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A qualitative descriptive study of the COVID-19 pandemic: Impacts on nursing care delivery in the critical care work system

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ABSTRACT

The COVID-19 pandemic drastically changed the delivery of nursing care in U.S. critical care settings. The purpose of this study was to describe nurses’ perceptions of the critical care work system during the COVID-19 pandemic in the U.S. We conducted interviews with experienced critical care nurses who worked during the pandemic and analyzed these data using deductive content analysis framed by the Systems Engineering Initiative for Patient Safety (SEIPS) 2.0 model. Concepts include the critical care work system structures, nursing care processes, outcomes, and adaptations during the pandemic. Our findings revealed a description of the critical care work system framed by the SEIPS 2.0 model. We suggest how human factors engineers can utilize a human factors and engineering approach to maximize the adaptations critical care nurses made to their work system during the pandemic.

1. Introduction

The U.S. has recorded almost 80 million cases and over 870,000 deaths due to COVID-19 (Centers for Disease Control, 2021). The COVID-19 pandemic led to an enormous increase in admissions to critical care settings (Huang et al., 2020), and subsequently, an unprecedented need for critical care nurses. In addition to a shortage of nurses there was also a shortage of resources such as inadequate personal protective equipment (PPE) and ventilators. These changes resulted in sweeping changes to the way nursing care was delivered in U.S. critical care settings. Little is yet known about the impact of these changes on nursing care in critical care work systems.

Prior to the pandemic, trained critical care nurses did the majority of patient care in critical care (Brilli et al., 2001). Typical nurse to patient ratios were 1:1 or 1:2 depending on state mandated staffing ratios (Brilli et al., 2001). Low ratios facilitated the critical care nurse’s ability to focus on fewer patients each shift while providing complex, life-sustaining care (Brilli et al., 2001). Critical care nurses are essential to providing complete patient care and attend to complex patient care tasks; less complex tasks are delegated to nursing assistive personnel (Shirey, 2008).

While the COVID-19 pandemic added complexity and stress to nurses’ critical care work system, it also highlighted the baseline imbalance of demands and capacity across multiple areas of nurses’ work. Nursing documentation was a significant burden for nurses due to its level of detail and frequency (Collins et al., 2018). Critical care nurses experienced high rates of burnout (Moss et al., 2016), moral distress (Sirilla et al., 2017) and turnover (Nursing Solutions Inc., 2019). Communication has historically been a challenge between critical care team members and the patient and family (Grant, 2015). There were also not enough nurses to meet the demand for nursing care in critical care (Seda and Parrish, 2019). Understanding nursing care in critical care work systems is important because nursing care is linked to patient and nurse outcomes (Cheung et al., 2008), which impact organizational outcomes.

According to a study by The International Council of Nurses (ICN, 2021), the COVID-19 pandemic significantly impacted nurse outcomes. A majority (76%) of nurses reported on average a three-fold increase in nurse-to-patient ratios (number of nurses who care for a number of patients), which nurses reported as contributing to their exhaustion, burnout, and stress (ICN, 2021). Increased nurse-to-patient ratios (having fewer nurses for more patients) and burnout are not only dangerous to nurses but can also be harmful to patients (ICN, 2021). For every extra patient per nurse, Aiken et al. (2002) found a 7% increase in the odds of patient failure-to-rescue and a 7% increase in the likelihood of dying within 30 days. Nurse burnout is associated with turnover, poor patient outcomes (Bae et al., 2010), and medical errors (Hall et al., 2016), which all have significant financial impact on hospitals (Hirose...
The pandemic intensified the thin financial margins for hospitals, or even caused them to close their doors, as many experienced low patient censuses due to hospital avoidance early in the pandemic. Nationwide, hospitals experienced a collective $36.6 billion loss from March to June 2020 (American Hospital Association, 2020). Patient care in critical care settings is very expensive (Reardon et al., 2018); hospitals, or even caused them to close their doors, as many experienced low patient censuses due to hospital avoidance early in the pandemic. Nationwide, hospitals experienced a collective $36.6 billion loss from March to June 2020 (American Hospital Association, 2020). Patient care in critical care settings is very expensive (Reardon et al., 2018).

