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EMERGENCY NURSES ASSOCIATION

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The Importance of Recharging

Jennifer Schmitz, MSN, CEN, CPEN, CNML, NE-BC, FNP-C

Two years since the beginning of the coronavirus disease 2019 pandemic. Two years since our world, particularly in health care, was flipped upside down. What we expected to last for 2 weeks has now gone on for that many years. As emergency nurses, you have been immersed in caring for patients, learning new clinical practices to help those with coronavirus disease 2019 feel better, breathe easier, and transition back home to their family. It has not been easy, but there isn't a group of people who more deserve the title of hero. I applaud all of you for your dedication to our profession and to our patients.

Our world may be changed forever, and this reality a part of our new normal. Recognizing that things may not go back to how they used to be or how we once knew them can be difficult and even painful. For emergency nurses, this new world includes continuous wearing of personal protective equipment and caring for patients in incredibly busy departments, all while we continue to be challenged with a nursing shortage. That can be daunting, so for 2022 and for the years to come, I encourage you to find a way to recharge.

What do I mean by recharge? Recharge is finding your connection to yourself and your profession and reigniting the passion you have for emergency nursing. You can recharge in different ways. Taking care of yourself—eating well, resting, and focusing on your health—keeps you strong and ready to continue your work. You can also look to professional development, continuing education, certification, or networking with colleagues. Learning is endless in this profession, with new clinical information being presented literally each day. Take time to think about what piece of this interests you and what you think would help to reenergize you.

ENA offers a community of emergency nurses with whom to connect. These are colleagues who understand both the struggles and the comradery of the work we do. They know both how hard it can be and how much your team becomes a family. Education events, networking opportunities, and your ENA State/Chapter meetings can be a great way to make the connections. There are also options for connecting virtually, via ENA Connect.

I've been an emergency nurse for 20 years; finding ways to recharge along the way has kept me engaged, energetic, and focused on supporting emergency nurses to be the best possible caregivers we can be. To this day, I still get excited on busy days, where managing patient flow within the department is like a giant puzzle to solve, seeing new chief complaints or new circumstances every shift, being present for someone in their most vulnerable time, and being able to help them through it. Those moments help to keep the fire within me burning. I often joke with others, saying I'm wired to be an emergency nurse, because there just doesn't seem to be another way to describe how deeply connected I am to this work. My hope is that each of you find that same wiring and develop ways to recharge as you navigate through your career.

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Journal of Emergency Nursing Diversity, Health Justice, and Inclusion Pledge

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Note from the Editor in Chief

In June of 2021, *the Journal of Emergency Nursing's (JEN)* Publisher at Elsevier contacted the editorial office about their Inclusivity and Diversity team initiative. This communication included a request for a tailored Journal pledge about a commitment to improve diversity (Scott Whitener, email communication, June 2021). The following pledge was generated through robust and respectful synchronous and asynchronous dialogue among *JEN* editorial board members. It was an honor to witness the tremendous humility, authenticity, commitment to our shared purpose and dedication to supporting colleague psychological safety that our editorial board demonstrated throughout this pledge development process. This collegiality was so important in the dialogue where opinions can vary widely, and emotions can run strong. In particular, we grappled together if our pledge should maintain a heavy focus on race/ethnicity and historic inequalities experienced by those who identify as Black/African Americans. Is it justified to address a group uniquely in this manner? Should we address ethnic disparities in general without naming any particular group? What about a priority focus on rural disparities in emergency care access? Should we individually list other disadvantaged and/or marginalized groups by religious affiliation, sexual orientation, or other identity? What about those over- or under- represented in nursing, but who experience social advantage or disadvantage outside the discipline in broader social contexts? Below, we publish the pledge we drafted to date as an editorial to spark continued consideration and dialogue with our readers. We welcome Letters to the Editor, commentary, and robust reader engagement with us on the topic.

It is important to note that our Journal editorial board pledge development process occurred independently and in parallel to the work of the Emergency Nurses Association's Diversity, Equity, and Inclusion (DEI) process.[1] The Emergency Nurses Association's official DEI Vision and Mission statements can be found at the link in the reference list,[2] which will also be posted at the *Journal of Emergency Nursing*'s homepage.[3] The ENA's Diversity, Equity, and Inclusion webpage also includes valuable resources on member engagement, cultural awareness resources, webinars, podcasts, toolkits, position statement, topic brief, and other staff recommended links.[2] Reader, we sincerely look forward to you joining us in this important conversation and work, as well as receiving your letters and responses.

Our Pledge to Our Journal Community

We pledge our commitment to health justice and genuine respect for all persons.

We pledge to prioritize and take meaningful actions to build and be worthy of trust from people who identify with historically disadvantaged and/or marginalized groups. We acknowledge that our commitment to health justice requires operationalizing equality and equity while removing barriers to equality so that each member of our Journal community, regardless of their identity, can experience full and meaningful inclusion in our work.

We pledge to create and maintain a social environment of cultural humility and continuous learning that honors intersectionality, which is the complex, cumulative way in which the effects of multiple forms of discrimination combine, overlap, or intersect in the experiences of marginalized individuals or groups.

Accountability

We strive and hold ourselves accountable for the full inclusion of editorial board members, authors, and reviewers who accurately reflect the nursing profession and specialty of emergency nursing with interdisciplinary emergentologists.[4] There are many identities in which the nursing discipline and emergency nursing specialty fail to represent the patients we serve in emergency care.[5,6] In response, we pledge our accountability by an editorial team composition that over-represents groups with identities from the census gap between our specialty and emergency care patients. In particular, we seek to over-represent men in nursing, religious minorities, people from other groups who have been marginalized, people with disabilities, and those with Black, Indigenous, and people of color identities. Although we aim to be inclusive of all groups, we acknowledge the profound and long-standing impact of historic anti-Black racism on health justice and opportunities in the nursing profession.[7-12] Thus, our commitment to justice and inclusivity may include a special initial focus on people with Black identities in the census gap between the specialty and the patients we serve.

Transparency

In full transparency, we acknowledge that diversity and identity aligned with a historically disadvantaged or marginalized group may not be apparent by outward appearance, name, or linguistics alone. Members of the editorial board, authors, or reviewers may choose not to disclose any or all of their internal identities to us. Although we aim to be trustworthy stewards of these disclosures, we acknowledge that our effort will be dynamic and necessarily require transparency about the uncertainties of our full diversity and representation. This will not lessen our commitment or accountability to full diversity, inclusion, and representation among our authors, reviewers, and editorial board.

Broader Publishing Community

Our work leads, amplifies, and is aligned with Elsevier's broader ongoing inclusion and diversity efforts to strengthen and advance us all.[13]

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Commentary on "Burnout and the Sexual Assault Nurse Examiner: Who is Experiencing Burnout and Why?"

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In the paper Burnout and the Sexual Assault Nurse Examiner: Who is Experiencing Burnout and Why? in this edition of the *Journal of Emergency Nursing (JEN),* Zelman et al[1] examine the frequency of burnout and its accompanying features among sexual assault nurse examiners (SANEs) in North Carolina using the Maslach Burnout Inventory scale. The authors' cross-sectional study provides the field of forensic nursing with essential knowledge and contextual understanding of burnout among SANEs working within forensic programs and those working in emergency departments of varying sizes, including some located in rural areas. The knowledge garnered from this study is also valuable for other nursing specialties, particularly in the emergency department and different acute care settings.

Zelman et al[1] share the findings of their study about SANE burnout amid an ongoing coronavirus disease 2019 global pandemic. The work of SANEs has never been more critical, and the support of SANEs by ensuring job satisfaction and retention and minimizing burnout has never been more dire. During this pandemic, scholars and advocates have noted that violence, particularly in the lives of women, has increased exponentially.[2] As a result, the workload of SANEs has increased, with the risk of burnout becoming even more significant.[3] The recent increase in prevalence of violence, compounded by the problem of burnout results in the lack of available SANEs to meet the health care needs of sexual assault survivors.

As a team of diverse scholars working with Indigenous and Black survivors of gender-based violence, including sexual assault, we note that a limitation of the study, as is the case with many studies, is that study implications are not uniquely tailored to speak to the needs of specific populations of women. Although the premise of most studies is not necessarily to center the needs of Black and Indigenous women and women of color (henceforth BIPOC women), it is critical to highlight that BIPOC women experience the highest rates of sexual assault and intimate partner violence.[4-6] In addition, BIPOC women experience the highest rates of homicides, with more than half (55%) being related to instances of intimate partner violence.[6] Yet BIPOC women and girls often face significant barriers in accessing health care services after an experience of sexual assault (SA).[7] Examples of barriers experienced by BIPOC SA survivors include the race of the offender, historical trauma, mistrust, social isolation (particularly in rural communities), access to transportation and a telephone, differences in culture and values, confidentiality concerns, and location and type of services offered.[8]

Findings from Zelman et al[1] Specifically regarding higher rates of burnout among nurses who performed dual roles and saw higher numbers of pediatric patients underscores the importance of proper education, preceptorship by experienced SANEs, ongoing support, and mentorship. Trained, precepted, mentored, and supported SANEs provide a patient-centered trauma- and violence-informed nursing approach to patients. According to Befus et al[9] and Poldon et al,[10] the trauma- and violence-informed care approach enhances health equity and improves patient care outcomes. Yet

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the trauma- and violence-informed care approach also requires organizational change and ongoing training.[9,10] A trauma- and violence-informed approach in the provision of nursing care includes the centering of a safe nurse–patient relationship. It also includes patient empowerment through nursing health care options of care as well as skill building, debriefing, and support for the SANE. Trauma- and violence-informed nursing care enhances overall support to the patient to promote postassault healing while also promoting health equity and upholding social justice.[9,10] Amaret et al[11] note that trauma- and violence-informed training calls for all SANEs to be committed to lifelong learning, having insight and knowledge and personally caring about their patients, including their cultural and social identity. It also requires SANEs to care how their patients encounter and navigate the intersectional experiences of racial, gender, and class oppression in their everyday lives.[11] Trauma- and violence-informed care is demonstrated and implemented through program development and sustainability by the SANE in the creation of a safe, quiet, and private space to allow for an intimate and sacred nurse–patient relationship to develop. This unique relationship ensures that patients are informed and aware and have the autonomy to make vital health care decisions. It is the physical as well as the emotional labor of SANEs that easily lends itself to burnout.

A future follow-up to the timely study by Zelman et al[1] is one that could help us better understand the phenomenon of SANE burnout, building on the authors' quantitative study to a qualitative study that captures the lived experiences of SANEs in a local context. Interviews with SANEs could offer valuable insight into the nuanced factors that lead SANEs to burnout by eliciting their lived experiences in caring for patients who experience violence and trauma. In addition, qualitative methodologies would elicit an understanding of the emotional experiences and triggers that SANEs may experience as they care for patients who experience violence and injustice in their everyday lives.[12,13] Narratives from SANEs garnered through qualitative inquiry could provide us with an understanding of an individual SANE's confidence in their training and learning regarding their scope of practice as well as how they apply evidence-based knowledge. Finally, qualitative research can offer the SANE an opportunity to self-reflect and create an opportunity to center the voices of SANEs with narratives and stories, providing insight into vicarious trauma and building nursing knowledge that enables us to address burnout.[13]

As practicing forensic nurses within the subspeciality of SANE (J.C.R, S.H., K.M.), we live, realize, and acknowledge the emotional toll related to the complex and intense nature of the SANE role. Apart from the emotional toll experienced as a result of the very nature of the SANE role, SANEs also observe the revictimization and retraumatization of SA patients by not only health care personnel and the health care establishment but also by law enforcement.[14,15] SANEs across the United States thus face innumerable challenges in their practice.

SA is a heinous, devastating, and traumatic form of violence affecting both the physical and mental health of the individual and necessitates urgent, violence- and trauma-informed care. Access to and availability of trained, violence- and trauma-informed SANEs is imperative for patients, their families, and communities in creating a foundation of safety and healing.

Author Disclosures

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Letters To The Editor

Letters to the Editor are encouraged and may be submitted at jenonline.org where submission instructions can be found in the Author Instructions.

Emergency Nurses Recognize a Need for Education of Delirium Prevention and Management in the Emergency Department

Dear Editor:

A recent article in the *Journal of Emergency Nursing*, Delirium in the Emergency Departments: Is It Recognized? by El-Hussein et al,[1] highlights key challenges for emergency nurses in recognizing ED delirium and using common delirium screening tools. This work points to a need for standardized training for emergency nurses on delirium screening tools and for policy change to integrate delirium tools into organizational practice. We support the arguments advanced in this important article and present 2 additional and novel points about (1) emergency nurses' self-perceived knowledge of delirium recognition, and (2) institutional prioritization of delirium detection.

We conducted a survey-based study of emergency nurses' knowledge, practices, and perceived need for resources regarding delirium in older ED patients.[2] The survey—released by the West Health Institute, a nonprofit, nonpartisan organization dedicated to geriatric medical research—queried members of the Emergency Nurses Association. The survey was posted on the West Health Institute website, LinkedIn, and Twitter accounts and was promoted at several relevant professional conferences. A convenience sample of 65 Emergency Nurses Association members from 15 states participated in the survey.

One major finding from our survey, not previously observed in the article by El-Hussein et al,[1] is a disconnect between emergency nurses' self-reported high knowledge of delirium detection and low ED delirium detection rates.[2] When asked to rate their own knowledge, most respondents reported intermediate or advanced skills in delirium detection (76.9%) and management (73.8%). This contrasts with previous research demonstrating that the majority of ED delirium goes undetected.[2] At the same time, however, respondents identified as a key challenge an overwhelming need for education on delirium for nurses (82%), echoing findings by El-Hussein and others.[3] Specific knowledge gaps identified by respondents included identifying delirium in patients with dementia (66%) and lack of recognition of the hypoactive delirium subtype (58%).

Our survey also demonstrates a gap between emergency nurses' and institutional prioritization of ED delirium detection. More than half (59%) of respondents thought that delirium detection in the emergency department was very or somewhat important, but less than one-third (32%) of respondents reported that the emergency department where they work has a protocol to address delirium, whereas 31% said that none was available, and 37% were unsure. As also observed by El-Hussein and colleagues, our survey data reveal a preference for the confusion assessment method (CAM) as a recognition tool. Among those emergency nurses working in institutions with delirium protocols, the majority reported their emergency department's delirium screening tool as the CAM (61%) or brief CAM (13%).

These results confirm and add to the findings by El-Hussein et al,[1] underscoring the need for education for emergency nurses and organizational policy change to implement delirium protocols in emergency departments. Resources to fill gaps in knowledge and training include the geriatric ED guidelines, which recommend protocols to address delirium in the emergency department,[4] and a recently published toolkit to aid emergency departments in implementing delirium programs, which includes educational materials for ED staff.[5] Providing emergency nurses with appropriate support to address ED delirium is one critical component toward improving emergency care for older adults.—*Anita N. Chary, MD, PhD, Department of Emergency Medicine, Department of Internal Medicine, Center for Innovations in Quality, Effectiveness and Safety, Baylor College of Medicine, 1 Baylor Plaza, Houston, TX 77030; E-mail: anita.chary@bcm.edu.* ***Twitter:*** *@anitachary*, ***ORCID identifier:*** https://www.doi.org/0000-0002-8839-7617; *Emily H. Weaver, PhD, MA, West Health Institute, San Diego, CA.* ***Twitter:*** *@EmilyWeaver_WHI*, ***ORCID identifier:*** *https://www.doi.org/0000-0003-4354-7797; Adriane Lesser, MS, MBA, West Health Institute, San Diego, CA.* ***Twitter:*** *@AdrianeLesser*, ***ORCID identifier:*** https://www.doi.org/0000-0003-3226-5022; *Sharon K. Inouye, MD, MPH, Department of Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, and the Aging Brain Center, Marcus Institute for Aging Research, Hebrew*

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Response to Chary Letter

Dear Editor:

We thank Chary et al[1] for taking the time to respond to our manuscript entitled "Delirium in Emergency Departments: Is it Recognized?"[2]

Delirium is perceived as a condition that primarily affects inpatient older adults.[3] Although older adults may spend several hours in the emergency department waiting for final disposition based on their required physical findings or diagnostics investigations, they are considered outpatients.[4] The assumption that most ED patients get discharged home and not admitted to the hospital gives false reassurance that these patients are less likely to develop delirium. Moreover, when older adults present to the emergency department, their cognitive dysfunction can be easily misinterpreted as their baseline or attributed to their acute illness.[2] Although the emergency department is an acute care setting, researchers in their studies and publications tend to group acute care settings together, ignoring the unique context of the emergency department. Several confounding factors affect the detection of delirium in the emergency department. Although the use of tools helps detect delirium, nurses repeatedly feel restricted in deciding on the steps they should follow after they suspect the presence of delirium.[2] Nurses in another study described dealing with delirium as *chasing a mirage*[5] because of the ever-changing presentation of the disease. The detection and diagnosis of delirium should initiate a management plan to prevent further cognitive dysfunction.[1,5] Delirium as a form of brain failure is a medical emergency but is rarely treated as such.[5] Treating delirium is not easy and should not be taken lightly because its mortality rates and the economic and human costs continue to rise.[1,3,5]

Our conviction is that the detection of delirium in the emergency department must be followed by a management algorithm similar to the ones triggered for chest pain or stroke.[4] The outcome would hopefully decrease delirium-associated mortality or morbidity—*Mohamed Toufic El Hussein, PhD, NP, is a Professor, School of Nursing and Midwifery, Mount Royal University, Calgary, Alberta, Canada, an Adjunct Associate Professor, Faculty of Nursing, at University of Calgary, Calgary, Alberta, Canada, and an NP at Cardiology CCU Alberta Health Services Rockyview Hospital, Calgary, Alberta, Canada*; *E-mail: melhussein@mtroyal.ca.* **Twitter:** *https://twitter.com/drmohamednp.* ***ORCID identifier:*** *https://orcid.org/0000-0002-9489-3254. Sandra P. Hirst, RN, PhD, GNC(C), Associate Professor, Emeritus, University of Calgary.* ***ORCID identifier:*** https://orcid.org/0000-0002-6579-5532.

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Recommendations for Emergency Departments Caring for Persons with Opioid Use and Opioid Use Disorders: An Integrative Review

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NCPD Earn Up to 11.5 Hours. See page 234.

Contribution to Emergency Nursing Practice

- The main findings of this paper are the best practices for (1) Screening: identifying and assessing persons who are at risk because of opioid use, (2) Brief intervention: delivering motivationally based interventions, (3) Pharmacotherapy: providing access to buprenorphine and naloxone, (4) Referral to treatment: making a referral to specialty treatment, and (5) Follow-up and monitoring: confirming that the patient is linked to treatment and outcomes are being monitored.

Abstract

Introduction: The emergency department is a primary portal to care for persons after an opioid overdose and those with an opioid use disorder. The aim of this integrative review was to provide best practice recommendations for nurses caring for this highly stigmatized and often undertreated population.

Methods: An integrative review was conducted using studies focusing on adults treated with opioid agonist-antagonist medications in the emergency department. The integrative review method by Whittemore and Knafl was used to guide this review and enhance its rigor.

Results: Twelve studies were included in the review. Opioid care begins with identifying opioid use risk, followed by implementing tailored strategies including opioid agonist-antagonist treatment if indicated, referral to treatment when warranted, and follow-up opioid use monitoring when feasible. Eleven recommendations provide guidance on integrating best practices into routine emergency care.

Discussion: The emergency department is an ideal setting for addressing the opioid crisis. Nurses can use the recommendations from this review to lead system change and more effectively manage the care of persons with opioid use and opioid withdrawal, and those at risk for opioid overdose.

Keywords: Emergency department; Opioid use; Opioid withdrawal; Opioid overdose; Nursing; Opioid agonist-antagonist

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Introduction

The results of the 2019 National Survey on Drug Use and Health[1] reinforced that use of nonprescription opioids and heroin requires the attention of health care providers. In 2018, more than 9.7 million Americans aged 12 or older reported using a nonprescribed opioid or heroin, and 1.6 million were identified with an opioid use disorder.[1] Concerning is that in 2019, nearly 50 000 people in the United States died from opioid-involved overdoses,[2] and this number has increased during the coronavirus disease 2019 (COVID-19) pandemic.[3]

The impact of the opioid epidemic on emergency departments (ED) is evident given the prevalence of opioid-related visits to US emergency departments. Specifically, there were 234 million adult visits to emergency departments in the US across 2016 and 2017; 2.88 million (1.23%) were opioid-related.[4] Although not nationally representative, over 3000 emergency departments across 48 states and Washington, DC, contributed data on the number of ED visits for opioid overdoses in 2019 and 2020. The number of ED visits for opioid overdoses was higher in 2020 (N = 5075; mean = 306.9) than in 2019 (N = 3940; mean = 211.1).[4] State-level reports confirm those multistate trends in ED visits for opioid overdose before and after the pandemic. For example, in Kentucky, there were 1133 and 1323 opioid overdose-related medical service transports in the 52-day period before the pandemic declaration in March 2020 versus the same period after, respectively, a 17% increase.[5] Also recorded were 12 versus 18 emergency medical service runs for suspected opioid overdose with death at the scene pre- versus intra-COVID-19, respectively, a 50% increase in fatal opioid overdose.[5] A reasonable speculation is that as the COVID-19 pandemic continues, there likely will be an increase in fatal opioid overdoses, and more ED use by persons with opioid use. As such, there is an opportunity for emergency departments to address the needs of persons presenting after an opioid overdose and provide universal screening to identify persons who may be at risk because of opioid use, those who exhibit opioid withdrawal while in the emergency department, and those with a suspected or actual opioid use disorder.

The World Health Organization[6] and US Surgeon General[7] recommend prescribing or dispensing naloxone for persons who are at risk for opioid overdose. Among patients presenting to a US urban emergency department in March 1 to June 30, 2019 compared with those presenting during the early months of the COVID-19 pandemic (March to June 2020), the number of nonfatal overdose visits increased from 102 in 2019 to 227 in 2020; yet there was only a 2% change in patients receiving a naloxone prescription from 2019 to 2020 (54% in 2019 and 56% in 2020).[8] Rates of receipt of treatment resources (ie, telephone numbers and addresses of community treatment providers) or referral to treatment were slightly higher for the 2020 period (68%) than in 2019 (44%).[8] A comprehensive discharge plan should include naloxone access for persons at risk for opioid overdose and linkage to specialty treatment providers in the community.

Efforts to increase treatment access for persons with opioid use disorder are critically needed, given the estimated 1 million individuals who go untreated annually.[9] The emergency department is a prime point of contact for persons detected to be at risk because of opioid use, persons in opioid withdrawal, those surviving an opioid overdose, and persons with a suspected or confirmed opioid use disorder. This review was guided by the following question:

> Among persons presenting to the emergency department who may be taking opioids (eg, heroin, fentaNYL, opioids not prescribed to them), persons surviving an opioid overdose, those in withdrawal from opioids, and those with a suspected or confirmed opioid use disorder, what are evidence-based approaches and treatments that can be provided in the emergency department, and what are the outcomes?

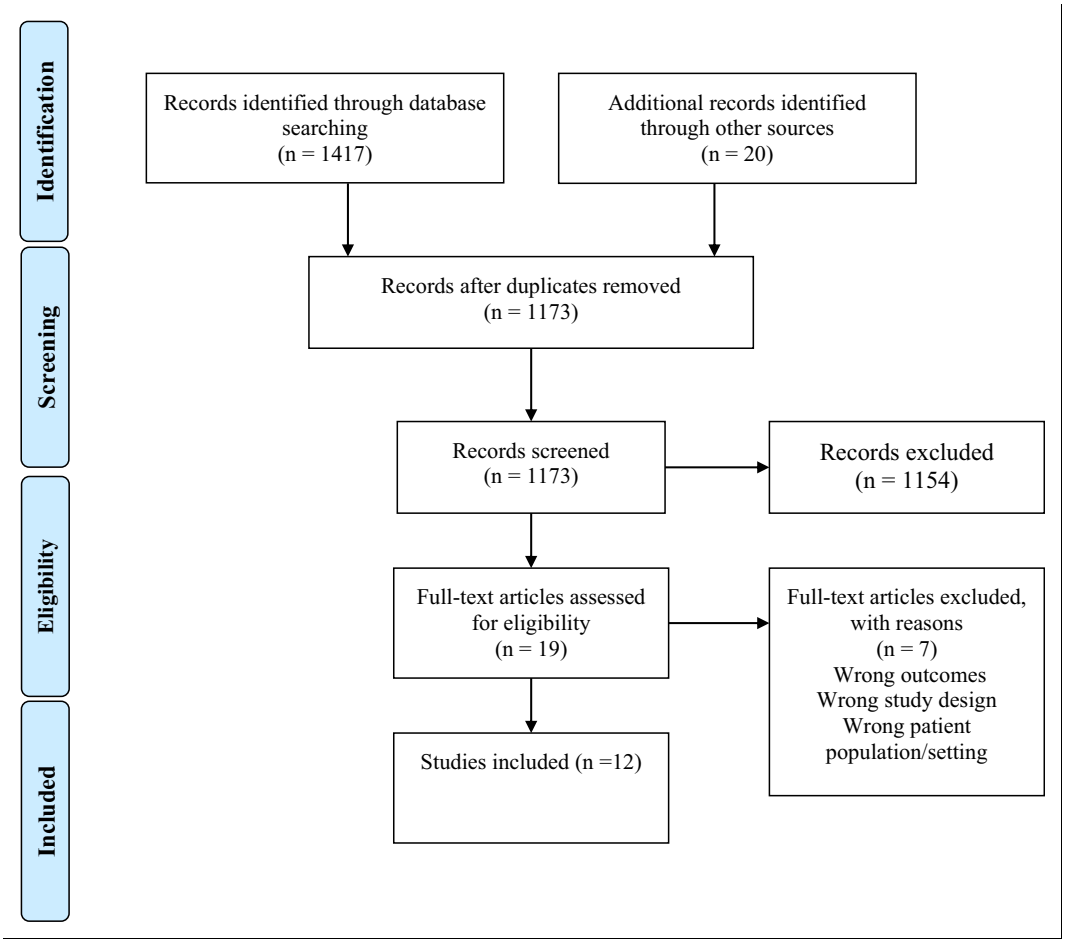
The purpose of this review is to provide emergency nurses with the evidence for a variety of opioid-care strategies that can be implemented to address the needs of this population. Best practice recommendations are provided to guide emergency nurses to act, lead practice change, and initiate evidence-based purposeful interventions for improved care in this highly stigmatized, often undertreated population.

Methods

The integrative review method is an approach that allows for the inclusion of experimental research and has the potential to play a greater role in evidence-based practice for nursing.[10] Completion of all stages of this proposed methodology, with attention to the issues specific to undertaking an integrative review, has the potential to strengthen the process and the outcomes of integrative reviews. The following stages were followed to promote the rigor of this integrative review.

PROBLEM IDENTIFICATION STAGE

A clear problem identification and review purpose are essential to provide focus and boundaries for the integrative review process.[10] The crisis related to opioid use and the emergency department as a primary portal for treatment led to the clinical question for this integrative review.



FIGURE

PRISMA flow diagram. Recommendations for emergency departments caring for persons with opioid use and opioid use disorders: an integrative review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis.[13]

LITERATURE SEARCH STAGE

A health sciences librarian was instrumental in developing the search strategy to ensure a comprehensive search. The search employed Medical Subject Headings terminology, truncations, and Boolean operators as applicable for the following databases: PubMed, Cumulative Index of Nursing and Allied Health Literature, and PsycINFO. The search dates spanned a decade, beginning with 2011 to capture any studies conducted before the landmark trial of ED-initiated buprenorphine treatment by D'Onofrio et al.[11] Key terms included opioid-related disorders, emergency service, hospital, delivery of health care, and model. Inclusion criteria were as follows: peer reviewed articles written in English that included adults in the ED setting and that studied interventions for persons with opioid use, opioid overdose, opioid withdrawal, or opioid use disorder. Excluded were articles that focused on substances other than opioids, settings other than emergency department, nonresearch, and samples focused on youth/children. The search strategy is provided in the Online Supplement.

Citations were imported into Covidence,[12] allowing the members of the team to work together on the project in real time. A total of 12 publications met the inclusion criteria. The Figure depicts the search results based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis.[13]

DATA ANALYSIS STAGE

A thorough and unbiased interpretation of primary sources is critical for the data analysis stage.[10] The empirical reports were evaluated using the Johns Hopkins Nursing

Evidence-Based Practice Guidelines framework through which evidence was appraised and leveled. In accord with the framework, Level I evidence included studies that employed a classic experimental design/randomized control trial (RCT); an explanatory mixed-methods study that employed an RCT; or any systematic review, with or without meta-analysis, of experimental studies/RCTs. Level II evidence included studies that employed a quasi-experimental design; an explanatory mixed-methods study that employed a quasi-experimental design; or a systematic review of a combination of RCTs and quasi-experimental studies, or only quasi-experimental studies, with or without a meta-analysis. Level III evidence included nonexperimental studies; a systematic review of a combination of RCTs, quasi-experiment, and nonexperimental studies, or nonexperimental studies only, with or without meta-analysis; exploratory, convergent, or multiphasic mixed-methods studies; explanatory mixed-methods design that includes only a Level III quantitative study; qualitative studies; or metasynthesis. Level IV evidence included opinions of respected/nationally recognized expert committees/consensus panels based on scientific evidence (clinical practice guidelines, consensus panels/position statements). Level V evidence included experiential and nonresearch work, such as integrative reviews; literature reviews; quality improvement, program, or financial evaluation; case reports; or opinions of nationally recognized expert(s) based on experiential evidence.[14]

Each team member extracted data (ie, study design, level and grade of evidence, sample, setting, measures, outcomes) from their assigned publications into matrices. Each matrix was reviewed by a second team member, and any revisions and additions were resolved in discussion with the primary reviewer. A further goal of the data analysis stage is the synthesis of the evidence.[10] Thus, the final step of this integrative review was the synthesis of important elements into an integrated summation of recommendations for care of the population in emergency departments.

PRESENTATION STAGE

The results of the integrative review capture the depth and breadth of the topic and contribute to a new understanding of the phenomenon of concern and implications for practice are emphasized.[10] This integrative review took into account the various scenarios of a patient being treated in the emergency department—from opioid use that puts the person at risk to persons with a suspected or confirmed opioid use disorder.

Results

Twelve studies were included in the review. On the basis of the Johns Hopkins Nursing Evidence-Based Practice Guidelines,[14] the majority of studies were Level III and only one study was a Level I. Sample sizes ranged from 18 to 2382. Across the studies reporting demographics, the samples were predominantly male, White, and for studies that reported age, participants were in their 30th year of life. Table 1 provides a summary of the studies organized in accord with each component of the continuum of care beginning with methods for screening for opioid use, assessment for opioid withdrawal and opioid overdose, and determination of opioid use disorder; approaches for a brief intervention; opioid agonist-antagonist medication provided; sources for referral to treatment; and outcomes related to follow-up monitoring. Table 2 provides an overview of medications included in this set of studies. More detailed information about those medications can be found in the Treatment Improvement Protocol from the Substance Abuse and Mental Health Services Administration.[15] Provided below is a summary of the continuum of care components based on the studies included in this integrative review.

SCREENING, ASSESSMENT, AND DIAGNOSIS

Opioid Use and Opioid Use Disorder

Two studies described integrating a single screening question into the electronic medical record, "In the last 12 months have you smoked marijuana, used another street drug or used a prescription pain killer, stimulant, or sedative for non-medical reasons?" to identify opioid use.[16,17] Kelly et al[18] asked, "How often in the past 3 months have you used an illegal drug or used a prescription medication for non-medical reasons?" while others relied on documentation in the electronic medical record on self-reported use in the past 30 days,[19] an opioid diagnosis,[20] or documentation of cellulitis or abscess suggestive of intravenous drug use.[18] Opioid use disorder (OUD) diagnoses were given by a researcher,[11] physician,[21] or licensed social worker[18]; 2 studies used criteria from the Diagnostic and Statistical Manual of Mental Disorders[22] in diagnosing OUD.

TABLE 1
Summary of articles included in the review

First author	Design, purpose, level of evidence	Sample	Screening/ Assessment	Brief intervention	Medication/ prescriber	Referral to treatment	Follow-up outcomes
Bogan[16]	Retrospective cohort study Provide initial outcomes for 3 EDs in South Carolina for SBIRT + opioid agonist treatment Level III Grade B	n = 727 (n = 241 buprenorphine eligible) Demographics: not reported	**Opioid use**: "In the last 12 months have you smoked marijuana, used another street drug or used a prescription pain killer, stimulant, or sedative for non-medical reasons?" **Opioid withdrawal**: COWS* >8	**Motivational interviewing** Assessment of readiness to change Goal: encourage reduction or quitting use and engagement in treatment	**Buprenorphine/ naloxone 8-2 mg or Buprenorphine sublingual 8 mg** Physician with X-waiver or under 3-d rule **Naloxone kit**	**Area treatment providers** (8-30 miles from ED)	**Initial intake:** 78% (187/241) **Naloxone distribution:** 209 of those with OUD
Devries[27]	Retrospective cohort study To assess whether any of 6 screening questions predicted naloxone prescriptions Level III Grade B	n = 182 Demographics: not reported	**Opioid use and Opioid Overdose:** Documentation of opioid prescription, OUD, current or past opioid use or history of opioid overdose	**Education** related to (1) preventing opioid-related overdose, (2) recognizing an opioid-related overdose, and (3) using naloxone should respiratory depression occur	**Naloxone prescription** (IM with syringe, intranasal, autoinjector)	Referred to **pharmacy** to obtain medication	**Proportion treated:** 31.9% (58/182) were recommended by MD to receive naloxone **Naloxone acceptance:** 62.1% (36/58)
D'Onofrio[11]	RCT Test efficacy of 3 interventions for persons with OUD Level I Grade A	n = 104; RT (S and referral) n = 111 BI (S, BI, RT to community-based treatment) n = 114 Buprenorphine (S, BI, ED-initiated treatment, RT primary care) Demographics (n = 329) Male: 76.3% White: 75.4% Age: 31.4 (SD = 10.6) Opioid overdose: 8.8%	**OUD:** Mini-International Neuropsychiatric Interview score ≥ 3 with positive toxicology for opiates or oxyCODONE **Opioid withdrawal**: COWS- moderate to severe withdrawal*	**Brief Negotiated Interview** 10-15 minute conversation based on structured framework. Tailored based on patient insurance, residence, and preference.	**Buprenorphine/ naloxone** (dosage not reported) Home induction dosage: 8 mg on day 1, 16 mg on days 2 and 3) All physicians held X- waiver	**Area treatment providers** for those not receiving buprenorphine Buprenorphine group – 10 wk in **office-based clinic per research protocol** then referred for ongoing care to community provider	**Initial intake** (30-d post randomization): Buprenorphine group: 78% (89/114) BI group: 45% (50/111) RT group: 37% (38/102): **Opioid use** in past 7 d: Buprenorphine group: 5.4 to 0.9 days (93/114) BI group: 5.6 to 2.4 d (93/111) RT group: 5.4 to 2.3 d (69/104):

continued

TABLE 1
Continued

First author	Design, purpose, level of evidence	Sample	Screening/ Assessment	Brief intervention	Medication/ prescriber	Referral to treatment	Follow-up outcomes
Dunkley[21]	Retrospective cohort study Describe management of persons with OUD Level III Grade C	n = 18 (19 data points as 1 patient presented twice) Demographics: Male: 74% Race: not reported Age: 36 (IQR 29-52) Opioid overdose: 26%	**OUD:** diagnosis based on *DSM* documented by Medical Toxicology Fellow **Opioid withdrawal:** COWS ≥ 10	**Education:** After assessing for withdrawal, Medical Toxicology Fellow provides information about buprenorphine, the opioid antagonist treatment clinic, and alterative treatment options.	**Buprenorphine/ naloxone (2 mg-0.5 mg)** Prescribers with X-waiver	Referral to **hospital associated opioid antagonist treatment clinic**	**Initial intake:** 64% (12/19)
Dwyer[19]	Retrospective cohort study Post discharge survey assessing overdose risk Level III Grade B	n = 415 Demographics: Male: 73% Age: 36 (SD = 10.6) White: 62%	**Opioid use**: self-reported use in the past 30 d **Opioid overdose**: self-reported overdose since discharge from ED	**Education** r/t opioids provided by ED-based LDAC. Content included: • overdose risks • how to recognize and respond to a witnessed overdose	**Naloxone kit 2 atomized 2 mg vials** Receipt depended on LDAC availability and patient preference. 13.5% (56/415) received naloxone kit	Not included	Survey completion rate: 12% (51/415) **Past 30-d use**: 35% Survived OD: 22% **Witnessed OD**: 52.9% • Called 911: 63% • Rescue breathing: 26% • Administered naloxone: 22% • Stayed with: 93%
Edwards[24]	Prospective cohort study Describe outcomes for ED-based buprenorphine administration. Level III Grade C	n = 62 Demographics: Male: 45% Race: not reported Age: 34 (median)	**Opioid withdrawal**: COWS ≥5	Not addressed	**Buprenorphine / naloxone 4 mg** 85% (53/62) met criteria for buprenorphine induction in ED Physician administered (not specified if X-waiver or 3-day rule)	Agreement with **local clinic to reserve 80 intake appointments**. Staff scheduled appointment during open hours (M-F, 9 AM to 5 PM) or, if closed, directed patient to present the next morning.	**Initial intake:** 81% (50/62)

continued

TABLE 1
Continued

First author	Design, purpose, level of evidence	Sample	Screening/ Assessment	Brief intervention	Medication/ prescriber	Referral to treatment	Follow-up outcomes
Hu[25]	Retrospective cohort study Determine retention in treatment after ED-initiated buprenorphine Level III Quality C	n = 49 Demographics: Male: 57% Race: not reported Age: 37 (SD = 12.3)	**Opioid withdrawal**: COWS >5	**Educational materials:** • Information on withdrawal symptoms • Options for managing withdrawal • Contact information for outpatient clinics and case management programs	**Buprenorphine 2 to 4 mg sublingually** 88% (43/49) induced in ED Buprenorphine prescription provided with up to 3 daily observed doses (Canadian pharmacy)	ED staff advised patient to go next day to **rapid access treatment clinic** accessible in community	**Initial intake**: 54% (23/43)
Kaucher[26]	Retrospective cohort study Opioid withdrawal Evaluate outcomes following ED-initiated buprenorphine Level III Quality B	n = 219 Demographics: Male: 56.2% White: 86% Age: 35 (SD = 10.3)	**Opioid withdrawal**: COWS 6 to 12 (Buprenorphine SL 2-4 mg) COWS ≥ 13 (Buprenorphine SL 4-6 mg)	Not included	**Buprenorphine sublingual 2 mg up to 6 mg initial dose** Physician assistants or nurse practitioners (X-waivered) conducted 58% of inductions. **Narcan Rescue Kit**	Opioid agonist treatment **clinic, located on health center campus**, served as "Hub" in "Hub-and-Spoke" model. If X-waivered prescribe Buprenorphine 16 mg maximum if >24 h delay in intake	**Initial intake**: 74%
Kelly[18]	Retrospective cohort study Evaluate protocol driven treatment with warm handoff. Level III Quality B	n = 120 Demographics: Male: 62.5% White: 69.1% Non-Hispanic: 77.5% Age: not reported	**Opioid use:** "How often in the past 3 months have you used an illegal drug or use a prescription medication for non-medical reasons?" query by RN. Provider documentation of cellulitis or abscess. **OUD:** 2 or more criteria met with *DSM 5* OUD Checklist completed by social worker. **Opioid withdrawal:** COWS (by RN) ≥8	**Motivational interviewing** techniques used by social worker with assessment readiness/stage of change.	**Suboxone 4 mg** Suboxone provided when provider was available (7 AM-11 AM each day of wk) Buprenorphine prescription provided to bridge to intake appointment	ED social worker worked with **community clinics** to determine most appropriate, then discussed with patient to schedule follow-up appointment (ie, warm handoff). Call back number for social worker was provided to patient in event further assistance was needed.	**Initial intake:** 61% (70/120)

continued

TABLE 1
Continued

First author	Design, purpose, level of evidence	Sample	Screening/ Assessment	Brief intervention	Medication/ prescriber	Referral to treatment	Follow-up outcomes
McLane[23]	Quality improvement To evaluate change in buprenorphine initiation rates over time when processes are put in place to increase uptake. Level V Quality B	n = 427 (n = 51 received buprenorphine) Demographics n = 51 receiving buprenorphine): Male: 48.9% Race: not reported Age (median): 34 (21-66)	**Opioid withdrawal:** COWS ≥ 12 (buprenorphine eligible) COWS < 12 (home induction eligible)	Not included	**Buprenorphine/ naloxone** (dose not specified) **Naloxone kit**	**Participating clinics**	**Initial intake:** 43% (16/37) **Filled prescription after first ED visit:** 74.4% (35/47)
Monico[17]	Retrospective cohort study To examine the scalability of SBIRT across 23 hospital EDs Level III Quality A	n = 950 with opioid withdrawal Demographics: not reported	**Opioid use:** "In the last 12 months have you smoked marijuana, used another street drug or used a prescription pain killer, stimulant, or sedative for a non-medical reason?" **Opioid withdrawal:** COWS ≥ 7 **Opioid overdose:** Unable to conduct screening due to altered mental state	**Motivational interviewing** based BI including assessing for motivation for treatment (trained by experts)	**Buprenorphine/ naloxone 8 mg sublingual** **Naloxone kit**	Established **rapid referral network** in which programs would accept ED patients within 24 h of discharge	**Initial intake:** Buprenorphine administered: 64.6% (430/630) Opioid overdose: 74.2% (244/329)

continued

TABLE 1
Continued

First author	Design, purpose, level of evidence	Sample	Screening/ Assessment	Brief intervention	Medication/ prescriber	Referral to treatment	Follow-up outcomes
Samuels[20]	Retrospective cohort study To determine practice changes from pre- to post-implementation of LOOP program Level III Quality A	n = 555 Demographics: Male: 63.6% White: 82% Age: • 18-29: 40% • 30-50: 43.4% • 51+: 16.6%	**Opioid use:** Documentation of diagnosis in medical record **Opioid overdose:** Opioid use resulting in decreased mental status or respiratory depression necessitating the use of naloxone before or during the ED visit	**Education** Pictorial and verbal instructions on assembly of naloxone for administration and administration instructions in English and Spanish	**Naloxone kit**: two doses of 2 mg intranasal naloxone, a mucosal atomizer device, and instructions	Documentation of one or both: • discussion with an outpatient treatment provider • specific treatment program follow-up details	**Naloxone distribution:** Total sample (n = 555): increased from none to 35.4%. ($P < .001$) Admitted with OD (n = 249): increased from none to 56.5% R**eceived peer recovery coach consult** when available: Total sample (n-555): 33.1% Admitted with OD (n = 249): 49.1% **RT:** Total sample (n = 555): increased from 9.16% to 20.74%. ($P = .003$) Admitted with OD (n = 249): D/C with RT increased from 1.9% to 14.9% ($P = .01$)

Under the "three-day rule" a practitioner in the emergency department can administer buprenorphine for the treatment of acute opioid withdrawal without a Drug Enforcement Agency (DEA) waiver, for no more than 3 consecutive days.[36]
SBIRT, Screening, Brief Intervention, Referral to Treatment; COWS, Clinical Opioid Withdrawal Scale; OUD, opioid use disorder; MD, medical doctor; IM, intramuscular; RCT, randomized control trial; RT, Referral to Treatment; S, screening; BI, brief intervention; IQR, interquartile range; DSM, Diagnostic and Statistical Manual; LADC, licensed alcohol and drug counselors; OD, overdose; LOOP, lifespan opioid overdose prevention; D/C, discharge; RN, registered nurse.
* COWS scores ranging from 5 to 12 = mild, 13 to 24= moderate, 25-26=moderately severe, > 36 = severe.

