

# The ETTO principle and organisational strategies: a field study of ICU bed and staff management

Tania Xiao · Penelope Sanderson · Samantha Clayton · Bala Venkatesh

Received: 16 January 2010 / Accepted: 21 February 2010 / Published online: 10 April 2010  
© Springer-Verlag London Limited 2010

**Abstract** The purpose of this study was to examine how Hollnagel's efficiency-thoroughness trade-off or ETTO principle (Hollnagel, *The ETTO principle: efficiency-thoroughness trade-off*. Ashgate Publishing Ltd, Farnham, 2009) can inform our understanding of the organisational strategies used to manage bed and staff resources in an Intensive Care Unit (ICU). We conducted a field study involving observations, interviews and analysis of artefacts used by the rostering nurse and nurse-in-charge of an ICU in a large metropolitan hospital. We identified five organisational strategies used by the nurses to maintain balance between efficiency and thoroughness demands: (a) a flexible unit-based staffing policy, (b) a theatre coordination rule, (c) a set of bed and staff (re)distribution options, (d) patient bed location preferences, and (e) staffing allocation order preferences. Our findings show that the ETTO principle is a useful descriptive model for understanding the factors that make organisational strategies successful. We also suggest how ideas from the organisational literature can enrich future research on the ETTO principle.

**Keywords** Coordination · Organisational strategies · Healthcare · Efficiency-thoroughness trade-off · Intensive care · Nursing management

---

T. Xiao · P. Sanderson (✉) · B. Venkatesh  
The University of Queensland, St Lucia, QLD, Australia  
e-mail: pennys@itee.uq.edu.au

P. Sanderson  
National ICT Australia (NICTA), St Lucia, QLD, Australia

S. Clayton · B. Venkatesh  
Princess Alexandra Hospital, Woolloongabba, QLD, Australia

## 1 Introduction

### 1.1 Overview

During a trip to Brisbane, Australia in 2007, Erik Hollnagel gave a workshop on the efficiency-thoroughness trade-off (ETTO) principle, and the first two authors (TX and PS) were fortunate enough to attend. The workshop was well-attended and very well-received. When the call came for contributions to this special issue of *Cognition, Technology, and Work* in honour of Erik stepping down as an Editor-in-Chief, two events aligned. First, Erik had just published his book on the ETTO principle (Hollnagel 2009). Second, the first author was analysing data from a major study on the daily management of bed and staff resources in an Intensive Care Unit (ICU), where nurses' need to balance throughput demands and patient well-being was a constant theme. How better to celebrate Erik's contributions than to take the ETTO principle, apply it to the ICU case, and even extend the ETTO principle just a little?

As Erik notes in his book, the ETTO principle is descriptive, not explanatory (Hollnagel 2009). As with so much of Erik's work, though, his exposition orients us to where the heart of a problem is and alerts us to where it is not. Erik's call to study work "when things go right" is appealing as well as logical. Accordingly, our report of the ICU bed and staff resource management task focuses on how nurses successfully balance efficiency and thoroughness demands.

The aim of this paper is to identify the organisational strategies that nurses use to balance efficiency and thoroughness demands relating to bed and staff management in the ICU. In the remainder of the paper, we provide a summary of the ETTO principle, connect it with key ideas

in the organisational literature, and then describe the basics of the bed and staff management problem and of the study itself. Then we outline five key organisational strategies used by nurses to achieve success, highlighting the heuristics that guide nurses' implementation of the strategies. Finally, we draw conclusions for how research on the ETTO principle at the organisational level might be further developed.

## 1.2 Research background

The ETTO principle states that people make trade-offs (i.e. sacrifices) between efficiency and thoroughness demands under conditions of limited resources and environmental uncertainty. Efficiency is defined as minimising the amount of resources used to achieve work outcomes, while thoroughness involves ensuring that all necessary conditions have been met for the successful completion of tasks. Hollnagel (2009) argues that it is not possible to maximise both efficiency and thoroughness at the same time. Failure can result if (a) thoroughness dominates because the activity is performed too late or (b) efficiency dominates because the activity may be inappropriate for the situation. Using a pair of scales as an analogy, Hollnagel states that successful performance requires maintaining a minimum level of both so that they remain balanced.

To maintain balance between efficiency and thoroughness demands, people often need to deviate away from prescribed work practices, especially if the prescriptions provide insufficient information about how to handle efficiency and thoroughness trade-offs. Hollnagel argues that this variability in performance is only noticed when it leads to negative outcomes. Consequently, performance variability is viewed as a 'failure of compliance' problem in the traditional accident investigation literature.

Hollnagel advocates a positive view of performance variability as a normal and necessary part of effective work practice. As he puts it:

Performance variability may introduce a drift in the situation, but it is normally a drift to success, a gradual learning by people and social structures of how to handle the uncertainty, rather than a drift to failure (Hollnagel 2009, p. 94).

Implied in the aforementioned quote is the idea that failures are special cases of performance variability. Therefore, Hollnagel argues that instead of focusing on failures, researchers should study performance variability and why it is normally successful.