Considering the link between nursing care with patient, nurse, and organizational outcomes, nursing care in critical care work systems should be further understood. To persevere financially through and beyond the COVID-19 pandemic, organizations should consider ways to redesign the critical care work system. Furthermore, a systems approach is recommended to mitigate clinician burnout (NAM, 2009), which urgently needs addressing for nurses’ well-being.

Carayon and Perry (2021) suggest use of the Systems Engineering Initiative for Patient Safety (SEIPS) model (Carayon et al., 2006) as a human factors and ergonomics approach for healthcare systems to redesign work systems in response to the COVID-19 pandemic. In the SEIPS model, Carayon et al. (2006) combined the work system model described by Smith and Carayon (2001) with Donabedian’s (1988) Quality (structure-process-outcome) Model. The SEIPS model (Carayon et al., 2006) is comprised of interconnected concepts including the work system (person, organization, task(s), tools & technology, and physical environment), processes (care and other), and outcomes (patient, employee, and organizational). SEIPS also incorporates Balance Theory which emphasizes the interconnectedness of the work system to adapt or facilitate overcoming barriers (Smith and Carayon, 2001; Smith and Carayon-Sainfort, 1989). Holden et al. (2013) described a SEIPS 2.0 model in which the work system construct includes the concepts of internal and external environments, the work processes are described as physical, cognitive, and social/behavioral, and added adaptation as a concept to describe the feedback mechanism to explain the evolution of work systems (Holden et al., 2013). See Fig. 1 for how the SEIPS 2.0 model has been used in this study.

Researchers suggest the COVID-19 pandemic impacted nursing care broadly in healthcare systems (Schroeder et al., 2020; Aliyu et al., 2021); however, little research has focused specifically on nurses’ perceptions of the changes in nursing care in U.S. critical care work systems during the COVID-19 pandemic. Critical care work systems are structures that organize the provision of healthcare (Holden et al., 2013) for critically ill patients experiencing life-threatening illness (Marshall et al., 2017). The purpose of this study was to describe the critical care work system during the COVID-19 pandemic in the U.S. from the perceptions of nurses. The study aims were to:

1. Describe nurses’ perceptions of the critical care work system during the COVID-19 pandemic.
2. Describe nurses’ perceptions of how the COVID-19 pandemic impacted the critical care work system, changed the processes and outcomes, and influenced adaptation.

2. Methods

2.1. Participants

We recruited critical care Registered Nurses via multiple venues, including social media (Facebook, Twitter, and LinkedIn), several large hospitals in the Southwest U.S., nursing organizations, and doctoral nursing students at [redacted]. Potential participants clicked a link to complete a screening questionnaire in Qualtrics (2021). They indicated their interest to participate and input their email address. The principal investigator (CB) reached out to potential participants via email to schedule an interview. Inclusion criteria were two or more years of experience working in an intensive care unit (ICU) in the U.S. and provided care for adult patients in the ICU for at least one month during the COVID-19 pandemic. We selected these criteria to ensure participants accrued substantial experience working in critical care both prior to, and during, the pandemic.

2.2. Procedures

The principal investigator (CB) developed a semi-structured interview guide based on the SEIPS 2.0 model. The guide included interview questions about nurses’ experiences with care; descriptions of the critical care work system structures, care processes, and outcomes; and the impacts of the COVID-19 pandemic. CB piloted interview questions with two nurses who met the inclusion criteria but did not participate in the study; the questions provoked rich responses, including descriptions of the critical care work system, nursing care processes, adaptations, and associated outcomes. Therefore, no changes were made to the interview guide.

We obtained institutional review board approval for the study prior to participant recruitment and data collection. CB conducted one interview with each participant using an online conference software with audio-only recording. Participants gave verbal consent at the beginning of the video-platform interview. Interviews took place in mid-April 2021 and lasted on average 32.4 min, in part because the participants were particularly eager to discuss the topics and were quite open with CB (who is experienced both as a nurse and as a semi-structured interviewer for qualitative descriptive research). The shortest interview lasted 25 min and the longest interview lasted 40 min. Participants received a $15 e-gift card as compensation for participation. We de-identified audio recordings by removing information, such as...