TABLE 2
Medications for the treatment of OUD and opioid overdose

Medication	Indication	Description
Buprenorphine	Treatment for OUD	• Partial opioid-agonist – activates mu receptors • Displaces morphine, methadone, and other full opioid agonists from receptors and therefore can precipitate withdrawal; thus, assessing with COWS is essential • Long half-life (24 to 60 h) leading to prolonged suppression of opioid withdrawal and blockade of exogenous opioids
Naloxone	Reverses the CNS effects of opioid intoxication and overdose	• Opioid antagonist – blocks mu receptors • Rapid onset of action; short (approximately 4-h half-life) • May require higher doses when potent opioids (eg, fentaNYL) have been taken • Extended-release formulation is indicated for treatment of OUD; requires stopping use of any opioids for a period of 7 to 10 d before treatment initiation

OUD, opioid use disorder; CNS, central nervous system; COWS, Clinical Opioid Withdrawal Scale.

Retrospective studies relied on documentation of OUD in the medical record.[16,21,23]

Opioid Withdrawal

Nine studies in which buprenorphine was administered in the emergency department measured symptom severity via the Clinical Opiate Withdrawal Scale (COWS).[11,16,17,21,23-26] COWS cut scores for buprenorphine induction ranged from ≥5[24,25] to a score of ≥36 corresponding to severe opioid withdrawal.[11]

Opioid Overdose

Studies focusing on opioid overdose included patients with a documented history of opioid overdose[27] or those with a self-report of overdose since previous ED discharge.[19] Others assessed opioid overdose on the basis of the inability to conduct screening because of altered mental state[17] and decreased mental status or respiratory depression necessitating the use of naloxone before or during the ED visit.[20]

Brief Intervention and Education

Motivational interviewing, assessment of readiness to change, and level of motivation were components of the brief intervention (BI).[11,16-18] D'Onofrio et al[11] provided the most detailed description of BI and cited the manual and associated materials that were used to deliver it. The BI delivered in D'Onofrio et al[11] was a structured 10- to 15-minute conversation. Their BI also focused on suggested treatment options based on insurance coverage, residence, and preferences.[11]

Educational interventions focused on opioid overdose prevention, including use of naloxone,[19,20,27] or on buprenorphine.[21,25] Dwyer et al[19] employed ED-based licensed alcohol and drug counselors to deliver a 5-minute overdose educational intervention, composed of overdose risks, how to recognize and respond to a witnessed overdose by calling 911, delivering rescue breaths, and staying with the individual until the emergency response team arrived.[19] Of the 415 people who underwent overdose education, 56 (13%) received a naloxone kit with verbal and written instructions for its use, as well as the telephone numbers for poison control and the hospital pharmacy.[19] Samuels et al[20] provided naloxone kits and used a video to educate participants on overdose prevention, response, and naloxone administration for overdose reversal; bilingual printed instructions were included with the naloxone kit. With a focus on buprenorphine, Hu et al[25] provided print educational materials explaining opioid withdrawal symptoms, options for managing withdrawal, and contact information for outpatient clinics and case management programs.

Buprenorphine Induction

Buprenorphine induction dosages ranged from 2 mg[25,26] to 8 mg[11,16,17] and varied across studies in response to a participant's COWS score. For example, participants whose

COWS score was greater than 5 received 2 mg buprenorphine,[25] whereas Kaucher et al[26] used a COWS cut score of 6 to 12. Most buprenorphine prescribers were physicians; 2 studies[11,16,17] reported that these providers were federally waivered to prescribe buprenorphine. The only study reporting specific details about the provider involved in the induction was by Kaucher et al,[26] who reported that advanced practice providers conducted most of the buprenorphine induction (58%).

Naloxone Prescription

Four studies in which naloxone was provided at discharge from the emergency department reported that it was either prescribed[27] or freely provided.[19,20] The contents of the naloxone kits varied and included either 2 mg naloxone vials[19] or 2 doses of 2 mg of intranasal naloxone, a mucosal atomizer device, and pictorial with written assembly and administration instructions in English and Spanish.[20]

Referral to Treatment

Referral to treatment was used as a stand-alone intervention or to augment ED buprenorphine induction. D'Onofrio et al[11] employed a stepped approach to care. That is, participants assigned to ED buprenorphine induction underwent 10 weeks of protocol treatment then community-based ongoing treatment; those assigned to the screening and referral to treatment arm were provided a handout that listed addiction treatment services of varied intensity and duration that included their names and contact information and were categorized according to the participating insurance plans. Participants in the screening, BI, and referral to treatment arm of the study were directly linked with the referral, considering participant's eligibility for services, ensuring insurance clearance, and arranging transportation.[11]

Other studies employed continuity of care approaches after ED buprenorphine induction. Dunkley et al[21] provided follow-up treatment at the hospital's associated clinic, in which the providers who evaluated study participants in the emergency department were those who provided care in the clinic. Kaucher et al[26] employed a hub-and-spoke model in which the emergency department and the health center's outpatient center served as the hub, and the community health providers were the poststabilization spokes. Others relied on community resources, such as the rapid access outpatient community-based clinics for participants[25] and bridge-building or established relationships with community clinics.[16-18,23]

FOLLOW-UP BUPRENORPHINE-FOCUSED STUDIES

Initial Appointment

Participant follow-up with the first appointment after ED or home-based buprenorphine induction ranged from 53.4%[25] to 81%.[24] Participants referred to their hospital's associated clinic[21,26] reported that 63% and 74% attended their initial appointment, respectively. Provider-facilitated referral to treatment reported rates for keeping the initial appointment of 77.5%,[16] 61%,[18] and 64.4%.[17] Among studies in which community treatment referral was accomplished without active involvement, rates for attending the initial appointment were 81%[24] and 53.4%.[25]

Opioid Use

Using self-reported data for opioid use in the past 7 days and urine toxicology testing, D'Onofrio et al[11] obtained data for 244 of 329 patients (74%), representative of all 3 study arms: buprenorphine group, brief intervention group, and referral group. Although participants in all 3 study arms reported reduced opioid use, there were statistically significant between-group differences and group-by-time interactions. The buprenorphine group (n = 93 of 114) reported greater reductions in the mean number of days of illicit opioid use per week, from 5.4 days to 0.9 days than the referral group (n = 69 of 104) from 5.4 days to 2.3 days or the BI group (n = 93 of 114) from 5.6 days to 2.4 days.[11] In addition, of 339 participants, 220 (66.9%) provided a urine sample for toxicology. There were no significant differences in rates of opioid-negative test results, with 57.6%, 42.9%, and 53.8% opioid-negative urine tests reported for the buprenorphine, the BI, and the referral study arms, respectively.[11]

NALOXONE EDUCATION AND/OR PRESCRIPTION/KIT DISTRIBUTION

Distribution Rates

Rates of naloxone distribution varied from a low of 13.5%,[19] to 35.4%,[20] to a high of 62.1%.[27] Of 58 participants, 22 (37%) declined the offered naloxone prescription[27]; among those participants who accepted naloxone, only 32.8% received a prescription at discharge.

TABLE 3
PRC: Requirements and responsibilities

First author	Requirements	Responsibilities
Bogan[16]	• Hired and supervised by local treatment program • Majority with 3-y of recovery • General Equivalency Diploma	• Screening • BI • Assess readiness for Buprenorphine • Referral to treatment
Monico[17]	At least 3 PRCs in each emergency department	• Respond to alert to see patient • For suspected opioid overdose: provide timely interventions focused on rapid harm reduction education, provision of naloxone kit, recording patient locator and contact information, refer to community PRC who would follow up in next day or 2 to offer additional support • Use motivational interviewing in delivering BI • Assess treatment motivation • Develop plan with patient • Make referral arrangements • Obtain consent to contact treatment program to confirm attendance • Contact provider to confirm follow-up • Document in electronic health record whether appointment was kept • Follow up to provide support and inquire about satisfaction with linkages
Samuels[20]	• In addiction treatment for ≥2 y • Completed 36 h PRC training • Employed by the partnering clinic • Completed HIPAA training • Available Friday 8 PM to Monday 8 AM (due to limited funding)	• Respond to page within 30 min • Provide BI • Identify risk factors for recurrent overdose • Provide teaching on use of naloxone kit • Provide individualized support and addiction treatment navigation at the time of and after the ED visit

PRC, peer recovery coach; BI, Brief Intervention; HIPAA, health insurance portability and accountability act.

Knowledge Retention, Opioid Use, Overdose Response

Dwyer et al[19] explored sustained overdose risk knowledge, opioid use, and overdose response for 51 respondents at 30-day follow-up. With respect to overdose risk, 73% identified the risk of mixing opioids with other substances, 31% identified risks related to opioid use after periods of abstinence, 22% identified the risk of using drugs alone, and 4% identified higher risk when chronic medical conditions were present.[19] Among these participants, 35% endorsed drug use, 22% reported opioid overdose survival, and 53% endorsed witnessing an overdose.[19] Among the 27 participants who witnessed an overdose, 93% stayed with the victim, 63% called 911, 26% performed rescue breathing, and 22% administered nasal naloxone. There was a trend for participants with those who received naloxone compared which those who received opioid overdose education to endorse overdose support interventions, but the difference was not significant.[19]

Peer Recovery Support Services

Across the set of studies, the peer recovery coach (PRC) worked directly with the person who could benefit from intervention, treatment, and recovery support. Whether employed by the emergency department[17] or hired by a partnering treatment program,[16,20] the PRC was an integral member of the health care team, Table 3 provides the requirements for the PRC position and their responsibilities across the set of studies.[16,17,20]

Discussion

The purpose of this review was to provide nurses with evidence specific to a variety of opioid care strategies that can be integrated into routine ED care. Care of patients affected by opioid use begins with identifying opioid use risk,

followed by implementing tailored strategies including opioid agonist-antagonist treatment if indicated, referral to treatment when warranted, and follow-up opioid use monitoring when feasible. The purpose of screening for opioid use is to identify risk, and when that risk is present, there is a need for further assessment and evaluation for an opioid use disorder. Persons who screen positive for opioid risk may not necessarily meet criteria for an OUD. Thus, there are opportunities in the ED setting for preventing the progression of opioid use to an OUD. The following recommendations for emergency nurses are made on the basis of this integrative review.

1. Screen all patients presenting to the emergency department for opioid-related risk using the single question, "How many times in the past year have you used an illegal drug or used a prescription medication for non-medical reasons, for instance, 'because of the experience or feeling it causes?' " A response of 1 or more is considered a positive screen and, thus, triggers the need for further assessment.
2. Assess patients with a positive screen for type and amount of opioid used, frequency and duration of use, and route of administration. Be alert to signs of opiate withdrawal. Complete the COWS when symptoms first appear and subsequently to track opioid withdrawal and effectiveness of opioid agonist treatment. The technical assistance publication from SAMHSA[28] is a valuable resource for emergency nurses seeking further information about opioid withdrawal, particularly in the context of buprenorphine treatment.
3. Assess patients who present after a suspected or confirmed opioid overdose and administer naloxone as indicated. Document information from the person or emergency responder about the number of naloxone doses administered and the elapsed time since rescued. Such information is important because multiple sequential doses of naloxone are indicative of potent synthetic opioids such as fentaNYL.[29] Opioid overdose risk is increased when there is a lifetime history of overdose,[30] and thus, it is important to assess and document any previous opioid overdose.
4. Defer diagnosis of an OUD to the qualified evaluator on the health care team or consultant to the emergency department (ie, physician, advanced practice nurse, physician assistant, licensed social work). In the absence of a formal diagnosis, the emergency nurse may suspect an OUD when there are signs and symptoms that reflect compulsive, prolonged use of opioids without medical purpose or opioid use greatly in excess of the amount prescribed.
5. Engage in a conversation with the patient about the recommendations and options after consulting with the health care team on the treatment plan. The emergency nurse can structure this discussion on the basis of the Brief Negotiated Interview format.[31] That is, the emergency nurse would begin by (1) raising the subject of opioid use, for example, "I'd like to talk with you about your use of oxyCODONE which is not prescribed for you."; (2) providing feedback by reviewing the screening and assessment data and connecting opioid use and the ED visit; (3) enhancing motivation by asking the patient to identify the benefits and risks of opioid use and asking how ready they are to change their opioid use; and (4) presenting the proposed treatment plan.
6. Provide patient education related to any opioid agonist and opioid antagonist medication provided/prescribed, symptoms of withdrawal, and how to prevent opioid overdose. This patient education can be supplemented by published written materials such as those published by Wistanley et al.[32] Emergency nurses and advanced practice providers can advance their knowledge about OUD and medication treatment through free online courses, such as offered by the American Psychiatric Nurses Association,[33] and access a variety of educational materials at the Providers Clinical Support System website.[34] In addition, the emergency nurse should also anticipate needing to educate patients who will be referred to specialty treatment about what that entails.
7. Know which providers on the ED team or consultants can administer, prescribe, and dispense buprenorphine. A DEA X-waiver allows qualified physicians, nurse practitioners, and physician assistants to administer, dispense, and prescribe buprenorphine in any setting.[35,36] However, under the "three-day rule," an ED practitioner can administer buprenorphine for the treatment of acute opioid withdrawal without a DEA X-waiver, up to 3 consecutive days.[36] If a clinical protocol is not in place to guide the implementation of buprenorphine treatment, the emergency nurse can lead the process to ensure that is in effect and disseminated to all ED health care team members. Emergency nurses can encourage their physician, physician assistant, and advanced practice nurse

colleagues to become buprenorphine-waivered providers, directing them to the Substance Abuse and Mental Health Services Administration website.[37]

8. Implement a process for naloxone distribution for patients at high risk of overdose. That process would include ensuring that these patients are discharged with a prescription or a naloxone kit. Patient education should be provided on the indications for use, summoning emergency help, and how to acquire naloxone in the future.
9. Engage patients in the referral to treatment process as this entails more than identification of the need for more extensive treatment. That is, advising patients to seek treatment after discharge from the emergency department does not translate into them following through with the referral.

It is important to know what treatment resources are in the region served by the emergency department. Emergency nurses can advocate for establishing partnerships between their facility and treatment programs to improve care coordination and linkages to care. Emergency nurses can lead the development of innovative models of care, working in the emergency department and the specialty treatment setting in their facility, and evaluate outcomes of that care coordination model such as increased rates of engagement in specialty treatment after discharge from the emergency department.

Emergency nurses can engage patients in discussing and problem-solving potential barriers to acceptance of a referral, such as insurance, transportation, job, and family responsibilities. Emergency nurses can engage with other members of the health care team, such as social workers and PRCs, to assist in removing those barriers.

Emergency nurses can employ the warm handoff approach by engaging in communication with the prospective treatment provider and the patient. In this manner, the patient is included in the referral process, which helps reinforce the reason for the referral and allows them to correct or clarify the information exchanged.

10. Lead quality initiatives, such as calling patients to ensure that they are being followed-up on and monitored after discharge from the emergency department. This follow-up call provides the opportunity to ask whether the patient is experiencing any symptoms, and if so, triage to the most appropriate level of care. Such interventions could prevent complications that lead to costlier care and support timely access to care in the most appropriate setting.
11. Appeal for hiring PRCs as members of the health care team. As persons with lived experience in substance use recovery, PRCs are experientially qualified to support others who are at risk because of opioid use. The PRC whose role extends beyond the emergency department to the community is in a unique position to provide care across the treatment continuum, help link the patient to treatment, provide support for ongoing engagement in treatment, help remove structural barriers to treatment and recovery, and collect data for ongoing follow-up. In a freely accessible video with the link in the reference list,[38] 4 PRCs discuss how they applied for and were hired into the position, how their experiences prepared them to help others, their ability to be credible and authentic because of that experience, their engagement with the person from the first encounter, and their advocacy and support throughout the recovery process.[38]

Implications for Emergency Clinical Care

Emergency nurses are in key positions to lead system change. Practice changes should focus on the continuum of care for persons presenting to the emergency department with opioid use, in opioid withdrawal, or after an opioid overdose. Implementing the recommendations based on this integrative review would advance the quality of care for this population within the emergency department and extend support for the person after discharge and foster linkage to ongoing treatment.

Conclusions

Emergency departments are key settings in which interventions and treatments can be initiated for persons with or suspected of opioid use. All articles in this review demonstrated some aspect of the care continuum that can feasibly be provided within the emergency department. Despite variable approaches to linking individuals to community-based opioid-related treatment, the majority who were referred kept the initial appointment. As more emergency departments use SBIRT and provide opioid agonist-antagonist treatment, they will serve as exemplars for other emergency departments and ultimately lead to widespread adoption of these lifesaving measures.

Author Disclosures

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Supplementary Materials

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Nurses and Efficacy of Ultrasound-Guided Versus Traditional Venous Access: A Systemic Review and Meta-Analysis

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NCPD Earn Up to 11.5 Hours. See page 234.

Contribution to Emergency Nursing Practice

- Ultrasound-guided venous cannulation, or USGIV cannulation, is becoming more popular, but its efficacy is not clearly elucidated.
- USGIV cannulation performed by nurses was associated with higher likelihood of first successful attempt. However, the number of attempts and length of procedures were similar between nurses' USGIV versus traditional method of peripheral venous cannulation.
- The recommendations for translating the findings of this study into emergency clinical practice include more USGIV training for emergency nurses and that further studies should investigate patient satisfaction.

Abstract

Background: Ultrasound-guided venous cannulation is an increasingly popular tool for peripheral intravenous catheter placement among nursing providers as opposed to standard of care landmark-based placement methods. This systematic review and meta-analysis assessed the use of ultrasound-guided versus landmark-based catheter cannulation among nursing providers across existing literature.

Methods: PubMed, Scopus, and Embase were searched for eligible studies from their beginning to June 11, 2021. Outcomes were the rate of first successful placement, procedure length, and number of total attempts. Bias and study quality were assessed using the Cochrane's Risk of Bias and the Newcastle-Ottawa Scale tools, respectively. Random-effects meta-analysis and assessed heterogeneity via Q-statistics and I^2 values were used.

Results: The meta-analysis included 7 randomized clinical studies and 527 patients; 276 (52%) underwent ultrasound-guided cannulation and were associated with 2 times higher likelihood (odds ratio, 2.08; 95% confidence interval, 1.43-3.0; $P < .001$; $I^2 < 0.001$; 95% confidence interval, 0-18) of first successful placement by nurse clinicians. Ultrasound-guided venous cannulation by nurses was associated with similar number of attempts, procedure length, and patients' satisfaction, compared with standard-of-care cannulation.

Conclusions: This study demonstrated the advantage of nurses' ultrasound-guided venous cannulation over landmark-based cannulation methods for first successful placement, although other outcomes were not significantly different between methods. Additional multisite studies with adequately powered sample sizes are necessary to confirm these findings.

Key words: Nurses; Ultrasound-guided venous access; Landmark; Palpation

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Introduction

Peripheral intravenous (PIV) catheter placement is among the most common invasive procedures in the evaluation and management of patients in the emergency department, medical ward, and intensive care units (ICUs).[1] Traditional landmark-based PIV is dependent upon the presence of visible or palpable veins and is complicated by failure rates in up to 26% of patients, often because of many factors including body habitus, age, chronic comorbidities, or intravenous drug use (IVDU).[2] Previous clinical prediction rules for patients who would have difficult venous access included palpability and visibility of veins and history of peripheral venous access.[3]

Difficulty in obtaining PIV access is known to cause significant delays in patient care.[4,5] Historically, failed PIV placements required either insertion of a central venous catheter (CVC) or, if available, consultation to a vascular access service to obtain venous access. CVC placement carries an increased risk of serious complications including infection, pneumothorax, arrythmia, venous air, and thromboembolism.[6] Both CVC placement and consultation to vascular access teams can result in even further delays in patient management.

Point-of-care ultrasound (POCUS) can aid providers in placing PIV catheters among patients with difficult PIV access. POCUS allows for the identification of deep peripheral veins not identified on physical examination and survey for complicating anatomy such as tortuous vessels paths or bifurcations and allows for a dynamic confirmation of PIV placement by visualizing an intravenous (IV) catheter within the lumen of a target vein.[7] Traditionally, ultrasound-guided peripheral venous access (USGIV) was performed by physicians. Nurses have performed USGIV more frequently[8] due to improvements in POCUS machine technology, and lower cost have made USGIV cannulation a more readily available technique for peripheral venous access by both nursing and physician clinicians. As a result, peripheral venous cannulation by nurses has become very popular and feasible. Multiple studies demonstrated that nursing USGIV protocols are safe and successful at obtaining vascular access in patients with known-difficult venous access.[8–10] USGIV protocols also result in a decreased need for physician vascular access interventions.[8–10]

Two meta-analyses were performed previously to compare cannulation by USGIV with cannulation by standard of care (SOC) among patients with difficult venous access.[11] One meta-analysis included 7 studies involving both pediatric and adult patients[12] and reported that USGIV cannulation was associated with higher success rates. However, this study did not specify how many attempts were necessary before the successful attempts. In contrast, a second meta-analysis showed that USGIV was not associated with higher first successful rate of PIV placement,[11] but USGIV was associated with higher overall successful rate than PIV by SOC. Neither meta-analysis specifically investigated the efficacy of nurses' USGIV cannulation.

Given that USGIV cannulation has become a more common nursing practice throughout hospitals, information regarding the procedural outcomes for USGIV cannulation represents a growing area of interest and a need for cumulative investigation, especially for administrators or nursing leaders to establish clinical programs for USGIV cannulation. Because no studies have investigated the efficacy of nurses performing USGIV cannulation and the first successful attempt, we performed a systematic review and meta-analysis to assess current literature about the efficacy of USGIV versus SOC landmark-based PIV cannulation by nursing providers in adult patients with expected or known-difficult venous access.

Methods

SEARCH STRATEGY AND SELECTION

Our meta-analysis was conducted according to the 2015 Preferred Reporting Items for Systematic Review and Meta-Analyses.[13] We searched PubMed, Scopus, and Embase databases from their beginning to October 2020. The updated search was performed in the same databases between October 2020 and June 11, 2021. Our protocol was placed in Covidence software,[14] and there was no amendment to the protocol after the screening process began.

The search terms were as follows in PubMed: (("Catheterization, Peripheral"[Mesh] OR "Vascular Access Devices"[Mesh) AND ("Ultrasonography, Interventional"[Mesh] OR "Veins/diagnostic imaging"[Mesh]) AND ("emergency Service, Hospital"[Mesh] OR "emergency"[all fields])) NOT ("Central Venous Catheters"[Mesh] OR "arterial catheterization, peripheral" [MeSH] OR "Central venous catheter"[all fields] OR "midline"[all fields] OR "PICC"[all fields]).

Any studies involving nurses performing USGIV, which compared between USGIV cannulation and SOC, were eligible. Any experimental studies (any randomized trials); quasi-experimental studies, such as time series studies; and any observational studies, including prospective or retrospective nonrandomized studies, were also included. We also included studies of adult patients whose age was older than or equal to 18 years and studies in English

language. Non–full-text studies (abstracts, conference reports) or studies that involved novel techniques (midline catheter, peripherally inserted central catheters, infrared devices such as the VeinViewer) were excluded. The included studies were searched for eligible references, but we did not contact authors for further information. We decided to focus on nurse interventionists because previous meta-analyses did not address the important question on whether nurses can perform ultrasound-guided peripheral venous cannulation effectively. The target was limited to venous access because registered nurses generally only cannulate veins and not arteries in traditional clinical settings. Finally, pediatric patients were excluded because of other modalities of cannulations in pediatric patients, such as the near-infrared light device. These modalities have been used more frequently in pediatric population because of their lower cost and fewer training requirements.[15]

The search results were imported to Covidence software,[14] which was used to manage our search and screening process. Two investigators independently assessed each title and abstract. Any eligible title and abstract required agreement from 2 investigators to advance to the next step. Any disagreement was adjudicated by a third and senior investigator.

OUTCOME MEASURES

Our primary outcome was the rate of the first successful attempt from ultrasound guidance, performed by nurses, compared with SOC (palpation, landmark). Other outcomes included procedure length, in minutes, as defined by the authors; number of total attempts; and patient's satisfaction.

QUALITY ASSESSMENT AND HETEROGENEITY

Similar to the process for title and abstract screening, 2 investigators independently assessed each included study for study quality. Any conflict was discussed and resolved by group consensus. Although we reported our final results as group consensus, we also measured inter-rater's agreement via weighted Kappa score. Kappa score ≤ 0.2 was considered poor agreement, 0.21 to 0.40 as fair agreement, 0.41 to 0.60 as moderate agreement, 0.61 to 0.80 as good, and 0.81 to 1.00 as very good agreement.

The Cochrane's Risk of Bias (RoB) tool[16] was used to assess risk of bias for any randomized trial and the Newcastle-Ottawa Scale[17] for any observational or other type of study. The RoB tool assessed each study across 5 domains (randomization process, deviations from intended interventions, missing outcome data, measurement of outcome, selection of reported results). If any domain was graded as having risk of bias, the study's overall assessment would reflect this risk of bias. The Newcastle-Ottawa Scale awards a maximum of 9 points for observational studies across 3 domains: quality of outcomes, comparability of groups, and cohort selection. High-quality studies achieve score ≥ 7, moderate-quality study have scores of 4 to 6, and low-quality study studies have score ≤ 3.

We used the I^2 statistic and Q-statistic to assess our meta-analysis' heterogeneity. The Q-statistic tests for the null hypothesis that all studies within our meta-analysis would share a common effect size. The I^2 statistic indicated that the percentage in variance of the meta-analysis' effect size was because of true variance and not sampling errors.

DATA EXTRACTION

Data were collected and entered into a standardized Excel spreadsheet (Microsoft Corp, Redmond, WA). Two investigators first extracted the data independently, before the inter-rater's agreement was calculated using the Kappa score. The difference was adjudicated by a third and senior investigator, and the final results were reported as the consensus of the group.

We collected studies' information including the studies' first authors' names, year of publication, study design (randomized trial or other, number of participants, types of nurses or other operators), and patient-specific data (eg, age, gender). Besides demographic data from the studies and patients, other clinical data that might have affected successful rates of venous cannulations[18] were also collected: patients' race, body mass index, history of renal dialysis, intravenous drug use (IVDU), sickle cell disease, and other. However, we did not report any of these data because most of the included studies did not report these data.

STATISTICAL ANALYSIS

There are fundamental differences between fixed-effects and random-effects meta-analysis models. Therefore, random-effects meta-analysis when any 2 or more studies reported the same outcome of interest was used. The fixed-effects model assumes that the true effect size is similar among all included studies because their characteristics are very similar. In contrast, the random-effects model assumes that there is a common effect among studies, but these studies are still different among each other. In real-life practices, most studies would differ in how the patients are selected and how interventions and outcome are defined so random-effects model would be more suitable.[19]

Prevalence results (rate of first successful attempts) were expressed as odds ratio (OR) and 95% confidence interval

(95% CI). Continuous data were presented as mean (standard deviation [SD]). When the studies reported data as median (interquartile range), we converted median to mean (SD) before performing analysis. Continuous outcomes (length of procedure, number of attempts, patient satisfaction) were reported as standardized difference in means (SDM) and 95% CI. As previously suggested,[20] an absolute SDM value ≤ 0.2 was considered a small magnitude between interventions and control group's effects size, an absolute SDM value of approximately 0.5 was considered a medium magnitude for effect size, and SDM value ≥ 0.8 was considered large magnitude.

ADDITIONAL ANALYSES

Owing to anticipated heterogeneity among studies being included in our studies, moderator analyses with categorical variables were performed. To describe differences among studies that might potentially contribute to heterogeneity between studies, we decided a priori to use each available study's demographic information in moderator analysis, to quantify the level of heterogeneity from each available study's demographic information.[19]

Furthermore, because of different study designs, sample sizes, and participants' selection, the effect size from one study may influence our study's overall effect size. For example, studies with small sample size can report large, positive findings, whereas large studies and more robust methodology would report nonstatistical finding.[19] Therefore, a sensitivity analysis was performed using one-study-removed random-effects meta-analysis. The meta-analysis would remove the very first study from the pooled study, which performed meta-analysis from the rest of the studies. It then removes the second study, while performing meta-analysis on the pool study of the first study and all other studies. By systemically removing individual studies, this sensitivity analysis investigates whether any one single study would affect the overall outcome of the meta-analysis' effect size.

We also performed random-effects cumulative analysis to assess the trend of the studies' effects over the years.[19] In this cumulative analysis, a random effects meta-analysis was performed with just one earliest study, and then a random effects meta-analysis added the second earliest study and performed meta-analysis on these 2 included studies. It subsequently added the third earliest study then performed a meta-analysis on these 3 included studies, and so on.

Our meta-analysis' publication bias was assessed using the funnel plot in addition to Begg's and Egger's tests. A symmetry of the included studies and Begg's test and Egger's test's $P > .05$ would suggest low likelihood of publication bias.[21] Additionally, the Orwin's fail-safe N test was performed to further assess publication bias. The Orwin's fail-safe N test would predict the number of missing or future studies that might have changed the effect size of our study's primary outcome.[19]

All one-study-removed meta-analysis, cumulative analysis, or our random-effects meta-analyses were performed with the software Comprehensive Meta-Analysis (www.meta-analysis.com; Englewood, NJ). All variables with 2-tailed $P < .05$ were considered statistically significant.

Results

STUDY DESCRIPTION

Our electronic search identified a total of 284 studies; after full-text review, we included a total of 7 studies in the final meta-analysis of our primary outcome (Figure 1).

All 7 studies included within the primary meta-analysis were prospective studies, with randomized selection of patients into USGIV and SOC arms[9,22–27] (Table 1). All studies enrolled patients who had difficult venous access and also needed peripheral venous access for clinical treatments. Three studies[9,22,26] defined difficult venous access from patients' self-report of previous history of having difficult access. Another 2 studies[25,27] identified difficult venous access as patients who did not have visible or palpable veins. Two studies[23,24] considered previous history of having difficult venous access, but also 2 failed attempts by SOC cannulation before enrolling them for their studies.

One study included an intention-to-treat model, with all patients requiring successful PIV placement for removal of CVCs.[18] All studies shared a common primary outcome of rate of first successful attempt. The studies varied in clinical setting, 3 occurring within the emergency department,[9,24,26] 3 within the ICU,[23,25,27] and 1 within the perioperative setting.[22] Our primary meta-analysis included a total of 527 subjects requiring PIV placement, with 276 undergoing USGIV and 251 via SOC (Table 1).

STUDY QUALITY

Given that all 7 included studies were randomized trials, only the Cochrane's RoB tool was used to grade the included studies' quality (Table 2). Three studies were assessed as having low risk of bias.[23–25] Four studies had some concern for bias.[9,22,26,27]

PRIMARY OUTCOME: USGIV VERSUS SOC

USGIV placement by nursing was associated with a significant increased rate of first successful attempts compared with SOC landmark-based practices (OR, 2.1; 95% CI, 0.4-10.8; $P <$

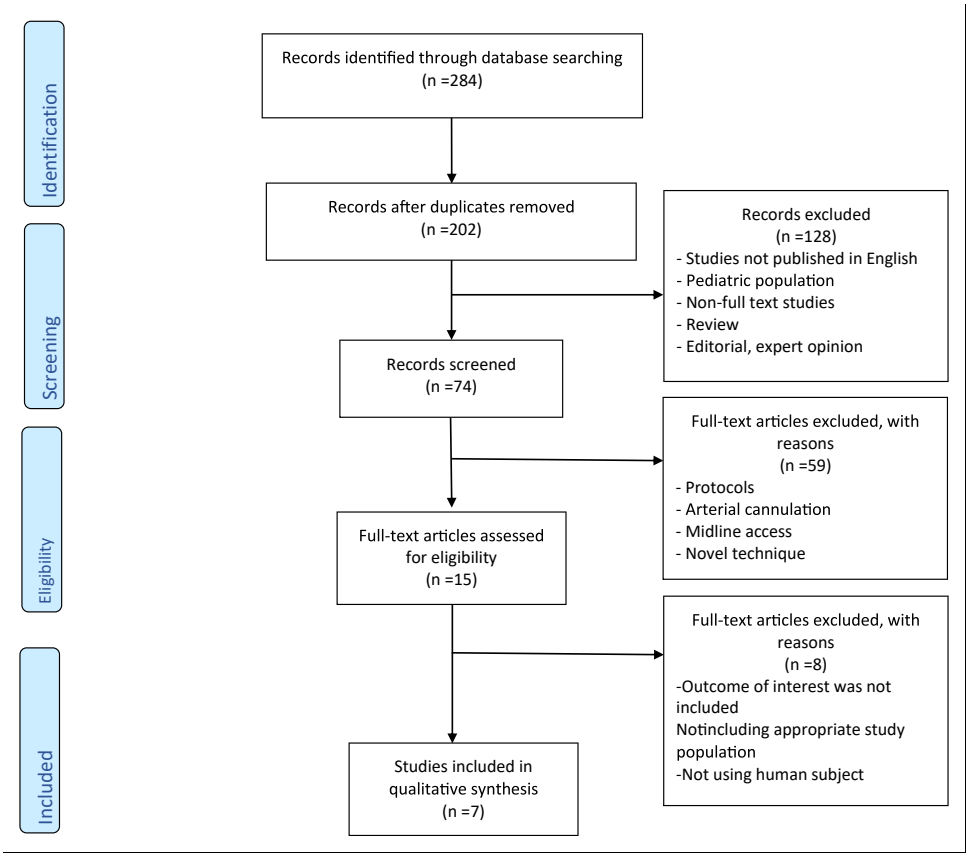

FIGURE 1

PRISMA-P diagram for study selection. PRISMA-P, Preferred Reporting Items for Systematic Review and Meta-Analyses Protocols. Non-full text studies include abstracts and conference reports.

.001) (Figure 2A). The *P* value for the Q-statistic was .59, suggesting that there was no significant difference between our study's effect size and the true effect size. Additionally, I^2 value for heterogenicity across our studies was < 0.001 (95% CI, 0-18), which suggested that there was no significant variance among included studies' effect size.

SENSITIVITY ANALYSES

The cumulative meta-analysis (Figure 2B) shows a chronologic trend favoring USGIV by the addition of the third study, published in 2013 by Weiner et al.[9] Statistical significance of this chronologic trend over time is not achieved until the fourth study is added, but reaching an OR of 1.96 and $P = .03$. This trend continued to remain significant with addition of every subsequent studies, until the most recent one in 2020 by Nishizawa et al.[23]

The one-study-removed meta-analysis showed that odd ratios remained between 1.9 and 2.2 favoring USGIV when the meta-analysis systemically removed individual studies. This range of odd ratios remained well within the 95% confidence intervals of the pooled studies and suggested that no single study would have a significant influence on the primary effect size (Figure 2C).

SUBGROUP ANALYSIS

Subgroup analysis using categorical variables was used to identify potential heterogenicity and to compare effect sizes between clinical settings and sample size. Differences between nursing clinical settings of the emergency department and ICU were assessed using the 6 publications within these settings (Table 3). Three studies were based within each setting and demonstrated no significance in between-group comparisons ($P = .44$). I^2 values across both settings were < 0.001 (95% CI, 0-18), demonstrating very low heterogeneity both within and between ED and ICU settings.

Similarly, subgroup analysis between studies' sample sizes was also conducted. There was no significance between both

TABLE 1
Characteristics of included studies

First author (y)	Study type	Total patients (N)	Clinical setting and definition of difficult access	Country	Nurse experience		Number of patients	Age (y), mean (SD)	Female, N (%)	Type of operator (N, %)	First successful cannulation, N (%)	Procedure length (min), mean (SD)	Number of attempts, mean (SD)	Patients' satisfaction (type of scale), mean (SD)	Any complications, (N, %)
2007 Aponte[22]	RCT	35	Setting: OR Definition: previous history of difficult access	USA	>3 y of experience	US guidance	19	55.5 (15.7)	15 (79)	CRNA (19, 100)	14 (74)	1.3 (0.5)	1.4 (0.7)	NR	NR
						SOC: landmark, palpation	16	57.3 (18.9)	12 (75)	CRNA (16, 100)	13 (81)	3.1 (3.8)	1.3 (0.9)	NR	NR
2012 Kerforne[27]	RCT	60	Setting: ICU Definition: no visible or palpable veins	France	NR	US guidance	49	61 (17)	63	Nurse (49, 100)	42.9	7.25 (5.06)	NR	NR	NR
						SOC: landmark, palpation	39	56 (15)	50	Nurse (39, 100)	28.2	6.67 (3.25)	NR	NR	NR
2013 Weiner[9]	RCT	50	Setting: ED Definition: previous history of difficult access.	USA	1 successful cannulation of model vein	US guidance	29	46.2 (14.6)	21 (72)	Physician (7, 24.1); Nurse (50, 100)	75.9	27.6 (31)	NR	Very satisfied, satisfied, somewhat satisfied, or not satisfied with the total experience of IV placement (86.2% patient satisfaction)	NR
						SOC: landmark, palpation	21	53 (14.2)	12 (57)	Physician (11, 52.4); Nurse (50, 100)	47.60	26.4 (22)	NR	Very satisfied, satisfied, somewhat satisfied, or not satisfied with the total experience of IV placement (63.2% patient satisfaction)	NR
2014 İsmailoğlu[26]	RCT	60	Setting: ED Definition: Previous history of difficult access	Turkey	Not specified	US guidance	30	52.7 (6.7)	19 (63.3)	Nurse (4, 100)	6 (20)	NR	2.1 (0.7)	NR	NR
						SOC: landmark, palpation	30	52.7 (6.7)	16 (53.3)	Nurse (4, 100)	9 (30)	NR	2.1 (0.6)	NR	NR
2016 Bahl[24]	RCT	122	Setting: ED Definition: Previous history of difficult access; 2 or more unsuccessful cannulations	USA	10 successful USGIV cannulations	US guidance	63	56.25 (16.75)	47 (74.6)	Nurse (63, 100)	48 (76.2)	20.7 (NR)	1.52 (NR)	NR	Rescue methods required (11, 17.4), total complications (11, 17.4)
						SOC: landmark, palpation	59	56.25 (16.75)	43 (72.9)	Nurse (59, 100)	33 (55.9)	15.8 (NR)	1.71 (NR)	NR	Rescue methods required (25, 42.4), total complications (25, 42.4)

continued

TABLE 1
Continued

First author (y)	Study type	Total patients (N)	Clinical setting and definition of difficult access	Country	Nurse experience		Number of patients	Age (y), mean (SD)	Female, N (%)	Type of operator (N, %)	First successful cannulation, N (%)	Procedure length (min), mean (SD)	Number of attempts, mean (SD)	Patients' satisfaction (type of scale), mean (SD)	Any complications, (N, %)
2018 Bridey[25]	RCT	112	Setting: ICU Definition: no visible or palpable veins	France	4 supervised successful USGIV cannulations	US guidance	56	65.2 (6.9)	22 (39)	Nurse (56, 100)	23 (41)	NR	2.0 (0.93)	Likert scale, 8 (0.6)	Bleeding (0), local inflammation (0), pain (0), extravasation (18, 34), accidental catheter removal (2, 4), total complications (20, 35.7)
						SOC: landmark, palpation	56	62.3 (6.6)	22 (39)	Nurse (56, 100)	18 (33)	NR	2.1 (1.4)	Likert scale, 8.1 (0.8)	Bleeding (0), local inflammation (0), pain (0), extravasation (9, 18), accidental catheter removal (6, 12), total complications (26.8)
2020 Nishizawa[23]	RCT	60	Setting: ICU Definition: no visible or palpable veins; 2 or more unsuccessful cannulations	Japan	5 successful supervised USGIV placements on gel model, 3 successful supervised USGIV placements on live patients	US guidance	30	74.2 (14.7)	15 (50)	Nurse 30 (100)	21 (70)	NR	1.3 (0.45)	NR	Extravasation (3, 13.6), hematoma (0), obstruction (0), infection (0), total complications (3, 13.6)
						SOC: landmark, palpation	30	79.4 (10.8)	10 (33.3)	Nurse (30, 100)	12 (40)	NR	1.6 (0.5)	NR	Extravasation (4, 28.5), hematoma (0), obstruction (0), infection (0), total complications (4, 28.5)

ED, emergency department; ICU, intensive care unit; NR, not reported; OR, operating room; RCT, randomized controlled trial; SOC, standard of care; US, ultrasound; USA, United States of America; USGIV, ultrasound-guided peripheral venous access.

TABLE 2
Study quality assessment of randomized trial using the Cochrane Collaboration's Risk of Bias tool 2

Study (y, first author)	Risk of bias arising from the randomization process	Risk of bias because of deviations from the intended interventions	Missing outcome data	Risk of bias in measurement of the outcome	Risk of bias in selection of the reported result
2007 Aponte[22]	Some concern	Low	Low	Low	Low
2012 Kerforne[27]	Some concern	Low	Low	Low	Low
2013 Weiner[9]	Low	Some concern	Low	Some concern	Low
2014 Ismailoglu[26]	Some concern	Low	Low	Low	Low
2016 Bahl[24]	Low	Low	Low	High	Low
2018 Bridey[25]	Low	Low	Low	Low	Low
2020 Nishizawa[23]	Low	Low	Low	Low	Low

Kappa's score: 0.61 (95% CI, 0.40-0.80).

groups ($P = .68$), and there was very low heterogeneity within each group (I^2 values were <0.001; 95% CI, 0-18). USGIV than the studies with ≥ 75 patients (Table 3) to be consistent with the new numbering system. These data suggested the small study's effects.

SECONDARY OUTCOMES

Five studies[9,21,23–25] reported data on the number of PIV attempts by nursing (Figure 3A). Owing to differences in reporting methods across studies, the results are reported as a standardized mean difference, but demonstrated no statistical difference between favoring SOC and ultrasound guidance. Four studies[9,22,24,27] reported data on procedural length in minutes, favoring SOC, but cumulatively showed no statistical difference (Figure 3B).

Only 2 studies[9,25] included within our meta-analysis reported patient satisfaction data (Figure 3C). There was no statistical difference between SOC or ultrasound. Owing to the limitations of size and significant heterogenicity (I^2 = 77%; 95% CI, 14-95), few conclusions can be drawn from this analysis aside from the need for further investigation of this outcome in future studies.

ADVERSE EVENTS AND COMPLICATIONS

Three studies reported complications or adverse events.[23–25] Extravasations were reported by Bridey et al[25] and Nishiziwa et al.[23] The total number of catheter extravasations from the USGIV group was 21 (24%, 21 of 86 patients) compared with 13 (15%, 13 of 86 patients) for the SOC group, and it was not statistically significant ($P = .11$). Bridey et al[25] also reported 2 incidences of accidental catheter removal (4%, 2 of 56 patients) compared with 6 accidental removal (11%, 6 of 56 patients), and the difference was not statistically significant ($P = .10$). Bahl et al[24] only reported adverse events as the number of patients who needed alternative venous cannulation for rescue, which was not considered a true adverse event for the purposes of our review.