According to Hollnagel (2009), there are three types of performance variability. *Teleological variability* occurs when people adjust their performance to anticipated changes in the environment such as fluctuations in demand

or supply. *Contextual variability* occurs when people adjust their performance using heuristics that have been satisfactory in the past. *Compensatory variability* occurs when people adjust their performance in response to unpredictable disturbances in the immediate present.

There are two key issues concerning the definitions mentioned earlier. First, despite the implications of the word *variability*, performance variability should not be interpreted as just random variation in responses to environmental pressures. Instead, performance variability is largely a collection of well-learned and well-accepted strategies that people use proactively to maintain balance between efficiency and thoroughness demands. For example, Hollnagel provides a set of individual and collective rules that people use when making efficiency-thoroughness trade-offs (e.g. 'It will be checked later by someone else' and 'Reduce unnecessary costs').

Second, it is important to remember that performance variability occurs at the organisational level as well as within the individual worker. Specifically, organisations may have strategies that help maintain the balance between efficiency and thoroughness. For example, Hollnagel (2009, pp. 30–31) gives an example of how detailed planning and standardisation of the camp layout for the Roman army provided the necessary support to enable officers to focus on battle operations.

Researchers in the organisation sciences have explored the idea of organisational strategies in some detail. In his seminal book on organisational design, Thompson (1967) argued that the operating core of an organisation needs stability to perform effectively. Therefore, organisations have various strategies for protecting the operating core from environmental disturbances. For example, organisations create *buffers* that absorb environmental disturbances, such as the stockpiling of resources. Organisations try to reduce environmental variations by *levelling* demand. For example, retail shops have sales during slow periods to level customer demand. Also, organisations try to *anticipate* changes in the environment (e.g. forecasting) and plan their operations accordingly. Finally, if organisations cannot protect core operations by buffering, levelling or anticipating, they resort to the *rationing* of resources by applying a set of rules that reflect work priorities.

Note the similarities between Thompson's core-protecting strategies and Hollnagel's (2009) performance variability classifications. Teleological variability is driven by environmental change. Therefore, the buffering, levelling and anticipating strategies can be considered forms of teleological performance variability. Contextual variability is driven by heuristics that 'satisfice' work objectives. Similarly, the set of priorities by which resources are rationed is a set of heuristics for addressing organisational goals and values. There is no organisational equivalent for

compensatory variability. However, the omission is not surprising given that compensatory variability reflects a less-structured, more opportunistic adjustment of work practices.

Hollnagel (2009) recognises that the ETTO principle is relevant to both individual and organisational performance. For example, as previously mentioned, he provides collective, or organisational, ETTO rules including *reduce unnecessary costs* and the *prioritising dilemma* (i.e. where managers sacrifice high workplace visibility for administrative efficiency). In addition, Hollnagel comments that individuals can learn from their mistakes and make changes to work practices that modify the ‘organisation’s underlying norms, policies and objectives’ (Argyris and Schon 1978). We extend this notion by arguing that, in light of Thompson’s work, changes in organisational strategies and policies can also result from a proactive attempt to make work practices less vulnerable to environmental disturbances. The next step is to identify such organisational strategies and investigate how they contribute to successful organisational performance.

### 1.3 The present study and research setting

In our study, we investigate the ETTO principle and organisational strategies in healthcare—a domain that involves many competing needs. There has been some prior research on the coordination strategies used to manage conflicting demands in the context of scheduling surgical procedures (Bardram 2000; Nemeth et al. 2006; Xiao et al. 2007). Furthermore, researchers have explored how conflicting pressures of demand and supply are handled across different levels of management in a trauma unit (Miller and Xiao 2006) and across clinical and non-clinical hospital departments (Abraham and Reddy 2009). These studies provide valuable insight into the challenges and strategies associated with hospital units operating at capacity (Miller and Xiao 2006; Cook 2006), the importance of making fair resource allocation decisions (Bardram 2000; Xiao et al. 2007), and the limitations of existing technology support (Abraham and Reddy 2009). We extend the above work by examining how the ETTO principle can further our understanding of the coordination strategies used to manage conflicting demands.

To achieve this aim, we focus on the daily management of bed and staffing resources in the Intensive Care Unit (ICU), an organisational function fundamental to the unit’s operational effectiveness. There is strong pressure for ICU resources to be managed efficiently so that the unit can meet hospital and patient demands. Inefficient management of ICU resources can limit the number of surgeries performed in hospital and the hospital’s ability to admit

trauma patients. Due to the critical condition of ICU patients, there is also strong pressure towards thoroughness with respect to the safety and quality of care provided. Ineffective management of nursing resources can result in inappropriate patient care, which can lead to adverse patient outcomes.

The daily management of bed and staff resources is shared between the rostering nurse and nurse-in-charge. Bed management involves (a) coordinating the flow of patients in and out of the ICU and (b) managing the number of patients that are cared for in the ICU. Daily staff management involves (a) maintaining an appropriate level of staffing resources to handle patient demands in the present and near future (i.e. next shift) and (b) distributing nursing resources in an effective and fair manner.

