Organizational Aspects of Critical Care: the Advanced Practice Provider

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Abbreviations

ACNP:	Acute care nurse practitioner
APP:	Advanced practice provider
CI:	Confidence interval
CLABSI:	Central line-associated bloodstream infection
CVC:	Central venous catheter
d:	days
DNAR:	Do not attempt resuscitation
EWS:	Early Warning Score
FTE:	Full-time equivalent
ICU:	Intensive care unit
IQR:	interquartile range
LOS:	Length of stay
MR:	Medical resident
NAPA:	Nationale Associatie Physician Assistants
NICE:	Nationale Intensive Care Evaluatie
NP:	Nurse practitioner
NPP:	Non-physician provider
NVIC:	Nederlandse Vereniging voor Intensive Care
PA:	Physician assistant
RRT:	Rapid Response Team
SD:	Standard deviation

Chapter 1:

General Introduction and outline of the thesis

This text has been published in a concise format in Critical Care:

Efficient organization of intensive care units with a focus on quality: the non-physician provider. HG Kreeftenberg, S Pouwels, PHJ van der Voort. Crit Care 2017:21:118

Introduction

Adequate staffing is increasingly a problem in intensive care units (ICUs) worldwide (1-5). This thesis focusses on a potential solution: the deployment of non-physician providers (NPP), later called advanced practice providers (APP), in critical care settings. Staffing problems that arise in ICUs across Europe, including the Netherlands (6), are caused by the increased use of ICUs due to expanding and ageing populations and to economic welfare (7). Also, migration to cities leaves several rural areas deprived of physicians (8-12).

These problems are exacerbated by an increased demand for high-quality health care.

Staffing problems impose pressure on the availability of intensivists, residents and nurses. In North America, solutions for the same problem are being explored (13, 14). One of the initiatives to alleviate physicians' workloads and to compensate for physician shortages was the introduction of APPs. APPs are physician assistants (PAs) and nurse practitioners (NPs) who work in the ICU in conjunction with an intensivist and perform the full scope of work that is usually done by residents. Studies have shown that APPs are able to provide this care without decreasing quality and are thus non-inferior (15-20). A review of these studies by Kleinpell et al showed promising results regarding the use of APPs in critical care in the United States (13).

In some European countries, such as the Netherlands, the shortage of physicians is still manageable. Continuity in ICU care is however, a struggle due to work-hour restrictions for residents and the short duration of internships on the ICU. This continuity of care is directly associated with quality (21). The pressure generated by these challenges, might be relieved by incorporating APPs into the critical care setting.

Besides staffing problems, health care in the Netherlands, as in other countries, is also faced with concerns about increasing health care expenses (22). Several solutions for this problem are being explored. The main problem remains how to preserve quality of care without increasing expenses. One of the initiatives is a 'task re-allocation program' which facilitates the implementation of APPs in Dutch healthcare. These APPs are seen as a more economical alternative for specialists and they are presumed to be able to take over certain tasks from these clinicians (23). In view of the organizational advantages, several areas of medicine are exploring the options for cooperation with this profession (24, 25). Preliminary experiences suggest that these providers perform well in several areas of medical expertise, and

the Netherlands Association of Physician Assistants (NAPA) is supporting the various clinical disciplines to generate cooperation documents regarding the tasks that may be fulfilled by APPs in specific medical domains (26, 27).

Literature demonstrating the advantages of re-allocating tasks from physicians to APPs in the area of critical care is scarce. In addition, in Europe in the few studies available the deployment of APPs has mainly been studied as a solution for problems such as physician shortages, whereas quality of critical care has not yet been a general consideration (28).

The available literature on APPs in critical care is often based on expert opinions and personal experiences. After 2000, research in this area evolved and comparable cohort studies were published, but these studies were mainly conducted in the United States (29). Since the healthcare system in the United States differs from that of other countries, it is questionable whether the findings of the sparse amount of existing literature can be extrapolated to the healthcare systems in other countries.

Despite the limited evidence on the effects of deploying APPs in critical care, several intensive care departments in the Netherlands have already started working with APPs (30). They often implement these providers carefully as a partial substitute for physician residents. These APPs do not have a medical degree, but since many APPs' previous training is ICU nursing, they tend to have more clinical experience than medical residents. Moreover, APPs tend to stay employed in the same hospital where they practiced nursing before, which means that they are better acquainted with local protocols and procedures than the rotating residents. The APPs' high level of experience provides opportunities to delegate additional tasks to the APPs, such as educating residents, supervising certain tasks, developing protocols and managing scoring systems in intensive care.

Since these developments exceed the evidence that is available at the moment, this thesis presents the outcomes of a research project focused on APPs in order to establish their role and added value in critical care.

This thesis addresses the following questions:

- How do APPs perform compared to residents in several areas of the critical care domain?

- Can APPs provide a beneficial role within the Dutch critical care system?

- Is an APP, positioned in the role of a junior resident, effective?
- What is the best way to compare the work of APPs to other clinicians?

We address these questions in the consecutive chapters of this thesis.

Outline of the thesis

Chapter 2 presents a review of the available literature on APPs in critical care, including a meta-analysis in the areas in which the available literature was sufficient for comparisons between physicians and APPs.

This chapter provides insight into the current status of implementing APPs in acute care and into the ensuing advantages and disadvantages. We aim to provide insight in the potential role of APPs in the Dutch critical care domain.

Chapter 3 presents a descriptive study on the tasks and performances of APPs in a large ICU in the Netherlands. It describes the daily workflow and the clinical and non-clinical aspects of an APP's work and assessed procedures like intravenous access procedures performed by APPs. The chapter evaluates the amount of procedures performed together with the quality of these procedures. The chapter elaborates about the additional tasks that are performed by an APP and the costs-effectiveness of employing an APP.

Chapter 4 describes a prospective study that aimed to assess the technical skills of an APP. A cohort of APPs is compared with a cohort of residents. The outcomes, such as success rate at first attempt of the procedure and number of attempts before success of the procedure, are compared between both groups as well as with the required standard in the literature. In addition, the study reports on the use of ultrasound and on supervision during an intervention.

Chapter 5 addresses the non-technical skills of the APP, which are measured in patient outcome parameters, such as length of stay and mortality. In this retrospective study, the patient outcomes of a resident-led outreach team are compared to those of an APP-led outreach team. Outreach teams were chosen as evaluation method because these teams handle several different aspects of a critical care situation on their own. The study also describes the limitations of such a comparison, such as measuring the performance of an entire team rather than

of one profession and the difficulty of measuring quality differences in an already high-quality healthcare system.

Chapter 6 evaluates outcomes during a simulation study in which the performances of APPs and residents are assessed individually. In this simulation environment, the virtual critical care problems inhibit direct measurement of patient outcomes, but process outcomes of APPs and residents can be compared. The study addresses the advantages of measuring process outcomes instead of patient outcomes as well as the advantages of the APP being a previous ICU nurse.

Chapter 7 evaluates and compares outreach performances of APP-led rapid response teams and resident-led rapid response teams. This prospective study measures patient outcomes as well as process outcomes. Trained students and experienced intensivists judge the performance of the leader of the rapid response team by means of validated measurement tools. The study describes the advantages of an APP in these situations as well as the difficulty for an inexperienced observer to adequately assess a team leader's accomplishments.

Chapter 8 evaluates the requirements for adequately implementing APPs in a Dutch critical care environment, its advantages and the necessary precautions for effective implementation. The available literature on the subject is taken into consideration.

Chapter 9 presents a Dutch survey of the ways in which Dutch ICUs have implemented APPs and of the related advantages and barriers, which were explored from the perspectives of intensivists and APPs. This survey was originally also endorsed and conducted by the European Society of Intensive Care Medicine, but the unfamiliarity with this profession in Europe resulted in too few answers. By contrast, the response from Dutch ICUs was sufficient, which is a clear sign of the Netherlands being a frontrunner in the implementation of this profession.

Chapter 10 provides a summary and conclusion of this thesis as well as the 'lessons learned'. It also elaborates on possible future developments in a changing ICU environment, which is subject to the portfolio choices that hospitals have to make. This differentiation in care has already resulted in large core ICUs and basic ICUs, both of which could benefit from the implementation of APPs. The possibilities of APPs operating in a health care setting that is increasingly subject to digital remote management are yet to be explored. In view of the continuous shortages of nurses, residents and intensivists, there are definite opportunities for the deployment of APPs.

References

1. Scheffler RM, Arnold DR. Projecting shortages and surpluses of doctors and nurses in the OECD: what looms ahead. Health Econ Policy Law. 2019;14(2):274-90.
2. Halpern NA, Pastores SM, Oropello JM, Kvetan V. Critical care medicine in the United States: addressing the intensivist shortage and image of the specialty. Crit Care Med. 2013;41(12):2754-61.
3. Ward NS, Afessa B, Kleinpell R, Tisherman S, Ries M, Howell M, et al. Intensivist/patient ratios in closed ICUs: a statement from the Society of Critical Care Medicine Taskforce on ICU Staffing. Crit Care Med. 2013;41(2):638-45.
4. Lois M. The shortage of critical care physicians: is there a solution? J Crit Care. 2014;29(6):1121-2.
5. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J, Jr., Committee on Manpower for P, et al. Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: can we meet the requirements of an aging population? JAMA. 2000;284(21):2762-70.
6. Te kort aan artsen voor ziekenhuizen MST en ZGT. 2017;07: https://www.tubantia.nl/enschede/tekort-aan-artsen-voor-ziekenhuizen-mst-en-zgt~a77a1cca/
7. Cooper RA, Getzen TE, Laud P. Economic expansion is a major determinant of physician supply and utilization. Health Serv Res. 2003;38(2):675-96.
8. Botezat A, Ramos R. Physicians' brain drain - a gravity model of migration flows. Global Health. 2020;16(1):7.
9. Boffa J. Is there a doctor in the house? Aust N Z J Public Health. 2002;26(4):301-4.
10. Kaduszkiewicz H, Teichert U, van den Bussche H. [Shortage of physicians in rural areas and in the public health service : A critical analysis of the evidence on the role of medical education and training]. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz. 2018;61(2):187-94.
11. Bradby H. International medical migration: a critical conceptual review of the global movements of doctors and nurses. Health (London). 2014;18(6):580-96.
12. Colombo A, Bassani G. [Lack of doctors, but for what System? Shortage of clinicians in Italy and Lombardy and reflections on structural constrains in training]. Ig Sanita Pubbl. 2019;75(5):385-402.
13. Kleinpell RM, Ely EW, Grabenkort R. Nurse practitioners and physician assistants in the intensive care unit: an evidence-based review. Crit Care Med. 2008;36(10):2888-97.
14. Woo BFY, Lee JXY, Tam WWS. The impact of the advanced practice nursing role on quality of care, clinical outcomes, patient satisfaction, and cost in the emergency and critical care settings: a systematic review. Hum Resour Health. 2017;15(1):63.
15. Fry M. Literature review of the impact of nurse practitioners in critical care services. Nurs Crit Care. 2011;16(2):58-66.
16. Costa DK, Wallace DJ, Barnato AE, Kahn JM. Nurse practitioner/physician assistant staffing and critical care mortality. Chest. 2014;146(6):1566-73.
17. Bevis LC, Berg-Copas GM, Thomas BW, Vasquez DG, Wetta-Hall R, Brake D, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. Am J Crit Care. 2008;17(4):357-63.
18. Alexandrou E, Spencer TR, Frost SA, Mifflin N, Davidson PM, Hillman KM. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Crit Care Med. 2014;42(3):536-43.
19. Scherr K, Wilson DM, Wagner J, Haughian M. Evaluating a new rapid response team: NP-led versus intensivist-led comparisons. AACN Adv Crit Care. 2012;23(1):32-42.
20. Edkins RE, Cairns BA, Hultman CS. A systematic review of advance practice providers in acute care: options for a new model in a burn intensive care unit. Ann Plast Surg. 2014;72(3):285-8.

21. Cook RI, Render M, Woods DD. Gaps in the continuity of care and progress on patient safety. BMJ. 2000;320(7237):791-4.
22. Toekomstverkenning zorguitgaven 2015-2060. RIVM 2020: https://www.rivm.nl/bibliotheek/rapporten/2020-0059.pdf
23. Becker D, Kaplow R, Muenzen PM, Hartigan C. Activities performed by acute and critical care advanced practice nurses: American Association of Critical-Care Nurses Study of Practice. Am J Crit Care. 2006;15(2):130-48.
24. Maier CB, Aiken LH. Task shifting from physicians to nurses in primary care in 39 countries: a cross-country comparative study. Eur J Public Health. 2016;26(6):927-34.
25. Maier CB, Aiken LH. Expanding clinical roles for nurses to realign the global health workforce with population needs: a commentary. Isr J Health Policy Res. 2016;5:21.
26. Wijziging van de Wet op de beroepen in de individuele gezondheidszorg in verband met het opnemen van de physician assistant in de lijst van registerberoepen, het toekennen van zelfstandige bevoegdheid voor bepaalde voorbehouden handelingen aan physician assistants en verpleegkundig specialisten. Tweede Kamer der Staten Generaal 2016;34 630: https://www.eerstekamer.nl/behandeling/20161213/koninklijke_boodschap_2/document3/f=/vka1kviutyzc.pdf
27. Wet van 4 oktober 2017, houdende wijziging van de Wet op de beroepen in de individuele gezondheidszorg in verband met het opnemen van de physician assistant in de lijst van registerberoepen, het toekennen van zelfstandige bevoegdheid voor bepaalde voorbehouden handelingen aan physician assistants en verpleegkundig specialisten. Staatsblad van het Koninkrijk der Nederlanden 2017;374: https://www.eerstekamer.nl/behandeling/20171013/publicatie_wet_6/document3/f=/vkie22jqx2wg.pdf
28. Skinner H, Skoyles J, Redfearn S, Jutley R, Mitchell I, Richens D. Advanced care nurse practitioners can safely provide sole resident cover for level three patients: impact on outcomes, cost and work patterns in a cardiac surgery programme. Eur J Cardiothorac Surg. 2013;43(1):19-22.
29. Kleinpell RM, Grabenkort WR, Kapu AN, Constantine R, Sicoutris C. Nurse Practitioners and Physician Assistants in Acute and Critical Care: A Concise Review of the Literature and Data 2008-2018. Crit Care Med. 2019;47(10):1442-9.
30. van Vught A, van den Brink G, Hilkens M, van Oers JAH. Analysis of the level of clinical skills of physician assistants tested with simulated intensive care patients. J Eval Clin Pract. 2018;24(3):580-4.

Part I

Chapter 2:

In depth search of the Literature.

Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis

Critical Care Medicine 2019; Volume 47: 722-30

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Abstract

Objective: To evaluate the effects on quality and efficiency of implementation of the advanced practice provider in critical care.

Data sources: Pubmed, Embase, The Cochrane Library and CINAHL were used to extract articles regarding advanced practice providers in critical care.

Study selection: Articles were selected when reporting a comparison between advanced practice providers and physician resident/fellows regarding the outcome measures of mortality, length of stay (LOS) or specific tasks. Descriptive studies without comparison were excluded. The methodological quality of the included studies was rated using the Newcastle-Ottawa scale (NOS). The agreement between the reviewers was assessed with Cohen's kappa. A meta-analysis was constructed on mortality and length of stay.

Data extraction: One-hundred fifty-six studies were assessed by full text. Thirty comparative cohort studies were selected and analyzed. These compared advanced practice providers with physician resident/fellows. All studies comprised adult intensive care. Most of the included studies showed a moderate to good quality. Over time, the study designs advanced from retrospective designs to include prospective and comparative designs.

Data synthesis: Four random effects meta-analyses on length of stay and mortality were constructed from the available studies. These meta-analyses showed no significant difference between performance of advanced practice providers on the ICU and physician residents/fellows on the ICU, suggesting the quality of care of both groups was equal. Mean difference for length of stay on the ICU was 0.34 (95% CI= -0.31 - 1.00; I^2=99%) and for in hospital LOS 0.02 (95% CI = -0.85 - 0.89; I^2=91%); while the odds ratio for ICU mortality was 0.98 (95% CI = 0.81 - 1.19; I^2=37.3%) and for hospital mortality 0.92 (95% CI 0.79 - 1.07; I^2=28%).

Conclusions: This review and meta-analysis shows no differences between acute care given by APPs compared to physician resident/fellows measured as length of stay or mortality. However, APPs might add value to care in several other ways but this needs further study.

Introduction

For more than two decades Acute Care Nurse Practitioners (ACNP) and Physician Assistants (PA) are increasingly embedded in Intensive Care Units (ICU), particularly in the United States. (1, 2) However, in the rest of the world this concept remains relatively unknown, despite the fact that research about the additional value of this concept continues to emerge. This systematic review and meta-analysis established an overview about the current available evidence in this area.

Nowadays, hospital care is challenged by several trends such as an increasing demand in efficiency and quality of health care, a rising proportion of patients with chronic diseases and on-going specialization in medical disciplines. This often coincides with increasing physician shortages in several regions in the world. (3-6) In light of these developments one of the applied solutions has been to reallocate patient care to Physician Assistants (PA) and Nurse Practitioners (NP) also called "Advanced Practice Provider" (APP). An APP is a non-physician with an independent license to practice as advanced practice provider. APPs, in collaboration with health care professionals and other individuals, provide a full range of primary, acute and specialty health care services.

This staffing model shows beneficial outcomes and has gained popularity within various medical disciplines, like surgical and trauma teams, but also in pediatric and adult ICUs. (1, 2, 7-9) Except for the United States where APPs were already legalized during the 1960s (10-12), they are currently increasingly recognized and adapted by other countries in the world and in the critical care processes of these countries. (3, 4) In the last years several reviews were undertaken to assess the added value of the critical care APP to clinical teams and the exact role of this APP. (7, 13-16) The review of Woo et al (16) highlighted that APPs can increase patients' access to emergency and critical care, and showed that APPs improve patient outcomes. The review of Fry et al (15) also demonstrated that the available evidence about APPs showed a contribution to positive patient, service and nursing outcomes. In addition, organizational models with APPs seem to be cost-effective, appropriate and efficient in delivery of critical care services. It was recognized that health systems and the role of APPs differs between countries and studies in specific local situations are needed. (15) The reviews of Edkins et al (14), Gershengorn et al (13), and Kleinpell et al (7) showed promising results regarding embedding of APPs in critical care. However, all review articles came to the same conclusion that the literature was mainly descriptive and not solid enough for definite conclusions.

The objective of this systematic review and meta-analysis is to gain insight in the place and additional value of the APPs in critical care and to investigate the quality and efficiency of care provided by APPs compared to physicians.

Methods

A systemic literature review was conducted till July 2018 Observational studies or randomized controlled trials were included if these studies reported the quality of care in critical care provided by APPs, physician residents/fellows or attending physicians. Studies were eligible for inclusion when they described adults (age ≥18 years) admitted to the ICU. In addition, the outcome data should be sufficiently described to be graded and compared. Data on mortality, ICU or length of stay, and the outcome of specific skills like insertions of intravenous catheters or communication skills, had to be reported. Exclusion criteria were studies in which the minimal data set for grading was absent, such as descriptive letters or poster abstracts. Studies performed on neonatal ICUs, written in another language than English or Dutch, and studies without full text available were also excluded.

Search strategy

Pubmed, Embase, The Cochrane Library and CINAHL were searched from the earliest date of each database up to July 2018 with the following keywords that were modified to suit each database: critical, care, unit, units, intensive, acute, nonphysician, provider, nurse, physician, assistant. (Table S1, Appendix A) The references from selected articles were manually searched to include references that were thought being eligible for inclusion.