PUBLICATION BIAS

Funnel plot and Begg's and Egger's tests were used to assess for publication bias for studies included within our meta-analysis. Symmetry was observed within the funnel plot (Appendix) with P values of Begg's and Egger's reaching .88 and .89, respectively, demonstrating low likelihood of publication bias.

Furthermore, the Orwin's fail-safe N calculation showed that, assuming that all potential missing or future studies would have odd ratio of 0.70, favoring SOC, 15 studies would be required to equate the efficacy of cannulation via landmark to that of USGIV.

Discussion

We found the rate of first successful attempt among nurse interventionists favored the use of USGIV over SOC. Our meta-analysis' result differed from a previous meta-analysis. van Loon et al[11] showed that ultrasound guidance was not associated with increased odds of first successful attempts. This finding was not only conducted from a smaller number of included studies (only 3 studies) but also from

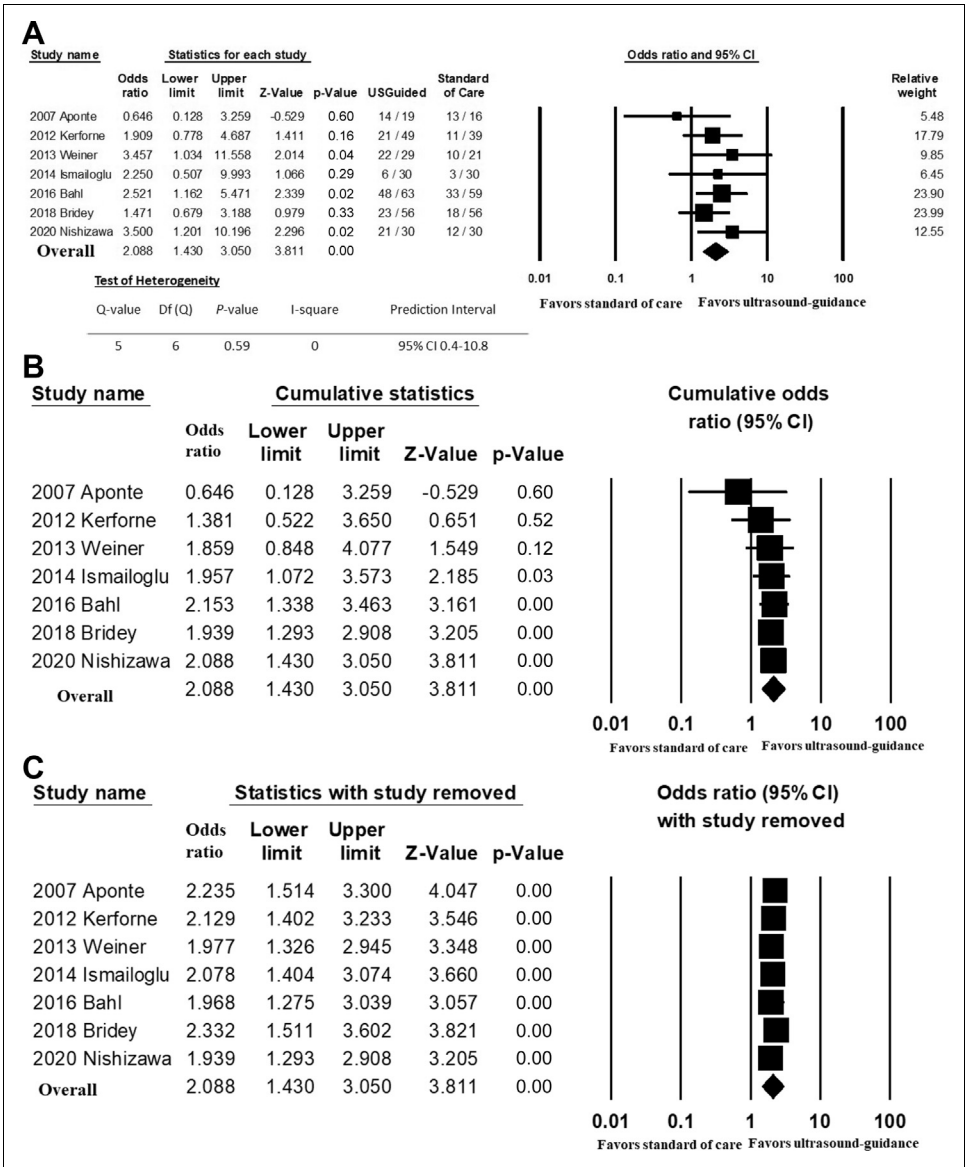

FIGURE 2

(A) Random-effects meta-analysis comparing first successful attempts by nurses using point-of-care ultrasound with traditional practices. (B) Random-effects *cumulative meta-analysis* of studies reporting first successful attempts by nurses using USGIV cannulation vs standard of care. (C) Sensitivity analysis using one-study-removed meta-analysis of studies reporting first successful attempts. USGIV, ultrasound-guided peripheral venous access.

older studies, all of which were published before 2016. It was also likely that USGIV was not as familiar to nursing providers in 2016. Additionally, van Loon et al's[11] study included smaller studies for the outcome of number of attempts, and this outcome was not different between USGIV and SOC approaches.

Our study identified significant variations among the included studies. For example, nurses from each study were trained in different manners, and there were different levels of nurses' experience using ultrasound. Furthermore, most authors did not report on certain patients' clinical factors that could have affected the successful cannulations. Despite these heterogeneous populations, our meta-analysis showed very low I^2 values for the primary outcome and most of the secondary outcomes. These low I^2 values are encouraging because they indicated that almost all studies included in our meta-analysis agreed with a single effect: that is, ultrasound-guided venous cannulation is favored over SOC cannulation and would be associated with better outcomes.

TABLE 3
Moderator analyses of subgroups, comparing effect sizes of first successful attempts, between clinical settings and studies' sample sizes

Meta-analysis				Test of heterogeneity					Between-group comparison
Group	Number of studies	Odd ratio	95% CI	*P*	Q-value	Df(Q)	*P*	I-square (95% CI)	
Clinical Settings									
ED	3	2.67	1.4-4.9	.001	0.25	2	.88	< 0.001 (0-1.9)	0.44
ICU	3	1.95	1.2-3.3	.01	1.66	2	.44	< 0.001 (0-1.9)	
Study sample size									
< 75 patients	5	2.25	1.3-3.8	.002	3.5	4	.47	< 0.001 (0-1.62)	0.68
≥ 75 patients	2	1.9	1.1-3.3	.02	0.9	1	.33	0 (0-17.5)	

Only categorical variables were used in these moderator analyses.
ED, emergency department; ICU, intensive care unit.

There was an interesting trend with our cumulative analysis. There was a clear chronological improvement in the rate of first successful attempts by USGIV, given that the meta-analysis from the earliest 3 studies by Aponte et al,[22] Kerforne et al,[27] and Weiner et al[9] did not show clear benefits of using ultrasound, but adding subsequent studies demonstrated that USGIV was associated with higher odds of first successful attempts. This observation was most likely because of the increasing availability of POCUS, which improves nursing providers' familiarity with POCUS devices for IV cannulation given that USGIV is operator dependent.[17] We expect that future studies and future meta-analyses will likely demonstrate a better USGIV's efficacy in many outcome markers as ultrasound technology becomes more available.

Our moderator analyses of subgroups showed no significant difference in first successful rates between the clinical setting (emergency department or ICU) among nursing providers. This is possibly because of the similarly timed adoption of USGIV practices and likely shared frequency of encountering patients with difficult IV access within these 2 clinical settings. Furthermore, as long as nurses are experienced and well trained, the success rates should not differ among different clinical settings, although further studies are necessary to confirm our observation. Given the demonstrated improvement in first successful attempts, nursing administrators within both settings may consider adopting clinical pathways for the earlier implementation of USGIV placement when patients are identified to have difficult IV access.

There was no significant difference in the number of attempts between USGIV and SOC. It was likely because of nurses' experience in our study, because it was shown that USGIV is heavily dependent on operators' experience.[28] There was substantial heterogeneity regarding nurses' experience in USGIV in our included study. Most of the studies did not report their nurses' experience with ultrasound-guided cannulation or what techniques of ultrasound-guided venous cannulation were used. In one study, nurse participants were required to perform only one successful attempt on a model vein,[9] and other studies required their participants to complete 4 to 10 successful ultrasound-guided cannulations before being part of the study.[24,25] This level of experience strongly suggested that most nurses in the included studies were not experienced with ultrasound-guided cannulation technique, which might have been associated with nonstatistically significant outcomes of procedural length and number of attempts. Consequently, there was no description of whether the nurses were trained with dynamic needle tip positioning, and it was less likely that the participants would be familiar with this technique, which had been shown to be superior to the palpation method and would have a lower number of attempts and shorter procedural time.[29]

Only 3 studies in our meta-analysis reported any complications or adverse events.[23–25] However, Bahl et al[24] only reported their adverse events as the number of patients who needed alternative venous cannulation for rescue. Therefore, we did not consider the need for rescue as true adverse events from venous cannulation. The overall pooled rate of extravasation in our study for either USGIV (24%) or SOC (15%) catheter groups was higher than previously reported. Favot et al[30] reported that the rate of extravasation from ultrasound-guided venous catheters was 4.1% compared

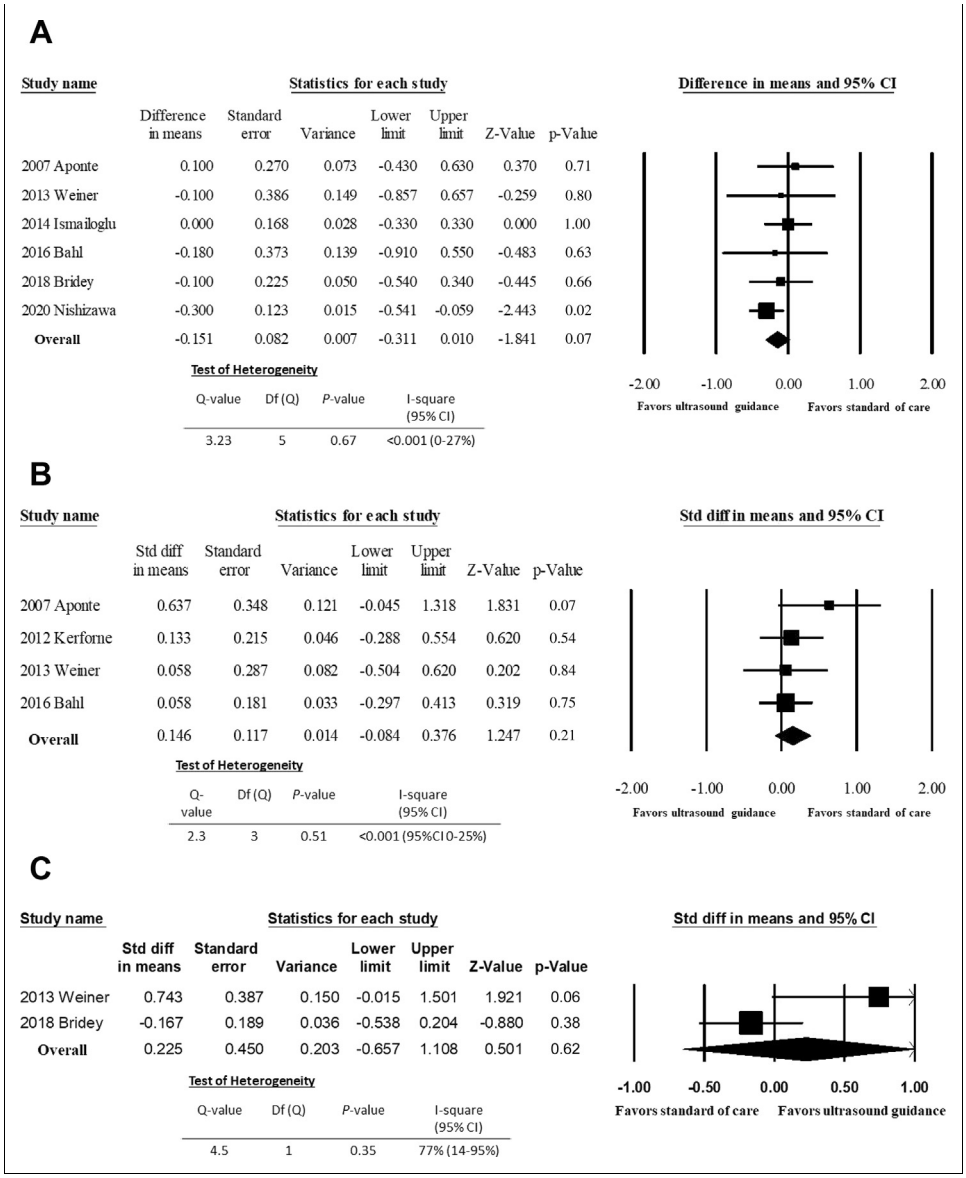

FIGURE 3

(A) Random-effects meta-analysis comparing number of attempts from nurses' ultrasound-guided peripheral venous (USGIV) with standard of care (SOC) cannulation. Result was expressed as standardized mean difference (SMD). (B) Random-effects meta-analysis comparing procedure length of nurses' ultrasound-guided peripheral venous (USGIV) with standard of care (SOC) cannulation. Results were expressed in standardized mean difference (SMD). (C) Random-effects meta-analysis comparing patient satisfaction from nurses' ultrasound-guided peripheral venous (USGIV) with standard of care (SOC) cannulation. Result was expressed as standardized mean difference (SMD).

with only 0.21% for SOC venous catheters. However, there were no factors reported being associated with the risk of extravasation, likely because Favot et al[30] also observed a small number of extravasations. Therefore, further studies with adequate sample size are needed to decide whether USGIV cannulation would be associated with higher rates of adverse events.

Inherently, USGIV is a more time-consuming process than SOC placement because of necessities such as sterilization of the probe, patients' skin, then providers' hand holding, manipulation of the ultrasound probe, and removal of ultrasound gel to place a catheter. Both van Loon et al's and our study showed that USGIV was not statistically associated with shorter time interval to successful cannulation.

However, there was a difference between the 2 studies. Our study indicated that USGIV may have been associated with longer procedure time while van Loon et al's[11] showed that USGIV was associated with shorter procedure time.

FUTURE RESEARCH

We also identified several potential areas for future research in USGIV placement by nursing providers. Future investigators should consider including many patients' clinical factors that might have been associated with successful cannulation. Some of those factors had been identified previously such as body mass index, patients' history of renal dialysis, sickle cell disease, and IVDU.[18] There was a lack about consensus on how to define procedure length. Aponte et al[22] defined procedure length as the total amount of time to successfully place a catheter, regardless of the number of attempts. In contrast, Bahl et al[24] defined procedure length as time interval from placing tourniquet to Tegaderm placement (tourniquet to Tegaderm), whereas other studies did not define their procedure length. Therefore, having a uniform definition on procedure length will allow researchers to assess POCUS's efficacy more accurately. Furthermore, most studies did not include patient satisfaction when comparing the 2 modalities of PIV placement. Less than half of the included studies about USGIV by nurses used patients' satisfaction as an outcome. Furthermore, only 2 studies or approximately 1 of 3 of the included studies investigated the number complications, such as rates of extravasation of infused medications, arterial puncture, line infection, or soft tissue injuries, from either USGIV or SOC landmark-based cannulation. With the growing availability of POCUS and the number of patients with difficult PIV access, these areas represent important opportunities to identifying procedural improvement such as decreasing patient pain, stress, and anxiety while improving efficiency of delivered care.

STUDY STRENGTHS

Our study also has a few strengths. Our study was the first meta-analysis demonstrating that nurses were able to establish significantly higher first successful cannulation rates by using ultrasound guidance than SOC cannulation. Our findings confirmed that the efficacy of ultrasound technology for nursing providers is not specific to any one ultrasound manufacturer, IV size, or venous location of cannulation. With the use of random-effects meta-analysis and a low heterogeneity across studies, our study's findings may be generalized to similar settings and similar patient population.

LIMITATIONS

There are many limitations to this meta-analysis. First, our review protocol was not registered with PROSPERO and did not receive external review. During the ongoing coronavirus pandemic, the PROSPERO team has not been able to review any non–coronavirus disease 2019–related protocols. Future studies would benefit from having external review. Additionally, there were a small number of studies in this field, which prevented us from performing moderator analyses in depth. Many of the included studies had relatively small sample sizes, which may inflate the effect size, causing the small study effect. There was no standardized procedural methodology among studies of the make and model of ultrasound devices, IV catheter size and length, or venous access sites used. However, this heterogeneity improves the generalizability of our study's findings given that different institutions invest in different vendors of both ultrasound machines and IV catheters.

Implications for Emergency Clinical Care

Our study demonstrated a clear benefit for USGIV placements by nurses in the emergency setting, as demonstrated by our subgroup analysis with studies. Further training programs to enable emergency nurses to perform more USGIV will benefit patient care and workflow. Based on our analysis, we anticipated that further studies involving nursing providers will show more efficacy from using USGIV, because our Orwin's fail-safe N analysis demonstrated that a large number of studies favoring SOC cannulation are required, to negate our current findings. This scenario of potentially negating our findings is less likely to occur as nursing providers become increasingly familiar with POCUS for IV cannulation.

Conclusions

The pooled analysis of this study shows a clear superiority of USGIV over SOC with respect to the rate of first successful attempts in patients with difficult venous access. This trend favoring USGIV over time improved in a chronological fashion and occurred in a likewise fashion between ED and ICU settings. The majority of the studies included within this meta-analysis had a small sample size. Adequately powered, multisite studies are indicated to confirm our observations and further investigate ancillary procedural outcomes.

Author Disclosures

The authors declared no conflict of interest.

Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jen.2021.12.003.

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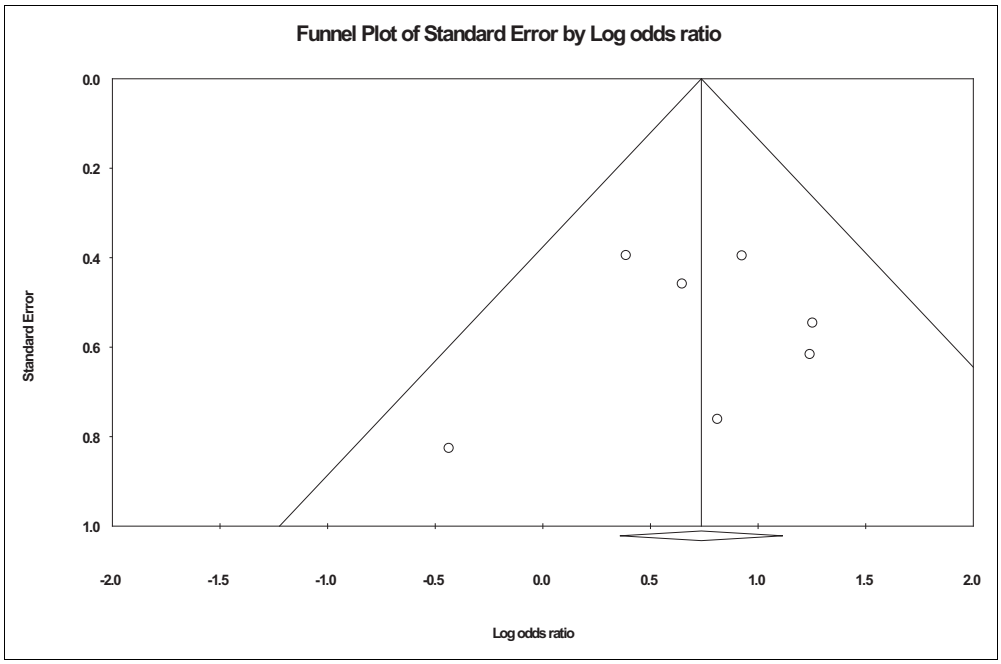
Appendix

Funnel to assess potential publication bias in the meta-analysis comparing efficacy of USGIV and standard of care.



Infrared Vein Imaging for Insertion of Peripheral Intravenous Catheter for Patients Requiring Isolation for Severe Acute Respiratory Syndrome Coronavirus 2 Infection: A Nonrandomized Clinical Trial

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NCPD Earn Up to 11.5 Hours. See page 234.

Contribution to Emergency Nursing Practice

- Evidence on peripheral intravenous access assistive technology has mainly applied to venipuncture in children.
- Infrared vein imaging may help nurses improve the peripheral intravenous access first attempt success rate, efficiency, and patient satisfaction among adult patients under pandemic infectious respiratory disease isolation conditions.
- The results of this nonrandomized study support the use of infrared vein imaging among adult emergency patients who require infectious disease isolation that may create difficulty in performing peripheral intravenous access procedures.

Abstract

Introduction: Establishing intravenous access is essential but may be difficult to achieve for patients requiring isolation for severe acute respiratory syndrome coronavirus 2 infection. This study aimed to investigate the effectiveness of an infrared vein visualizer on peripheral intravenous catheter therapy in patients with coronavirus disease 2019.

Methods: A nonrandomized clinical trial was performed. In total, 122 patients with coronavirus disease 2019 who required peripheral intravenous cannulation were divided into 2 groups with 60 in the control group and 62 in the intervention group. A conventional venipuncture method was applied to the control group, whereas an infrared vein imaging device was applied in the intervention group. The first attempt success rate, total

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procedure time, and patients' satisfaction score were compared between the 2 groups using chi-square, *t* test, and *z* test (also known as Mann-Whitney U test) statistics.

Results: The first attempt success rate in the intervention group was significantly higher than that of control group (91.94% vs 76.67%, $\chi^2 = 5.41$, $P = .02$). The procedure time was shorter in the intervention group (mean [SD], 211.44 [68.58] seconds vs 388.27 [88.97] seconds, $t = 12.27$, $P < .001$). Patients from the intervention group experienced a higher degree of satisfaction (7.5 vs 6, $z = -3.31$, $P < .001$).

Discussion: Peripheral intravenous catheter insertion assisted by an infrared vein visualizer could improve the first attempt success rate of venipuncture, shorten the procedure time, and increase patients' satisfaction.

Key words: COVID-19; Infrared vein visualizer; Peripheral intravenous catheter insertion

Introduction

Coronavirus disease 2019 (COVID-19) is highly contagious and transmissible, requiring isolation precautions during treatment. Respiratory droplets and close contact were recognized as the major virus transmission routes in the early phases of the pandemic, and the population is generally susceptible.[1] Therefore, patients must be treated in isolation conditions, and health care staff needs to wear personal protective equipment. In many international settings, the required personalized protective equipment included goggles.[2] This personalized protective equipment presents challenges and additional workload when providing nursing care. The evaporated body heat forms water vapor in goggle glasses, which may block nurses' eyesight. Moreover, wearing an extra layer of gloves negatively affects the palpating sensation. Nursing responsibilities commonly include peripheral intravenous cannulation (PIVC). Traditionally, nurses rely on their senses of sight and touch to perform PIVC. However, under isolation ward conditions described in earlier text, nurse proceduralists may not be able to see the vein clearly and assess the venous elasticity well, making venipuncture particularly difficult.

The infrared vein imaging device emits infrared wavelength of 4 to 400 μm with a 3 to 5 cm penetration depth to pass through the skin and subcutaneous fat efficiently. On absorbing the infrared wave, the vein turns blue-green. Hence, the distribution and direction of subcutaneous veins, especially those invisible to the naked eye, can be clearly displayed by an infrared vein imaging instrument.[3] In brief, infrared imaging could facilitate the identification of the most suitable blood vessels for PIVC. Accordingly, the first attempt success rate may be increased, and the total procedure time may be shortened using the infrared imaging device to locate suitable PIVC sites. Evidence from a review of the literature indicates that infrared vein imaging technology is effective in improving PIVC outcomes, especially for patients with less visible veins.[4,5] Sun et al[6] reported that the near-infrared (NIR) vein-viewing device could help decrease the time for finding the first available blood vessel (mean = 383.61, SD = 112.14 vs mean = 126.37, SD = 26.33 seconds) and decrease the number of PIVC attempts (2 vs 1 median of attempts per patient) in critically ill children.[6] In a systematic review, Park et al[7] concluded that the use of an NIR device did not influence the overall failure rate at the first attempt of PIVC in pediatric patients. However, in a subset of patients at high risk, which were determined by the clinician's subjective rating of difficulty or an objective index for difficulty (difficult intravenous access score or skin color grading), using NIR light devices showed a lower risk for PIVC failure than the traditional method. Patients with poor vascular conditions in isolation wards may be considered high risk for PIVC failure. Previously, we have applied infrared vein imaging assisted venipuncture in patients with rheumatic diseases with increased efficiency (procedure time shortened from an average of 382.11 seconds to 203.06 seconds).[8] To our knowledge, no similar study on NIR light devices and PIVC outcomes has been conducted with patients in COVID-19 isolation settings. To address the gaps in the literature, combined with our own experience under the COVID-19 disaster conditions, this present study aimed to evaluate the effectiveness of the infrared vein visualizer on PIVC outcomes for patients in COVID-19 isolation.

HYPOTHESIS

Our hypothesis was that the intervention group with the infrared vein visualizer for PIVC would demonstrate (1) increased success rate at the first attempt, (2) shorter procedure time, and (3) increased satisfaction compared with the control group.

Methods

STUDY DESIGN

This was a nonrandomized, double-blinded by not knowing the conditions under study, and controlled clinical trial performed in patients of the COVID-19 isolation wards from February 2020 to April 2020. The study was conducted in Tongji hospital (Wuhan, China), where each unit contained 50 beds and 30 working staff during the COVID-19 outbreak.

PARTICIPANT ALLOCATION

A randomization method was not adopted because it was difficult to conduct grouping in the isolation environment and justify under the rapidly changing disaster conditions. The control group and the intervention group were from 2 different COVID-19 isolation wards, respectively. The control group adopted the traditional venipuncture approach. The intervention group adopted the infrared vein visualizer–assisted approach. The study followed TREND guideline guidance.[9]

PARTICIPANT INCLUSION AND EXCLUSION CRITERIA

Patients (all adults aged ≥18 years) were enrolled from 2 isolation wards of the same hospital where patients who were severe and critically ill with COVID-19 were treated. Inclusion criteria for patients included the following: (1) patients positive for severe acute respiratory syndrome coronavirus 2 nucleic acid test with ground-glass shadow on computed tomography image of bilateral lungs; (2) patients needing PIVC; and (3) patients with veins classified as level 0 to 2 according to the standard proposed by Li et al[10] as follows:

- Level 0: Subcutaneous superficial thick veins at the back of the hand and foot or thick veins at the forearm and wrist. Veins prominently protrude on the skin surface with good tension, fixed shape, and an elastic, soft touch.
- Level 1: Subcutaneous superficial small- and medium-sized veins at the back of the hand and foot or medium-sized veins at the forearm and wrist. Veins slightly protrude on the skin surface, and they are touchable but not stiff.
- Level 2: Obscure small veins at the back of the hand and foot or small veins in the fingers. Veins are nonfully filled, less palpable, and partially stiff.
- Level 3: Obscure small veins at other sites. Subcutaneous veins are stiff, hardly palpable, and/or accompanied with phlebitis.

Exclusion criteria were as follows: (1) patients with unstable vital signs, unconsciousness, or restlessness related to conditions such as shock, respiratory failure, and multiorgan dysfunction; and (2) veins at level 3.

PROCEDURALISTS

Nurse proceduralists were required to have at least 3 years working experience with solid competency and success rate of venipuncture outside the COVID units. All nurses on the intervention unit received training on how to operate the infrared instrument (Type AV300, Accu Vein Company, USA).

OUTCOME MEASURES

The effectiveness of an infrared vein visualizer on PIVC was evaluated by the success rate at the first-time attempt, procedure time, and patients' satisfaction degree. A successful PIVC satisfied the following criteria: (1) after the intravenous indwelling needle puncture, there was blood return; (2) once the needle was immobilized and the infusion speed was accurately adjusted, 100 mL of intravenous fluid was successfully injected without evidence of extravasation.

Procedure time referred to the time spent from placing a tourniquet on the upper arm to the accomplishment of venipuncture and was recorded by the data collector. Patients' satisfaction degree on the PIVC procedure was determined by a 0 to 10 visual analog scale scoring with 0 denoting the most unsatisfactory and 10 denoting the most satisfactory.

SAMPLE SIZE

Referring to previous studies[5,6] in which approximately 30 patients were included in each group with the same intervention and outcome measurement adopted, this study expanded the sample size to 60 patients in each group.

DATA COLLECTION PROCEDURES

During the daily operation, a specified data collector who was a nurse qualified in PIVC was assigned to record the success rate of the first attempt, the time taken for the venipuncture, and the satisfaction score immediately after the

TABLE 1
The baseline characteristics of patients

Characteristics	Control n = 60		Intervention n = 62		Statistics		*P* value
	Mean or n	SD or %	Mean or n	SD or %	Test	Value	
Age, y, mean (SD)	55.75	10.68	55.79	11.10	*t*	−0.02	.98
Sex, n (%)							
Female	21	35.00	24	38.71	χ^2	0.18	.67
Male	39	65.00	38	61.29			
Blood pressure, mm Hg, mean (SD)							
Systolic	118.01	8.89	120.90	11.67	*t*	−1.55	.12
Diastolic	72.27	8.24	73.82	8.34	*t*	−1.04	.30
Comorbidities, n (%)							
Hypertension	18	30.00	19	30.65	χ^2	0.01	.94
Diabetes	13	21.67	7	11.29	χ^2	2.40	.12
Coronary heart disease	2	3.33	6	9.68	Fisher	–	.27
Chronic renal failure	3	5.00	0	0.00	Fisher	–	.12
Chronic obstructive pulmonary disease	4	6.67	5	8.01	Fisher	–	.10

venipuncture was completed. We recorded the patients' general information such as sex, age, and blood pressure. Data on chronic disease status known at the time as the most common chronic diseases related to COVID-19 susceptibility and severity were collected (hypertension, diabetes, coronary heart disease, chronic renal failure, chronic obstructive pulmonary disease). Finally, the proceduralist nurse's years of working experience were also recorded. Data were entered initially on a paper form. The form was taken from the isolation ward and entered in the computerized software. One member of the research team entered the data, and a second verified the data entry for accuracy.

STATISTICAL ANALYSIS

The data were entered in the SAS 9.4 software. Ratio and median were used to describe the count data (first attempt success rate and satisfactory score). The mean and SD were used to describe the quantitative data (procedure time). Student *t* test was used to analyze the difference in time taken for venipuncture between the 2 groups. Chi-square test was used to analyze the difference in the success rate of the first venipuncture. The *z* test (Mann-Whitney U test) was used to analyze differences in patients' satisfaction. The 2-tailed α level was set as .05.

ETHICAL CONSIDERATIONS

All patients provided verbal informed consent and voluntarily engaged in this study. The study was approved by the medical ethics committee of the Tongji Hospital Affiliated to Tongji Medical College of Huazhong University of science and technology before implementation (IRB approval number: TJ-C20200157).

Results

SAMPLES AND CHARACTERISTICS OF PARTICIPANTS

A total of 122 patients with COVID-19 were enrolled in the study, which was carried out by 8 nurses (4 nurses in each group). There were 62 patients in the intervention group and 60 patients in the control group. The demographic data for the 122 patients are summarized in Table 1. There were no significant differences between the 2 groups in sex, age, blood pressure, and chronic diseases status.

OUTCOMES

The outcomes measured were the first attempt success rate, total time taken to accomplish a successful PIVC, and patient satisfaction with the procedure. In the intervention group, 57

TABLE 2
Comparison of evaluation index between groups

Index	Control n = 60		Intervention n = 62		Statistics		*P* value
	Mean, n, or median	SD, %, or IQR	Mean, n, or median	SD, %, or IQR	Test	Value	
Procedure time, s, mean (SD)	388.27	88.97	211.44	68.58	t	12.27	< .001
First attempt success rate, n (%)							
Success	46	76.67	57	91.94	χ^2	5.41	.02
Failure	14	23.33	5	8.06			
Patients' satisfaction degree, score, median (IQR)	6	4-7	7.5	6-9	z	−3.31	< .001

IQR, interquartile range.

cases were successful with a first attempt success rate of 91.94%. In the control group, 46 cases were successful, and the first attempt success rate was 76.67%. The first attempt success rate in the intervention group was significantly higher than that of the control group ($\chi^2 = 5.41$, $P = .02$). In the intervention group, it took an average of 211.44 seconds to complete the PIVC procedure, whereas the time was 388.27 seconds in the control group. The total time taken to complete the PIVC was significantly shorter in the intervention group than the control group ($t = 12.27$, $P < .001$). The patient satisfaction scores in the intervention group were significantly higher than that of the control group (7.5 vs 6, $z = -3.31$, $P < .001$). The results are shown in Table 2.

Discussion

Our results suggest that the use of an infrared vein visualizer for cannulation in patients with severe COVID-19 was effective in increasing the first attempt success rate, reducing total operating time, and improving patients' satisfaction. This provides an important additional method to standard care to facilitate PIVC under COVID-19 isolation conditions.

PIVC is widely used in clinical nursing practice. In some cases, inserting an intravenous cannula can be a challenge even for experienced nursing personnel. Failed cannulation is more likely among children and patients with darker skin tones in which the veins are more difficult to visualize, anxiety, critical illness, and chronic disease.[11–15] Older adults and those with complications such as chronic obstructive pulmonary disease, diabetes, hypertension, and heart disease are at an increased risk of COVID-19 infection.[16] These previously documented COVID-19 risks are consistent with our finding that approximately half of the patients suffer from pre-existing chronic diseases. All subjects in our study were severe COVID-19 cases. COVID-19 not only causes physical health declines but also results in a number of psychological complications.[17] One month after hospital discharge, 42% of COVID-19 survivors still suffered from anxiety.[18] Given that chronic disease and patient anxiety are also risk factors for failed PIVC, the PIVC procedure when the proceduralist is wearing personal protective equipment in the COVID-19 isolation ward combines to make the procedure more difficult.

For nurse proceduralists, the special environment of the COVID-19 isolation ward also increased the difficulty of PIVC. In our isolation wards, health care workers must wear protective clothing and goggles, which can slow their actions, extend working time, complicate the assessment of patients' veins, and delay the PIVC insertion procedure. In addition, the nurses were required to put on several layers of rubber gloves in the isolation wards, which made it difficult to palpate the thickness, elasticity, and direction of blood vessels. Thus, longer time was needed for vessel selection for patients in COVID-19 isolation. Once the tourniquet is applied, lengthy periods of time spent on searching for suitable veins can also cause several unwanted effects such as pain, trauma, and subcutaneous bleeding. In the care of patients with COVID-19 in isolation, PIVC is at a high risk of failure at the first attempt. Failure of PIVC not only increases the pain for the patient but may also bring added anxiety and stress to the patient and proceduralist, making subsequent PIVC attempts increasingly challenging. Stevens et al and others have reported that improper venipuncture may lead to peripheral nerve injury

and many other adverse consequences.[19–21] Walsh[22] pointed out that multiple venipuncture attempts can heighten patient anxiety and suffering, delay vital treatment, and increase costs.

For many years, researchers have been investigating the state-of-art venipuncture technologies, and at the same time, various tools, and methods[23,24] have been developed to improve the success rate of venipuncture in clinical practice. The application of devices to visualize subcutaneous vessels and nerves is particularly useful for novice proceduralists and may improve the success rate in patients requiring special care, such as patients who are elderly, children, or obese, or those with darker skin tones whose veins are difficult to identify with unassisted eyesight or palpation.[25]

In addition to the infrared device, ultrasound may also be used to assist in the PIVC procedure. The efficacy of ultrasound has been reported; however, ultrasound is expensive and requires substantial skill.[26] Our results with an infrared vein visualizer were consistent with the findings of Sun et al[6] that the application of vein visualizers improved the first attempt success rate and shortened the procedure time. In opposition to our findings, several other studies[27–29] did not report a benefit to using infrared venous visualization technique in pediatric patients. The difference may be attributed to benefits specific to adult patients with severe COVID-19 in isolation conditions and our exclusion criteria for patients with level 3 veins. This difference may be further explained by the following specific reasons. First, patients varied greatly in disease condition and age. Second, the special COVID-19 isolation environment made traditional PIVC a procedure with a high risk of failure compared with nondisaster clinical conditions. Third, our patients were all Asian with a skin color that varied less than a study sample inclusive of patients who identify as Black, White, Indigenous, Pacific Islander, or multiracial.

In this study, the difference in patients' satisfaction scores between the 2 groups was statistically significant. Venipuncture, as the initial step of intravenous infusion treatment, is an invasive procedure. The failure of venipuncture increases both the pain that patients experience and the pressure for nurses, which can even cause interpersonal tension by potentially creating a decrease in patient trust in the clinical competency of the nurse. In particular, patients with COVID-19 are more likely to be elderly people with poor vascular condition, and the isolation wards further make venipuncture more difficult. By using an infrared vein visualizer, the satisfaction of patients may be significantly improved, thereby supporting a more trusting, therapeutic, and harmonious relationship between patients and nursing staff.

For future research, randomized and controlled trials are recommended to further test the efficacy of infrared vein visualizers. Such application can also be encouraged in other emergent and/or nonemergent clinical conditions, wherein a high quality of PIVC is demanded.

Limitations

This study had several limitations. First, the sample size was relatively small and collected in 2 units in only 1 Chinese hospital setting. Patients in our sample were not racially diverse. Thus, generalizability may have been limited. Second, owing to the constraint of the disaster conditions, we did not randomize the groups. Third, the nurse proceduralists were required to grasp this new technique in a short period of time under new disaster working conditions. Fourth, we did not collect data on the total number of PIVC attempts per patient.

We also assessed the risk of bias on the basis of the Risk of Bias in Non-randomized Studies of Interventions tool.[30] (1) Confounding: The potential confounding bias could result from prognostic variables related to vascular condition. In our study, patients with vein levels of 0 to 2 were included for PIVC. Because of the emergent and isolation condition, further stratification of patients was not conducted. Thus, this may bring bias into the study. (2) Selection bias: The included samples comprised severe COVID-19 cases with yet stable vital signs. Although we had objective inclusion and exclusion criteria, minor bias may still exist. (3) Bias in measurement classification of interventions: The satisfactory score of patients could have been affected by their psychological state and practices unrelated to the PIVC procedure. (4) Bias in measurement of outcomes: The study was carried out by 2 groups of nurses in 2 different isolation wards. Despite standardized training for the nurses, there could have been possible bias regarding intervention fidelity and outcome measurement. Since the study was conducted in a blinded manner and the patients were more than willing to participate in the research, no missing data generated during the study and the bias resulting from intended intervention and selection of reported results could be neglected. Overall, this study had moderate risk of bias compared with a well-performed randomized trial.

Implications for Emergency Clinical Care

Our study has implications for emergency clinical practice. In the emergency department, nurses perform PIVC in a wide variety of patient acuity, age, and isolation conditions. In the case of patients who need urgent intravenous access, if

the vascular condition is poor and the venipuncture is difficult, it may increase nurse workload and stress. Difficult PIVC may delay patient rescue and resuscitation in the ED setting. Under COVID-19 isolation conditions, infrared technology to assist PIVC may improve the success rate at first attempt, decrease procedure time, and increase patient satisfaction with the procedure. We recommend that bedside infrared imaging devices and proceduralist training to use the devices be made available to emergency nurses caring for adult patients who require COVID-19 isolation.

Conclusion

Nurses may encounter difficulty when performing PIVC under disaster and COVID-19 isolation conditions. The application of infrared venipuncture assistive technology in patients with COVID-19 could improve the first attempt success rate, shorten the total procedure time, and enhance patients' satisfaction.

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Author Disclosures

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A Comparison of Two Different Tactile Stimulus Methods on Reducing Pain of Children During Intramuscular Injection: A Randomized Controlled Study

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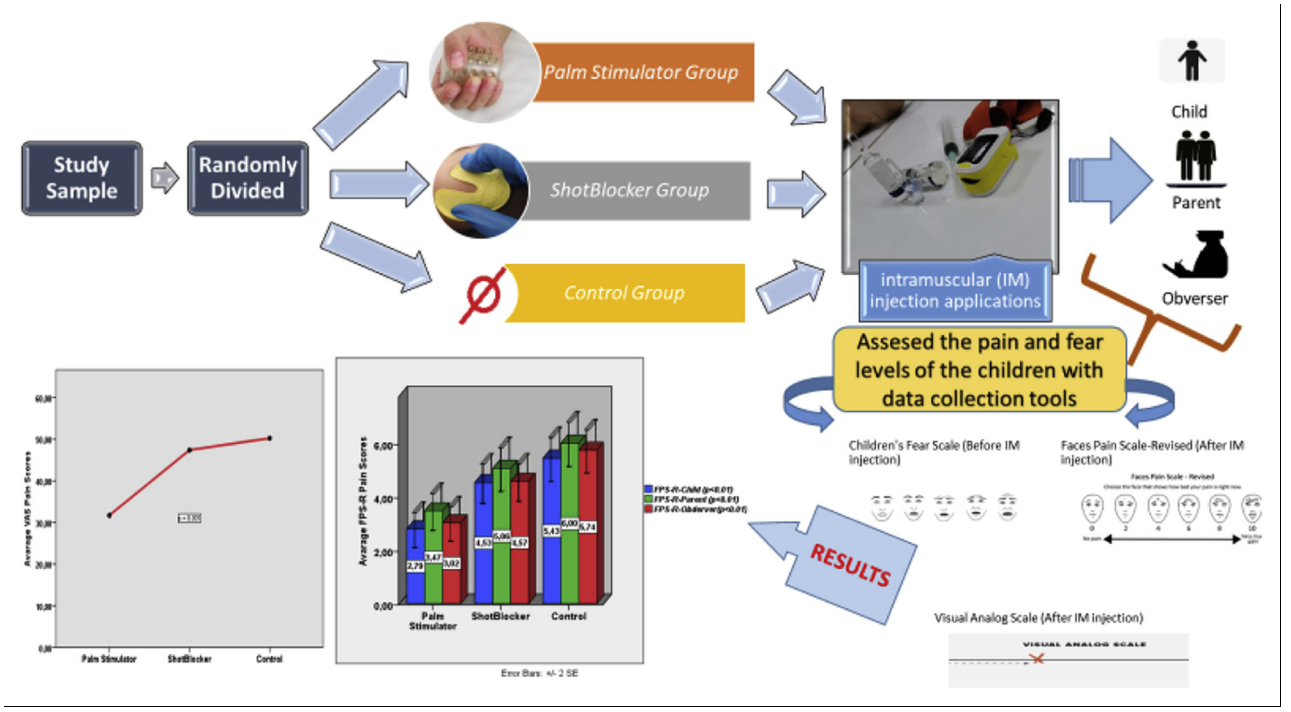

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A Comparison of Two Different Tactile Stimulus Methods on Reducing Pain of Children During Intramuscular Injection: A Randomized Controlled Study

Authors: Mürşide Zengin, PhD, RN, and Emriye Hilal Yayan, PhD, RN, Adıyaman and Malatya, Turkey

Contribution to Emergency Nursing Practice

- Several nonpharmacologic methods are used for reducing pain and fear of pediatric patients during intramuscular injection in the pediatric emergency department.
- The present study provides unique information about an innovative nonpharmacologic pain-reducing Palm Stimulator device tested during intramuscular injection for children in the emergency department.
- The results of this study support the efficacy of the Palm Stimulator device to reduce intramuscular injection needle–related pain for children in the emergency department setting.