To show the context in which organisational strategies are performed, the key events and activities associated with bed and staff management are described in the following paragraphs and are illustrated in Fig. 1 (where we have done homage to Erik’s inimitable graphical style with a “screen bean” diagram).

- At 7 am, the rostering nurse and nurse-in-charge start the day shift. The rostering nurse asks the nurse-in-charge from the night shift if there is enough staff for the current shift. The rostering nurse then assesses the number of staff rostered for that day.
- At 8 am, the rostering nurse meets with the ICU consultant-in-charge to negotiate the number of beds that the unit can staff that day. During this meeting, the consultant also considers how many patients can be discharged and admitted that day.
- At 9 am, the rostering nurse attends a bed management meeting involving the nurses-in-charge of all units in the hospital, plus the Nurse Managers of the Bed Management Unit and Nursing Resource Unit. During this meeting, the rostering nurse discusses with other nurses-in-charge and Nurse Managers the number of admissions and discharges expected by the ICU that day.
- After the bed management meeting, the rostering nurse confirms with the ICU nurse-in-charge which patients will be discharged. The nurse-in-charge then starts to coordinate patient discharges.
- During their shift, the nurse-in-charge also needs to plan for new elective and emergency admissions and prepare staff allocations for the next shift.
- While the rostering nurse is on duty (i.e. 7 am–3:30 pm Monday–Friday), he or she manages staffing demand and availability issues. When the rostering nurse is off duty, the nurse-in-charge performs this task.
- Throughout the shift, there is high uncertainty related to the timing of patient admissions and discharges and the

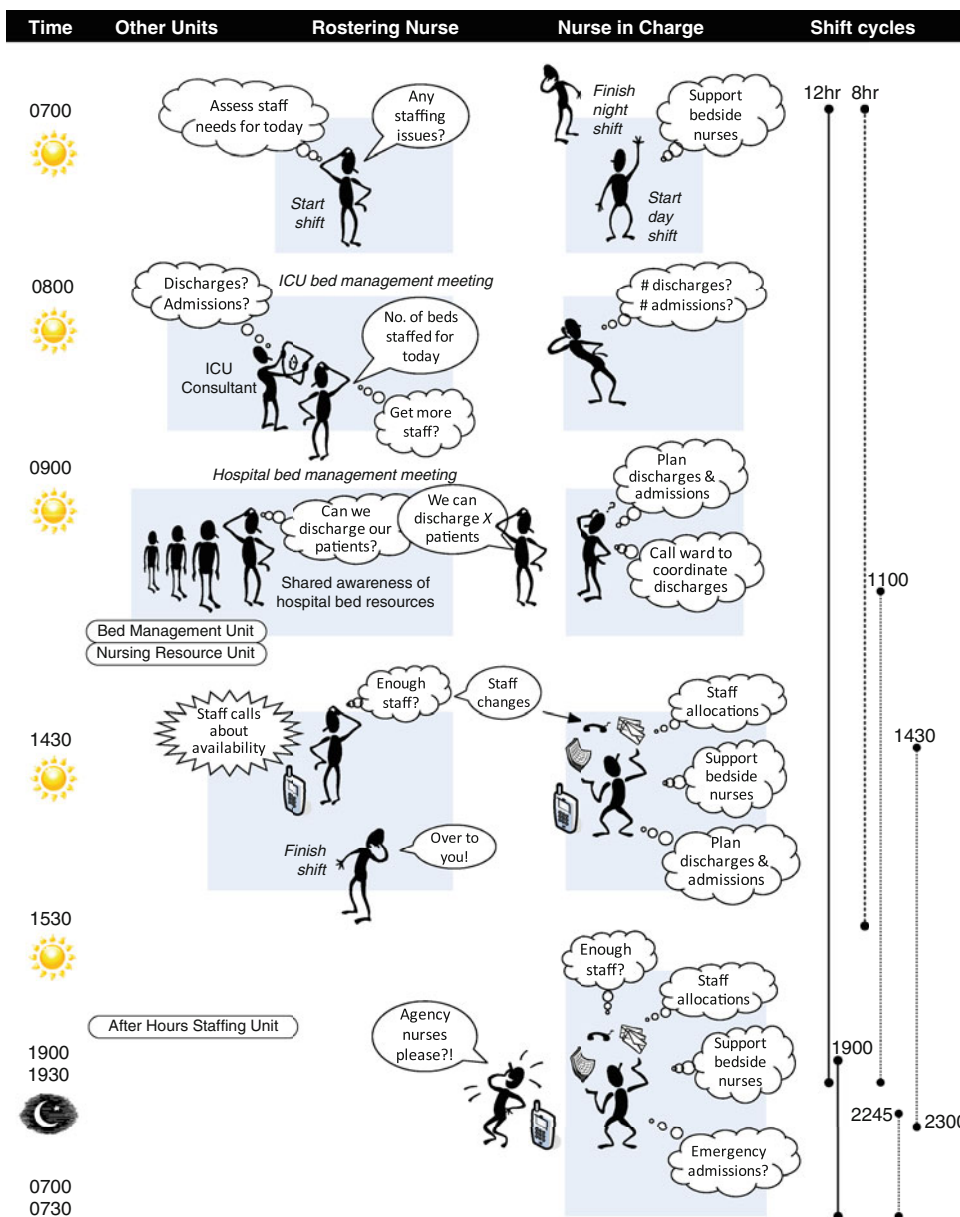


Fig. 1 Key events and activities associated with daily staff and bed management

availability of staffing resources. It is the nurse-in-charge’s responsibility to plan for contingencies and (re)distribute resources given changes in demand (as shown in the following quote).