Study selection and data extraction

Authors (H.G.K.,S.P.) independently screened and included studies based on the retrieved titles and abstracts. The same two authors reviewed then the full text of the selected studies and determined suitability for inclusion, based on the established selection criteria. For further eligible studies, cross-references were screened. Disagreements were resolved by discussion and consensus with each other, author (A.d.B.) and senior author (P.v.d.V.).

All relevant data was independently extracted (by H.G.K., A.d.B.) and subsequently verified by (P.v.d.V.).

Assessment of quality

The Newcastle Ottawa scale (NOS) was used to assess the methodological quality of the included non-randomized studies. (17) Two authors (H.G.K., A.d.B.) performed this assessment separately. This 9-point scale is based on three domains: 1) Selection of the cohort, 2) Comparability of the groups and 3) Quality of the outcomes. High quality studies have a score of greater than or equal to 7, whereas moderate and low quality studies have scores of 4-6 and less than or equal to 4.

Statistical analysis

The level of agreement of the independently scored NOS between the two authors was assessed by a Cohen's kappa score. A Cohen's kappa of <0.20 was considered as poor agreement, 0.21-0.40 as fair agreement, 0.41-0.60 as moderate agreement, 0.61-0.80 as good agreement, and 0.81-1.00 as very good agreement. (18)

Meta-analyses were performed when more than 3 studies with comparable design and sufficient data were available. To avoid bias we only included studies comparing two distinct groups of APPs and physicians. All meta-analyses were performed with the open-source software Openmetaanalyst. (Brown University, Center for Evidence Synthesis in Health, School of Public Health, Providence, RI) (19) Adjusted outcome data were used when available. No structural risk of bias assessment was performed. Data reported as medians were converted to means with standard deviations according to the method described by Luo et al. (20) A DerSimonian and Laird random effects models was used to pool the dichotomous data while the weighted mean difference with 95% CIs was used for continuous data. Hedges "g" was used for the pooled sample variance. Statistical heterogeneity was examined using the Cochran's test and I^2 statistic. Values of $p<0.05$ were considered statistically significant. Statistical Package for Social Sciences (SPSS, Chicago, IL, USA Version 20.0) was used to prepare the database and for statistical analysis.

Results

The Preferred Reporting Items for Systematic Reviews and Meta-analyses flowchart in Figure 1 demonstrates the search results. The initial database search produced 11643 results, including 3364 duplicates. After screening on title and abstract, 156 studies were considered relevant for a full text critical appraisal. A total of 126 studies were excluded due to deficient data reporting. Thirty studies were included in this systematic review, while eight studies were suitable for the meta-analyses. (21-28)

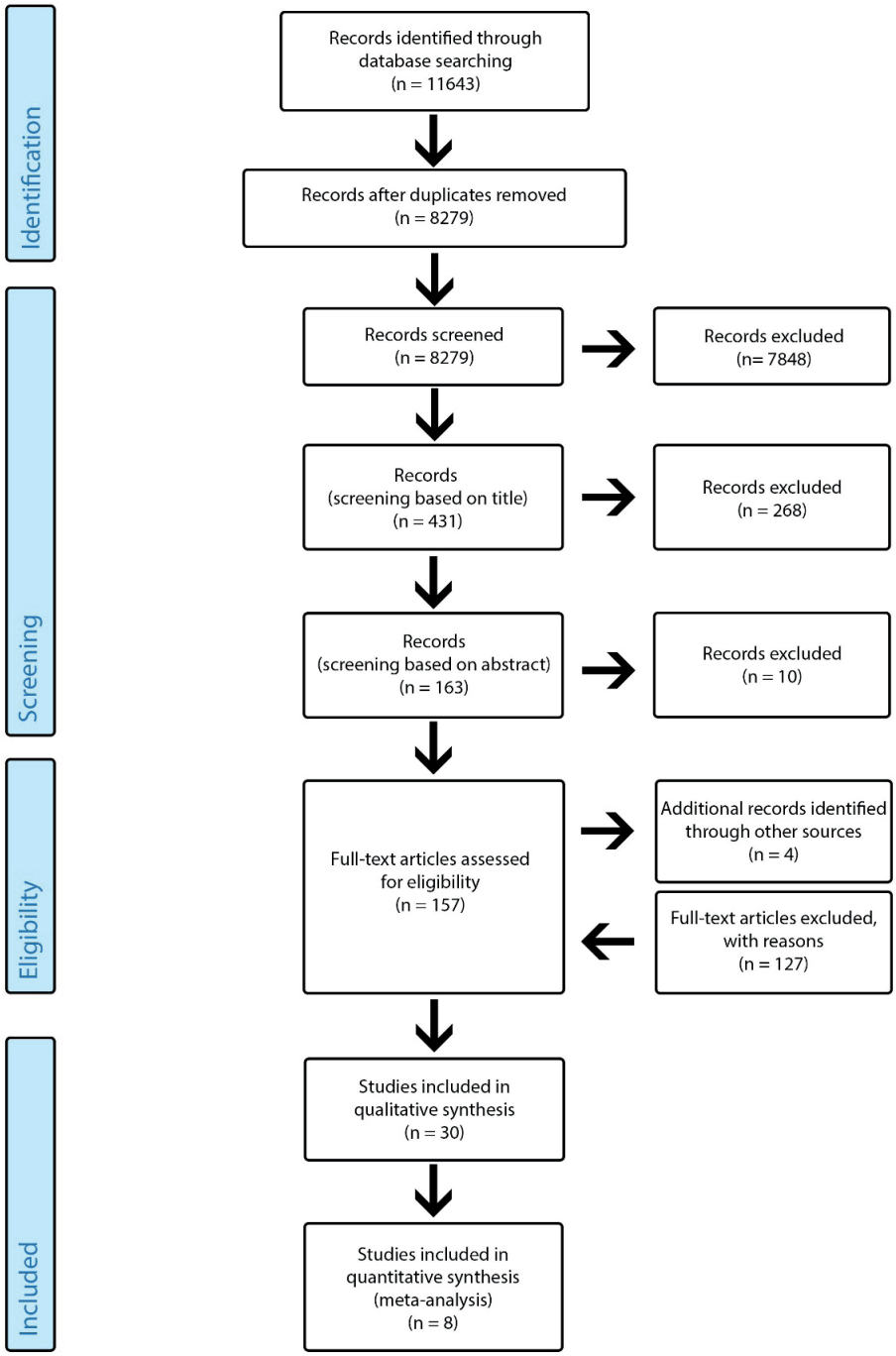

Figure 1. PRISMA Flowchart

Study quality

A Cohen's kappa of 0.69 reflected a good agreement between authors (H.G.K., A.d.B.) Table 1 describes the NOS assessment of the methodological quality for the included studies per author. Sixteen studies were assessed as high quality with eleven studies reaching the maximum score of 9 (table 1). Fourteen studies were assessed as moderate quality (table 1).

Table 1. Assessment of methodological quality using the Newcastle Ottawa Scale (NOS)

Author	NOS Results			
	Selection (4)	Comparability (2)	Outcome (3)	Total (9)
Alexandrou et al. 2012	2	0	3	**5**
Alexandrou et al. 2014	2	0	3	**5**
Bevis et al 2008	4	0	3	**7**
Burns et al. 2003	4	0	2	**6**
Butler et al. 2011	4	0	1	**5**
Christmas et al. 2005	4	0	2	**6**
Collins et al. 2014	4	0	2	**6**
Costa et al. 2014	4	2	3	**9**
Dubaybo et al. 1991	4	0	2	**6**
Gershengorn et al. 2011	4	2	3	**9**
Gershengorn et al. 2016	4	2	3	**9**
Gillard et al. 2011	4	1	2	**7**
Gracias et al. 2008	3	0	2	**5**
Hoffman et al. 2003	4	2	3	**9**
Hoffman et al. 2005	4	2	2	**8**
Hoffman et al. 2006	4	2	2	**8**
Jefferson et al. 2018	4	2	3	**9**
Kapu et al. 2014	4	2	3	**9**
Kawar et al. 2011	4	2	3	**9**
Landsperger et al. 2016	4	2	3	**9**
Matsushima et al. 2016	4	2	3	**9**
Pirret 2008	4	0	2	**6**
Rayo et al. 2014	4	0	2	**6**
Rudy 1998	3	0	3	**6**
Russell et al. 2002	3	0	2	**5**
Scherzer et al 2017	4	2	3	**9**
Sidani et al. 2005	4	0	2	**6**
Sirleaf et al. 2014	3	0	2	**5**
Skinner et al. 2013	4	1	2	**7**
van Vught et al. 2018	4	2	3	**9**

Summary of studies

A total of 30 cohort studies were included of which 13 were retrospective, 13 were prospective and 4 were mixed cohort studies in which prospective data was compared with a retrospective obtained baseline situation. An overview of the studies is depicted in supplemental table S2 (Appendix B). The studies compared ACNPs or acute care PAs to physician residents, fellows or for some instances attending physicians. This was done by measuring the performance of separate APP groups to physician resident/fellows, or by comparing mixed groups with physician resident/fellows and added APPs to a situation without APPs. The only uniform and comparable studies to create a meta-analysis were the studies which compared ICU care of APPs with that of physician residents/fellows. Four meta-analyses were constructed from the available studies which showed no significant difference between performance of APPs on the ICU and physician residents/fellows on the ICU suggesting the quality of care of both groups was equal.

APP on the ICU:

Mortality

Ten studies reported mortality data in the ICU or both in the ICU and hospital. Six studies had a prospective observational cohort design (21, 22, 26, 29-31) and four had a retrospective observational cohort design (23-25, 32). Six studies reported on ICU mortality (21-24, 29, 30) and seven studies reported on hospital mortality. (21, 23, 25, 26, 31-33) One study (29) was a subgroup of another larger study (22). Of the prospective mortality studies, four (21, 22, 29, 30) analyzed ICU mortality, three by measuring the results of a combined team of physician resident/fellows and APPs and one, the study of Landsperger et al, compared the results of an ICU run by ACNPs and an ICU run by physician residents, both with intensivist oversight. This study showed a significant difference in ICU mortality in favor of ICUs run by ACNPs in conjunction with an intensivist. Hospital mortality was not significantly different. All other prospective studies showed no difference between APPs and physician resident/fellows.

Of the retrospective studies, two reported about ICU mortality. (23, 24) All these retrospective studies reported an equal mortality when comparing APPs with physician resident. In the pooled analysis, the subgroup analysis of Hoffman et al. (29) was excluded because data had already been reported to some extend and the study of skinner et al. (30) was excluded, because it provided insufficient data.

In the studies measuring hospital mortality, the study of Costa et al. (32) was the largest study and investigated 29 medical and mixed medical-surgical ICUs in 22 hospitals with teams with and without APPs. The risk adjusted hospital mortality was

similar between the groups. Due to the survey design of this study and therefore possible biased results we excluded this study in the meta-analysis. The other six studies reported no differences in hospital mortality. The study of Matsushima et al. (31) which reported on a work scheme change of APPs instead of the addition of new APPs was also excluded. Unadjusted data with adjusted data, if available, showed no significant difference for ICU mortality (OR 0.98; 95% CI: 0.81 - 1.19; p = 0.04, I^2 = 37,3%) and hospital mortality (OR 0.92; 95% CI: 0.79 - 1.07; p = 0.33, I^2= 28%) between both groups (Fig 2, data on hospital mortality not shown). The figures report the studies with adjustment for confounders.

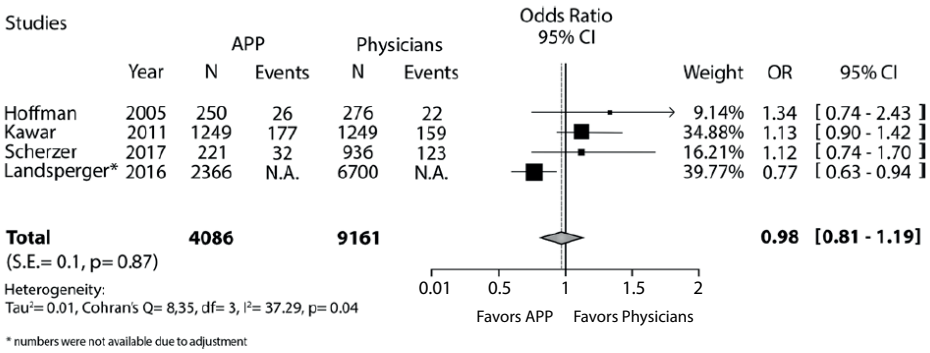

Figure 2. ICU mortality. APP = advanced practice provider, *df* = degrees of freedom, N.A. = not applicable

Length of stay

Twelve studies report about the ICU LOS with an APP present on the ICU. (21-29, 31, 33, 34). Seven of these were prospective cohort studies (21, 22, 26, 29, 31, 33, 34) and five were retrospective cohort studies. (23-25, 27, 28) Three of the prospective studies compared the ICU LOS of ACNP-staffed ICUs with physician resident/fellows staffed ICUs with both groups being supervised by an attending intensivist (21, 22, 29). All these three studies showed no significant difference of ICU LOS between both groups. One study compared a work scheme change where NPs were implemented in night shifts. (31) The other studies compared either implementation of APPs in a physician resident/fellows team or the outcomes of specific patients groups cared for by ACNPs.

The difference in ICU LOS in the five retrospective studies varied. When four midlevel practitioners were added in a trauma service which included ICU care, the ICU LOS decreased (4.08 d (SD 0.27d), vs. 3.28 d (SD 0.20d)). (28) In contrast two other studies

found a longer ICU LOS when patients when APPs were implemented. In one study the authors attributed the difference to baseline characteristics (the assumption was more chronically ill patients were included in the NP group) and to discharge location (mean 7.9 d (SD 7.5d), vs. 5.6 d (SD 6.5d)). (24) The other study, that did not adjust for confounders, reported a longer ICU LOS for patients on PA-staffed ICUs compared to physician resident/fellows staffed ICUs without explanation (mean 3.96 d (SD 0.92d), vs. 4.62 d (SD 1.91d)). (27) The last two of the five retrospective studies reported no significant difference of ICU LOS after adjustment for confounders. In the pooled analysis four studies were excluded. Matsushima et al. and Hoffman et al. were excluded because one was a subgroup analysis of another included study and one was a work scheme change. (29, 31) The study of Burns et al. was excluded because it reported on implementation of an outcome manager which supervised protocol adherence. (33) The study by Russel et al. was excluded because the study provided insufficient data. (34)

Nine studies reported hospital LOS. (21, 23-26, 28, 31, 33, 34) Five studies were prospective cohort studies (21, 26, 31, 33, 34) and four studies were retrospective cohort studies. (23-25, 28) One study reported on hospital mortality using a work scheme change of the APPs. This did not result in changes in hospital LOS. The study did not differentiate between patients treated by APPs or physician resident; therefore, it was not included in the meta-analysis. Only the prospective study of Landsperger et al. compared ACNP-staffed ICUs with physician resident staffed ICUs, both with attending physician oversight, and also adjusted for confounders. This study reported a significant lower hospital LOS for patients who were admitted on ACNP-staffed ICUs (OR 0.87; 95% CI 0.80-0.95; p= 0.001). The prospective study of Rudy et al. with a similar design did not report a significant difference but lacked adjusting for confounders. (26) The other two prospective studies by Burns et al. and Russell et al. implemented APPs to supervise treatment of patients via specific protocols. Both studies showed a significant reduction of hospital LOS when the ACNP was implemented but there was insufficient data available to include them in the meta-analysis. (33,34)

Of the four retrospective cohort studies, one study was the earlier mentioned implementation of four additional midlevel practitioners with an associated reduction in Hospital LOS (5.09 d (SD 0.20d) vs. 4.84 d (SD 0.20d)). (28) Because not all patients received ICU care, the results do not solely reflect the APP in critical care. Therefore, we excluded the study from the pooled analysis for hospital LOS. All other studies compared APP-staffed ICUs with physician resident/fellows staffed ICUs and did not show a significant difference for hospital LOS.

Pooled ICU and hospital LOS showed no statistically significant differences for patients that were treated by teams with an ACNP compared to teams without an ACNP. Mean differences were 0.34 days (95% CI −0.31 - 1.0; I^2 = 99.85%) and 0.02 days (95% CI −0.85 - 0.89; I^2 = 90.76%) respectively (Fig 3, data on hospital LOS not shown).

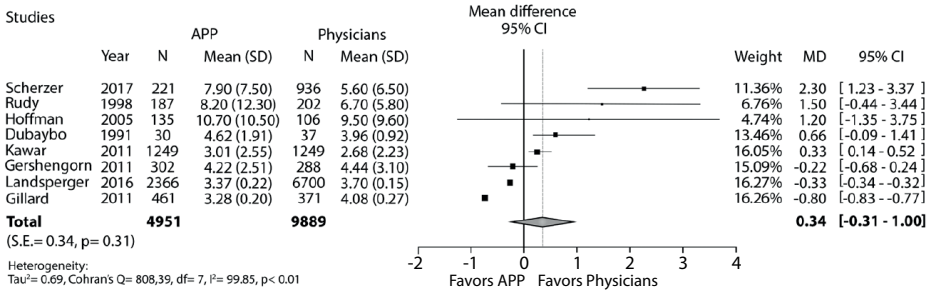

Figure 3. ICU length of stay. APP = advanced practice provider, *df*= degrees of freedom

APPs in trauma service

Three studies reported on the implementation of APPs in trauma services (28, 35, 36), one was a prospective study which integrated two nurse practitioners to the trauma service. (35) This expedited patient depositions between wards which reduced ICU, hospital and general ward LOS (18 vs 12 d, 12 vs 9 d, 7 vs 3 d) and thus reduced costs. Two studies were retrospective studies. (28, 36) The study of Gillard et al. introduced four additional midlevel practitioners to the trauma service and extended their ordinary tasks. (28) This resulted in a significant reduction in urinary tract infection (2.6% vs 0.9%) and reduced ICU LOS (4.08 (SD 0.27) vs. 3.28 (SD 0.20)). The study of Collins et al. implemented five ACNPs in a special care stepdown unit with responsibility for the daily care and communication. (36) The average LOS of the stepdown unit decreased 0.35 days (p = .0033) in 3 years. The average LOS for the overall trauma service reduced with 0.55 days (p = .024) and reduced costs with $8.9 million in 6 months.

APPs implemented in teams

Three studies reported about implementation of PAs and NPs in other teams. Two studies reported about APPs in a critical care outreach team. One of the studies compared the critical care outreach team in two hospitals and introduced a PA in one team. This intervention reduced time to transfer to the ICU significantly with 3.7 hours. ICU and hospital LOS did not change. (37) The other study about critical outreach teams introduced an NP as leader of a critical care outreach team. (38) The introduction of the NP resulted in a reduction of ICU readmissions of patients which were admitted less

than 72 hours without an increase in complications. The study of Kapu et al. analyzed the financial impact of NP implementation in a neuroscience ICU team, a cardiovascular ICU team, a surgical ICU team, medical ICU team and a trauma stepdown unit team. (39) After implementation the gross collections for the Neuroscience ICU, Surgical ICU and Medical ICU were 62%, 36% and 47% of the salary and fringe expenses. The team in the Cardio Vascular ICU exceeded salary and fringe expenses with 32%. The stepdown unit realized 0.8 days adjusted LOS reduction translating in a net charge reduction of $27.8 million. The risk adjusted LOS after implementation of NPs decreased for all these units. Scores on satisfaction surveys and protocols were good.