Abstract

Introduction: Pediatric patients in the emergency department often require intramuscular injection procedures, which may lead to pain, fear, and anxiety. The purpose of this study was to test a novel nonpharmacological intervention to reduce needle-related pain in the pediatric emergency department.

Methods: The study was conducted as a parallel-group, randomized controlled design. The study population consisted of 159 children aged 7 to 10 years cared for in the emergency department who received an intramuscular injection of ampicillin/sulbactam. The children were randomly assigned to Palm Stimulator, ShotBlocker, or control groups. The children's preprocedure fear levels were evaluated using the Children's Fear Scale, and their perceived pain levels during the procedure were evaluated using the Faces Pain Scale-Revised and Visual Analog Scale. Parents and observers also completed the pain level scores.

Results: According to all raters (child, parent, and observer), the Palm Stimulator group had the lowest mean Faces Pain Scale-Revised score averages ($P < .001$). The Visual Analog Scale score averages of the children in the Palm Stimulator group (Visual Analog Scale: M = 27.94, standard deviation = 19.13) were statistically significantly lower than the ShotBlocker (Visual Analog Scale: M = 46.07, standard deviation = 24.96) and control group (Visual Analog Scale: M = 53.43, standard deviation = 29.01) score averages ($F = 14.94$, $\eta^2 = 0.16$, $P = .001$).

Discussion: The results of this study support the effectiveness of the Palm Stimulator to reduce perceived pain in children during intramuscular injection administration in the pediatric emergency department.

Key words: Child; Intramuscular injection; Nursing practice; Pain management; Pediatric emergency department

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Introduction

Many health care applications, especially intramuscular (IM) injection applications, cause pain, anxiety, and fear in pediatric emergency department patients.[1-3] The American Academy of Pediatrics states that children

should not be subjected to painful medical interventions and that every effort should be made to reduce the pain that children may experience because of these health care interventions.[4] It is important to reduce perceived pain during painful procedures because pain experienced in childhood can affect the pain response to future events.[3,5]

Pharmacological and nonpharmacological methods may be used together to reduce injection-related pain in children.[6] Nonpharmacological methods used in pain management can be divided into 3 groups: supportive, cognitive/behavioral, and physical.[7] One of the physical interventions designed to reduce injection pain in children is called ShotBlocker. It was designed in accordance with the principles of the Gate Control Theory.[8] According to the theory, providing a physical stimulus, such as a massage or vibration, to the skin at the injection site prevents the transmission of pain by closing the pain gate in the spinal cord.[9,10] ShotBlocker (Bionix, USA) creates a stimulus at the injection site to close the pain gate in the spinal cord in order to reduce the perceived injection pain.[10-13]

Palm Stimulator, developed by researchers for reducing perceived pain during IM injections in children, was also designed in accordance with the principles of the Gate Control Theory.[8] Although a tactile stimulus physically placed in the palm can have a similar expected mechanism of action as ShotBlocker, Palm Stimulator is based on the use of a more sensitive body part in transmitting a potentially stronger stimulus according to the somatosensory map and prevailing theory.[14-16]

Different studies have evaluated the effect of creating a physical stimulus on the skin during painful medical interventions to reduce perceived pain. For this purpose, the Buzzy (MMJ Labs, Atlanta, GA, USA)[17,18] or ShotBlocker[8,11-13,19,20] devices are well studied in the field, as are methods of human touch or applying manual pressure.[21-23] In considering ShotBlocker-related studies, whereas some studies have reported that this intervention had no effect on reducing perceived pain,[10,24] others report that it is an effective method for reducing the perceived pain experienced during injection.[8,11-13,19,20,25]

There are several studies evaluating the effect of squeezing a soft ball in the palm of children's hands in reducing pain experienced during painful procedures.[26,27] These studies have used the ball as a distraction instead of creating a stimulus in the palm of the hand, with soft balls preferred for this purpose. However, there are currently no studies that evaluate the effect of a device creating a stimulus in the palm of the hand, as ShotBlocker is intended to accomplish near the injection site, in reducing perceived pain.

It is important that effective-appropriate and ineffective-inappropriate perceived pain reducing intervention strategies are evidence-based.[2] In this regard, it is important to conduct well-designed studies that compare various nonpharmacological methods among children of different age groups in addition to studying their effectiveness in pain management. The aim of this study is to evaluate the effect of ShotBlocker and the Palm Stimulator for reducing pain associated with the administration of IM injection in pediatric emergency department.

This study has 3 hypotheses as follows:

H_1. The application of the Palm Stimulator method reduces the perceived pain levels of children during the IM injection.

H_2. The application of the ShotBlocker method reduces the perceived pain level of children during the IM injection.

H_3. The effects of the Palm Stimulator and ShotBlocker methods on children's levels of perceived pain during the IM injection differ.

Methods

STUDY DESIGN AND SETTING

The study was conducted using a randomized controlled research design. A parallel trial design was used describing 2 different experimental groups (Palm Stimulator and ShotBlocker) and a control group (no intervention used) as the third arm. This study was guided by the Consolidated Standards of Reporting Trials guidelines and checklist.[28] The single-site study took place in a state hospital located in the eastern part of Turkey between February 2019 and July 2109. The majority of patients in this setting were ethnically Turkish and Kurdish.

POPULATION

The study population consisted of children in the 7-10 age group receiving care in the emergency department. The study sample was composed of children admitted to an emergency department during the dates of the study undergoing nurse-administered IM injection of the ampicillin/sulbactam group of antibiotics as part of their usual medical treatment prescribed by the physicians. Ampicillin/sulbactam group antibiotics were selected as they cause less drug-related pain compared with some other antibiotics such as penicillin. In addition, this group of drugs was frequently administered in the emergency department. Therefore, children preparing for treatment with

ampicillin/sulbactam group antibiotics constituted the source study population. The study included children who (1) had no diagnosed physical or mental disability or chronic illness; (2) had no communication problems; (3) received a single injection, (4) required ampicillin/sulbactam group of antibiotics for standardization, and (5) received ventrogluteal muscle injection during the study. Parents who were unable to collaborate in the fear and pain evaluation, children who were overweight or underweight (under the third or above the 97th percentile), children with any incision or scar tissue in the injection area, and children who received a sedative, analgesic, or narcotic drugs 6 hours before the procedure on the basis of parental statements and medical history were excluded from the research. Expert opinion was obtained from a professional in the field of pharmacology in determining that receiving a sedative, analgesic, or narcotic drugs 6 hours before the procedure constituted justified exclusion criteria. The use of these sedative, analgesic, or narcotic drugs was checked on the patient chart and confirmed by the parents.

SAMPLE SIZE ESTIMATION AND RANDOMIZATION

The G*Power (v3.1.9; Heinrich-Heine-University, Düsseldorf, Germany) program was used to determine the sample size, and the sample number was determined to be 53 for each group, with a 0.95 effect size,[12] 0.95 representative power, and 0.05 type-1 error margin. The decision was made to add 3 additional children (a 5% increase) to each group (Palm Stimulator: 56, ShotBlocker: 56, Control: 56), considering that there will be losses in the groups.

In this study, the assignment of participants to the control and experimental groups was performed using the stratification and block randomization methods by the researcher. The age, sex, and fear of children can affect procedural pain and anxiety.[29-31] In the study, the children were stratified and blocked according to age (7-8 and 9-10 years old), sex (male or female), and fear of the injection procedure (afraid and not afraid). By ensuring that the strata formed according to the specified variables was repeated 7 times, 56 children were included in each group ($2 \times 2 \times 2 \times 7$). The research groups were written on separate papers, folded, and drawn randomly to determine the assigned group of each child during the data collection phase. Thus, the number of individuals in the groups was evenly distributed, with equal probability of assigning each child participating in the study to any one of the intervention groups or the control group. This random assignment process was continued until there were 56 participants in each group. Because of the nature of the intervention, double-blinding was not possible in this study.

DATA COLLECTION

In the study, only the pain associated with the injection administration was assessed. The study data were collected by the researcher in the pediatric emergency department using the child-parent information form, Children's Fear Scale (CFS), Faces Pain Scale-Revised (FPS-R), and Visual Analog Scale (VAS) via face-to-face interviews lasting 25 minutes in duration on average. Separate evaluations were provided by the children themselves, their parents, and an independent observer using data collection tools.

Child-Parent Information Form

The standard information form, which was developed by the researcher and consists of a total of 12 items, 8 of which include the descriptive characteristics of the children (eg, age, sex, weight, height, hospitalization unit, etc.) and 4 of which include the sociodemographic characteristics of the parents (eg, age, sex, educational level, socioeconomic status), was collected from all children and parents involved in the study.

Children's Fear Scale

The CFS is a scale used to assess the level of anxiety in children. The scale is a visual measurement tool with scores ranging from 0 to 4 points. It consists of 5 facial expressions, ranging from a neutral to a frightened expression, and is suitable for use with children aged 5 to 10 years.[32-34] The evaluation of the Turkish psychometric properties of the scale, which was developed by McMurtry et al[32] for pediatric patients, was conducted by Özalp Gerçeker et al,[33] and the scale was translated into the Turkish language. The CFS has demonstrated good evidence of test-retest ($r_s = 0.76$, $P < .001$), and inter-rater ($r_s = 0.51$, $P < .001$) reliability, as well as construct validity ($r_s = 0.73$, $P < .001$).[33]

Faces Pain Scale - Revised

The FPS-R is a scale used to assess the level of pain in children in the 4-to-12 age group.[35] There are facial expressions that show the increasing levels of pain severity from left to right in the scale. Rated according to the severity of pain (between 0-10 points), the leftmost face refers to "no pain," and the rightmost face refers to "too much pain," comprising a total of 6 facial expressions. The faces exhibit an increase in pain severity to correspond with the scores 0, 2, 4, 6, 8,

and 10 from left to right, respectively.[18] In school-aged children, the FPS-R is felt to be the most valid and reliable measure of acute pain, and it was used in more than 140 studies.[18,25,35,36]

Visual Analog Scale

The VAS consists of a horizontal or vertical ruler 10 cm in length, with the phrase "no pain" on one end and "the worst pain imaginable" on the other. The child is asked to mark the point on this line that most accurately reflects his/her pain. The distance between the child's mark and the left end of the scale is measured in cm and recorded as points. It has been suggested that the widely researched scale should be used for children aged ≥ 7 years.[13,25] It was reported that the VAS is a useful and valid tool for pain and anxiety assessment in routine clinical practice. The validity of VAS was established in a study of acute pain.[37,38]

INTERVENTIONS

Palm Stimulator

The Palm Stimulator was created by the present researchers/authors of the study. The device is 1.6 cm in diameter, 4 cm in length, and has a cylindrical, nonslippery structure for an easy grip to ensure maximum contact with the palm (Figure 1). The national patent application for the apparatus developed by the researchers was filed with the Turkish Patent and Trademark Authority with the number 2018/06479, and the Patent Cooperation Treaty (PCT) application was filed with World Intellectual Property Organization with the number PCT/TR2018/000089. The Palm Stimulator consists of firm and blunt protrusions that provide a tactile stimulus on the palm. The blunt protrusions do not penetrate into the skin. The simulator design is based on the Gate Control Theory, which allows for a reduction in the perceived amount of pain experienced during injection by closing the pain gate in the spinal cord in creating a stimulus on the skin.

ShotBlocker

The ShotBlocker features short, blunt protrusions on one side touching the skin and has a hole in the middle that exposes the injection site (Figure 2). ShotBlocker's mechanism of action is that the pressure the blunt protrusions exert on the skin stimulates faster nerve cells (in terms of their traveling speed) that are smaller in diameter. This stimulus temporarily blocks pain signals by closing the gates to the central nervous system and thus reducing the amount of perceived pain experienced during injection.[11,24,25]

FIGURE 1
Palm Stimulator.

PROCEDURE

The injection was administered by the same volunteer clinical nurse to all children involved in the study. The clinical nurse is a nurse who has completed training at the undergraduate level and has had 8 years of professional experience, including 4 years in pediatric departments. All injections were administered using 22 Gauge and 0.70 ×32 mm needle tips. Injection volumes were between 1.5 mL and 2.0 mL for each child.

A pediatrician made the clinical decision for IM injection as a part of necessary medical care of the pediatric patients. This decision was not influenced by the study procedures and only constituted the trigger for recruitment and defined the source sample population. All child and parent participants in the study were informed about the research and were told that they would be in one of the 3 groups. First, the Children-Parent Information Form was administered to all participants by the researcher. Second, the children's preprocedure fear levels were assessed 1 minute before the injection by the child, parent, and an independent observer through CFS. Then, the process steps were applied on the basis of the children's study group assignment. Finally, the perceived pain levels were measured by the children themselves (using both VAS and FPS-R), their parents (using FPS-R), and an independent observer (using FPS-R). The independent observer had completed undergraduate

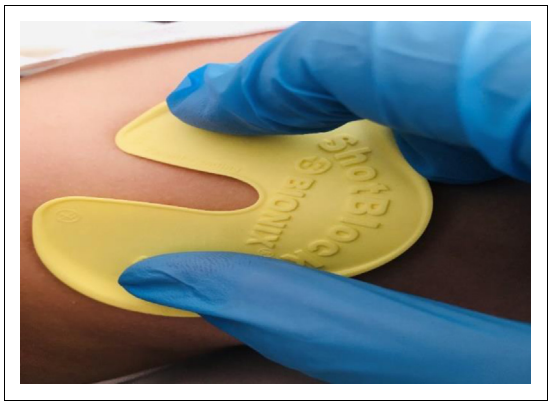

FIGURE 2
ShotBlocker.

education in the field of nursing and worked as a nurse at the hospital where the study was conducted. She was trained by the researcher to assess the children's fear and pain levels. The independent observer was not involved in the creation of the Palm Stimulator and was not the author of this study. The observer volunteered to evaluate the fear and pain of the children. No blinding occurred in this study.

The Palm Stimulator Group

Children in the Palm Stimulator group were shown the Palm Stimulator, which provides a tactile stimulus, by the researcher before the injection process, to allow the child to become familiarized with the device. The Palm Stimulator was placed in the palm of the child's dominant hand 20 seconds before the injection. The researcher ensured that the apparatus was held tightly in the child's palm throughout the procedure. The device was retrieved from the child after completing the injection process. After each application, the Palm Stimulator was disinfected and then reused.

The ShotBlocker Group

Children in the ShotBlocker group were shown the ShotBlocker by the researcher before the injection process to allow them to examine it. ShotBlocker was placed in the ventrogluteal area 20 seconds before injection. It was fixed at the injection site until the injection process was completed. After completing the injection process, it was disinfected and reused.

The Control Group

In order to prevent the children in the control group from being influenced, they were separated from the intervention groups, and the application was performed so that the children could not see each other. The routine IM injection (ventrogluteal area in the prone position) was applied to the children in the control group.

The children were evaluated for their pain levels 1 minute after the injection using VAS and FPS-R. For each child, a parent and an independent observer assessed their pain levels during the procedure 1 minute after the injection using the FPS-R.

ETHICAL CONSIDERATION

Ethics committee approval was obtained from the İnönü University Clinical Research Ethics Committee (Protocol 2018/146). The purpose of the study was explained to the children and their parents who met the research inclusion criteria. Then the children and their parents were informed about the method of the study, and the volunteers were included in the study. Participants were informed about the procedure of the study before participation and that they could withdraw from the study at any time without explanation. Written informed consent was obtained from all parents, and verbal assent was obtained from all children by researchers.

DATA ANALYSIS

The study data were analyzed with the SPSS 21.0 program (IBM Corp, Armonk, NY). Shapiro–Wilk test was implemented to determine whether the sample data were normally distributed, and it was determined that all data were normally distributed. Descriptive statistics (mean, median, interquartile range, percentage, standard deviation) and comparative statistics (analysis of variance, Pearson chi-square tests) were used for the evaluation of the data. Comparisons of pediatric procedural fear (CFS scores) and pain (FPS-R scores) for the 3 groups were conducted using analysis of variance, and the post hoc advanced analysis Tukey HSD for binary comparisons were used for the statistical analyses. The intraclass correlation coefficient was used to evaluate the correlation between IM injection pain and the fear scores among children, parents, and the observer. A partial- η^2 coefficient was used to calculate the effect size. According to the literature,[39,40] the η^2 value was considered small if $0.01 \leq \eta^2 < 0.06$, moderate if $0.06 \leq \eta^2 < 0.14$, and large if $\eta^2 \geq 0.14$. The research findings were evaluated at a 95% confidence interval (CI) and a significance level of $P < .05$. As previously stated, the G*Power

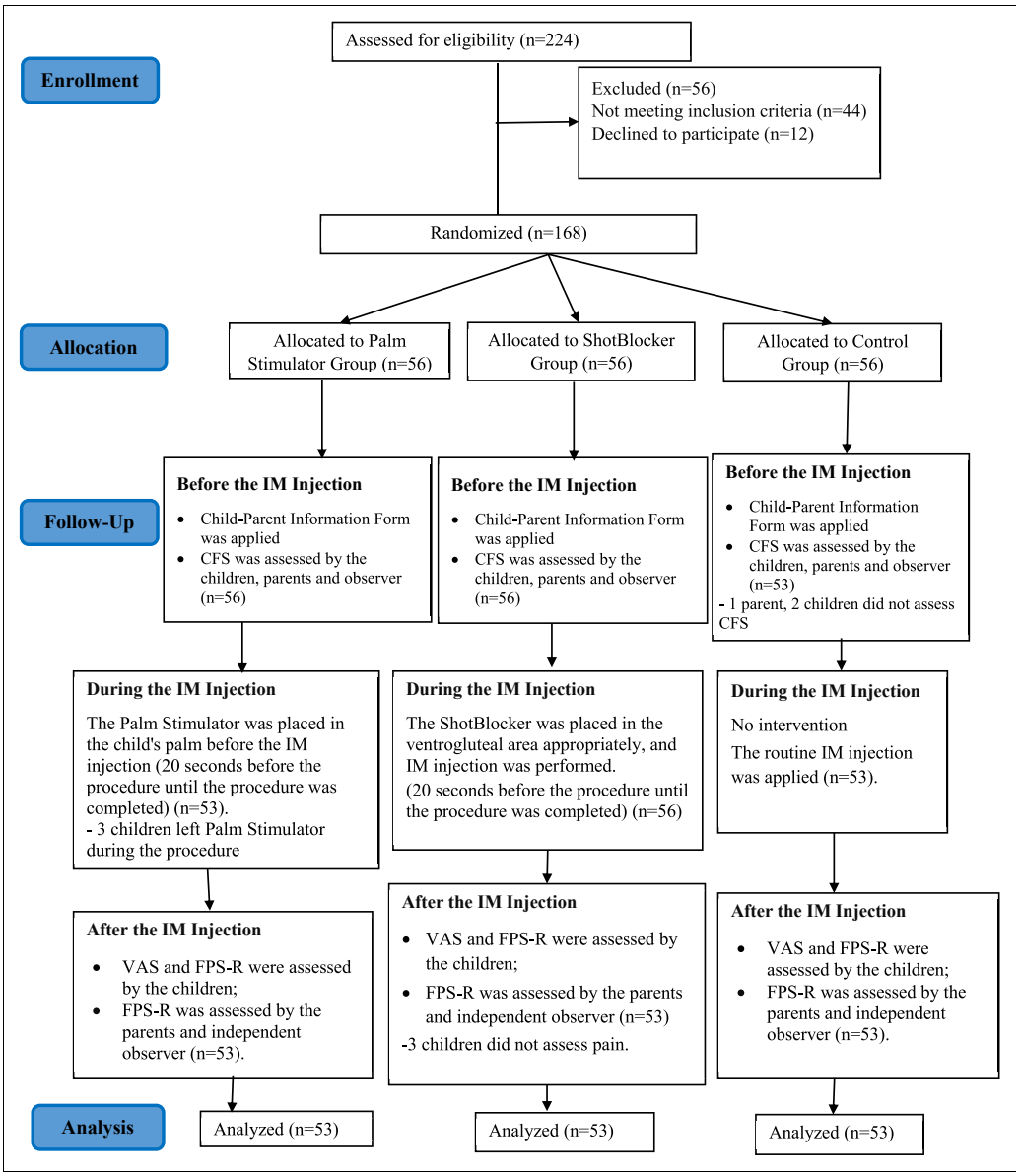

FIGURE 3
CONSORT Flow Chart.

(v3.1.9) program was used to estimate power and sample size recommendations.

Results

In the present study, 224 children were assessed for eligibility, and 168 children who met the inclusion criteria were randomized as 56 individuals in each group (Figure 3). The median age of the children was 8 (7-10) years. In the study, there was no statistical difference between the groups in terms of sex, age, weight, height, parental age, parental education status, family socioeconomic status ($P > .05$, Table 1).

Table 2 shows the consistency between the measurements by the children, parents, and observer. According to the evaluation conducted by the children, parents, and the observer, the difference in the CFS score averages between the children in the control and experimental groups was not statistically significant ($P > .05$, Table 3; Figure 4A).

TABLE 1
The comparison of the sociodemographic characteristics between the children in the control and experimental groups (N = 159)

Variables	Palm Stimulator group (n = 53)		ShotBlocker group (n = 53)		Control group (n = 53)		Test values	*P*
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	F/χ^2	
Age (y)	8.45	1.11	8.50	1.18	8.52	1.21	0.06*	.94
Weight (kg)	28.09	7.71	28.41	6.97	29.60	9.19	0.52*	.59
Height (cm)	128.71	11.37	128.86	9.95	130.71	10.81	0.57*	.57
Body mass index	16.72	2.78	16.92	2.59	16.96	3.39	0.10*	.90
Parental age	38.18	6.40	36.98	8.35	39.47	6.93	1.55*	.22
	n	%	n	%	N	%		
Sex								
Female	26	49.10	27	50.90	27	50.90	0.05†	.98
Male	27	50.90	26	49.10	26	49.10		
Parental education status								
Primary school	22	41.50	25	47.20	31	58.50	5.12†	.28
High school	21	39.60	23	43.40	15	28.30		
University	10	18.90	5	9.40	7	13.20		
Family socioeconomic status								
Low income	19	35.80	22	41.50	18	34.00	4.82†	.31
Middle income	23	43.40	20	37.70	16	30.20		
High income	11	20.80	11	20.80	19	35.80		

SD, standard deviation.
* Analysis of Variance test was used.
† Pearson Chi-Square test was used.

A comparison of the FPS-R score averages of the children in the Palm Stimulator, ShotBlocker, and control groups according to the evaluations of the children, parents, and observer is given in Table 4 and Figure 4B. Overall for all 3 treatment arms, the 95% CI for the FPS-R scores of the children was 3.79-4.70, parents was 4.36-5.31, and observer was 3.99-4.88. The difference between the 3 treatment groups was statistically significant in terms of the perceived pain levels of the children evaluated via the statements of the children. According to post hoc analysis, the difference between the groups was due to the Palm Stimulator group. According to the FPS-R pain score averages, the η^2 values for all 3 assessments were 0.143 (large effect size) for the children, 0.120 (moderate effect size) for the parents, and 0.155 (large effect size) for the observer.

The 95% CI for the VAS score averages for all 3 treatment groups combined was 38.28-46.68. There was a statistically significant difference between the groups in terms of their VAS score averages. The VAS score averages of the children in the Palm Stimulator group (VAS: M = 27.94, Standard deviation [SD] = 19.13) were statistically significantly lower than the ShotBlocker (VAS: M = 46.07, SD = 24.96) and control group (VAS: M = 53.43, SD = 29.01) score averages (F = 14.942, $P = .001$). The fact that $\eta^2 = 0.16$, according to the VAS score assessment of the children, indicates a large effect size (Table 4).

Discussion

The present study was conducted to determine the effect of the Palm Stimulator and ShotBlocker methods on the reduction of perceived pain during the administration of IM injection in pediatric emergency department. The Palm Stimulator demonstrated effectiveness in reducing perceived pain in children. Although the perceived pain

TABLE 2
Consistency between the measurements by the children, parents, and observer

Groups	CFS*		FPS-R	
	ICC*	*P*	ICC	*P*
Palm stimulator	0.928	<.001	0.946	<.001
ShotBlocker	0.938	<.001	0.934	<.001
Control	0.983	<.001	0.941	<.001

CFS, Children's Fear Scale; FPS-R, Faces Pain Scale-Revised; ICC, intraclass correlation coefficient

* The ICC is a measure of reliability, specifically the reliability of different raters to measure subjects similarly.

levels of the children in the ShotBlocker group were lower than those of the control group, this difference was not statistically significant.

Variables such as child age, sex, and developmental level are considered among the biological factors that affect pain perception and response.[29-31] In the study, there was no difference between the groups in terms of age, sex, location, and parental educational level. Thus, we have increased confidence our findings were due to the intervention and not the patient's characteristics. In other studies aiming for similar reductions in pain, the effects of interventions have been evaluated by controlling for certain features of the study groups, including their sociodemographic characteristics.[19,20,31,41] In the present study, the factors that may have affected the perceived pain levels of the children were found to be homogeneous between the control and experimental groups. Thus, the influence possibility of these variables was reduced when evaluating the effect of the Palm Stimulator and ShotBlocker methods in reducing perceived pain.

High levels of anxiety and fear experienced during painful medical interventions can increase the amount of perceived pain.[32,42] In our present study, the difference in the preprocedure CFS score averages between the children in the groups was not significant according to the evaluations conducted by the children, parents, and observer. This was an important finding as a way to address the potential confounding influence of fear, because children's level of fear and anxiety experienced before a procedure can affect the level of pain experienced during the procedure.

It is important to include parents in the assessment process for the more accurate pain assessment and effective pain management of children.[43] In this study, there was a high correlation between the pain score averages assessed by the children, parents, and observer (Table 2). The high degree of consistency between the measurements in the groups indicates the consistency of the evaluations.

The Palm Stimulator group in our study was the only group with statistically significant decreases in perceived pain levels of the children according to the FPS-R and VAS scores of the evaluators. Restated, our hypotheses were as follows: (1) the application of the Palm Stimulator method reduces the perceived pain levels of children during the IM injection, (2) the application of the ShotBlocker method reduces the perceived pain level of children during the IM injection, and (3) the effects of the Palm Stimulator and ShotBlocker methods on children's levels of perceived pain during the IM injection differ. Our first and third hypotheses were confirmed, whereas our second hypothesis was rejected. The results of other studies, which indicate

TABLE 3
The comparison of the Children's Fear Scale score averages of the children in the control and experimental groups (N = 159)

Evaluated	95% CI for CFS Score, all groups (n = 159)*	Palm Stimulator group (n = 53)		Shot Blocker group (n = 53)		Control group (n = 53)		Test Values	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	F	*P*
Child-reported	1.79-2.27	2.00	1.58	2.05	1.51	2.03	1.51	0.02†	.98
Parent-reported	1.60-2.05	1.81	1.37	1.79	1.45	1.88	1.50	0.06†	.94
Observer-reported	1.54-1.96	1.64	1.27	1.77	1.35	1.84	1.43	0.32†	.73

CFS scores ranging from 0 to 4 points.

SD, standard deviation.

* 95% CI values for CFS scores of all three groups.

† Analysis of variance test was used.

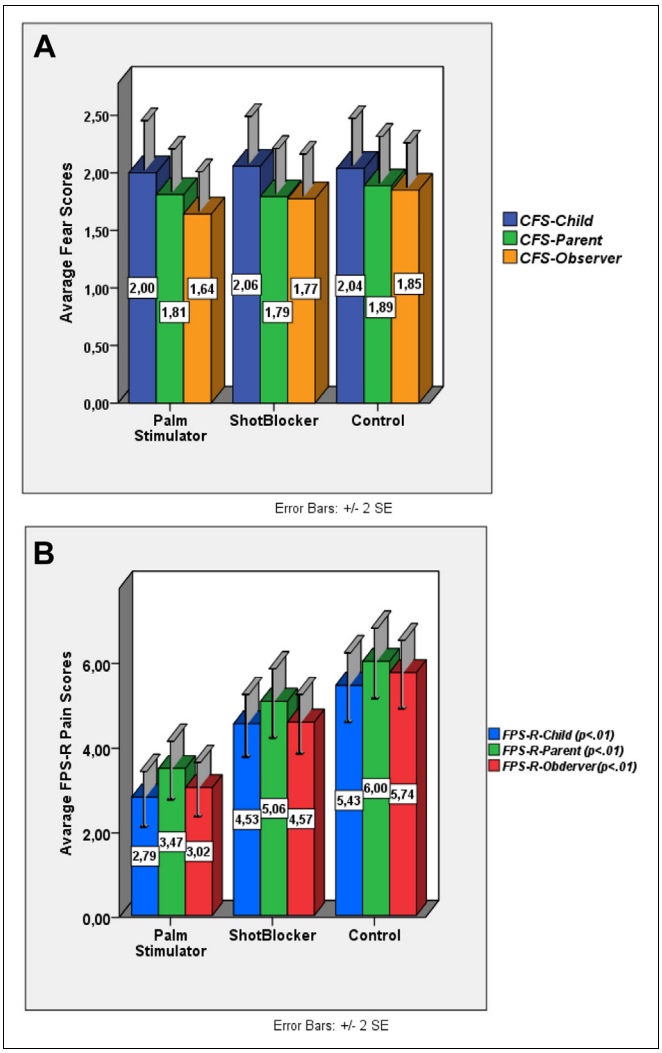

FIGURE 4

The Comparison of the CFS (A) and FPS-R (B) Score. Averages of the Children in Control and Experimental Groups (N = 159).

that the use of the ShotBlocker has no significant effect on reducing injection-related pain in children, also support the findings of our research.[10,24] Given that the Palm Stimulator is a novel device, there is no other literature yet to support or refute our current findings related to this device.

The palm, compared with other body parts, is overrepresented in the somatosensory cortex and is more sensitive to transmitting stimuli.[14-16] Several studies have evaluated the effect of stimulus applied to the palms for reducing perceived pain due to invasive interventions.[27,44] The interventions in these studies use a soft ball or hand tactile stimulus technique to divert attention by using palms, but no tactile stimulus creation technique was found in similar studies that uses any device or apparatus as ours does. In the study of Safari et al,[44] a stimulus was provided by touching and stroking the palm for 5 minutes during painful invasive interventions in school-age children. Providing tactile stimulus to the palm was effective in reducing perceived pain in children. Similarly, Sadeghi et al.[27] determined that squeezing a soft ball was an effective and usable method for reducing perceived pain. Although the results of these previous studies are similar to the findings of our study, the Palm Stimulator used in the present study was novel and created by researchers of the study. It was developed as a nonpharmacological pain reduction method in children for ease of use, ease of disinfection, reusability, and complication-free or anticipated harm-free properties.

We recommend replication of our intervention study by other research teams in other settings. For study replication for teams with limited statistics support, a minimum total sample size of 159 is recommended on the basis of our results for estimated power of .95, type-1 error margin of 0.5, and large effect size of .399.[39] Research teams are encouraged to calculate a project-specific estimated sample size justification based on variability and population heterogeneity at their data collection sites, additional variables to be tested, and desired effect size detection as their resources allow.

Limitations of the Study

This study had several limitations. First of all, although a homogeneous sample increases internal validity, it may raise questions about the generalizability of these findings to children of different ethnicities and ages. Second, because of the nature of the intervention, double-blinding was not possible in this study. To reduce this limitation, the children were randomly assigned to the groups. A major limitation of the study is that the researchers/authors of this study are also the creators of the device. To mitigate potential bias of researchers/creators bias, study was conducted as a randomized controlled study design, and pain and fear scores were obtained from the children, their parents, and an independent observer. Data collectors and injection proceduralists had no relation to the developed device and were only trained by the researchers to assess fear and pain levels. The researchers who created the device did not assess the children's levels of fear and pain, but data collection, data entry, and data analysis process were conducted by the researchers/authors of the study. Thus, the potential for bias in the design and/or writing of the results is still present. Although the protocol was publicly preregistered before

TABLE 4

The comparison of the FPS-R and VAS score averages of the children in control and experimental groups (N = 159)

Evaluated	All groups combined, 95% CI for score, n =159‡‡	Palm Stimulator* (n = 53)		Shot Blocker† (n = 53)		Control‡ (n = 53)		Test values		Eta-square (η^2)
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	F	*P*	
Child-reported§	3.79-4.70	2.79¶	2.39	4.52	2.69	5.43	2.99	13.034‖	<.001 *<‡	0.143
Parent-reported#	4.36-5.31	3.47¶	2.51	5.05	2.97	6.00	3.03	10.627‖	<.001 *<‡	0.120
Observer-reported**	3.99-4.88	3.01¶	2.34	4.56	2.55	5.73	2.93	14.321‖	<.001 *<‡	0.155
F		4.843††		3.718††		3.731††				
P		.01 §<#		.03 **<#		.03 §<#				
VAS score (child-reported)	38.28-46.68	27.94	19.13¶	46.07	24.96	53.43	29.01	14.94‖	.001	0.161

FPS-R scores ranging from 0 to 10 (0, 2, 4, 6, 8, 10) points.
VAS scores ranging from 0 to 100 points.
FPS-R, Faces Pain Scale-Revised; VAS, Visual Analog Scale; SD, standard deviation.

* Palm Stimulator group.
† ShotBlocker group.
‡ Control group.
§ FPS-R score of child-reported.
¶ Group that caused significance according to the post hoc analysis.
‖ Analysis of variance test was used.
FPS-R score of parent-reported.
** FPS-R score of parent-reported.
†† Variance analysis test in repeated measurements was used.
‡‡ 95% CI values for FPS-R and VAS scores of child-, parent-, and observer-reported.

publication of the results, it was deposited after the study data collection was complete. Future work would be improved by registering the trial before data collection. It is important to replicate the results in a multicenter setting where the developers of Palm Stimulator are uninvolved in implementation and data collection.

Implications for Emergency Clinical Care

Pediatric emergency nurses work in a fast-paced environment, but they must be aware of the fear and pain associated with the IM injection procedure. Hospital policies should support the combined use of pharmacological and nonpharmacological methods to reduce injection-related pain in children. There is evidence to support the effectiveness of several nonpharmacologic methods to decrease pain and distress in the Emergency Nurses Association's Clinical Practice Guideline.[3] Our study advances the evidence associated with this guideline using randomized control trial methods and a novel nonpharmacological device. The present study provides unique information about an innovative pain-reducing method to be used during IM injection in children in the emergency department. As a practical method, our results support that the Palm Stimulator reduces pain caused by IM injection among pediatric emergency department patients.

It is important to provide training to health care providers, especially pediatric emergency nurses, and increase their ability to effectively use pain-reducing methods such as Palm Stimulator during needle-related procedures. Further studies are needed to evaluate the effect of the apparatus on pain reduction during other needle-related interventions such as blood sampling, intravenous catheterization, or subcutaneous injections.

Conclusion

The Palm Stimulator, which was created by the researchers, was effective in reducing perceived pain in children during the administration of an IM injection. Although the perceived pain levels of the children in the ShotBlocker group were lower than the control group, this difference was not statistically significant.

This research contributes to the scientific literature by presenting an innovative pain-reducing method to be used during IM injection in children. We recommend further use and research on the Palm Stimulator apparatus as a practical and innovative nonpharmacological intervention for reducing perceived pain caused by IM injections in children treated in the emergency department.

Acknowledgments

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Author Disclosures

Conflict of interest: none to report.

Clinical trial number: NCT04594083.

The authors of the study created the Palm Stimulator device and have filed for a patent under the Turkish Patent and Trademark Authority with the number 2018/06479, and the World Intellectual Property Organization with the number PCT/TR2018/000089. The authors did not administer the injection, directly deliver the study procedures with patients, or collect the data presented here. The authors disclose no other conflicts of interest in the study between the device creator, the authors, the independent observer, and the nurse who administered the injections. No external funding was provided in the development of the device or in the patent application process.

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Verification of Endotracheal Tube Position by Emergency Nurses Using Ultrasound: A Repeated Measures Cadaver Study

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Contribution to Emergency Nursing Practice

- Nurses have successfully used ultrasonography for vascular access, volume assessment, and focused sonography in trauma patients.
- This study's results demonstrate that ultrasound can be performed by nurses for confirmation of esophageal and tracheal intubations quickly and accurately.
- Emergency nurses may be able to acquire competency through cadaver training and practice to accurately identify endotracheal tube placement using ultrasound. These results need to be replicated with a larger sample size, actual practice setting, and multi-center study.

Abstract

Introduction: Endotracheal intubation is a lifesaving procedure frequently performed in emergency departments. It is associated with some potential risks. Rapid and reliable confirmation of endotracheal tube placement during intubation is critical. Nurses play an important role in the care of patients in various settings. Ultrasound can be performed and interpreted not only by physicians but also by nurses. The aim of this study was to evaluate how well nurses without previous ultrasound experience can determine both esophageal and tracheal localization of endotracheal tubes in cadavers after a short ultrasound training.

Methods: This was a repeated measures study with an educational intervention and no control/contemporaneous comparison group. The study was performed to evaluate the ability of emergency nurses to confirm correct endotracheal tube placement and identify esophageal intubations. A total of 7 emergency nurses were given theoretical education and hands-on training about ultrasound. They diagnosed tracheal or esophageal intubation using ultrasound.

Results: Four cadavers were used 8 times each for the study. A total of 32 intubation procedures were evaluated with ultrasound by each nurse. In the analysis based on 224 responses, sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, and overall accuracy of ultrasound applied by nurses to detect tracheal intubation were 95.61% (90.06%-98.56%), 97.27% (92.24%-99.43%), 35.06 (11.48-107.10), 0.05 (0.02-0.11), and 96.43% (93.08%-98.45%), respectively. The mean time to evaluate the tube location by ultrasound was 6.57 seconds.

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Discussion: The results support that ultrasound can be performed by nurses for the confirmation for esophageal and tracheal intubations quickly and accurately.

Key words: Endotracheal tube; Esophageal intubation; Emergency nurse; Emergency department; Point-of-care ultrasound

Introduction

Endotracheal intubation is a lifesaving procedure frequently performed in emergency departments, but it is associated with several risks. Complications more frequently arise in the presence of emesis, bleeding, excessive secretions and with inappropriate patient positioning. Unintended esophageal intubation is a preventable complication that can lead to death in 5% to 10% of patients undergoing emergent intubation.[1] Therefore, rapid and reliable confirmation of endotracheal tube (ETT) placement during intubation is critical.[2] The American College of Emergency Physicians recommends more sensitive methods such as chest radiography, measurement of end tidal carbon dioxide, and capnography besides routine examination methods such as 5-point auscultation, pulse oximetry, symmetrical chest rise, and tube misting for ETT verification.[3] However, since these methods are time-consuming, incorrect intubation may occur and harm the patient prior to confirmation. Capnography is recommended as the gold standard to confirm ETT placement. However, it increases the risk of aspiration in patients with esophageal intubation as it requires the patient to be ventilated. In addition, cardiac arrest, airway obstruction, and markedly decreased tissue perfusion all compromise the reliability of capnography.[4] Many studies have shown that ultrasound (US) can be used safely and reliably to confirm ETT placement,[5,6] with comparable sensitivity of capnography.[7-9]

A nurse is a valuable resource for successful patient care and good medical outcomes in the emergency and intensive care units. Health service delivery requires teamwork of physicians and nurses in full harmony. With a number of patients rapidly deteriorating in the emergency and intensive care units coupled with the shortage of physicians, nurses have been increasingly performing a number of procedures, thus expanding their roles.[10] In recent years, nurses have been successful in performing US-guided vascular access, volume assessment, fracture detection, soft tissue foreign body detection, focused sonography in trauma patients, and ejection fraction measurement.[11-19] To our knowledge, there are not enough studies evaluating the ability of nurses to use US in confirming ETT placement. The aim of this study was to evaluate how well nurses without previous US experience can determine both esophageal and tracheal ETT localization in cadavers after focused US training.

Methods

STUDY DESIGN

This was a repeated measures study with an educational intervention and no control/contemporaneous comparison group. The study was performed to evaluate the ability of emergency nurses to confirm correct ETT placement and identify esophageal intubations. After the ethical approval of our study was obtained at Istanbul Medipol University (no. E-10840098-772.02-3666), the study was carried out on cadavers in the Ege University Department of Anatomy. Written informed consent was obtained from all nurses before participating in the study.

SAMPLE

Seven nurses participating in the study were emergency nurses who had also received intensive care training and had more than 5 years of experience. The nurses had not received any previous formal sonography training.

CADAVER MODEL

One female and 4 male recently deceased cadavers were used. The neck circumferences of the cadavers were 36 cm, 39 cm, 42 cm, 44 cm, and 46 cm. The cadavers were removed from the refrigerator a day before the study. Senior anatomy physicians stretched the jaws and necks of the cadavers manually to relax and soften the muscles during the day. The oropharynx of each cadaver was also cleaned with a portable aspiration device. Cadavers with a neck mass, a previous surgery, or a sign of trauma in the neck region were not used in the study.

STUDY SESSIONS

For the study, 5 cadavers were provided by laboratory personnel under the legal supervision of the laboratory. The female cadaver with a neck circumference of 36 cm was used as a training cadaver (Figure 1). The identified training cadaver was not used in the acquisition of study data to avoid any bias arising from study participants' familiarity with the cadaver's airway.

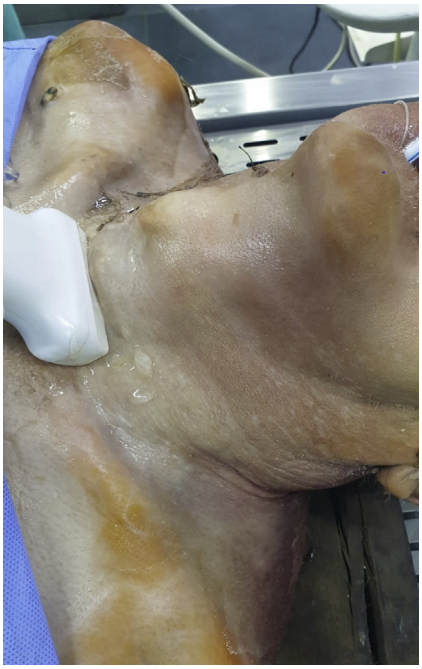

FIGURE 1
Ultrasound probe placement on intubated cadavers.