In the day shift you [...] coordinate the staffing [...] with [...] the NUM-DR [rostering nurse] [...] to work out the number of staff you have and then assess your available beds and therefore the number of patients you can admit. Look at also just appropriate staff allocations and skill mix. Just try to have contingency plans so if we get an admission or someone deteriorates, you can deal with that. You’ve got some idea in

the back of your head what you’ll do when that does or does not occur.

The quote suggests that the nurse-in-charge has strategies for balancing productivity (efficiency) and patient care (thoroughness) demands. In the following sections, we examine these strategies in detail and their relationship with efficiency and thoroughness demands. Specifically, we (a) examine how the general efficiency and thoroughness demands mentioned earlier are reflected in the bed and staff management task and (b) identify the organisational strategies developed in the ICU to maintain balance between the efficiency and thoroughness demands. Finally,

we discuss the implications of our findings for furthering research into the ETTO principle at the organisational level.

## 2 Methods

### 2.1 Site

The ICU investigated is in a large metropolitan tertiary hospital in Australia. It has 30 beds, but it is currently funded for 22 beds on weekdays and 16 on weekends. There are two sections in the unit: a post-operative area with 10 beds and a general area with 20 beds. There are approximately 200 nurses in the unit. The nurse patient ratio ranges from 1:1 to 1:2. Most nurses work in either 12 or 8-h shifts. Unit management objectives are to provide 30 h of direct nursing care per patient per day (the “30 DNHPPD” or 30 Direct Nursing Hours Per Patient Day objective), which involves 24 h of bedside care and 6 extra hours from a more experienced bay nurse who supports 4–5 bedside nurses.

### 2.2 Data collection

Ethical approval for this study was obtained from the Human Research and Ethics Committees of the Princess Alexandra Hospital and The University of Queensland. Our data collection activities included field observations, interviews and analysis of various artefacts. The first author (the “researcher”) observed over 120 h of work in the ICU from July to August, 2008, taking detailed field notes throughout. The observations covered 12 and 8-h shift types, weekends and weekdays, and both day and night shifts. The observations numbered 8 shifts with nurses-in-charge, 4 day shifts with the rostering nurse, and 1 part-day shift with the Nurse Unit Manager.

In addition to informal interviews during the observations, the researcher conducted 6 formal interviews, including interviews with two nurses-in-charge, the current rostering nurse, two former rostering nurses, and the Nurse Unit Manager. The interviews were taped and later transcribed. Finally, the researcher also collected copies and took photos of tools and artefacts (electronic and non-electronic) used by the rostering nurse and nurses-in-charge, including whiteboards as well as various staff and bed management procedures, guidelines and forms.

### 2.3 Data analysis

The analysis of the interview and observation data was guided by grounded theory (Strauss and Corbin 1998). Interview transcriptions, observational notes and scans of

artefacts were imported into the qualitative data analysis software NVivo (QSR International; Melbourne, Australia). During the initial coding process, the high-level themes of efficiency-thoroughness trade-offs and the organisational strategies emerged. The following low-level categories captured the principal distinctions in the Hollnagel (2009) and Thompson (1967) models: efficiency demands, thoroughness demands, buffering, anticipating and rationing. Finally, empirical evidence from the observations, interviews and artefacts were selected and integrated to illustrate instances of the demands and strategies. Therefore, all the work descriptions are derived directly from the interview, observation and artefact data.

## 3 Results

In this section, first we consider the efficiency and thoroughness demands pertinent to the bed and staff management task. Then we describe the organisational strategies developed and used by the ICU’s rostering nurse and nurses-in-charge to maintain balance between the efficiency and thoroughness demands.

### 3.1 Efficiency and thoroughness demands

Our analysis revealed several efficiency and thoroughness demands related to staff and bed management. There were two main efficiency goals and two main thoroughness goals. Efficiency goals were: (a) admit as many patients as would meet the demand for the ICU and (b) minimise nursing staff costs. Thoroughness goals were: (a) provide a high quality of patient care and (b) promote staff well-being.

There is strong pressure for the ICU to admit as many patients as possible. Consequently, there is pressure at times to admit more patients than for whom there are funded beds, and to discharge patients as soon as possible to make room for new admissions (as illustrated in the following quotes).

Lately often because of our staffing not being ideal we’ve been running more at 20 but even at times [that] we’re supposed to be running at 20 until we get our staffing up, we’ve had at times 22 or 23 patients.

There’s always this pressure that we know that if there’s internal emergency or a trauma, we have to take a patient.

The shift obviously always starts off with the pressure to you know make sure that your patients that are current there are right to be discharged.

