures have been inferred from other studies of expertise.[16,35,74–77] For the qualitative measures, our previous experience with qualitative methods have shown that highly homogenous groups will tend to view the world similarly and reach

saturation at lower numbers. Other exploratory studies on expert and novice emergency physician thinking revealed that a sample size of 6 in each group was sufficient to reach saturation.[16] Our original target sample size (for the purposes of qualitative analysis, and pilot quantitative analysis) was a total of 15 expert emergency physicians, though further sampling was required to ensure saturation for the critical incident interview part (qualitative methods). Interim analysis using constant comparative method showed that saturation of themes was noted at around 5 participants for the 'think aloud' experiment, and around 10 participants for the critical incident interviewing. As a result, we ended our recruitment after 10 participants in each group, providing a total number of 20 participants.

2.3 Considering the Think Aloud Technique

Some of the early chess studies in the psychological literature used various ex vivo chess-board simulations to clarify expertise thinking in chess masters.[74,78,79] Tracing expertise studies to their origins with De Groot's work,[80,81] it is noted that the origins began with protocol analyses and 'think aloud' approaches which take a qualitative approach. More recent techniques have returned to using such protocols to understand the contextual effects on clinical reasoning, e.g. real world tasks that are interspersed with pure patient-care activities.

One study of nurses has revealed the importance of breaks and relationship maintenance in the setting of the patient care environment,[82] something that might not be uncovered in the context of less naturalistic studies. Recent experimental data from a functional MRI (fMRI) study has also revealed that there may be a discrepancy between brain patterns when participants are asked to explicitly think about multiple choice questions when compared to simply answering those same

questions.[83] The literature, therefore, suggests that there may be a difference between the thinking processes that occur innately and when being asked to think aloud.[83] As such, we examined time differences between a subset of cases, looking at the effect on time to completion of think aloud versus sorting only conditions as a surrogate marker of similarity between the conditions.

3. RESEARCH QUESTION & HYPOTHESES

3.1 Research Question

We have one main research question, which has three subparts.

3.1.1 Main Question

What insights can we gain from examining task prioritization in the Emergency Department (ED) via a naturalistic cognitive simulation of an ED tracker board from three different analytic approaches?

Sub-Questions:

1. What heuristics and strategies do emergency physicians report using to prioritize patients and tasks on a simulated ED tracker board without actually performing the task?
2. What tacit processes and functions become apparent to expert emergency physicians as they prioritize patients and tasks on a simulated ED tracker board?
3. Based on physicians' actual decisions on the tracker boards, what are the implicitly used processes and functions that expert emergency physicians use in a simulated ED tracker board?
    a) Does increasing complexity alter decision-making?
    b) If so, what factors drive this?
    c) Are these different between novices and experts?

We used a simulated tracker board as a knowledge elicitation tool to better understand the macrocognitive strategies used by emergency physicians when completing prioritization tasks on tracker boards of increasing complexity.

Furthermore, we compared their functions and processes to those of novices in hopes of understanding differences between expert and novice emergency physicians, or to identify commonalities. We used a number of different techniques (e.g. semi-structured interviews, simulator performance indices and think aloud protocols) to elicit knowledge from expert and novice participants to gather data to generate our models of task- and patient-prioritization for emergency physicians.

3.2 Hypotheses

3.2.1 Primary Hypotheses.

- Adding unrelated (extraneous) patients will slow completion times (and may increase perceived difficulty)
- Adding similar patients (similar in acuity or presentation) will increase perceived difficulty (and slow completion times)
- The above effects will be stronger in novices than experts
- Adding patients in unexpected places will slow completion times
- The above effect will be stronger for experts than novices (because it will interfere with the chunking that benefits experts)

Placing patients in highly unexpected places (e.g. a heart attack in the rapid assessment zone) will neutralize the increased speed associated with expertise and thus disproportionately affect experts' performance time with task prioritization. This will simulate mistakes that can occur during the course of an emergency department shift. For the qualitative portions of our CTA, we do not have hypotheses, but will attempt to situate and relate our findings to other previous literature in a constructivist manner.

4. MATERIALS & MEASURES

4.1 Materials

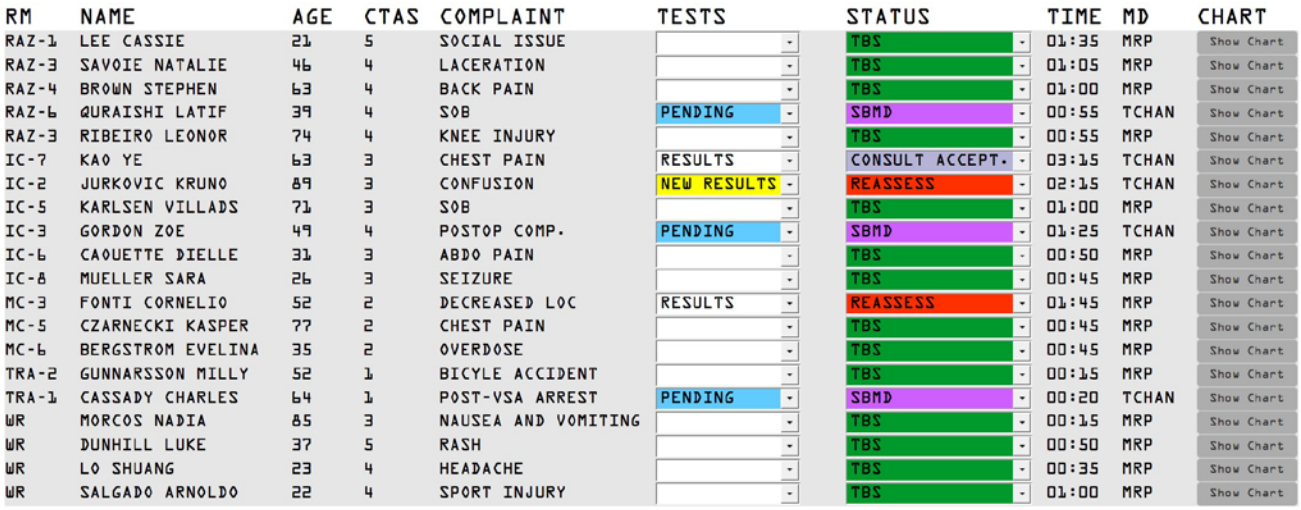
4.1.1 Simulated Patient Database. In an effort to create higher fidelity triage notes, we recruited five CTAS Triage System trained nurses and two emergency medicine physicians (one resident, one attending) to assist with creating triage notes. Each group was asked to develop triage notes for very sick (CTAS 1), moderately sick (CTAS 2/3), and ambulatory (CTAS 4/5) patients. The physicians then assigned appropriate vital sign ranges to each of the cases, and used a randomization process to assign random assortments of medications, past medical/surgical history, and simulated names. Each simulated patient triage note was read by at least 2 different people (either one practicing registered nurse and one practicing medical doctor, or two doctors) to ensure fidelity and appropriateness, and edits were made when required.

4.1.2 Simulated Tracker Board Creation

The simulated tracker board interface was developed using simple website development software by a research associate (KVD) using Adobe's Dreamweaver CS6 (12.0.0.5808) as the GUI platform to write both the HTML, JavaScript and CSS. HTML5 W3C, CCS4 standards were used in the design. Adobe's Photoshop CS6 (13.0.1.3) was used for designing graphical elements. Specific simulated tracker boards with requisite numbers of patients with similar acuity, chief complaints, and “extraneous patients” (patients under the care of other physicians) were assembled according to the pre-specified factorial design. The tracker board appearance was designed to appear similar to existing tracker boards used by the local area hospitals to optimize easy usage. Microsoft Office Excel 2013 (Redmond, WA) was used for creation and organization of the simulated patient database and to populate the tracker board interface with

simulated patient profiles. The digital webfiles are hosted on a private web server (NameCheap.com, Los Angeles, USA). Figure 1 depicts a sample tracker board interface

Figure 1 Sample tracker board interface



RM	NAME	AGE	CTAS	COMPLAINT	TESTS	STATUS	TIME	MD	CHART
RAZ-1	LEE CASSIE	21	5	SOCIAL ISSUE		TBS	01:35	MRP	Show Chart
RAZ-3	SAVOIE NATALIE	46	4	LACERATION		TBS	01:05	MRP	Show Chart
RAZ-4	BROWN STEPHEN	63	4	BACK PAIN		TBS	01:00	MRP	Show Chart
RAZ-6	QURAISHI LATIF	39	4	SOB	PENDING	SBMD	00:55	TCHAN	Show Chart
RAZ-3	RIBEIRO LEONOR	74	4	KNEE INJURY		TBS	00:55	MRP	Show Chart
IC-7	KAO YE	63	3	CHEST PAIN	RESULTS	CONSULT ACCEPT.	03:15	TCHAN	Show Chart
IC-2	JURKOVIC KRUNO	89	3	CONFUSION	NEW RESULTS	REASSESS	02:15	TCHAN	Show Chart
IC-5	KARLSEN VILLADS	71	3	SOB		TBS	01:00	MRP	Show Chart
IC-3	GORDON ZOE	49	4	POSTOP COMP.	PENDING	SBMD	01:25	TCHAN	Show Chart
IC-6	CAOUETTE DIELLE	31	3	ABDO PAIN		TBS	00:50	MRP	Show Chart
IC-8	MUELLER SARA	26	3	SEIZURE		TBS	00:45	MRP	Show Chart
MC-3	FONTI CORNELIO	52	2	DECREASED LOC	RESULTS	REASSESS	01:45	MRP	Show Chart
MC-5	CZARNECKI KASPER	77	2	CHEST PAIN		TBS	00:45	MRP	Show Chart
MC-6	BERGSTROM EVELINA	35	2	OVERDOSE		TBS	00:45	MRP	Show Chart
TRA-2	GUNNARSSON MILLY	52	1	BICYLE ACCIDENT		TBS	00:15	MRP	Show Chart
TRA-1	CASSADY CHARLES	64	1	POST-VSA ARREST	PENDING	SBMD	00:20	TCHAN	Show Chart
WR	MORCOS NADIA	85	3	NAUSEA AND VOMITING		TBS	00:15	MRP	Show Chart
WR	DUNHILL LUKE	37	5	RASH		TBS	00:50	MRP	Show Chart
WR	LO SHUANG	23	4	HEADACHE		TBS	00:35	MRP	Show Chart
WR	SALGADO ARNOLDO	22	4	SPORT INJURY		TBS	01:00	MRP	Show Chart

4.1.3 Tracker Board Composition

Figure 2 shows the factorial design that outlines the experimental conditions. We did not use a fully-crossed design and each participant saw the same tracker boards in the same order. The experimental design only permitted us to examine two-way interactions, while holding the third factor constant at zero each time. For each of these scenarios, there was a base of five simulated patients in each scenario, and the properties of these five patients were changed per our factorial design in Figure 2. Extraneous patients were additional to the core 5 patients, i.e. they added to the total number of patients on a tracker board.

Figure 2
Factorial design of tracker boards

		Number of Patients with SIMILAR ACUITY (SA)			Number of Patients with SIMILAR PRESENTATIONS (SP)		
		0	2	4	0	2	4
Number of EXTRANEOUS PATIENTS (under the care of other physicians)	0	0 SA 0 Extra (Case 1.1)	2 SA 0 Extra (Case 1.2)	4 SA 0 Extra (Case 1.3)	0 SP 0 Extra (Case 2.1)	2 SP 0 Extra (Case 2.2)	4 SP 0 Extra (Case 2.3)
	5	0 SA 5 Extra (Case 1.4)	2 SA 5 Extra (Case 1.5)	4 SA 5 Extra (Case 1.6)	0 SP 5 Extra (Case 2.4)	2 SP 5 Extra (Case 2.5)	4 SP 5 Extra (Case 2.6)
	10	0 SA 10 Extra (Case 1.7)	2 SA 10 Extra (Case 1.8)	4 SA 10 Extra (Case 1.9)	0 SP 10 Extra (Case 2.7)	2 SP 10 Extra (Case 2.8)	4 SP 10 Extra (Case 2.9)
Number of Patients with SIMILAR PRESENTATIONS (SP)	0	0 SA 0 SP (Case 3.1)	2 SA 0 SP (Case 3.2)	4 SA 0 SP (Case 3.3)			
	2	0 SA 2 SP (Case 3.4)	2 SA 2 SP (Case 3.5)	4 SA 2 SP (Case 3.6)			
	4	0 SA 4 SP (Case 3.7)	2 SA 4 SP (Case 3.8)	4 SA 4 SP (Case 3.9)			

4.1.4 Orientation Video

An orientation video was created to provide an overview of the tracker board interface to participants. The video was narrated by the research associate (KVD) who created the simulated tracker board using Screencast software (Techsmith's Camtasia Studio 8.1.2). The orientation video was reviewed & edited for content and length by a second researcher (TC).

4.1.5 Interview Guides

For the first part of the experiment, the participants underwent a semi-structured interview about the overall process of task prioritization, techniques used to increase efficiency and barriers to emergency department management. A critical incident interviewing methodology was used, based on the work previously done in nursing about task prioritization.[12] This interview tool has been augmented using Klein's Eight Dimensions of Expertise.[40] This technique provided a

prompt to stimulate the participant into recalling a 'critical incident' where they had to prioritize patients and then elicited their thinking around that occasion. Appendix 2 shows the questions I asked. This model incorporates eight areas that encompass expertise: 1) Past & future observations; 2) Big picture; 3) Noticing; 4) Job Smarts; 5) Improvising/spotting opportunities; 6) Self-monitoring; 7) Anomalies; 8) Equipment difficulties.

4.1.5 Sorting Task Data Collection Tool

There is no well-validated sorting tool for determining priorities in the emergency department. Based on personal experience, we created a classification schema that is based on naturalistic priorities that emergency physicians seem to use during a shift. This schema has four categories as described (Appendix C). For clarification, this schema includes:

1. See First - allowing only one patient to be classified into this category;
2. See Soon (i.e. within the next hour) - allow for up to 5 additional simulated patients into this category;
3. Write Orders and See Upon Completion of Orders - allow for up to 5 simulated patients in this category;
4. Ignore - allowing all the rest of the patients to be in this category.

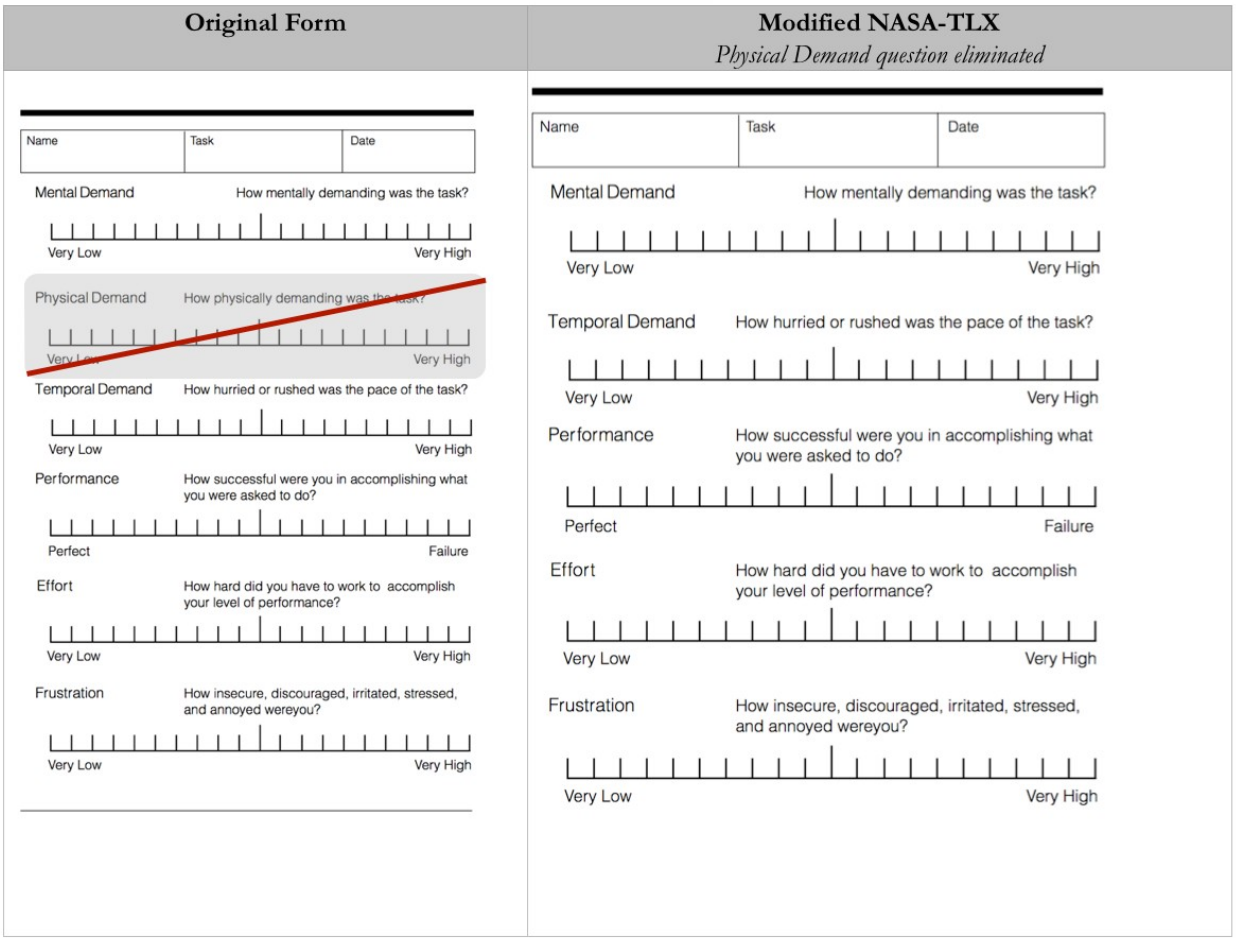
To ensure this categorization schema is ecologically-valid, this sorting task guide was piloted on non-participatory physicians prior to initiating the study.

4.1.6 Modified NASA-TLX

During the rating exercise, participants were asked to rate their task load for a sample of 6 different tracker boards. In order to approximate task load, we used a modified version of the

NASA Task Load Index (NASA-TLX). The NASA-TLX is a well validated scoring system previously used in order high-cognition simulations.[84,85] Since our simulation did not require any physical component, we modified the NASA-TLX scale by eliminating the question pertaining to physical activity. We piloted this NASA-TLX with junior non-participatory colleagues to ensure ease of use and understanding. Figure 3 is a depiction of our modified NASA-TLX.

Figure 3: The modified NASA-TLX used in this study



4.1.7 Think Aloud Scenarios

A subset of cases were randomly chosen and used as the prompting scenarios for the think aloud phase of this project to check the effect of the think aloud procedure on the time-to-completion. These cases may be found at the web addresses in Table I. The think aloud scenarios are depicted in appendix F.

Table I Listing of web addresses for the think aloud tracker board scenarios	
Think aloud scenario #1	http://www.virtualer.org/TC_2_6.html?
Think aloud scenario #2	http://www.virtualer.org/TC_3_3_a.html?
Think aloud scenario #3	http://www.virtualer.org/TC_2_6_b.html?
Think aloud scenario #4	http://www.virtualer.org/TC_1_3_c.html?
Think aloud scenario #5	http://www.virtualer.org/TC_3_9_MP_d.html?

4.2 Outcome Measures

The main outcome measure for the quantitative part of this work was time spent prioritizing and the divergence in prioritization of participants' answers, as measured by an intraclass correlation coefficient (ICC) of the four different categorizations of the patients featured in 4.1.5: See First, See Soon, Write Orders and See Upon Completion, Ignore for now. We also examined participants' number of clicks back into simulated patient files to recheck the file data (as manifest by their clicking to see individual patient-level details such as vital signs and patient triage story, but also by the clicks deeper into the interface where they could access past patient files), as we hypothesized that inexperienced participants would require more frequent access to information since their working memory may be more taxed.

There were no a priori defined outcome measures for the qualitative parts of this thesis.