Other:

Interventions

Five studies reported on the outcome of technical skills of APPs compared to physician resident/fellows. (26, 40-43) The two studies of Alexandrou et al. reported complication rates of central venous catheter insertions. Within the ACNP group the percentage of pneumothorax varied between 0.4% and 1.0% with a catheter-related bloodstream infection rate 0.2 - 1.3 per 1,000 catheters. This last rate is up to published standards. The retrospective comparative cohort study of Sirleaf et al. reported on mortality, hospital LOS and the ICU LOS after various invasive procedures performed by either ACNPs or physician residents. They found no significant difference within all outcomes while the Acute Physiology and Chronic Health Evaluation III and age was higher in the patients who were treated by the ACNPs. (43) The study of Bevis et al. was a comparison of complications rates of thoracostomies done by either ACNPs or trauma surgeons. (42) Retrospective analysis showed no significant difference between either groups regarding to complications.

Communication

One study addressed the difference of the quality of handovers done by registered nurses, ACNPs, physician residents and attending physicians. (44) The results of 133 patient handovers demonstrated that the difference in communication depended on the experience level rather than on the clinician type. Furthermore, the physicians engaged more in critique on actions than ACNPs or nurses did. In addition, in an older study by Rudy et al. (26) the physician residents discussed patients more actively during rounds and provided more hands-on treatment ($p<.05$) while the ACNPs communicated more with the registered nurse ($P<.05$).

Protocol adherence

There were two studies that reported on protocol adherence. Garcias et al. (45) found a higher rate of protocol adherence by ACNPs than by physician residents when

measuring prescription of thrombosis prophylaxis (93% vs. 98%, p<.001), stress-ulcer prophylaxis (51% vs. 91%, p<0.001) and anemia management (67% vs. 93%, p<.001). Russell et al. (34) found less skin breakdown (0% vs. 2%, p<.05) and less urinary tract infections (2% vs. 6%, p<.05) in favor of the ACNP.

Patient satisfaction

One study evaluated the patients' satisfaction rate with the Patient Judgment of Quality Questionnaire group and the functional status of the patients with the Medical Outcome Study-Short Form (SF-36). Both the satisfaction rate and the functional performance of patients treated by ACNPs were significantly higher compared to the patients who were treated by physician residents/fellows. (46)

Activities

In the study of Hoffman et al. the activities performed by either physician residents or PAs were monitored. (47) There was no difference in time spent with the routine management of patients but the PAs spent more time in coordination of care compared to the physician residents who spent more time on unit activities ranging from meetings to personal time.

Simulation

The study of van Vught et al. compared ICU trained PA's in a simulation setting where different scenarios were presented. (48) There was no difference between the performance of physician residents or PAs.

Non-clinical work

The study of Buttler et al. investigated optimized billing procedures by PAs on the ICU. (49) After the implementation of PAs there was an increase in charge capture with net revenue increase of 54%. The results were corrected for the increase in beds during this period.

The study of Jefferson et al. measured the impact of an acute care nurse practitioner which discussed the usefulness of the ordered laboratory tests with patients in the ICU. (50) This showed that the total number of laboratory tests increased but the tests were more specific for the condition of the patient.

Discussion

This review summarizes the current comparable outcome studies concerning the quality of APP care in the ICU/acute care settings when compared to physician resident/fellows care. In general, the literature shows beneficial effects of these practice providers. This review and meta-analysis confirms that good quality of care is provided by APPs in terms of mortality and LOS. The arguments for implementation of APPs are diverse, from providing necessary care in places where no care is available, to improvement of work processes by improving quality or alleviating workload. In addition, continuity of care is often defined as an important benefit. Most studies are, however descriptive and when comparable outcome studies are available several of these studies are only published as abstract and therefore provided insufficient information to be graded. Several studies with a survey design show the beneficial effects of APPs in acute care. (32, 51) Although one of the survey studies was gradable by NOS and reported mortality rates, the survey design made it impossible to technically include the study in the meta-analysis.

All studies that we included were cohort studies. The reason for encountering a cohort design in all the selected studies is probably because this design is the most applicable design instead of, for example, double blinded randomized controlled trials. Previously, this issue has been addressed by Kleinpell et al. (7) Four meta-analyses were constructed from the available studies which showed no significant difference between performance of APPs on the ICU and physician residents/ fellows on the ICU suggesting the quality of care of both groups was equal. We only pooled data on the endpoints of mortality and LOS in a meta-analysis because enough relative indisputable data was available on these endpoints. In the limited number of studies on other endpoints, the critical care model incorporating the APP often surpasses the traditional physician resident/fellow led model in quality of care for critically ill patients. The APP excelled in teams and team work. Studies on cost reduction and managing processes effectively by providing continuity of care showed an improvement with APP implementation. In addition, the APP also performed better in protocol adherence, communication and patient satisfaction. With respect to invasive procedures, only a few studies have been conducted which demonstrated similar outcomes of APPs to physician resident/fellows, however additional research is warranted.

A review in a field like this is challenging due to the different study designs. The study of Fry (15) provides a broad overview and also concluded that research in this field comprises a lot of different study designs. One of the additional conclusions was that

practices and job descriptions of APPs differ per country. This might influence the general applicability of the results. Our review for example found only six gradable studies originating from outside the United States. (30, 38, 40, 41, 46, 48) and none of these studies matched the inclusion criteria for the meta-analysis.

In studying the available research, we saw a maturation of study designs over the years. The earlier studies used a retrospective design often introducing a few APPs in an existing team instead of comparing teams of APPs to physician residents/fellows. These studies were conducted to establish the impact of APPs by adding them to ICU teams as solution to meeting the workforce needs in the ICU. The results were not always corrected for confounders. Later studies were more often designed for establishing the additional value of the APP over physician residents/fellows in ICU care. The difficulty remains that both APPs and physician residents/fellows work in conjunction with other specialists. The fact that their work is overseen and corrected by physicians makes it difficult to draw a definite conclusion about LOS and mortality. This problem can be approached in two ways. One of the solutions is presented by the study design of Landsperger et al. (21) This is a large prospective study where the care during the entire ICU stay was provided by either APPs or physician residents in conjunction with attending physician oversight. When the results were corrected for confounders the ICU mortality proved lower in the APP group. The difference existed despite the fact that inadequate treatment proposals are corrected by other specialists supervising the physician residents and APPs. Probably, the large prospective study design played a role in measuring this mortality difference.

A second approach to establish an additional value of APPs, is to measure specific aspects of care provided by APPs instead of measuring hard endpoints. This has been shown by Sidani et al, and Garcias et al. (45, 46) They respectively show an improvement in quality of patient care by APPs and an improved adherence to practice guidelines by APPs.

The results of this meta-analysis have to be interpreted with caution. Although this review gives an overall view on the effects of APPs in the critical care setting, with a selection of the evidence based cohort studies gradable by NOS score, there are differences in design of the studies which are also reflected by the sometimes high heterogeneity in the meta-analysis. In addition, the conversion from medians to means necessary for the comparison may introduce bias by itself as length of stay usually shows a skewed distribution. Moreover, regarding the NOS scale no structural evaluation of bias was performed. However, of the included NOS studies the minimal score was 5 which implies a reasonable comparability.

Despite these limitations, we have given an overview for both clinicians and researchers of the available literature on APP care in ICU/acute care settings. Those who have to make decisions in their clinical practice can use this review for argumentation. We have shown that the acute care APP seems a promising clinician with regard to quality and, likely, continuity of care. Well-designed comparative cohort studies with larger groups of patients or comparative cohort studies about specific tasks of APPs are needed to further establish their impact.

References

1. Hooker RS, Brock DM, Cook ML. Characteristics of nurse practitioners and physician assistants in the United States. J Am Assoc Nurse Pract 2016;28(1):39-46.
2. Hartsell Z. The emerging role of PAs in the hospitalist movement. JAAPA 2007;20(8):10.
3. Kreeftenberg HG, Pouwels S, van der Voort PHJ. Efficient organisation of intensive care units with a focus on quality: the non-physician provider. Crit Care 2017;21(1):118.
4. Kreeftenberg HG, Aarts JT, de Bie A, et al. An alternative ICU staffing model: implementation of the non-physician provider. Neth J Med 2018;76(4):176-183.
5. Cook RI, Render M, Woods DD. Gaps in the continuity of care and progress on patient safety. BMJ 2000;320(7237):791-794.
6. Cooper RA, Getzen TE, Laud P. Economic expansion is a major determinant of physician supply and utilization. Health Serv Res 2003;38(2):675-696.
7. Kleinpell RM, Ely EW, Grabenkort R. Nurse practitioners and physician assistants in the intensive care unit: an evidence-based review. Crit Care Med 2008;36(10):2888-2897.
8. Hascall RL, Perkins RS, Kmiecik L, et al. PAs reduce rounding interruptions in the pediatric intensive care unit. JAAPA 2018;31(6):41-45.
9. Johal J, Dodd A. Physician extenders on surgical services: a systematic review. Can J Surg 2017;60(2):1516.
10. https://www.aapa.org/wp-content/uploads/2018/03/What-is-a-PA-Infographic-Legal-Size_3.22_FINAL.pdf. [cited Accessed Aug 2018]
11. https://www.aanp.org/about-aanp/historical-timeline. [cited Accessed Aug 2018]
12. Kleinpell RM. Acute-care nurse practitioners: roles and practice profiles. AACN Clin Issues 1997;8(1):156-162.
13. Gershengorn HB, Johnson MP, Factor P. The use of nonphysician providers in adult intensive care units. Am J Respir Crit Care Med 2012;185(6):600-605.
14. Edkins RE, Cairns BA, Hultman CS. A systematic review of advance practice providers in acute care: options for a new model in a burn intensive care unit. Ann Plast Surg 2014;72(3):285-288.
15. Fry M. Literature review of the impact of nurse practitioners in critical care services. Nurs Crit Care 2011;16(2):58-66.
16. Woo BFY, Lee JXY, Tam WWS. The impact of the advanced practice nursing role on quality of care, clinical outcomes, patient satisfaction, and cost in the emergency and critical care settings: a systematic review. Hum Resour Health 2017;15(1):63.
17. Wells GA, O'Connell D. The New-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. In. New York: Oxford; 2000.
18. Altman D. Practical statistics for medical research. London: Chapman and Hal; 1991.
19. Wallace BC, Dahabreh IJ, Trikalinos TA, et al. Closing the Gap between Methodologists and End-Users: R as a Computational Back-End. Journal of Statistical Software 2012;49(5):1-15.
20. Luo D, Wan X, Liu J, et al. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Stat Methods Med Res 2016.
21. Landsperger JS, Semler MW, Wang L, et al. Outcomes of Nurse Practitioner-Delivered Critical Care: A Prospective Cohort Study. Chest 2016;149(5):1146-1154.
22. Hoffman LA, Tasota FJ, Zullo TG, et al. Outcomes of care managed by an acute care nurse practitioner/attending physician team in a subacute medical intensive care unit. Am J Crit Care 2005;14(2):121-130; quiz 131-122.
23. Kawar E, DiGiovine B. MICU care delivered by PAs versus residents: do PAs measure up? JAAPA 2011;24(1):36-41.

24. Scherzer R, Dennis MP, Swan BA, et al. A Comparison of Usage and Outcomes Between Nurse Practitioner and Resident-Staffed Medical ICUs. Crit Care Med 2017;45(2):e132-e137.
25. Gershengorn HB, Wunsch H, Wahab R, et al. Impact of nonphysician staffing on outcomes in a medical ICU. Chest 2011;139(6):1347-1353.
26. Rudy EB, Davidson LJ, Daly B, et al. Care activities and outcomes of patients cared for by acute care nurse practitioners, physician assistants, and resident physicians: a comparison. Am J Crit Care 1998;7(4):267-281.
27. Dubaybo BA, Samson MK, Carlson RW. The role of physician-assistants in critical care units. Chest 1991;99(1):89-91.
28. Gillard JN, Szoke A, Hoff WS, et al. Utilization of PAs and NPs at a level I trauma center: effects on outcomes. JAAPA 2011;24(7):34, 40-33.
29. Hoffman LA, Miller TH, Zullo TG, et al. Comparison of 2 models for managing tracheotomized patients in a subacute medical intensive care unit. Respir Care 2006;51(11):1230-1236.
30. Skinner H, Skoyles J, Redfearn S, et al. Advanced care nurse practitioners can safely provide sole resident cover for level three patients: impact on outcomes, cost and work patterns in a cardiac surgery programme. Eur J Cardiothorac Surg 2013;43(1):19-22.
31. Matsushima K, Inaba K, Skiada D, et al. A high-volume trauma intensive care unit can be successfully staffed by advanced practitioners at night. J Crit Care 2016;33:4-7.
32. Costa DK, Wallace DJ, Barnato AE, et al. Nurse practitioner/physician assistant staffing and critical care mortality. Chest 2014;146(6):1566-1573.
33. Burns SM, Earven S, Fisher C, et al. Implementation of an institutional program to improve clinical and financial outcomes of mechanically ventilated patients: one-year outcomes and lessons learned. Crit Care Med 2003;31(12):2752-2763.
34. Russell D, VorderBruegge M, Burns SM. Effect of an outcomes-managed approach to care of neuroscience patients by acute care nurse practitioners. Am J Crit Care 2002;11(4):353-362.
35. Christmas AB, Reynolds J, Hodges S, et al. Physician extenders impact trauma systems. J Trauma 2005;58(5):917-920.
36. Collins N, Miller R, Kapu A, et al. Outcomes of adding acute care nurse practitioners to a Level I trauma service with the goal of decreased length of stay and improved physician and nursing satisfaction. J Trauma Acute Care Surg 2014;76(2):353-357.
37. Gershengorn HB, Xu Y, Chan CW, et al. The Impact of Adding a Physician Assistant to a Critical Care Outreach Team. PLoS One 2016;11(12):e0167959.
38. Pirret AM. The role and effectiveness of a nurse practitioner led critical care outreach service. Intensive Crit Care Nurs 2008;24(6):375-382.
39. Kapu AN, Kleinpell R, Pilon B. Quality and financial impact of adding nurse practitioners to inpatient care teams. J Nurs Adm 2014;44(2):87-96.
40. Alexandrou E, Murgo M, Calabria E, et al. Nurse-led central venous catheter insertion-procedural characteristics and outcomes of three intensive care based catheter placement services. Int J Nurs Stud 2012;49(2):162-168.
41. Alexandrou E, Spencer TR, Frost SA, et al. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Crit Care Med 2014;42(3):536-543.
42. Bevis LC, Berg-Copas GM, Thomas BW, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. Am J Crit Care 2008;17(4):357-363.
43. Sirleaf M, Jefferson B, Christmas AB, et al. Comparison of procedural complications between resident physicians and advanced clinical providers. J Trauma Acute Care Surg 2014;77(1):143-147.
44. Rayo MF, Mount-Campbell AF, O'Brien JM, et al. Interactive questioning in critical care during handovers: a transcript analysis of communication behaviours by physicians, nurses and nurse practitioners. BMJ Qual Saf 2014;23(6):483-489.

45. Gracias VH, Sicoutris CP, Stawicki SP, et al. Critical care nurse practitioners improve compliance with clinical practice guidelines in "semiclosed" surgical intensive care unit. J Nurs Care Qual 2008;23(4):338-344.

46. Sidani S, Doran D, Porter H, et al. Outcomes of nurse practitioners in acute care: an exploration. Internet J Adv Nurs Pract 2005:8(1). http://ispub.com/IJANP/8/1/12232

47. Hoffman LA, Tasota FJ, Scharfenberg C, et al. Management of patients in the intensive care unit: comparison via work sampling analysis of an acute care nurse practitioner and physicians in training. Am J Crit Care 2003;12(5):436-443.

48. van Vught A, van den Brink G, Hilkens M, et al. Analysis of the level of clinical skills of physician assistants tested with simulated intensive care patients. J Eval Clin Pract 2018;24(3):580-584.

49. Butler KL, Calabrese R, Tandon M, et al. Optimizing advanced practitioner charge capture in high-acuity surgical intensive care units. Arch Surg 2011;146(5):552-555.

50. Jefferson BK, King JE. Impact of the acute care nurse practitioner in reducing the number of unwarranted daily laboratory tests in the intensive care unit. J Am Assoc Nurse Pract 2018;30(5):285-292.

51. Joffe AM, Pastores SM, Maerz LL, et al. Utilization and impact on fellowship training of non-physician advanced practice providers in intensive care units of academic medical centers: a survey of critical care program directors. J Crit Care 2014;29(1):112-115.

Chapter 3

An APP implementation study in a high volume Intensive Care Unit in the Netherlands

An alternative ICU staffing model: implementation of the non-physician provider.

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Abstract

Introduction: The literature in Europe regarding implementation of nurse practitioners or physician assistants in the Intensive Care Unit (ICU) is lacking, while some available studies indicate that this concept can improve the quality of care and overcome physician shortages on ICUs. The aim of this study is to provide an insight on how a Dutch ICU implemented non-physician providers (NPP), besides residents, and what this staffing model adds to the care on the ICU.

Methods: This paper defines the training course and job description of NPPs on a Dutch ICU. It describes the number and quality of invasive interventions performed by NPPs, residents, and intensivists during the years 2015 and 2016. Salary scales of NPPs and residents are provided to describe potential cost-effectiveness.

Results: The tasks of NPPs on the ICU are equal to that of the residents. Analysis of the invasive interventions performed by NPPs showed an incidence of central venous catheter insertion for NPPs of 20 per fulltime equivalent (FTE) and for residents 4.3 per FTE in one year. For arterial catheters the NPP inserted 61.7 per FTE and the residents inserted 11.8 per FTE. The complication rate of both groups was in line with recent literature. Regarding their salary: after five years in service a NPP earns more than a starting resident.

Conclusion: This is the first European study which describes the role of NPPs on the ICU and shows that practical interventions normally performed by physicians, can be performed with equal safety and quality by NPP.

Introduction

Both the scale at which nurse practitioners (NP) and physician assistants (PA) are implemented, and their exact tasks and responsibilities on the Intensive Care Units (ICUs) throughout Europe remain unclear today. Nevertheless, these non-physician providers are already implemented with equal competences as residents in some ICUs in European countries. Although implemented in ICU staff, European literature on this subject is lacking, with the only research being conducted in the United States of America (USA).

Available research from the USA shows that from the 1960 till the 1990s the NP as well as the PA were implemented in the ICU. Back then, they were mainly introduced in regions with physician shortage to execute the tasks normally done by resident physicians. Their role was based on a natural evolvement from registered nurse in the ICU to an acute care nurse practitioner (ACNP) who could provide the necessary medical care for patients. Because the ACNP became indispensable on several American ICUs and emergency departments, the ACNP received a legislated title in the 1990s.

In 2008 the review of Kleinpell et al. concluded that ACNPs and PAs on the ICU provided high quality care which was non-inferior to that of residents (1). The ICU length of stay (LOS) and mortality were comparable if patients were treated by teams with ACNPs and an intensivist or by teams consisting of residents or fellows and an intensivist. In contrast to the non-inferiority, the advantage of ACNPs was their continuity of care and an experienced ACNP needed less supervision of intensivists compared to residents doing an internship. Moreover, a review of 2012 by Edkins et al. revealed that ACNPs provided high quality care at a low cost (2).

Around the year 2000, the general concept of NPs and PAs in medicine and their training course was also recognized in the Netherlands because of an expected increase in healthcare demand as a result of economical welfare and ageing population (3). They were also implemented in some ICUs. Although the function of NPs and PAs on the ICU is similar to the tasks performed by ACNPs, ACNPs mostly cover a broader part of acute care and their comparable legislated title has not yet been introduced in the Netherlands. The theoretical and practical skills of the NPs and PAs on the ICU however, are comparable with those of the ACNPs and similar to the job description of residents in the ICU. Therefore, the more general accepted term "acute non-physician providers (NPP)" will be used in this article to refer to NPs and PAs working on the ICU.