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**Fig. 1. SEIPS 2.0 Model in this study.**
Twenty experienced critical care nurses (15 women, 5 men) ranging in age from 27 to 50 years old participated in this study and were from a variety of geographic regions of the US: Southwest (11), West (1) Northwest (2), Northeast (4), and Southeast (2). Participants reported working on their “home” units including surgical, trauma, medical, neurology, and cardiac/cardiovascular critical care units. One participant moved from working on a pediatric to an adult critical care unit during the COVID-19 pandemic. See Table 1 for demographics.

We used the SEIPS 2.0 model as a framework for deductive content analysis to describe nurses’ experiences providing care in the critical care work system during the COVID-19 pandemic and how nurses adapted nursing care to avoid the impacts of system barriers on patients. Below we report on the elements from each of the main concepts (work system, processes, outcomes, and adaptations) of the SEIPS 2.0 model. In Table 2 we provide a summary of exemplar quotes.

### 3.1. The critical care work system during the COVID-19 pandemic

Nurses’ descriptions of the work system elements aligned with the SEIPS 2.0 model; including the elements of critical care nurses, critical care patients, nursing tasks for the patient, tools and technology, organization, and internal and external environments.

#### 3.1.1. Patients

Participants described the patients as critically ill and isolated from the healthcare system. They reported overwhelming emotions and difficulty reading faces. Some participants described the environment as very similar to their own experiences. The quotes in this table are representative of participants’ descriptions of each of the elements of the SEIPS 2.0 model.

**Table 2:** The quotes in this table are representative of participants’ descriptions of each of the elements of the SEIPS 2.0 model.

| SEIPS 2.0 Main Concepts | Elements | Exemplar Quote |
|-------------------------|----------|----------------|
| Critical care work system during COVID-19 | Patients | “Very sick, they made it tough to the ICU. I’ve been in this unit for about a year and a half, two years … I don’t really recall paralyzing and proning patients nearly at the volume that we were for, for these COVID patients. So they were very, very sick.” – participant #4. |
| | Critical care nurses | “I’ve been on my unit for 15 years, um, and I’m, I’m one of the night shifts. The breed of people who like ICU nursing are a very specific subset type of people, generally very ‘type a’, detail oriented.” – participant #5. |
| | Nursing tasks for the patient | “The RT would phone in to me and tell me, like, I would talk over the breath sounds, what was going on with the vent. And they would tell me where to put the vent settings, you know? Um, but I would do, like, I would be the only one in the room there also early on, because we didn’t know a lot about this.” – participant #13. |
| | Tools & technology | “So the ventilators, we were using pretty much the full capacity, they were very old and were getting ready to retire. And then at some point, we were short on those tubes that go from the tube to the ventilator, those extensions, I remember, were really short.” – participant #8. |
| | Organization | “Upper management was nowhere to be seen during the pandemic. I mean, they did what they called leadership rounds, but nobody, by that time you’ve been ripped to pieces. No one has any time for you right now. You know, if you’re not bringing help, then we don’t need to see you right now.” – participant #5. |
| | Internal environment | “We turned [the pediatric unit] into the COVID ICU for adults. It wasn’t really equipped for ICU patients so there were a lot of things that had to be changed. We had to switch out the monitors to ICU monitors. They weren’t in negative pressure rooms, actually. What they had to do was turn the entire floor into a negative pressure floor so that we didn’t constantly have COVID going around the whole unit all the time and being aerosolized.” – participant #2. |
| | External environment | “You know, you’re safe inside your house and you’re safe within your four walls, but it wasn’t like that for us. We would, I would, watch it all day or all week on TV and you know, you absorb all those negative ‘COVID isn’t real’ comments. Those types of things got really bad in the political climate and it was all tied into what, for some reason it was all tied into what we were doing. And so as a healthcare worker, you go and you see these things firsthand and you see people dying and…” – (continued on next page)
There was a chance that I would be going to work each day. I knew that and suddenly became like ‘only patients or giving them mouth care. We didn’t work. We didn’t allowing visitors at that point. So it just was a kind of, like I said, it was just every day something new and then like next day something would change and it got fairly overwhelming pretty quick.” – participant #19.

“We didn’t have time for certain like nursing interventions, like turning patients or giving them mouth care or doing some typical things that we would do on a very consistent basis and suddenly became like ‘only when you had time’ basis. So we definitely had to ration the care that we gave to our patients and our other staff members would always be helped too. So yeah, it definitely impacted the care that we gave patients.” – participant #16.