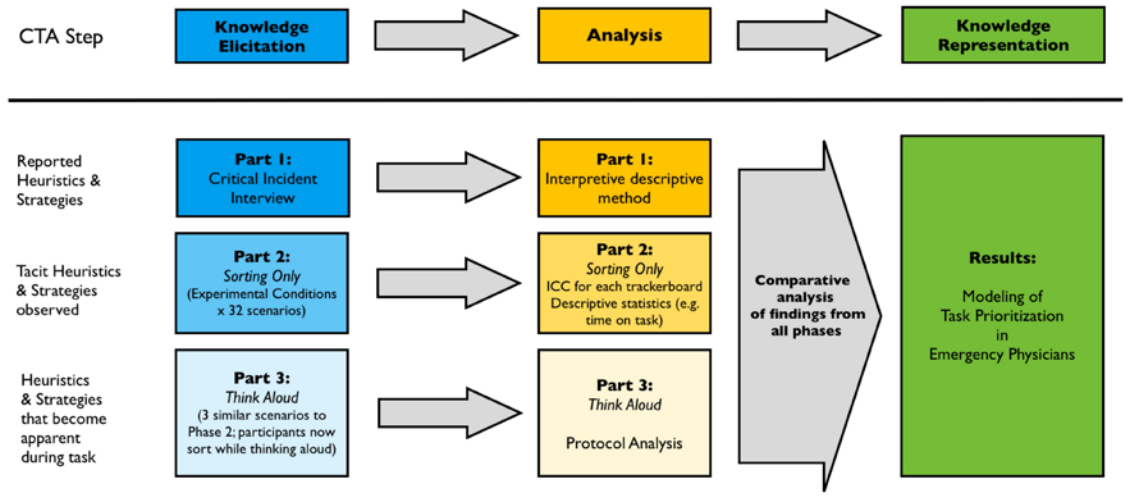
For the qualitative phases of this CTA, we aimed to gather data that allowed us to represent the explicit knowledge and tacit thinking processes of our participants during the prioritization processes.

5. Methods & Procedure

5.1 Overview

There are three phases of this study, which elicit both the tacit and explicit knowledge of participants regarding task and patient-prioritization. The overall study flow diagram is depicted in Figure 4. It details the three phases of a CTA and how our study aligns with each of these components.

Figure 4: Overall study flow diagram



The first part of the study was the critical incident interview, wherein we will simply asked the participants to describe challenging scenarios in the ED, and then prompted them to subsequently recall situations with multiple patients. This allowed us to understand how they experience these multi-patient environments. We also asked them about their heuristics, strategies, and macrocognitive functions/processes that are used in handling these experiences (e.g. work smarts). Finally, we asked them about how they learned (and how they as faculty members teach) the skills of prioritization or handling high volume patient flow.

The second phase of the study comprised of a series of sorting exercises using the tool featured in section 4.1.5. In this phase, participants were asked to sort the patients in 32 tracker boards into categories based on their anticipated actions. Embedded within this phase was a factorial design where two of the following factors were manipulated at a time for each trial (keeping the third factor constant at 0):

1) extraneous patients (who are listed as being under the care of other physicians);
2) patients with similar acuity (i.e. the same Canadian Triage Acuity Score, CTAS);
3) patients with similar presentations (i.e. the same chief complaint, e.g. abdominal pain).

We also had five special tracker boards with misplaced patients, to allow us to examine how these patient placements affect the thinking processes of the physicians.

The third phase of the study was a think aloud exercise. In this phase participants were asked to engage in the sorting task on five additional tracker boards as they did in the previous section while being encouraged to think aloud. They were prompted and reminded to explain their thoughts and decisions. Some of these tracker boards resembled ones that they had previously seen, allowing us to examine the effects of the think aloud procedure on our outcome measure. The think alouds were always presented after their original similar boards, which may have resulted in some confounding factor due to thinking aloud or practice effects.

There was a final open-ended question at the end of the experience (“Is there anything else you would like to tell us?”), allowing participants to explain other aspects that they deemed important for the prioritization process.

5.2 Participants

To recruit the experts, the chiefs of the EDs from four area hospitals were asked to nominate physicians whom they consider efficient managers of the ED. These physicians were then emailed three times, each one week apart, to recruit them into our study (e.g. a modified Dillman technique).[86] These individuals were asked to participate in a respondent-driven, snowball sampling technique, since our intention was to discover a new expertise model in our target group of experienced emergency physicians.[87,88] Specifically, the question asked of the chiefs and participants was: "Please nominate three colleagues that you feel are efficient managers of the emergency department."

Following initial recruitment, a snowball sampling technique of peer nomination was used to optimize the chance for saturation. Each attending-level participant was asked to nominate three peers that they admired for their ED managerial skills or efficiency. Subsequently, participants were asked the following question: "If at all possible, please give suggestions for people that you feel manage the emergency department differently than you do (but still equally as efficiently)."

Resident-participants were not recuited a snowball method, and we merely enrolled the first ten volunteers into the study in a convenience sampling technique.

All participants underwent procedures only after obtaining informed consent.

5.3 Setting

All data were collected from emergency physicians and junior trainees who worked within Hamilton, ON, Canada, between January 2014 and April 2015. Participants were interviewed for 1.5 hours at various administrative offices and given access to a single, web-enabled laptop computer. Efforts were taken to ensure that the instructions of each session were similar to previous sessions.

5.4 Procedure

5.4.1 Demographics & Initial Survey

Basic demographics were collected on participating individuals (Age; # of years in practice; # of years/rotations of training, training background - Royal College, CFPC-EM, Practice Entry, etc.. - perceived speed compared to colleagues; estimate of average number of patients seen per hour). We gathered demographic information to describe the experts (i.e. attendings) compared to the novices (i.e. residents) in terms of these demographics. These served as descriptive statistics to define the study populations more fully. See Appendix 1 for the initial demographics collection survey.

5.4.2 Part 1: Critical Incident Interviewing & Knowledge Audit

A single investigator (TC) administered a semi-structured interview lasting no longer than 15 minutes about the overall processes of task prioritization, techniques used to increase efficiency, and barriers to efficient ED management. A critical incident interviewing methodology was used, based on work previously done in nursing about task prioritization.[73] The interview tool was then altered using Klein's Eight Dimensions of Expertise,[22] to create further prompts for

participants if they were not forthcoming with illustrative or elaborative answers as needed. Appendix 2 details the interview elicitation tool.

5.6.3 Part 2: Sorting Exercises & Task Load Ratings

During this part, participants were asked to examine a series of 32 tracker boards and make decisions regarding their 'initial plan'. Recall, they rated each simulated patient along an ordinal scale of priority with four levels (See First; See Soon [within one hour]; Write orders and see upon completion of orders; Ignore).

Appendix C depicts the sample data collection form with the instructions. During this part, a select group of scenarios were repeated with subtle differences in the placement of patients (i.e. the patients were intentionally misplaced into inappropriate settings such as a very sick patient in the low acuity zone). Table II describes the matched scenarios for this variation.

Table II: Tracker Boards that containing misplaced patients and matched conditions

Scenario #	Misplaced Condition	Control Condition
1.2	3	1
1.9	11	28
2.9	29	13
3.9	37	19

For cases 1-30, every fifth case was rated with the modified version of the NASA-TLX tool.

5.4.4 Part 3: Think Aloud

For the last 5 tracker boards, participants were asked to undergo a recorded think aloud exercise, and then a semi-structured interview. Appendix 4 details the prompts for the think aloud part. For each tracker board in this part of the experiment, participants were asked to think aloud

about their prioritization process.[89,90] They were given a set script to explain the technique and an example case was reviewed with the investigator if there were questions about the technique. For three of the tracker boards in this case, there was a matched version of the case with similar conditions in the previous sorting exercises for which no think aloud was conducted. One tracker board was repeated twice for two think aloud scenarios. Table III describes where the think aloud cases were located within the sequence of scenarios.

Table III: Tracker Boards that were used in the think aloud and their matched conditions

Scenario #	Case number for first encounter	Case number for think aloud
3.3	10	34
1.3	20	36
3.9 (with misplaced patient)	2	37
2.6	N/A	33, 35

5.4.5 Part 4: Exit interview

After the sorting exercises and think alouds, the participants had the chance to say anything they wished to add. Appendix 5 shows the data collection prompts for the exit interview part of this study.

5.5 Analysis

5.5.1 Quantitative

Demographic information, time-to-completion for tracker boards, and number of clicks were compared between groups using a t-test or chi-squared analysis. The NASA-TLX data was analyzed using a mixed Analysis of Variance (ANOVA). To determine divergence in decision-making between the novices and experts in each tracker board scenario, we calculated the intra-

class correlations coefficients (ICCs) in each group and then we compared this statistic in the various scenarios.

To determine the degree to which experience and tracker board scenario manipulations affected time to completion, a series of mixed ANOVAs were run. Experience (i.e. attending vs. resident), number of previous exposures to tracker boards with similar attributes (incidence – i.e. the first time, second time, third time encountered.), and the three manipulated factors (number of patients with similar diagnoses, number of patients with similar acuity, and number of extraneous patients) were used as factors in these analyses. We also utilized a linear regression model to check to see if there was a relationship between the repeated encounters with the simulation and participants' completion times.

5.5.2 Qualitative

The method of qualitative analysis chosen was that of interpretive descriptive technique,[91] which was conducted after collecting data from 10 participants in each group (10 novices, 10 experts). A constant review of the texts generated was completed after each interview by a single researcher. Notes and memos were used to ensure that thematic saturation was being reached. The 20 transcripts were then analyzed in clusters of 3-4 transcripts at a time in a derivative constant comparative approach until saturation was reached as determined by the analysis team (Think aloud Team – TC, MM; Critical Incident/Exit Interviews – TC, KVD). A decision was made to group the analysis of the Critical Incident Interviews with the Exit Interviews since the topics addressed tended to be more thematically similar than that of the Think Aloud, as the participants tended to recall or describe additional strategies for optimizing their management of

busy days. Although the study protocol had originally determined that there should be up to 15 individuals per grouping, after the third group of transcripts, it was clear that we had reached thematic saturation for both the think aloud and critical incident interviewing parts of the study, and thus, further collection of subjects was halted. A member check was conducted for a two-week period via e-mail contact after the analysis was completed.

5.5.3 Triangulation via a Mixed Methodology

The intention of our study design was to triangulate the perspectives around physician task prioritization by comparing the results from the three unique parts. By comparing the think aloud part to the recalled events from the critical incident interviewing, while incorporating information from the task prioritization exercises, the intention was to allow these techniques to complement each other in helping to elucidate effects of thinking aloud on participants' macrocognition. Comparing the explicit tasks that our participants recall and those used in the think aloud procedures will allow us to infer techniques that are explicit and those that experts may use implicitly. Comparing all three parts allowed us to determine if there are non-apparent skill sets that are not easily described by participants.

6. RESULTS OF THE SORTING EXERCISE

6.1 Demographics

Attendings and residents were significantly different in age, years of practice, and proportion of time spent in an academic centre. They did not significantly differ in their self-reported number of patients seen per shift (8-10 hours in duration), but attendings generally reported seeing 250% more patients per hour than their residents. Table IV shows these demographics.

Table IV: Demographics

	Attending	Resident	t-test p-value
Average Age (Years)	38.7±5.4	29.0±2.4	<0.001
Average Years in Practice	12.0±4.7	1.5±0.5	<0.001
Number of patients per hour (self-reported)	5.1±2.2	1.9±0.5	<0.001
% time spent at an academic centre	96.0±12.6%	99.5±1.6%	<0.001

6.2 Average Completion Time / Average Clicks – per group

Overall, there were no significant differences detected between groups with regards to: average or total time completion for tracker, total number of charts opened across all scenarios, and the total number of past medical records accessed for the simulated patients. The details for this are shown in Table V.

Table V: Comparing completion time (in seconds) and charts accessed during the tracker board scenarios between groups

	Average For Attendings	Average For Residents	p-value (t-test)
Average time to completion for each tracker board for individuals	116±31.5 seconds	126±38.2 seconds	0.18
Total number of charts opened across all tracker board scenarios	290±57.7	305±97.3	0.41
Total number of past medical records accessed across all tracker boards	1.8±1.2	2.7±3.2	0.21

6.3 Agreement of Attendings and Residents in the Various Tracker Boards

We calculated intra-class correlation coefficients (ICCs) for the sorting of the simulation patients within each of the scenarios as a measure of agreement within each of the groups. Broadly speaking, each manipulation of the various tracker boards resulted in similar results between attendings and residents (see tables VI, VII, VIII). For each combination of experimental conditions, agreement in how to prioritize patients was similar for residents and attendings. There were no observed trends across the tracker boards with regards to the ICC within any of the scenarios with similar attributes (i.e. number of patients with similar acuity, number of patients with extraneous patients, number of patients with similar presentations).

Table VI. The agreement on various tracker boards as measured by two-way random effects ICC for tracker boards containing varying number of patients with similar acuity, and varying number of extraneous patients

		Number of patients with Similar Acuity		
		0	2	4
Number of extraneous patients	0	**Attendings** ICC 0.57 (0.26-0.92) **Residents** ICC 0.56 (0.25-0.92)	**Attendings** ICC 0.64 (0.35-0.92) **Residents** ICC 0.39 (0.30-0.90)	**Attendings** ICC 0.53 (0.27-0.86) **Residents** ICC 0.53 (0.27-0.86)
	5	**Attendings** ICC 0.82 (9.67-0.94) **Residents** ICC 0.72 (0.52-0.90)	**Attendings** ICC 0.94 (0.86-0.98) **Residents** ICC 0.84 (0.69-0.95)	**Attendings** ICC 0.39 (0.18-0.71) **Residents** ICC 0.41 (0.20-0.73)
	10	**Attendings** ICC 0.62 (0.43-0.81) **Residents** ICC 0.66 (0.50-0.83)	**Attendings** ICC 0.53 (0.35-0.75) **Residents** ICC 0.57 (0.38-0.78)	**Attendings** ICC 0.74 (0.58-0.88) **Residents** ICC 0.78 (0.63-0.90)

p-values <0.001. Bracketed numbers display the 95% confidence interval.

Table VII. The agreement on various tracker boards as measured by two-way random effects ICC for tracker boards containing varying number of patients with similar presentations (Chief Complaints) and varying number of extraneous patients

		Number of patients with Similar Presentation		
		0	2	4
Number of extraneous patients	0	**Attendings** ICC 0.57 (0.26-0.92) **Residents** ICC 0.56 (0.25-0.92)	**Attendings** ICC 0.51 (0.21-0.91) **Residents** ICC 0.60 (0.29-0.93)	**Attendings** ICC 0.74 (0.48-0.95) **Residents** ICC 0.62 (0.33-0.91)
	5	**Attendings** ICC 0.56 (0.34-0.82) **Residents** ICC 0.57 (0.34-0.83)	**Attendings** ICC 0.65 (0.44-0.87) **Residents** ICC 0.71 (0.51-0.90)	**Attendings** ICC 0.62 (0.40-0.85) **Residents** ICC 0.41 (0.20-0.72)
	10	**Attendings** ICC 0.62 (0.44-0.81) **Residents** ICC 0.68 (0.51-0.85)	**Attendings** ICC 0.69 (0.51-0.85) **Residents** ICC 0.75 (0.60-0.89)	**Attendings** ICC 0.67 (0.37-0.95) **Residents** ICC 0.69 (0.38-0.85)

p-values <0.001. Bracketed numbers display the 95% confidence interval.

Table VIII. The agreement on various tracker boards as measured by two-way random effects ICC for tracker boards containing varying number of patients with similar acuity and varying number of patients with similar presentations (Chief Complaints)

		Number of patients with Similar Acuity		
		0	2	4
Number of patients with Similar Presentation	0	**Attendings** ICC 0.57 (0.26-0.92) **Residents** ICC 0.56 (0.25-0.92)	**Attendings** ICC 0.74 (0.45-0.96) **Residents** ICC 0.66 (0.35-0.95)	**Attendings** ICC 0.52 (0.21-0.91) **Residents** ICC 0.36 (0.10-0.85)
	2	**Attendings** ICC 0.67 (0.46-0.95) **Residents** ICC 0.71 (0.42-0.96)	**Attendings** ICC 0.76 (0.48-0.96) **Residents** ICC 0.66 (0.35-0.94)	**Attendings** ICC* 0.12 (0-0.66) **Residents** ICC 0.38 (0.11-0.86)
	4	**Attendings** ICC 0.56 (0.29-0.92) **Residents** ICC 0.61 (0.30-0.93)	**Attendings** ICC 0.52 (0.22-0.91) **Residents** ICC 0.47 (0.18-0.89)	**Attendings** ICC 0.47 (0.20-0.86) **Residents** ICC 0.41 (0.15-0.83)

* p = 0.07. p-values <0.001 unless otherwise denoted with a *. Bracketed numbers display the 95% confidence interval.

6.4 Task Load

Table IX compares the task load as measured by the modified NASA-TLX (mNASA-TLX) to the control exemplar scenarios.

Table IX. Comparing the task load as measured by the modified NASA-TLX (mNASA-TLX) across exemplar scenarios

	Average total mNASA-TLX For Attendings	Average total mNASA-TLX For Residents	p-value (t-test)	Average total mNASA-TLX For All participants
Tracker Board #5	40.2	51.0	0.07	45.6
Tracker Board #10	46.5	52.7	0.32	49.6
Tracker Board #15	41.5	45.7	0.47	43.6
Tracker Board #20	40.3	49.6	0.21	45.0
Tracker Board #25	27.6	38.8	0.14	33.2
Tracker Board #30	31.8	38.6	0.30	35.2

A 2x6 (expertise x board) mixed ANOVA revealed that there was an effect of the individual cases on the reported task load as measured by the mNASA-TLX. There was a main effect ($F(5,13)=4.8$, $p<0.01$) of the individual cases on the mNASA-TLX scores of the participants, suggesting that cases differed in their perceived task load, with later cases perceived as having lower task load. We did not detect any effect of expertise on the mNASA-TLX scores within each case ($F(5,13)=0.93$, $p=0.96$).

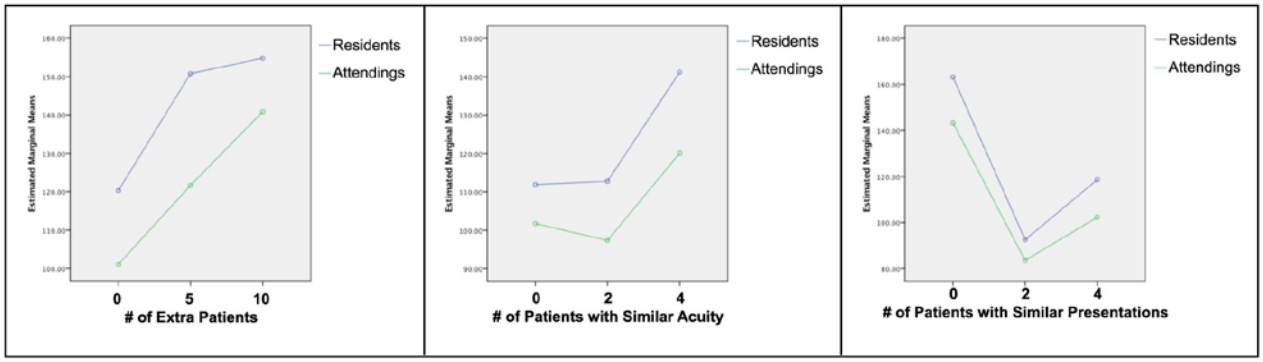
6.5 The Effect of our Scenario Manipulations

6.5.1 The effect of the various conditions

There was a significant main effect of increasing the number of patients with similar acuity on time to completion ($F(2,17) = 18.8$, $p<0.001$, linear). There was also a significant main effect of increasing the numbers of extraneous patients ($F(2,17) = 11.2$, $p=0.001$, linear) on time to completion. In the scenarios with increasing numbers of patients with similar presentations, there was an interesting phenomenon observed in that the relationship with time to completion

seemed to be non-linear (quadratic, $F(2,17)=35.6$, $p<0.001$). Figure 5 below depicts the estimated marginal means of the three conditions, as split by expertise. Of note, the lines seem disparate with attendings generally requiring less time to complete the task than the residents, though there was no statistically discernible difference detected in our study between the groups in any of the three conditions.