The aim of this paper is to describe the course of training and implementation of an alternative ICU staffing model with NPPs besides residents and intensivists in the Netherlands. In addition, a description of invasive procedures, performed by NPPs, residents or intensivists, is reported with a retrospective cohort analysis to provide some insights on the quality of care and one of the tasks of NPPs on a high volume ICU in the Netherlands.

Methods

Setting

Catharina Hospital is a tertiary hospital in Eindhoven the Netherlands containing all medical specialties, except for complex neurosurgical patients who require intensive care admission. The hospital has a 33 bed mixed medical and surgical ICU and provides care as a referral center for the region with the characteristics described in table 1. The medical staff of the ICU consists of intensivists, 8.8 fulltime-equivalent (FTE), supported by residents, residents in training and NPPs for which the FTEs are reported in table 2. Residents in training are on a rotating schedule of 3 to 4 months in which ICU experience is mandatory for their specialist training. The weekly required hours for residents, residents in training and NPPs are equal and 38 hours per week according to a local agreement.

Table 1. baseline characteristics of ICU patients in the two study years

	2015	**2016**
No of admissions	2922	2935
Age	65.6 (SD 12,5)	65.8 (SD 12,6)
SAPSII	34.9 (SD 18,3)	33.5 (SD 16,9)
Mortality ICU	5.1%	4.5%
Mortality Hospital	8.3%	4.2%
Standardized Mortality Ratio Apache IV	0.50	0.54
Standardized Mortality Ratio SAPS II	0.39	0.46
Length of Stay ICU mean	2.5 days	2.7 days
Length of stay ICU median	1.1 days	1.1 days

Table 2. ICU experience of residents, residents in training and NPPs in 2015 and 2016

	ICU experience	Residents (FTE)	Residents in training (FTE)	NPP's (FTE)
2015	< 1 year	10.00	1.75	
	> 1 year	1.50	1.00	
	> 2 years			4.28
2016	< 1 year	7.50	3.55	
	> 1 year	1.00	0.16	
	> 2 years			3.60

The nurse practitioner (NP) training course

For 10 years now, the training program to obtain a master degree of acute care nurse practitioner (NP) is available in the Catharina Hospital together with Fontys University of applied sciences. A minimum of 4-year experience as an ICU nurse is arbitrarily chosen as a local requirement to be eligible for the acute care NP training as a certain settlement in and acknowledgement from the nursing group is required to attain the supervising role of an acute care NP. In 2016 the NP training consisted of theoretical medical skills, practical skills and nursing skills. For the theoretical medical skills participants are trained in clinical reasoning based on broad medical and pathophysiological insights to create differential diagnoses. The nursing part includes training in nursing diagnosis, like recognizing problems like fear, discomfort and decubitus combined with the aim to prevent these problems. The practical part consists of 2-year hands-on clinical physician work on the ICU like the resident physicians with the focus on the different medical specialties and their problems. After graduation, the acute care NP has the same job description and responsibilities as the resident.

The physician assistant (PA) training course

In contrast to the NP training course the physician assistant (PA) training course is more focused on the medical domain and consists of a theoretical part, which attends to medical problems in all specialties from psychiatry, surgery to internal medicine. The participants are assessed with multiple station exams in which the participant has to solve clinical problems, propose therapies and prescribe medication. The practical part consists of hands-on training in the ICU and traineeships within several specialties. Graduation also results in a master degree with the same job description as the residents in the ICU. This course is also provided in the Catharina hospital together with the HAN university of applied sciences.

Job description

Both the NP and the PA master degrees grant permission to legally perform medical care on the ICU, such as making treatment plans including prescribing treatment medication, presenting at multidisciplinary meetings, and performing invasive procedures. A specialist always supervises these tasks, which in this case is an intensivist. There is no difference in practice between the NPs and PAs on the ICU. Both have the same competence and tasks as all residents on the ICU. These NPPs perform some extra tasks as improving local ICU protocols and, like intensivists, they are also involved in guiding starting residents, as mentors, during their first month in the ICU to familiarize them with the ICU and protocols.

In Catharina Hospital a day shift of NPPs is made up of various components, which start with a morning handover. After this collective handover the NPPs and residents start off with the clinical examination of the admitted ICU patients. Both NPPs and residents compose an initial treatment plan with optional additional examinations based on their findings. This proposed plan is assessed and adjusted, if necessary, by the intensivist during the ward round at the end of the morning. In the beginning of the afternoon the NPPs and residents report the main problems with the initiated treatment of all admitted patients in a multidisciplinary meeting containing representatives of all relevant specialties and three intensivists. After this meeting the NPPs and residents take care of the additional requested examinations, check all prescribed medication and communicate with family. If necessary, the NPPs or residents can perform invasive procedures, like insertion of central venous or arterial lines, thoracotomies with tube insertion, intubations and electro-cardioversion. Only arterial lines or peripheral venous catheters are placed without supervision of the intensivist if the NPP or resident who is taking care of the patient is confident enough. If not confident or in case of one of the other interventions, the intensivist decides whether the invasive procedure needs to be supervised based on the characteristics of the patients and the NPPs' or residents' experience and his or her confidence. Supervision ranges from observation to hands-on guidance. All upper central venous accesses are performed by either intensivist or NPP, since residents have limited experience in placing upper central venous catheters. Ultrasound for additional guidance is used when deemed necessary. The day shift ends after eight hours with a handover. Two NPPs, two residents or one NPP and one resident cover the eight-hour shifts of the evening and night. Those in attendance are responsible for all admitted ICU patients, resolve upcoming problems that may emerge and can perform invasive procedures. Besides these duties during these shifts, both NPPs and residents are part of the rapid response team in Catharina hospital.

Data collection and analyses

Since 2015, all patients undergoing an invasive procedure by a NPP are entered in the quality database of NPPs. The data of 2015 and 2016 was extracted and loaded into Microsoft Excel 2013 in an anonymized manner. Since 2016 the inserted central venous or arterial catheters on the ICU, which are entered in a central hospital database to monitor the number the catheter-related bloodstream infections, could be attributed to either residents together with intensivists or NPPs. All these databases are prospective databases with variables such as medical history, relevant medical scoring systems, the diagnose, complications and interventions. After extracting these data and comparing them with the separate NPPs' quality database, the study group was able to recognize which catheters were inserted by the group of NPPs or inserted by the group of residents and intensivists, or by intensivists in case of upper central venous lines during 2016. It was only possible to determine if a catheter was inserted with or without supervision of an intensivist by the NPPs. For the group residents and intensivists it was not possible to determine whether a venous or arterial catheter was inserted by either the intensivist or the resident, or by the residents with supervision of the intensivist. However, arterial catheters are mostly inserted without supervision by either NPPs or residents and not by intensivists. The number of inserted catheters was plotted against the fulltime-equivalent (FTE). An ultrasound was available for guidance and its depended on the preference of the person placing the line combined with patient characteristics.

Because of the descriptive nature of this study we collected a diverse amount of outcomes of interest. First of all the baseline characteristics of the ICU in 2015 and 2016 were collected to give an overview over the general ICU performance and the ICU population. The collected baseline characteristics were age, Simplified Acute Physiology Score (SAPS II), ICU and hospital mortality, standardized mortality ratio correct for the APACHE IV score and the SAPS II, and the length of stay on the ICU and in the hospital. Second, the number and device characteristics of documented invasive procedures combined with the number of procedural complications for central venous catheter (CVC) insertions were recorded. The Included invasive procedures were insertion of central venous or arterial catheters, thoracotomies with tube insertion, intubations and electro-cardioversion. Procedural complications were pneumothorax, as recognized on chest radiograph, major bleedings, defined as bleeding causing hemodynamic instability or endangered vascularization of the limbs, and catheter-related bloodstream infections (CLABSI), defined as a primary bloodstream infection in a patient who had a central catheter inserted within the 48 hour period before the development of the blood stream infection and that is not bloodstream related to an infection at another site. (4), and malposition defined as

tip placement of the CVC in the distal portion of the superior vena cava just above the junction with the right atrium (cardiac silhouette) as judged by radiologist.

To gain insight in the costs of NPPs and residents, the salary scales of both were adapted from the collective labor agreement hospitals of the Dutch Hospital Association (table 3). The FTE for residents, residents in training and NPPs in the ICU in the Catharina Hospital was equal and consists of 38 hours a week.

Statistical analysis

Statistical analysis was performed with Microsoft Excel 2013. The data for this retrospective cohort study are described as numbers or percentages or given as a mean with standard deviation. A median and interquartile range are shown if the data was not normally distributed.

Results

The baseline characteristics of all admitted ICU patients in 2015 and 2016 are summarized in table 1. The number of admissions, mean age, SAPS II, standardized mortality ratios and length of stay were alike for both years.

In 2015 and 2016 NPPs performed 251 and 407 invasive procedures, which were 58.6 and 113.1 procedures per FTE respectively. Figure 1 shows the distribution of all invasive procedures that were performed by the NPPs for 2015 and 2016. Figure 2 demonstrates the distribution for which central venous catheters and which arterial catheters were performed by unsupervised NPPs, by residents supervised by NPPs, by NPPs supervised by intensivists, and by residents or intensivists in 2016. The total number of CVCs inserted in 2016 by NPPs and physicians together was 125. Of these CVCs, 58% (n=73) were inserted by or under supervision of NPPs, while 42% (n=52) were inserted by residents or intensivists or by a NPP supervised by an intensivist (Figure 2). The incidence of CVC insertions by NPPs was 20 per FTE, while the incidence of CVC insertion by residents, with or without supervision was 4.3 per FTE and 2.5 per FTE if the 8.8 FTEs of the intensivists were taken into account along with the residents.

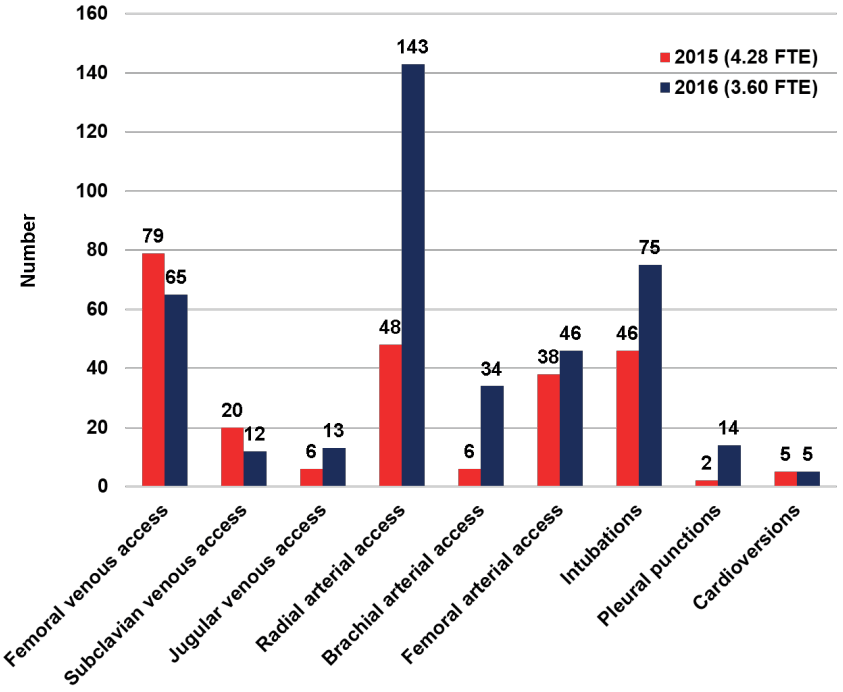
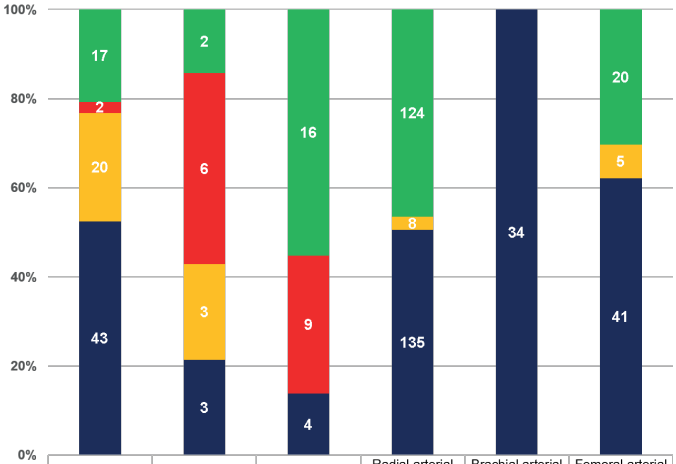


Figure 1. Graph: invasive procedures NPs and PAs in 2015-2016



	Femoral CVL	Subclavian CVL	Jugular CVL	Radial arterial line	Brachial arterial line	Femoral arterial line
Intensivist or resident supervised by intensivist	17	2	16	124	0	20
NP supervised by Intensivist	2	6	9	0	0	0
Resident supervised by NP	20	3	0	8	0	5
NP unsupervised	43	3	4	135	34	41

Figure 2. Graph: NPs and PAs vs residents in 2016, all vascular access in percentages (bars)

The incidence of inserting arterial catheters combined with supervising arterial cannulation all by NPPs was 61.7 per FTE and if the rest of the arterial catheter insertions was distributed over only residents the incidence was 11.8 per FTE. When both the FTEs of intensivists and residents are taken into account, this incidence becomes 6.9 per FTE.

Both the number of intubations and thoracostomies by NPPs increased in 2016 compared with 2015. The increased number of thoracostomies was explained by the fact that most NPPs became self-dependent in performing this procedure. In 2015 only the complication rate of NPPs for central venous catheters was available; there were two misplacements and one failure to place. Of all invasive procedures with CVCs, there were five complications for NPPs and intensivists together in 2016, all while placing upper CVCs. There was one pneumothorax caused by a NPP during insertion of a subclavian catheter. There was one CLABSI, 14 days after insertion a CVC by an NPP. Three complications arose during the insertion attempts of a CVC by an intensivist in one single patient. There was a pneumothorax and a mediastinal bleeding after an attempt of placement of a subclavian catheter. After this attempt an ultrasound guided Jugular catheter was inserted too deep (in the right atrium). Considering the data over 2015 and 2016 for NPPs showed two misplacements, one failure to place and one pneumothorax. There were no other complications during the invasive procedures documented.

The salary scale of NPPs and residents is depicted in table 3. The payment in Euros represents the salary per month. The increments of salary are represented by the numbers in front of the Euros and increase one per working year.

Discussion

This descriptive study shows how intensive care nurses can successfully be trained locally, based on an university program, and be implemented as a NPPs in the ICU. The included retrospective cohort analysis demonstrates that NPPs perform more invasive line insertions per FTE than intensivists or residents, with a complication rate that is up to standard and comparable to the intensivist. These findings show that implementation of NPPs can result in a reduction of workload of intensivists who can then allocate time to other tasks. In addition, both the NPPs' experience and thorough knowledge of the ICU by NPPs may add a quality impulse to the ICU care.

Table 3. Salary scale of the NPP and of the Resident

Salary scale	NPP	Resident
1	Eur 2960	Eur 3363
2	Eur 3097	Eur 3490
3	Eur 3227	Eur 3636
4	Eur 3363	Eur 3774
5	Eur 3490	Eur 3917
6	Eur 3636	Eur 4054
7	Eur 3774	Eur 4177
8	Eur 3917	Eur 4303
9	Eur 4054	Eur 4431
10	Eur 4115	Eur 4557
11	Eur 4177	Eur 4684
12	Eur 4241	Eur 4812

Although the results of this descriptive study may indicate a beneficial role of NPPs in the ICU, the concept of a NPP in the Netherlands and Europe remains relatively unknown.

There is no Dutch and European medical evidence available describing the role and potential advantages of NPPs in the ICU. This lack of literature is becoming increasingly important; such evidence may even be essential, since ICU medicine and therefore ICUs are undergoing change. Nowadays, Dutch intensivists mainly work in a closed format which means that they have the final responsibility for their ICU patient and their daily treatment plans. They base their treatment on their own knowledge combined with the advice requested from specialists. Compared with the earlier days of the ICU, where the surgeon, internist or other specialists treated the patient on the ICU, this change has improved the quality of care, but also intensified the workload on the ICU. The NPPs may be a viable staffing alternative to achieve the goal of managing increasing workloads while retaining a high quality of care.

In the foreseeable future more changes may be expected, such as physician shortage due to advances in complex medical techniques, the increasing age of ICU patients and migration of physicians to cities (5, 6). Some rural areas of Europe are already coping with physician shortage (7-9). Although there is not yet a shortage of intensivists in the Netherlands, finding nurses and residents to cover 24/7 shifts on

the ICU is becoming more difficult due to duty hour restrictions of residents and the desire to work in specific areas of the country.

Moreover, the quality of care of residents on the ICU could be organized more efficiently. For most residents the ICU internship is the first encounter with ICU care. Their time for acquiring knowledge and experience in this area mostly remains limited due to their rotating internships for the specialists' training. Training of these residents consumes time and the quality improvement of this training on ICU care becomes only noticeable at the end of their internship. Both reasons, the availability of residents and their limited experience, affect the continuity and quality of daily ICU care and may provide opportunities for the NPP.

Both residents and NPPs require training and supervision by intensivists. While the training to become a NPPs takes longer, a reasonable assumption is that at the end residents require more training time and supervision as they consist of a larger group, generally have no ICU experience, and continuously rotate after a mean of 3-4 months resulting in limited time to profit from their acquired experience. In addition, since NPPs already worked in the ICU as nurses they know the local protocols and require less supervision from the intensivists. This knowledge even makes it possible to guide the new residents in the ICU by explaining local protocols and training or supervise the more simple interventions.

The second part of this descriptive study underscores a potential advantage of implementing NPPs by describing routine invasive procedures in the ICU. The number of inserted venous and arterial catheters per FTE was higher for NPPs (CVC: 20/FTE, arterial catheters 61.7/FTE) than for residents and intensivists together (CVC: 4.3/FTE, arterial catheters: 11.8/FTE). Although information bias could have influenced these numbers, the hypothesis could be that these numbers are due to NPPs not being subjected to time limited experience on the ICU, in contrast to the residents. This experience results in their capability to insert venous and arterial catheters without supervision of an intensivist. Our observed complication rate of the NPP data from 2015 and 2016 was in line with the study from Alexandrou et al. Their comparable complication rate during a 13 years follow-up of a catheter insertion service executed by non-physicians of the ICU is up to international standards. (10-12) Moreover, figure 2 shows that NPPs are indeed able to educate and supervise residents in our hospital. These examples indicate that NPP's can facilitate a broader span of control by taking over some of the tasks of the intensivist with the same quality of care. A further advantage of this workflow is centralisation of these interventions, which is in line with the observed success and complication rate.

American literature already supports implementation of NPPs by reporting a quality impulse on several aspects of ICU care. Both mortality and length of stay in the ICU and in the hospital remain the same or are even slightly better in cohorts of ICUs with NPPs compared to ICUs staffed by only residents and intensivists.(13-17) Additionally, one study analysed the communication between nurses, non-physicians and physicians and found a satisfactory communication of NPPs by all groups and a better communication of NPPs than physicians from the perspective of some groups.(18)

This is in line with the study of Rayo et al. that suggests better comprehended hand-overs and patient orders by experienced NPPs compared to new residents (19). These results refer to the problems residents encounter on the ICU in terms of understanding and carrying out orders during multi-disciplinary meetings.(20) Both outcomes can be explained by ICU-NPPs being more experienced in protocols, routine ICU processes and familiarity with patient orders on the ICU than most residents.