Efficient turnaround of ICU patients can have benefits for the rest of the hospital and the surrounding community, including the reduction of theatre waiting lists and times. If efficiency is sacrificed so that the ICU admits fewer patients, the well-being of patients outside the ICU could be compromised (e.g. rejection of trauma patients, reduction in operation numbers). In addition, the hospital may experience a reduction in Government funding because of its reduced productivity.

Nevertheless, a strong tendency towards this efficiency goal can have detrimental effects on the thoroughness goals of patient care and staff well-being, given that bed and staff resources are limited. For example, patients may receive less adequate care in terms of either (a) fewer direct hours of nursing care (i.e. the 30 DNHPPD objective is not reached) or (b) being cared for by a less-experienced nurse. In addition, there is the risk of patients being discharged before they are well enough to be in the wards. Finally, staffing resources may be stretched to the point that there is an increased incidence of sick leave or staff burnout.

ICU nursing wages make up a significant proportion of ICU costs. Therefore, there is strong pressure to minimise staffing costs in terms of both ICU nurses and agency nurses (as shown in following quotes).

You're funded for 22 beds. There's one stage where we looked like running 23 beds—we had to staff for that and then later in the day it changed and I guess you're under a bit of pressure to make sure people know if you have too many nurses and you can't just hide them and make it up. You have to justify why you have nurses here.

And again you need to include times if someone's [agency nurse] booked to either keep them all or get rid of them.

Efficient management of nursing staff costs can have benefits for the ICU because the funds can be used in other areas such as equipment upgrades, professional development or education programs. If efficiency is sacrificed, there are possible flow-on effects for staff morale. Staff oversupply may result in some staff being redeployed to other hospital units. Because many ICU nurses do not like working in other hospital units, some perceive redeployment as a failure by the unit to appreciate their skills and abilities. The nurses would prefer to be given recreation leave in appreciation for the more intense work they do when the unit is busy.

Nevertheless, a strong tendency towards this efficiency goal can also have detrimental effects on the thoroughness goals of patient care and staff well-being. Staffing resources may be continually overstretched if nursing managers are reluctant to maintain spare staff, call in extra staff, or

order agency staff. Again, if nursing staff are overworked, patients may receive reduced quality of care.

Given the above, it is clear that daily bed and staff management is an extremely challenging function that involves balancing the needs of the patient, staff and the ICU. Failure to maintain an adequate response to the ICU's efficiency and thoroughness objectives has serious consequences for patients, staff, and the unit as a whole. Next, we discuss organisational strategies that the rostering nurse and nurse-in-charge use to maintain a balance between the efficiency and thoroughness goals.

### 3.2 Organisational ETTO strategies

In this section, we describe five organisational strategies used by either the rostering nurse or nurse-in-charge to balance the efficiency and thoroughness goals discussed earlier. The strategies are categorised into three of Thompson's (1967) core protecting strategies: buffering, anticipating and rationing. In our data, we did not identify levelling strategies which is not unexpected given that the ICU has limited control over fluctuations in patient demand. Table 1 summarises the features of these strategies and the efficiency-thoroughness demands they address.

#### 3.2.1 Buffering

Our analysis revealed one organisational strategy that the unit had developed to buffer against fluctuations in patient demand: a unit-based staffing policy.

**3.2.1.1 Unit-based staffing policy** To minimise staffing costs, the hospital has a policy under which spare nurses from any unit in the hospital may be redeployed to another unit. If there is an oversupply of ICU nurses, they can be asked to work in the general wards. An unfortunate outcome of this policy is that it supports overall hospital efficiency at the expense of staff well-being. Many ICU nurses do not like working in the wards because of unfamiliarity with the ward routines and surroundings. Until recently, ICU staff had to take recreation leave if they wanted to leave when the ICU was quiet. If staff were refused recreation leave, some staff chose to call for sick leave rather than be pooled to the wards. Conversely, when it was busy, the ICU would order more agency nurses to fill in the gaps if their own staff were unavailable. Although agency nurses are qualified to care for critical patients, they are less familiar with the ICU routines and equipment. They therefore require more assistance from the ICU nurses, thereby increasing the workload of ICU nurses.

**Table 1** Organisational strategies for balancing efficiency and thoroughness demands

Organisational strategy	Basic description	Relevant efficiency demand*	Relevant thoroughness demand(s)*
<b>Buffering</b>			
Unit based staffing policy	If there is staff oversupply, staff can leave and work off those hours when there is staff undersupply	+ Reduce staff costs	+ Staff wellbeing
<b>Anticipating</b>			
Theatre coordination rule	Call theatre by 5 pm to confirm admissions	+ Reduce staff costs	+ Patient care
Patient bed location preferences	Locate patients with similar illnesses together if possible	+ Meet demand for ICU beds	+ Staff well-being
<b>Rationing</b>			
Bed and staff distribution options	Options for (re)distributing bed and nursing resources	+ Meet demand for ICU beds	=/- Patient care
Staffing allocation order preferences	Rules and options for making the best possible match between patient and staff needs given staff skillmix	N/A	=/- Staff well-being; Patient care

\* Note: + is a tendency towards demand; – is a tendency away from demand; = is a negligible effect on demand

In response to the aforementioned problem, several years previously the ICU formed its own Unit-Based Staffing (UBS) policy. When staffing levels exceed requirements, staff can be given the option to work reduced shift hours or take the entire shift off without having to take sick leave or recreation leave. Staff were still paid for the hours they were supposed to work but those hours are logged as time owed by the staff to the unit. Alternatively, when staffing levels are below requirements, staff can be asked to work additional hours or shifts. Staff who owe hours can take this opportunity to pay back time owed to the unit. Staff who do not owe hours can also accrue positive work hours and take time off in lieu at a later date.