“The process of the interdisciplinary team; the masks made it very hard to explain to somebody that didn’t understand. You would just press the walkie talkie, “Hey, can somebody bring me that,” like to whoever is available outside and not in PPE.” – participant #8.

“I’m seeing a therapist, starting to eat healthy again, because I’m not working four to six to seven shifts a week. It’s a lot about going back to taking care of myself because I for sure have not done that in the last year plus, talking to people, it can be helpful, but a lot of it’s personal and it’s very hard to explain to somebody that didn’t go through it.” – participant 15.

Table 2 (continued)

| SEIPS 2.0 Main Concepts | Elements | Exemplar Quote |
|-------------------------|----------|----------------|
| The Process of Nursing Care | Physical Work Processes | It was the hardest thing I have ever done in my nursing career, both emotionally and physically... we had probably ten codes minimum a day by noon and probably lost two to three patients a day.” – participant #15. |
| Cognitive Work Processes | “We had a lot going on in regards to trying to organize communication with the families because the families were wanting to come in and they weren’t allowing visitors at that point. So it just was a kind of, like I said, it was just every day something new and then like next day something would change and it got fairly overwhelming pretty quick.” – participant #19. |
| Social/behavioral Work Processes | “I mean, it’s one of the things where we’re working in new areas, not with the same teammates, the same coworkers we’ve had before, and we’re not too sure exactly what these other nurses’ strengths and weaknesses are. So it kind of made it really challenging to know who I can lean on to compensate for my weaknesses, while I’m building up their weaknesses at the same time.” – participant #10. |

Table 2 (continued)

| SEIPS 2.0 Main Concepts | Elements | Exemplar Quote |
|-------------------------|----------|----------------|
| Adaptations | Patient Care Adaptations | it out, you know, like use those critical thinking skills and just work together and be there for each other.” – participant #20. |
| Coping Adaptations | “We even implemented those little walkie-talkies... You would just press the walkie talkie, ‘Hey, can somebody bring me that,’ like to whoever is available outside and not in PPE.” – participant #8. |

their family members. These were some of the most critically ill (COVID-19 and other diagnoses) patients the participants had ever cared for (see Table 2); as they required intravenous vasoactive medications, steroids, continuous renal replacement therapy, extracorporeal membrane oxygenation, and early mechanical ventilation.

3.1.2. Critical care nurses

The critical care nurse participants in this study were experienced (see Tables 2 and 1 for demographics) and described themselves and their colleagues as detail-oriented. During the pandemic participants primarily provided direct nursing care for patients alongside nurses who were redeployed from other departments (neonatal ICU, obstetrics, perioperative settings).

3.1.3. Nursing tasks for the patient

Critical care nurse participants performed both typical critical care nursing tasks for the patient and atypical tasks that, during non-pandemic times, would be performed by other health care professionals. For example, nurses were at times the only ones allowed to enter patient rooms, so they communicated with respiratory therapists to obtain guidance on managing ventilators (see Table 2). These tasks are not typically required of critical care nurses. Additionally, they were required to delegate tasks to re-deployed nurses. Participants noted inconsistencies in the amount and type of critical care training deployed nurses received, which therefore impacted the tasks they were able to assist with, which participants described as a major barrier to care.

3.1.4. Tools & technology

The participants indicated tools, such as PPE, were in short supply, and staff were forced to reuse or purchase their own PPE. Aging and outdated equipment was a common experience among participants due to shortages (see Table 2). Nurses described difficulty managing aging ventilators that had been decommissioned. Masks became a barrier to communication among the interdisciplinary team; the masks made it difficult to hear coworkers’ muffled voices over negative pressure ventilation systems. The technology participants used to facilitate patient-family communication included iPad tablets supplied by the organization. In many instances organization-supplied technology for patient-family communication was not available, therefore, nurses accomplished this by using their own personal cell phones. There were also inconsistent documentation standards throughout the cycles of the pandemic. For example, several participants described feeling unsure because what was required for them to document on their patients were
constantly changing. Many felt communication within the electronic health record (EHR) could have facilitated appropriate documentation.