All these benefits can provide an improved continuity of quality for care on ICUs, which is the primary reason for considering implementing NPPs. Whether this quality improvement by NPPs is also cost-effective, remains an unanswered question. Although several studies address this question, it remains difficult to extrapolate their results to other ICUs, as the workflow in each ICU can differ significantly. However, one can hypothesize that outsourcing several tasks of an intensivist to a more inexpensive NPP can save intensivists time and be cost-effective. Based on the plain salaries, NPPs cost more than residents on the long term. The extra costs come with the potential benefit of quality improvement as a result of the NPPs' continuity and experience on the ICU.

Limitations

The most important limitations are inherent to the retrospective cohort design of this study and description of one single ICU. The first limitation is selection bias as the more difficult invasive interventions are more likely done by the most experienced person available, so the NPP or the intensivist. This could explain the higher number of interventions performed by the NPPs compared to the residents. It can also overestimate the number of complications caused by intensivists as they potentially had to insert upper central venous catheters in more sick or less technical accessible patients.

Considering the data collection, retrieving data on catheter insertions performed by residents or intensivists was only possible in the year 2016, while NPPs' data could be obtained over the years 2015 and 2016. Moreover, the aggregated data of intensivist and residents made a desired in depth comparison between residents and NPPs impossible. Additionally, the second bias is the information bias. This could underestimate the number of performed interventions of residents as in our experience they underreport interventions more often since they do not have a separate database. Co-intervention bias is a third possible bias as potentially one group could have increased the use of ultrasound in the analyzed years.

Comparability between residents and NPPs remains difficult. In general, residents have less ICU experience than NPPs due to their shorter presence on the ICU. In contrast, this limited time and therefore experience are also the main reasons for considering implementation of NPPs. Their continuity, experience and knowledge of ICU processes is the main advantage.

Finally, this study describes a training course and staffing model with NPPs in one single center and therefore results can be different in other ICUs with other case mixes.

Conclusions

This descriptive report covers a successful local method of implementing NPPs in the ICU, as a new staffing model concept in Europe. To provide insight on the quality of their skills, an included retrospective cohort analysis indicates that the quality of invasive procedures with a low complication rate seems comparable between NPPs, and residents and intensivists. Whether sustainable quality improvement can be achieved with NPPs in the ICU setting should be subject to further study, both in the Netherlands and in Europe.

References

1. Kleinpell RM, Ely EW, Grabenkort R. Nurse practitioners and physician assistants in the intensive care unit: an evidence-based review. Crit Care Med. 2008;36(10):2888-97.
2. Edkins RE, Cairns BA, Hultman CS. A systematic review of advance practice providers in acute care: options for a new model in a burn intensive care unit. Ann Plast Surg. 2014;72(3):285-8.
3. Cooper RA, Getzen TE, Laud P. Economic expansion is a major determinant of physician supply and utilization. Health Serv Res. 2003;38(2):675-96.
4. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis. 2011;52(9):e162-93.
5. Ward NS, Afessa B, Kleinpell R, Tisherman S, Ries M, Howell M, et al. Intensivist/patient ratios in closed ICUs: a statement from the Society of Critical Care Medicine Taskforce on ICU Staffing. Crit Care Med. 2013;41(2):638-45.
6. Maier CB, Barnes H, Aiken LH, Busse R. Descriptive, cross-country analysis of the nurse practitioner workforce in six countries: size, growth, physician substitution potential. BMJ Open. 2016;6(9):e011901.
7. Hnilicova H, Vavreckova J, Dobiasova K. [Migration trends of Czech physicians]. Cas Lek Cesk. 2008;147(1):49-54.
8. Murias G, Sales B, Garcia-Esquirol O, Blanch L. [Telemedicine: Improving the quality of care for critical patients from the pre-hospital phase to the intensive care unit]. Med Intensiva. 2010;34(1):46-55.
9. Durupt M, Bouchy O, Christophe S, Kivits J, Boivin JM. Telemedicine in rural areas: general practitioners' representations and experiences. Sante Publique. 2016;28(4):487-97.
10. Alexandrou E, Spencer TR, Frost SA, Mifflin N, Davidson PM, Hillman KM. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Crit Care Med. 2014;42(3):536-43.
11. Taylor RW, Palagiri AV. Central venous catheterization. Crit Care Med. 2007;35(5):1390-6.
12. Eisen LA, Narasimhan M, Berger JS, Mayo PH, Rosen MJ, Schneider RF. Mechanical complications of central venous catheters. J Intensive Care Med. 2006;21(1):40-6.
13. Kawar E, DiGiovine B. MICU care delivered by PAs versus residents: do PAs measure up? JAAPA. 2011;24(1):36-41.
14. Landsperger JS, Semler MW, Wang L, Byrne DW, Wheeler AP. Outcomes of Nurse Practitioner-Delivered Critical Care: A Prospective Cohort Study. Chest. 2016;149(5):1146-54.
15. Burns SM, Earven S, Fisher C, Lewis R, Merrell P, Schubart JR, et al. Implementation of an institutional program to improve clinical and financial outcomes of mechanically ventilated patients: one-year outcomes and lessons learned. Crit Care Med. 2003;31(12):2752-63.
16. Scherzer R, Dennis MP, Swan BA, Kavuru MS, Oxman DA. A Comparison of Usage and Outcomes Between Nurse Practitioner and Resident-Staffed Medical ICUs. Crit Care Med. 2017;45(2):e132-e7.
17. Grabenkort WR, Meissen HH, Gregg SR, Coopersmith CM. Acute Care Nurse Practitioners and Physician Assistants in Critical Care: Transforming Education and Practice. Crit Care Med. 2017;45(7):1111-4.
18. Aslakson RA, Wyskiel R, Shaeffer D, Zyra M, Ahuja N, Nelson JE, et al. Surgical intensive care unit clinician estimates of the adequacy of communication regarding patient prognosis. Crit Care. 2010;14(6):R218.
19. Rayo MF, Mount-Campbell AF, O'Brien JM, White SE, Butz A, Evans K, et al. Interactive questioning in critical care during handovers: a transcript analysis of communication behaviours by physicians, nurses and nurse practitioners. BMJ Qual Saf. 2014;23(6):483-9.
20. Mount-Campbell AF, Rayo MF, O'Brien JJ, Jr., Allen TT, Patterson ES. Patient-Centered Handovers: Ethnographic Observations of Attending and Resident Physicians: Ethnographic Observations of Attending and Resident Physicians. Qual Manag Health Care. 2016;25(4):225-30.

Part II

Chapter 4

Prospective evaluation of interventions by APPs

Procedures in the ICU performed by Advanced Practice Providers compared to Medical Residents: a prospective observational study.

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Abstract

Objective: To assess the frequency and safety of procedures performed by Advanced Practice Providers and Medical Residents in a mixed bed ICU.

Design: A prospective observational study where consecutive invasive procedures were studied over a period of 1 year and 8 months. The interventions were registered anonymously in an online database. End points were success rate at first attempt, number of attempts, complications, level of supervision and teamwork.

Setting: A 33-bedded mixed ICU.

Subjects: advanced practice providers and medical residents

Interventions: Registration of the performance of tracheal intubation, central venous and arterial access, tube thoracostomies, inter-hospital transportation and electrical cardioversion.

Measurement and Main Results: A full-time advanced practice provider performed an average of 168 procedures and a medical resident an average of 68. The advanced practice provider inserted significant more radial, brachial and femoral artery catheters (66% vs 74%, p=.17, 15% vs 12% p=.14, 18 vs 14% p=.14). The number of attempts needed to successfully insert an arterial catheter was lower and the success rate at first attempt was higher in the group treated by advanced practice providers (1.30 [interquartile range 1-1.82] vs 1.53 [interquartile range 1-2.27], p<.0001 and 71% vs 54%, p<.0001). The advanced practice providers inserted more central venous catheters (247 vs 177) with a lower number of attempts (1.20 [interquartile range 1-1.71] vs 1.33 [interquartile range 1-1.86]) and a higher success rate at first attempt (81% vs 70%; p<.005). The number of intubations by advanced practice providers were 143 and by medical residents 115 with more supervision by the APP (10% vs 0%; p=.01). Team performance, as reported by nursing staff was higher during advanced practice provider procedures compared to medical resident procedures (4.85 [4.85-5] vs 4.73 [4.22-5]). Other procedures were also more often performed by advanced practice providers. The complication rate in the advanced practice provider-treated patient-group was lower than the resident group.

Conclusions: Advanced practice providers in critical care performed procedures safe and effectively when compared to medical residents. Advanced practice providers appear to be a valuable addition to the professional staff in critical care when it comes to invasive procedures.

Introduction

The Advanced Practice Provider (APP) increasingly contributes to the clinical expertise in the area of critical care. They provide timely and high-quality care for the critically ill patient. Although a fair amount of articles about this relatively new profession have been published, some critical care organizations consider this evidence to be too limited to support the widespread implementation of APP's (1, 2). Besides this, there is a certain global unawareness among critical care professionals about the full potential and valuable contribution of the APP to critical care (3). According to the literature APPs are embedded in critical care areas in several countries including the United States (4-8).

The APP in critical care can perform multiple lifesaving tasks as part of a multiprofessional team and can even extend coverage of critical care expertise in critical access areas where physician coverage is limited. Therefore cost-efficiency or a shortage of critical care physicians in several countries might lead to an increased demand of APPs (9, 10). Because of the increasing utilization of APPs in critical care it is important to clearly define their role and investigate areas where these professionals provide high-quality care.

One of the aspects of this high-quality care is performing procedures on the ICU. To measure and establish the quality of these procedures, we performed a prospective observational study in which we compared the quality of ICU procedures performed by APPs to the procedures performed by medical residents (MRs).

Methods

Setting

This study was performed in a 33 bedded mixed medical, surgical and cardiothoracic ICU in the Catharina Hospital in Eindhoven, the Netherlands. This is a major teaching hospital in the Netherlands providing a wide variety of clinical care including cardiac surgery. The medical staff of the ICU consists of intensivists supported by MRs, and APPs. Some residents have a rotating schedule of 3 or 4 months in which ICU experience is obtained for their specialist training and some residents remain longer, for a maximum of 1.5 years. The weekly required working hours and night shifts for residents and APPs on our ICU are equal and are limited to 38 hours per week according to Dutch legislation and local agreements.

APPs

The APPs are qualified as Physician Assistants (PAs) and followed a training of 2.5 years with theoretical and practical examinations in the medical domain to obtain a master degree. ICU experience is acquired on the job. All PAs have an ICU nursing background. In the area of critical care the PAs are licensed to diagnose and treat patients autonomously together with other professionals. Accreditation has to be obtained during 5-year intervals.

MRs

The different specialty tracks the MRs are coming from are: Surgery, Internal Medicine, Cardiology, and Pulmonology.

Study Design

The study was planned over a period of 1 year and 8 months. All consecutive procedures performed by APPs and MRs were prospectively monitored and analyzed. The ethics committee and local institutional review board reviewed and approved the study.

Data collection and procedures

A registration website with restricted access was developed for all procedures. A database with standardized forms was created with mixed limited choice and free-text answers. For each procedure, the APPs or MRs name, date, supervising clinician and assisting nurse (RN) were registered. In addition, the ICU nurse assisting with the procedure was instructed to score team performance and patient communication in the same form. Team performance was graded by the RN on a performance scale from 1 to 5: 1 being poor and 5 being optimal team performance. The scoring was a subjective opinion about the situation which was not anonymous. APPs cross-checked whether procedures of either APPs or MRs were registered.

Inclusion criteria

All procedures performed by APPs and MRs are stated below.

Exclusion criteria

none.

Arterial catheters

For all arterial catheters the anatomic location of artery, type of catheter, use of ultrasound, presence of vasopressors, the mean arterial blood pressure of the patient during the procedure, palpability of artery, number of attempts, success rate and

earlier attempts by another APP or MR and the Acute Physiology and Chronic Health Evaluation (APACHE) score were registered.

The following complications of arterial line insertion were recorded: hematoma (subcutaneous containment of bleeding), bleeding (macroscopic bleeding) and the inability to insert a guide wire in case of using the Seldinger technique. In all cases a 20-Birmingham gauge (G) radial artery catheter was used with or without Seldinger technique (Becton Dickinson, Franklin Lakes, NJ) or an 18G femoral artery catheter with Seldinger technique was used (Arrow Teleflex, Wayne, PA)

Central venous catheters

For all central venous catheters, the anatomic location, type of catheter, the use of ultrasound, number of attempts, success rate and earlier attempts by another APP or MR were registered.

Regarding the complications, arterial puncture, bleeding (hemothorax), hydrothorax and pneumothorax (subcutaneous emphysema was also regarded as pneumothorax) were registered and labeled as major complications. Guide wire insertion problems, introducer problems, local hematomas and other technical problems with easy solutions were registered as minor problems. Due to institutional processes regarding monitoring for central line infection, this data was not collected through our website registration system. However, this data was obtained through a separate system and checked against our registration. Infections occurring after one week were excluded from this study due to possible confounding factors outside of insertion techniques. Correct placement of the catheter was obtained after review of the chest X-ray. In all cases, an 8.5 F triple-lumen catheter (Arrow Teleflex) or a 11 F femoral dialysis catheter or a 14 F soft tip dialysis catheter for jugular insertion were used (Dirinco, Oss, the Netherlands).

Intubations

All intubations were prepared according to a pre-intubation checklist. This checklist includes the technical devices that must be present, the back-up plan in case of an 'unable to intubate' scenario and the instructions to the team regarding the procedure and the back-up plan. The registration noted all medications that were used, the reason for intubation, the type of laryngoscope , and the Cormack-Lehane classification (11).

Multiple attempts, esophageal placement of the tube, aspiration, resuscitation, and other relative complications were registered as complications including tube migration, change of laryngoscope and intervention by supervising clinician.

Residents and APPs were allowed to perform the intubations without direct supervision after an authorization from the ICU management. In all cases, a 7- to 8.5-mm oral/nasal cuffed tube was used (Covedian, Mansfield, MA).

Chest tube insertion

The registration comprised the location, the kind of diagnostic procedure (pleural drainage or tube insertion), the type of chest tube that was used and complications. Because the internship of the resident is relatively short (minimum 4 months and maximum 1.5 years) in comparison to APPs and the amount of procedures is limited, only absolute numbers are presented, and no p-values were given.

Transportation

This registry comprised intra-hospital transportation with medical accompaniment, for example a CT scan with patients on mechanical ventilation. The transportation to and from the operating theatre is excluded, because an escort is provided by the anesthesiologist. Because the internship of the resident is relatively short (minimum 4 months and maximum 1.5 years) in comparison to APPs and the amount of procedures is limited, only absolute numbers are presented, and no p-values were given.

Electrical Cardioversion of rhythms:
Baseline registration and complications were registered. Because the internship of the resident is relatively short (minimum 4 months and maximum 1.5 years) in comparison to APPs and the amount of procedures is limited, only absolute numbers are presented, and no p-values were given.

Tracheostomy cannula exchange:
Baseline registration and complications were registered.

Supervision

When supervision was required a physician was present and supervised the procedure by verbally guiding the MR or APP or by providing hands-on supervision. Supervision provided by the APP to MRs or colleagues was performed in the same way. MRs deemed qualified by the intensivist to perform a procedure alone were also permitted to supervise other procedures.

Statistical analysis

Data are described as numbers and percentages or given as a mean with standard deviation. In case of skewed distribution, the median and interquartile range (IQR) is

reported. APPs and residents are compared as independent groups with the χ2 test all with Yates Continuity Correction (large samples) for ordinal or dichotomous data and with the Fisher exact test for small samples. The Mann-Whitney-U test was used for continuous data. A two-sided p value lower than 0.05 is considered as statistically significant. All statistical analyses were performed with SPSS version 25 (IBM corporation, Armonk, NY). In the subdivision complications, p-values were only calculated when there were enough events to calculate any clinically relevant difference.

Results

In 2017 five APPs covering a total of 4.84 full time equivalent (FTE) and ten MRs covering a total of 9.54 FTE performed all procedures. In 2018 these FTEs were 5.59 and 9.56, respectively. Because most MRs did not stay the entire year and one new APP started during the study, the FTEs differed during the two years and were not equal, round numbers. The average experience of the APPs working on the ICU during this study was 6.75 years. The experience years are presented in **figure 1**. The two most inexperienced APPs had less than 1-year ICU experience. The ICU experience of all MRs was less than 2 years, although residents from the surgical and cardiologic specialties often had some experience in procedures like intravascular catheterization. The residents from the department of internal medicine occasionally gained experience during earlier internships on the ICU.

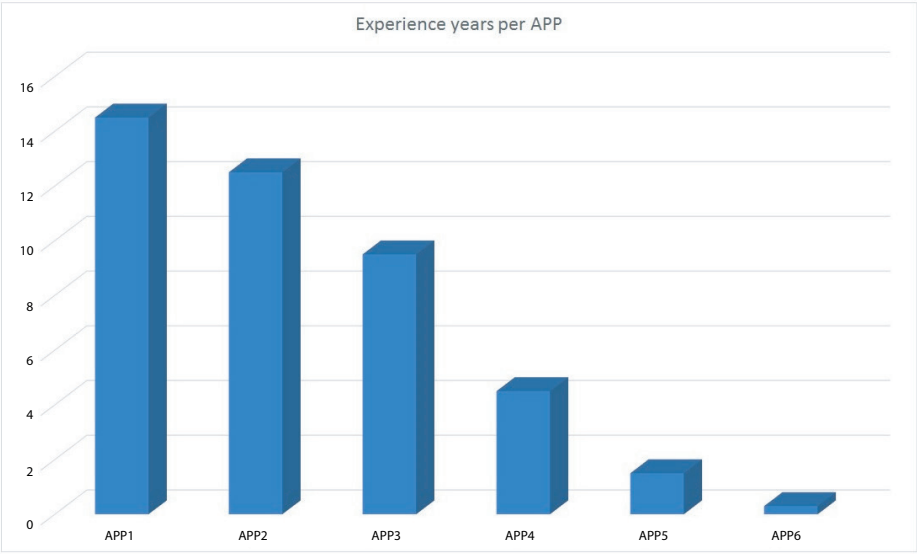

Figure 1. Years of experience of advanced practice provider (APP). Every separate bar represents the number of years of experience per APP.

The total number invasive procedures (arterial catheters, central catheters and intubations) performed by APPs was 868 and by MRs 647. This resulted in 168 procedures per FTE APP and 68 procedures per FTE MR

Arterial access

The total number of arterial invasive cannulations was 835; 478 performed by APPs and 355 by MRs (**table 1**), 90 cannulations per FTE APP and 37 cannulations per FTE MR. The results are summarized in table 1. The number of attempts before success in the APP group was median 1.30 (IQR 1-1.82) and in the MR group median 1.53 (IQR 1-2.27) (p<0.001). The patients treated by APPs used significantly more vasopressors (p=0.04), they had a significantly lower systolic blood pressure (p=0.04) and the arteries of their group of patients were significantly less palpable (p<0.001).

Table 1. Baseline Characteristics of Patients and the Performance of Both Groups Regarding Insertion of Arterial Cathaters

Arterial catheters:	**APP**	**MR**	**p**
Total numbers:	478	355	
Radial artery	317 (66%)	265 (74%)	.017
Brachial artery	73 (15%)	41 (12%)	0.14
Femoral artery	88 (18%)	51 (14%)	0.14
Diversion to other sites then radial artery	161 (34%)	92 (26%)	0.048
Systolic blood pressure (mmHg)	110 (90-125)	110 (90-130)	0.04
Vasopressor use	158 (33%)	93 (26%)	0.035
Ultrasound use	53 (11%)	60 (17%)	0.02
Palpability	346 (72%)	293 (82%)	<0.001
Nr of attempts before success	1.30 (1.0 -1.82)	1.53 (1.0 -2.27)	<0.0001
Success rate first attempt	340 (71%)	200 (54%)	<0.0001
Complication rate	36 (7.5%)	40 (11%)	0.09
Acute obstruction arterial vessel	0	1 (<1%)	na
Hematoma	25 (5%)	30 (8%)	0.91
Bleeding	0	2 (<1%)	na
Other	11 (2%)	7 (2%)	na
Need for direct supervision	12 (2.5%)	77 (22%)	<0.001

na: not assessed because of low numbers

APACHE II and IV scores were available for 73% of the patients. They were not significant different between the APP and MR groups (APACHE II: p=0.4, APACHE IV: p=0.92)

APPs were significantly less inclined to use ultrasonography as guidance when inserting arterial catheters 11% vs 17%, p=0.02. The APPs up till 2 years' experience used ultrasonography as often as the residents. APPs used the radial artery less often than the MRs and diverted to another site more easily, p=0.017. The complication rate of APPs did not differ from the complication rate of the MRs (7.5% vs 11%, p=0.09).