ULTRASOUND TRAINING

Three emergency medicine physicians were recruited in this study: 1 for the US training (sonographer), who had more than 10 years of experience in the use of US in the emergency department and had a clinical study on confirming the ETT location with US; 1 as the intubator; and 1 as the controller. The training and the study were completed in 1 day. All nurses received 30 minutes of theoretical training on emergency US by a certified emergency medicine physician (sonographer).[20] In the didactic session, participants were instructed on US technique, image acquisition, expected airway appearance with and without ETT, along with tracheal and esophageal artifacts. After the didactic session, hands-on US training was undertaken. The topics covered didactically were reiterated through demonstration by the sonographer. The participants were first allowed to define the trachea and esophagus by performing neck US on the cadaver. All nurses evaluated both tracheal and esophageal intubations at least 5 times with US. They were allowed to practice and ask questions as much as they felt competent about both normal and abnormal findings. The study began when all participants felt competent. No additional training sessions were held. The cadaver used in the practice application was not used to collect data. The cadavers were

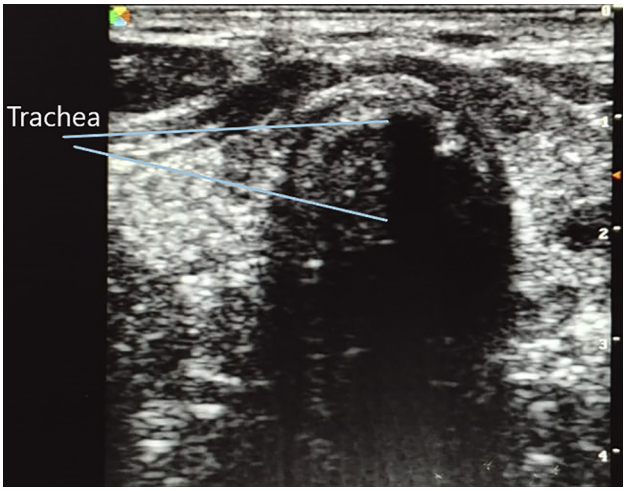

FIGURE 2
Ultrasound image of tracheal intubation.

intubated with a size 7 ETT (Cardinal Health; Waukegan, IL) and confirmed by the sonographer. ETTs were placed into the trachea, distal to the vocal cord by direct laryngoscopy. For esophageal placement, the tube was intentionally placed into the esophagus by direct laryngoscopy. The US machine (Sonosite, Bothell, WA) was placed to the left of the cadaver and the volunteer. The 10-MHz linear probe was placed transversely on the cadaver's neck, just proximal to the suprasternal notch, with the probe indicator facing the nurse's left side. On US, a tracheal image is defined as a hyperechoic line and a reverberation artifact is seen posteriorly. The US image of the esophagus is a multilayered, elliptical structure or an anechoic area to the left of the trachea. Endotracheal intubation was defined as a hyperechoic double line within the trachea with a single air-mucosa interface and an empty esophagus (Figure 2). Esophageal intubation was defined by the "double trachea" or "double path" sign and the presence of 2 air-mucosa interfaces, one each in the esophagus and trachea (Figure 3).

ULTRASOUND IDENTIFICATION OF PREPLACED TUBES

Four study cadavers were intubated into the trachea or esophagus by direct laryngoscopy by the intubator. ETT placement was predetermined in the cadavers using a random number generator of the same number of tracheal and esophageal intubations to best describe the testing characteristics of each approach. For ETT confirmation, the

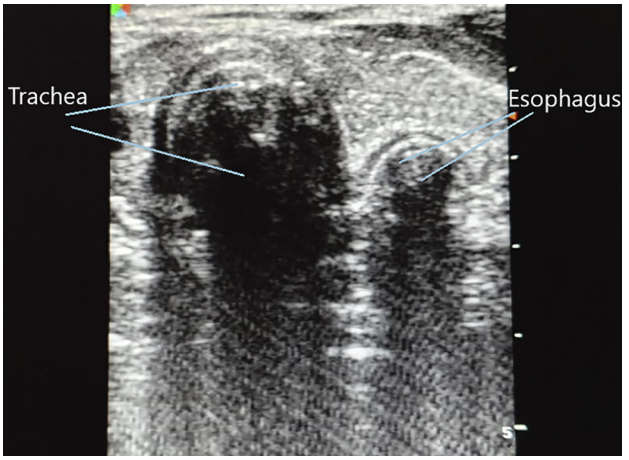

FIGURE 3
Ultrasound image of esophageal intubation.

intubation was confirmed by the sonographer using US. The nurses were taken to the study room one by one, and when the evaluation was over, they were taken to a separate room. During the evaluation, the intubator and sonographer were removed from the study room each time to prevent a possible reaction. In the study room, only the controller physician who wrote the nurses' response and the evaluation period remained.

The face of the cadaver, including the tube, was covered with a cloth to avoid any suspicion of tube location. Throughout all phases of the study, all nurses were blinded during tube insertion. Using US, the nurses diagnosed tracheal or esophageal intubation using static technique. The static technique is the procedure of placing the probe transversely just proximal to the suprasternal notch after intubation and turning the tube slightly to its side to create a motion artifact. The nurse was then able to manipulate the tube under US guidance to further confirm the position of the tube. The time to diagnosis was recorded. Time began with the insertion of the probe into the cadaver's neck and ended when the nurse verbally reported the tube position. The controller recorded both the verbally reported tube location and the time.

DATA ANALYSIS

Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for the determination of tube position. Statistical Analysis System (SAS) 9.2 was used for all calculations, including confidence intervals (SAS Institute, Cary, NC).

TABLE 1
Nurse demographics, evaluation time, and intubation type

Characteristics	Mean	Min–max
Nurse age, y	33.9	24–45
Nurse professional experience, mo	149.6	64–252
Evaluation time, s	6.57	4–31
Tracheal	7.05	3–20
Esophageal	6.08	3–31

Type of intubation	Total	%
Tracheal	16	50
Esophageal	16	50

STATISTICAL METHODS

In statistical analysis, mean diagnostic times for esophageal and tracheal intubation, evaluation of inter-observer agreement, sensitivity, specificity, positive predictive value, negative predictive value, accuracy, and area under the curve calculations were made with SPSS version 26. In all statistical evaluations, $P < .05$ was accepted as the statistical significance limit value, and the 95% CIs were used for the mean values of all parameters.

Results

The study was conducted with 7 nurses. Four cadavers were used 8 times each for the study. A total of 32 intubation procedures were evaluated with US by each nurse. A total of 224 answers were given by the nurses. The mean age of the nurses was 33.9 (range = 24-45) years, and the average work experience period was 149.6 (range = 64-252) months. The mean time to evaluate the tube location by US was 6.57 seconds (tracheal, 7.05; esophageal, 6.08) (Table 1) (Figure 4) .

In the analysis based on 224 responses, sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, and overall accuracy of US applied by the nurses to detect tracheal intubation were 95.61% (95% CI, 90.06%-98.56%), 97.27% (95% CI, 92.24%-99.43%), 35.06 (95% CI, 11.48-107.10), 0.05 (95% CI, 0.02-0.11), and 96.43% (95% CI, 93.08%-98.45%), respectively (Table 2).

The general agreement (kappa) of the answers given by the nurses about the intubation site to the actual intubation site was 0.93 ($P < .001$) (Table 2), and the area under the curve was 0.96 ($P < .001$).

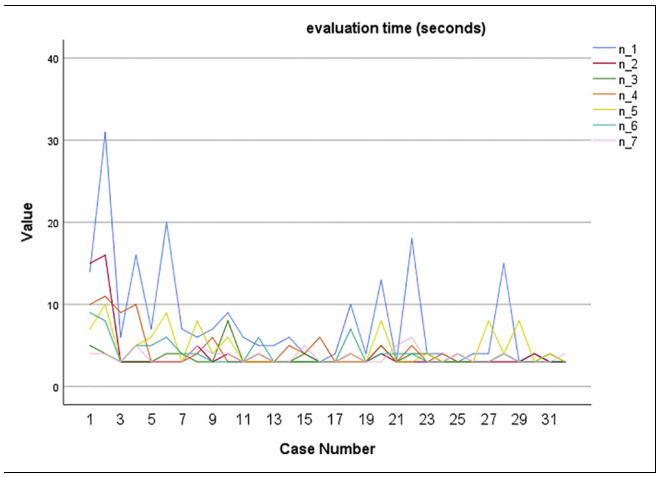

FIGURE 4
Development of nurses' evaluation time (second).

Discussion

This is the first study to examine emergency nurses' ability to differentiate tracheal from esophageal ETT placement using US in cadaver models. Our results showed that a brief targeted training session resulted in emergency nurses being able to make this differentiation efficiently and accurately. This study was carried out by 7 emergency nurses who were inexperienced in US. With our educational training intervention, we demonstrated that sonographic verification of ETT placement should be explored as a valuable skill for nurses in the emergency specialty.

Currently, none of the ETT placement verification methods have been proven to be 100% reliable. US is one of the promising additional confirmation methods in airway management. US has the advantage of being faster, noninvasive, and not requiring multiple ventilations to confirm tube placement compared with other tube verification methods. Over the past decade, many studies have emphasized the role of sonographic ETT placement confirmation.[5,8] In their meta-analysis, Gottlieb et al[21] reported that transtracheal US confirmed tube placement with 98.7% sensitivity and 97.1% specificity. In addition, the mean time to tube verification was 6.0 seconds.[21] In a recent meta-analysis, Sahu et al[22] reported that US had a sensitivity of 98.2% and a specificity of 95.7% in confirming tube placement. In a meta-analysis of 969 patients, Das et al[6] showed that US was 98% accurate in tube confirmation. Muslu et al[23] reported in their prospective and randomized study that US reached 100% sensitivity and specificity in determining tracheal tube position in adult surgical patients. They determined the position of the tube within 3 seconds of insertion of the tube. Thus, they showed that US is a fast and effective technique to confirm tracheal intubation.[23] Adi et al[8] performed a study comparing capnography with US to confirm tube position and found 98% sensitivity and 100% specificity. The mean confirmation time with US was 16.4 seconds.[8] Göksu et al[24] in their cadaver model study found the sensitivity and specificity of tube verification with US as 95.7% and 98.2% respectively, after a 15-minute presentation. After a 5-minute briefing, Ma et al[5] reported that US tube confirmation in a cadaver model had 97% sensitivity and 100% specificity. In their cadaver model study, Uya et al[25] found that after a 50-minute training, including 20 minutes of theory lectures and 30 minutes of practical hands on, a sensitivity of 96% was achieved for tracheal placement. In the simulation-based study of Joyce et al,[26] paramedics were used to confirm tube location with US and detected endotracheal placement with 92.5% accuracy and esophageal intubations with 90.0% accuracy. In addition, the mean time to diagnosis was 10.6 seconds for endotracheal placement and 15.5 seconds for esophageal placement.[26] In a cadaver model, Lema et al[27] studied with 57 paramedics to confirm tube location with US and evaluated a total of 228 intubations, of which, 113 were tracheal and 115 were esophageal. They reported the sensitivity of confirming the tube location with US as 87% and the specificity as 83.2%.[27] In our study, after a short training, the nurses defined tracheal intubations and esophageal intubations with an accuracy of 96.4%. In this study, the mean time to confirm with US was 7.05 seconds for tracheal placement and 6.08 seconds for esophageal placement. The results of our study were also compatible with the literature. It has been shown that nurses can be skilled in confirming intubation placement in airway management in emergency and intensive care conditions. Thus, US can be a useful method to confirm tube placement; however none of the methods, including US, is recommended to be used alone for tube verification in emergency department conditions.

Limitations

The first of the limitations of this study was the use of a small-size cadaver model for training, which causes sample bias. In addition, this model may not have fully reflected the characteristics of a live patient in the emergency department setting. The 7 nurses who participated in

TABLE 2
Test performance characteristics for the tracheal and esophageal intubation

Characteristics	Sensitivity		Specificity		+LR		−LR		PPV		NPV		Accuracy		Kappa	*P* value
	%	95% CI	%	95% CI	Ratio	95% CI	Ratio	95% CI	%	95% CI	%	95% CI	%	95% CI		
Tracheal	95.61	90.06%–98.56%	97.27	92.24%–99.43%	35.06	11.48–107.10	0.05	0.02–0.11	97.32	92.24%–99.11%	95.54	90.08%–98.06%	96.43	93.08%–98.45%	0.93	< .01
Esophageal	97.27	92.24%–99.43%	95.61	90.06%–98.56%	22.18	9.41–52.29	0.03	0.01–0.09	95.54	90.08%–98.06%	97.32	92.24%–99.11%	96.43	93.08%–98.45%		

+LR, positive likelihood ratio; −LR, negative likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

the study may have also not been representative of the emergency nursing specialty. The fact that the study was conducted immediately after the training was an important limitation. The unequal number of male and female in cadavers was also an important limitation. In addition, the cadaver model design allowed for a quiet, interruption-free environment compared with the busy emergency department practice setting. This different environment may have resulted in a more accurate assessment of both endotracheal and esophageal intubations compared with the emergency department setting. Only 5 cadavers were used in the study, which was less likely to fully reflect the larger population. However, we deliberately used cadavers with significant differences in neck sizes to best reflect the differences represented in the larger population. In addition, owing to the intense amount of work in the anatomy laboratory, the training time was limited to 30 minutes, which may have been a major contributing factor to the lower accuracy. In light of these findings, further multicenter and prospective studies are recommended in the chaotic environment of the emergency department. The unit of analysis for this study was the individual assessment, and since individual nurses performed multiple assessments, these assessments did not meet the independence assumptions of the statistics.

Implications for Emergency Clinical Care

Intubation is a crucial and lifesaving intervention in intensive and emergency care settings. Successful patient outcomes depend on early and accurate detection of proper ETT placement in the trachea. Accurate ETT placement after intubation is confirmed using chest radiography, measurement of end tidal carbon dioxide, and capnography.[3] Emergency nurses also use additional assessments of 5-point auscultation, pulse oximetry, symmetrical chest rise, and tube misting for early and ongoing detection of potential ETT placement problems.[3] US offers an emerging method for the rapid detection of accurate ETT placement. The results of this study indicate that emergency nurses can acquire the competency through cadaver training and practice to accurately identify ETT placement using US. More study is needed to determine how accurately and consistently this skill can be applied by emergency nurses in the practice setting. The emergency nurse is an important and indispensable part of the emergency care team, and the potential practice contribution of the nurse who has acquired cadaver-based US ETT placement verification competency may demonstrate added value in future emergency care practice.

Conclusions

We demonstrated that emergency nurses who are inexperienced in US can successfully identify ETT placement and recognize esophageal misplacement after a short US cadaver training. However, our results may not be generalizable to other settings, and a replication of our study with a larger sample size, actual practice setting, and multicenter study is required.

Author Disclosures

Conflicts of interest: none to report.

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Periodic Resuscitation Cart Checks and Nurse Situational Awareness: An Observational Study

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Contribution to Emergency Nursing Practice

- A delay of 1 minute due to poor resuscitation cart readiness is associated with approximately 10% decrease in resuscitation success rates and outcomes.
- The common observations of resuscitation cart–related readiness issues identified were empty oxygen tanks (32%), drained batteries or equipment failure (16%), incorrect size of equipment (16%), and missing or expired equipment (15%), with fewer issues observed in the critical care units than emergency departments and other wards.
- Even though some of the carts were checked several times in the same shift by different participants, cart-related readiness failure was observed by researchers.
- Key implications for emergency nursing practice from this research include the need for more interventions to increase resuscitation cart readiness and nurse situational awareness during periodic resuscitation cart checks.

Abstract

Introduction: The periodic check of the function and integrity of the resuscitation cart is very important to ensure that the cart is prepared for use to provide emergency care to critical patients. Little is known about situational awareness during the periodic inspection of resuscitation carts. The purpose of this study was to measure hospital clinical nurses' situational awareness immediately after completion of a check of the resuscitation cart content and to directly observe and assess the resuscitation cart readiness in the selected hospitals.

Methods: An observational correlational study with a self-report measure design was used in which the Situation Awareness Rating Technique was collected immediately after the completion of checking of the resuscitation cart.

Results: Among the 332 nurse participants, the mean situational awareness score was 16.42 (standard deviation 5.26), reflecting an average situational awareness during the task of checking and inspection of the resuscitation cart. Knowing the policies and guidelines relating to resuscitation and the resuscitation cart is associated with the participants' situational awareness ($F_{3,33} = 3.70$, $P = .04$). In addition, working in critical areas and the number of years of working experience are associated with the participants' situational awareness ($F_{2,33} = 3.24$, $P = .04$ and $F_{3,33} = 3.00$, $P = .02$, respectively). Assessing the resuscitation cart readiness revealed several issues such as empty oxygen tanks (32%); drained batteries and equipment failure (16%); incorrect size of equipment (16%); and missing, expired, and unavailable equipment (15%). Some of these issues were noted even though the carts were checked several times by different participants.

Discussion: Much work needs to be done, because inadequate situational awareness during the periodic check of the resuscitation cart content can affect patient safety in life-threatening emergencies.

Key words: Awareness; Nurses; Resuscitation; Self-report; Policy

Introduction

A resuscitation cart is a movable storage device with a set of drawers and shelves used in emergency events in hospitals. It enables clinicians to intervene immediately, thereby saving

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time and lives. Resuscitation carts contain medication and equipment required to save patients presenting with life-threatening conditions.[1] Indeed, medications such as EPINEPHrine and equipment such as a defibrillator are essential to resuscitate respiratory arrest, cardiac arrest, drug overdose, and shock. Therefore, it is very important for nurses to continually ensure that all the needed elements and supplies are available and ready to use.

Resuscitation cart supplies and the preparedness and readiness of the equipment are core components of an effective resuscitation approach. For example, in emergency situations, a delay of 1 minute due to difficulties in accessing resuscitation cart supplies and equipment is associated with around a 10% decrease in resuscitation success rates and outcomes.[2] However, there are reports in the literature of a number of incidents in which resuscitation cart supplies were not available or outdated.[2] Such cart preparedness-related failure may have critical consequences for the timely and successful management of emergency situations and may lead to decreasing the chances of positive outcomes for patients with a life-threatening condition.[3-5] Emergency resuscitation carts need to be carefully checked, equipped, and maintained.[2] In this regard, recommendations have been made to have a consistent approach for organizing resuscitation cart drawers to reduce the occurrence of unsupplied or outdated medication incidents.[6]

Inpatient hospital clinical nurses as well as their counterparts in emergency departments must fulfill their general role as first responders in emergency situations. This can only happen if there is appropriate and well-functioning life-saving equipment and medication. Nurses are assigned to ensure that the resuscitation cart is in good working order and that all required items are available, up-to-date, and well-functioning.[2,7] However, it is not unusual for nurses to be required to answer telephones and respond to health care team members, patients, family members, and visitors during the checking procedure of the emergency resuscitation carts.

The working environment of nurses is complex and influenced by several contextual factors.[8] Monteiro et al[9] found that about 31% of nurses' activities were interrupted, and the mean number of interruptions per activity was 1.6. Researchers found that distraction and interruption can decrease nurses' situational awareness.[10] Likewise, distraction and interruption during resuscitation cart checking activity may decrease nurses' situational awareness and consequently may have critical consequences for patient safety.[11,12]

The concept of situational awareness is referred to as "the perception of the elements in the environment in a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."[13] Many researchers have incorporated situational awareness as a key component construct when evaluating health care providers' clinical performance in emergency situations.[14-16] Within these studies researchers recommended using situational awareness training to improve health care workers' performance. Nurses' situational awareness in the context of resuscitation cart checking refers to identifying and making meaning of factors and elements relevant to the resuscitation cart activity and readiness. The concept of situational awareness is necessary for patient safety.[17] According to Green et al,[18] lack of situational awareness can result in poor outcomes and errors.

Situational awareness is fundamental for improving the performance of any activity,[11,12] including resuscitation cart checking. Many researchers have investigated situational awareness specific to patient care activities such as clinical observation, medication administration, and decision-making.[18-20] Meanwhile, much of the literature on resuscitation carts is about nurses' compliance, knowledge, practices, and adherence to resuscitation cart guidelines, as well as medication errors, without being specific to situational awareness.[6,21] It is important to evaluate nurses' situational awareness during the resuscitation cart checking activities, because it may have an important impact on the process and outcome of the cart checking activities and may have a potential to directly influence nurses' performance. However, situational awareness has not been investigated in relation to the cart check procedure. This study seeks to fill this gap in the current literature by investigating hospital clinical nurses' situational awareness immediately after completion of a check of the resuscitation cart content.

AIM

The purpose of this study was to measure hospital clinical nurses' situational awareness immediately after completion of a check of the resuscitation cart content and to directly observe and assess the resuscitation cart readiness in the selected hospitals.

Methods

STUDY DESIGN AND SETTING

An observational design with participant self-report and direct researcher observation measures covering 3 main government hospitals in the Kingdom of Saudi Arabia was used, during a period of 4 months from January 2021 until April 2021.

SAMPLE

It is a typical practice in the hospitals included in this study to have the resuscitation cart checked every shift by a registered nurse (RN). The task of checking the resuscitation cart is not limited to a particular RN, and all RNs are required to check the cart at some point during the year. Consequently, it is expected that all RNs in the 3 hospitals be familiar with and actively involved in the checking procedure. A convenience sampling technique was used in which all RNs (N = 2000) in the 3 hospitals were considered eligible for this study.

SAMPLE SIZE CALCULATION

Fink and Major[22] investigated the situational awareness of 260 participants (pilots) using Situation Awareness Rating Technique (SART). In this study, sample size table for a correlation study[23] was used to identify the estimated sample size to detect low difference with alpha of 0.05 and power of 80%. Consequently, the estimated number of participants required should range from 59 to 751.

DATA COLLECTION INSTRUMENTS

The research instrument consisted of 2 parts to collect data from the study participants. Part 1 was constructed by the researchers to elicit data on a variety of demographic characteristics of study participants, and part 2 was the SART instrument[24] to assess situational awareness.

SURVEY PART 1: DEMOGRAPHIC

The demographic questionnaire included 7 items to provide a richer context for understanding the data. Each participant was asked to respond to the questions including those pertaining to employment as a hospital clinical nurse. This employment information included number of years since employment, category of unit at which the participant is assigned, and whether the unit is a medical, surgical, emergency, or intensive care unit. Information was collected if the participant had ever had training in the last 2 years: whether the participant had a certificate in basic life support, advanced cardiac life support, or pediatric advanced life support and was involved in resuscitation training events (mock codes). In addition, data were collected on whether the participant was familiar with resuscitation and resuscitation cart policies, quantified as the number of times participant reviewed the policies and procedures for the checking of resuscitation cart in the past 6 months. Data regarding the participant's age, education, and sex were also collected.

SURVEY PART 2: SART

Second, to gain a subjective assessment of participants' situational awareness during the entire procedure of checking and inspecting a resuscitation cart, the SART instrument[24] was used. SART is a self-report questionnaire that rates attention demand, supply of attentional resources, and an understanding of the situation on a 7-point Likert scale ranging from 1 (low) to 7 (high).

SART includes 3 dimensions and 10 items as follows: demand (3 items: instability, complexity, and variability of situation), supply (4 items: arousal, concentration on the situation, division of situation, and spare mental capacity), and understanding (3 items: information quantity, information quality, and familiarity of situation).

Justifying using SART to measure situational awareness

There are various objective techniques for assessing situational awareness including real-time probes and freeze probes. The Situational Awareness Global Assessment Technique[25] may produce the most valid and reliable measure. However, an alternative to an objective assessment of situational awareness is to collect subjective reports in which individuals rate their own situational awareness after the activity has been completed. The SART[24] is one of the most comprehensively tested rating scales for estimating situational awareness.[26] Its strengths come from its design featuring 3 logical phases: (1) scenario generation, (2) construct elicitation, and (3) construct structure validation.[27] SART is a multidimensional rating scale to assess operator perception of situational awareness. The technique assesses 3 dimensions of situational awareness: (1) understanding (U), (2) supply (S), and (3) demand (D). According to Taylor,[24] situational awareness depends on the quality and amount of information an individual receives (U), the complexity of the activity (D), and the ability of the individual to concentrate (S).

Validity of SART

The validity of SART was examined by several studies.[24,28] Although the tool has not been previously used in a health care setting, the tool was found to have high ecological validity in aviation when measuring situational awareness of flight crew as it has been developed in a real (nonartificial) environment.[26] SART can be administered during or immediately after the test task. In this study, the tool was given immediately after performing the procedure of checking and inspecting a resuscitation cart. This allowed the participants to know to which setting and period the questions

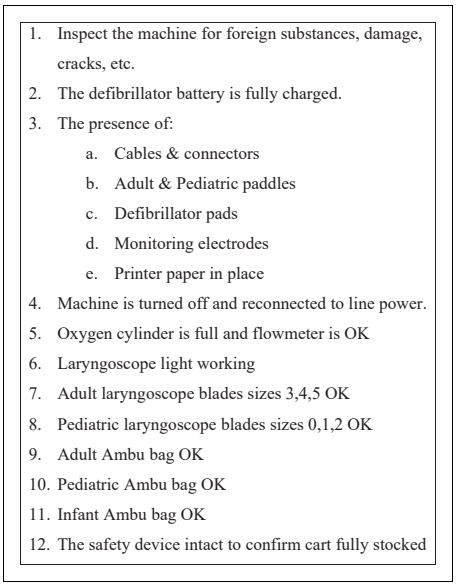

FIGURE 1
Resuscitation chart daily checklist.

referred.[29] Furthermore, it allowed the researcher to measure the participant's situational awareness during the entire procedure of checking and inspecting a resuscitation cart by determining the demand on the participant's attention, the supply of the participant's attention, and the understanding of the attentional resources available to the participant.

The overall SART score is calculated by summing the understanding (U) components and subtracting the difference of the sums of the demand (D) and supply (S): [situational awareness = Understanding–(Demand–Supply)]. SART scores range from –14 to 46.

Observation: Resuscitation cart readiness

A standardized checklist (Figure 1) was used as an observational instrument to assess the resuscitation cart readiness in the selected hospitals. The design of the checklist was largely due to previous cooperative efforts from Western Regional Health Directorates employee stakeholders. This standardized checklist works as a guiding tool to help hospital staff assess the readiness of the resuscitation carts in different units. Its use involved assessing the availability and functionality of essential equipment of the emergency carts.

STUDY PROCEDURES

Recruitment

A recruitment invitation was sent by email to all potential participants at the 3 hospitals. The email-based invitation strategy included an email describing the study purpose and nature (explanatory statement) and eligible participants, inviting participation, and a telephone number to call for more information. The emails were sent under the name of the principal researcher with the subject line, "Help us identify the influence of situational awareness on RN checking procedure of resuscitation carts."

The researcher visited the 3 hospitals and sought the collaboration of department heads and participants' agreement. It is a typical practice in the 3 selected hospitals to check the resuscitation cart at the beginning of each shift mainly in the first 2 hours of the shift. Hence, the visits for data collection were made in the first 2 hours of the day (7 AM to 9 AM) and during the afternoon shift (3 PM to 5 PM).

During the visit time, the researchers first met with the heads of the departments to explain the process of data collection. Any RN who worked in the department and received and read the recruitment invitation could agree to participate, regardless of whether or not they were assigned to check the resuscitation cart that day. This allowed all RNs interested in the topic to be involved in the study during the data collection time. Once the collaboration of the heads of the departments was agreed, interested participants were asked to sign a consent.

Situational awareness during resuscitation cart check

Once nurse participants consented to participate, they were asked to complete the first part of the survey (demographic questionnaire). Upon completion of this, the survey was collected by researchers, and the participant was instructed to perform the resuscitation cart check (Figure 2). During this step, participants commenced checking and inspecting the resuscitation cart content available in their department based on the hospital policy and procedure. The intention was to measure the situational awareness in the real working environment with its disruptions and distractions. Indeed, any interruption that occurred while participants were performing the task was not prevented, intentionally influenced, or manipulated by the research team. To limit any Hawthorne effect, the researchers stayed at a distance from the participants and waited for them to finish the assigned task.

After the participant completed the resuscitation cart check, we requested that the participant complete the SART instrument (the second part of the survey). This data collection step was timed immediately after the participant's resuscitation cart check. Participants were instructed to rate the level of situational awareness they experienced while performing the resuscitation cart check task, using SART.

FIGURE 2
Participant checks and inspects the resuscitation cart content.

Direct observation of resuscitation cart readiness

The shift nurse in charge and a member of the research team directly observed the resuscitation carts at the end of each shift. In this study, a total of 138 resuscitation carts were identified in the 3 main government hospitals. The total number of these 138 resuscitation carts approached for observation in this study was 86, and 126 observations were made. In these observations, the resuscitation cart contents were reviewed, and the resuscitation cart readiness checklist was completed. There was no link to individual participant surveys or identifiers to gain study site access, as there was no intention to double-check any individual participant's performance. Study procedures are summarized in Figure 3.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was granted from Ethics Review Committee of the Ministry of Health number HAP-02-T-067. Written informed consent was obtained.

STATISTICAL ANALYSIS

Data management and analysis were performed using SPSS Version 25 (IBM). The analysis included 2 parts. First, descriptive statistics (number, percentage, mean, median, range, and standard deviation) were used to describe sample characteristics. Second, 2-tailed *t* test and 1-way analysis of variance were used to examine whether there were statistically significant differences between the situational awareness of the nurse's scale or subscale during emergency resuscitation cart activity and demographic data. To control the likelihood of a type I error, an adjustment to the level of significance was done using a Bonferroni correction.

Results

A total of 332 participants agreed to take part in this study. Of these, 89% (n = 296) were female, and 76% (n = 253) held a bachelor's degree. The mean age of the participants was 34.15 (SD = 6.6). More than half of participants (69%, n = 227) had a work experience of more than 6 years. At the time of the study, 62% (n = 206) of participants were working in general wards, 20% (n = 68) in emergency areas, and 18% (n = 58) were working in critical care areas. A total of 79% participants had taken basic life support training (Table 1).

SITUATIONAL AWARENESS SCORE

The mean scores for the demand dimension, the supply dimension, and the understanding dimension were 8.59 (SD = 2.83), 14.11 (SD = 3.42), and 10.9 (SD = 2.26), respectively. SART scores are limited to values between –14 and 46. The overall SART score was at the midpoint of this range 16.42 (SD = 5.26), which reflects that they had average situational awareness during the checking activity.

SITUATIONAL AWARENESS DIMENSIONS WITH DEMOGRAPHIC VARIABLES

One-way analysis of variance was used to investigate mean differences between the overall score of the situation awareness and the demographic variables. Among all the demographic variables, there were significant differences between the familiarity with the policies and guidelines relating to resuscitation and resuscitation cart ($F_{3,33}$ = 4.26, P = .04), working area ($F_{2,33}$ = 3.24, P = .04), working experience ($F_{3,33}$ = 3.00, P = .02), and the overall situational awareness score (Table 2).

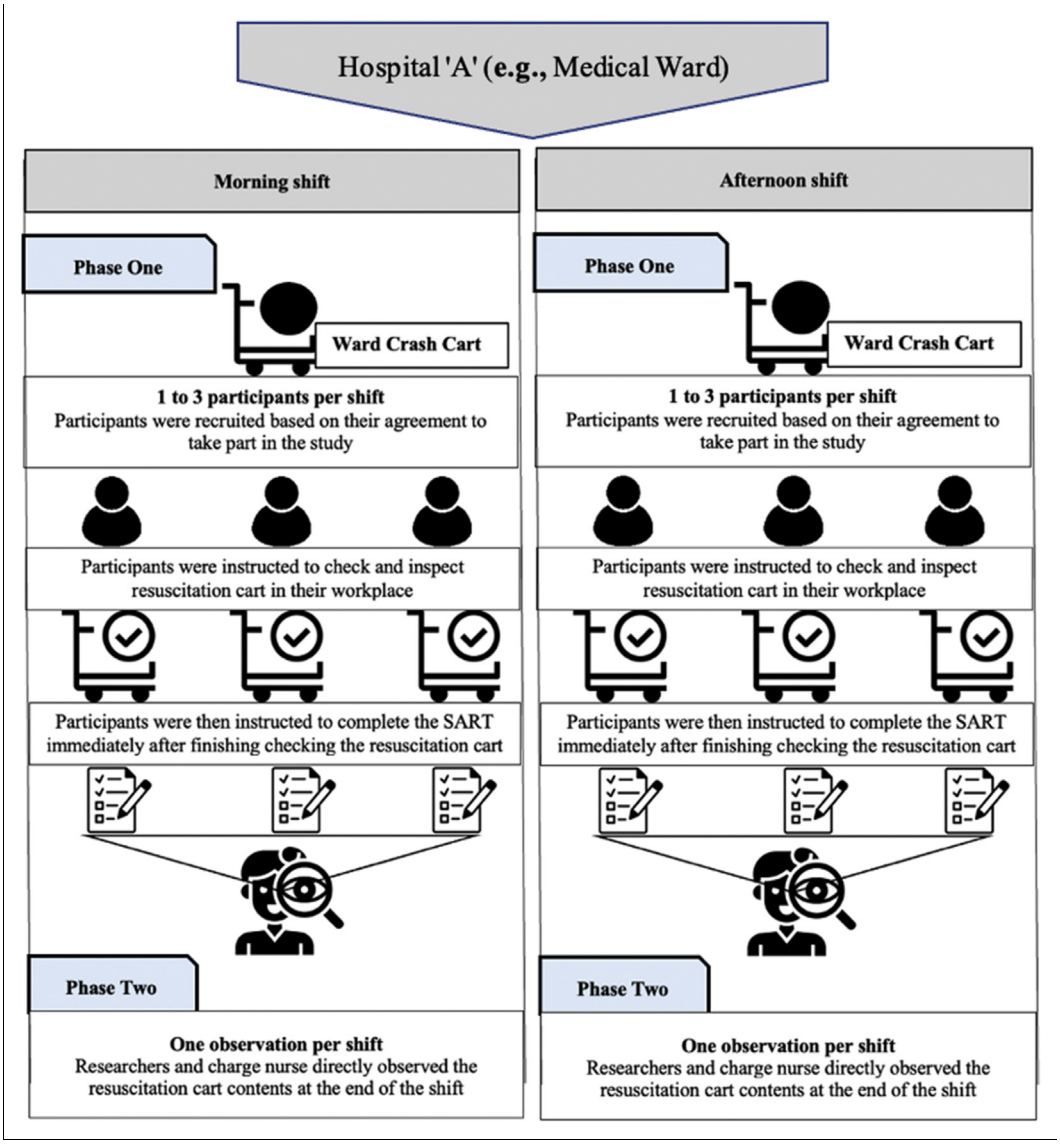

FIGURE 3
Study procedure.

The mean differences between each situational awareness dimension (D, S, and U) and the demographic variables were further investigated and are shown in Table 3. In general, there were significant differences between the SA-attention D and participants' age. In addition, there were significant differences between the SA-attention S and the familiarity with the policies and guidelines relating to resuscitation and resuscitation cart and working area. Finally, there were significant differences between the SA-U and the familiarity with the policies and guidelines relating to resuscitation and the resuscitation cart.

CART READINESS

In this study, a total of 126 cart observations in the 3 main government hospitals were made. Table 4 shows the issues observed by researchers during the data collection process. It is worth noting that although that some of the observed carts were checked several times in the same shift by different participants as required by the study (Figure 3), issues related to readiness failure were observed by researchers. Analysis revealed that in 40 observations (32%), researchers noted empty oxygen tanks being left unfilled. Meanwhile,

TABLE 1
Demographic variables

Variables	Categories	Frequency	%
Sex	Female	296	89.2
	Male	36	10.8
Age group	20-30 y	117	35.2
	31-40 y	167	50.3
	41-50 y	39	11.7
	>50 y	9	2.7
Education	Associate Degree in Nursing	66	19.9
	Bachelor	253	76.2
	Master	13	3.9
Years of work experience	0-1	11	3.3
	2-5	94	28.3
	6-10	114	34.3
	>10	113	34.0
The number of times they reviewed policies and procedures in the past 6 months	0-1	70	21.1
	2-5	142	42.8
	6-10	43	13.0
	>10	77	23.2
Additional training	None	1	0.3
	ACLS or PALS	57	17.2
	BLS	263	79.2
	Mock shock	11	3.3
Unit	Emergency department	68	20.4
	Intensive care units	58	17.5
	General wards and units	206	62.04

ACLS, advanced cardiac life support; BLS, basic life support; PALS, pediatric advanced life support.

drained batteries and equipment failure were observed 20 times (16%). In 8 of these observations, the defibrillator battery was drained, and in 12, the laryngoscope light was not working. Furthermore, 20 observations (16%) revealed a lack of the presence of all adult and pediatric blades and paddles/pads sizes. Missing, expired, and unavailable equipment was observed 19 times (15%) during data collection, as follows: 2 observations revealed missed cables and connectors, 16 observations revealed missing bag-valve masks of different sizes, and 1 observation revealed a missed O_2 flow regulator. In 6 observations, the carts were not secured, and 1 of these observations was found in the emergency department.

These observed issues could contribute to patient safety events. Interestingly, critical care units tend to have fewer issues observed than emergency departments and other wards. As we did not link the checklist to individual participants, no correlation among participant situational awareness and cart readiness was tested in this preliminary study.

Discussion

Reviewing the larger amount of research conducted in psychology, cognition, ergonomics, and human factors and the lesser amount in the health care domain has allowed researchers in health care to understand what situational awareness is and how it can be measured.[20,30] This is the first exploratory research study conducted to evaluate the relationship between hospital clinical nurses, situational awareness during the checking of the resuscitation cart, and their demographic characteristics.

TABLE 2
Results of a one-way ANOVA evaluating associations between situational awareness sum score and demographic variables

Dependent variable	Demographic variable	Category	Mean situational awareness	SD	df	*F*	Sig
	Sex		-	-	330	2.03	.41
Situational awareness overall score	Age	20-30 y	16.15	5.207	3,32	1.641	.18
		31-40 y	16.17	5.051			
		41-50 y	18.05	5.680			
		>50 y	17.56	6.88			
	Education	Associate Degree in Nursing	15.23	6.126	2,33	2.148	.12
		Bachelor	16.70	5.031			
		Master	16.92	3.90			
	Work experience (y)	0-1	15.73	2.901	3,33	3.002	.02*
		2-5	16.49	5.281			
		6-10	15.40	5.394			
		>10	17.45	5.09			
	The number of times they reviewed policies and procedures in the last 6 mo	0-1	15.14	4.927	3,33	4.257	.04*
		2-5	16.37	4.659			
		6-10	15.92	5.806			
		>10	18.33	5.27			
	Additional training	ACLS or PALS	16.12	5.295	2,33	2.84	.63
		BLS	17.21	4.753			
		Mock shock	19.36	5.75			
	Working area	Emergency department	15.60	5.362	2,33	3.24	.43*
		Intensive care units	17.90	4.659			
		General wards and units	16.27	5.31			

ACLS, advanced cardiac life support; ANOVA, analysis of variance; BLS, basic life support; PAL, pediatric advanced life support; SD, standard deviation.
* The mean difference is significant at the .05 level.

SART allows nurses to rate their perception on a variety of scales such as demand, supply, and understanding.[30] This study revealed that the overall situational awareness score from the SART was 16.42, indicating average but not high situational awareness. Participants' scores for each SART dimension (D, S, and U) were 8.59, 14.11, and 10.9, respectively. These results are lower than those reported in literature.[30] Indeed, Salmon et al[30] found that the situational awareness score of military pilots who were involved in a military task was around 19.75, and for S, D, and U dimensions, the results were, 13.9, 20.15, and 13.5, respectively. In another and more recent study, seafarers scored 23.18 overall situational awareness.[31]

Inadequate situational awareness has been linked to the failure of nurses to identify changes in a patient's condition, leading to failure to respond effectively to those changes to prevent deterioration.[19,32] In this context, some researchers have examined nurses' errors and lapses in clinical practice through the lens of situational awareness[20] and concluded that certain adverse patient outcomes resulted from lack of situational awareness. Accordingly, these conclusions were used to initiate quality improvement strategies focusing on improving the situation awareness level.[32]

Researchers have consistently reported that very often resuscitation carts are not ready for life-threatening emergency because of equipment failure or missing or outdated supplies.[33-36] This correlates with the results of this study.

TABLE 3
Results of a 1-way ANOVA evaluating associations between situational awareness dimensions and demographic variables

Dimensions	Demographic variable	df	*F*	Sig
	Sex	330	-1.603	.10
Demand	Age	3,33	3.13	.04*
	The number of times they reviewed policies and procedures in the last 6 mo	3,33	0.86	.46
	Working area	2,33	0.28	.76
	Work experience	3,33	2.41	.07
	Additional training	2,33	0.26	.77
	Education	2,33	0.59	.55
	Sex	330	1.35	.18
Supply	Age	3,33	0.67	.57
	The number of times they reviewed policies and procedures in the last 6 mo	3,33	3.70	.06*
	Working area	2,33	2.98	.05*
	Work experience	3,33	3.02	.45
	Additional training	2,33	2.71	.07
	Education	2,33	2.87	.06
	Sex	330	0.66	.51
Understand	Age	3,33	1.23	.29
	The number of times they reviewed policies and procedures in the last 6 mo	3,33	3.04	.02*
	Working area	2,33	1.12	.33
	Work experience	3,33	1.89	.13
	Additional training	2,33	3.59	.03*
	Education	2,33	1.23	.29

ANOVA, analysis of variance.
* The mean difference is significant at the .05 level.

Such issues raise critical questions about whether this preparedness-related failure be attributed to a lack of situational awareness on the part of the person checking the cart. Thus, nurses who are not practicing with high situational awareness may increase the incidence of lapses and pitfalls,[9,19,37] with the potential to have a critical impact on patient safety.

In this study, results suggest that there is an association between greater experience and higher situational awareness. In particular, we found that there was an association between experience and attention resources of the situation and, consequently, increases in overall situational awareness. This is probably due to the influence of experience on implicit knowledge, which is the knowledge gained without the direct intention of learning.[38] Experiential knowledge is acquired through nurses' experience and mainly used unconsciously.[38] It occurs without intention and in the absence of awareness of what has been learned. Researchers have found that implicit knowledge enhances situational awareness through enhancing attention focus.[39]

Conversely, the explicit knowledge is a conscious learning process and can increase situational awareness.[39] Frequent reviewing of the required policy and procedure in this study is assumed to enhance the explicit knowledge through increasing attention resources relating to the situation, and understanding of the situation consequently increases overall situational awareness. Researchers emphasized the importance of reviewing nurses' compliance with policies and procedures concerning resuscitation cart checking activities.[40] The influence of implicit and explicit knowledge on nurses' situation awareness may have implications for the maintenance of situational awareness during periodic checks of resuscitation cart supplies and equipment. However, little is known about this area of research.

TABLE 4
Common observations of resuscitation cart–related readiness issues

Issues	Emergency departments		Intensive care units		General wards		Total (N = 126 obs)	
	n	%	n	%	n	%	n	%
Oxygen cylinder (empty)	5	4	2	2	33	26	40	32
Missing, expired and unavailable equipment	4	3.1	2	1.6	13	10.3	19	15
Drained batteries or equipment failure	5	4	4	3	11	9	20	16
Unsecured carts (the safety device is not intact)	1	0.8	0	0.0	5	3.9	6	4.7
Size of equipment problem	6	5	3	2	11	9	20	16

In this study, results also suggested that nurses who are working in critical care areas tend to have more situational awareness compared with those working in general wards.[19] This might be because in areas such as critical care, nurses are more vigilant regarding any changes in a patient's condition.[20] Situational awareness is a mindset of vigilance.[41] This result is in agreement with evidence in the previously published literature, as nurses in intensive care units were found to have high level of vigilance in clinical practice.[42] Indeed, studies in cognitive psychology have shown that working in areas that require continuous focused attention increases situational awareness.[41] Adapting training to create behaviors that mimic those necessary for work in critical area environments and improved situational awareness is required for general ward nurses as well.[12]

The common observed issues in this study are drained batteries, equipment failure, inappropriate size of equipment, and empty oxygen tanks. These issues are similar to those previously reported in the literature[43,44] and, in combination, may produce delays in providing emergency intervention[43] and compromise patient safety. Lack of situational awareness may be the contributing factor of these incidents. However, this preliminary study did not examine the association between resuscitation cart preparedness failure and situational awareness. Studies investigating the relationship between situational awareness and resuscitation cart checking activities were not identified in literature to produce conclusive evidence about situational awareness influence. Therefore, we highly recommend additional empirical studies investigating situational awareness in relation to resuscitation cart–related preparedness failure.