3.1.5. Organization
Participants recounted organizational policies that constantly changed due to evolving knowledge of COVID-19 and different experiences with both unit and organization-level leadership. Policies regarding visitor restrictions were modified according to the severity of the pandemic. Some participants described leaders who clearly facilitated communication of changes and the status of resources (such as PPE), while others described leaders who were barriers to staff understanding and lack of available resources (see Table 2). Participants described a general feeling of frustration with the leaders’ decisions to bring redeployed nurses to critical care with insufficient training; they felt the redeployed nurses were not able to provide assistance that was meaningful to the critical care nurses.

3.1.6. Internal environment
Participants described the internal environment of the ICUs as being retrofitted to meet patient care needs during the pandemic. Multiple participants shared how organizations created ICUs in settings that previously were used for different patient populations (eg, pediatric intensive care or unused units). As a result, several participants described cumbersome negative pressure equipment that was in the way or completely changed the environment of the unit (see Table 2). One participant even described how their organization resorted to opening the windows in the peak heat of the summer to create negative pressure in patient rooms.

3.1.7. External environment
Participants described considerable influence of the external environment on the critical care work system. Nurses indicated that group gatherings in the community and the general public’s anti-mask sentiment directly impacted the patients, healthcare professionals, the organization, and the community. Several participants described taking care of critical care patients who did not believe they had COVID-19 despite a positive diagnosis. Consequently, participants felt frustration with political leaders for not communicating the severity of COVID-19 illness and with their community for not believing the reality of COVID-19 illness and its reverberating impacts. Participants described this as impacting not only the number of patients admitted to the ICU, but also nurse morale and the way patients’ family members treated nurses.

3.2. The process of nursing care

3.2.1. Physical work processes
Participants recounted the physical work of nursing care as exhausting due to manual proning (turning a patient onto their abdomen) of patients and frequent cardiopulmonary resuscitations (see Table 2). Physical work was often also described as emotionally exhausting as their patients frequently died. Nurses described completing most of the patient care with fewer staff. They spent significant time donned in PPE to deliver care and facilitate video chats between patients and their family. Participants described the physical work of putting on and taking off of PPE as time-consuming, which impacted the way nursing care was delivered because care had to be done all together at the same time instead of as-needed.

3.2.2. Cognitive work processes
Participants described feeling overwhelmed by the increase in cognitive work during the pandemic (see Table 2) due to the increased tasks despite being short-staffed. Very little was known about the pathophysiology or course of illness and navigating associated changes, so nurses spent time seeking out information on how to care for patients with COVID-19. Participants described taking on the lead role in team nursing models where the critical care nurse bore the cognitive work typical of critical care nursing (critical thinking, decision-making, and documentation). They described doing this while incorporating cognitive work atypical of critical care nursing such as grouping together patient care tasks to avoid using PPE and deciphering which skills could be delegated (as appropriate for nurses re-deployed to help in critical care). Participants described confusion as to what documentation was required throughout the different surges in patient volume throughout the pandemic due to the constant changes communicated by leaders.

3.2.3. Social/behavioral work processes
The social/behavioral work participants described included learning how to work with new team members and new or additional communication responsibilities with family members (due to visitor restrictions). Participants described learning to balance the strengths and weaknesses of each team member (see Table 2). Due to the volume of patients, nurses described veering from the industry standard of bedside patient hand-offs to using standardized report sheets to facilitate a quick shift transition. Critical care nurses assumed the facilitation of communication between patients and their loved ones and the emotional work of being present with patients, holding their hand, as they died so they would not be alone.

3.3. Outcomes

3.3.1. Patient outcomes
Participants detailed missed care and death as patient outcomes. Patient ratios were higher during the pandemic and coupled with increased tasks, participants experienced difficulty delivering the minimum standard of nursing care (e.g. turning patients and performing activities of daily living) which resulted in missed care. Nurses rationed care to ensure the most important, life-saving tasks were completed for patients while activities of daily living were only completed if there was time (see Table 2). The amount of death participants witnessed during the pandemic was unparalleled in all of the nurses’ years of experience. One participant described critical care as a “fishbowl of death” during the pandemic (see Table 2).