One major complication was encountered. After introduction of the guidewire in the femoral artery by one of the MRs, the patient developed an acute arterial occlusion of the lower part of the leg. The other complications as depicted in table 1 were mostly guide wire advancement problems.

The MRs needed significantly more supervision compared to the APPs, (22% vs 2.5%, p<0.001).

An analysis of the 2 APPs with less than 2 years' experience showed the same difference. The number of arterial invasive cannulations by this subgroup of APPs was 139 which is 69.5 per FTE (MRs 37 per FTE). The number of attempts before success were significant less than those of the MRs median 1.32 (IQR 1-1.83; p<0.001) Supervision was needed in 8.3% of the cases, less than the 22% of the MRs. (p<0.001)

Central venous access

The total number of central venous catheters inserted in the study episode was 436. Four hundred twenty-four were inserted by either APP or MR as shown in **table 2** the remainder was inserted by an APP in training. Two hundred forty-seven procedures were performed by the APPs and 177 were performed by MRs. APPs performed 47 central venous catheters per FTE and MRs 19 per FTE.

All venous catheter insertion characteristics are depicted in table 2. The APPs were significantly more successful regarding the number of attempts before success and the success rate at first attempt. Supervision during catheter insertion was provided to APPs in 15% of the cases and to MRs in 54% of the cases, p<0.001. The APPs provided significantly more supervision to MRs than MRs provided supervision to colleagues (p<0.001). A subgroup analysis of the 2 APPs with less than 2 years' experience showed the same difference. The number of venous catheters inserted by this subgroup of APPs was 57 (28.5 per FTE). The number of attempts before success

were significant less than that of MRs median 1.11 (IQR 1-1.61 p<.002) Supervision was needed in 39% of the cases which was not significant different from the MRs.

Table 2. Baseline Characteristics of Patients and the Performance of Both Groups Regarding Insertion of Central Venous Catheters

Central venous catheters:	**APP**	**MR**	**P value**
Number of catheters	247	177	
Femoral vein	165 (67%)	110 (62%)	0.38
Subclavian vein	30 (12%)	15 (9%)	0.30
Jugular vein	52 (21%)	52 (29%)	0.06
Overall			
Ultrasound	137 (56%)	117 (66%)	0.035
Nr of attempts before success	1.20 (1.0 -1.71)	1.33(1.0 - 1.86)	<0.005
Success rate first attempt	200 (81%)	123 (70%)	<0.005
Total complication rate	15 (6%)	12 (7%)	1.0
Arterial punctures	7(3%)	5 (3%)	1.0
Major complication rate	2 (1%)	2 (1%)	na
Pneumothorax	1	1	na
Bleeding	0	1	na
Hematoma	0	3	na
Arrhythmia + reanimation	0	1	na
Catheter wrong route	1	0	na
Other	2	2	na
Supervision	38 (15%)	95 (54%)	<0.001
Providing supervision	47 (19%)	9 (5%)	<0.001
Femoral venous access:			
Number of catheters	165	110	
Ultrasound	86 (52%)	69 (63%)	0.11
Success rate first attempt	130 (79%)	75 (68%)	0.05
Arterial punctures	7 (4%)	3(3%)	0.74
Major complication rate	0%	1 (1%)	

Table 2. Continued

Subclavian venous access:			
Number of catheters	30	15	
Ultrasound	2 (6.7%)	3 (6.7%)	
Success rate first attempt	25 (83%)	8 (53%)	0.07
Arterial punctures	0%	0%	na
Major complication rate	1 (3%)	1 (7%)	na
Jugular venous access:			
Number of catheters	52	52	
Ultrasound	49 (94%)	47 (90%)	0.71
Success rate first attempt	45 (87%)	40 (77%)	0.31
Arterial punctures	1 (2%)	2 (4%)	na
Major complication rate	1 (2%)	1 (2%)	na

na: not assessed because of low numbers

One hundred sixty-five catheters were placed in the femoral vein by APPs and 110 by MRs. The complications are shown in table 2. The overall complication rate did not differ between APPs and MRs. One complication was a cardiopulmonary resuscitation due to ventricular tachycardia during insertion of a dialysis catheter in the femoral vein by a MR. The APPs had a significant higher success rate at their first attempt (p=0.05).

Thirty catheters were placed in the subclavian vein by APPs and 15 by MRs. Both groups encountered 1 pneumothorax as major complication.

Fifty-two Jugular vein catheters were placed by APPs and 52 jugular vein catheters were placed by MRs. All characteristics of the central venous catheterization are summarized in table 2. The major complication rate in both groups was equal; the APP encountered one accidentally placed arterial catheter which could be removed without resulting neurologic impairment. The MRs encountered one hemothorax which did not require additional intervention.

Intubations

A total of 258 tracheal intubations were performed during the study period. 143 (55%) were performed by APPs and 115 (45%) were performed by MRs (**table 3**). The APPs performed 27 intubations per FTE during the study period and the MRs 12.

Table 3. Baseline Characteristics of Patients and the Performance of Both Groups Regarding Intubations

Intubations:	**APP**	**MR**	**p**
Number of intubations	143	115	
Video Laryngoscope	101 (71%)	78 (68%)	0.73
Direct Laryngoscope	38 (27 %)	35 (30%)	0.49
Video Laryngoscope with Gum-Elastic Bougie	4 (3%)	2 (2%)	na
Supervision	91 (73%)	115 (100%)	<0.0001
Provided supervision	14 (10%)	0%	0.01
Cormac-Lehane >1	44 (31%)	33 (30%)	0.82
Emergency intubation	128 (91%)	94 (82%)	0.07
Nurse satisfaction teamwork	4.85 (4.34-5.0)	4.73 (4.22-5.0)	0.02
Complication rate	13 (9%)	12 (10%)	0.88
Complications:			
Aspiration	1 (<1%)	1 (<1%)	na
Esophageal intubation	4 (3%)	1 (<1%)	na
Hemodynamic collapse	2 (1%)	0	na
More than one attempt	6 (4%)	8 (7%)	na
Dislocation of the tube	0	1 (<1%)	na

na: not assessed because of low numbers

The APPs performed 71% of the intubations with video laryngoscopy and used direct laryngoscopy in 26% of the cases. The MRs used video laryngoscopy in 68% and direct laryngoscopy in 30% of the cases.

The APPs were supervised in 73.4% of the cases and the MRs in 100% of the cases. In 10% of the cases the supervision to MRs was provided by APPs. No resident was considered experienced enough during this study period, to perform intubations without supervision.

The complication rate between MRs and APPs did not differ. The APPs encountered adverse events in 13 cases (9%) and the MRs in 12 (10%) (p=0.88). Adverse events are shown in table 3. Multiple attempts to intubate were encountered in 4.2% of the intubations by APPs (6) and in 7.0% of the MRs (8).

The APP scored a bit higher on teamwork (p=0.02) as judged by the assisting registered nurse. In 3 cases the performance of the team with an APP was graded 3 or less and in 1 case the team with a MR was graded 3 or less.

Other procedures

The other registered procedures are in-hospital transportation, pleural drainage, electrical cardioversion and changing tracheostomy cannulas. The results are summarized in **table 4**.

Table 4. Characteristics of other procedures

Pleural drainage:	**APP**	**MR**	**p**
Number of procedures	10	7	
Inter-Hospital transport:			
Number of procedures	66	54	
Electrical cardioversion:			
Number of procedures	15	14	
Number of supervised procedures	4 (27%)	11 (79%)	0.059
Changing tracheostomy cannulas:			
Number of procedures	4	2	

Discussion

We have shown that, in our setting, APPs perform more invasive procedures than MRs during the daily ICU care. According to the items analyzed during arterial catheterization, the APP's performed these procedures either with comparable success rate or better than MR's. The APPs needed less attempts before a catheter was inserted and needed more often only one attempt. Furthermore, the group of patients treated by APPs used more vasopressors, had a lower blood pressure and the palpation of arteries appeared more difficult. This implies that the APPs treated a more complex group of patients, although the APACHE score between the two

groups showed no significant differences. Possibly, experience of the APP plays a role in these differences.

Similar results were found for central venous catheter insertion. The number of catheters introduced by APPs exceeded those of MRs with higher success rates at first attempt. The number of procedures by APPs requiring supervision was less than in the MR group and often the APPs provided supervision to the MRs. Within the group of APPs we observed no outliers either in poor or excellent performance.

There was an excess in the total number of procedures performed by APPs. Apparently, there is an easy referral of these procedures to APPs by other physicians. This likely occurs because the APP is considered a fast, effective and safe performer, while the MR is often not as experienced as the APP. The term quality of procedures is not strictly defined but in the literature items like complication rate, number of attempts, time till insertion, overview of the situation and teamwork are used for evaluation of procedures. If we use these items as definition for the quality of the procedure, the quality of procedures by APPs was well in range of established performance rates for clinicians performing these procedures (12, 13). Although in this study, the APP often refrained from the use of ultrasound, the success rate and complication rate were comparable to the rate mentioned in the literature with the use of ultrasonography (12, 13). These results are remarkable since the studies described in these Cochrane reviews reported data in often less complex patient groups.

A few studies have been published regarding interventions by APPs (5, 14-16). In general, these reports confirm the results of our study. APPs do not have a higher rate of mechanical complications or infections during insertion procedures of central venous lines (14), neither do APP's have higher complication rates in other procedures (5, 15, 16).

Strengths and limitations

Strengths of this prospective study are the large amount of procedural data which enables a thorough estimation of the performance of APPs, their rates and some psychological assessment data about team performance and communication.

However, we also acknowledge some limitations. Comparing APPs to residents is comparing a relative experienced group to a group which is still learning interventions. A subgroup analysis of our data with APPs less than 2 years of experience compared to the results in the MR group is probably a more valid comparison. This comparison also shows that in this subgroup the differences in

success rate and the larger amount of procedures remained. This at least justifies the conclusion of non-inferiority as far as interventions are concerned. The fact that the complication rate was also low compared to the Cochrane reviews show that the APP is very capable of performing all kind of procedures safely.

This study is also not randomized and/or blinded. This implies that preferences from either APPs, MRs, or supervisor for certain patients or procedures are not entirely eliminated. Moreover the grading of teamwork performance by the nursing staff could potentially be biased. Finally, because no literature has been published about predictions of successful small catheter arterial line insertion, the items we scored could be considered surrogate markers and possibly do not predict quality adequately. Therefore, differences between the groups regarding arterial insertion must be interpreted with caution.

Future directives

It would be interesting to examine time frames of procedures because they may reflect the ease with which the procedure is performed. Also more subtle parameters as patient and nurse interaction and evaluation of psychological considerations could attribute to the understanding of the preferential use of either APPs, or MRs or intensivists performing procedures.

Conclusions

This study indicates that APPs are able to perform routine procedures such as arterial catheters, central venous catheters and tracheal intubations in critically ill patients safe and effectively. Moreover, APP's perform the procedures more often and more seamlessly. This makes APPs a valuable addition to the professional staff of an ICU.

References

1. Kleinpell RM, Grabenkort WR, Kapu AN, et al. Nurse Practitioners and Physician Assistants in Acute and Critical Care: A Concise Review of the Literature and Data 2008-2018. Crit Care Med 2019.
2. Kreeftenberg HG, Pouwels S, Bindels A, et al. Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med 2019.
3. Fry M. Literature review of the impact of nurse practitioners in critical care services. Nurs Crit Care 2011;16(2):58-66.
4. Alexandrou E, Spencer TR, Frost SA, et al. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Crit Care Med 2014;42(3):536-543.
5. Sirleaf M, Jefferson B, Christmas AB, et al. Comparison of procedural complications between resident physicians and advanced clinical providers. J Trauma Acute Care Surg 2014;77(1):143-147.
6. Skinner H, Skoyles J, Redfearn S, et al. Advanced care nurse practitioners can safely provide sole resident cover for level three patients: impact on outcomes, cost and work patterns in a cardiac surgery programme. Eur J Cardiothorac Surg 2013;43(1):19-22.
7. Pirret AM. The role and effectiveness of a nurse practitioner led critical care outreach service. Intensive Crit Care Nurs 2008;24(6):375-382.
8. van Vught A, van den Brink G, Hilkens M, et al. Analysis of the level of clinical skills of physician assistants tested with simulated intensive care patients. J Eval Clin Pract 2018;24(3):580-584.
9. Kleinpell RM, Ely EW, Grabenkort R. Nurse practitioners and physician assistants in the intensive care unit: an evidence-based review. Crit Care Med 2008;36(10):2888-2897.
10. Pastores SM, O'Connor MF, Kleinpell RM, et al. The Accreditation Council for Graduate Medical Education resident duty hour new standards: history, changes, and impact on staffing of intensive care units. Crit Care Med 2011;39(11):2540-2549.
11. Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. Anaesthesia 1984;39(11):1105-1111.
12. Brass P, Hellmich M, Kolodziej L, et al. Ultrasound guidance versus anatomical landmarks for subclavian or femoral vein catheterization. Cochrane Database Syst Rev 2015;1:CD011447.
13. Brass P, Hellmich M, Kolodziej L, et al. Ultrasound guidance versus anatomical landmarks for internal jugular vein catheterization. Cochrane Database Syst Rev 2015;1:CD006962.
14. Alexandrou E, Murgo M, Calabria E, et al. Nurse-led central venous catheter insertion-procedural characteristics and outcomes of three intensive care based catheter placement services. Int J Nurs Stud 2012;49(2):162-168.
15. Bevis LC, Berg-Copas GM, Thomas BW, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. Am J Crit Care 2008;17(4):357-363.
16. Kreeftenberg HG, Aarts JT, de Bie A, et al. An alternative ICU staffing model: implementation of the non-physician provider. Neth J Med 2018;76(4):176-183.

Part III

Chapter 5

A patient outcomes study of non-technical skills by APPs.

Advanced Practice Providers versus Medical Residents as Leaders of Rapid Response Teams: a 12-month retrospective analysis.

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Abstract

Purpose

In a time of worldwide physician shortages, the advanced practice providers (APPs) might be a good alternative for physicians as the leaders of a rapid response team. This retrospective analysis aimed to establish whether the performance of APP-led rapid response teams is comparable to the performance of rapid response teams led by a medical resident of the ICU.

Material and Methods

In a retrospective single-center cohort study, the electronic medical record of a tertiary hospital was queried during a 12-months period to identify patients who had been visited by our rapid response team. Patient- and process-related outcomes of interventions of rapid response teams led by an APP were compared with those of teams led by a medical resident using various parameters, including the MAELOR tool, which measures the performance of a rapid response team.

Results

In total, 179 responses of the APP-led teams were analyzed, versus 275 responses of the teams led by a resident. Per APP, twice as many calls were handled than per resident. Interventions of teams led by APPs, and residents did not differ in number of admissions (p=0.87), mortality (p=0.8), early warning scores (p=0.2) or MAELOR tool triggering (p=0.19). Both groups scored equally on time to admission (p=0.67) or time until any performed intervention.

Conclusion

This retrospective analysis showed that the quality of APP-led rapid response teams was similar to the quality of teams led by a resident. These findings need to be confirmed by prospective studies with balanced outcome parameters.

Abbreviations

APP: advanced practice provider
DNAR: do not attempt resuscitation
FTE: full time equivalent
ICU: intensive care unit
MR: medical resident
RRT: rapid response team

Introduction

Hospital medicine is dealing with patients with increasingly complex disorders that require a highly efficient and high-quality healthcare organization [1, 2]. Rapid response systems with teams led by physicians have been shown to reduce in-hospital cardiopulmonary arrests and mortality [3, 4]. However, the organization of these rapid response systems is subject to the worldwide emerging shortages of physicians, especially in rural areas. [5, 6]

These shortages force numerous hospitals to reorganize their rapid response systems and other teams in order to be able to continue to provide a 24/7 coverage.

One option that has been considered is that a rapid response team might be led by different health care professionals, ranging from attending physicians to nurses. Limited scientific evidence suggests that teams led by a physician perform better than teams led by non-physicians [7, 8]. In practice however, an increasing proportion of in-hospital acute and emergency care is delivered by junior clinicians in the first years of their training, including the responsibility of leading a rapid response team, which might reduce the efficacy and quality of these teams. One of the potential solutions is to reallocate this responsibility to physician assistants or nurse practitioners, also called advanced practice providers (APP). This profession is gaining recognition in critical care which is supported by clinicians who recognize their quality and continuity of their work. [9, 10]

Very few experiences with APPs as leaders of a rapid response team have been reported [11, 12].

Two previous studies provided some guidance about the outcomes of patients visited by a team led by an advanced practice provider, but inter-comparability is hampered by differences between the considered health care systems and by the lack of validated outcome parameters. A third, retrospective single center study comparing outcome data of rapid response teams led by a nurse practitioner and by a registrar showed an improved hospital mortality in the nurse practitioner -led group after propensity matching. This study mainly reported patient outcomes [13].

The main objective of the present study was, to establish whether the performance of APP-led rapid response teams is comparable to the performance of teams led by a medical resident of the ICU, focusing on process- as well as patient-related outcomes.

Methods

Study design and setting

We performed a single-center retrospective cohort study over a period of 12 months. This time period was chosen to reduce the influence of confounders, such as changes within the organization of the hospital and the ward, for instance the implementation of a completely new operational Electronic Medical Record (EMR) in the hospital or the use of continuous monitoring devices within certain departments. The study was performed in the Catharina Hospital Eindhoven, a Dutch tertiary teaching hospital which houses all specialties except for neurosurgery and transplantation surgery. The hospital has a 33-bedded ICU, which facilitates a mix of post-operative cardiac and oncologic surgery and, on the other hand, specialties such as, neurology, pulmonology and gynecology and internal medicine, including dialysis. During the period of the study, clinical protocols regarding the rapid response system remained unchanged.

Patient selection

The EMR was queried to identify patients who had been assessed by the rapid response team. Patients and assessments were eligible if a bed-side assessment had been performed by the rapid response team in patients aged 18 years of older. Medical consultations by telephone were excluded.

Rapid response team triggering, modified early warning score and the MAELOR tool

On the wards, the modified early warning score is used as described by v Galen et al [14] to identify deteriorating patients or patients in need of advanced care. In short, this tool assigns points to abnormal physiological parameters and in turn triggers a rapid response team call. It also provides the opportunity to call in support if there is a sense of unease about the condition of the patient.

The MAELOR tool is a validated tool to measure and quantify the performance of a rapid response team [15]. This tool consists of a flow chart which is triggered if the patient has a high modified early warning score and stops triggering if a patient is admitted within 4 hours after the initial call or has a resolution of critical clinical symptoms within 48 hours. The tool also stops triggering if there are treatment limitations and if ICU admittance is not warranted.

The MAELOR tool flow diagram is depicted in Fig 1. Clinical variables necessary for the MAELOR tool were only recorded until 48 hours after the initial call.