The UBS policy has been fairly successful because it addressed the need to minimise staffing costs while minimising negative effects on staff well-being. The ICU can adjust staff numbers to match patient demand while reducing waste of staffing resources. Specifically, this policy allows the unit to ‘stockpile’ nursing hours when demand is low and use it when demand is high. The UBS policy also reduces the need for agency nurses, which improves cost efficiency because agency nurses are more expensive than ICU nurses. Furthermore, the reduced use of agency nurses reduces staff workload because less monitoring and assistance is needed. Finally, there are additional benefits to patient care because the ICU nurses are more familiar with the ICU and more experienced with handling patients’ critical care needs than are the agency nurses. Interestingly, the main obstacle to this policy being more successful is that it is not fully supported at the hospital level. The hospital still prefers ICU nurses to be redeployed to other units rather than being allowed to go home.

### 3.2.2 Anticipating

Our analysis revealed two organisational strategies used by nurses in the unit to help them anticipate and prepare for patient demand: (a) a theatre coordination rule and (b) patient bed location preferences.

*3.2.2.1 Theatre coordination rule* The ICU receives many bed bookings from the operating theatre. From the surgical team’s point of view, there is comfort in knowing that their patient can receive intensive care if needed post-surgery. Unfortunately, the surgical team’s concern for their patients’ welfare makes it harder for the ICU to manage staffing costs efficiently. To prepare resources for admissions, the rostering nurse or nurse-in-charge may have to ask ICU nurses to work overtime or call in agency nurses. Theatre staff often forget to inform the ICU that a patient no longer needs to be admitted to the ICU because the patient was well enough to be discharged back to the ward (see quote below). The ICU may not find out this information until it is too late to cancel the extra staff, resulting in unnecessary staffing expenses.

We could have times where we’ve allocated, say, for patients to come in here and you think oh they’re taking a long time. I might ring and see what’s happening and they’ll say ‘Oh, they’ve gone to the ward. They didn’t need to come to ICU post theatre’ or something and then you’ve actually allocated staff and kept staff for them.

During our data collection period, one of the senior nurses introduced a rule whereby before 5 pm, either theatre or the ICU would call the other to give/get an update

on which theatre patients need an ICU bed and when to expect the admissions. This simple rule addressed the ICU's need to efficiently manage staffing costs without having a negative impact on how the surgical team managed patient well-being. Specifically, by following the rule, the nurse-in-charge can develop a more accurate assessment of patient demand in the near future and manage resources accordingly. The rule also benefits patient care because the nurse-in-charge can accept potential trauma patients who might otherwise have been sent elsewhere if the nurse-in-charge had still been reserving resources for the theatre admission.

**3.2.2.2 Patient bed location preferences** ICU patients require round-the-clock care, which can be very demanding on nursing staff. Some nurses-in-charge preferred to locate patients to ICU bed areas in a way that would reduce demand on nursing staff (thereby promoting staff well-being) without sacrificing patient care. For example, the nurse-in-charge avoids locating patients in isolated bed areas unless they need to be isolated as a virus precaution. Having patients adjacent to other patients lets bedside nurses coordinate tea breaks so that only one of them is away at a time (see the following quotes). Otherwise, a bay nurse must remain with the patient and is thus unable to perform other duties until the bedside nurse returns.

So you try not to have patients in pods by themselves because then every break you [the bay nurse] have to go there and the two nurses can't inter-relieve.

You'd like to have all the new patients in a certain order [because it] means that you have better coverage and support since splitting people, one there, one there, spreads your resources a bit thin.

Also, in anticipation of potential increases in patient demand, some nurses-in-charge prefer to place patients with similar care needs next to one another. Although this preference requires thorough planning, it promotes efficient use of staff resources in several ways. First, two patients of similar criticality may become more stable at a later time, providing the opportunity to have one nurse care for both if nursing resources are limited. Second, if patients have similar illnesses, the nurse-in-charge can allocate a less-experienced nurse to one of the patients if there are limited experienced nurses because the less-experienced nurse can get guidance from a more-experienced nurse allocated to the other patient.

### 3.2.3 Rationing

Our analysis revealed two organisational strategies that provided a set of rules to help the nurse-in-charge ration

bed and staff resources during periods of high demand and limited resource: (a) a set of bed and staff (re)distribution options and (b) staffing allocation order preferences.