Figure 5: Estimated marginal means for time to completion in the experimental conditions, split by expertise

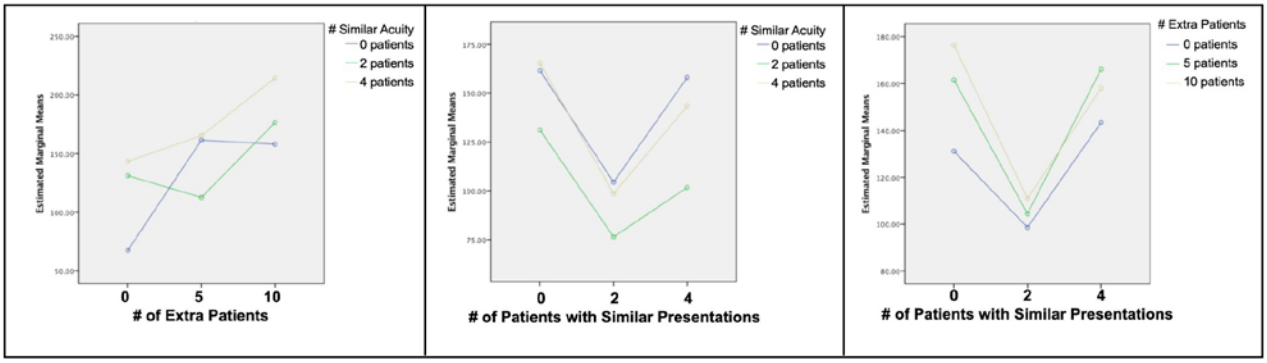


6.5.2 Interactions between conditions

A subset of the tracker boards was used in a factorial design to help elucidate whether interactions between the conditions would result in increased time spent. The following chart and graphs summarize these findings (Table X and Figure 6). There was only one significant interaction between conditions, and this was in the case of the interaction between the similar acuity patients and the number of extraneous patients. As there was an increase in the number of extraneous patients to five extraneous patients, this affected the time to completion of participants in the conditions with no patients of similar acuity.

Table X: Interactions between conditions without expertise considered		
	Similar Patients	Extraneous Patients
Similar Acuity	F(4,72)=1.50 P=0.211	F(4,72) = 10.4 P<0.001
Similar Patients	N/A	F(4,72) = 1.8 P=0.13

Figure 6: Estimated Marginal Means for time to completion, detailing two-way interactions



Of note, when expertise is factored into the interactions as a different facet, there is no longer any notable significance in the effect of the interactions between the two conditions. See Table XI for details of these effects and interactions.

Table XI: Interactions between Conditions with expertise considered		
	Similar Patients	Extraneous Patients
Similar Acuity	F(4,72)=0.74 P=0.57	F(4,72) = 0.62 p=0.65
Similar Patients	N/A	F(4,72) =0.83 P=0.14

6.5.3 Misplaced patients

Recall that we attempted to see if there would be an increased time-to-completion in scnarios with misplaced patients in the tracker board, hypothesizing that attendings might be more affected by patients in an inappropriate location. While there seem to be significant main effects

of misplacement on the effects of participants' completion time, these depend on the sequential placement of the cases. Of note, in the situations where the control was seen before the misplaced condition (Scenarios 1, 2, 2.9), the time to completion was actually lower in the misplaced condition. Similarly, in situations where the misplaced condition was encountered by participants before the control (Scenarios 1.9, 3.9), the time to completion was actually higher for the misplaced condition. Table XII depicts the Tracker Boards wherein misplaced conditions are compared to the scenarios with misplaced patients.

Table XII: Mean completion times for tracker boards that containing misplaced patients and their matched conditions

Scenario #	Misplaced Condition	Control Condition	F-value
1.2	Case 3 Ave. Attending time 79 sec Ave. Resident time 116 sec	Case 1 Ave. Attending time 92 sec Ave. Resident time 143 sec	F (1,18) = 8.121 p < 0.01
1.9	Case 11 Ave. Attending time 163 sec Ave. Resident time 218 sec	Case 28 Ave. Attending time 83 sec Ave. Resident time 120 sec	F (1,18) = 18.7 p <0.001
2.9	Case 29 Ave. Attending time 96 sec Ave. Resident time 126 sec	Case 13 Ave. Attending time 116 sec Ave. Resident time 166 sec	F (1,18) = 8.8 P <0.01
3.9 (with misplaced patient)	Case 17 Ave. Attending time 84 sec Ave. Resident time 170 sec	Case 19 Ave. Attending time 53 sec Ave. Resident time 82 sec	F (1,18) = 28.7 P<0.001 Effect of expertise found F(1)=7.5 p=0.01

6.6 The Effect of Think Aloud

The think aloud process had a heterogenous effect on time to completion. Generally, it did take longer to complete the think aloud scenarios; however, this did not occur in all conditions. In two cases (Scenarios 3.3, 1.3) it did not significantly affect the total time taken to completion (p=0.31 and p=0.75 respectively). In one case, the case with a misplaced patient, there was a significant effect of the think aloud on the time to completion (F=17.8, df(1), p=0.001). The attendings tended to take significantly less time than the residents to complete the think aloud scenarios in

all but one condition (Scenario 3.3). Table XIII depicts the average completion times for tracker boards that were used in the think aloud and their matched conditions, as well as the effect of the think aloud process.

Table XIII: Average completion times for tracker boards that were used in the think aloud and their matched conditions

Scenario #	First Encounter	Think Aloud		F-value
3.3	Case 2 Ave. Attending time 99 sec Ave. Resident time 129 sec	Case 34 Ave. Attending time 107 sec Ave. Resident time 146 sec		F(1,18) = 1.077, p = 0.31 Expertise F=2.1 p=0.16
1.3	Case 20 Ave. Attending time 109 sec Ave. Resident time 170 sec	Case 36 Ave. Attending time 123 sec Ave. Resident time 163 sec		F(1,18) = 0.108, P=0.75 Expertise F=8.3 P =0.01
3.9 (with misplaced patient)	Case 2 Ave. Attending time 105 sec Ave. Resident time 129 sec	Case 37 Ave. Attending time 136 sec Ave. Resident time 196 sec		F (1,18) = 17.8, P=0.001 Expertise F=4.7 p=0.04
2.6	N/A	Case 33 Ave. Attending time 136 sec Ave. Resident time 196 sec	Case 35 Ave. Attending time 109 sec Ave. Resident time 170 sec	F (1,18) = 28.7 P<0.001 Effect of expertise found F=6.5 df =1 p=0.02

6.7 The Effect of Increasing Exposure to the Tracker Board Simulator

Across all three conditions, participants seemed to be affected by the number of times where they encountered a similar condition. There was a significant main effect of repeated exposure to a similar type of case, that is to say, that as a participant became exposed to a tracker board with two patients with similar acuity repeatedly they would spend less time on that tracker board. The interactions of exposure to the various conditions are listed in Table XIV below.

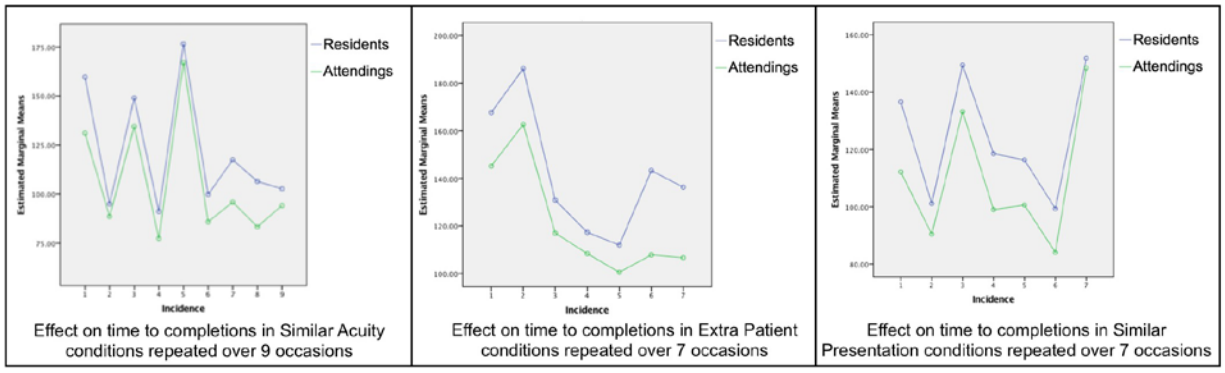
Table XIV: Effect of increasing exposure to conditions

	Interaction effect of each variable with increasing exposure to that variable	3-way Interaction of each variable with Expertise and Increasing Exposure
Increasing number of patients with Similar Acuity	F (16,3)= 16.6, p=0.02	F (12,7)=3.6, p=0.05
Increasing number of patients with Similar Presentation	F (12,7)= 7.4, p = 0.007	F (12,7)=1.3, p=0.39
Increasing number of Extraneous Patients	F (12,7)= 3.6, p = 0.05	F (12,7)=0.62, p=0.78

Note: The scenario series had different numbers of repeats for the various scenarios within each grouping. Some types of scenarios were repeated 7 times, some 9 times, some 13 times. The minimum number of repeats was chosen to run within the mixed ANOVA.

The following graphs (Figure 8; Parts 1, 2, 3) depict the estimated Marginal Means times for completion mapped by the incidence for the three conditions. Generally, the trend was observed that the residents took more time to completion, however, there was no significant difference between attendings and residents.

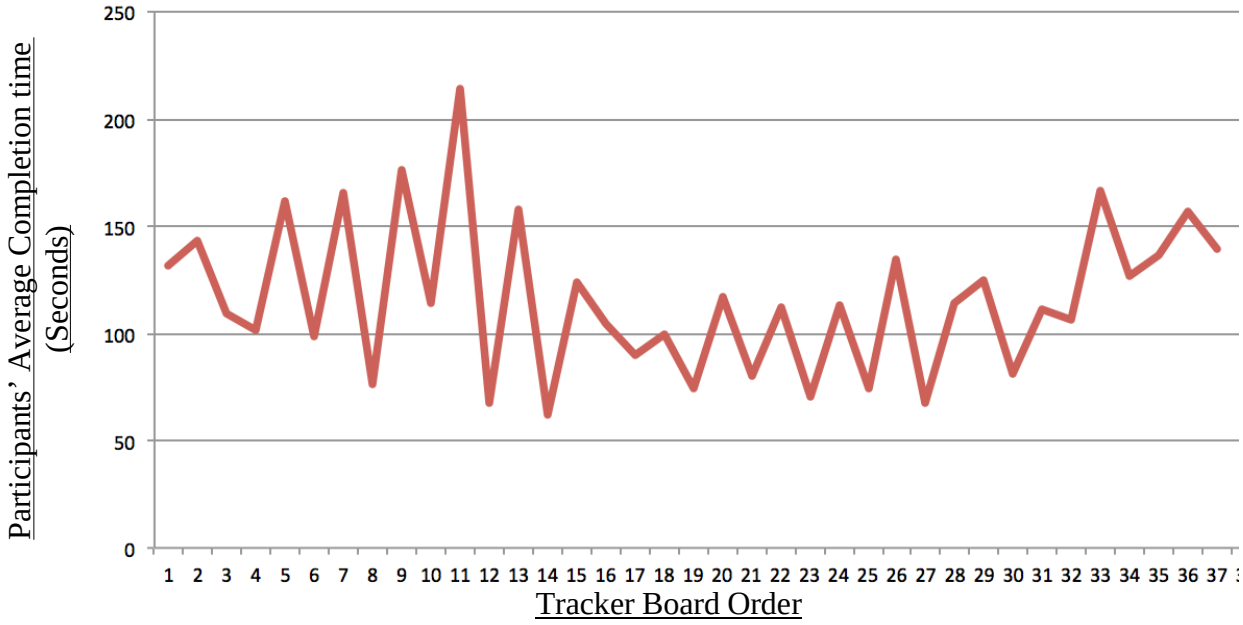
Figure 8: Estimated marginal mean completion times by exposure to experimental conditions



We also performed a regression analysis to ensure that across all the tracker board scenarios, there was not a significant effect of exposure to the simulator on the participants' completion times. We ran a linear regression model to determine if there was a relationship between the order of the tracker board and the associated average time to completion of the sorting task for

that same board. Figure 9 depicts a plot of tracker board number and the participants' average completion time. The regression model was not significant in either situations where the think aloud trackers were included (R = 0.07, p = 0.70) or not included (R=0.34, p = 0.06).

Figure 9 A plot of tracker board number and the participants' average completion time (in seconds).



7. RESULTS OF THE INTERVIEWS

7.1 Part 1 & Part 4 Results (Qualitative)

7.1.1 Defining Busy-Ness in the ED

During the initial part of the critical incident interview, participants were asked to describe busy ED situations. We analyzed their responses that seemed to describe what attendings and residents felt resulted in difficult or challenging situations, where they felt were "busy". There were four subtypes of situations that the participants described in their descriptions of a busy day: 1) Single High Acuity Cases; 2) High-Volume Days; 3) Multiple High-Acuity Cases simultaneously being managed; and 4) High Acuity case(s) in the setting of High-Volume Days with Saturated Resources. A table showing these four subtypes of situations and an illustrative quote is shown in Table XV.

Table XV: Four subtypes of "busy" emergency department situations

Situation Subtype	Illustrative Quotes
Single High Acuity Case	*"...[I]t was a busy night and there was a patient who came in with like (sic.) a decreased LOC secondary to like (sic.) a hypoglycemia and the question was whether or not to give the usual like (sic.) D50. [H]owever this was a patient who had, like, a genetic condition which put them in, like, a very small weight, very small structure so it was like a forced decision and there was a lot of pressure from nursing. So I said yes, go ahead because his sugars were, like, below one and he was completely in a comatose state. But then, of course, because he was so small and it was, like, a rash decision and we were just trying to work out his sugars, like rocketed, skyrocketed afterwards and it was the difficult decision of whether I would do … So it was something in hindsight that I should have thought about doing like a pediatric dosing because of the size of the patient. And it was something that was, it was challenging and I debriefed with my staff and she was, like, I understand why in the moment."* –HH-26-BR (Resident)

High-Volume Days requiring High-Volumes of Tasks e.g. Lots of patients; lots of tasks; lots of interruptions	*"I was working in nightshift… I was trying to balance a relatively busy department and make sure that people were seen and that disposition happened and that people were moving through and it began to get busy once you had seen a few people and had to then keep track of their labs and their x-rays and what was coming back and if they were being moved and where they were being moved to and making sure all of the consultants were phoning you back and actually seeing the patients who you had sent to them. So that was definitely very busy and I was task saturated."* –HH-30-HO (Resident) *"Okay so last… so Wednesday night, I worked night shift and I came in to five hours wait with over a dozen people waiting to be seen and a couple of people in the sort of acute care area. Um, so the first thing I did was… and then there was also my colleague that was leaving let me know about a complex laceration on a 12 year-old boy and… so that's sort of what I started with"* – HH-44-HA (Attending)
Multiple High-Acuity Cases simultaneously being managed	*"[I]t would have been a shift I had some multiple septic patients who presented around at the same time. I was the only staff physician at the time. I did have learners with me. So the way I dealt with it was I quickly eyeballed all of them, decided who was the sickest of them, and started accessing that patient while at the same time ordering lab work and investigations and even broad-spectrum antibiotics without actually seeing the other patients. The second sickest patient I sent my resident to see, and as we were the only people there the third and fourth patients could not be assessed however I had already eyeballed them and ordered investigations and the nurse were comfortable with that plan and they knew where to come and find me if any of the less sick patients became sicker. In that way we managed to assess, start resuscitation and managing all of them."* – SJ-32-JA (Attending) *"…I was working in a busy community emergency department in which there eight to 10 people waiting to be seen in the acute side. And the staffing model is one where you are isolated to cover a specific area; so in this case I was covering the acute, and most of those patients were undifferentiated chest pain, abdominal pain or dyspnea in the elderly. None of them were thought to be acutely over sick requiring acute resuscitation. [Three] EMS [crews subsequently] arrived within probably six to seven minutes with one VSA patient, a patient in rapid atrial fibrillation and a boarded and collared patient with moderate velocity MVC. The challenge was: 1) prioritizing the management of the patients; and, 2) managing flow in the emergency department's situation."* – SJ-42-MI (Attending)

High Acuity case(s) in the setting of High-Volume Days with saturated resources.	*"[I]t was busy overall at [the hospital], one of the busier ones, we probably had six patients on the go at the same time and then I was pulled to the acute care area with a young guy with query DKA which had to be managed, the source was likely just that he fell ill and then didn't take his insulin and so on and so forth and his sugars went."* -SJ-32-SH (Resident) *"[A] recent situation that was challenging for me, okay I can give you a good one. So the, it was at The Tertiary Care Center, a very busy department, one other attending staff was there finishing charts, then it was myself, multiple handovers, lots of bed no admits and we had a pediatric arrest come in. So the pediatric arrest was managed with the assist of the second doc that took a lot of resources and a lot of staff kind of emotion which definitely affected the flow of the department and it was a challenge in that it was something that was hard to pull back on training for necessarily."* – SJ-42-FL (Attending) *" So it was one of our typical days in the emerge. So, as always, we had no beds, lots of critical patients. … We had 4 CTAS1s. It was a night shift. We had 4 CTAS1s over about 4.5 hours. Our department was full. Our waiting room was full, and so there was a lot of decisions about who to move to where and when…"* – HH-35-JA (Attending)

In general, the residents tended to favor describing busy days with regards to Single-High-Acuity Cases or High-Volume Days. The residents did not usually consider the context of the "busy days" as opposed to their more senior colleagues. Attending physicians tended to focus more on systems level issues, such as: nursing priorities, staffing issues (i.e. number of absentee staff), physical plant issues (i.e. location of sick patients), "bed-blocking"/admission volume, and volume of handovers. Only one resident mentioned the waiting room or admission volumes, as opposed to the majority of attending physicians who noted these phenomena.

7.1.2 Factors that Contribute to Perceptions of a Busy ED

There were also multiple factors that contributed to perceived busy-ness. These factors were found to be along three themes: 1) External Factors; 2) Physician-related Factors; 3) Patient-related Factors. Table XVI depicts the various factors in each of these three areas.

Table XVI: Factors that contribute to perceptions of a busy emergency department

External Factors that make the ED feel busier or more difficult to manage

Resources
- Technological problem (eg. IT issue, computers down, not enough computers)
- Human resources/ Nurses
  - Unknown team members unable to trust team (MDs / resident / nurses etc.)
  - Multiple learners with varying skill sets are hard to balance.
    - Junior learners often slow you down
- Lack of patient care areas (e.g. beds)
  - Gridlock / Bed blocking
    - EMS offload delay
    - Filled with own patients
    - Filled with others' patients (e.g. admissions)
- Materials required for patient care (supplies, etc.)

Different shifts (e.g. overnight)
- Mondays – due to increased volume
- Nightshift
  - Fatigue
    - Increased Errors
    - Decreased concentration

Site-specific nuances
- Variation in culture - diligence
- Skill sets (especially lack thereof at rural sites)

Physician-related Factors that make the ED feel busier or more difficult to manage

Increased need for concentration / diligence

Tasks that are required of the physician
- More tasks to do
  - Increased monitoring / attention demands
  - stay up-to-date with charting
- Reassessing
  - Lack of control over timing of reassessments
  - Takes time
  - Need to reorient to patient again
- Decisions on action
  - What to do next with yourself
  - What to do next with the patient care
  - What to do next with multiple learners

Patient-related Factors that make the ED feel busier or more difficult to manage

Single Time-Consuming Cases
- Psychiatric patients
- Not given needed/correct information about sick patient
  - Mis-triaging of patients
  - Admitted patients who had been ignored and then deteriorated

- When a case does not seem to make sense (due to lack of experience or an atypical archetype)
- Cases where procedures are required
- High Acuity Case (Single cases)
    - Nursing pressure to act
    - Don't have Medical expert/decision-making
    - VERY high acuity patient arrives while department is busy
        - Active Resuscitation Required
        - Pediatric arrest
        - Vital Signs Absent (VSA) patient
        - Rapid Atrial Fibrillation (AFib)
        - MVC patient (Boarded Collared)
        - Intubation
        - Complexity of case
        - Emotionally charged situations
            - Hard to recover and to not carry over emotions

Multi-patient environments

- Multiple interruptions
- Failing to mobilize all available resources / space
- Increased cognitive load when there are more patients to manage concurrently
    - Integrating multiple sources
    - Multiple Decision points
    - Multiple answers (ways to proceed)
- Missing a sick patient accidently
- Wait times
    - Metrics for performance (Flow targets)
- Competing/conflicting interests of different patients
    - Timing to see
- Volume of patients to see
    - Feeling overwhelmed initially
    - Multiple zones
    - Waiting room full of patients
    - Acuity
        - CTAS
        - Vitals
    - Patients handed over by other physicians

Residents tended to mention reassessments as a source of increased busy-ness. Specifically, they expressed concern over the unanticipated nature of these reassessments, and how the task of reassessment would often detract from their other patient care duties. They also more frequently mentioned interruptions or their difficulties with integrating information from multiple sources and using these to make decisions (i.e. being indecisive about having multiple ways in which to proceed). Unique to the residents' interviews were situations where supervising physicians were sources of the 'challenging' situations. One resident described a situation where a supervising physician provided them with a number of patient charts all at once and asked them to prioritize

their patient-care tasks. The following is the verbatim quote: "I was handed six charts and told how to prioritize them, to best see my patients, we also had fifteen patients waiting in the waiting room that had to come in." – SJ-26-SM (Resident)

Multi-patient environments were perceived differently between the two groups as well. Attending physicians were more likely to describe both the recalled busy ED situation *and* their approach to handling a difficult situation, while residents merely described their difficult scenarios.