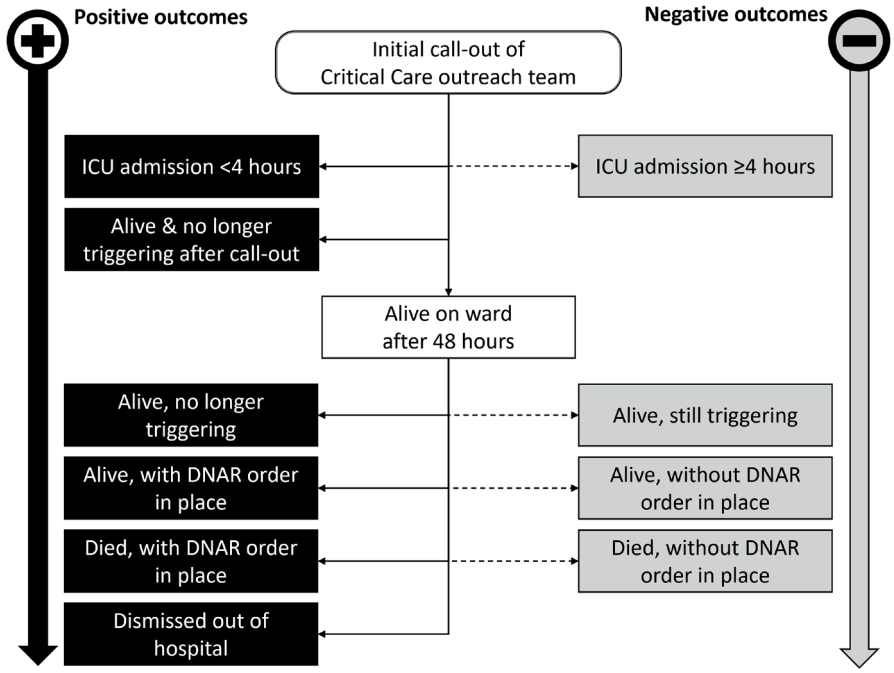

Fig 1. Flow chart MAELOR tool

Rapid response team organization

The organization of the local rapid response system has been described in the COMET study, a multicenter study that evaluated the implementation of structured rapid response systems in the Netherlands [3]. Since implementation of the rapid response team in the Catharina Hospital Eindhoven in 2013, These teams have consisted of an ICU nurse and a team leader, the leader being either a medical resident working on the ICU or an advanced practice provider. One of the medical residents or advanced practice providers on the ICU manages the pager for the rapid response team during duty. A call to the rapid response team can be made if a patient on the ward scores a modified early warning score of ≥ 3 points or if a nurse experienced a substantiated sense of worry about a patient. This call can either be made by medical residents or by registered nurses on the general ward. Usually, when the modified early warning score indicates a critically ill patient, the nurse on the ward informs the resident, who in turn decides if a rapid response team assessment is necessary. The rapid response team call is postponed if the cause of the high early warning score is known and additional treatment, such as an operation, has been planned or if a sepsis can be treated on the normal ward.

The team carries a basic set of materials, which consists of resuscitation fluids, masks for supplemental oxygen and lifesaving medication, such as glucose or phenylephrine.

Following the first assessment, the leader of the rapid response team discusses the case with the intensivist on call for the ICU. This consultation results either in ICU admission or in recommendations for treatment on the general ward, which can include changing treatment limitations, such as the "do not resuscitate" (DNR) code or the "do not intubate" (DNI) code and other treatment limitations. If it was decided that the patient is to be admitted to the ICU, the rapid response team transports the patient and admits him or her to the ICU. After the admission to the ICU the leader of the rapid response team remains responsible for the care of the patient until the end of his duty, together with a dedicated ICU nurse. Shortly after ICU admission, the intensivist visits the patient in the ICU. The hospital has a separate team for non-ICU-related in-hospital cardiac arrests. In case of a cardiac arrest the rapid response team is involved if the patient experiences a return of spontaneous circulation and will be admitted to the ICU or the cardiac care unit (CCU).

Advanced practice providers and medical residents

The advanced practice providers who work in the ICU are qualified as physician assistants. They received a 2.5-year training in the medical domain, which grants them a master's degree, and after graduation, they are qualified to perform all ICU tasks autonomously. The APPs all worked as ICU-nurse before their training to become an APP. They work in collaboration with intensivists. The medical residents originate from the following disciplines: internal medicine, cardiology, pulmonology, and surgery. The medical residents attend an internship during a period ranging from 3 months to 1 year.

Shifts

The ICU ward uses a system of rotating shifts with a minimum of four clinicians in each shift (advanced practice providers and medical residents). Usually, six of these clinicians are present during the day shift. During the evening shift, two or three of these clinicians are present, and during the night shift, two. The number of FTE in the entire group of advanced practice providers is 4.99, and in the MR group it is 10.69.

Ethics

Approval for the study was obtained from the national and regional Ethics committee in accordance with Dutch and European legislation (Medical Research Ethics Committees United (MEC-U); W17.095). A local applicability permission was obtained separately. This article was prepared using the Standards for Quality Improvement Reporting Excellence (SQUIRE) guidelines [16].

Data

Data of all the consecutive rapid response team visits over a period of 12 consecutive months (2017-2018) were retrospectively extracted from the hospital data base. The patient variables collected were age sex, diagnosis, hospital admission, discharge data, death, Apache IV score on admission and after 24 hours, all blood samples before and after the rapid response team consultations and treatment limitations. Additionally, the composition of the team was noted.

Since there are no mandatory rules for the composition and organization of a rapid response team, the performance and efficiency of different teams are difficult to measure and compare. We gathered several parameters to measure the efficiency of the process. The parameters could be categorized in three groups. First, the patients' outcome data: length of stay, mortality, and if applicable, treatment limitations. Second, parameters of team performance: to measure team performance, we used the time until change in early warning system score together with the time until various interventions: the time between the consultation of the rapid response team and the arrival on the ICU, the time between the consultation and interventions such as central or arterial catheterization or intubation. Arterial and central venous lines can be inserted both by residents and by APPs. Intubations by residents are performed under supervision. Third, the MAELOR tool, a validated instrument to assess the performance of rapid response teams was scored.

Statistics

The data were analyzed with SPSS statistical package version 25 (IBM corporation, Armonk, NY, USA). Means are reported with standard deviations for normal distributions and medians with interquartile range are reported for other distributions. Parameters which were recorded once every hour were considered continuous. Categorical independent variables were compared using the Chi-square test with Yates continuity correction. Categorical and continuous independent non-parametric variables were compared with the Mann Whitney U test, and for the independent parametric variables were analyzed with the independent samples t-test.

Categorical variables with two continuous variables at different points were compared using the mixed between-within subjects analysis of variance was used. A p-value of $p< 0.05$ was considered statistically significant.

Results

All 454 consecutive rapid response team calls during the assessed period were included in the analysis. Because not all patients received every treatment that was assessed in this study, data on antibiotic change, central venous access, arterial catheters and intubation were not available for all patients.

The team was led by an advanced practice provider in 179 cases and by a medical resident in 275 cases. Of the 454 rapid response team calls, 296 resulted in the patient being admitted to the ICU. This represents approximately 10% of the total yearly ICU admittances. The percentages of rapid response calls resulting in an admission to the ICU were comparable between teams led by an APP and those led by a medical resident (118 (65%) vs 178 (66%), p=0.78). The level of experience of the APPs was a median of 6.25 years (3.33y-8.25y). In general, an APP handled twice as many calls as a MR.

Table 1 presents the baseline characteristics of patients assessed by APP-led teams and by teams led by a medical resident. Most patients were assessed in the emergency department and on the internal medicine ward. The APACHE IV score of the patients indicates a high severity of illness. No significant differences were found between these two groups except for diastolic blood pressure, which was significantly higher in patients assessed by MR-led teams.

Table 1. Patient characteristics on arrival of the rapid response team.

Data are given as numbers with percentages or as medians with IQR.

	Leader of rapid response team		
	APP Median (IQR) n=179	**MR Median (IQR) n=275**	***p*-value**
Age (years)	68 (56-76)	70 (58-78)	0.19
Sex (male)	99 (55%)	168 (61%)	0.26
Sex (female)	80 (45%)	107 (39%)	0.26
Apache IV predicted mortality	58 (42-86)	62 (37-76)	0.89
Temperature (degrees Celsius)	37.3 (36.9-38.5)	37.4 (37.0-38.4)	0.80
Systolic Blood Pressure (mmHg)	120 (99-140)	128 (109-151)	0.06
Diastolic Blood Pressure (mmHg)	69 (50-75)	70 (60-80)	0.03
Pulse (rate/min)	108 (86-124)	100 (85-119)	0.28
Respiratory Rate (rate/min)	25 (18-30)	20 (16-30)	0.37
Location of outreach for ICU-admitted patients	**APP Number (%)**	**MR Number (%)**	
Surgery	18 (6.1%)	26 (8.8%)	1.00
Internal Medicine	21 (7.1%)	24 (8.1%)	0.40
Cardiology	4 (1.4%)	6 (2.0%)	NA
Pulmonology	14 (4.7%)	24 (8.1%)	0.82
Cardiothoracic surgery	7 (5.9%)	2 (1.1%)	NA
Neurology	2 (0.7%)	8 (2.7%)	NA
Gastroenterology	7 (2.4%)	7 (2.4%)	0.61
Emergency department	38 (12.8%)	73 (65.8%)	0.16
Other	7 (5.9%)	8 (4.5%)	NA

APP: advanced practice provider, MR: medical resident, IQR: interquartile range

Both the patient- and the process-related outcomes are described in table 2.

Table 2. Outcome variables.

	Leader of rapid response team		
	Response by APP: N(%), Med (IQR)	**Response by MR: N(%), Med (IQR)**	**p-value**
Number of calls	179	275	
Admission ICU	118 (66%)	178 (65%)	0.87
Time to ICU (hours)	1.19 (0.56-1.75)	1.16 (0.59-1.75)	0.67
Within 24h:			
Hospital mortality	13 (7%)	17 (6%)	0.80
ICU mortality	6 (5%)	10 (6%)	1.00
Time to insertion arterial line (hours)	1.68 (0.87-2.94)	1.54 (0.78-2.72)	0.50
Time from visit to insertion Central venous catheter(hours)	2.17 (1.24-5.78)	1.71 (0.92-3.30)	0.30
Time from visit to intubation (hours)	3 (1.5-16)	2 (1.07-10.50)	0.24
MAELOR not triggering anymore (good outcome)	165 (92%)	261 (96%)	0.19
MEWS admission	4.04 (2.03-6.29)	3.92 (1.98-6.56)	0.90
MEWS at 24 hours	2.13 (1.04-3.46)	1.63 (0.51-3.06)	0.12
Δ MEWS between leaders			0.20
Change in antibiotics	27 (30%)	40 (29%)	1.00
Time to change of antibiotics (hours)	1.33 (0.62-2.25)	1.40 (0.65-2.30)	0.77
ICU LOS (days)	1.00 (0.20-2.79)	1.10 (0.17-3.43)	0.80
Treatment limitation initiated (%)	54 (30%)	72 (26%)	0.44

MEWS: Modified Early Warning Score, APP: advanced practice provider, MR: medical resident, IQR: interquartile range

The baseline characteristics of the patients assessed by teams led by advanced practice providers and medical residents demonstrate that no statistically significant differences were encountered between the groups except for diastolic blood pressure. The differences in blood pressure were very small and are therefore considered clinically unimportant.

Concerning the validated MAELOR tool, we were able to retrieve the MAELOR tool outcome in 451 of the 454 cases. Three cases were excluded due to insufficient data. In the analysis of the MAELOR tool outcomes, no significant differences were found between patients treated by teams led by an advanced practice provider or by a medical resident.

Since the rapid response team leader in our ICU model remains responsible for the care provided to the admitted ICU patients, the efficiency of the team could be reflected in the time until arterial line insertion, the time until central venous catheter insertion and the time until intubation. These variables did not differ significantly between patients attended to by a team led by an APP or by a resident (table 2).

To determine the efficiency of non-technical procedures, we also compared the times until change of administered antibiotics in the first 12 hours after admission to the ICU. In the 296 patients admitted to the ICU, the time until change of antibiotics after ICU admission was not significantly associated with the rapid response team leader being an APP or a resident (table 2). In addition, no association was found between the leader of the rapid response team being an APP or a medical resident and the time until antibiotics administration after ICU admission.

The ICU LOS was determined for 283 of the 296 ICU admitted patients. No significant difference in ICU LOS was found between the patients attended to by APP-led teams and those attended to by rapid response teams led by a medical residents.

The early warning score was assessed at two different points in time (on admission and after 24h). There was no significant difference between the rapid response team leader and the early warning score, or the reduction in early warning score after 24 hours.

Of the 158 patients who remained on the general ward after the rapid response team visit, we were able to extract the early warning score after 24 hours for 123 patients. The warning scores after 24 hours and the reduction in warning scores did not differ between the APP-led teams and the resident-led teams.

In 126 out of 452 patients new treatment limitations were applied after the rapid response team visit. There was no significant association between the instigation of treatment limitations and the rapid response team leader (table 2). In addition, no effect of rapid response team leadership on mortality was not found in the patients who were deceased on the ward or in the ICU within 24 hours after the RRT visit.

Discussion

The present study provides insight into the performance of APPs as leaders of rapid response teams in direct comparison with medical residents. In this retrospective study, we found no differences in either process-related or patient-related outcomes

between rapid response teams led by APPs and teams led by medical residents. This comparability included the trend of the early warning score after the call and the triggering of the MAELOR tool 48 hours after the call, a tool validated for assessing the quality of rapid response team assessments [17].

To measure patient- and process-related outcomes, we used a wide variety of parameters, ranging from the standardized measurement tools that were validated for these rapid response team assessments to the times until interventions and general outcome data. Moreover, the environment and organization of the rapid response teams we assessed are in line with those in a multi-center trial that established a standard deployment of the rapid response teams which reduced in-hospital morality rates [3]. In our study, this organizational structure was considered efficient, based on the high number of calls that resulted in ICU admissions (60-70%) suggesting an effective afferent limb (detection), and on the relative fast reaction time as a parameter for the efferent limb (response) [18]

The absence of significant differences in outcomes between teams led by APPs and teams led by medical residents suggests that APPs are suitable alternatives for medical residents in leading rapid response teams. This finding is also supported by the higher number of calls handled per FTE by the APPs compared to the number of calls handled per FTE of medical residents of the ICU: one FTE APP handled approximately 2.5 times more calls than one FTE medical residents. An explanation for this substantial difference might be the continuity of care that APPs provide. This continuity is established by the APPs' continuous coverage in most shifts together with their presence alongside the residents. This continuity of care probably also explains the observation that APPs more easily decide to respond to the calls than the rotating medical residents, who regard these calls as stressful events (personal communication).

The outcomes of this study are in line with the outcomes of the few previously published studies, although the settings of those studies were different, which makes a sound comparison is difficult. One study showed no differences in quality after the introduction of a nurse practitioner as leader of a rapid response team [12]. The study compared a situation with and without a rapid response team, but in the group of patients treated by a rapid response team, the nurse practitioner was not always available, and deployment restrictions for the rapid response team were in place. Additionally, another publication reported an shorter time until admission to the ICU in a APP-led rapid response team [11]. Despite this improvement, however, the time span was much longer than the 4 hours suggested to be adequate by the MAELOR tool. Also our results are in line with the findings of a recent retrospective

single-center analysis. This study compared an APP-led rapid response team with a resident-led rapid response team. This study found no differences between the groups except for a shorter in-hospital stay of the patients visited by the APP-led group but after propensity matching [13]. The study mainly focused on patient outcomes and less on process outcomes.

In accordance with this study, there is growing evidence that APPs are a valuable substitute for a physicians as leaders of a rapid response team.

Although the implementation of an RRT in this study is the general method used in the Netherlands, comparability between countries and healthcare systems remains cumbersome because different RRT models that are used [3]. Apparently, so far, an optimal composition and implementation of a rapid response team has not yet been established [8, 19]. This fact and the lack of validated measurement tools except for the MAELOR tool probably explains why the literature reports different success rates and struggles with aligning outcome data when reporting on the performance of rapid response teams. [3, 8, 13, 20, 21]

The main limitations of the present study are the retrospective design and the single-center setting. Before extrapolating our results to other hospitals, the local situation should be considered. Another limitation is that patients might have been missed if they did not fit our query, or were not registered in the database. However, we know that the database is used consistently and that registration is a central part of the workflow for all APPs and medical residents. It is therefore unlikely that selection is a major bias of this study. Another important limitation is that the patient- and process-related outcome measures were chosen arbitrarily, although they are clinically relevant. When focusing on time before intubation for example, there is a difference between the groups in time from admission to intubation without reaching significance. This is probably caused by the fact that there are a lot of oxygen therapies available which can be applied as initial treatment and if the included sample size is too small, significant differences in patient-related outcomes are difficult to detect. In addition, the outcomes are affected by many other variables related to the patient, the pathology, and the organization of the ward and the ICU. Especially, an ICU nurse may have a substantial influence on the rapid response team's performance. Necessary critical steps such as oxygen administration or positioning of the patient to enable adequate breathing are steps often overlooked by junior clinicians. Even simple treatment recommendations provided by the nurse, can be very valuable for junior clinicians. These steps are often independently covered by the accompanying ICU nurse.

Regarding the use of the MAELOR tool, this tool was validated to evaluate the performance of a rapid response team. However, the acquaintance of researchers with this tool is limited and therefore its use to compare between studies is limited as well. In addition, the added value of APPs might have been underestimated because certain benefits of APPs might have been missed, such as patient satisfaction, communication skills, team guidance, situational awareness, and other non-technical skills. This same issue has been addressed in the literature before [22]. Prospective cohort studies are therefore needed to confirm the outcomes of the present study and to assess the potential additional benefits of APP-led rapid response teams.

Conclusion

In this observational retrospective single-center study on process- and patient-related outcome parameters of RRTs led by APPs and MRs, we have shown that APPs perform at least as well as MRs in leading a rapid response team. As the performance of rapid response teams is influenced by the organization of healthcare systems prospective studies in other institutions are needed to confirm our findings.

References

[1] Clark AV, LoPresti CM, Smith TI. Trends in Inpatient Admission Comorbidity and Electronic Health Data: Implications for Resident Workload Intensity. J Hosp Med 2018;13(8):570-2.

[2] Steventon A, Deeny S, Friebel R, Gardner T, Thorlby R. Emergency Hopsital admissions in England: which may be avoidable and how? The Health Foundation - Publications 2018.

[3] Ludikhuize J, Brunsveld-Reinders AH, Dijkgraaf MG, Smorenburg SM, de Rooij SE, Adams R, et al. Outcomes Associated With the Nationwide Introduction of Rapid Response Systems in The Netherlands. Crit Care Med 2015;43(12):2544-51.

[4] Maharaj R, Raffaele I, Wendon J. Rapid response systems: a systematic review and meta-analysis. Crit Care 2015;19:254.

[5] Cook RI, Render M, Woods DD. Gaps in the continuity of care and progress on patient safety. BMJ 2000;320(7237):791-4.

[6] Cooper RA, Getzen TE, Laud P. Economic expansion is a major determinant of physician supply and utilization. Health Serv Res 2003;38(2):675-96.

[7] Lighthall GK, Parast LM, Rapoport L, Wagner TH. Introduction of a rapid response system at a United States veterans affairs hospital reduced cardiac arrests. Anesth Analg 2010;111(3):679-86.

[8] Moreira AAS, Ramos RO, Ligorio ABS, Junqueira KD, Correa KS. Rapid response team: what factors interfere with your performance? Invest Educ Enferm 2018;36(2).