Limitations

The study has several limitations. First, although there is a strong claim about the SART ecological validity and diagnostic capability in assessing situational awareness, SART is inherently limited by self-report factors such as recall error. However, this limitation was managed by introducing the tool immediately after completion of the test task to reduce the possibility of failure to recall. Second, the study did not assess whether there are differences in situational awareness scores among the 3 shifts (morning, evening, and night). Perhaps additional studies are required to assess this area of inquiry, for example, the influence of the work shift in participants' situational awareness. Third, participants knew that they were being observed, and this may have influenced their behavior. This limitation was managed by informing participants that their performance would not be double-checked.

Implications for Emergency Clinical Care

This study has assessed the situational awareness of hospital clinical nurses who work within various wards and units, in general, emergency, or critical wards. We recommend further studies be conducted to better understand the specialty-specific situational awareness during cart checks. However, our current study may have several implications for emergency nurses. For instance, training emergency nurses who have not developed a high level of situational awareness can compensate for the shortage of situational awareness. Indeed, training helps develop

understanding of the situation. Information obtained from training experience can quickly and rapidly be recalled during an emergency incident and lead to a more rapid and efficient performance. In addition, training emergency nurses in situations requiring optimum attention is another critical way to ensuring an adequate response to an urgent clinical situation. Such training, when used effectively, can enhance nurses' vigilance, consequently promoting efficient response to emergency situations.

Many of the cart-related readiness issues that threaten the hospitalized patient's safety, including empty oxygen tanks, failure, or inappropriate equipment size, are observable and tangible issues. Creating clinical experience addressing as many of these issues as possible using low- and high-fidelity simulation to identify, practice, and evaluate situational awareness during cart checking procedure can make tangible the situations in which those issues occur.[45] Situational awareness requires utilization of electronic solutions such as a web-based resuscitation cart tracking system.[46] This electronic system is well described and often successful. It alerts nurses to any item missed or near its expiration date.

Emergency departments are highly stressful and dynamic work areas that can affect nurses and patient outcomes. Hence, it is of great importance to change the culture of the institution to empower emergency nurses to check resuscitation carts outside the high traffic areas or areas of high activity, where distractions are less likely. This may reduce factors contributing to cart preparedness–related failure.

In general, investigation of situational awareness with regard to checking the resuscitation cart is still in many ways in its infancy in the nursing emergency field, and the results of this study should be taken as a starting point for further studies to form a clearer picture. Using a more robust study design (eg, interrupted time-series experiment) able to determine the influence of interruptions on emergency nurses' work is recommended.

Conclusion

Situational awareness has been recognized as an essential factor for successful clinical performance in emergency situations. Although resuscitation carts may have hidden issues that could contribute to patient safety events such as expired or inoperable equipment, we cannot confirm whether situational awareness truly accounts for some of these preparedness-related failures. Further research should be undertaken, as this construct can affect patient safety in a life-threatening emergency.

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Author Disclosures

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Burnout and the Sexual Assault Nurse Examiner: Who Is Experiencing Burnout and Why?

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Contribution to Emergency Nursing Practice

- What is already known on burnout and the sexual assault nurse examiner is that vicarious trauma and occupational stressors are significant contributors to sexual assault nurse examiner burnout.
- The main findings of this paper are as follows: Nurses that practice both emergency nursing and sexual assault nurse examiner work (dual function) have a higher frequency of meeting burnout threshold criteria as defined by the Maslach Burnout Inventory.
- The recommendations for translating the findings of this paper into emergency clinical practice include the following: We recommend additional research into the relationship between dual function work and burnout to determine whether mutual exclusivity would help to prevent burnout in sexual assault nurse examiners. Additional studies on the effects of a higher pediatric case mix should be conducted.

Abstract

Introduction: A sexual assault nurse examiner role exemplifies the high-stress and highly emotional patient interactions that are often associated with burnout. The purpose of this study was to examine the frequency of burnout among sexual assault nurse examiners in North Carolina.

Methods: This cross-sectional study was an anonymous survey of practicing sexual assault nurse examiners within North Carolina using the Maslach Burnout Inventory and additional demographics. Results were analyzed with odds ratios, confidence intervals, Fisher exact, chi-square, and Kruskal Wallis tests as appropriate.

Results: Among 95 respondents, burnout was more frequent in sexual assault nurse examiners who stopped both emergency and nurse examiner work (55.6%, odds ratio 4.41, 95% confidence interval 1.07-18.06) and in dual function nurses (both emergency and nurse examiner work, 35.7%, odds ratio 2.71, 95% confidence interval 1.04-7.06). Sexual assault nurse examiners who had a high percentage of pediatric cases (above the median of 40%) were more likely to meet burnout thresholds for emotional exhaustion scores > 26 (48.78% vs 25.93%, $\chi^2 = 5.30$, $P = .02$) and more likely to meet burnout thresholds for depersonalization scores > 9 (48.78% vs 24.07%, $\chi^2 = 6.28$, $P = .01$).

Discussion: Higher frequency of burnout threshold criteria was found in those people who worked concurrently as a sexual assault nurse examiner and an emergency nurse and in those who had retired from both specialties. We also found that sexual assault nurse examiners with a higher case mix of pediatric cases had higher emotional exhaustion scores and higher depersonalization scores.

Key words: Sexual assault nurse examiner; Burnout; Sexual assault; Emergency nursing

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Introduction

SEXUAL ASSAULT NURSE EXAMINERS AND SEXUAL ASSAULT NURSE EXAMINER BURNOUT

Sexual assault nurse examiners (SANEs) are undoubtedly one of the most essential components of a multidisciplinary team that cares for sexual assault patients. SANEs are specifically trained to use age-appropriate, trauma-informed knowledge to conduct timely expert physical assessment, complete thorough documentation, obtain forensic evidence, and prophylactically treat survivors of sexual violence for potential sexually transmitted infections and unintended pregnancy.[1] Furthermore, at the completion of the patient encounter, SANEs provide ongoing services in the form of follow-up recommendations and access to health care, as well as to mental health and legal resources within the community. SANEs serve as the vital link among the medical, legal, and mental health care arenas for survivors. Most importantly, SANEs provide their patients with much-needed emotional support in the aftermath of a sexual assault, an event with significant mental health consequences.[2]

The incorporation of the specialized care delivered by a SANE is increasingly becoming the new standard in the care of the sexual assault patient, establishing the SANE as an invaluable resource. However, SANEs are at risk of vicarious trauma and burnout because of occupational stressors as noted and explored in previous studies.[3,4] For example, one multi-state study noted that more than half of SANEs (67%) reported vicarious trauma and burnout as being some of the most difficult elements of their role caring for survivors of sexual assault.[3] In addition, increased burnout contributes to increased turnover and can result in a decrease in SANE availability.[5] Decreased SANE availability could, in turn, ultimately affect the quality of care offered to patients affected by sexual assault in the emergency department.

DEFINING BURNOUT

The concept of burnout is often used interchangeably with or in close association with other terms such as compassion fatigue, vicarious trauma, secondary trauma, and moral distress/injury; however, in the literature, these terms are separate concepts with overlapping and related, yet different, characteristics.[6] The term burnout has been described by Maslach et al[7] as exemplified by the feelings of emotional exhaustion, depersonalization, and low personal accomplishment. Maslach et al[7] developed a tool to measure burnout called the Maslach Burnout Inventory Human Services Survey (MBI-HSS), which is a 22-question survey to query medical professionals for evidence of burnout in their professional role. Owing to the history of numerous validating studies, the MBI-HSS for medical personnel was selected as the tool used to identify the prevalence of burnout in the selected SANE population. Balancing the questions investigating the effects of burnout are 8 questions examining accomplishments. Although low accomplishment scores are commonly associated with burnout, feelings of competence and successful achievement may be present in professionals experiencing burnout.[8]

SEXUAL ASSAULT NURSE EXAMINER MODELS IN NORTH CAROLINA

There are a variety of different SANE program models used across the state of North Carolina; however, the most common model of accessing specialty care after sexual abuse is in the ED setting. In acknowledgment of the necessity for such specialty care in this vulnerable patient population, the Emergency Nurses Association and the International Association of Forensic Nurses have developed a shared position statement advocating for the consultation of SANEs after sexual abuse whenever possible.[1] This emergency department–based model can blur the role of the SANE and emergency nurse, often requiring serving in both roles. Furthermore, although there is conflicting information about the correlation between duration of practice as a SANE and burnout, the dual role expectations of emergency nurses who also work as SANEs can contribute to the risk of burnout.[3,4]

Unfortunately, in North Carolina, the prevalence and impact of SANE burnout remain unclear. Aggregated state metrics that are specific to ongoing SANE practices are not currently measured. To date, there is no available state-specific information about the prevalence of burnout in SANEs in North Carolina. In the absence of this information, the identification, development, and implementation of protective occupational measures for SANEs as a means of supporting and sustaining this critical nursing specialty are handicapped. Therefore, the purpose of this study was to examine the frequency of burnout among SANEs in North Carolina, with the specific aim of identifying specific burnout factors or characteristics that could be ameliorated. This information could then be used as a foundation for

possible strategy development to help prevent future burnout in this group of specialized health care professionals.

Methods

DESIGN AND ETHICAL CONSIDERATIONS

This study used a cross-sectional survey design. The survey and study protocol were approved as an exempt study by the Wake Forest School of Medicine Institutional Review Board, using the anonymous survey to protect confidentiality. As an exempt study, a written documentation of consent was not required.

SETTING AND PARTICIPANT RECRUITMENT

We sought to recruit SANEs in North Carolina State. We used a convenience and referral recruitment design. To raise awareness and promote this investigation in both the sexual assault nurse and emergency nursing populations, the proposed study abstract was reviewed as a part of new business and announcements during 1 state chapter meeting of the International Association of Forensic Nurses in September of 2018 and 1 state chapter meeting of the Emergency Nurses Association in November of 2018. A link to the voluntary and anonymous MBI survey was also provided in the meeting minutes sent on December 11, 2018, along with the contact information of the study team to assist with any additional questions.

In addition to discussions with the membership of 2 state organizations, emails were sent to prospective participants, and social media private messaging was used to connect with current and previous SANEs between May 2019 and November 2019. The original email was sent a second time to the same group of nurses approximately 6 months following the initial email. All email outreach and discussions in state meetings occurred before social distancing mandates associated with severe acute respiratory syndrome coronavirus 2, concluding January 31, 2020. Emails contained study details, the contact information of the study team for more information, and a link to the MBI survey, providing a convenience sample. In the introduction to the study, we also encouraged the recipients to forward the email at their discretion to those in their professional network who were also current or previous emergency nurses or SANEs. As with the announcement of the study during open meetings, no monetary or nonmonetary incentives were offered or provided for study participation, and no organizational membership list serves were exclusively used for study promotion purposes.

VARIABLES

The survey tool was designed to collect characteristics of SANEs and their practice settings, including emergency nurse experience. Data collected included sex, age, current/former SANE work duration, current/former emergency work duration, yearly ED volume, and highest degree attained. SANEs were asked to estimate the percentage of pediatrics cases that characterized their case mix in their work setting and the percentage of the total sexual assault exam cases they were personally responsible for. Burnout was measured using the MBI.[8,9]

INSTRUMENTS

Although the SANE-related demographic questions of the survey have not been validated, the MBI is considered the criterion standard and has been validated in multiple settings for nurses.[8] We made a license purchase from Mind Garden, Inc, and received permission to use a specified number of MBI forms for use in our study.

The MBI[9] scores, used to measure burnout in our SANE study participants, were as follows. The commonly cited threshold scores of > 26 on the emotional exhaustion scale and > 9 on the depersonalization scale were used to signify a positive result; accordingly, positive results on both scales were used to define meeting the burnout threshold for individual survey responders.[10,11]

ANALYSIS

The data were analyzed using SAS version 9.2 (SAS Institute Inc, Cary, NC). Chi-square, Fisher exact test, odds ratios (ORs), Kruskal Wallis, and logistic regression were used where appropriate to compare groups; $P < .05$ was used to define statistical significance. Moreover, 95% confidence intervals (CIs) were calculated where appropriate. No empirical sample size justification was calculated.

Results

Our study participants consisted of 95 current or former SANEs. Of the 95 nurses studied, the mean age was 46.5 years (SD = 9.3) with a median of 47 years and a range of 28 to 68 years. The mean number of years working as a SANE was 8.67 (SD = 6.37) with a median of 7 years

and a range of 1 to 30 years. For the 80 SANEs who worked in the emergency department, the mean number of years working as an emergency nurse was 12.2 (SD = 9.90), with a median of 10 years and a range of 1 to 42 years.

The 95 SANE survey respondents were categorized into 5 different SANE groups based on current and former SANE and ED work experience (see Table 1, Demographics). The 5 groups consisted of 42 nurses currently working as both an emergency nurse and a SANE, 22 nurses currently working as a SANE but had stopped working as an emergency nurse, 9 nurses who had stopped work both as an emergency nurse and as a SANE, 7 nurses who are current emergency nurses but stopped work as a SANE, and 15 nurses who work as SANEs, but never worked as an emergency nurse. Mean age, mean years as a SANE, mean years as an emergency nurse, and percentage of each group with an advanced, master's, or doctorate degree in nursing are listed in the demographics table.

FREQUENCY OF MEETING BURNOUT THRESHOLDS IN EACH GROUP

Table 2 presents the frequency of each SANE group meeting the threshold criteria for depersonalization (score > 9), emotional exhaustion (score > 26), number meeting both thresholds, and the OR of meeting both criteria, which meets the Maslach criteria for burnout.

Shown in Table 2, when comparing the 5 different SANE groups, dual function nurses who work both the emergency department and as SANEs had a higher percentage of nurses who met the criteria for burnout by Maslach scores, 35.7%, than 26.7% of all SANEs, with an OR of 2.71 (95% CI 1.04-7.06, $P = .04$). In addition, former dual function nurses who are no longer working in the emergency department and as a SANE were more likely to meet criteria for burnout by Maslach scores, 55.6%, than 26.7% of all SANEs, with an OR of 4.41 (95% CI 1.07-18.06, $P = .04$).

Table 3 compares the median Maslach emotional exhaustion, depersonalization, and accomplishment scores of each SANE group.

Subgroup comparison revealed the current dual function nurses, those who currently work as both emergency nurses and SANEs, experience higher median emotional exhaustion scores. When median emotional exhaustion scores of 42 current dual function nurses (median 23.5) are compared with 22 current SANEs who stopped emergency work (median 10.5), the emotional exhaustion scores of dual function nurses are statistically significantly higher by Kruskal Wallis test ($\chi^2 = 8.37$, $P = .01$). Likewise, when the median emotional exhaustion scores of 42 nurses who currently work as both SANE and emergency nurses (median 23.5) are compared with 7 current emergency nurses who stopped SANE work (median 16.0), the emotional exhaustion scores of the dual function nurse are statistically significantly higher by Kruskal Wallis test ($\chi^2 = 4.11$, $P = .04$). With median scores ranging from 34 to 39, we did not find significant differences in accomplishment scores between SANE groups (see Table 3).

TABLE 1
Demographics

SANE group	N	Age		Years as emergency nurse		Years as SANE		Advanced degree* %
		Mean	(SD)	Mean	(SD)	Mean	(SD)	
Current emergency nurse, current SANE	42	45. 3	(10.1)	14.2	(8.5)	7.5	(6.9)	16.7
Current SANE, stopped former work as emergency nurse	22	48.8	(8.3)	13.9	(9.3)	10.2	(6.1)	41.0
Former emergency nurse, former SANE	9	44.2	(6.9)	11.8	(6.6)	5.9	(1.8)	55.6
Current emergency nurse, stopped former work as SANE	7	51.7	(10.0)	22.6	(13.0)	12.0	(6.4)	42.9
Current SANE, never worked as emergency nurse	15	45. 1	(8.4)		Does not apply	9.9	(6.2)	60.0
Totals	95	46.5	(9.3)	12.2	(9.90)	8.67	(6.37)	34.7

SANE, sexual assault nurse examiner.
* Master's or doctorate degree, significant difference by category, $\chi^2 = 12.57$, $P = .01$.

TABLE 2
Respondents meeting threshold levels correlated with Maslach Burnout indices

SANE group	N	Depersonalization score >9		Emotional exhaustion score >26,		SANEs meeting both thresholds		Odds ratio for meeting burnout criteria*	
		Number	%	Number	(%)	Number	(%)	Ratio	95% CI
Former emergency nurse, former SANE	9	6	66.7	6	66.7	5	55.6	4.41	1.07-18.06†
Current emergency nurse, current SANE	42	20	47.6	19	45.2	15	35.7	2.71	1.04-7.06‡
Current SANE, never worked as emergency nurse	15	1	6.7	5	33.3	1	6.7	0.18	0.02-1.43
Current SANE, stopped former work as emergency nurse	22	4	18.2	3	13.6	2	9.1	0.23	0.05-1.08
Current emergency nurse, stopped former work as SANE	7	2	28	1	14.3	1	14.3	0.47	0.05-4.12
Overall	95	Overall, 33 SANEs (36.1%) meet threshold.		Overall, 34 SANEs (38.1%) meet threshold.		Overall, 24 SANEs (26.7%) meet both thresholds.			

SANE, sexual assault nurse examiner.
* Odds ratio for each SANE group meeting threshold criteria for both depersonalization and emotional exhaustion.
† Significant difference, Fisher's Exact test, $P = .04$.
‡ Significant difference, $\chi^2 = 2.72$, $P = .04$.

ASSOCIATION OF INCREASED PERCENTAGE OF PEDIATRIC CASE MIX AND SEXUAL ASSAULT NURSE EXAMINER'S MASLACH BURNOUT SCORES

The mean percentage of pediatric cases was 37.8 (SD = 27.3) with a median of 40% (interquartile range 50). We stratified the different SANE groups by median percent pediatrics cases (see Supplementary Table 1). Using the median of 40% as a cut point, when SANEs who examined a percentage of pediatric sexual assault cases higher than the median of 40%, those SANEs had a higher number of nurses meeting criteria for emotional exhaustion (score > 26, 48.78% vs 25.93%, $\chi^2 = 5.30$, $P = .02$), and a higher frequency of meeting depersonalization threshold criteria (score > 9, 48.78% vs 24.07%, $\chi^2 = 6.28$, $P = .01$). The 2 groups of SANEs who stopped SANE work had a slightly higher frequency of meeting burnout criteria (EE > 27 and DP > 10) than the other combined SANE groups (37.5% vs 22.78%), but this difference did not reach statistical significance because of the small number in this combined group (n = 16).

ASSOCIATION OF HIGHER CASE LOAD PER SEXUAL ASSAULT NURSE EXAMINER AND MASLACH BURNOUT SCORES

SANEs were asked to estimate the percentage of the total cases per year examined by the surveyed respondent at their clinical site. The mean percentage of total cases per year was 28.0% (29.2), with a median of 20% (interquartile range 44). The different SANE groups were stratified by the median percentage of total cases per year. The former emergency nurse, former SANE group and the current emergency nurse, current SANE group had slightly higher percentages of total cases (median 30 and 29, respectively) than other groups (medians 10-20); however, the difference was not statistically significant (see Supplementary Table 2).

ASSOCIATION OF ED VOLUME AND SETTING AND BURNOUT

Four percent of nurses worked at a low volume emergency department (up to 20 000 visits per year), 25.5% worked at a moderate volume emergency department (between 20

TABLE 3
Median Maslach emotional exhaustion, depersonalization, and accomplishment scores

SANE Group	N	Emotional exhaustion scores		Depersonalization scores		Accomplishment total	
		Median	IQR	Median	IQR	Median	IQR
Former emergency nurse, former SANE	9	32	22	13	16	34	6
Current emergency nurse, current SANE	42	23.5	28	8.5	14	38	9
Current SANE, never worked as emergency nurse	15	17	24	3	5	34	15
Current SANE, stopped former work as emergency nurse	22	10.5	12	3.5	5	38	12
Current emergency nurse, stopped former work as SANE	7	16	7	4	10	39	8

IQR, interquartile range; SANE, sexual assault nurse examiner.

000 and 60 000 visits per year), and 70.5% worked at an emergency department with more than 60 000 visits per year. ED volume did not affect burnout scores in the statistical comparisons we performed.

ASSOCIATION OF ADVANCED DEGREES AND SEXUAL ASSAULT NURSE EXAMINER BURNOUT

For all 95 nurses, 19 (20%) had an associate degree, 43 (45.3%) had a bachelor's degree, 31 (32.6%) had a master's degree, and 2 (2.1%) had a doctorate in nursing. Nurses in the former SANE, former emergency nurse group, and the SANE-only group had higher frequency of advanced degrees (defined as a master's or a doctorate in nursing) at 55.6% and 60%, respectively (see Table 1) ($\chi^2 = 12.57$, $P = .01$). We analyzed the frequency of advanced degrees as possibly being protective from burnout. In the group that attained advanced degrees, significantly fewer SANEs met the burnout criteria (4 SANEs [12.1%], OR 0.29, 95% CI 0.09-0.936, Fishers Exact test, $P = .04$). In contrast, 20 (32.3%) of those with associate or bachelor's degrees met the criteria for burnout.

ASSOCIATION WITH AGE

The average age of 24 SANEs that met the criteria for burnout, 42.9 (SD = 8.89) years, was younger than those who did not, 47.7 (SD = 9.2) years. This difference was statistically significant by Kruskal Wallis, test ($\chi^2 = 4.82$, $P = .03$).

MULTIVARIATE ANALYSIS, RELATIONSHIP OF DUAL FUNCTION SEXUAL ASSAULT NURSE EXAMINERS

Detailed earlier, the highest percentage of burnout in active SANEs was found in the current emergency nurse, current SANE, 20 of 42 SANEs, at 47.6%. This relationship appeared to persist in the subgroup that stopped both

TABLE 4
Multivariate analysis, factors associated with criteria for burnout

Characteristic	Odds ratio	95% CI	Standard error	*P* value
Current or former dual function SANE-ED nurses*	4.44	1.30-15.14	0.63	.02†
SANE with > 40% of pediatric cases	2.04	0.71-5.87	0.54	.19
SANE with master's or doctorate degree	0.35	0.10-1.26	0.65	.11
Age	1.05	0.99-1.11	0.03	.12

SANE, sexual assault nurse examiner.

* Defining these nurses as dual function SANEs, we constructed a multivariate logistic regression model to control for other factors that had statistical association with burnout, including age, advanced degree, and percent pediatric case mix, the last of which had near statistical significance.

† Independent association with burnout as determined by Maslach criteria.

SANE and emergency nursing, 6 of 9 former SANEs, 66.7% meeting the burnout criteria.

Table 4 presents the results of the multivariate logistic regression analysis. The only factor that retained independent association with meeting criteria for burnout was dual function status, simultaneously working as a SANE and an emergency nurse.

Discussion

This study is the first to explore the concept of burnout in SANEs in North Carolina using the Health Professional MBI-HSS. Our study group surveyed SANEs who currently work or have worked in the state of North Carolina, to assess their frequency of burnout and determine specific demographics associated with burnout. SANEs are a valuable community resource, so we initiated this study to try and better understand the reasons for burnout in this population of professionals.

As noted in the Results section, there was a higher frequency (a total of 64) of nurses meeting the burnout threshold criteria who worked as dual function nurses, that is, those nurses who either currently work both as an emergency nurse and as a SANE or had previously done so. This finding corroborates findings of other studies and reviews that explore high rates of burnout in nurses[5,12] and in SANEs.[3] Given the high degree of stress and vicarious trauma found in the field of emergency nursing in general, it is not surprising that these feelings would be compounded when combined with another high-intensity, high-stress job such as SANE work.

However, individuals who only work as a SANE but never in the emergency department seem to be somewhat protected, but not immune, from burnout. Only 6.7% of these nurses (total of 15) met the number meeting threshold levels for depersonalization and emotional exhaustion. This is compared with the highest value of 55% met by the former dual function nurses. Again, both emergency nursing and SANE work are inherently stressful and can be emotionally exhausting. Given that there have been no previous studies exploring dual function nursing and burnout, we hypothesize whether the coping mechanisms developed during SANE work and complexities of SANE training help in developing a resiliency that could be overwhelmed when combining both SANE and ED work. This is a finding that deserves further study.

We found that an advanced degree, defined as a master's or doctorate degree, could possibly be protective from burnout. The groups of nurses with the highest frequency of advanced degrees were the former dual function nurses and the SANE-only nurses. We expected that an advanced degree might provide some protection from burnout. A meta-analysis by Zhang et al[13] found an inverse correlation between compassion fatigue and burnout in nurses (not specifically emergency nursing) with master's degrees, and a study by Harolds et al[14] found that physicians with high levels of engagement in their field also had lower levels of burnout. We extrapolated the possibility that obtaining an advanced degree might constitute an advanced level of engagement in one's field, thus reducing burnout.

Our results do not indicate a relationship between ED volume and burnout. Intuitively, one would expect a higher volume emergency department to significantly affect burnout percentages given the possible higher number of overall cases, SANE or otherwise. However, in our findings, although 70.5% of our respondents worked in an emergency department with more than 60 000 visits/year, this moderate to large volume of patients did not have a statistically significant association with burnout. It is plausible that our results are just a reflection of our specific respondents, because only 4% of our nurses worked in a low volume emergency department. An alternative plausible explanation could be that larger volume emergency departments, while likely having a larger number of cases, have more support in place for SANEs, thus preventing burnout. It is also possible that larger volume emergency departments are more likely to support a SANE-only program, thus circumventing the higher burnout rates seen in dual function nurses. More studies will need to be done in this specific area to determine reasons for the associations we observed.

Regarding the estimated percentage of pediatrics in our respondents' case mix, those with a higher percentage of pediatrics (greater than a median of 40%) had a higher number of nurses meeting the threshold criteria for emotional exhaustion and depersonalization. Why a higher pediatric percentage in one's caseload is associated with a higher frequency of burnout is unclear. It may be that these cases involve an extra level of complexity given the inherent differences in childhood communication skills, ability to cooperate with the examination and interview, and the presumed emotional expenditure inherent in navigating the care of childhood survivors of trauma. A higher pediatric caseload is an important factor to consider when trying to ameliorate SANE burnout, given that SANE involvement in pediatric cases had been shown to positively affect the quality of pediatric care after a sexual assault in multiple ways.[15]

Limitations

We have identified several limitations with our study. First, we had difficulty obtaining a comprehensive and complete list of current and past SANEs who practice in North

Carolina given that there is not one uniform database that includes all this information. Instead, we relied on links in state professional meeting minutes, current and past list serves, social media groups, and previous known contacts who are current and/or previous SANEs. This method in which we obtained respondents may have inadvertently led us to leave out possible respondents who may not have been active in the list serve or social media groups, possibly leading fewer responses overall, thus reducing the study's potential sample size, representativeness, and statistical power. We did not empirically justify a sample size a priori.

Owing to the coronavirus disease 2019 pandemic, another limitation is our inability to obtain an adequate control or comparison group consisting of non-SANE emergency nurses as respondents to our survey.

A third limitation is that, of the nurses that stopped both emergency and SANE work, we did not differentiate among SANEs who left the nursing profession entirely and found work in another profession, found a nursing job in another specialty, or retired completely. This is an important distinction because reasons for changing profession or retiring may not be because of burnout, but financial considerations, family situation, or reaching age of retirement. Further distinction of reasons why SANEs stopped working as a SANE/emergency nurse needs to be further delineated to shed more light on the role of burnout in leaving said professions vs other factors.

Although all of the participants who answered the survey were SANE certified, a fourth limitation is that we did not explore SANE certification status (SANE-A, CEN, etc). It is unclear whether attainment of further certification beyond initial SANE certification could be protective against burnout or a contributor. This needs to be further explored.

Finally, it should be noted that, given the number of respondents, demographics of the respondents, and geographic location of our survey population (North Carolina), some results may not be generalizable to all SANE programs.

Implications for Emergency Clinical Care

Multiple sources have investigated the benefits of having SANE involvement in the care of the sexual assault patient. This specific professional involvement not only leads to more accurate evidence collection and documentation resulting in more conviction rates of assailants,[16] but to the quality of care and the attention to ongoing details of further care.[17] Given these evidence-based benefits to this patient population, it is imperative that we start to identify factors that cause burnout in SANEs so that we can begin to ameliorate them. Some suggestions, based on or extrapolated from the results of this study, include limiting or reducing the number of pediatric cases per SANE, allowing for mutually exclusive SANE and emergency nursing work, and availability of peer or other emotional support measures. Overall, we need to understand burnout among SANEs so that we can intervene and mitigate it, both to protect the nursing workforce and to ensure patients affected by sexual assault who present to the emergency department for treatment are getting the best care possible. This will only be possible through understanding the needs of and supporting our SANE workforce.

In addition, ED administrators should consider investing in SANE specific program development in their departments. This will not only serve to train more SANEs but will show an institutional investment in and respect for this nursing specialization. There is already a workforce shortage in SANEs; we anticipate that society cannot afford to lose more of these professionals to burnout. Additional resources and Internet links are provided in the Resources Box.

Conclusions

In our study of SANEs in North Carolina, we found a higher frequency of nurses meeting the burnout threshold criteria in those SANEs who concurrently worked in the emergency department and in those SANEs who no longer work in the emergency department or as a SANE. We also found that SANEs with a higher case mix of pediatric cases had higher emotional exhaustion scores and higher depersonalization scores. Exclusive work as a SANE and possibly decreasing the mix of pediatric cases per SANE may decrease the frequency of burnout in SANEs. A larger study of SANE work practices is needed to help inform ongoing SANE programs to retain qualified SANEs. SANE program directors, with an understanding of the longevity of their current and former SANEs, may benefit from using the results of this study to provide career counseling or other support mechanisms to current SANEs to prevent burnout and promote SANE longevity.

Author Disclosures

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Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jen.2021.10.008.

Resources

1. If you are not already SANE trained and would like more information on becoming a patient advocate or counselor:
   NSVRC: National Sexual Violence Research Center: https://www.nsvrc.org/
2. Resources for patients and families:
   RAINN: Rape, Abuse and Incent National Network: https://www.rainn.org/ There's a 24/7 hotline on this site: 800-656-HOPE, which is the National Sexual Assault Hotline
   NCADV: National Coalition Against Domestic Violence: https://ncadv.org/
   NHTH: National Human Trafficking Hotline: https://humantraffickinghotline.org/ 1-888-373-7888
3. Pediatric Specific:
   NCAC: National Children's Advocacy Center: https://www.nationalcac.org/
   The National Child Traumatic Stress Network: https://www.nctsn.org/
4. Resources for patients and families specific to North Carolina:
   NC Coalition Against Sexual Assault: https://nccasa.org/
   Children's Advocacy Centers of North Carolina: https://cacnc.org/

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Supplementary Data

SUPPLEMENTARY TABLE 1
Percent pediatric SANE cases for SANE groups

Group	N	Median	Interquartile range	Minimum	Maximum
Former emergency nurse, former SANE	9	60	10	0%	75%
Current emergency nurse, current SANE	42	40	45	0%	90%
Current SANE, never worked as emergency nurse	15	40	40	0%	99%
Current SANE, stopped former work as emergency nurse	22	20	40	0%	99%
Current emergency nurse, stopped former work as SANE	7	70	65	0%	80%
Overall score for SANEs	95	40	50	0%	99%

SANE, sexual assault nurse examiner.

SUPPLEMENTARY TABLE 2
Percentage of total SANE cases for SANE groups

Group	N	Median	Interquartile range	Minimum	Maximum
Former emergency nurse, former SANE	9	30	10	1%	90%
Current emergency nurse, current SANE	42	29	60	1%	100%
Current SANE, never worked as emergency nurse	15	20	20	1%	98%
Current SANE, stopped former work as emergency nurse	22	10	25	1%	100%
Current emergency nurse, stopped former work as SANE	7	13	30	0%	90%
Overall	95	20	44	0%	100%

SANE, sexual assault nurse examiner.

Multimodal Quality Improvement Intervention With Dedicated Patient Flow Manager to Reduce Emergency Department Length of Stay and Occupancy: Interrupted Time Series Analysis

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NCPD Earn Up to 11.5 Hours. See page 234.

Contribution to Emergency Nursing Practice

- Crowding in the emergency department is a problem worldwide and can affect patient safety and clinical outcomes. Crowding is a complex issue with a variety of contributing factors: input, throughput, and output factors. Interventions to address input and throughput factors are only successful if departments also address the outflow of patients from the emergency department.
- A multimodal system load-balancing approach quality improvement intervention that includes a patient flow manager can reduce length of stay and occupancy in the emergency department.
- Reductions in ED length of stay may not sustain over time without additional intervention.

Abstract

Introduction: Crowding in the emergency department is a problem worldwide that can affect patient safety and clinical outcomes. The aim of this project was to evaluate a multimodal quality improvement intervention with a new patient flow manager to reduce ED length of stay and ED bed occupancy.

Methods: This single-site interrupted time-series analysis study was conducted in a tertiary hospital emergency department in South Korea. Interventions for a novel system load-balancing approach included a data-driven patient flow tracking informatics system, adding medical specialists, point-of-care creatinine testing (when required before diagnostic imaging) with dedicated imaging test slots for emergency patients, and introducing patient flow managers. Records of adult patients visiting the emergency department from January 2016 to March 2020 were included. Outcomes were ED length of stay and ED bed occupancy. Regression discontinuity analysis of an interrupted time series was used adjusting for seasonality and the number of patients per staff.

Results: A total of 46,494 patients in the preintervention period and 151,802 patients in the postintervention period were included. After the intervention, ED length of stay decreased by 4.07 hours, whereas the slope indicated a return to preintervention levels over time. Monthly average ED bed occupancy decreased by 34.6%, and the slope remained consistent over time.

Discussion: The multimodal quality improvement intervention that included a patient flow manager was an effective intervention to reduce the ED length of stay and the ED bed

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occupancy at the study site. The change for length of stay may not sustain over time without further intervention.

Key words: Bed occupancy; Crowding; Emergency service; Hospital; Length of stay; Patient transfer

Introduction

Crowding in the emergency department is a problem worldwide and can affect patient safety and clinical outcomes.[1-7] Crowding is a complex issue with a variety of contributing factors. Asplin et al[8] developed an ED crowding model that classified contributing factors with input-throughput-output components and stressed the need for a systems approach to solve ED crowding.

AVAILABLE KNOWLEDGE

Some studies reported that ED crowding could be reduced by using a method that addresses input factors, such as case management for ED frequent users or crowd informing to balance the patient loads among emergency departments.[9,10] However, it is difficult to control most input factors such as patient complexity and referral from other hospitals at the hospital level. To increase ED throughput, hospitals have invested in additional resources and implemented changes in the care process. However, investing in additional resources is costly and is only partially effective. In particular, studies have found that additional staffing can be effective, but expanding treatment areas is not as effective.[11,12] Therefore, most current interventions and strategies address care process changes to facilitate patient flow. Although strategies to facilitate patient flow reduced the ED length of stay (LOS) of discharged patients, they did not reduce the ED LOS of admitted patients.[13] These results indicate that interventions targeted at the arrival and evaluation phase are only successful if departments also address the outflow of patients from the emergency department.[3,7,14]

Interventions to resolve the output bottlenecks or blockage include establishing an independent emergency ward and increasing the availability of inpatient beds. The operation of an emergency ward with short turnaround times could reduce the ED LOS of admitted patients.[3] To increase the availability of inpatient beds, numerous hospital-level interventions are needed such as early discharge times, sharing information about empty beds in real time, and increasing bed allocation for ED patients.[6,15,16] For these interventions to be successfully conducted, it is also essential to garner leadership support and cooperation from other departments. However, gaining such support can be difficult, especially when there is an insufficient number of inpatient beds.[15,17] For addressing ED output bottlenecks in such cases, expanding inpatient bed availability by using other hospitals (ie, transferring patients to other hospitals) can be effective as a system load-balancing approach.[18,19]

LOCAL PROBLEM

Because our setting was one of the most crowded emergency departments in Korea for many years, we implemented various interventions to address the crowding: operating an independent emergency ward and emergency intensive care unit (EICU), point-of-care testing (POCT) laboratory, critical pathways to provide standardized care, operating specific patient care areas (eg, minor patients, trauma patients), digital signage to show the waiting list and treatment progress, and diverting emergency medical services (EMS) when the emergency department was full. Despite these interventions, crowding did not improve.

In 2016, new hospital leadership and ED leadership were appointed, who decided that a comprehensive process innovation was needed to address ED crowding. We have begun to investigate all structures and processes that may affect ED crowding. In terms of structure, we did not have a dedicated laboratory, pharmacy service, case manager, or social worker for the emergency room. During the process analysis, we recognized that the existing data were insufficient for detailed process analysis and identified that radiology test turnaround was often delayed. We compared each patient's ED LOS. The ED LOS of admitted patients was the longest, whereas the ED LOS of psychiatric patients was not a priority concern or problem, unlike other countries.[20] The number of psychiatric beds per 1000 population in Korea is 1.25 beds, far exceeding the World Health Organization's recommended level (1 bed per 1000), creating sufficient availability and inpatient capacity to ease the transfer of psychiatric patients out of the emergency department. Here, initial improvement targets included developing a novel informatics tracking system, reducing time to radiologic tests, and reducing boarding time for admitted patients.

AIM

We assumed that a multimodal quality improvement intervention addressing the entire ED throughput and output process was needed. In this study, we aimed to evaluate the effect of the multimodal quality improvement

intervention with a new patient flow manager to reduce ED LOS and ED bed occupancy.

Methods

STUDY DESIGN AND SETTING

This quality improvement study was a single-site regression discontinuity analysis of an interrupted time series. The preintervention period was from January to December 2016, and the implementation period was from January to March 2017. The postintervention period was from April 2017 to March 2020.

The study institution was a tertiary regional emergency medical center in the Northwestern area of Seoul, South Korea. It is a level-1 center with approximately 70 000 patients annually (adults, 50 000; pediatric, 20 000). Before the intervention, ED space was 1502 m^2 with 3 care zones including a resuscitation area, a treatment area, and an observation area. The total number of hospital beds (1778 beds) did not change during our study period. Inpatient beds are grouped into specialized units, which rarely admitted overflow patients from other departments, and bed assignments were partially centralized.

All medical departmental specialists were available 24 hours a day, 7 days a week in the emergency department. The emergency ward and EICU were included in the emergency center, and adult and pediatric emergency departments are separate. Medical equipment such as simple X-ray and ultrasound remained unchanged during our study period. The computed tomography (CT) operation method was changed during the intervention period. At first, 2 CT machines were shared with outpatient department patients, but from November 2017, only 1 unit was operated exclusively for ED patients and 1 unit was changed to operate only for outpatient department patients. The ED endoscopy room operated from 9 AM to 5 PM, but in March 2019, it was discontinued. The total number of nurses, nurse assistants, and other health care personnel in the emergency department also did not change.

PARTICIPANTS

Study participants were patients who visited the adult emergency department from January 2016 to March 2020. The exclusion criteria were patients who cancel the registration due to nonemergency condition. Here, if a patient visits the emergency room with a nonemergency clinical presentation, the provider may perform a simple examination and cancel the emergency registration. In this case, we could not obtain the patients' data, so they were excluded.

ETHICAL APPROVAL

This study was approved by the institutional review board (H-1803-011-925), and all data were stored in a deidentified form.

INTERVENTION

The ED leadership began exploring several interventions with the ED operation committee as follows:

Developing a Patient Flow Tracking Informatics System

Before the intervention, only data on entrance time, initial blood test result report time, radiology test result report time, and discharge time were included in the initial clinical data warehouse, so we could not verify the exact patient flow. Thus, data were added to track the time of events such as triage and time to physician evaluation in November 2016. In addition, it was recognized that real time of disposition-decision time and consultation reply did not match the time clinicians were saving in the medical record, and we developed a new disposition-decision time and reply time input program in June 2017. The new patient flow tracking informatics system could show the amount of time spent for each event in detail.

Setting a Target Time for Each Event With Feedback

A benchmark target time was set for each event and reviewed 3 times a week in the operations meeting. The goal was for each patient to leave the emergency department within 12 hours. If a consultation was needed, the consultant should have evaluated the patients within 3 hours, and disposition should have been decided within 6 hours. The target compliance level was reported monthly to hospital leadership and fed back to each department. If an outlier was observed, the cause was analyzed and addressed. The time to CT was set for 1 hour from prescription to test and magnetic resonance imaging (MRI) for 2 hours.

Changes in Medical Staffing and Physical Treatment Areas

Before the intervention, Korean triage and acuity scale (KTAS) levels 3 to 5 patients were evaluated by emergency residents, level 2 by an emergency specialist, and level 1 by the emergency medical director. After completing the initial

evaluation, patients were referred to the attending resident of internal medicine, neurology, or orthopedic, as needed. After the intervention, some of the level 3 to 5 patients were evaluated by an emergency specialist for a quick treatment decision. After completing the initial evaluation, if needed, patients were referred to the attending specialist of each department. The average number of emergency specialists increased from 11.2 to 15.4 full time equivalents, and they supported the emergency residents. The allocation of work position to specialists was adjusted based on monthly discussions. The number of nurses did not change. However, the number of working nurses (working pattern) in a day was slightly adjusted according to the workload, but, the change was not adjusted as substantial as physicians' work patterns with extra staff and expertise reallocation by KTAS.

In October 2017, the entire emergency department was expanded to 1675 m^2. The number of ED beds (40 beds) did not change, but the distance between the beds was widened in accordance with the national policy for infection management. Physically, the ambulance triage zone was separated to reduce the triage time, and a critical care zone with emergency physician specialists was added to minimize delay in treatment for ambulance patients.

Prioritizing ED Diagnostic Imaging and the Addition of POCT

Before the intervention, we found CT scans were delayed because of the process and time for checking the serum creatinine level before the CT scan. POCT was added to check the serum creatinine level in the emergency department in November 2017. After discussing the delay in MRIs, the existing MRI slots were carefully divided to increase the number of slots allocated to ED patients from November 2017. We checked the time from imaging prescription to test implementation at the operational committee meetings 3 times a week (Supplementary Figure 1).

Introducing Patient Flow Managers

A new policy was enacted to reduce boarding time for admission, which was the biggest obstacle to the 12-hour target. All patients who needed admission care but could not be assigned an inpatient bed at our facility were scheduled for transfer to another hospital. The ED operation committee decided to assign personnel exclusively for patient flow management to operationalize this new policy. Patient flow managers should be experts in predicting the treatment process and prognosis.[2] In addition, they should have communication skills for coordination and counseling for patients.[21] The committee determined that emergency nurses with more than 5 years of experience were appropriate for the responsibilities. Three nurses were appointed as the patient flow managers and changed their role without adding nursing staff to the emergency department.

Patient flow managers were responsible for the 12-hour target performance, but there were no established tasks or job description. Therefore, they had to create the detailed roles and strategies for the patient flow. They discussed the issues with nurses in the emergency center, referral center nurses, and nursing managers. These discussions informed all emergency staff of the patient flow manager's role and helped determine the patient flow manager's detailed tasks. ED leadership was extremely supportive and cooperative.

Patient flow managers were responsible for monitoring patients' timelines through the patients' medical records and arranging the transfer (in and out) process. Generally, the ED bed occupancy in our setting was highest from 2 PM to 6 PM and lowest from 12 AM to 6 AM. In addition, during the night shift, it was rarely possible to transfer patients given the insufficient personnel in other hospitals. Therefore, the patient flow managers' working hours were set from 7 AM to 11 PM (day and evening shifts). One nurse per shift started working in the emergency department in March 2017.