Attending physicians tended to describe more multi-patient environments when describing factors that resulted in busy or difficult-to-manage situations. Some residents and attendings noted that there were certain patient-specific factors that added to the perception of busy-ness. Both populations tended to describe high acuity patients as a source of additional busy-ness. Attendings, however, were more apt to describe phenomena such as wait times, bed-blocking, and/or needing to effectively deploy house-staff.

7.1.3 Teaching & Learning Strategies of ED Management & Prioritization

In this section, we analyzed responses that seemed to describe what attendings and residents felt were strategies used to teach the skills required for being good at handling a busy ED (i.e. improving ability to prioritize and manage multi-patient environments). There were three main types of strategies whereby the physicians recalled being taught, or, now use to teach others.

These three types of strategies fell mainly into the following thematic areas:

1) Formal Teaching (e.g. Didactic content delivery)

2) Observation (whereby the learners observe the teachers)

3) *In situ* Emergency Department Instruction (including informal, on-the-job teaching)

The details of these strategies can be found in Table XVII.

Table XVII: Teaching & learning strategies of ED management & prioritization

Strategies denoted by an asterix (*) are strategies that are learner-driven, and NOT initiated by the teacher. *Italics* denote items added in the member check.

Formal Strategies

- Formal teaching
  - CTAS system training

Observational methods

- Lack of other formal instruction
  - Especially for juniors
- Largely, this is an 'intuitively learned' process*
  - perceived as part of the "hidden curriculum"
- Role-modeling
  - Demonstrating correct attitude
    - working efficiently and industriously
  - Learner actively observes role models*
  - Learner is invited by attending to see multiple patients (ride along)
  - learner "spies" on attending and observes their actions, tacitly inferring meaning from their actions*

In Situ Instructional Methods (i.e. active teaching strategies used at the Emergency Department on shift)

- Positive encouragement
- Collaboratively solving problem with teacher
  - Running through specific scenarios with junior ("find me a resuscitation bed")
- Informal conversation with staff
  - Think aloud for instruction (e.g. looking at a board and explaining what they are thinking and what they are about to do).
    - With or without discussion with learner
  - Teacher provides clinical pearls, tips, pointers
    - Coaching (adjustment of plan after discussion involving senior resident to discuss plan)
    - Debriefing actions with staff (after actions, discuss and talk about how to change)
    - Making time to address this when situation is calmer
    - Guide senior learners in deployment of junior learners
  - "Run the board" - Joint review of department with staff
  - Storytelling – tells learners about recalled difficult situations ("cautionary tales")
    - normalization of imperfection
  - "Walk-around" – attending takes learner around to department in an effort to help them gain situational awareness. Along the way, they ask the following questions:

- Where is your next resuscitation bed going to come from?
- Where are your outs?
- Who can you call for help?
- Looking at the tracker, the way it looks right now, how would you prioritize the patients that you have currently?

- Troubleshooting problems – discussions around:
  - ways to get help
  - systems-level procedures to improve bed-space issues

- Experience – Learner manages multiple patients at once
  - Learner is given the reins: Performing the actual job of live prioritization
    - "Thrown into deep end"* – Unknowingly or with little preparation, learner is asked to take the lead on "flowing" department (full experience, little coaching)
      - "Trial and error" – learner repeatedly given the lead, learns through experience and making mistakes along the way.
      - Reflective practice – Learner attempts to manage and prioritize multiple patients, reflects on how they did it. This is distinct from the above since in this scenario the learner mindfully and independently initiates a reflective component to improve.
    - Shared decision to use strategy at beginning
      - Learner asks teacher for permission to have this experience*
      - Learner is pushed by teacher to do it (out of comfort zone)
  - "Divide and conquer" - Defines limits of resident's responsibility (assigns "section" – e.g. Resuscitation; Trauma, Cardiac)
  - "Safety net approach" (staff sees more and more patients, and assists in flow management as learner gets more overwhelmed)
    - When SUPER BUSY – just takes over 100% to captain the ship

- Developing Gestalt / Acumen via Experience
  - Coaching on how best to incorporate judgment of other clinicians (Triage nurse, bedside nurse, paramedic)
  - Coaching around trusting colleague
  - Helping learners to use "archetypes" for a patient (i.e. creating "classic" cases that are representative of how to proceed):
    - Archetypal hierarchy (e.g., abdominal pain more important than psychiatric) for comparing patients
    - Archetype helps with disposition planning
    - Deciding what tests to order based on archetype / thin slicing
    - Using archetype to plan anticipate time needs of archetype
  - Learning to identify a "concerning story" based on the triage note
  - Visual inspection (i.e. eyeball)
  - Double checking to see if you agree with triage
  - Re-triage patients when necessary (i.e. when it has been hours since the patient was first seen)

- Strategies for teaching residents the skill of leading their team (managing human resources)
  - "Deploy the attending": Inverted roles between learner and attending (attending sees patients independently but reviews with learner)
  - Recognition of needs and skills of different learners
    - Instructor trust with learner
    - Staggering review with learners / reviewing efficiently
    - Appropriate delegation of learners and task assignment
      - Take into account skill level of learner
        - Speed

- Independence
- Alignment of learner interests to availability (Cases for learning)
  - Ensuring cases are of educational merit and not "scut"
- Utilization of learners in a manner which increases department flow while providing learning opportunities
  - procedures / family conversations etc.
  - Take into account time best spent (e.g. providing learners with interesting but higher-time requirement cases, while attending sees quick cases that are routine/simple, such as a prescription refill request)

7.1.4 Barriers to Learning ED Management & Prioritization

In this section, we analyzed responses that seemed to describe what attendings and residents felt were barriers to teaching or learning the skill of prioritizing and managing multi-patient environments. There were three themes that arose in the interviews regarding barriers to teaching and learning the tasks required to manage a busy ED. These barriers fell mainly into the following thematic areas: 1) lack of foundational skills in the residents, 2) lack of teaching capacity in faculty, and 3) other competing interests. The details of these strategies can be found in Table XVIII.

Of note, some of the key barriers discussed were around the preparedness (or lack thereof) of residents to take on the skill of balancing multiple patients. Being able to handle individual cases and anticipate the needs of those cases was thought to be an important precursor skill to taking on multiple patients. Additionally, in order to be entrusted with attempting to manage the ED, attendings identified that it would be important for learners to be able to anticipate their patients' needs and disease course, understand/diagnose system difficulties, and the ability of the system to accommodate those within the current context.

If a learner did not display these precursor skills, it was unlikely that the attending would trust them to attempt a further managerial role. As such, this explained why many junior learners noted that they had minimal exposure to the basic tenets of task prioritization, and they were often assigned duties by their attendings and were not prompted to take on multiple tasks at once.

Table XVIII: Barriers to learning ED management & prioritization

Lack of Foundational Skills in the residents

- Lack of clinical experience
  - Not having enough experience to anticipate needs of typical patients (i.e. not having breadth in archetypes – e.g. typical "abdominal pain" requires X and takes Y long to get done)
  - "chess pieces and how they move", e.g. thinking ahead about possible strategies
  - Learner not recognizing the sickness
    - Not anticipating change in patients
- Difficult individual cases
  - Little exposure to very emotionally charged cases and how to deal with this (e.g. dealing with low acuity patients after resuscitation of child)
  - Very high acuity patient (very sick) = difficult to teach
- Minimal exposure to the basic tenets of task prioritization as junior resident
  - Deployment of junior directly by staff, not actively involved in multiple tasks
  - Unable to cope with multiple patients
  - Educational value of individual cases prioritized over systems level education
- Poor understanding of players in system (i.e. other health care providers and whether you can trust them; questioning competence, etc..)
- Unable to assess system capabilities
- Lack of trust in the learner (e.g. Attendings don't always trust learners to "run the department" or act as a manager – especially junior residents.)

Lack of Teaching Capacity in Faculty

- Poor faculty development
  - Teaching strategies tied ONLY to how you were taught
  - No instruction on department management post-residency
- Faculty find it hard to determine how best to teach, since there is a high amount of heterogeneity in the needs of learners

Competing Interests

- Competing interests of learners' needs and patients' needs.
- Need for efficiency –There was generally a sense of tension between Efficiency vs. Education - Balancing time to assess the case (efficiency) versus learning value of the case (education)
  - Learners are inefficient
  - Metrics of system (i.e. pay for performance metrics) may deter attendings from letting rookies take the reins since it slows them down and may result in penalties for the hospital
  - Time resources / Human Resources (redundant work if learner does a simple task)
  - Not always time to observe and provide feedback (especially in high volume situations)

7.1.5 "Rules of the Road" - Approaches and techniques recalled as being helpful in handling multi-patient environments

In this section, we analyzed responses that seemed to describe what attendings AND residents felt were pieces of advice or general 'rules' that they had been taught (or that they have utilized) to prioritize and manage multi-patient environments. The advice could largely be grouped into two main themes:

1) Advice for Individual Physicians – i.e. advice regarding how to conduct one's own actions
2) Team/Systems-level Advice – i.e. advice on how best to run the team and/or function within the greater context.

See Table XIX for details regarding the 'Rules of the Road' that we discovered during our interviews. In this part of the analysis, there were two major subthemes that seemed to stand out in the exit interviews: the role of parallel processes and the role of trust in the system context.

Table XIX: "Rules of the Road" – Approaches and techniques recalled as being helpful in handling multi-patient environments

Advice for Individual Physicians

- Utilizing parallel processes - Know what resources are available and anticipate team members' abilities to do tasks (i.e. write orders for one room's nurses, go to another area, do same)
  - Need to leave bedside of sick patients
  - Write orders and walk away
- Use of an Organizational system
  - Follow-up investigations before seeing new
  - Prioritize reassessments
  - Mindful of time/ Wait time for patient / Time in Dept.
  - Own personal time spent
- See simple stuff first then seek complex
  - See quick things yourself
- See sickest patients first
  - CTAS score
  - Abnormal vitals
  - Early analgesia for patients in pain
- Keep patient disposition in mind
  - Earlier the better
  - Incorporate gestalt
  - Group patients by "complaint"
- Meticulousness / double check
- Be efficient with testing
  - Hone/Use your clinical gestalt so as only to order necessary tests/investigations that answer an

emergent question
- Visual inspection
  - Order tests after seeing patient (so as not to over order)
- Be Mindful of yourself and your abilities
  - Mindful of cognitive load
  - Don't see more patients than can manage

Team/Systems-related Advice
- Diagnose the problem in department flow
- Triage notes are not always accurate
  - Read Triage Note to double check that they are not mis-triaged
    - Subjective CTAS (seems objective falsely)
  - Trust objective parts of triage (eg. Vital signs)
- Call for help
  - Delegate to your team, but check in with them.
    - Trusting team (resident / nurses etc.)
      - Trusting consultant
    - Encourage others to come to you with problems (create positive culture)
    - Use your resources
    - Communicating with consultant
      - keeping track of consultants called
- Gather geographic / space information
  - Where all the sick patients are
  - Where all the patients who are in critical care beds who are movable are
  - Who's in OBS beds
  - Who doesn't necessarily need an OBS bed
  - Who could potentially move to RAZ; as well as trying to get a sense of what my capacity in other parts of the hospital are
  - How many beds do I have?
  - How many available medicine and non-medicine beds are there?
  - How many DWAs are available (DWAs: designated waiting area)?
  - How many contingency beds do I have?
  - How many unit beds do I have?
  - How many patients are we expecting?
  - How many critical patients are we expecting to come in?
    - Speak with nurses
    - Communicate with other departments in hospital
    - Speak with EM colleagues
  - Maintain Geographic / Spatial awareness
    - Not to waste travel time / be personally more efficient
    - Rearranging patients to optimize ability to observe
    - Need to go between rooms
  - making due with space available, seeing patients where you can
- Keep overall departmental situational awareness at all times
  - Gather all available information from all sources
  - Free up nursing resources
  - Awareness of expectant volume
    - Incoming EMS

The Role of Parallel Processes in a Team Environment. Of note, one of the big 'rules' that was mentioned by the attendings was that they often initiated parallel processes. In fact, the inability to very quickly initiate parallel processes (i.e. moving two patients to be in the same room next to each other, 'eye-balling' four patients within a minute, calling out orders to a trusted RN in one room while attending to another patient) during the tracker-board exercises lead a number of them to remark that it made the exercise seem very contrived. In contrast, residents did not mention the use of and/or incorporation of this in their practices. One attending participant describes the advantages of folding other members of the team into their patient care activities:

> *…[I]n the environment in which I work, I have a complicated, complex team of people to assist with residents, students, learners, experienced nurses, and in the case of many of these kinds of tracker [board scenarios] where there are simultaneously critically ill patients deploy a team in a much more sophisticated fashion than this [simulation] allows for.*

One attending participant (HH-31-BA) describes this vividly in this passage:

> *So, carrying my phone on me, probably realistically between five minutes a patient, realistically, so I would probably look at all three in thirty seconds, decide in my head who is the most critical so even though they are a STEMI and they need to go to the HIU and they have had chest pain for two hours, their vitals are fine and they are, I would probably prioritize that person the least, same with the labouring patient, if the head is not at the entrance then I have some time and I can call OB and have them here.*

Trust & The Role of the System. One of the key comments in the exit interviews was that the participants felt lost when they could not consider the other "players" on the board – i.e. their colleagues. For instance, when a patient was listed as being under the care of another physician, both residents and attendings felt that they could not gauge whether they should trust the other physicians within the situation.

One Resident participant (HH-26-MA) noted:

> *It's frustrating not knowing the other docs, the other MRP's whether essentially whether I trust their judgment and think they are competent, that would really change how much I look at their patients. It seems like most of what I use is I like presume a diagnosis from the triage note and that is presuming you have an accurate triage note. And then base it on vitals.*

An attending participant (HH-35-JA) described similar frustrations:

> *I would take into account who the triage nurse is because there are some triage nurses who I give more credence to than others, but we don't tell anybody about that. They are also based on the emerg[ency]physicians, so if there are some emerg[ency] physicians - not to name names - but there are emerg[ency] physicians who if they are in there seeing the patient, I don't need to go in and see the patient because I know that they will be well managed. I will walk by, lay eyes on them, but really just so that I know what's, I can, I can say that I have seen them. There are others who I will go in and chat with the bedside nurse, possibly lay eyes and hands on the patient because I am less sure about what's going on, because I have certain concerns. I think that is really the process that also comes into play, so today I assumed that everybody was a dunce, because I don't know any of the doctors that were listed because they were all fictitious, but there is a lot of variability based on who the triage nurse is, who the charge nurse is, who the other doc is in terms of how I go through that list.*

Clearly, these participants noted that they often incorporate a judgment on their colleagues into their algorithm for analyzing the situation. Not only do they wish to know whether they can trust their colleagues (and therefore, ignore the patients listed as being under the care of another physician), but they imply that some triage notes (and therefore, the assessments by the triage nurses) are more accurate and trustworthy than others.

Moreover, in a system wherein trust exists, participants described that they would often engage their trustworthy colleagues when they were faced with multiple sick patients.

One Attending participant (HH-31-BA) describes this phenomenon:

> *So the exercise is a little artificial in that there is not one patient that you are going to go see and at the same token there are patients that we were asked that if there was something to get started and then see them after that hour, and really I think it comes down to do you think simultaneously if you have any acute stroke, if you have an acute STEMI and you have a patient that is crowning with a vaginal delivery I am probably going to call a cardiologist immediately or the usual therapy on the STEMI, confirm that it that is a STEMI and do screen labs and then walk away, look at the crowning patient, call OB immediately and then call a stroke team and CTA about the stroke patient and I do that probably simultaneously.*

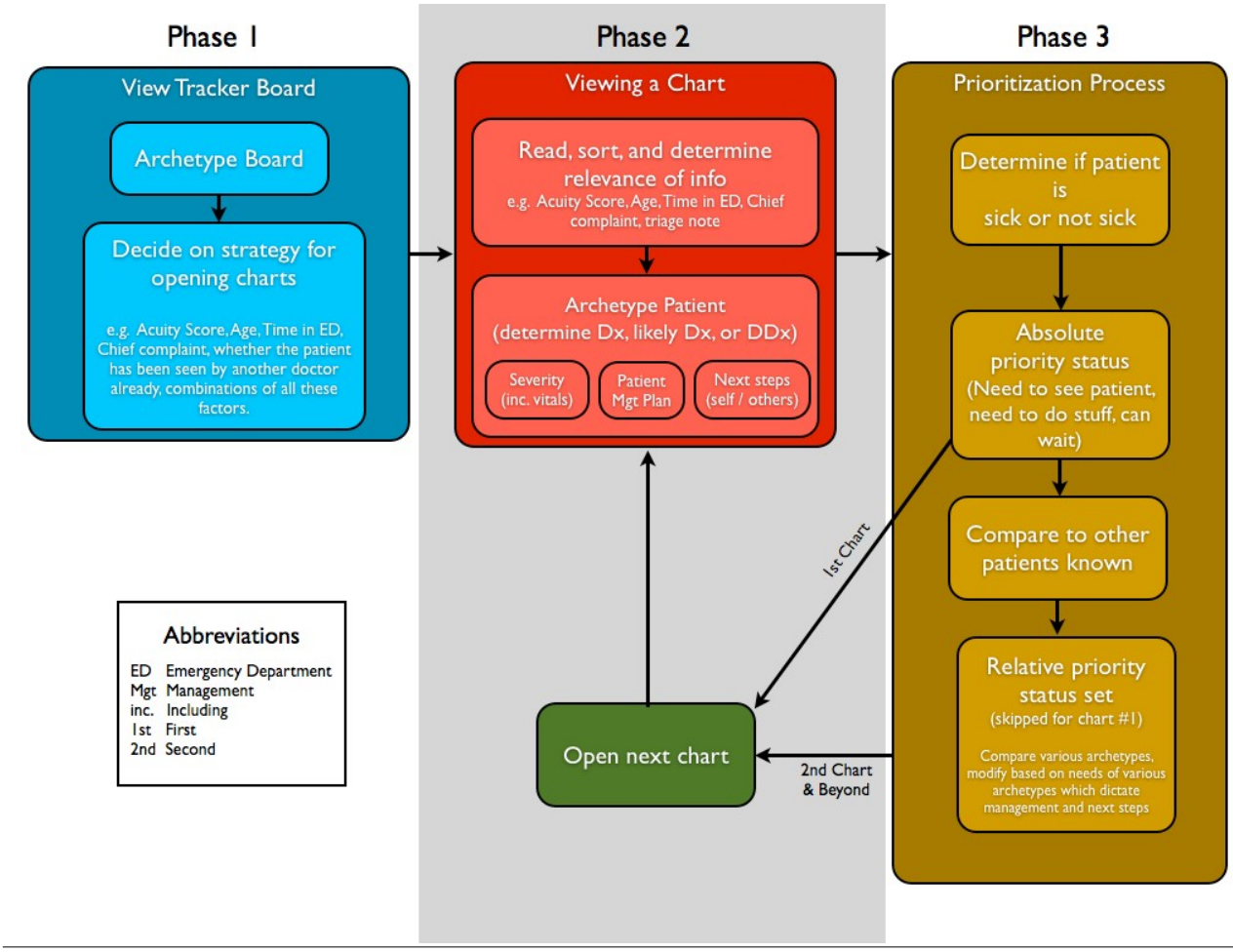
Similarly, another attending (SJ-32-JA) noted how readily they entrust the other ED team members (i.e. trusted nurses) to initiate orders and to alert them if a patient requires attention:

> *"I think I do rely a lot about on verbal orders, nurses will come and tell me and acute care 4 is sick, 4 is sick, three is sick and they might give me a brief blurb, and I would right away give verbal orders, septic orders, I might even order antibiotics before I have seen the patient. That is something I will do if things are getting really crazy."*

8. RESULTS OF THE THINK ALOUD

The following is a diagram based on the 'think aloud' process. In order to generate this diagram, we analyzed the think-aloud transcripts for the final five scenarios, and then identified all the processes involved in prioritization exercises. We then assembled these steps back into this visual representation, which depicts the final cognitive task analysis of the prioritization exercise. See Figure 10 for the overview of the prioritization process.