3.3.2. Nurse outcomes
Participants described both negative and positive outcomes for critical care nurses. Negative nurse outcomes included stress, burnout, fatigue, and moral injury. Patient outcomes of missed nursing care and death were particularly stressful to participants and as a result, they described experiencing fatigue and burnout. Moral injury is defined as when an individual witnesses, fails to prevent, or perpetuates something that contradicts their beliefs and expectations (Forbes et al., 2015). The conditions created by the pandemic produced morally injuring dilemmas outside nurses’ control; some participants felt forced to make decisions outside their scope of practice while others stated they couldn’t provide the minimum standard of nursing care. Positive nurse outcomes included gaining new skills and having a sense of purpose during the pandemic. The skills nurses gained included managing patients on continuous renal replacement therapy and manual proning. Nurses also described satisfaction with the rate of translation of new knowledge into practice. Despite the many challenges they experienced, participants felt a great sense of pride for having worked in critical care during the pandemic. One participant even felt their work gave them something to do where they were needed and felt safe (see Table 2).

3.3.3. Organizational outcomes
Organizational outcomes included significant nurse turnover; however, participants also described improved teamwork. While none of the participants left their positions, many of their peers left for nursing opportunities in outpatient settings, travel nursing, or even left the nursing profession. They described this turnover was a direct result of
the stress and lack of leadership support they experienced during the pandemic. Participants reported the conditions created during the pandemic required nurses to collaborate with physicians, respiratory therapists, and leaders (who were part of proning teams) in new ways. The enhanced teamwork contributed to nurses’ enjoyment of their work despite the challenges they faced during the pandemic.

3.4. Adaptations

3.4.1. Patient care adaptations

Participants described overcoming barriers to patient care using several novel approaches including tools, technology, communication, and ways to access resources. Nurses described how the pandemic forced them out of their comfort zones and to creatively solve challenges to everyday tasks in their work. While nurses were frustrated to learn they would have to reuse PPE, they adapted by purchasing respirators (such as those bought at hardware stores) or storing the PPE in brown paper bags. During shortages of commercially available sheets designed to lift patients, nurses would place patients between two standard bed sheets and roll them together to adjust the patient in bed. To avoid unnecessary donning of PPE to enter a room, participants used long intravenous (IV) tubing to keep the IV pump outside the patient room. Nurses described experiencing difficulty communicating to others outside the patient room was difficult (due to masks muffling voices and the volume of the negative pressure equipment). They used walkie talkies (see Table 2) or learned sign language to communicate simple needs (such as supplies) to their colleagues. Participants described turning to social media, podcasts, and colleagues across the globe to learn how to take care of COVID-19 patients (see Table 2). Novel technologies, such as mechanical chest compression devices, were put in place to deliver safe and effective cardiopulmonary resuscitation while limiting hazards to staff. Because many of the COVID-19 ICUs were actually on medical-surgical units that were designed to maximize patient privacy as opposed to the standard ICU high-visibility rooms, they brought in their personal baby monitors from home to facilitate remote monitoring of patients who were susceptible to falls.

3.4.2. Coping adaptations

Participants described multiple coping strategies in order to sustain themselves as they worked throughout the pandemic. Several coped by speaking with other critical care nurses and/or seeking counseling services (see Table 2). While many coped by spending time with family, exercise, and rest, some participants coped by avoidance (not watching the news) and depersonalization (referring to the patient as a body). ‘Survival mode’ (e.g. compartmentalizing their work and avoiding discussion of how they were coping with loved ones) was a common description among nurses’ descriptions of their coping mechanisms during the pandemic; participants described separating their personal and professional lives and using distraction.

4. Discussion

In this paper we used the SEIPS 2.0 model to frame a description of nurses’ perceptions of the critical care work system, processes, outcomes, and adaptations during the COVID-19 pandemic in the U.S. Critical care nurse participants described taking care of some of the most critically-ill patients despite short staffing, strained resources, constant change, and increased workloads. Participants described multiple barriers and facilitators to care and significant impacts on their patients, critical care nurses, and healthcare systems. Critical care nurse participants adapted patient care and their own coping strategies to sustain themselves in their work during the pandemic. The SEIPS 2.0 model framed the description of how the work system could be improved from the perception of nurses. Human factors engineers can help critical care nurses improve the critical care work system going forward.

The COVID-19 pandemic presents an opportunity for organizations to change (Davidson and Patch, 2021). Carayon and Perry (2021) suggest a five principle human factors and ergonomics approach for healthcare work systems to adapt to the changes brought on by the COVID-19 pandemic. The five principles include: 1) deferring to local expertise, 2) facilitating adaptive behaviors, 3) enhancing interactions between system elements and levels, 4) re-purposing existing processes, and 5) encouraging dynamic continuous learning.