**3.2.3.1 Bed and staff (re)distribution options** To achieve thoroughness in patient care, one of the ICU objectives is to provide 30 h of direct nursing hours per patient per day (the 30DNHPPD objective, consisting of 24 h of bedside care plus 6 extra hours from the bay nurse). So long as this objective is met, the nurse-in-charge is reasonably confident that there are sufficient resources to provide high-quality patient care. However, the objective is often sacrificed because of patient admission demands. A very challenging aspect of bed management is to respond effectively to admission demands without compromising the care of existing patients (as expressed in the quote below).

A difficult day is when they [consultants] keep accepting patients that are more emergency admission so [you need to look] at how can we accommodate an emergency admission.

The nurses-in-charge observed in this study shared a common set of options that guided their choices about how to ration bed and staff resources to accommodate emergency admissions. Table 2 provides a list of the options, the amount of effort spent by the nurse-in-charge to achieve an option, and the likelihood that an option would result in a drop in the thoroughness of patient care. The allocation of a spare nurse to that patient (Option 1) is the ideal solution but often it is not possible if there are no spare staff. Identifying a stable patient to discharge and coordinating that discharge (Option 2) or calling in an extra ICU or agency nurse (Option 3) have minimal impact on patient care, but they require much time and effort to achieve. Therefore, having one nurse look after two extubated patients (Option 4) or allocating a bay nurse to that patient (Option 5) are often the most popular because they usually require less time to achieve. Achieving a quick solution is a priority, especially if the admission is an urgent one. However, the nurse-in-charge is aware of the sacrifices to thoroughness resulting from Options 4 and 5 as is illustrated in the following quote.

If you couldn't do all those things [less resource heavy options] you would probably [...] break the rules so to speak [in] having so many support nurses to patients [...] but again your risk assessment is that if anything does go wrong then the outcome is even worse. So I guess you have to discuss that with your consultant, saying I'm telling you that this is the outcome, we're taking a patient by dropping a bay, it leaves this many nurses to a patient. If one of them



**Table 2** Bed and staff (re)distribution options and the associated trade-off in patient care objectives and effort needed to achieve option

Option	Thoroughness trade-off	Effort needed to achieve option
1 If there are spare staff, allocate the staff to the new admission	Low	Low
2 Try to find a patient who can be discharged, coordinate their discharge in time so that patient's nurse can take on the new admission	Low	High
3 Try to call in ICU staff or book an agency staff	Low	High
4 If there are two stable patients, move them together (if they are not already located next to each other) and allocate one nurse to them so that the other nurse can take on the new patient	Medium	High if patient movement required. Low otherwise
5 Drop a bay nurse and allocate that nurse to the patient. Redistribute that bay nurse's responsibilities to the other bay nurses	High	Low

was to get sick and you needed to do some interventions we don't have the staff to support that.

**3.2.3.2 Staffing allocation order preferences** The nurse-in-charge is also responsible for preparing staffing allocations for the next shift. The goal of staffing allocations is to match patient needs with staff capabilities and needs, to promote high-quality patient care, and to promote staff well-being (as shown in the following quote). Given that nursing staff resources—especially experienced nursing staff—are limited, sacrifices must be made to patient care and staff well-being goals.

It can be quite hard getting the skill mix and so [...] you've got to try and allocate appropriately [...] you don't have all your junior staff together and people aren't allocated a patient that's too complex for them to manage.

Our observations revealed that all the nurses-in-charge performed allocations in the following order: general-side bay nurse team leader and other bay nurse roles first, complex patients second and the remaining patients last. More importantly, experienced nurses were rationed in that order so that the most-experienced nurses were given bay nurse roles and the least-experienced nurses the least-complex patients. The benefit of this approach is that even if a patient cannot be allocated a suitably experienced bedside nurse, the bedside nurse will at least be assisted by a suitably experienced bay nurse.

There are some allocation rules that nurses must follow to provide high-quality patient care. For example, new staff who are going through developmental transition phases cannot be given patients beyond their competencies. Each transition staff member also has a "preceptor" with whom they need to work closely as part of their training. Unless a patient is especially complex, experienced staff are usually given bay nurse roles than bedside nurse roles. One form of compensation is to give a "preceptor" a bay nurse role in the section of beds in which the new staff works, so that

they can spend some time working together. Although this solution still compromises the thoroughness goal of meeting staff development needs, such rationing of experienced staff is necessary to achieve the most effective staffing plan possible.

## 4 Discussion

In this section, we discuss the implications of the findings on the ETTO principle and for furthering research at the organisational level. We also note avenues for future research.

### 4.1 Implications

The purpose of this study was to investigate the efficiency and thoroughness demands related to bed and staff management and to identify the organisational strategies used by the rostering nurse and nurse-in-charge to maintain balance between those efficiency and thoroughness demands. First, our findings support the notion that efficiency-thoroughness trade-offs are a normal and very important part of work performance. Bed and staff resource management is an extremely challenging function with serious consequences for patient well-being, staff well-being and ICU performance. Despite the tough decisions and sacrifices made in response to the various conflicting efficiency and thoroughness goals, patient care was never compromised and no adverse consequences were observed during the period of our investigations. Interestingly, one rostering nurse noted:

The main things I learnt were [that] things generally will work out in the end. It's just [that] you are going to have to do the work to get it there.