Figure 10: A typical sequence used by participants to prioritize patients in a simulated multi-patient environment



There are three main phases in the cognitive task of setting priorities.

1) Phase 1: Viewing the Big Picture
2) Phase 2: Archetyping the Patient
3) Phase 3: Creating a Relativistic Prioritization List

8.1 Phase 1: Viewing the Big Picture

The first step is taking in the big picture (i.e. viewing the entire tracker board). During this phase, participants make a determination of the complexity of the simulated scenario. For most participants, this at times resulted in some sort of emotional reaction (e.g. '*sighs* this is a busy board…') or some archetyping behaviour (e.g. 'Oh, this is a scenario with lots of vaginal bleeding cases.'). Once they have made this determination, they decide upon a strategy for opening the charts. Mostly, participants opened charts in one of four ways:

1) Sequentially (top-to-bottom);
2) By order of CTAS (with higher acuity CTAS 1 cases being opened first);
3) By looking at only charts listed as "To Be Seen" (i.e. not under another physician);
4) By some other strategy (age, chief complaint, time in ED, etc.).

The Role of Trust in Phase 1

In this phase, we did see a divergence in behaviour between some physicians who displayed higher levels of trust than others. Trusting physicians (which existed both within the attending and residents populations), would more likely initiate a chart-opening strategy that would focus on 'To Be Seen' charts, and not open the charts listed under other physicians. Some other physicians would selectively open the charts of high acuity patients under another physician's

care, but not low acuity charts. Some highly skeptical physicians opened every chart on the boards and incorporated all relevant patients into their plans regardless of the involvement of other physicians.

The role of trust in a real clinical environment was further elucidated by one of the attendings during the member check. Upon reviewing the cognitive task analysis diagram, this truly resonated with him that he usually checks to see if a patient has already been seen by someone (either another emergency physician or consultant), and that this "will dictate [his] level of involvement." (HH-35-JA). He also noted that something not captured in this diagram was the pure act of walking around the department, seeing the patients, and engaging with the nurses to determine if there are any patients in need of assistance regardless of their admission status. Notably, in our simulation, admitted patients were absent from the tracker boards, and this participant wished to ensure that these unofficial tasks were also noted in this study to more fully encapsulate how physicians might prioritize patients in the ED. Specifically, he wished to find the patients who were "… still potentially sick, referred to but not seen by another service." (HH-35-JA).

8.2 Phase 2: Archetyping the Patient

In this phase, the physician opens a chart and begins to read the information available. During this phase, participants initially quickly scan all available information that they deem relevant (usually the Age, Chief Complaint, CTAS score, triage note, triage vitals, and more rarely the time in ED, past medical history, medications, allergies, and previous medical records).

After extracting relevant information, participants then engaged in a phenomenon that we have dubbed 'archetyping' – which can be thought of an operationalizable, ED context-specific illness script for these simulated patients.[92,93] Specifically, this is the act of filing a simulated patient within a certain categorization (e.g. Young, healthy, stable female patient with vaginal bleeding vs. Young, healthy, UNSTABLE patient with likely ectopic pregnancy). This process incorporates a filtering process wherein the participant utilizes relevant elements within the patient chart to create a construct which best describes the patient. This then allows for the physician to make a determination about next steps in investigations (i.e. their presumptive diagnosis allows them to determine what blood work might be needed for the patient). An interesting observation during analysis of the transcripts revealed that attending physicians were much more certain about their patient archetypes, and tended to quickly label the patients upon reading the available information. Often attendings would go so far as to make a diagnosis, or make a best guess about a patient's presumptive diagnosis or the leading differential diagnosis. Take the following quote for example (boldface denotes emphasis added by authors):

> *"…We have three vaginal bleedings, oh that is always hard to keep track of! We would look at the CTAS 1 first. So tachy [sic, as in tachycardic], having heavy period, 34 year old, irregular periods but we don't know if she could be pregnant. Okay, um… So this one is tachycardic, positive preg [sic, as in pregnancy] test, short of breath, and appears in distress with severe pain. So she could be* ***ectopic pregnancy****, she's tachy…so more tachy anyways than the first one whose heart rate was 110." (SJ-48-HE, Attending)*

Some participants tended to be less certain in some cases, or at least less willing to speak aloud about their presumptive diagnoses. These participants would often wonder about multiple diagnoses, and some would even stop short of this, hinging on surface features such as vital signs to make their decisions. The following quote illustrates an attending and a resident remarking on their differential diagnosis for one case, and expressing diagnostic uncertainty in another case.

> *"And then I will check my CTAS 3 patient. Sounds like an alcoholic pancreatic or gastritis or something with relatively okay vitals, not super worried about that one. My CTAS 4 I am not sure what is going on there but vitals are normal. definitely not an emergency…"* (HH-31-BA, Attending)

> *"Next patient is a thirty-three year old with abdominal pain, there is a bit tachycardic, drank a lot of alcohol on their trip but otherwise well. So again probably not someone who needs to be seen urgently and then finally a sixty-two year old with abdominal pain who is febrile, hypertensive, and tachycardic and although the pain has been there for two months it is worse after eating so I think I am considering whether or not this patient has acute cholecystitis or pancreatitis based on the fact that they are febrile and meeting kind of sepsis criteria…"* (SJ-29-LE, Resident)

8.3 Phase 3: Creating a Relativistic Prioritization List

During this phase, the physician uses the available information to make a determination regarding the priority status of a patient. During our think aloud processes, it seemed clear that most participants had 4 steps within this phase:

1) Determine whether they believed their patient was sick or not sick;
2) Decide how emergently this patient needed the doctor's attention, a nurse's attention or orders fulfilled, or if they could wait – i.e. a absolute priority was established;
3) The newest patient was then compared to other known patients in the same scenario;
4) A relativistic prioritization list was then generated.

Relative priorities and Archetyping

The idea of the archetype was very strongly associated with the relative priority setting process. During this phase, participants leaned heavily on the previously determined archetype (e.g. the Stable Vaginal Bleeding case vs. the Unstable ectopic pregnancy) substantially.

Used previously, the quote by resident SJ-29-LE more fully illustrates this phenomenon:

> *"Next patient is a 33 year old with abdominal pain, there is a bit tachycardic, drank a lot of alcohol on their trip but otherwise well. So again probably not someone who needs to be seen urgently and then finally a sixty-two year old with abdominal pain who is febrile, hypertensive, and tachycardic and although the pain has been there for two months it is worse after eating so I think I am considering whether or not this patient has acute cholecystitis or pancreatitis based on the fact that they are febrile and meeting kind of sepsis criteria I would prioritize them over seeing them over the abdominal pain patient."* (SJ-29-LE, Resident).

The above quote illustrates the resident comparing a patient with undifferentiated abdominal pain versus a patient with what she worries has intra-abdominal sepsis. Most participants relied heavily on the archetypes they had generated for their patients previously, referring to patients as ‘the ectopic’ or ‘the old person with abdominal pain’.

9. DISCUSSION

In our study, we have attempted to determine if there are differences in the thinking processes of experienced attendings ("expert") and junior residents ("novice") physicians as they prioritize patients and tasks within multi-patient environments. Our findings have shown that using three different techniques to elicit the cognitive processes of our participants has yielded very different findings in each phase of this study.

9.1 Qualitative findings from the initial interviews

In the first phase of our study, we discerned that what seemed to be a difference in the way that junior physicians (residents) perceived challenging scenarios. The residents in our study tended to view single hyperacute scenarios as challenging cases, as opposed to attendings, who considered the complexities of system and how individual cases were situated within the complex ED scenario. This difference in perception may suggest that the junior physicians find the main challenges in clinical care to be centered around their action in difficult clinical scenarios, whereas attendings tended to view the single hyperacute cases as part of the whole ED scenario. This may be purely a function of their situational awareness, but may also be an artefact of the difference in role for these players within the system. Attending physicians tend to 'run the ED', and junior residents tend to be entrusted with caring for their smaller portfolio of patients.

This is interesting as our results showed that there were a number of explicit processes and strategies that emergency physicians used to assist them in being more efficient in the ED. Section 7.1.5 summarized many of their recalled strategies for being more efficient. Notably, many of these strategies related to macro-level tasks such as utilizing and trusting other

practitioners in the system (including nurses or residents), as well as many meso- and micro-level suggestions about personal conduct.

Meanwhile, it was interesting to find that most of the participants were of the impression that prioritization was not a skill that was formally taught, but instead it is learned in the clinical environment. Many of the answers of both the attendings and residents revealed a significant role of experiential learning for developing this skill set presently. Not surprisingly, many of the teaching strategies listed by attending physicians were mentioned by residents as teaching/coaching methods that they had experienced in the clinical setting.

Section 7.1.3 revealed the thoughts of participants on how they learned or taught these prioritization processes. Meanwhile, the most interesting finding within our qualitative findings is that most attending physicians stated that they were very seldom taught the skills that made them more efficient in a formal manner. Attending physicians were quite able to describe their own personal teaching techniques around these skills, however. These included strategies like thinking aloud, co-problem solving with their residents, providing actual experiences to residents in the ED for managing multiple patients, and direct observation of residents engaging in the skill with feedback. Reassuringly, most of the teaching techniques described by the attendings were mentioned by the residents. Residents were more apt to describe strategies for how they were learning these skills. Many of these junior residents described some level of role-modeling/mimicry and occasional coaching that occurred in the clinical environment. Most physicians (both residents and attendings) described processes where they simply learned the task by doing it repeatedly – suggesting that experiential learning is important in the acquisition of this skill.

Regarding barriers to skill acquisition (Section 7.1.4), these findings are most interesting when the actual task analysis diagram generated in Section 8 is taken into account. As denoted in our diagram depicting the cognitive task, it seems that creating a robust archetype for various patient presentations was very critical within the workflow. It seems that in discussing barriers around managing multi-patient environments, attendings were unwilling to entrust learners in these situations when either they lacked clinical experience (i.e. were unable to recognize archetypes or use these to steer management) or lacked systems awareness.

9.2 Quantitative findings from the experimental sorting tasks

We intended to explore if there were differences between experts' and novices' thinking around prioritizing patients in multi-patient environments. In the quantitative portion of our study, we failed to detect any specific effect of 'expertise' in either time to decision or homogeneity of decision-making. Perhaps our present exploratory study was underpowered to detect any differences in time-to-prioritization-to-decision or complexity. Increasing complexity (as measured by increasing number of patients within the three conditions) did not result in a sharp fall within the intra-class correlations (ICCs) for the decisions made. This suggests that individuals likely choose (and stick to) similar approaches within their own prioritization strategies, and may not be greatly affected by increased complexity.

9.2.1 The Effect of 'Expertise'. Throughout the ANOVA analyses, when time to completion was treated as the dependent variable, expertise did not seem to interact strongly with the various scenario manipulations (Similar Acuity, Similar Presentation, Extraneous Patients). Of note,

there are a few tracker boards (e.g. tracker board with 2 patients of similar acuity and 0 extraenous patients, shown in Table 6) in which attendings tended to have a higher agreement (ICC 0.64 vs. 0.39), which suggests that there may be some cases wherein experts may have a more similar approach in that case. That said, the 95% confidence intervals are overlapping, and therefore, this is mainly hypothesis generating at this point. More research into the nature of the differences between the attendings' decision-making processes will be required to determine the reference standards for establishing an 'answer key' for simulations where residents can practice and develop this skill. There may be, in fact, multiple 'correct' answers for how best to approach a given tracker board scenario, and this may be useful in exploring further ways to better inform differences in practice patterns on this topic. Determining a way to quantify practice variations and determine normatively acceptable variations of said practice is something that, at the present time, the decision-making literature in medical education does not handle well. To date, we do not have good measures for accommodating teaching and assessment strategies for scenarios with multiple possible 'right answers' or approaches. In the clinical setting, individual teachers are asked to make judgments about what is 'reasonable', while in testing platforms we are rather more dogmatic with our approach to the correct answers. Recently, one study has examined the heterogeneity of EPs with regards to their adherence to known guidelines,[94] showing that contextual and patient-level factors may sway decision-making quite substantively. In terms of the assessment literature, the script concordance testing (SCT) format has recently been debated and the merits of simply finding ways of 'handling' the heterogeneity of expert answers has been called into question.[95,96] As we consider more and more naturalistic scenarios like the one examined in this thesis, it seems that perhaps we will need to find ways to handle varying-yet-

reasonable approaches, and acknowledge that practice variation is not something that always needs to be ironed out, but rather should be distilled for our learners to better understand.

9.2.2 The Effect of the Scenario Manipulations. An interesting finding within our study was the significant interaction between increasing numbers of extraneous patients and similar acuity. With increasing number of extraneous patients, marginal means estimates of completion times increased when there were generally more similar acuity patients. This finding suggests that in the setting of a very busy emergency department scenario with many patients, more patients with similar acuity may result in more difficult prioritization processes. In the other situations, in scenarios with two patients with similar presentations (or chief complaints) there was a trend towards lower estimated marginal means for completion time when either there were more patients with similar acuity or more extraneous patients.

9.2.3 Effect of Exposure to the Tracker Boards. What we were able to detect is that there may have been substantive learning that occurs through course of this experiment, specifically for scenarios with increasing number of extraneous patients. It is not possible, however to discern whether the decreased time to completion is due to increasing familiarity with the simulated tracker board interface or a derivation of rules with regards to the heuristics they apply to various tracker board scenarios. Recall Section 6 where we examined the interaction between exposure to a given type of condition and time spent on the scenario. The main effects detected based on the encounter suggest that individuals may have been learning to some degree for conditions with increasing number of extraneous patients. However, individuals did not display a similar learning curve in the other two conditions. These findings suggest that perhaps each of

our different factors may require different learning times. Bearing in mind the qualitative findings within this thesis, it may be inferred that the presence of extraneous patients was an easier condition under which to learn within the tracker board experiment. After one or two encounters, the participants decided on their algorithms for opening charts, many participants choosing to trust the other physicians within the tracker board simulation, resulting in lower times.

With the other conditions (multiple similar acuity patients, or multiple patients with similar presentations), more complex thinking was required. In particular, when comparing two or more patients with similar acuity, participants had to engage in relativistic decision-making, comparing patients who are both of similar severity of illness (at least by the CTAS criteria), and this may have resulted in a longer decision-making time, requiring the participant to weigh the idiosyncrasies of two very different cases before arriving at a decision point.

9.3 Qualitative Findings from the Think Aloud

Of note, our cognitive task analysis revealed that there was not a substantial difference in the overall structure of the cognitive task of prioritization in the expert and novice groups in the simulated scenarios. This suggests that by the end of our experimental sorting exercises, the two groups had created a similar mental model for how best to initially handle a multi-patient prioritization scenario.

The most interesting aspect of the think aloud was the process by which the physicians in our study created archetypes. The depth of archetype generation was the key difference between our

residents' and attending physicians' thinking processes. The residents' thinking processes seemed to be weaker, wrought with more uncertainty about how next to proceed and multiple considerations. Attendings seemed to be more committed to their prioritization decisions.

9.4 Findings Revealed by our Mixed Methodology

One interesting finding was the non-linear effect of increasing numbers of patients with similar presentation (i.e. chief complaints) on time to completion, especially when taking this finding in concert with the archetyping process we have proposed in our qualitative methods. In table 15 and figure 6, we showed that there was a non-linear relationship between the increasing number of patients presenting with the same presentation; that is, there was a decrease in the time to completion in instances where there were two patients with similar presentations, but with four patients with similar presentations, completion times markedly increased.

When taking the archetyping process described in our qualitative work, we posit that the participants may be able to simple treat both patients with similar presentations in a similar manner in our sorting exercise (i.e. both patients with vaginal bleeding get X testing), whereas with four patients of similar presentation, the decision to prioritize one over another required a deeper archetyping process to differentiate between all the *seemingly* similar patients. It could also be an effect of overly similar archetypes creating a dilemma for our participants (i.e. how to pick and prioritize ONE patient with chest pain above all others, when all else is equal). However, based on our critical incident interviewing and 'think aloud' processes, attributes such as wait times or age of the patient would often come into play, and as a result, these attributes

became part of a participant's archetypes (e.g. the elderly patient with abdominal pain vs. the young man with abdominal pain).

9.5 Relationship to previous studies

The findings in this study add to the literature around physician decision-making by revealing the multi-faceted and complex parallel processes that are occurring when an emergency physician attempts to prioritize patients within a multi-patient environment.

9.5.1 Archetyping, Stacking, Chunking, and Illness Scripts

In De Groot's original studies of chess masters, it seemed that masters tended to examine chessboards and view the pieces as constellations of pieces. Numerous interactions between pieces are noted together ('this rook', 'this pawn', 'that king'), and thought of as a 'chunk'.[69] Familiar constellations of pieces are more easily recognized and recalled[97,98] and in fact Chase & Simon theorized that it is the recognition of these chunks that allow chess masters to make good moves.

Our findings in these studies mirror the findings of the chess master. Particularly, our qualitative findings revealed the critical importance of generating these archetypes before being able to enter into relativistic decision-making processes. Moreover, both attendings and residents recognized the importance of clinical experience in helping to create these archetypes, and seldom entrusted residents to proceed to managing the emergency department unless they had enough clinical experience, so as to allow them to generate solid archetypes. One might infer then, that the patient archetype is the analogy in the emergency physician world of a micro-level

'chunk', or more functionally, like one of the 'stacks' that were described by nursing literature. Chunked within that stack are the diagnostic and management algorithms, as well as an absolute priority setting, modified by the patient's appearance and vitals. When one considers that stacks have been found to facilitate experienced nurses' ability to fluidly transition between parallelized complex multi-part tasks, this explains how considering a patient as a task allows the experienced attending physicians to jump between parallelized patients' needs more fluidly.

Returning to the origins of chunking theory, it is as if our emergency physicians are playing chess – but chess with billions of subtypes of pieces. Imagine a chess game in which there are 16 subtypes of pawns, all of which could move in a slightly different and nuanced manner. Indeed, in that thought experiment, it becomes immediately apparent that in order to even play such a game, it is first necessary to understand all the various types and variations of the pieces and how they move, before engaging in any more advanced play.

The relevance of the archetyping process is that it allows us to understand why there is such a drive for EPs to engage with System 1 thinking. Essentially, to become efficient and to offload their cognitive processes, EPs are essentially gathering and then creating 'chunks' and 'stacks' of data about a patient, a process that we have dubbed 'archetyping' – a process that is akin to a highly contextualized illness scripts, a phenomenon have been previously described by Feltovich and Barrows.[92,99] Once the archetype has been determined, there is a System 1 type process wherein experienced clinicians will access the database of all their management plans and strategies to recognize the associated decision plan. The archetype then becomes the cue for the

EP to engage in a specific response, thereby reacting via a recognition-primed decision-making type process.

9.5.2 Expertise & the Role of Experience

Based on our experiment, it seems that there is great promise in creating simulation scenarios in which physicians might actually engage in practice with regards to decision-making in multi-patient environments. In the *2008 Society of Academic Emergency Medicine Consensus Conference on Simulation in Healthcare,* the question was posed if simulation could help identify expert behaviour. To this end, our study endeavored to isolate and define a skill set (e.g. multi-patient prioritization).[100] In this study, we used experience as a surrogate measure of expertise, and have found very few differences between groups. However, within the participants of our study, there are clear individual differences between participants in their time to decision-making, suggesting that there may be elements of a skill set that is not well captured in our experience-based differentiation.