Critical care nurses spend more time than any other healthcare professional with patients (Butler et al., 2018), making them the local experts in critical care work environments. Consequently, nurses can readily identify barriers and facilitators in their work systems. Human factors engineers can partner with nurses and leaders to address their needs. For example, critical care nurse participants in our study indicated re-deploying nurses to help in ICUs without appropriate critical care skills is a barrier to care. Nurses have flocked to travel nursing jobs (where nurses typically work with an external agency to address staffing shortages on a contract basis) since the beginning of the COVID-19 pandemic because of the need for highly-specialized yet flexible nurses. This has created extreme demand for ICU nurses. Therefore, human factors engineers could assist in creating algorithms for a staffing matrix that facilitates selection of ICU-trained nurses within the organization to redeploy into ICU settings when needed, or for multi-hospital healthcare systems to proactively deploy nurses from one hospital to another in anticipation of patient volume surges (with surging COVID-19 rates).

Sharing ideas across organizational departments can facilitate adaptive behaviors in an environment of constant change (Carayon and Perry, 2021). Carayon and Perry (2021) suggest a rapid design-implementation-redesign process, which can be based on the creative ways nurses go about achieving their goals for work. Human factors engineers can work with nurses to understand their complex needs for communication and to help identify solutions (Carayon and Perry, 2021), such as facilitating family video chats remotely (outside the patient room) to reduce PPE usage and communicating with workers using technology despite muffling caused by PPE.

Human factors engineers should not just pay attention to individual work systems elements, but also enhance interactions (Carayon and Perry, 2021). Participants in our study shared how constant change in organizational documentation policies made it difficult for nurses to identify documentation tasks required of them, and consequently suggested an alert within the electronic health record to notify of documentation changes. However, alarm fatigue (including documentation task alerts) is a well-known phenomenon in critical care settings where excessive alarms can lead to desensitization and missed alarms (Sendelbach et al., 2013). With this knowledge, human factors engineers and nurses can partake in the rapid design-implementation-redesign process to create alerts within the EHR that meaningfully communicate required documentation tasks.

Carayon and Perry (2021) suggest re-purposing processes that facilitate communication. In our study, nurse participants described a lack of clear communication from leadership regarding PPE supply status as a barrier in the work system. In the early stages of the COVID-19 pandemic, many nurses reported re-using PPE and felt unsafe doing so considering the single use design (American Nurses Association, 2020). Adequate access to PPE is required to ensure safety of healthcare professionals due to repeated exposure to pathogens (CDC, 2014). Therefore, human factors engineers can partner with leaders to communicate PPE status. Many organizations already communicate patient census, staffing, and other pertinent operational information on an electronic dashboard or during a morning leadership huddle, both of which could be amended to include PPE status.

Finally, human factors engineers should partner with not just nurses, but the entire interdisciplinary healthcare team in the work system, to learn their needs in real time to encourage dynamic continuous learning, resilient healthcare systems, and to address patient safety concerns (Carayon and Perry, 2021). For example, one critical care nurse...
participant in our study shared that their hospital had resorted to opening windows in patient rooms d the peak heat of summer to create a negative pressure effect in response to a lack of available rooms with negative pressure capability. To avoid potential safety concerns regarding heat, nurses, leaders, and human factors engineers can partner with hospital engineers to address patient care needs that are safe for patients and staff.

4.1. Limitations

Limitations of this study include its cross-sectional design with a convenience sample of experienced critical care nurses working primarily day shift. Had this study been conducted at an earlier time during the course of the pandemic, participants may have recalled different details. However, participant recruitment may have been more difficult during peaks throughout the pandemic. Critical care nurses with less experience may have different experiences and perceptions of working during the COVID-19 pandemic and its impact on nursing care.

4.2. Conclusion

The SEIPS 2.0 model provided a framework to describe nurses’ perceptions of the critical care work system, processes, outcomes, and adaptations during the COVID-19 pandemic. Carayon and Perry (2021) suggest a five-principle human factors and ergonomics approach to maximize the adaptations critical care nurses made to their work system during the pandemic. We suggest how human factors engineers can utilize Carayon and Perry’s (2021) suggestions to maximize the adaptations critical care nurses made to their work system during the pandemic.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apergo.2022.103712.

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