If each event was delayed or a patient was over the target time, the patient flow manager would troubleshoot the issues to prevent further delays. If there was a problem they could not address, they alerted the emergency medical director.

Before our quality improvement intervention, when an outside hospital requested a transfer to the study institution, the emergency medical director was in charge of the reply. If resources of other departments were needed for treatment (ie, surgery), they had to contact the other department's physician to confirm acceptance. However, the emergency medical director was also responsible for the treatment of acute ED patients, so the transfer-in procedure was often interrupted. After the intervention, the patient flow manager identified the patient's condition through a transfer hotline and coordinated the transfer-in process independent of the medical director.

Before the intervention, most of the transfers-out were conducted through the referral center nurses who arranged patient transfers of the entire hospital including the emergency department. This referral center was available from 9 AM to 6 PM. After the intervention, the patient flow manager was in charge of emergency department patients'

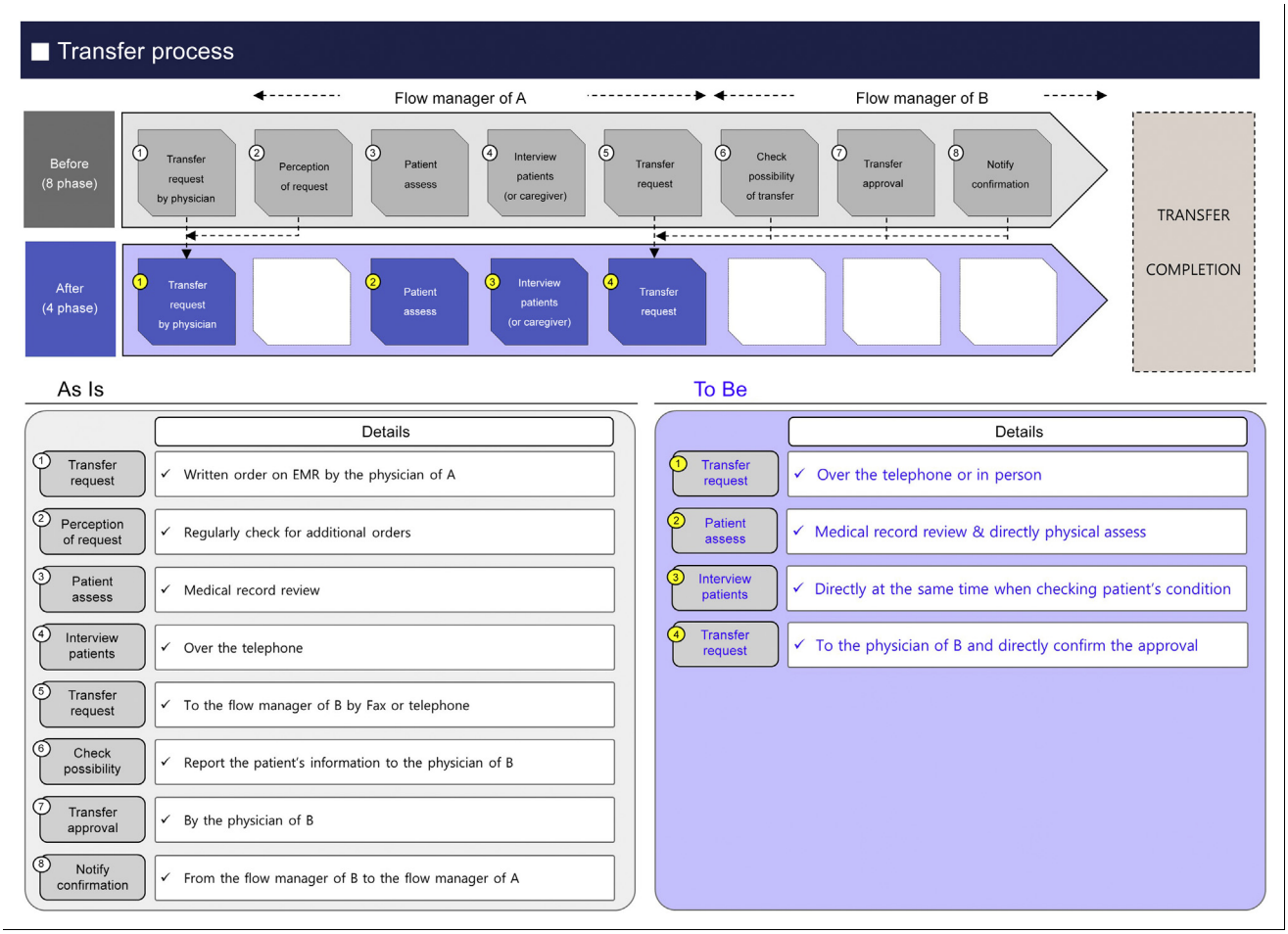

FIGURE 1

Comparison of patient transfer processes pre- and postpatient flow manager deployment. EMR, electronic medical record.

transfer-out process. Patient flow managers were trained at the referral center for a week to learn the transfer-out process. The transfer-out process by the patient flow manager differed in several ways from the conventional method by the referral center nurses (Figure 1). The patient flow manager could directly contact the other hospital's emergency department to receive a fast and definite acceptance answer through the on-call system, which made a speedy transfer possible.

Patient flow managers attended the operational committee meetings 3 times a week. They shared information about the target compliance rate and reported the emergency department utilization rate, the number of transfers (in and out), and all cases of patients who failed to meet the 12-hour target. Additionally, they discussed the possible and likely causes of failure and solutions.

MEASUREMENTS

There is no consensus on an operational definition of crowding, and various indicators have been used to measure crowding.[8,22] In this study, the ED LOS and the ED bed occupancy, the most widely accepted measures, were used as the outcome variables.[23] Patient demographics, reason to visit, route of visit, mode of visit, KTAS level, clinical outcomes, and the ED LOS were collected from the research institution's clinical data warehouse.

We checked clinical outcomes of transferred patients at the beginning of the intervention (from May to September 2017). The clinical outcomes were identified by reviewing the medical records 3 months later. If there was no medical record in our hospital after the transfer, we called and asked for the result (Supplementary Table 1). Clinical outcomes were classified into discharge,

admission, and transfer. Admission was defined as hospitalization to all inpatient wards and intensive care unit (ICU), including emergency ward and EICU. Discharged patients included patients who left without seeing a physician if they initially registered and met our inclusion criteria. The ED LOS was calculated as the time difference between registration and discharge. After analyzing the overall ED LOS, we compared the LOS of subgroups: admitted, discharged, and transferred patients. The bed occupancy rate was calculated using the bed occupancy index (average LOS × total number of patients × 100/the number of beds × 24 hours), which is also used to evaluate emergency medical institutions in Korea.[24]

DATA ANALYSIS

The characteristics of the patients were summarized as percentage, mean, and standard deviation. There were no missing data regarding patients' characteristics and ED LOS. Distribution of patients' characteristics and ED LOS between pre- and postintervention periods was compared using *t* tests for continuous variables and chi-square test for categorical variables, and the difference between 2 periods was presented.

Adjustment for multiple testing was made using Bonferroni correction. The effect of the intervention on monthly average of ED LOS and ED bed occupancy was assessed using regression discontinuity analysis of interrupted time series data.[25] In the analysis, changes in the baseline level and trends between the 2 segments (pre- and postintervention) were estimated after controlling for seasonality and the ED staff to patients ratio (Supplementary Table 2), which was adjusted because the number of patients and ED staff could affect the LOS.[1,7,11] The number of ED staff was calculated monthly by summing up the total working members. For example, if 10 nurses worked the day shift, 15 nurses worked the evening shift, and 10 nurses worked the night shift; the number of staff per day was 35. Residual autocorrelation was assessed by a residual plot, the partial autocorrelation function, and the Breusch-Godfrey test (Supplementary Figure 2). The data were analyzed with the SPSS 22.0 (SPSS Inc., Chicago, IL, USA) and R3.4.0 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

CHARACTERISTICS OF PATIENTS

The total number of cases visiting the emergency department during the study period was 208 303, of which 46 494 cases were in the preintervention period and 151 802 cases in the postintervention period. After the intervention, the number of discharges increased by 1.2%. The total number of admissions decreased by 5.0%, but the number of admissions to all of the ICUs in the hospital increased by 0.4% in the same postintervention period. The number of transfers increased by 3.7% (Table 1).

LOS IN THE EMERGENCY DEPARTMENT

The mean ED LOS was significantly reduced from 9.47 hours in the preintervention period to 5.76 hours after the intervention. Subgroup analysis based on the clinical outcomes showed that the ED LOS of admitted patients decreased the most, followed by transferred patients (Table 2). The regression discontinuity analysis of interrupted time series data revealed that the slope in the preintervention period appeared to slightly decrease (–0.11 hours, $P = .01$). After the intervention, the change in the baseline decreased by 4.07 hours ($P < .001$), and the slope change increased (0.18 hours, $P < .001$) (Table 3, Figure 2).

BED OCCUPANCY RATE

The regression discontinuity analysis of interrupted time series data showed that the slope in the preintervention period slightly decreased by 1.46%, but it was not statistically significant ($P = .19$). After the intervention, the change in the baseline decreased by 34.56%, and the slope increased by 1.91%, but it was not statistically significantly different from zero, meaning there was no change observed over time in the postintervention period ($P = .09$).

DIAGNOSTIC IMAGING TIME

Time to CT and MRI is presented in Supplementary Figure 1.

Discussion

LESSONS LEARNED

This study showed that our multimodal quality improvement project that included patient flow managers could decrease the ED LOS and ED bed occupancy. Patient flow managers were able to reduce ED LOS through continuous monitoring and troubleshooting using data and transfer of patients in need of admission. Transferring patients to other hospitals when no beds were available was a way to

TABLE 1
Characteristics of patients

Characteristics	Total (N = 208 303)		Pre- (a) (n = 46 494)		Implementation (b) (n = 10 007)		Post (c) (n = 151 802)		(c)–(a)		
	N or Mean	% or SD	n or Mean	% or SD	n or Mean	% or SD	n or Mean	% or SD	Mean difference (95% CI)	t/χ^2 value	*P* value*
Sex										0.27	1.00
Male	99 532	47.8	22 243	47.8	4 873	48.7	72 416	47.7	–0.1 (–0.7 to 0.4)		
Female	108 771	52.2	24 251	52.2	5134	51.3	79 386	52.3	0.1 (–0.4 to 0.7)		
Age, y	57	18.6	55.73	18.6	56.77	18.5	57.54	18.57	1.8 (1.6-2.0)	18.38	<.001
Reason to visit										2.89	.63
Disease	182 930	87.8	40 713	87.6	8842	88.4	133 375	87.9	0.3 (–0.1 to 0.6)		
Injury	25 373	12.2	5781	12.4	1165	11.6	18 427	12.1	–0.3 (–0.6 to 0.1)		
Route of visit										303.99	<.001
Direct	164 208	78.8	36 322	78.1	7792	77.9	120 094	79.1	1.0 (0.6-1.4)		
Transfer	30 086	14.4	6288	13.5	1407	14.1	22 391	14.8	1.2 (0.9-1.6)		
OPD	14 009	6.7	3884	8.4	808	8.1	9317	6.1	–2.2 (–2.5 to –1.9)		
Mode of visit										205.10	<.001
Public ambulance	35 835	17.2	7318	15.7	1267	12.7	27 250	18.0	2.2 (1.8-2.6)		
Private ambulance	14 746	7.1	3296	7.1	683	6.8	10 767	7.1	0.0 (–0.3 to 0.3)		
Private vehicle	156 993	75.4	35 811	77.0	8043	80.4	113 139	74.5	–2.5 (–2.9 to –2.1)		
Others	729	0.3	69	0.1	14	0.1	646	0.4	0.3 (0.2-0.3)		
KTAS level										785.56	<.001
1	4375	2.1	889	1.9	181	1.8	3305	2.2	0.3 (0.1-0.4)		
2	25 628	12.3	6368	13.7	1248	12.5	18 012	11.9	–1.8 (–2.2 to –1.5)		
3	116 088	55.7	26 263	56.5	5761	57.6	84 064	55.4	–1.1 (–1.6 to –0.6)		
4	53 476	25.7	11 980	25.8	2643	26.4	38 853	25.6	–0.2 (–0.6 to 0.3)		
5	8736	4.2	994	2.1	174	1.7	7568	5.0	2.9 (2.7 to 3.0)		
Outcome										1471.87	<.001
Discharge	148 451	71.3	32 764	70.5	6927	69.2	108 760	71.6	1.2 (0.7-1.7)		
Transfer	10 741	5.2	1132	2.4	337	3.4	9272	6.1	3.7 (3.5-3.9)		
Admission	48 539	23.3	12 510	26.9	2718	27.2	33 311	21.9	–5.0 (–5.4 to –4.5)		
Ward	40 976	19.7	10 947	23.5	2381	23.8	27 648	18.2	–5.3 (–5.8 to –4.9)		
ICU	7563	3.6	1563	3.4	337	3.4	5663	3.7	0.4 (0.2-0.6)		
Death	572	0.3	88	0.2	25	0.2	459	0.3	0.1 (0.1-0.2)		

SD, standard deviation; CI, confidence interval; OPD, outpatient department; KTAS, Korean triage and acuity scale; ICU, intensive care unit.
* *P* value after Bonferroni correction.

TABLE 2
Comparison of length of stay in the emergency department

	Total		Pre- (a)		Implementation (b)		Post (c)		(c)–(a)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean difference (95% CI)	t value	*P* value*
Overall, h	6.62	8.80	9.47	13.20	6.49	8.84	5.76	6.67	–3.7 (–3.8 to –3.6)	–58.35	<.001
Admitted, h	11.73	12.50	20.06	17.60	12.34	11.86	8.55	7.97	–11.5 (–11.8 to –11.2)	–70.5	<.001
Discharge, h	4.42	5.12	5.14	7.23	3.97	5.34	4.23	4.25	–0.9 (–1.0 to –0.8)	–21.64	<.001
Transfer, h	13.96	13.72	17.68	19.00	10.69	11.84	13.63	12.91	–4.1 (–5.2 to –2.9)	–6.98	<.001
Death, h	6.38	11.56	8.82	12.80	10.35	22.07	5.70	10.37	–3.1 (–6.0 to –0.3)	–2.16	.17

CI, confidence interval; OPD, outpatient department.
* *P* value after Bonferroni correction.

reduce ED crowding and increase the capacity to treat emergency patients by reducing the boarding time.

In Korea, out-of-pocket medical costs are relatively low owing to the national health insurance and ease of access to tertiary hospitals by the general public. Therefore, tertiary hospitals are often preferred by patients, which affects ED crowding. Cha et al[1] reported that only 10 of the 120 levels 1 to 2 emergency departments nationwide were crowded, and severe input was related to crowding. However, the study comparing Pakistan's and the Netherlands' emergency departments indicated that process management is more important than the number of arriving patients and the structure of the hospital. Although Pakistan's emergency departments had more patient visits and sicker patients, the ED LOS in Pakistan was much longer (279 minutes vs 100 minutes) even though there were more staff, ED beds, and inpatient beds.[7] Therefore, the most effective intervention to address ED crowding appears to be facilitating patient flow. Interventions to address patient flow should be a multimodal, hospital-level intervention, not solely an ED-level intervention.

PHYSICAL LAYOUT CHANGES

The study institution created a new critical care area and ambulance (EMS) triage area to facilitate patient flow. Establishing separate areas for patients (ie, dedicated EMS triage area, fast track) in the emergency department has been shown to reduce ED LOS.[5,26,27] In contrast, ED expansion has been shown to increase ED LOS.[12] Thus, functional zoning seems to have a greater impact than expansion on crowding, and our findings provide corroborating evidence to focus on process rather than number of physical treatment bays.

TARGET TIMES

The new patient flow tracking informatics system could show the amount of time spent for each event in detail. However, data such as disposition-decision time and consult reply time, which were not automatically saved and had to be entered by physicians, were insufficient. We

TABLE 3
Change in length of stay and occupancy rate

Variables		Beta (95% CI)	*P* value
Length of stay	Slope in preintervention period	–0.11 (–0.20, –0.03)	.01
	Step change in postintervention period	–4.07 (–4.91, –3.24)	<.001
	Slope change in postintervention period	0.18 (0.09, 0.27)	<.001
Occupancy rate	Slope in preintervention period	–1.46 (–3.61, 0.69)	.19
	Step change in postintervention period	–34.56 (–55.46, –13.66)	<.001
	Slope change in postintervention period	1.91 (–0.28, 4.10)	.09

introduced POCT and discussed with related departments several times to reduce the time to test. CT mostly achieved the target time, whereas MRI did not reach the target time. The introduction of POCT reduced the result reporting time and the time to CT implementation was reduced. However, it is difficult to confirm that this alone reduces the ED LOS because reading time or other factors can affect it.[28]

SPECIALISTS

Another component of the multimodal intervention in our project was the addition of specialists. Initial assessments by these attending specialists could avoid replication of work, and disposition decisions could be made more quickly.[6] However, we could not accurately confirm the effect of the additional placement of specialists on the ED stay period because we could not distinguish specialists from all medical staff in the data.

PATIENT FLOW MANAGER AND INTERFACILITY TRANSFERS

A recent study reported that a disposition prediction model using the patient's data could help the physician's disposition decision and reduce boarding time,[29] but only if an inpatient bed was available. In the study institution, occupancy of inpatient beds was close to 90%; less than 20% of inpatient beds were assigned to the ED patients (excluding emergency wards). The hospital leadership had a long history of attempting to solve this problem, but without success. Given this institutional culture of little coordination across departments, a system load-balancing approach such as off-service placement could not be easily adopted.[30] In addition and in the past, physicians at our site in each department had often pragmatically considered the emergency department as a spare ward for their departments and had their patients treated for days in the emergency department. Therefore, ED leadership decided that all patients who needed admission care but could not be assigned an inpatient bed should be transferred elsewhere. Initially, there was strong resistance from the other medical departments, but the hospital leadership's strong support was the driving force behind this policy.

Patient flow managers monitored patient flow and arranged transfers-out. They were experienced nurses in the emergency specialty, so they could effectively screen patient flow through the electronic medical record system. The system showed the patient list with color coding based on the LOS and whole process in real time. Therefore, they could identify the cause of delay in real time and troubleshoot the problem. Patients were often scared of transfer and thought they were treated as unimportant people. Previous study expressed this psychological state as "slide into insignificance."[31] Therefore, they often refused the transfer-out. To persuade them, staff should explain the purpose of the transfer and be careful not to give the impression of being rushed and to meet the patient and caregiver's expectations and preferences.[32]

Before the intervention, if the patient or caregiver refused the transfer, the arrangement was terminated. The patient flow manager could persuade the patient or caregiver by explaining the patient's condition and necessary treatment in detail. They selected an appropriate hospital that could not only provide the necessary treatment but also meet the patient and caregiver's needs. In addition, they arranged transport personnel, delivered accurate information and medical records, checked for signed consent, and adjusted the follow-up plan to enable continuous treatment.[33,34] Although these efforts are thought to have led to safe transfers of patients, preintervention safety data were not collected, which limits the support for this claim based on our data.

LENGTH OF STAY AND OCCUPANCY

After the intervention, the ED LOS was reduced by 4.07 hours and ED bed occupancy rate by 34.6%. Similar to the present study, some studies confirmed that nurse-led patient flow managers named "emergency journey coordinators" or "navigators" reduced the ED LOS through identifying and resolving any delays.[2,35] Other studies reported that the ED LOS was reduced through patient transfers.[18,19] However, there was no study on cases in which both transfers and patient flow managers were implemented.

Through this quality improvement intervention, the overall ED LOS was reduced, but among them, the ED LOS of admitted patients was the most reduced. The ED LOS in the preintervention period in our study was the longest for admitted patients, so transferring patients who needed admission could be effective in reducing ED LOS. Unfortunately, ED LOS increased toward the preintervention level over time in the postintervention period. It is possible that during the first year the efforts of all staff and help from other departments were concentrated, but that staff fatigue gradually accumulated and support from other departments gradually weakened. This finding suggests that to solve ED crowding over the long term, sustainability of the multimodal interventions and with buy-in from all departments must be addressed.

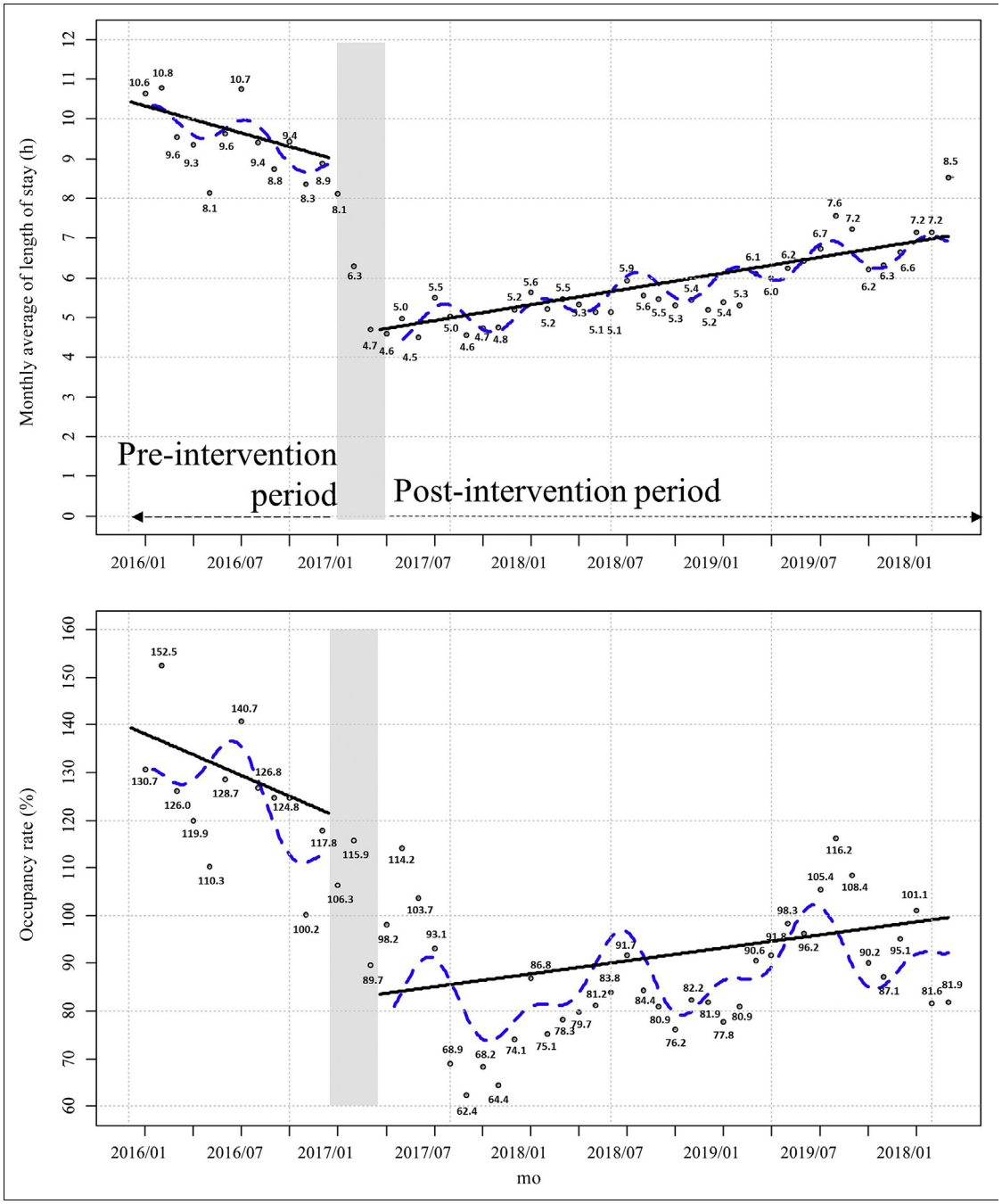

FIGURE 2

Change of LOS and occupancy rate. Note: Blue dotted line = expected values assuming ED staff to patient ratio of 2.96, which is the average of the entire study period; black solid line = De-seasonalized expected values assuming ED staff to patients ratio of 2.96.

DISPOSITION

After the intervention, the discharge rate increased. This is comparable with a previous study reporting that physicians prescribed fewer admissions and reduced unnecessary hospitalizations to address crowding.[36] Reducing ED crowding allows more patients to use the emergency department, especially severely acute patients. In this study, the annual average number of patients in the emergency department increased from 46 494 to 50 600 and patients who were admitted to ICU increased from 1563 to 1887 over the study period. Two contributing factors may explain this trend. First, because the patient flow manager was responsible for transfer-in, the number of transferred-in patients in critical condition increased. Second, after the intervention, the number of total ICU beds had not changed, but the number of EICU beds increased from 12 to 20 beds in July 2017, and conversely, medical ICU beds declined from 20 to 12 beds. This evidence supports that the ED-exclusive ICU is an effective throughput measure, like an emergency ward, to address ED patient flow.[3]

Limitations

This study has several limitations. Many factors were not controlled for in our models, such as physical expansion, the difference in working hours between referral center nurses and patient flow managers, and change of facilities in the emergency department. These may have unmeasured effects on the ED LOS. We could not collect all data related to each intervention, so we could not analyze the exact effect of each component of our multimodal intervention.

Despite numerous studies on crowding, research is still needed on ways to better measure ED crowding.[37] ED LOS and ED bed occupancy rate were used as methods to measure ED crowding in this study. Some researchers[20] have argued that the LOS is significantly influenced by outliers and should be presented as a median value. However, given that the outliers influence real crowding, this study used an average value for comparison. Because the number of ED patients varies greatly throughout the day, the bed occupancy rate should be calculated as the number of patients relative to the real-time bed capacity. However, the bed occupancy rate of this study, calculated based on the number per day, has limitations that do not reflect the actual crowding situation well.[22] Although no additional nursing staff was added to take on the role of patient flow manager, physician staffing was added during the intervention period. Thus, an additional cost analysis should be conducted.[6] Although there was no critical incident reported during the interfacility transport period, the clinical outcome of transferred patients and inpatients should be compared to ensure the safety of the transfer intervention. Finally, it is difficult to generalize the results of the study to other hospitals because this study was conducted in a single institution. It may be necessary to modify the interventions to fit the unique needs and characteristics of each hospital.

Implications for Emergency Clinical Care

This study showed that multimodal intervention including patient flow manager could reduce ED LOS and ED occupancy, although ED LOS increased over time. It is necessary to install an informatics tracking system for detailed data to manage ED LOS, and it is important to monitor the flow of patients in real time using it. However, if the occupancy of inpatient beds is high, only interventions targeted at the arrival and evaluation phase cannot reduce ED LOS. In this case, transfer-out of the emergency department to other hospitals can be considered as a way to address the outflow of patients. Managing ED LOS requires strong and continuous support from all hospital departments and leadership.

Conclusions

In the study institution, a multimodal intervention reduced patients' LOS and the bed occupancy rate. Additionally, the number of patients and number of critical patients increased, suggesting improved ED capacity. To maintain such improvements, institutions need to deploy additional personnel with knowledge, communication skills, and coordination skills, along with continuous interest and support from leadership. Further research is also required on total costs of care and the long-term sustainability of the intervention effectiveness.

Acknowledgments

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Author Disclosures

Conflicts of interest: none to report.

Ethical Approval

This study was approved by the institutional review board (H-1803-011-925), and all data were stored in a form that could not be identified by an individual.

Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jen.2021.12.001.

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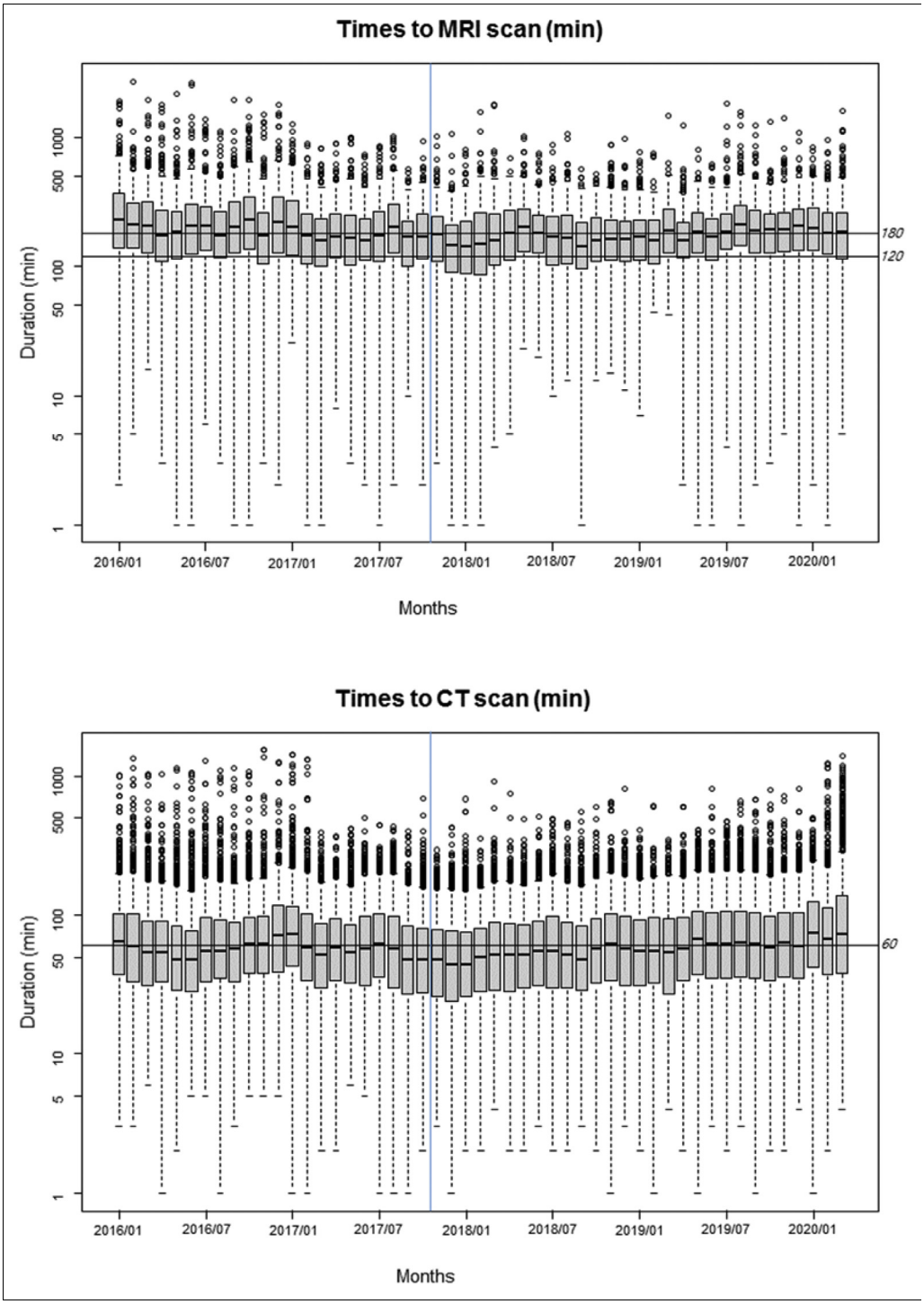


SUPPLEMENTARY FIGURE 1

Time distribution from prescription to implementation. CT, computed tomography; MRI, magnetic resonance imaging.

SUPPLEMENTARY TABLE 1

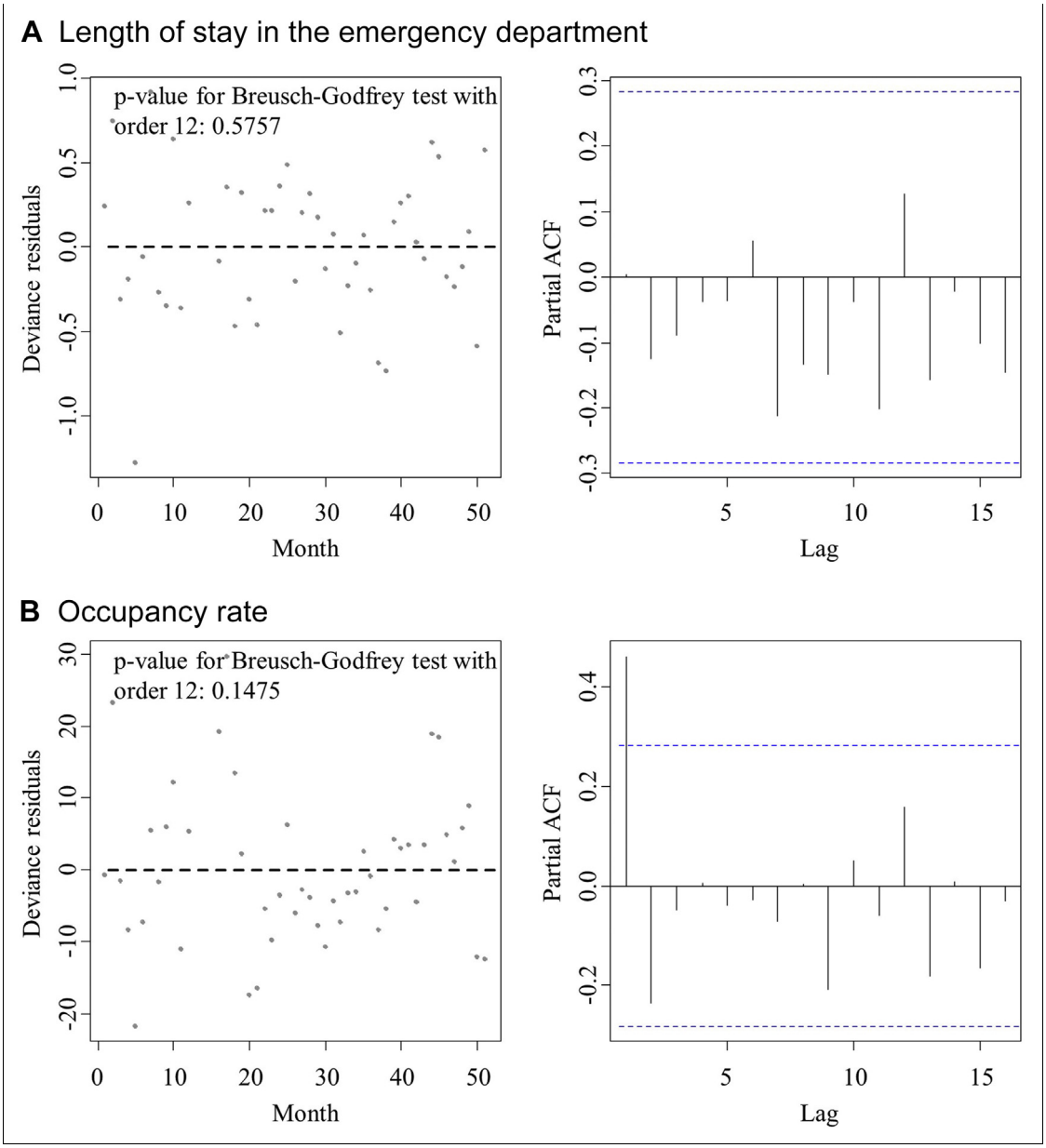
Final clinical outcome at the transferred hospital (N = 730)

Clinical outcome	N (%)
Discharge	558 (76.4)
Hospitalized (long-term care hospital)	20 (2.7)
Revisit to emergency department	29 (4.0)
Admission to study institution	19 (2.6)
Retransfer	9 (1.2)
Death	1 (0.1)
Death	65 (8.9)
d/t pneumonia (age > 85)	5 (0.7)
d/t terminal cancer	60 (8.2)
Unknown	58 (8.0)

SUPPLEMENTARY TABLE 2

Descriptive statistics for ED staff to patient ratio according to periods

Characteristics	Total (N = 51 mo)	Pre- (a) (N = 12 mo)	Implementation (b) (N = 3 mo)	Post (c) (N = 36 mo)	(c)–(a)		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean difference (95% CI)	*t* value	*P* value
ED staff to patient ratio	2.96 (0.28)	3.07 (0.11)	2.51 (0.38)	2.96 (0.28)	0.11 (0.00, 0.23)	2.04	.05



SUPPLEMENTARY FIGURE 2

Assessment of residual autocorrelation. Residual autocorrelation assessment of two outcome variables: (A) length of stay in the emergency department and (B) occupancy rate.

Cardiac Arrest Quality Improvement: A Single-Center Evaluation of Resuscitations Using Defibrillator, Feedback Device, and Survey Data

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Section Editor: Mohamed El Hussein, PhD, RN, NP

NCPD Earn Up to 11.5 Hours. See page 234.

Abstract

Background: High-quality cardiopulmonary resuscitation is foundational to cardiac arrest care. Visual feedback devices can improve chest compression quality, but are infrequently used. Quality improvement data were examined to determine whether handheld visual feedback and backboard use improved chest compression quality, whether resuscitation team size affected resuscitation indicators, and whether feedback sources are comparable.

Methods: From August 2019 to December 2020, data from 50 resuscitations were collected using a handheld device (n = 35), defibrillator (n = 23), and surveys (n = 35) and shared with providers. Aggregated and individual case data, along with education and research, were distributed to staff as quality improvement measures.

Results: The mean duration of resuscitation was 1080 compressions (SD = 858); there were no differences in the durations of resuscitations that did or did not use handheld feedback; 50% of resuscitations used handheld feedback and had more compressions at target rate (74.68% vs 42.18%, $t_{(21)} = 2.99$, $P = .007$). Moreover, 25% of resuscitations used backboards; these had more chest compressions at target depth (72.92% vs 48.73%, $t_{(25)} = 2.08$, $P = .048$). Team size was not associated with duration of resuscitation or chest compressions quality. There was no improvement in other quality indicators (leadership, family presence, or debriefing) during the data collection period. Feedback sources (defibrillator and feedback device) had good agreement and correlation (r = 0.77, $P = .01$).

Conclusions: Incorporating handheld feedback and backboards improved chest compressions quality. Further work to improve the frequency of device use and to examine their relationship to patient-specific outcomes is needed. Study is needed to find interventions that improve other teamwork

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metrics, inclusion of family during the resuscitation, referral for tissue donation, and rates of postevent debriefing.

Key words: Cardiopulmonary resuscitation; Feedback; Quality improvement; Chest compression; Resuscitation

Introduction

Cardiac arrest is a leading cause of mortality,[1] and basic interventions such as high-quality chest compressions can improve defibrillation success,[2] the likelihood of return of spontaneous circulation,[3,4] and neurologically intact survival.[5] International resuscitation guidelines promote high-quality chest compressions[6] and continuous quality improvement (CQI) to improve resuscitation performance and survival.[7] Unfortunately, chest compressions quality is often suboptimal,[8–10] and despite chest compression feedback devices having been shown to improve compression quality[9–11] and survival,[12] they are often not available to clinicians.[13–15] Moreover, reviews have shown that other simple nurse-led interventions such as backboard use during simulated cardiopulmonary resuscitation (CPR) improve chest compression depth, but these have apparently not been assessed clinically.[16–18] CQI initiatives, despite having shown mortality benefit,[19,20] often face barriers to full implementation and frequently lack comprehensive data reporting.[14]

This project addressed the quality improvement (QI) problems of low chest compression quality, unknown optimal resuscitation team size, and whether chest compression quality measures obtained from different devices were comparable or not. This project used survey data to correlate data from 3 sources and describe quality indicators for cardiac arrest care. Correlating these data allowed for an examination of the reliability of data from different chest compression feedback sources and demonstrates that simple nurse-initiated interventions such as visual chest compression feedback and backboard use can increase chest compression quality metrics.

Methods

This project retrospectively examined resuscitation data that were collected from a single-center CQI project within a single emergency department. Data were collected using surveys and defibrillator and feedback devices. Results were communicated to staff in feedback cycles.

DESIGN

This was a retrospective analysis of QI data that were collected from consecutive resuscitations performed over a 5-month period. Data were collected as part of an ongoing CQI initiative to improve cardiac arrest care using 3 existing data collection sources already in clinical practice: handheld visual feedback devices (CPRmeter 2, Laerdal Corp, Stavanger, Norway), LifePak 20 Defibrillator (Physio-Control Corp, Redmond, WA), and a locally developed QI feedback survey (Supplementary Appendix 1) that measured priorities set as part of a province-wide priority setting and consensus exercise.[21]

QUALITY IMPROVEMENT FEEDBACK CYCLES

Resuscitation data were shared with staff after each resuscitation, monthly, and quarterly. Individual resuscitation case data shared with staff included the device generated resuscitation reports from the CPRmeter 2 (Supplementary Appendix 2) and LifePak20 (Supplementary Appendix 3) for individual cases and aggregated resuscitation data in the form of a dashboard that detailed the percentage of cases using feedback and chest compression rate, depth, and release (Figure 1). Anonymized individual resuscitation case data were posted on a CQI board that was hung outside the resuscitation space and in the breakroom. In addition, staff were notified of updates using social media. Monthly reports were generated and distributed to staff and leadership as part of the department's QI council. Quarterly education focused on the clinical effects of backboard and feedback device use in the department and highlighted studies that support their use. Education was distributed to staff on the CQI notice board and by email.

SETTING AND ETHICS

Data collection occurred between August 2019 and December 2020 and included the period from clinical incorporation of the visual feedback devices to the point at which data collection was halted because of the incorporation of LUCAS mechanical CPR devices (Physio-Control Corp, Redmond, WA) to limit the number of staff exposed to CPR-related aerosols[22] and the cessation of data collection owing to the redeployment of the principal investigator to support clinical operations during the coronavirus disease 2019 (COVID-19) pandemic. The emergency department is located in a community hospital that services 50 000 patients per year and is one of 4 metro hospitals serving a population of 1.4 million people.[23] Data were collected as part of a multiyear QI initiative. The project received institutional and regional operational approval. Ethical evaluation

was performed using the A Project Ethics Community Consensus Initiative ethics guideline tool,[24] an online tool for determining levels of ethical risk and level of required ethics review. Data were collected without patient identifiers and as a routine practice for QI; therefore, it was assessed as low ethical risk and did not require full institutional review board ethics review. This project is reported according to the Standards for Quality Improvement Reporting Excellence 2.0 guidelines.[25] Our CQI project was based on the guiding principles of the systems of care and CQI methods of the 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[7] Our CQI project attempted to improve patient care by highlighting beneficial processes changes (use of backboard) and by providing feedback equipment. The CQI project also attempted to improve the overall culture of our emergency department by adopting a just culture and a philosophy of continuous learning and improvement. Micro and macro plan-do-study-act cycles[26] were performed by CQI team leads and ED staff.

PROVIDERS

Provider demographics were not routinely collected for local QI initiatives. However, resuscitation teams comprised specially trained and licensed emergency care providers (ED physicians and nurses and prehospital providers) all of whom are required to maintain annually recertified CPR training as a condition of employment. The QI team consisted of 2 clinical nurse educators, the patient care manager, the zone clinical nurse specialist, and a project lead from another site in the zone. The program manager was responsible for clinical oversight, and the educators were responsible for data collection, feedback, and education. The zone clinical nurse specialist and project lead assisted with gaining project approval, data analysis, and manuscript preparation.

OUTCOME MEASURES

Data collection occurred within the context of QI, and the use of devices and submission of feedback forms were not mandated but left to clinician discretion. As a result, not all resuscitations have complete data from all 3 data collection sources (handheld feedback device, defibrillator, and survey). When multiple data sources were available, they were correlated by matching the resuscitation date/time data and in the case of surveys with a patient label that was affixed to the survey.