9.5.3 Heterogeneity of Decisions. Previous literature has suggested that prioritization processes are ill-defined[101] and therefore difficult to discuss and study. In this study, we aimed to narrow our area of interest to the processes that govern multi-patient scenarios experienced by emergency physicians on a daily basis. Triages scores can be helpful, but as our experiment reveals, they are limited when there are multiple patients with similar acuity waiting to be seen at once.[102]

Whereas this has been previously discussed in mass casualty scenarios where triage for resources is important and where there are very defined algorithms (and therefore less heterogeneity in decision-making)[103], the more routine processes that occur on a day-to-day basis provide more laxity in the rules that govern physicians' decision-making. Emergency preparedness modules and games have shown some promise in providing experience to calibrate decisions[104]; however, in the setting of our experiment it was apparent that even our experienced physicians were highly heterogeneous in their prioritization processes. While some of these differences may have resulted from varying interpretations of the severity of illness in our simulated patients, our 'think aloud' protocols revealed that some of these differences may simply be a matter of preference or taste. Keeping the practice variation literature in mind, it is crucial to remember that the lack of homogeneity of decision-making even within groups of experienced physicians will likely preclude the use of simulations such as this one from being used in high stakes assessment. Moreover, when one is teaching using these scenarios, teachers must be mindful that there is likely a wide berth of reasonable approaches, and acknowledging this will likely be useful to help students deal with learning the skill and understanding practice variations. For instance, the data from this study might inform curricular developments wherein students are provided with multi-patient simulated patient scenarios, which have been piloted in various centres at the undergraduate medical education level.[105]

9.5.4 The Complexity of the Real ED and the Role of the Team

One of the findings from the exit interviews was the difference that attending physicians felt about the psychological fidelity of the simulation. One of the key differences was that in our exercise, attending physicians felt that they were working in a vacuum. Many of the factors that

they often took into account when making decisions regarding procedures were not available. This finding is consistent with the work by Schubert et al. which concluded that understanding organizational complexity was an innate skill that was thought to be incorporated in the cognitive tasks of expert emergency physicians.[16]

For instance, their trust of the triage nurses, the other emergency physicians in the department at the time, and even the consultants who were tending to patients already consulted are all factors many attending physicians described as parts of their thinking with regards to how they might conduct themselves. Some described how their lack of trust in colleagues might prompt them to intervene on patients referred for consultation or participate more actively on resuscitations. If they trusted the other team members in the ED, then they would redirect their attention to other factors. This relates well to other concepts that Lorelei Lingard has recently described in her writing around team-based competency.[106] The attending physicians (more so than the residents) complained of the fidelity of the simulation scenario as it removed their ability to assess the shared competence of the team, and therefore, kept them from tailoring their activities around the other components of the very dynamic, albeit simulated, scenario. Our finding mirrors some of my own previous work wherein we found that trust underpinned the relationships and conflicts between emergency and consulting hospital-based physicians.[107,108]

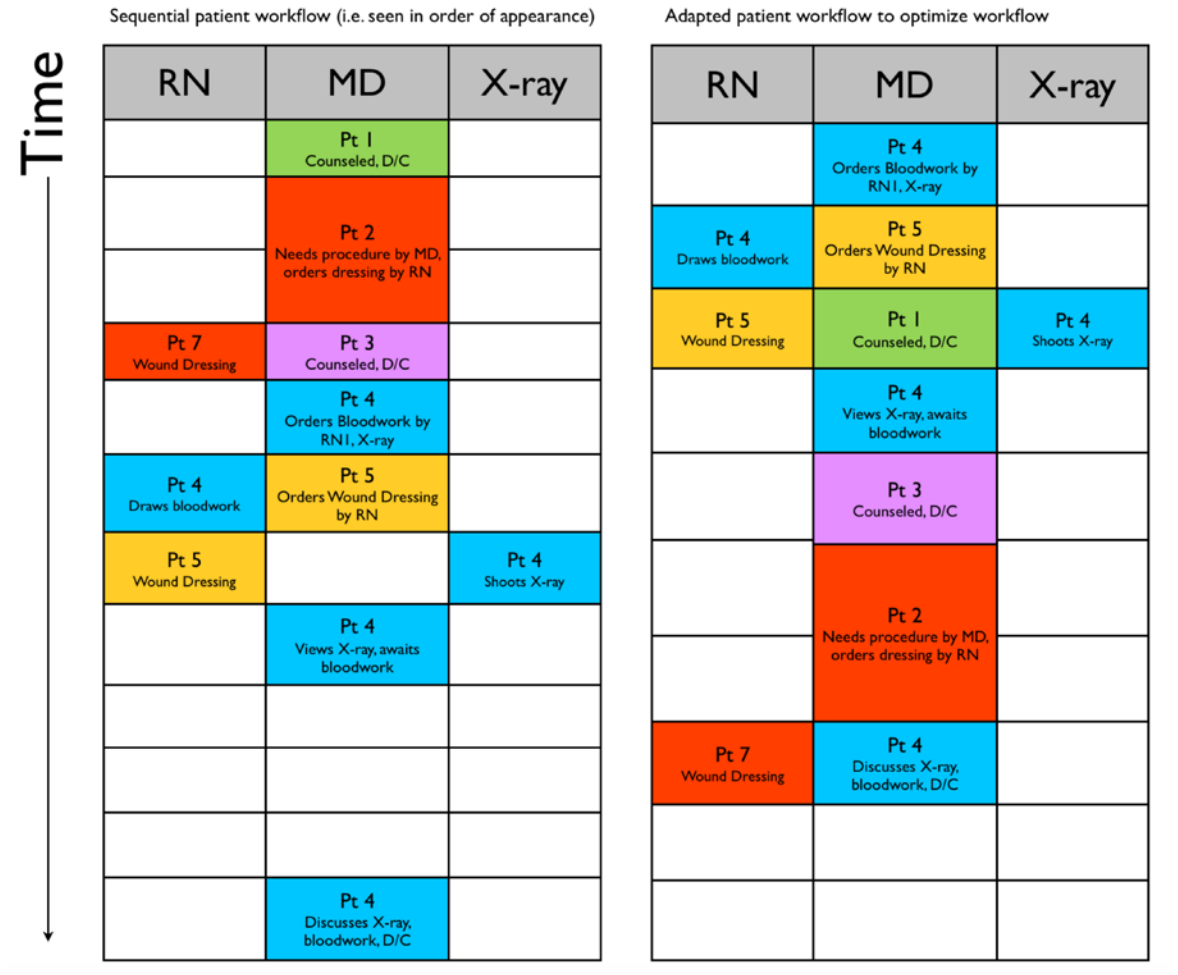
Considering the multi-faceted, team-based approach that occurs in the ED, it might be inferred that the management plans of an efficient EP might involve a systems-level awareness and anticipation that incorporates multiple parallel work-streams (the EPs, the nurses, the radiology technicians, etc.). Essentially, for a single patient archetype, an efficient EP might cue to initiate

a multi-faceted plan that considers the actions of multiple ED team members at once (which might be seen as a multi-team member stack), balancing their activity load to more efficiently optimize the workflows of all team members.

The goal of an efficient EP, therefore, would be to imagine the workflows of multiple ED teammates working in parallel, and then find a way to optimize these flows in a dynamic way, not overloading a single player, but distributing tasks across the system. An analogy would be a temporal version of the game Tetris ("Time Tetris"): If any one column is over-burdened, then the entire system becomes log-jammed.

Similarly, if one does not anticipate the time needs of each patient across all team members, then there may be times when there is extra capacity being wasted if the system is not optimized for team members. If, however, one can distribute work across multiple parallel streams, then the workload becomes distributed, and more patients can be cared for together. Figure 11 below depicts a diagram that proposes this new conceptual framework for optimizing multi-patient systems.

Figure 11: Two workflows, each displaying two different workflows, one demonstrating an optimized workflow that decreases total time for patients and staff



9.6 Limitations

The most obvious limitation of this study was the sample sizes (n=10 for each group) for the quantitative parts of the study. There are several trends that seem apparent, especially when examining the estimated marginal means between groups, but our sample size was too small to detect any but very large differences between groups. Meanwhile, in the qualitative work, it was felt that we were better able to reach data saturation within the groups with roughly 7-8 participants; however, it is certainly possible that with more participants, more themes and insights could have become available. This was, however, an exploratory study – the results of

this study allow for better sample size calculations for studies within this program of research, and perhaps more importantly, they suggest many hypotheses for more focused consideration in follow-up studies. The fixed order of our tracker boards may also have had a confounding effect on our outcomes, as there may have been some effect of repeated exposure to the different types of tracker boards. Randomization of the order of the tracker boards may have allowed us to adjust for this effect.

Another limitation for this study might have been poor definition of the expertise within this area. Similar to previous work[16], we chose to define 'expertise' based on relative experience initially, although after some interim discussions, we did amend our protocol to allow our peer nomination technique to result in more junior attending physicians (i.e. <5 years in practice) being included within our sample size. We allowed for the peer nomination technique to override our previous parameters since the skills set of efficient task prioritization is not well defined and we deemed the peer nomination process to possibly have more strength in identifying this expertise than pure experience. The ill-defined expertise may also have made it difficult to actually discern expertise well. In some instances, some second-year residents were exceedingly nuanced in their discussions and considerations, displaying that they have already formed archetypes and begun to recognize patterns of behaviour clustering around certain archetypes. As such, perhaps using junior residents in PGY1 and 2 may have decreased our ability to detect a difference between groups because they are already *too experienced* and acquiring some expert-level decision-making tools. Alternatively, our convenience sampling may have resulted in an unintentional bias that more efficient residents might have been more likely to have time to volunteer for our experiment.

Additionally, there may not have been enough tracker boards in the experiment to generate good learning effects across all three conditions. The extraneous patient condition resulted in a learning curve across the two groups, with vastly improved estimated marginal mean completion times, whereas the other conditions varied greatly, showing a level of fluctuation that is reminiscent of the erratic learning parts of growth curves for new skills.[109] Alternatively, we did not have any practice trials to allow the participants to gain experience with the simulation interface, and as such we did not ensure we were seeing steady-state effects of the tracker boards and manipulations on the participants performance.

Another very possible limitation was that perhaps the skill of task prioritization is a skill that has simply not been well described previously, and may not be tied directly to expertise since it has not traditionally been taught in a formal sense. Therefore, the analysis of the subgroups by their experience level may have been a red herring, and in fact, there may be other nascent groupings of participants that would result in more robust results.

9.7 Implications for further research

9.7.1 Our Intervention

The novel, web-based virtual tracker board interface may be of use to researchers in the future when attempting to simulate multi-patient environments and creating situations that will allow for consideration of multiple patients simultaneously. The current iteration of this interface, however, does not allow for dynamic usage (i.e. having the game evolve and patients change or deteriorate), which limits its usage as a truly immersive simulation.

9.7.2 Think Aloud

'Think aloud' protocols have been shown to reveal similar results as pure thinking in some studies and yet disparate results in other studies (fMRI study vs other TA studies).[110–113] Our results suggest that 'think aloud' processes may be slower initially, and that over time participants may compensate for these differences in a period of learning, but also they may begin to use verbal shortcuts to decrease their time spent on the 'think aloud' part. We advise that other investigators using a 'think aloud' protocol consider either doing multiple rounds of 'think aloud' as we have, to allow for participants' learning, but also to consider if the 'think aloud' processes will override innate pattern recognition (or system 1) type thinking that will result in participants generating verbal chunks/short forms in order to make their answers align more with their innate thinking.

9.8 Implications for future research – Hypothesis generating

This marks an interesting foray into a new area of decision-making in the context of multi-patient scenarios. There is great promise in using some of the findings in our work to scaffold further teaching, learning, and research.

The chunking theory literature would suggest that perhaps the introduction of chunks that are essentially nonsensical (i.e. randomly placed pieces on a chess board) may create problems with expert processing of the information. In our study, misplaced patients (i.e. patients in the wrong place) did not consistently result in effects on time to decision-making within our study. However, in this study we found that experts tended to draw extensively on their illness scripts and archetyping process to make decisions. Therefore, perhaps it would worth exploring how

patients with non-archetypable features affect the decision-making processes of attendings and their more novice counterparts.

Another area for further research and exploration would be to determine methods for teaching and assessment that acknowledge practice variations. Our exploration of the decision-making processes of attendings and residents has shown that there is substantively divergent thinking with regards to how best to prioritize a list of patients in both of our resident and attending populations. As such, if we are to proceed on to teaching and testing this skill, further work is required to acknowledge the wide variety of 'reasonable' approaches, which may serve as the exemplars for students as they learn this critical skill.

9.9 Future directions

One future direction in this line of research would be to examine the differences in worldviews between the professionals that view the tracker boards. For instance, generating 'think aloud' scripts to compare an emergency physician's view of a given tracker board and a charge nurses' view of that same board. Although these professionals work together frequently, the divergent cognitive tasks and expertise of these individuals might result in substantively different perceptions of the same phenomena (i.e. the same tracker board).

10. CONCLUSION

Using a mixed-methods study, we have generated a cognitive analysis of how physicians perceive and prioritize within multi-patient environments. We have discovered that the processes that underpin prioritization within multi-patient environments are related but subtly different to other known processes, such as chunking and stacking. The insights gained from our participants have clarified how we presently teach and learn the skill of prioritization within multi-patient environments, but more importantly, we have elucidated some new insights about how physicians sort through multiple patients whom may have similar acuity or presentations. We feel that this exploratory study can inform future development of didactic and clinical educational materials. Ultimately, this research may form the basis that will allow us to harness heuristic generation processes such as recognition-primed decision making via simulation.

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APPENDICES

APPENDIX A | *Demographics sheet*

Demographics

Age at time of enrollment into study (write #): _____

Gender: O Male O Female

Training (check one):
- O Emergency Medicine (CCFP Stream)
- O Emergency Medicine (Royal College Stream)
- O American Board of Emergency Medicine O Practice Entry
- O Other: _____

I am a… O Resident O Attending

Residents		**Attendings**	
Postgraduate Year (PGY)	Write # below:	Number of Years in Practice, including residency/fellowship	Write # below:

Your percentage split between Academic & Community Emergency Department Care:

% Academic _____ % Community _____ (total = 100%)

Approximately how many patients will you see per hour in a shift:_____

Are these statistics based on your own recollection/approximation or based on data from your emergency department group? (Check one)

- **O My own approximation**
- **O My own recollection**
- **O Based on departmental data (i.e. statistics supplied by group)**

APPENDIX B | *Critical Incident Questions*

NB: Additional prompts to ensure coverage

Based on the Dissertation work by Wiles et al. 2013 – used with permission.[73,114] Also, I have incorporated aspects of Klein's Eight Dimensions of Expertise.[21,22]

The physicians who participate in individual interviews will be asked the following three primary research questions:

	Questions
1	Think back to a recent busy emergency department situation that was challenging for you - one in which you were asked to make difficult clinical decisions about how to proceed next with your overall management of the Emergency Department. Please share that experience with me.
2*	When you are working with other doctors that are less experienced than you such as residents, how do you incorporate them into your management strategies?
3*	When you are coaching junior doctors – for example, senior residents - to manage the emergency department, how do you teach them about these management strategies?
4	How were you taught to manage a busy emergency department

*Questions 2 & 3 will only be asked of experienced physicians.

If during the course of the first question the individual did not provide the information sought, the above research question will be augmented with the following questions for detail expansion or clarification. These clarification prompts are based on Klein's 8 Dimensions of Expertise.(45) The explanation of how these questions fit Klein's framework is found below in the Table 2. The following are the 'semi-structured' interview prompts:

Prompt 1: Tell me about what was concerning or challenging to you.

a. What was your gut telling you?

b. What did you notice about the scenario that made it stand out?

Prompt 2: Tell me how you proceeded with Emergency Department management that day?

a. What are the big picture issues that you take into consideration?

b. What cues did you use to help fine-tune your approach?

Prompt 3: How did you evaluate the outcomes of the plan that you chose?

Prompt 4: As you think back what do you notice differently now? What stands out to you?

Prompt 5: What, if any, equipment do you use to help you plan your actions in the ED?

APPENDIX C | *Sorting Data Collection Form*

Instructions Given

The following script was presented to all participants prior to the Sorting Only section:

"We will now begin the sorting only phase of this experiment. Imagine you are about to begin a typical day or overnight shift. You are walking into the emergency department and you login to your tracker board. As you would see in real life, there will be a number of patients that need to be seen by you on the tracker board, at times intermingled with other admitted patients or patients already seen by other emergency physicians.

You will have access to all of their electronic medical records and triage notes. These other patients will be clearly labeled. We would like you sort the patients that should be seen into 3 categories.:

Category A) Patient I will see First

Category B) Patient I will See Soon (e.g within the next hour)

Category C) Write Orders and see when orders completed.

You do not need to assign every patient to a category. You need only write the bed number of the patient onto the form (not the patient's name). You may only choose 1 patient to be seen first, 5 patients to be seen in the first hour, and an additional 5 patients for which you can write orders, and see them after the orders are completed. Patients may (and will) be left uncategorized. Also, you may classify patients in both category B and C simultaneously.

Before you are a number of work sheets. You will use each of these worksheets to render your answers. Do you have any questions?"

Sample Worksheet for Sorting Only sections

	1	2	3	4	5
A **See First** **(Choose 1)**					
B **See Soon** ***in next hour*** **(Choose up to 5)**					
C **Write orders** **See upon order completion** **(Choose up to 5)**					

You may leave this table partly incomplete if there are fewer than 11 patients on the board OR if you do not desire to rank the patients left on the board.

If you would like to ignore the patient for now, you should just leave this patient off of the above chart.

APPENDIX D | *Think Aloud Prompt*

The following script was presented to all participants prior to the Think Aloud section.

"We will now begin the think aloud phase. As before, imagine you are about to begin the shift. There will be a number of patients that need to be seen by you on the tracker board. This time, we will ask that you perform the same prioritization task as before, but we would like you to think aloud when you're prioritizing the patients that you should see next."

'Some examples of things you might say:

"The first thing I need to do is…."
"I just thought of_____, so, I'm going to do_____"
"I'm considering…."'

"We will now do a practice think-aloud procedure. I will give you feedback with regards to whether you are thinking aloud enough to let us understand your processes."

Insights on constructing this script were derived from:

Van Someren, M. W., Barnard, Y. F., & Sandberg, J. A. (1994). The think aloud method: A practical guide to modelling cognitive processes (p. 26). London: Academic Press.

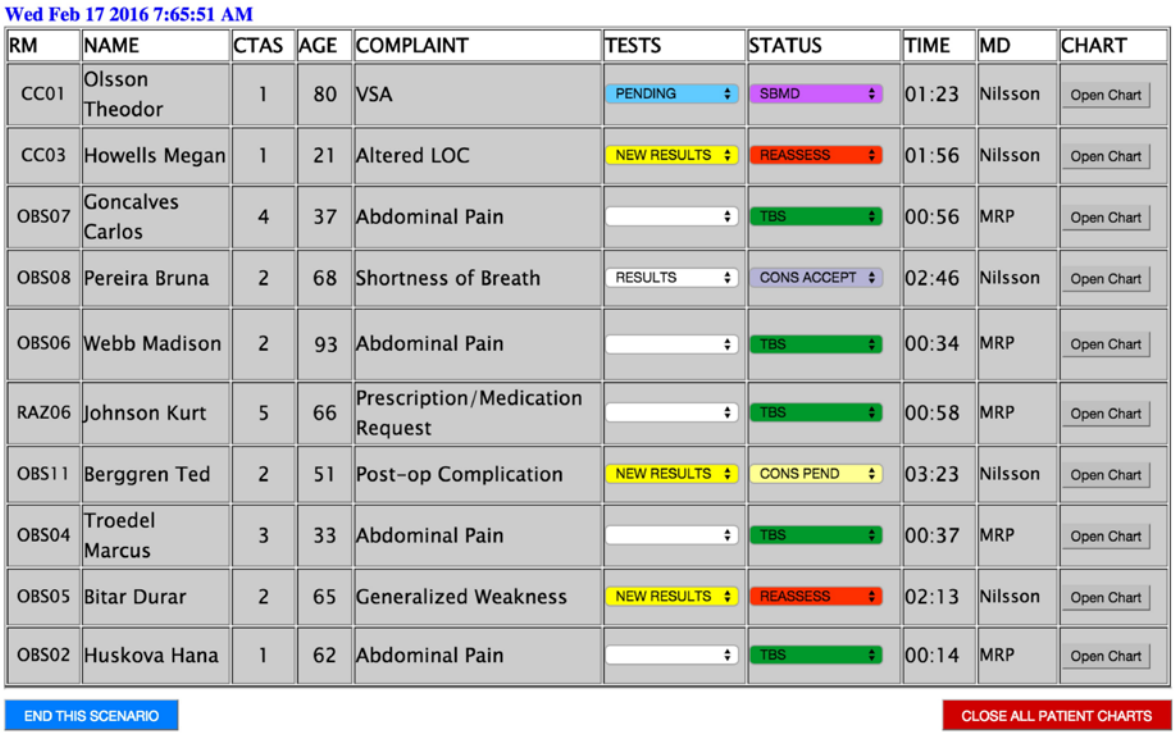
APPENDIX E | *Exit Interview*

This part comprised of a single question to ensure that participants have a chance to further clarify any thoughts they have on the topics of task and patient prioritization. They were asked asked:

"Is there anything you would like to add regarding your thoughts on prioritization processes you use in the emergency department?"