Second, our findings show that the rostering nurse and nurse-in-charge developed and used a range of organisational strategies to help them maintain a balance between efficiency and thoroughness demands. For example, in

addition to the hospital policy, the ICU has a Unit-Based Staffing (UBS) policy that lets them redistribute nursing resources over time thereby providing a buffer between the unit and changes in patient demand. In anticipation of future patient demand, nurses-in-charge will try to locate patients in a way that creates opportunities for implementing more efficient bed management options later on. Also, by calling theatre in the afternoon, the nurse-in-charge can make more accurate predictions of future demand and plan for resources accordingly. Finally, the bed and staff (re)distribution options and staffing allocation order preferences promote effective rationing of bed and staff resources.

Third, our findings suggest that one of the factors that make organisational strategies effective is that the strategies address multiple goals. On the one hand, the hospital staff redeployment policy addressed the need to minimise staffing costs at the expense of staff well-being. On the other hand, the UBS policy helped the unit minimise staffing costs but also addressed staff well-being demands by allowing staff to go home when it was quiet, at no personal loss. On a related point, we also found that the nurse-in-charge had to make thoroughness-thoroughness trade-offs between patient care and staff well-being when doing staff allocations. This finding suggests that organisational strategies are not limited to efficiency-thoroughness trade-offs but of course can be used to maintain balance between any set of conflicting demands.

#### 4.2 Future research

In this study, we show how people use organisational strategies to maintain balance between efficiency and thoroughness demands. In an attempt to promote use of the ETTO principle at the organisational level, we connected Hollnagel's (2009) conceptualisations of performance variability with Thompson's (1967) organisational strategies for protecting the operating core from environmental disturbance. Thompson's ideas about buffering, anticipating and rationing enriched our understanding of performance variability at the organisational level. However, there are other theories that may also contribute to our understanding of organisational variability, such as organisational routines (Feldman and Pentland 2003) and organisational structure (Mintzberg 1979).

Finally, Hollnagel mentioned that failures are a special case of performance variability and that by understanding what makes performance variability successful, we can develop support systems that improve the likelihood of success across a wider range of situations. Another avenue for future research would be to identify situations in which organisational strategies become vulnerable to breakdown,

which would help to identify where support systems are needed.

## 5 Conclusion

Erik Hollnagel's (2009) ETTO principle has proven to be a useful descriptive model for organising our thinking about bed and staff resource management in the ICU. We focused on how nurses respond to efficiency and thoroughness demands at an organisational level, and we uncovered a range of organisational strategies that addressed multiple efficiency and thoroughness goals. Nurses select from organisationally sanctioned strategies to meet work demands, and they do so both successfully and in a sustainable way. It is clear that there is indeed much to be learned from studying success. Overall, we are confident that Erik's future contributions will continue to stimulate our thinking, wherever those contributions appear.

**Acknowledgments** This research was supported by Australian Research Council Grant DP0880920 to Sanderson and Venkatesh. We thank the staff members in the Princess Alexandra Hospital Intensive Care Unit for their time and support.

## References

- Abraham J, Reddy M (2009) Challenges to inter-departmental coordination of patient transfers: A workflow perspective. *Int J Med Inform.* doi:10.1016/j.ijmedinf.2009.11.001
- Argyris C, Schon D (1978) *Organizational learning: a theory of action perspective.* Addison-Wesley, Reading Mass
- Bardram J (2000) Temporal coordination: on time and coordination of collaborative activities at a surgical department. *Comp Sup Coop Work* 9:157–187
- Cook RI (2006) Being bumpable: consequences of resource saturation and near-saturation for cognitive demands on ICU practitioners. In: Woods DD, Hollnagel E (eds) *Joint cognitive systems: patterns in cognitive systems engineering.* CRC Press, Boca Raton, pp 23–35
- Feldman MS, Pentland BT (2003) Reconceptualizing organizational routines as a source of flexibility and change. *Adm Sci Q* 48(1):94–118
- Hollnagel E (2009) *The ETTO principle: efficiency-thoroughness trade-off.* Ashgate Publishing Ltd, Farnham
- Miller A, Xiao Y (2006) Multi-level strategies to achieve resilience for an organisation operating at capacity: a case study at a trauma centre. *Cogn Technol Work* 6:207–222
- Mintzberg H (1979) *The structuring of organizations.* Prentice-Hall, Englewood Cliffs
- Nemeth C, O'Connor M, Klock PA, Cook R (2006) Discovering healthcare cognition: The use of cognitive artifacts to reveal cognitive work. *Organ Stud* 27(7):1011–1035
- Strauss A, Corbin J (1998) *Basics of qualitative research: techniques and procedures for developing grounded theory.* Sage, Thousand Oaks
- Thompson JD (1967) *Organizations in action.* McGraw Hill, New York
- Xiao Y, Kiesler S, MacKenzie CF (2007) Negotiation and conflict in large scale collaboration: a preliminary field study. *Cogn Technol Work* 9(3):171–176