Data collected from the CPRmeter 2, a handheld device that was affixed to the patient's sternum using double-sided adhesive, included the time and duration (minutes) of the resuscitation; number of chest compressions; flow fraction (duration of time with chest compressions/duration of time without); mean chest compression depth (mm), chest compression rate (compressions/minute), peak force in kilograms (kg), and cumulative pause time; and percentage of chest compressions at the target depth and recoil (2 inches or 5 cm) and rate (100-120 compressions/min).[27] These data were automatically recorded whenever the device was used and were downloaded using an accompanying computer application.

Data collected from the LifePak20 defibrillator included resuscitation time and duration, longest pause in chest compressions, number of chest compressions, number of pauses in chest compressions over a 10-second duration, mean chest compression rate, chest compression ratio (duration of time with chest compressions/duration of time without), and minute-to-minute breakdown of chest compression rate. These data were automatically recorded by the defibrillator and downloaded by infrared cable using CodeStat 11 (Physio-Control Corp, Redmond, WA). The inclusion of LifePak20 data allowed the QI team to assess how many resuscitations had data collected through the handheld feedback device and survey.

Data collected using the postresuscitation QI feedback survey included date, time, recorder, and patient demographic information so that follow-up could be performed if needed; fixed response fields for patient arrival and handover; resuscitation parameters that included team size, satisfaction with the number of providers, use of a backboard, and other interventions; feedback device evaluation; postresuscitation debrief data; and free-text space for staff to offer feedback on what went well and what could be improved (Supplementary Appendix 1). Data collection was voluntary and feedback surveys were returned to the QI project leads for extraction.

STATISTICAL ANALYSIS

Data from each source were matched, when possible, using device dates and times and were extracted by the clinical educators (authors C.P. and R.D.) into Microsoft Excel (Redmond, WA, Microsoft Corp). Statistical analyses were performed using IBM SPSS statistics 26 (IBM Corp, Armonk, NY). For descriptive statistics, normally distributed data were described using mean and standard deviations; for nonnormally distributed data, median and interquartile rangers were used. Differences in chest compression quality and duration of resuscitations between resuscitation that did and did not use a feedback device or a backboard were

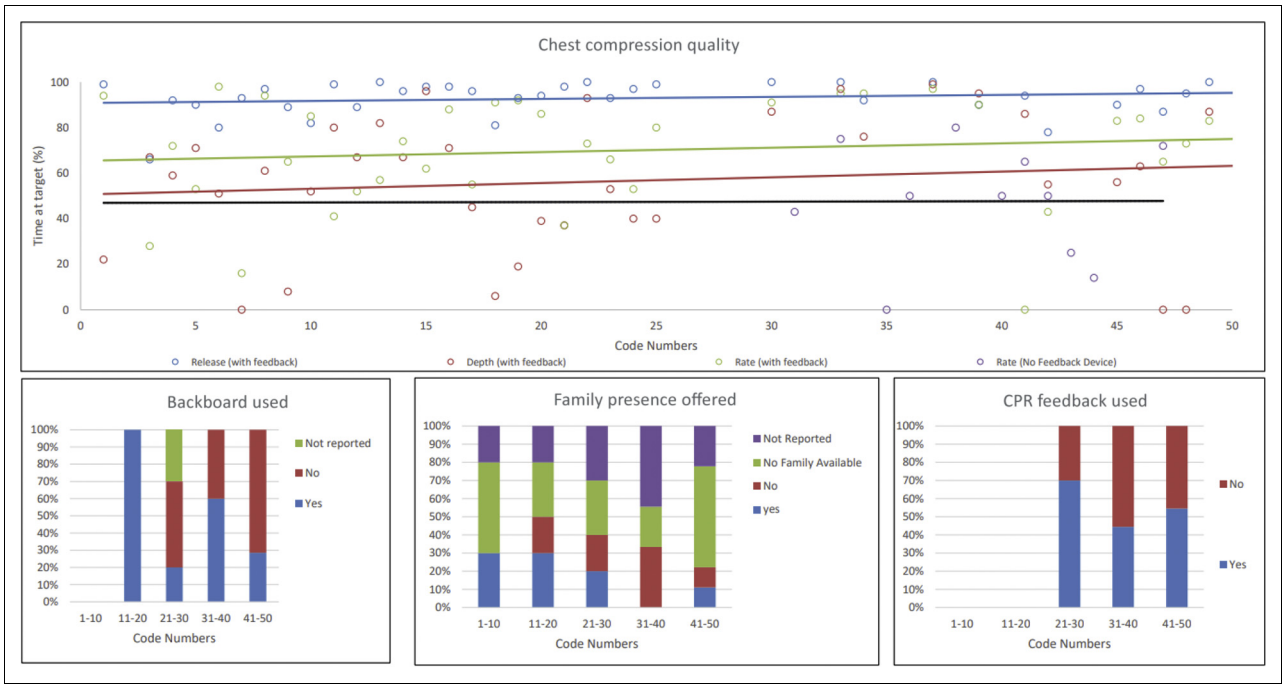

FIGURE 1

Cardiac arrest CQI dashboard used for staff feedback. CPR, cardiopulmonary resuscitation; CQI, continuous quality improvement.

compared using independent *t* testing. Differences in chest compressions at the target depth, release, and rate between the numbers of staff involved were assessed using analysis of variance. Differences in survey responses during the second half of data collection (when both CPRMeter2 and LifePak 20 data were available) were examined using the Fisher exact test. Agreement between the resuscitations that were evaluated using 2 tools were compared using paired *t* testing, Pearson correlations, and Bland-Altman plots. All tests were 2-tailed with predetermined significance levels set at a = 0.05.

Results

FEEDBACK CHARACTERISTICS

There were 50 resuscitations included in our analysis. Data collection using the CPRMeter2 and feedback survey occurred between August 2019 and December 2020. Because of administrative barriers and delays, LifePak20 data collection occurred between June 2020 and December 2020. A total of 35 resuscitations had data collected using the CPRmeter 2, 23 resuscitations had data collected using the LifePak20, 35 resuscitations had data collected using the feedback survey, and 10 resuscitations had data collected using all 3 methods (see Figure 2).

FEEDBACK SURVEY DATA

The feedback survey offered insights into resuscitation performance and staff perceptions and provided a means for making comparisons. Staff reported that a high proportion (more than 90%) of resuscitations had a clearly identified team leader and preassigned roles, that 80% of resuscitations were conducted with 4 to 7 staff members, and that staff were generally satisfied with the team size (Supplementary Appendix 4). There were 24 resuscitations occurring during the full data collection period. During this period, we saw no significant improvements in survey completion rates; end-tidal carbon dioxide use, preassignment of provider roles, clear identification of a leader, noninterruption rates during emergency medical service handover, smoothness of transfer, rates of referral for tissue donation, rates of debriefing, and rates of offering a bereavement package; or the number of staff (and satisfaction with staffing) present during resuscitations (Supplementary Appendix 5). In addition, there were no improvements in the rates of inclusion of family members

in the resuscitation or the use of backboard and feedback devices (Figure 1, Supplementary Appendix 5). Despite the remaining data fields having high (>25%) nonresponse rates, the survey data allowed us to group and compare feedback device measurements according to resuscitations team size and presence or absence of a backboard.

HANDHELD DEVICE FEEDBACK

Measures unique to the CPRmeter 2 were mean compression depth (mm) and peak force and the percentages of compression at target depth and recoil. Using these measures, we were able to compare resuscitations with and without a backboard and found that resuscitations utilizing a backboard achieved target depth on 72.92% (SD = 27.64, n = 12) of compression compared to only 48.73% (SD = 31.90, n = 15) of compressions when no backboard was used. Use of the backboard was associated with a mean difference of 24.18% (CI = 0.018-48.19) more compressions achieving the target depth of 2 inches, t(25) = 2.08, $P = .05$ (Figure 3). We did not find that there was a difference in the duration of resuscitation attempt or percentages of chest compressions at the target depth, release, or rate (all $P > .05$) between resuscitations with different sized teams (Supplementary Appendix 6).

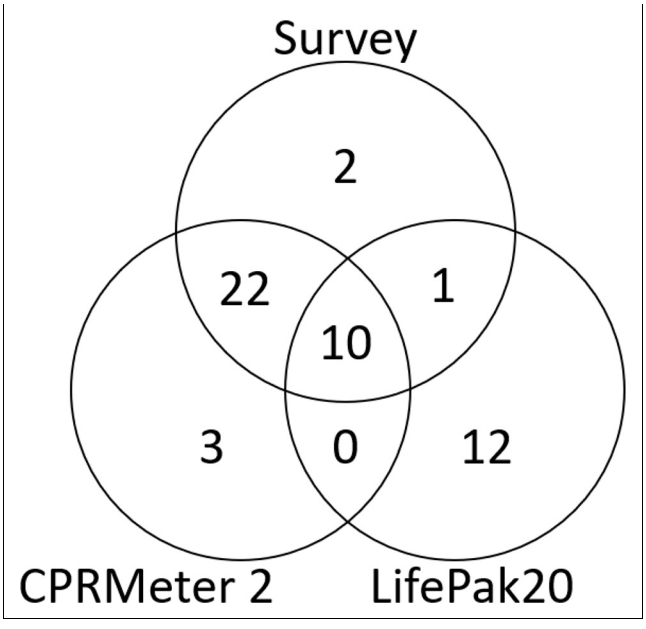

FIGURE 2

Number of cardiac arrests by data collection type.

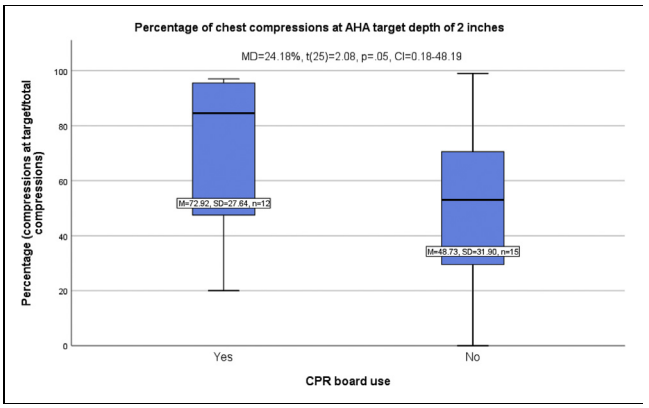

FIGURE 3

Effects of backboard use on chest compression depth. AHA, American Heart Association; CPR, cardiopulmonary resuscitation; M, mean; MD, mean difference; CI, confidence interval.

DEFIBRILLATOR FEEDBACK

The defibrillator measured the same variables as the CPRmeter 2 and allowed us to make some inferences about the effect of visual feedback. There were no differences ($P > .05$) in duration (number of compressions) of resuscitations that used a defibrillator for feedback (M = 1103.00, SD = 711.02, n = 10) versus those with handheld visual feedback (M = 942.18, SD = 973.96, n = 11). When we examined the percentage of chest compressions at target rate (100-120 compressions/min) measures made by the defibrillator for resuscitation with (M = 74.68, SD = 22.39, n = 12) versus without (M = 42.18, SD = 29.63, n = 11) feedback, we found that those using visual feedback had 33% more chest compressions at ($t_{(21)} = 2.99$, $P = .007$) target rate (Figure 4). When we compared resuscitations that had quantitative measurements using both devices, there was a strong correlation between devices (r = 0.771, $P = .005$, n = 11) and no significant difference in the mean percentages (M = 0.0039) measured ($t_{(10)} = 0.01$, $P = .99$), with all values falling within the Bland-Altman confidence intervals of −36.72 and 36.72 (Figure 5).

Discussion

We successfully implemented a low-cost and impactful CQI cardiac arrest initiative that significantly improved resuscitation quality in multiple ways: we increased the percentage of chest compression within target range for rate (100-120 compressions/min) and depth (2 inches or 5 cm)[27] and determined that our resuscitation team size did not seem to affect

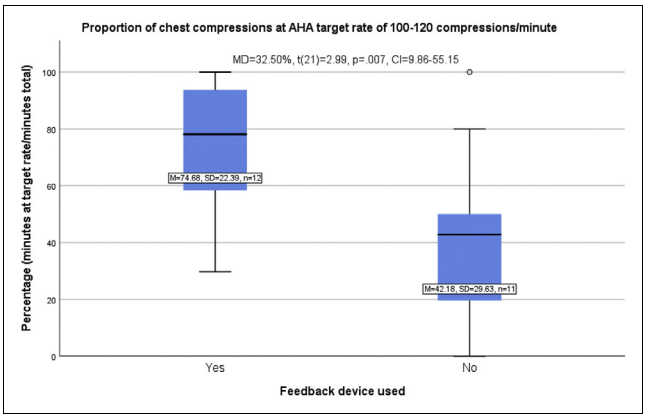

FIGURE 4

Effects of visual feedback on chest compression rate. AHA, American Heart Association.

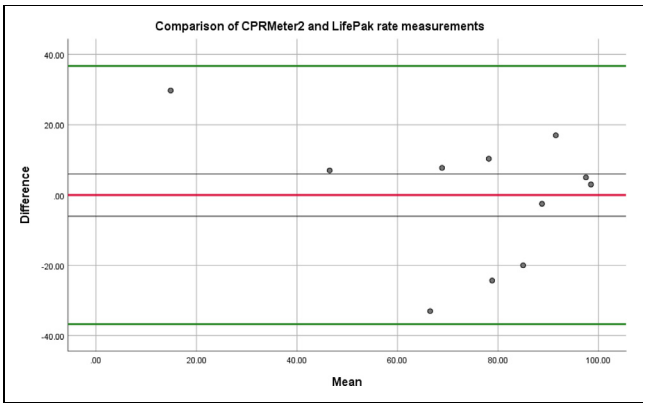

FIGURE 5

Bland-Altman plot comparing chest compression rate measurements.

chest compression performance. We determined that different methods of obtaining chest compression performance metrics are comparable and we affected the culture of cardiac arrest care in a meaningful and sustainable way.

The postresuscitation feedback surveys suggest that there was generally good team function and dynamics, and these findings align well with survey data from other countries.[14] Because the overwhelming majority of survey responses reported preassigned roles and a clearly identified leader, we were unable to examine the effects of leadership on resuscitation outcomes: future studies could consider finding objective measures for assessing leadership because staff may feel uncomfortable offering criticism of the team. The low rates of chest compression feedback use at our site are surprising given that the majority of Canadian emergency physicians (72.3%) in one study reported feedback devices should be a standard of care.[13] This may suggest that the decision to not use a feedback device may have been driven by other providers (eg, nursing staff) or that other tasks (eg, bed transfers, vascular access) may have taken priority. The increased rate of no family presence during COVID-19 and the low rates of structured debriefing at our site are comparable with other studies,[14,15] but these numbers need to be interpreted cautiously given the high nonresponse (data field left blank) rate. There were other survey fields that were frequently left blank (Supplementary Appendix 4); these questions directly addressed quality indicators and responses tended to be either positive or the field was left blank, despite other fields being completed. Previous research suggests that the decision to leave the field blank could be caused by the negative valence associated with reporting noncompliance with accepted best practices (and could represent social desirability bias)[28]; however, more research is needed to determine whether this phenomenon is true in resuscitation research.

Data from the postresuscitation feedback survey allowed us to compare resuscitations that did, or did not, use a backboard. Despite many previous studies assessing the effect of chest compression surface on compression depth, a 2020 systematic review[17] and subsequent guideline update[18] suggest there are insufficient data to make strong recommendations on their use. A 2020 systematic review performed by the International Liaison Committee on Resuscitation did not find any clinical studies examining the effects of backboards on CPR in the clinical setting, suggesting that our results may the first of their kind.[17] However, these findings do need to be interpreted with caution given that depth measures provided by feedback devices may not accurately measure compression depth when performed on soft surfaces such as a mattress.[29]

The handheld visual feedback device seemed to improve chest compression rate compared with not using a device. This has been previously noted in simulation study data,[10] but as of a 2020 systematic review the CPRmeter 2 had not been assessed in a clinical setting, suggesting that these data may also be novel in the literature.[30] Although previous research has examined resuscitations using 2 data sources, our comparison between these 2 devices is novel for 2 additional reasons: the devices assessed and the analyses performed. There is limited previous research that examined resuscitation data from more than one device. One similarly structured study examined clinical resuscitation data gathered from CodeStat and a handheld feedback device data, but they did not compare the data sources.[31] Furthermore, there was one clinical study that evaluated handheld visual feedback device measurements using video analysis; they found that because of poor interrater agreement they were

not able to compare the measures.[32] Simulation studies have compared the measured rates and depths by different devices using manikins with built-in chest compression analysis sensors and found that the rate measurements were comparable.[33–36] Despite the emerging literature, there is an absence of data comparing the CPRmeter 2 with LifePak20 measured rates or comparison of multiple cross device measurements in a clinical setting. Our findings suggest that there is agreement between the CPRmeter 2 and LifePak20 measured rates and that they are a reliable method for assessing chest compression rate in clinical settings such as emergency departments.

LIMITATIONS

The findings in this analysis should be interpreted in light of the nonexperimental and retrospective nature of QI data, the patients typical to a predominantly adult community hospital population, the effects COVID-19 had on the data collection period, and limited collection of patient information. Although visual feedback seemed to improve chest compression rates in our sample, an experimental study is needed to determine whether the relationship is causal of the noted improvements. Likewise, establishing whether our noted correlation between improved chest compression depth and backboard use is causal would require an experimental design. Although we found the rate measurements generated by the LifePak and CPRmeter 2 to be comparable, the sample size was small and thus the comparison should be approached with caution. The survey data and chest compression metrics should be interpreted understanding that the resuscitations occurred at a nontrauma center community hospital and that the needs associated with special populations such as pediatric or traumatic cardiac arrests are likely quite different. The unprecedented impact of COVID19 resulted in the implementation of mechanical CPR and cessation of data collection. The incorporation of mechanical CPR reduced the number of standard CPR resuscitations. The redeployment of the principal investigator resulted in the abandonment of the CQI program. In addition, COVID-19 will have influenced many of the decisions made by the resuscitation team: the number of rescuers and ability to facilitate family presence during resuscitations, as well as postarrest tissue donation and debriefing. Finally, the outcome measures for this QI project did not include patient- or provider-specific data, and as a result, we are unable to report on patient-specific factors such as age and sex, patient-important outcomes such as return of spontaneous circulation and short- or long-term survival, or the effect that individual provider's characteristics (experience, fatigue, body stature, etc) may have had on performance.

Implications for Emergency Clinical Care

Continuous quality improvement may improve performance and patient outcomes. Chest compression feedback can improve chest compressions quality in simulation studies. Guidelines have supported chest compression feedback in practice, but there is a paucity of data describing whether devises that provide chest compression feedback improve care or patient outcomes, and whether different methods of assessing compressions have been compared.

This paper presents 4 findings: (1) visual chest compression feedback increased the percentage of chest compression within target range, (2) backboard use improved chest compression depth, (3) resuscitation team size was not associated with an overall performance, and (4) chest compression rate measurements made by different devices were comparable.

Continuous quality improvement of cardiac arrest care can be supported using defibrillators or handheld devices to guide chest compression performance. However, handheld visual feedback devices offer more data. Simple interventions like backboards and visual feedback can improve chest compression quality. Further research is needed to determine whether measures are consistent across different feedback devices and whether visual feedback improves outcomes.

Conclusions

Our work suggests that nursing-specific interventions such as the incorporation of handheld CPR feedback devices were associated with improved chest compression rates. Our work seems to be the first clinical (nonsimulation) study to show that backboard use during CPR is associated with an improvement in chest compression depth. We did not find that team size had an effect on resuscitation duration or performance and that the measures obtained from 2 sources were not significantly different. Further study is needed to compare the measurements made by similar different devices to see whether all devices have comparable measurements. Our data also suggest that additional investigations are needed to determine why providers do not use feedback devices and that additional supports may be needed to incorporate handheld feedback devices into more resuscitation attempts. The improvements we noted

in chest compression quality suggest that further research is needed to determine whether chest compression feedback devices are associated with changes in patient-specific clinical outcomes such as mortality and neurologically intact survival.

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Christopher Picard reports that Styker (Physio-Control) provided the software used for this project, but had no influence or participation on the design, conduct, or data analysis. Matthew J. Douma reports that Laerdal has provided resuscitation equipment for the purposes of resuscitation evaluation and research although they have had no influence on the design, conduct, or analysis of any project. The other authors have no conflicts of interest to report.

Supplementary Data

Supplementary data related to this article can be found at https://10.1016/j.jen.2021.11.005.

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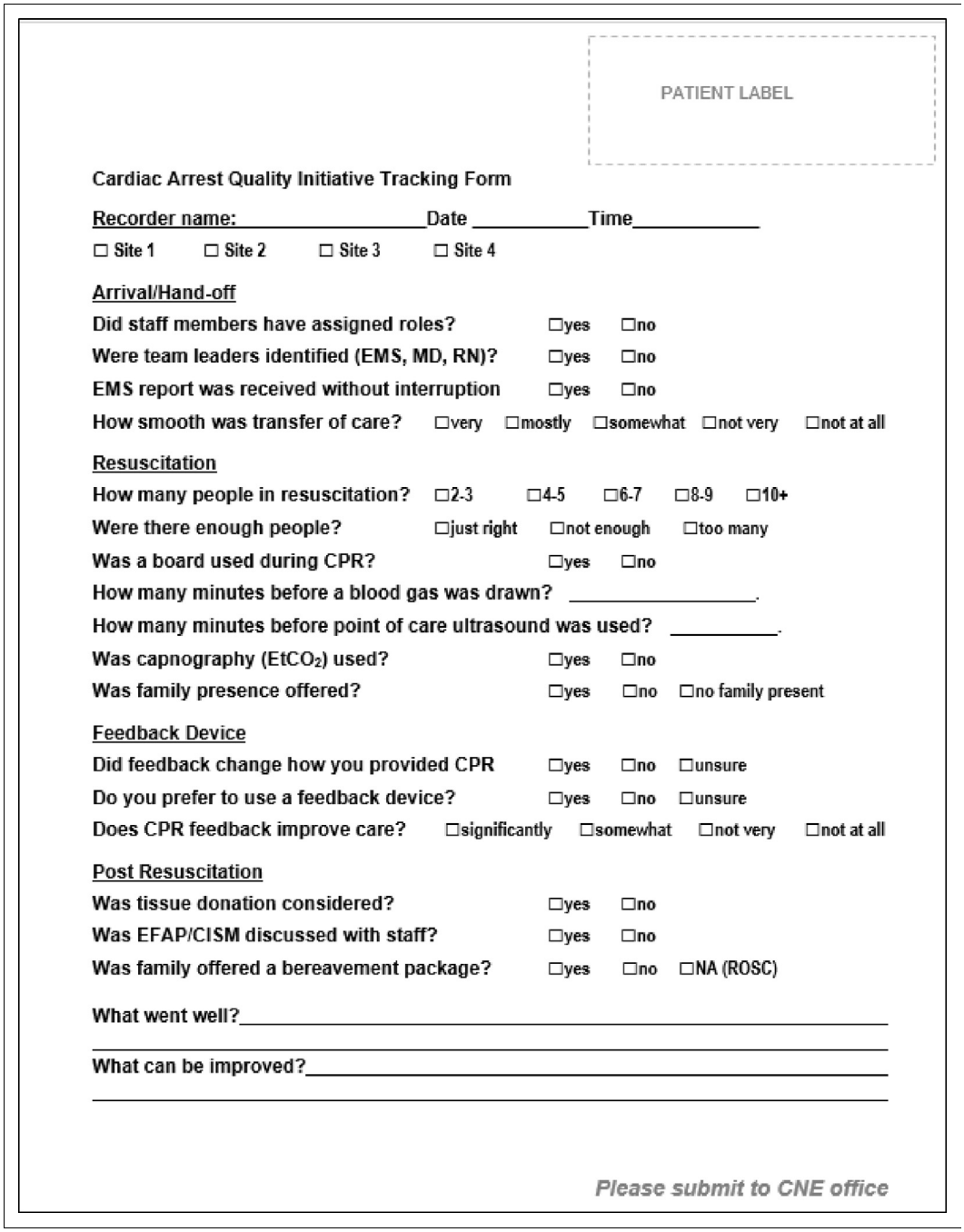
Supplementary Appendix 1

Quality improvement data tracking survey. CISM, Critical Incident Stress Management; CPR, cardiopulmonary resuscitation; EFAP, Employee and Family Assistance Program; EMS, emergency medical service; MD, doctor of medicine; RN, registered nurse.



PATIENT LABEL

Cardiac Arrest Quality Initiative Tracking Form

Recorder name:_____Date _____Time_____

☐ Site 1 ☐ Site 2 ☐ Site 3 ☐ Site 4

Arrival/Hand-off

Did staff members have assigned roles? ☐yes ☐no

Were team leaders identified (EMS, MD, RN)? ☐yes ☐no

EMS report was received without interruption ☐yes ☐no

How smooth was transfer of care? ☐very ☐mostly ☐somewhat ☐not very ☐not at all

Resuscitation

How many people in resuscitation? ☐2-3 ☐4-5 ☐6-7 ☐8-9 ☐10+

Were there enough people? ☐just right ☐not enough ☐too many

Was a board used during CPR? ☐yes ☐no

How many minutes before a blood gas was drawn? _____.

How many minutes before point of care ultrasound was used? _____.

Was capnography ($EtCO_2$) used? ☐yes ☐no

Was family presence offered? ☐yes ☐no ☐no family present

Feedback Device

Did feedback change how you provided CPR ☐yes ☐no ☐unsure

Do you prefer to use a feedback device? ☐yes ☐no ☐unsure

Does CPR feedback improve care? ☐significantly ☐somewhat ☐not very ☐not at all

Post Resuscitation

Was tissue donation considered? ☐yes ☐no

Was EFAP/CISM discussed with staff? ☐yes ☐no

Was family offered a bereavement package? ☐yes ☐no ☐NA (ROSC)

What went well?_____

_____

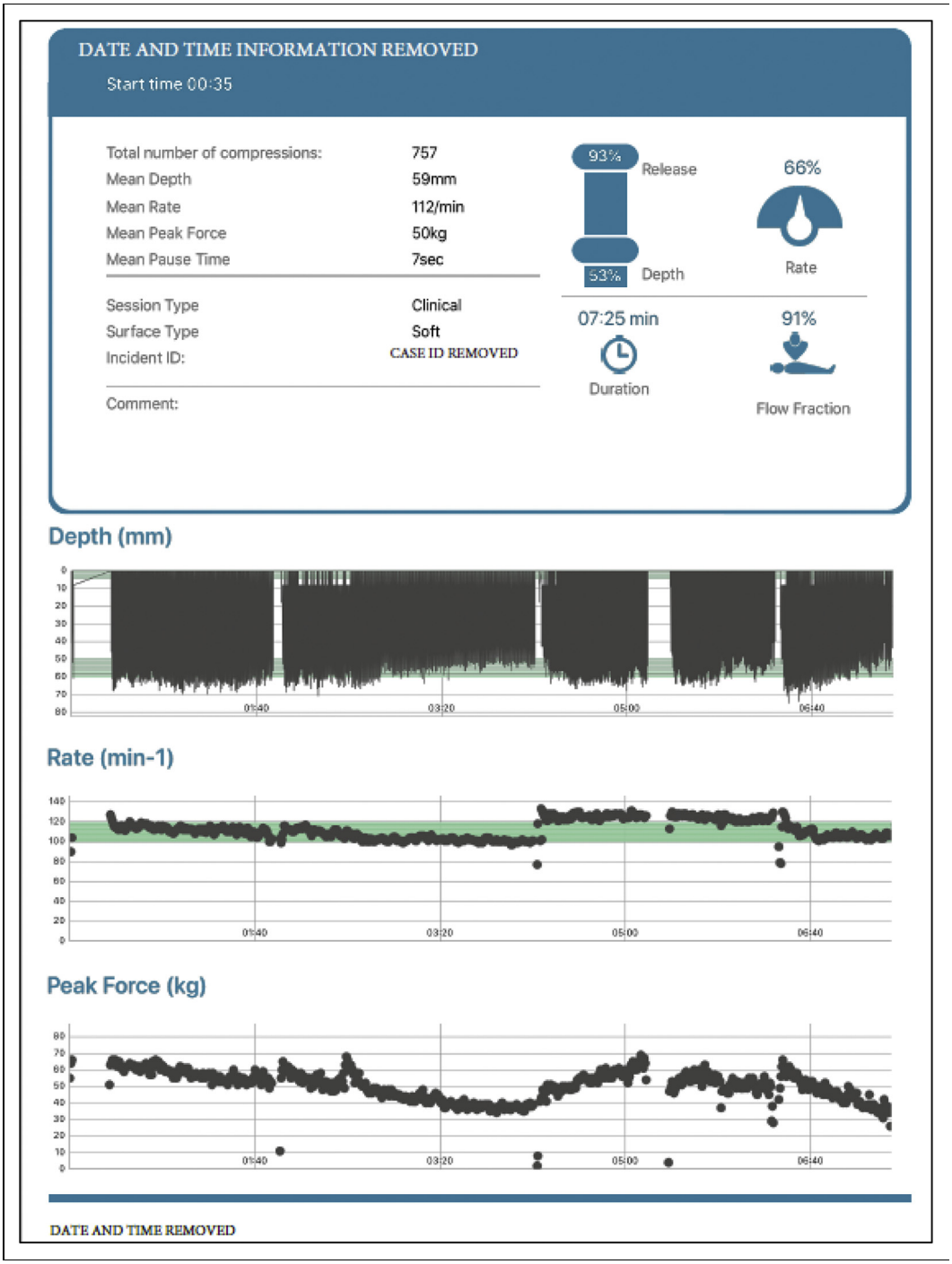
What can be improved?_____

_____

Please submit to CNE office

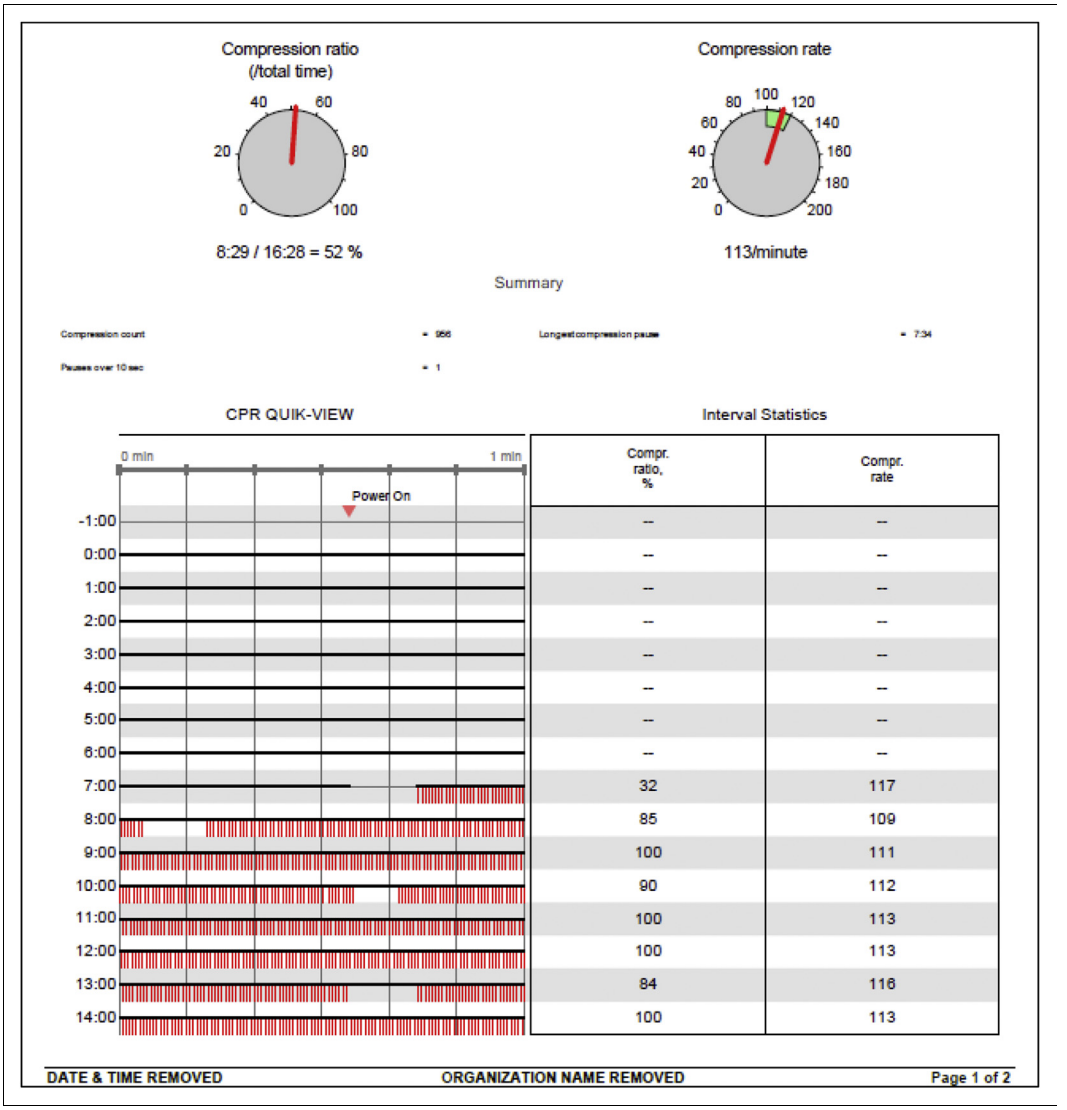
Supplementary Appendix 2

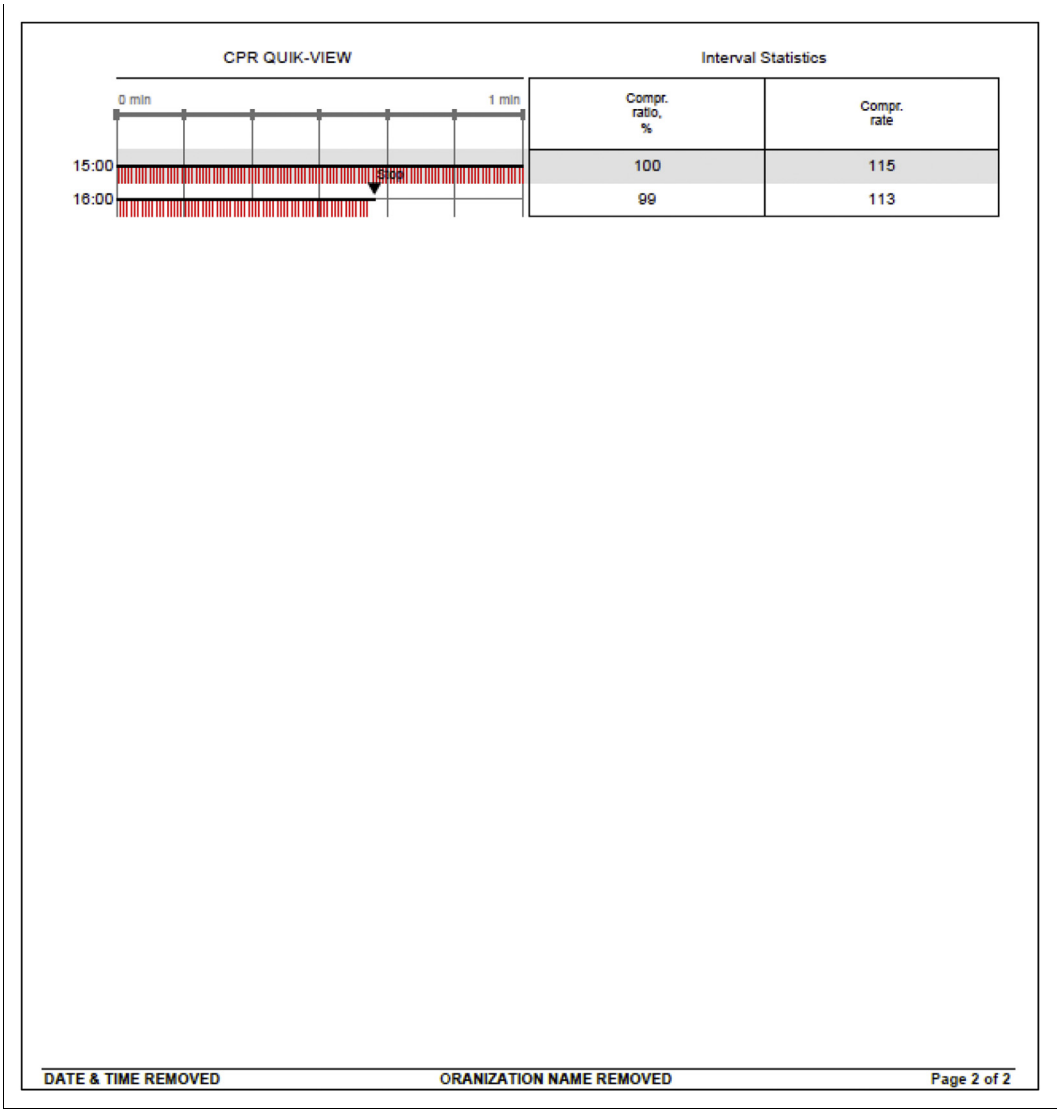
Feedback device generated report. CPR, cardiopulmonary resuscitation.



Supplementary Appendix 3

Defibrillator generated report. CPR, cardiopulmonary resuscitation.




CPR QUIK-VIEW
Interval Statistics
0 min
1 min
15:00
16:00
Compr. ratio, %
Compr. rate
100
115
99
113
DATE & TIME REMOVED
ORANIZATION NAME REMOVED
Page 2 of 2

SUPPLEMENTARY APPENDIX 4
Frequencies of feedback survey responses

Data field	n	%
Providers had assigned roles		
Yes	32	91.43
No	3	8.57
Not reported	0	0
Team leader was identified		
Yes	34	97.14
No	1	2.86
Not reported	0	0
Uninterrupted EMS report		
Yes	25	71.43
No	3	8.57
Not reported	7	20
Transfer smoothness		
Very	9	25.71
Mostly	18	51.43
Somewhat	3	8.57
Not very	1	2.86
Not at all	0	0
Not reported	4	11.43
Number of providers in resuscitation		
2 to 3	0	0
4 to 5	5	14.28
6 to 7	6	17.14
8 to 9	1	2.86
10 or more	0	0
Not reported	12	34.29
Perception of staffing level		
Just right	29	82.86
Not enough	1	2.86
Too many	5	14.29
Backboard used during CPR		
Yes	10	28.57
No	13	37.14
Not reported	12	34.29
$EtCO_2$ monitoring was used		
Yes	18	51.43
No	5	14.29
Not reported	12	34.29

continued

SUPPLEMENTARY APPENDIX 4
Continued

Data field	n	%
Compression feedback improved care		
Significantly	17	48.57
Somewhat	1	3
Not very	7	20
Not at all	0	0
Not reported	10	28.57
Tissue donation was considered		
Yes	14	40
No	10	28.57
Not reported	11	31.43
Employee counseling resources were discussed		
Yes	0	0
No	26	74.29
Not reported	9	25.71
Family was offered a bereavement package		
Yes	13	37.14
No	11	31.43
Not reported	11	31.43

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; $EtCO_2$, end-tidal carbon dioxide.

SUPPLEMENTARY APPENDIX 5

Effects of time on quality metrics

Survey Item	Resuscitation 27-30	Resuscitation 31-40	Resuscitation 41-50	Sig
Questionnaire returned				0.66
Yes	1	5	6	
No	3	5	4	
Feedback device used				0.66
Yes	1	5	6	
No	3	5	4	
Assigned roles				0.71
Yes	1	4	6	
No	0	1	0	
Not reported	3	5	4	
Clear leader				0.66
Yes	1	5	6	
No	0	0	0	
Not reported	3	5	4	
EMS report uninterrupted				0.75
Yes	1	5	5	
No	0	0	0	
Not reported	3	5	5	
Transfer smoothness				0.71
Very	1	2	4	
Mostly	0	3	1	
Somewhat	0	0	0	
Not very	0	0	0	
Not at all	0	0	0	
Not reported	3	5	5	
Number of providers in resuscitation				0.75
2-3	0	0	0	
4-5	1	1	3	
6-7	0	3	3	
8-9	0	1	0	
10 or more	0	0	0	
Not reported	3	5	4	
Enough people				0.68
Just right	1	3	6	
Not enough	0	1	0	
Too many	0	1	0	
Not reported	3	5	4	
Was a backboard used				0.73
Yes	0	3	2	
No	1	2	4	
Not reported	3	5	4	

continued

SUPPLEMENTARY APPENDIX 5
Continued

Survey Item	Resuscitation 27-30	Resuscitation 31-40	Resuscitation 41-50	Sig
Was $EtCO_2$ used				0.65
Yes	1	4	4	
No	0	0	2	
Not reported	3	6	4	
Family presence offered				0.71
Yes	0	1	0	
No	1	4	6	
No family available	0	0	0	
Not recorded	3	5	4	
Tissue donation considered				0.86
Yes	1	2	3	
No	0	0	1	
Not reported	3	8	6	
Debriefing complete?				0.88
Yes	0	0	0	
No	4	3	4	
Not reported	0	7	6	
Was a bereavement package offered?				0.42
Yes	1	2	2	
No	0	0	3	
Not reported	3	8	5	

EMS, emergency medical service. $EtCO_2$, end-tidal carbon dioxide.

SUPPLEMENTARY APPENDIX 6

Analysis of variance by resuscitation team size

Quality metric	SS	df	MS	F	Sig.
Number of compressions					
Between groups	4 428 707.75	3	1 476 235.92	1.79	0.17
Within groups	29 724 536.15	36	825 681.56		
Total	34 153 243.90	39			
Release percentage					
Between groups	107.05	3	35.68	0.74	0.54
Within groups	1797.14	37	48.57		
Total	1904.20	40			
Depth percentage					
Between groups	4721.13	3	1573.71	1.71	0.18
Within groups	33 977.26	37	918.30		
Total	38 698.39	40			
Rate percentage					
Between groups	1157.08	3	385.69	0.54	0.66
Within groups	26 306.53	37	710.99		
Total	27 463.61	40			
Mean depth (mm)					
Between groups	349.48	3	116.49	1.17	0.34
Within groups	3594.42	36	99.84		
Total	3943.90	39			
Mean rate (compressions/min)					
Between groups	1748.38	3	582.79	1.21	0.32
Within groups	17 277.59	36	479.93		
Total	19 025.98	39			
Mean peak force (kg)					
Between groups	296.73	3	98.91	0.58	0.63
Within groups	6124.64	36	170.13		
Total	6421.38	39			

df, degrees of freedom; F, F statistic; MS, mean squares; Sig., significance; SS, sum of squares.

The Common Nightingale

Author: Mike Fellenbaum, MD, Cleveland, OH

Rhyming isn't easy
When you don't set the tempo
And your patients sing in different keys
And you have two too many sopranos
And the patient in bed 32 is urinating on the wall

Known for their song,
the common nightingale

A ground nester
A migratory species
A relentless serenador

Fashioning nests for each of my loving sufferers

Burdened with my decisions
My lyrics, her melody
My feathers are too wet, but she continues to fly

Not so common, are they?

Mike Fellenbaum, Department of Emergency Medicine, University Hospitals Cleveland Medical Center & Case Western Reserve University School of Medicine, Cleveland, OH.

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