APPENDIX F | *Think Aloud Scenario Screen Captures*

Think aloud scenario #1
Available at http://www.virtualer.org/TC_2_6.html?



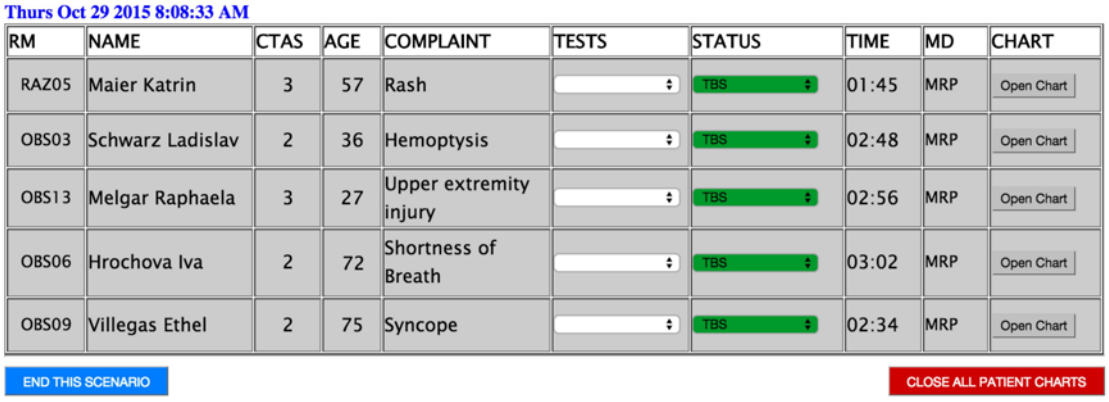
Wed Feb 17 2016 7:65:51 AM

RM	NAME	CTAS	AGE	COMPLAINT	TESTS	STATUS	TIME	MD	CHART
CC01	Olsson Theodor	1	80	VSA	PENDING	SBMD	01:23	Nilsson	Open Chart
CC03	Howells Megan	1	21	Altered LOC	NEW RESULTS	REASSESS	01:56	Nilsson	Open Chart
OBS07	Goncalves Carlos	4	37	Abdominal Pain		TBS	00:56	MRP	Open Chart
OBS08	Pereira Bruna	2	68	Shortness of Breath	RESULTS	CONS ACCEPT	02:46	Nilsson	Open Chart
OBS06	Webb Madison	2	93	Abdominal Pain		TBS	00:34	MRP	Open Chart
RAZ06	Johnson Kurt	5	66	Prescription/Medication Request		TBS	00:58	MRP	Open Chart
OBS11	Berggren Ted	2	51	Post-op Complication	NEW RESULTS	CONS PEND	03:23	Nilsson	Open Chart
OBS04	Troedel Marcus	3	33	Abdominal Pain		TBS	00:37	MRP	Open Chart
OBS05	Bitar Durar	2	65	Generalized Weakness	NEW RESULTS	REASSESS	02:13	Nilsson	Open Chart
OBS02	Huskova Hana	1	62	Abdominal Pain		TBS	00:14	MRP	Open Chart

END THIS SCENARIO

CLOSE ALL PATIENT CHARTS

Think aloud scenario #2
Available at http://www.virtualer.org/TC_3_3_a.html?



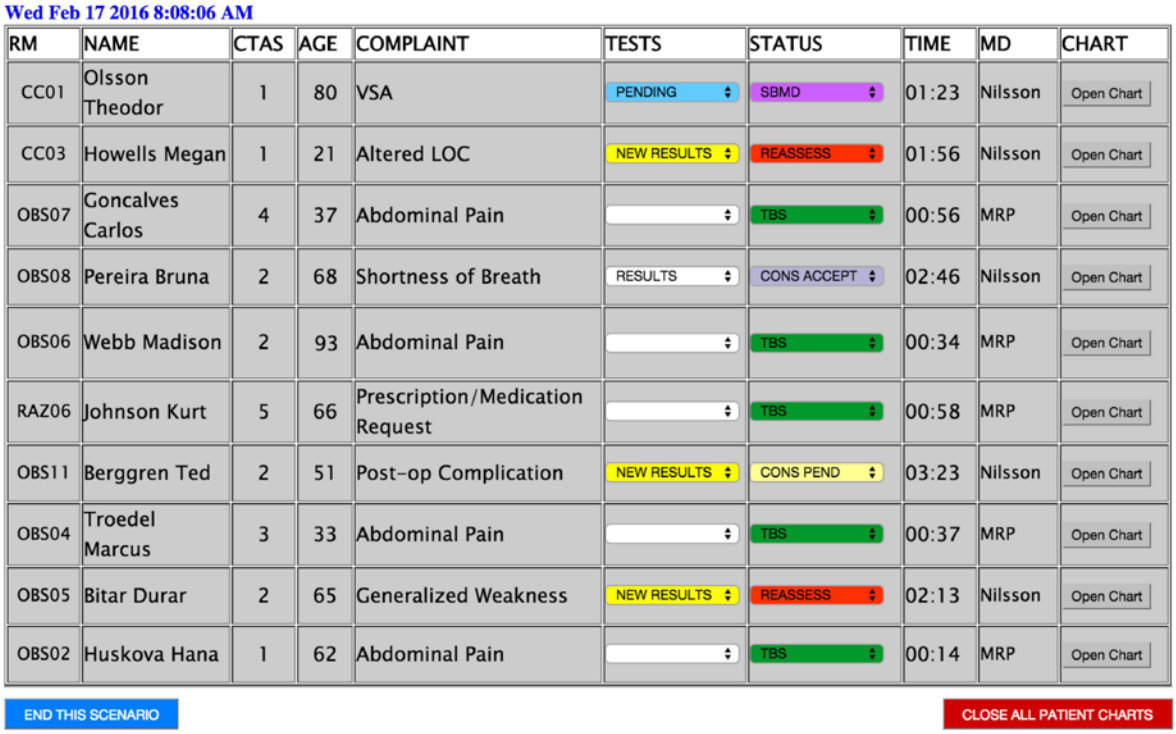
Thurs Oct 29 2015 8:08:33 AM

RM	NAME	CTAS	AGE	COMPLAINT	TESTS	STATUS	TIME	MD	CHART
RAZ05	Maier Katrin	3	57	Rash		TBS	01:45	MRP	Open Chart
OBS03	Schwarz Ladislav	2	36	Hemoptysis		TBS	02:48	MRP	Open Chart
OBS13	Melgar Raphaela	3	27	Upper extremity injury		TBS	02:56	MRP	Open Chart
OBS06	Hrochova Iva	2	72	Shortness of Breath		TBS	03:02	MRP	Open Chart
OBS09	Villegas Ethel	2	75	Syncope		TBS	02:34	MRP	Open Chart

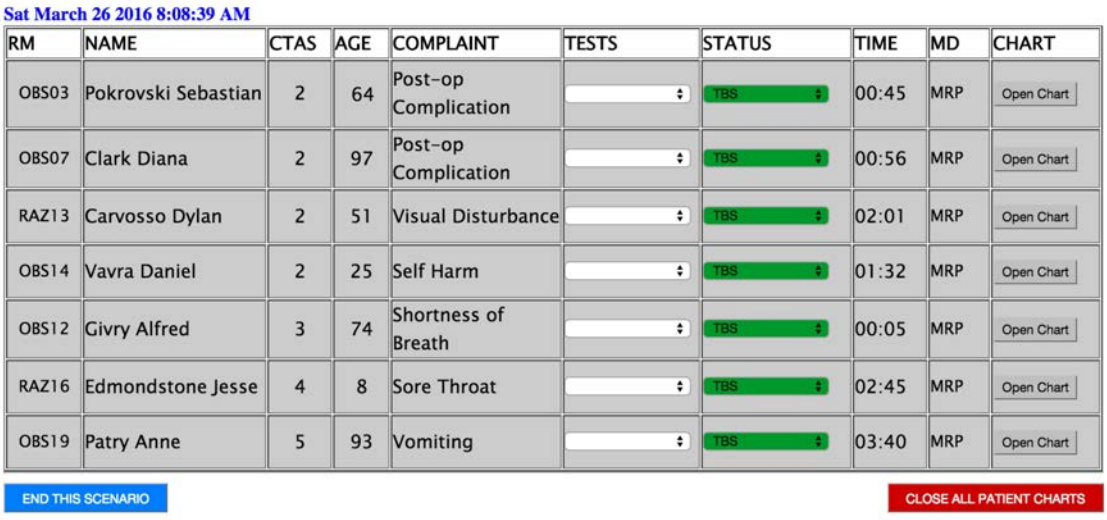
END THIS SCENARIO

CLOSE ALL PATIENT CHARTS

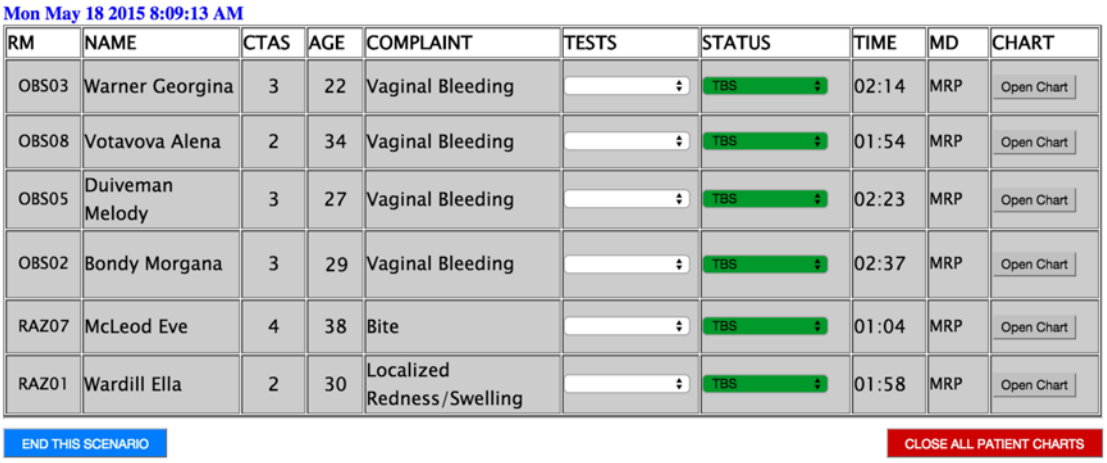
Think aloud scenario #3
Available at http://www.virtualer.org/TC_2_6_b.html?



Think aloud scenario #4
Available at http://www.virtualer.org/TC_1_3_c.html?



Think aloud scenario #5
Available at http://www.virtualer.org/TC_3_9_MP_d.html?



Mon May 18 2015 8:09:13 AM

RM	NAME	CTAS	AGE	COMPLAINT	TESTS	STATUS	TIME	MD	CHART
OBS03	Warner Georgina	3	22	Vaginal Bleeding		TBS	02:14	MRP	Open Chart
OBS08	Votavova Alena	2	34	Vaginal Bleeding		TBS	01:54	MRP	Open Chart
OBS05	Duiveman Melody	3	27	Vaginal Bleeding		TBS	02:23	MRP	Open Chart
OBS02	Bondy Morgana	3	29	Vaginal Bleeding		TBS	02:37	MRP	Open Chart
RAZ07	McLeod Eve	4	38	Bite		TBS	01:04	MRP	Open Chart
RAZ01	Wardill Ella	2	30	Localized Redness/Swelling		TBS	01:58	MRP	Open Chart

END THIS SCENARIO

CLOSE ALL PATIENT CHARTS

VITA

NAME:	Teresa Man-Yee Chan
EDUCATION:	University of Illinois at Chicago, Department of Medical Education | Chicago, IL *Masters of Health Professionals Education Candidate – July 2011 - Present*
	University of Western Ontario, Schulich School of Medicine & Dentistry | London, Ontario; *Doctor of Medicine, Sept. 2004 –May 2008*
	University of Toronto, Ontario Institute of Studies in Education | Toronto, Ontario; *Bachelor of Education (Biology/Chemistry), Sept. 2003 – June 2004*
	University of Toronto, Victoria University in the University of Toronto | Toronto, Ontario; *Honours Bachelor of Science (Immunology) with Distinction, Sept. 1999 – May 2003*
TEACHING:	Medical Foundations 3 – Problem Based Learning, DeGroote School of Medicine (2015)
	Clerkship EBM Lecture series, DeGroote School of Medicine (2014-Present)
	Medical Foundations Unit 1 and 3, DeGroote School of Medicine, Clinical Skills Preceptor for the Undergraduate Medicine Program (2008-2011)
	McMaster University Postgraduate Medical Education Office Multidisciplinary Academic Day (MAD) program coordinator (2011-present)
INVITED PRESENTATIONS	National Review Course in Emergency Medicine – Top Literature Review (September 28-29, 2014)
	Chairs Rounds, McMaster University – Education in the Age of Social Media (November 20, 2014)
	Faculty Development Retreat at University of Saskatchewan, Keynote Speaker (January, 15-16, 2015)
	Free Open Access Medical education Track: Do you get what you pay for? Quality in the free online educational environment – Council on Residency Directors of Emergency Medicine, Phoenix, AZ. (April 13, 2015)
	Calgary Research Day Panel Discussion – Free Open Access Medical Education (April 30, 2015)
	Lessons Learned from Transitioning to a Competency Based Medical Education Assessment System, Canadian Association Emergency Physician's Conference, Alberta, AB. (June 1, 2015)
SELECTED HONOURS:	PAIRO Trust Fund Citizenship Award (2007)
	John William Rohrer Memorial Scholarship (2008)
	UME Prize for Outstanding Extracurricular Accomplishment
SELECTED AWARDS:	Royal College Fellowship for Studies in Medical Education, from the Royal College of

Physicians & Surgeons of Canada. (2011)
Ontario Medical Association Resident Achievement Award (McMaster)
Canadian Association of Emergency Physicians 2012 - Top Resident Research Award
McMaster Emergency Medicine Undergraduate Teacher of the Year Award
Victoria College Emerging Leader Award
W. Watson Buchanan Clinician Educator Internal Career Award
2015 *Academic Medicine* Excellence in Reviewing Award

PROFESSIONAL MEMBERSHIPS:

Ontario College of Teachers (2004-2005)
Ontario Medical Association (2004-Present)
Canadian Medical Association (2004-Present)
Professional Association of Interns and Residents of Ontario (PAIRO) (2008-2012)
PAIRO Board of Directors (2009-2012) [Elected Position]
Canadian Association of Emergency Physicians (2009-Present)
Emergency Medicine Residents Association (2010-2011)
Society of Academic Emergency Medicine (2012-Present)
Wilson Centre (University of Toronto) – General Member (2013-Present)
Canadian Association of Medical Educators – Member (2012-Present)

SELECTED ABSTRACTS:

Oral Abstracts

June 2011 — **Teresa M Chan,** Donika Orlich, Kulamakan Kulasegaram, Jonathan Sherbino. *Understanding Communication between Emergency and Consulting Physicians: A qualitative study that defines the essential elements of a referral-consultation.*

Abstract presented at the Canadian Association of Emergency Physicians Conference 2011, Oral presentation. 2011 CAEP/ACMU Scientific Abstracts June 5–9, 2011 St. John's, NL, *CJEM* 2011;13(3):173-226

- Also, abstract presented at the International Conference on Residency Education 2011, Oral presentation.

June 5, 2012 — **Teresa M Chan,** Francis Bakewell, Donika Orlich, Jonathan Sherbino. *Understanding Communication between Emergency and Consulting Physicians: Manifestations of Conflict, Conflict-Prevention and Conflict-Resolution*. **Presented as a Plenary Presentation (Top 4 Abstracts Nationally 2012; Top Resident Abstract 2012)** at Canadian Association of Emergency Physicians Conference 2012.

- Also **Presented as an oral abstract** at the International Conference on Residency Education 2012. Abstract available at: http://www.jgme.org/userimages/ContentEditor/1349452674087/ICRE.Abstracts.with.Links.to.ToC.Final.pdf
- Abstract presented at the Canadian Association of Emergency Physicians Conference 2012, Oral Plenary presentation. 2012 CAEP/ACMU Scientific Abstracts June 5–9, 2012 Niagara Falls, ON, *CJEM* 2012;14(1):S2.
- CAEP Slides available at: http://caep.ca/sites/default/files/caep/files/t.chan_-_research_plenary_june_5-915h-cp.pdf

Oct. 20, 2012 — **Teresa Chan,** Jonathan Sherbino. *Developing McMAP: The McMaster Modular Assessment Program.* Presented as a 'What Works' oral abstract at the International Conference on Residency

Education 2012. Selected as one of the **Top 5 'What Works' abstracts**.

Sept. 27, 2013 **Teresa Chan**, Jonathan Sherbino, Yoo Soo Park, Alison Kirkham, Clare Walner, Tom Swoboda, Bryan Judge. Establishing content validity and standards for the McMaster Modular Assessment Program. International Conference on Residency Education, Calgary, AB.

2014 **Teresa Chan**, Jonathan Sherbino. The McMaster Modular Assessment Program (McMAP) improves quality of in-training evaluation reports via aggregated work-based assessments and guided narrative global assessment.

a) The Ottawa conference 2014: Transforming Healthcare through Excellence in Assessment and Evaluation. Ottawa, Ontario. Oral Presentation. April 28, 2014.
b) The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Poster Presentation. June 1.

April 2014 Meghan McConnell, **Teresa Chan**, Jonathan Sherbino. Testing Construct Validity of the McMaster Modular Assessment Program (McMAP). The Ottawa conference 2014: Transforming Healthcare through Excellence in Assessment and Evaluation. Ottawa, Ontario. Oral Presentation.

June 1, 2014 **Teresa M. Chan**, Alim Pardhan, Michelle Welsford. Description of a Successful Longitudinal Pre-hospital Care Emergency Medicine Curriculum. The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Oral Presentation. June 1.

June 1, 2014 **Teresa Chan**, Ian Preyra, Jonathan Sherbino. The McMaster Modular Assessment Program (McMAP): The Junior Emergency Medicine Competency Pilot Project. The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Lightning Oral Presentation. June 1, 2014.

Oct. 24, 2014 **Teresa Chan**, Meghan McConnell, Bandar Baw. Stratifying objectives: An interdisciplinary milestone setting for a toxicology curriculum. The International Conference on Residency Education. Oral Presentation. October 23-25, 2014.

Apr. 27, 2015 Stefanie Sebok, Jonathan Sherbino, Don Klinger, **Teresa Chan**. "Mixed Messages or Miscommunication: The relationship between Workplace-Based Assessment scores and Written Comments in the McMaster Modular Assessment Program (McMAP)." 2015 Canadian Conference on Medical Education. Oral Presentation. Vancouver, BC, Canada.

Apr. 28, 2015 Tanya Horsley, Teresa Chan, Shiphra Ginsburg, Redouane Bouali, Asif Doja, Danielle Fréchette, Rose Hatala. "Advancing Medical Education Research one Grant at a Time: Assessing the Impact of a National Grants Program for Medical Education")." 2015 Canadian Conference on Medical Education. Oral Presentation. Vancouver, BC, Canada.

June 1, 2015 Isabelle Colmers, Kieran Walsh, Teresa Chan. "Assessment of Emergency Medicine Residents: A Systematic Review" Canadian

Association of Emergency Physicians conference. Lightning Oral Presentation. Edmonton, AB, Canada.

Oct 23, 2015 Eve Purdy, Sarah Luckett-Gatopoulos, Heather Murray, Brent Thoma, **Teresa Chan**. "Reviewing with the staff": BoringEM's creation of a robust peer review process for a learner-oriented blog to promote scholarship and collaboration. International Conference on Residency Education, Vancouver, BC, Canada. Selected for the **Top Five What Works** Oral Presentation presented by Eve Purdy.

Oct 23, 2015 Paola Camorlinga, Sarah Luckett-Gatopoulos, **Teresa Chan**. A blog literacy level project: Analyzing the relationship between FOAMed resource characteristics in blog posts and knowledge dissemination. International Conference on Residency Education, Vancouver, BC, Canada. Selected for the **JGME Top Five Resident Research Papers** Oral Presentation presented by Paola Camorlinga.

Oct 23, 2015 Alim Pardhan, April Kam, Teresa Chan. Integration of daily faculty evaluations in the emergency department. Oral Presentation, presented by Alim Pardhan.

Oct. 2015 Teresa Chan, Mike Paddock, Andy Grock, Mahan Kulasagaram, Lainie Yarris, Michelle Lin. Determining the Reliability of the ALiEM AIR Score for rating educational online learning materials. Oral Presentation, presented by Mike Paddock.

Conference Workshops

Oct 24, 2014 **Teresa M. Chan**, Brent Thoma, Michelle Lin, Anne Marie Cunningham, Nikita Joshi, Natalie Laferty, Nishan Sharma, Alireza Jalali. "Digital You: Creating an Engaging Digital Presence" Full day, pre-conference for the International Conference on Residency Education 2014. Thursday, October 24, 2014.

April 26, 2015 Eve Purdy, **Teresa M. Chan**, Michelle Gibson. "Personal Learning Environments." Canadian Conference on Medical Education. Sunday, May 26, 2015.

June 23, 2015 Social Media And Critical Care (SMACC) Conference | Pre-conference workshop on the Medical Education in Cases Series

July 30, 2015 **Teresa Chan**. The McMAP conundrum: Growth Curve Modeling in small populations **Presented as a works-in-process** at University of Illinois at Chicago's Masters of Health Professionals Education Summer Conference 2015.

Oct 23, 2015 Teresa Chan. How to make a great #MedEd Blog. Lightning workshop.

Poster Abstracts

2007 ***Teresa M Chan****, Peter Flanagan, P. Guillaume Poliquin. Redeveloping a Patient-Centered Learning Program: Student-Faculty Collaboration for Curriculum Change,* Poster Presentation, AFMC Conference 2007

2007 *Guillaume Poliquin, Peter Flanagan, Katherine Monkman,* ***Teresa***

***Chan**, Paul Martin. Evaluating a Patient-Centered Learning Program: A Student-Driven Needs Assessment Project,* Poster Presentation, AFMC Conference 2007

Apr. 16, 2012 Ricardo Viana, **Teresa Chan**, Daniela Lanc, Clarissa Holding, Stephanie Soo, Joanna Zurwaska, Urszula Zurwaska Joel Krause, Mathew Plant, Mark Speechley. *The effects of a structured debate in medical ethics education.* Presented May 2012 at the Canadian Conference on Medical Education (Banff, Alberta).

June 5, 2012 Brendon Trotter, **Teresa M Chan**, Caillin Langmann, Serena Sennik, Andrew Worster, Michelle Welsford. *Communication in the Emergency Department between Physicians and Paramedics: A pilot quantitative study to determine Emergency Physician's accuracy, awareness and satisfaction with Paramedic handov*er. **Presented as a Moderated Poster Presentation** at Canadian Association of Emergency Physicians Conference 2012.

- Abstract presented at the Canadian Association of Emergency Physicians Conference 2012, Oral Plenary presentation. 2012 CAEP/ACMU Scientific Abstracts June 5–9, 2012 Niagara Falls, ON, *CJEM* 2012;14(1):S28.

June 5, 2012 Serena Sennik, **Teresa M Chan**, Brendon Trotter, Andrew Worster, Michelle Welsford. *Communication in the Emergency Department between Physicians and Paramedics: A pilot qualitative study to determine areas for improvement.* **Presented as a Moderated Poster Presentation** at Canadian Association of Emergency Physicians Conference 2012.

- Abstract presented at the Canadian Association of Emergency Physicians Conference 2012, Oral Plenary presentation. 2012 CAEP/ACMU Scientific Abstracts June 5–9, 2012 Niagara Falls, ON, *CJEM* 2012;14(1):S28.

June 6, 2012 **Teresa M Chan**, Kameron Sabir, Sarila Sanhan, Jonathan Sherbino. *Understanding Communication between Emergency and Consulting Physicians: Interpersonal Relationships and the Emergency Department Referral-Consultation Process.*

- **Presented as a Moderated Poster Presentation** at Canadian Association of Emergency Physicians Conference 2012.
- **Presented as an oral abstract** at University of Illinois at Chicago's Masters of Health Professionals Education Summer Conference 2012.

May 9, 2012 **Teresa Chan**, Thomas Swoboda, Clare Wallner. *Breakout Session: Assessment of Observable Learner Performance | Interpersonal and Communication Skills.* Society of Academic Emergency Medicine Consensus Conference - Education Research in Emergency Medicine: Opportunities, Challenges and Strategies for Success. Poster Presentation at SAEM Consensus Conference 2012.

Oct. 19, 2012 Colleen Fuller, **Teresa Chan**, Tristan Alie, Oxana Kolchenko, Brenda Montesanto, Jessica Hopkins. "Curricular Change by Residents... for Residents." Presented by Colleen Fuller, as a "What Works" poster at the International Conference on Residency Education 2012.

Sept. 2013 Winnie Chan, Mary Salib, **Teresa Chan**, John You, Mohammed Panju. A novel nurse shadowing program to improve resident-nurse collaboration: A pilot study. Abstract presented at the International Conference on Residency Education 2013. Poster Presentation. 2013.

Sept 2013 Laura Morrison, Winnie Chan, Kathleen Quinn, **Teresa Chan**, Brenda Montesanto, Jessica Hopkins. Using a CanMEDS Framework for the restructuring of a resident-led multidisciplinary academic day curriculum. Abstract presented at the International Conference on Residency Education 2013. Poster Presentation. 2013.

Sept. 2013 Kenneth Van Dewark, Alexander Chorley, Laura Morrison, **Teresa Chan**, Brenda Montesanto, Jessica Hopkins. Such a MAD idea: Using educational branding for increasing stakeholder engagement. Abstract presented at the International Conference on Residency Education 2013. Poster Presentation. 2013.

Sept. 2013 Laura Morrison, Colleen Fuller, **Teresa Chan**, Brenda Montesanto, Jessica Hopkins. Coordinated MADness: The successes and lessons of the shift to resident-directed multidisciplinary sessions for developing CanMEDs Competencies. Abstract presented at the International Conference on Residency Education 2013. Poster Presentation. 2013.

Nov 2013 Zain Kassam, Nauzer Forbers**, Teresa Chan**, Alim Ladha, P Moayyedi, Florence Tse. Gastroenterology Residents Educating and Teaching (GREaT) Curriculum: Development of a Resident-Driven Learning and Teaching Tool for Evidence-based Gastroenterology at the Bedside. Harvard Macy Institute Program For Educators in Health Professions AAMC Innovations. Poster Presentation.

May 21, 2014 Winnie Chan, Mary Salib, Shelley-Ann Li, **Teresa Chan**, John You, Mohammed Panju. Understanding of Interprofessional Team Education (UNITE): A Nurse Shadowing Program for Internal Medicine Residents. Core Internal Medicine Research Day. Poster Presentation. Wednesday, May 21, 2014.

June 3, 2014 **Teresa Chan**, Michael Callaham, Salim Rezaie, Ryan Radecki, Brent Thoma, Michelle Lin. Journal Club 2.0: Collaboration between a Traditional Journal and an Academic Blog to Create a Global Journal Club Experience. The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Moderated Poster Presentation. June 3, 2014.

June 3-4, 2014 Todd Raine, Brent Thoma, **Teresa Chan**, Michelle Lin. FOAMSearch: A Search Engine Optimized for Emergency Medicine Physicians. The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Poster Presentation. June 3-4.

Oct. 25, 2014 **Teresa Chan**, Brent Thoma, Michelle Lin. The Medical Education in Cases Series: Online Faculty Development for Medical Education.

a) The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Moderated Poster Presentation. June 3, 2014.
b) The MEdIC Series: Faculty and Resident Development in the Brave New World Wide Web; International

Conference on Residency Education, October 2014. Selected for the Top 5 What Works abstracts.

Oct. 25, 2014 Brent Thoma, **Teresa Chan**, Jason Sanders, Nikita Joshi, Michelle Lin. Online Portfolios: The Curriculum Vitae 2.0. Poster Presentation.

a) The Canadian Association of Emergency Physician's conference 2014. Ottawa, Ontario. Moderated Poster Presentation. June 3, 2014.
b) International Conference on Residency Education; Poster presentation. October 23-25, 2014.

Oct. 24, 2014 Meghan McConnell, Jonathan Sherbino, **Teresa Chan**. 'The Value of Zeros: Dealing with Missing Data in Competency Based Assessments'. The International Conference on Residency Education. Oral Presentation. October 23-25, 2014.

Oct. 24, 2014 Winnie Chan, May Salib, Shelley Anne Li, **Teresa Chan**, John You, Mohammed Panju. 'Program Evaluation using Focus Groups: Experience with a nurse-shadowing program'. The International Conference on Residency Education. Oral Presentation. October 23-25, 2014.

Oct. 24, 2014 **Teresa Chan**, Andrew Worster, Suneel Upadhye, Teresa Vallera, Margaret Ackerman. Resident behaviour during the online preparation phase for a 'flipped classroom' method: The Clin Epi Blitz Experience. The International Conference on Residency Education. Poster Presentation. October 23-25, 2014.

Nov 6, 2014 Brent Thoma, Javier Benitez Michelle Lin, **Teresa Chan**. Educational Scholarship in the Digital Age: A Review and Analysis of Scholarly Products. 2014 AAMC Medical Education Meeting. Poster presentation. November 6, 2014.

Nov 6, 2014 Quinten Paterson, Brent Thoma, Michelle Lin, **Teresa Chan**. Quality Indicators for Medical Education Blog Posts and Podcasts: A qualitative analysis of themes from published literature.

a) 2014 AAMC Medical Education Meeting. Chicago, IL. Poster presentation. Nov. 6, 2014.
b) 2015 CAEP Conference. Edmonton AB. Moderated Poster Presentation. May 31, 2015.

Apr. 28, 2015 Eve Purdy, Sarah Luckett-Gatopoulos, Brent Thoma, Heather Murray, **Teresa Chan**. "Reviewing with the Staff": BoringEM's creation of a robust peer review process for a learner-oriented blog." 2015 Canadian Conference on Medical Education. Poster Presentation. Vancouver, BC, Canada.

May 30-Jun1, 15 Alia Dharamsi, Andrew Petrosoniak, Eve Purdy, Brent Thoma, Teresa Chan, Nadim Lalani. Poster Presentation. "Learner-designed, crowd-refined: developing innovative electives in social media, education, and emergency medicine" Canadian Association of Emergency Physicians conference. Poster Presentation. Edmonton, AB, Canada.

June 2, 2015 Ian Buchanan, Simperpreet Sandhanwahalia, Melissa Hayward, Teresa Chan, Mark Mensour, Andrew Healey. "Procedural Learning Dynamics of a Point**-** of**-** care Ultrasound Education Experience". Canadian Association of Emergency Physicians conference.

Moderated Poster Presentation. Edmonton, AB, Canada.

June 2, 2015 Paola Camorlinga, Sarah Luckett-Gatopoulos, Teresa Chan. "A Blog Literacy Level Project: Analyzing the Relationship Between FOAMed Resource Characteristics in Blog Posts and Knowledge Dissemination" Canadian Association of Emergency Physicians conference. Moderated Poster Presentation. Edmonton, AB, Canada.

July 30, 2015 Stefanie Sebok, **Teresa Chan,** Don Klinger, Jonathan Sherbino. Mixed Messages or Miscommunication: The relationship between Workplace-Based Assessment scores and Written Comments in the McMaster Modular Assessment Program (McMAP). **Presented as a poster abstract** at University of Illinois at Chicago's Masters of Health Professionals Education Summer Conference 2015.

SELECTED PUBLICATIONS:

Teresa Chan, Clare Wallner, Thomas Swoboda, Katrina Leone, Chad Kessler. *Assessing Interpersonal and Communication Skills in Emergency Medicine: Summary of the Working Group on Assessment of Observable Learner Performance at the 2012 AEM Consensus Conference on Education Research in Emergency Medicine.* Society of Academic Emergency Medicine Consensus Conference - Education Research in Emergency Medicine: Opportunities, Challenges and Strategies for Success. Consensus Paper. *Academic Emergency Medicine Journal* in July 2012. Online first on December 27, 2012. PMID: 23279246

Chad S. Kessler, **Teresa M. Chan,** Jennifer M. Loeb, S. Terez Malka. *I'm clear, you're clear, we're all clear (about this consultation): A multidisciplinary call for improving consultation communication in Undergraduate Medical Education.* Acad Med; 2013; 88(6): 753-758. PMID: 23619069

Jonathan Sherbino, **Teresa Chan**, Karen Schiff. *The Reverse Classroom: Lectures on your own; Homework with faculty.* CJEM 2013; 15(3):178-180. PMID: 23663466

Teresa M Chan, Donika Orlich, Kulamakan Kulasegaram, Jonathan Sherbino. *Understanding Communication between Emergency and Consulting Physicians: A qualitative study that describes and defines the essential elements of the Emergency Department consultation-referral process for the junior learner.* CJEM. 2013;15(1):42-51. PMID 23283122

Teresa M Chan, Kameron Sabir, Sarila Sanhan, Jonathan Sherbino. (2013). Understanding the Impact of Residents' Interpersonal Relationships During Emergency Department Referrals and Consultations. *J Grad Med Ed*. 2013:5(4):476-581. DOI: 10.4300/JGME-D-12-00211.1 PMID: 24455004

Teresa M. Chan, Francis Bakewell, Donika Orlich, Jonathan Sherbino (2014). Conflict Prevention, Conflict Mitigation, and Manifestations of Conflict During Emergency Department Consultations. *Academic Emergency Medicine, 21*(3), 308-313.

Lindsay Melvin, **Teresa Chan**. Using Twitter in Clinical Education and Practice. J Grad Med Ed. 2014:6(3):581-2. DOI: 10.4300/JGME-D-14-00342.1 Available at: http://www.jgme.org/doi/pdf/10.4300/JGME-D-14-00342.1

Brent Thoma, Nikita Joshi, N. Seth Trueger, **Teresa M Chan** & Michelle Lin. Five strategies to effectively utilize online resources in emergency medicine. Annals of Emergency Medicine. Online first June 21, 2014. Oct;64(4):392-395. DOI: 10.1016/j.annemergmed.2014.05.029. PMID: 24962889.

Mike Cadogan, Brent Thoma, **Teresa Chan**, Michelle Lin. Free Open Access Meducation (FOAM): The rise of emergency medicine and critical care blogs and podcasts (2002-2013). Online on Feb 19, 2014. Emerg Med J 2014;31:e76–e77. doi:10.1136/emermed-2013-203502

Bandar Baw, **Teresa M Chan**, Suneel Upadhye. Clinical Education Guideline Creation by Residents for Junior Learners in Emergency Medicine: A Novel Educational Innovation for Canadian EM Educators. Canadian Journal of Emergency Medicine; *CJEM* 2014;16(6):490-493. Online first May 7, 2014. PMID: 24742792

Brent Thoma, **Teresa Chan**, Javier Benitez, Michelle Lin, Educational Scholarship in the Digital Age: A Scoping Review and Analysis of Scholarly Products, The Winnower 1:e141827.77297 (2014). DOI:10.15200/winn.141827.77297 Available at: https://thewinnower.com/papers/educational-scholarship-in-the-digital-age-a-scoping-review-and-analysis-of-scholarly-products

Brent Thoma, **Teresa M Chan**, Natalie Desouza, Michelle Lin. Implementing peer review at an emergency medicine blog: bridging the gap between educators and clinical experts. Can J Emerg Med. 17(2):188-191. DOI: 10.2310/8000.2014.141393. PMID: 25927262

Teresa M Chan, Serena Sennik, Brendon Trotter, Amna Zaki. Studying with the Cloud. Can J Emerg Med. 2015 Apr 1;17(2):192-195. PMID: 25154331

Brent Thoma, Rohit Mohindra, Jennifer Artz, **Teresa M. Chan**. CJEM and the changing landscape of medical education and knowledge translation. Can J Emerg Med. 17(2):184-187. DOI: 10.1017/cem.2015.16 .

Esther K. Choo, Megan L. Ranney, **Teresa M. Chan**, N. Seth Trueger, Amy E. Walsh, Ken Tegtmeyer, Shannon O. McNamara, Ricky Y. Choi & Christopher L. Carroll (2015) Twitter as a tool for communication and knowledge exchange in academic medicine: A guide for skeptics and novices, Medical Teacher, 37:5, 411-416 (doi:10.3109/0142159X.2014.993371) PMID: 25523012

Thoma B, Sanders JL, Lin M, Paterson QS, Steeg J, **Chan TM**. The Social Media Index: Measuring the impact of emergency medicine and critical care websites. Western Journal of Emergency Medicine, 0(0). DOI: http://dx.doi.org/10.5811/westjem.2015.1.24860 . Published March 17, 2015. Retrieved from: http://escholarship.org/uc/item/7t7777m7

Teresa Chan, Brent Thoma, Michelle Lin. Creating, Curating, and Sharing Lessons in Online Professional Development: The Medical Education in Cases Series experience. Academic Medicine. 2015. 90(6), 785-789. doi: 10.1097/ACM.0000000000000692

Teresa Chan, Nikita Joshi, Michelle Lin, and Neil Mehta (2015) Using Google Hangouts on Air for Medical Education: A Disruptive Way to Leverage and Facilitate Remote Communication and Collaboration. J of Grad Med Ed: June 2015. 7(2): 171-173. doi: http://dx.doi.org/10.4300/JGME-D-14-00545.1

Teresa M. Chan, Brent Thoma, Ryan Radecki, Joel Topf, Henry H. Woo, Lilian S. Kao, Amalia Cochran, Michelle Lin. (2015). Ten Steps for Setting Up an Online Journal Club. Journal of Continuing Education in the Health Professions, 35(2), 148-154.

Teresa M. Chan, Jonathan Sherbino, on behalf of the McMAP collaborators. McMaster Modular Assessment Program (McMAP): A theoretically-grounded, work-based assessment program. Academic Medicine. 90(7), 900-905. DOI: 10.1097/ACM.0000000000000707.

Melissa Hayward, **Teresa Chan,** Andrew Healey. (2015). Dedicated time for deliberate practice: one emergency medicine program's approach to point-of-care ultrasound (PoCUS) training. CJEM, 17, pp 558-561. doi:10.1017/cem.2015.24.

Teresa M. Chan, S. Luckett-Gatopoulos, Brent Thoma. (2015). Commentary on competency-based medical education and scholarship: creating an active academic culture during residency. Perspectives on medical education, 4(5), 214.

Isabelle N. Colmers, Quinten S. Paterson, Michelle Lin, Brent Thoma, **Teresa M. Chan**. Quality checklists for health professions blogs and podcasts. The Winnower. 2:e144720.08769 (2015). DOI: 10.15200/winn.144720.08769

Brent Thoma**, Teresa M. Chan**, Quinten S. Paterson, W. Kenneth Milne, Jason L. Sanders, Michelle Lin. Emergency Medicine and Critical Care Blogs and Podcasts: Establishing an International Consensus on Quality. Annals of Emergency Medicine. Accepted for publication on March 2, 2015. Online First: March 31, 2015. Available at: http://www.annemergmed.com/article/S0196-0644(15)00189-4/pdf

Michelle Lin, Brent Homa, N. Seth Trueger, Felix Ankel, Jonathan Sherbino, **Teresa M Chan.** (2015). Quality indicators for blogs and podcasts used in medical education: modified Delphi consensus recommendations by an international cohort of health professions educators. Postgraduate Medical Journal, Online First. Available at: http://pmj.bmj.com/content/early/2015/08/14/postgradmedj-2014-133230.abstract doi:10.1136/postgradmedj-2014-133230