[9] Kreeftenberg HG, Pouwels S, Bindels A, de Bie A, van der Voort PHJ. Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med 2019;47(5):722-30.

[10] Kleinpell RM, Grabenkort WR, Kapu AN, Constantine R, Sicoutris C. Nurse Practitioners and Physician Assistants in Acute and Critical Care: A Concise Review of the Literature and Data 2008-2018. Crit Care Med 2019;47(10):1442-9.

[11] Gershengorn HB, Xu Y, Chan CW, Armony M, Gong MN. The Impact of Adding a Physician Assistant to a Critical Care Outreach Team. PLoS One 2016;11(12):e0167959.

[12] Scherr K, Wilson DM, Wagner J, Haughian M. Evaluating a new rapid response team: NP-led versus intensivist-led comparisons. AACN Adv Crit Care 2012;23(1):32-42.

[13] Gupta S, Balachandran M, Bolton G, Pratt N, Molloy J, Paul E, et al. Comparison of clinical outcomes between nurse practitioner and registrar-led medical emergency teams: a propensity-matched analysis. Crit Care 2021;25(1):117.

[14] van Galen LS, Dijkstra CC, Ludikhuize J, Kramer MH, Nanayakkara PW. A Protocolised Once a Day Modified Early Warning Score (MEWS) Measurement Is an Appropriate Screening Tool for Major Adverse Events in a General Hospital Population. PLoS One 2016;11(8):e0160811.

[15] Morris A, Owen HM, Jones K, Hartin J, Welch J, Subbe CP. Objective patient-related outcomes of rapid-response systems - a pilot study to demonstrate feasibility in two hospitals. Crit Care Resusc 2013;15(1):33-9.

[16] http://www.squirestatement.org/index.cfm?fuseaction=Page.ViewPage&pageId=471

[17] Repasky TM, Pfeil C. Experienced critical care nurse-led rapid response teams rescue patients on in-patient units. J Emerg Nurs 2005;31(4):376-9.

[18] Hall KK, Shoemaker-Hunt S, Hoffman L. Rockville (MD): Agency for Healthcare Research and Quality (US);2020 Mar.

[19] Hillman K, DeVita M, Bellomo R, Chen J. Meta-analysis for rapid response teams. Arch Intern Med 2010;170(11):996-7; author reply 7.

[20] Hillman K, Chen J, Cretikos M, Bellomo R, Brown D, Doig G, et al. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. Lancet 2005;365(9477):2091-7.

[21] Chan PS, Jain R, Nallmothu BK, Berg RA, Sasson C. Rapid Response Teams: A Systematic Review and Meta-analysis. Arch Intern Med 2010;170(1):18-26.

[22] Sarani B, Sonnad S, Bergey MR, Phillips J, Fitzpatrick MK, Chalian AA, et al. Resident and RN perceptions of the impact of a medical emergency team on education and patient safety in an academic medical center. Crit Care Med 2009;37(12):3091-6.

Chapter 6

Prospective assessment of teamwork and performance in a simulation environment of non-technical skills by APPs.

Advanced practice providers in critical care improve team performances. A post-hoc analysis of the BASIC trial.

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Introduction

Advanced practice providers (APP), physician assistants and acute care nurse practitioners, in critical care aim to improve quality and continuity in critical care, especially in rural areas where they can overcome physician shortages. We assessed the non-technical skills of APPs and physicians as leaders of rapid response teams (RRT) during simulated scenarios with deteriorating patients of the BASIC trial.(1)

Description

The BASIC-trial is a multicenter simulation study evaluating the non-technical skills of 32 leaders of rapid response teams with or without a digital checklist application. (1) The high-fidelity simulation center in the Netherlands assessed these skills in nine ICU residents during 52 scenarios and in four ICU related APPs during 22 scenarios. The number of omitted predetermined critical steps were compared between both groups, such as administering oxygen, fluids and antibiotics. Non-technical skills were evaluated by the Mayo High Performance Teamwork Scale and the FoNTS-Matrix assessing four domains: Situational Awareness, Decision Making, Task Management, and Teamwork each with associated subcategories. In addition, the leaders' performance in these domains was assessed by team members via a questionnaire after each scenario.

Results

The mean years of experience for registered physicians was 2.25 years(range 0.3-5.0) which included an ICU rotation. The four APPs worked as registered critical care APPs for respectively one, three, seven and >10 years.

The residents omitted per scenario one critical step more than APPs($p=.005$). APPs scored better than the residents in three subcategories of the FoNTS, while the two most experienced APPs scored higher for three of the four domains (**Figure 1**). The twenty-six team members assessed that the APPs performed significantly better than residents for situational awareness(3.7 vs 4.2($p<.001$)), decision making(3.8 vs 4.2($p=.012$)), task management(3.8 vs 4.1($p=.011$)) and teamwork(4.1 vs 4.4($p=.019$)). APPs scored similar for communication(4.0 vs 4.2($p=.09$)).

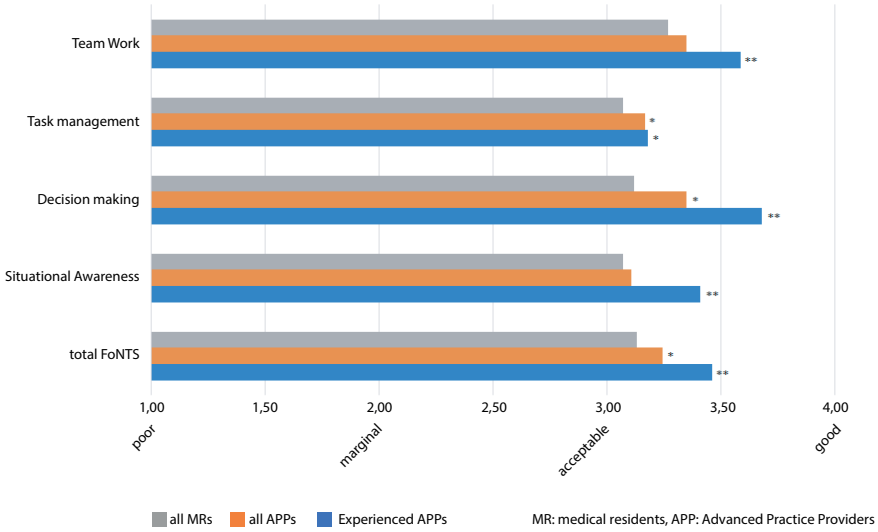

Figure 1. Mean FoNTS-matrix performance scores of APPs and physicians:

* statistical significance in a subcategory (p<.05), ** statistical significance for a complete domain (p<.05)

Discussion

Recent research on APPs in critical care often focused on the evaluation of clinical patient-related outcomes and performances of these APPs in conjunction with a coordinating medical specialist.(2-4) In this study the non-technical skills of APPs and residents as leaders of a RRT were assessed without this additional consultation. APPs performed better than residents in several subcategories and omitted overall less predefined critical steps. The latter may be explained by their ICU-nursing background with bedside experience. Moreover, their team members assessed their performance to be better in almost all non-technical-skills domains. These differences increased when the residents were compared with the two most experienced APPs. Considering the fact that the emergency care within hospitals is often delivered by junior clinicians, these results suggest that the dedication, continuity of care and bedside experience of APPs in critical care can improve the quality and teamwork of critical care teams. More research on this topic is required to draw firm conclusions as we evaluated a limited number of participants in a simulation environment.

This study implies that APPs in a critical care setting can be a valuable workforce that improves the team performance in contrast to rotating residents. More experienced APPs seem to perform even better in non-technical skills in critical care.

References

1. De Bie Dekker AJR, Dijkmans JJ, Todorovac N, Hibbs R, Boe Krarup K, Bouwman AR, et al. Testing the effects of checklists on team behaviour during emergencies on general wards: An observational study using high-fidelity simulation. Resuscitation. 2020;157:3-12.
2. Kreeftenberg HG, Aarts JT, Bindels A, van der Meer NJM, van der Voort PHJ. Procedures Performed by Advanced Practice Providers Compared With Medical Residents in the ICU: A Prospective Observational Study. Crit Care Explor. 2020;2(4):e0101.
3. Kreeftenberg HG, Pouwels S, Bindels A, de Bie A, van der Voort PHJ. Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med. 2019;47(5):722-30.
4. Gupta S, Balachandran M, Bolton G, Pratt N, Molloy J, Paul E, et al. Comparison of clinical outcomes between nurse practitioner and registrar-led medical emergency teams: a propensity-matched analysis. Crit Care. 2021;25(1):117.

Chapter 7

A Prospective study of process outcomes by APPs in critical care.

Advanced Practice Providers as leaders of a Rapid Response Team: a prospective cohort study

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Abbreviations:
APP: Advanced Practice Provider
EWS: Early Warning Score
ICU: Intensive Care Unit
MR: Medical Resident
RRT: Rapid Response Team

Abstract

Abstract: In view of the shortage of medical staff, the quality and continuity of care may be improved by employing Advanced Practice Providers (APPs). This study aims to assess the quality of these APPs in critical care. In a large teaching hospital rapid response team (RRT) interventions led by APPs were assessed by independent observers and intensivists and compared those led by medical residents MRs. Mortality and MAELOR tool (assessment of RRT intervention), time from RRT call until arrival at the scene and time until completion of clinical investigations, were assessed. Process outcomes were assessed with the Crisis-management-skills checklist, the Ottawa-Global-Rating-Scale and the Mayo-High-Performance-Teamwork Scale. The intensivists assessed performance with the handoff-CEX recipient scale. Mortality, MAELOR-tool, time until arrival and clinical investigation in both groups were the same. Process outcomes and performance observer scores were also equal. The CEX-recipient scores however, showed differences between MRs and APPs which increased with experience. Experienced APPs had significantly better situational awareness, better organization, better evaluations and better judgement than MRs with equal experience ($p<.05$). This study shows that APPs perform well in leading an RRT and maybe provide added quality over a resident. RRTs should seriously consider the deployment of APPs instead of junior clinicians.

Introduction

A combination of increasing demand for healthcare, an accompanying demand for quality and a shortage of medical staff, poses a continuous burden for the continuity of healthcare including critical care. In critical care much of this care is performed by junior clinicians which are regulated by working hours for residents. Moreover, these junior clinicians are not always the best clinicians to counter the problems of the complex critical care patients. Advanced practice providers and nurse practitioners are increasingly employed to help meeting the demand for quality and continuity in critical care

Research in this area supports the supposition that the quality and continuity of care may be sustained by employing Advanced Practice Providers (APPs). (1, 2) Published reports demonstrated that the APPs' clinical performance was non-inferior to the performance of physicians. (3, 4) Besides the non-inferiority, there is increasing evidence on the advantages of employing APPs in critical care. The advantages of these APPs have been assessed by measuring the quality of technical and non-technical skills in the critical care environment and compared qualities with several other clinicians in the surgical and medical domain. (5-11) One of the tasks which combines several skills necessary for critical care, is the participation in a rapid response team (RRT). This team is an in-hospital emergency team which provides critical care for deteriorating patients on wards and arranges transfer to critical care wards if necessary. (12) At the moment the optimal composition of this RRT is not yet know; evaluation of rapid response teams emphasizes experience rather than certain composition although involvement of intensive care professionals may be beneficial. (13-15) A recent study using propensity score matching found that participation of an APP in a RRT resulted in a decreased length of hospital stay. (16) Moreover, a recent study showed that the APPs often provide direct additional value compared to a physician, as it measured process-related outcomes of APPs in a simulated rapid response team environment and showed that an APP might perform better than a medical resident (MR). (17)

Although several studies have been performed to assess differences in the level of technical and non-technical skills of APPs, it remains difficult to establish the specific individual contribution of an APP's performance to the combined outcome of a complex multidisciplinary process of care. Previous studies suggested that this topic should be analyzed in prospective studies using more sophisticated statistical methods. (18, 19)

The aim of this study was to determine whether the process-related performance outcomes of APPs are equal or superior to those of MRs in a rapid response team. We aimed to determine if we could establish differences between clinicians, in which domains of process performance these differences existed and to what extend the several participants could recognize these outcomes.

Methods

Design

A single-center prospective observational cohort study was performed in a large teaching hospital (Catharina Hospital in Eindhoven, the Netherlands). In this hospital, all specialties are available, except for neurosurgery and transplant surgery. The study period lasted from April 1 to September 30, 2018. An RRT system has been operational since 2009 as a result of the COMET trial, and such a system is mandatory by law. (20) The RRT is activated by the hospital wards by means of a modified early warning score (EWS). (21) The efferent limb of the RRT system consists either of an APP or an MR, accompanied by an ICU nurse. The clinician carries a pager and can be contacted directly by physicians and nurses in the hospital, based on the EWS. In addition, an intensivist is available for consultation or physical presence if deemed necessary by the RRT.

Population

Posters were displayed at the ICU to encourage all nurses, residents, and APPs to contact the independent observers/researchers to enable the observers to assess the RRT visits. The RRT calls could originate from all wards in the hospital including the emergency ward. The resident or APP carrying the pager answered these calls and when they visited the wards, they called the independent researchers to join them on their visit. Visits were excluded from analysis if they required the physical presence of an intensivist to prevent bias in the independent validation of team members by the researcher.

Power analysis

No studies were available for power analysis pre-testing. Based on the mean RRT calls per month, we chose to collect data on a minimum of 50 RRT calls in a 4-month period.

Ethical considerations

The study was approved by the ethics committee (Medical Research Ethics Committees United, Nieuwegein). An informed consent waiver was granted (W17.09)

as this study did not change the actual working process nor the level of care. Local permission for the study was granted by the executive board of the Catharina Hospital. The procedures followed were in accordance with the ethical standards of the Dutch committee on human experimentation (CCMO) and the above mentioned ethics committee and with the Helsinki Declaration of 1975.

Data collection

The observers (independent researchers) were thee final year medical students with clinical experience and knowledge about RRTs. The three students served as independent assessors and tried to attend evening night and weekend shifts on a voluntary base within the legal limits. One student registered the results in the database. The three students were trained by two physicians (HK and AdB) to assess RRT calls. The training consisted of watching three videos of simulated RRT visits led by different APPs and MRs. The evaluation and registration were performed by all three students together to facilitate achieving adequate interobserver results. During the second part of the training, the students evaluated another two simulated RRT visits and assessed them separately. An inter-observer variation was obtained to assess the inter-observer variability. The goal was to obtain an inter-observer variability of > 0.7. In the Ottawa Global Rating Scale, the inter-class value proved too low. To address this problem, the students were requested to assess another two videos together and thereafter to evaluate two videos separately. The pathology and the teams in the scenarios to assess differed. The results of the inter-class correlation for the Mayo High Performance Teamwork scale, the Ottawa Global Rating Scale and the Crisis management skills were all acceptable to good, with Crohnbach alpha values from 0.75 to 0.96.

During the study, the investigators were called by the RRT participants before the RRT visit to join the RRT. The investigators observed the team without intervening the process.

Items registered were time until the assessment of airway, breathing, circulation and neurological status and time until diagnosis. Process outcomes were measured with the Ottawa crisis management skills checklist, the Ottawa Global Rating Scale and the Mayo High Performance Teamwork Scale (appendix C:1-3). (22, 23) Twenty-four hours after the visit, the MAELOR tool was registered, which served as a validated tool to assess the quality of the RRT visit using the early warning score as reference. (21, 24)

The RRT leader assessed his own performance using the Ottawa Global Rating Scale and the Mayo High Performance Teamwork Scale. The leaders also assessed their overview over the situation and their handover on the ICU by the Handoff CEX

"provider" questionnaire (appendix C:4). (25) This questionnaire is a validated tool to assess the organization, communication, clinical assessment and professionality during the handover of the patients to other clinicians.

The accompanying ICU nurse and the ward nurse who initiated the RTT call were asked to also complete the Ottawa Global Rating Scale and Mayo High Performance Teamwork Scale.

The supervising intensivist completed the Handoff CEX "recipient" (appendix C:4). (25) The specific questionnaires are included in supplement S1.

All the results were collected in an SPSS® 25 (IBM. Corp., Armonk, NY, USA) and Excel database on a secure hospital server. In addition, the following data were registered: laboratory results, vital parameters, comorbidity, consecutive early warning scores, diagnosis at admission, mortality, data of admission and discharge, and DNR code.

These data were used to calculate the Charlson comorbidity index to assess the prognosis, as well as the (quick)SOFA score to assess severity of illness. (26) The patients data were collected until discharge from the hospital or three months.

The MAELOR tool was used to assess the quality of the rapid response team intervention. This tool comprises decisions about 'do not resuscitate' and early or late admissions to the ICU of patients with high early warning scores.

Study outcomes

Primary outcome

The primary outcome was the difference in the quality of performance of the RRT with either an APP or an MR as the RRT leader. The quality of performance was measured with three patient outcome parameters: MAELOR score, 30-day mortality and hospital mortality.

Also, process-related outcomes were assessed in 4 ways: 1) the assessor completed the crisis management skills checklist, the Ottawa Global Rating Scale and the Mayo High Performance Teamwork Scale; 2) the APPs and MRs completed the Ottawa Global Rating Scale and the Mayo High Performance Teamwork Scale as well as the handoff CEX "provider" questionnaire; 3) the ICU nurse participating in the RTT and the nurse initiating the RTT call completed the Ottawa Global Rating Scale and the Mayo High Performance Teamwork Scale; and 4) the responsible intensivist completed the handoff CEX "recipient" questionnaire.

Secondary outcomes

As secondary outcomes, the quality of performance of the RTTs led by APPs versus those led by MRs was measured in three ways: 1) time from RTT call until arrival of the RTT at the patient's bed; 2) time from RTT call until assessment of airway, breathing, circulation, and Glasgow Coma Score; 3) time from RTT call until diagnosis and diagnostic evaluations.

Statistical analysis

A two-way random consistency intra class correlation coefficient was calculated with SPSS® 25 (IBM. Corp., Armonk, NY, USA). The use of either parametric or non-parametric distribution was determined with the Kolmogorow-Smirnov test. Dichotomous variables were analyzed with the Chi-square test, parametric data with the independent t-test and continuous non-parametric data with the Mann-Whitney-U-test. A p-value of $p<0.05$ was considered statistically significant.

Results

Participants and RRT calls

A total of 5 APPs and 16 residents participated in the study. The APPs had a median of 5 months experience and the residents had a median of 6 months experience.

During the study period, a total of 247 RRT calls were made, leading to 247 RRT interventions. Of these interventions, 10 were excluded from analysis because the RRT leader forgot to call the investigator and 177 were excluded from analysis because no observer was present despite efforts to cover shifts during day, evening and night. The remaining 60 RTT interventions were assessed by the observers and included in the analysis. Of these interventions, 20 were led by one of the 5 APPs and 40 by one of the 16 residents.

Of the collected variables, only the qSOFA score had a parametric distribution, and this score is presented as mean with confidence interval. All other data had a non-parametric distribution. There were no significant differences between the participants' characteristics, nor between the patients' characteristics. *(Table 1)*.

Table 1. Baseline characteristics of patients treated by either APP or MR.

Characteristics	APP	MR
Experience of the clinician in months*	5(1-104)	6(2-17)
Reason for RRT call		
Respiratory or airway problems	12	11
Hemodynamic instability/sepsis**	7	21
Electrolyte disorders	1	1
Altered consciousness	0	1
other	0	6
Specialism		
Surgery	7	6
Internal medicine	3	13
Cardiology	3	3
Pulmonology	2	2
Cardiothoracic surgery	2	1
Gastroenterology	0	3
Neurology	3	1
other	0	11
Admitted to the ICU	13	25
Patient qSOFA	0.95	1.2
Patient age*	69 (63-80)	68 (55-78)
Patient gender male	20	26
Patient gender female	8	14
Age-adjusted Charlson comorbidity index*	7(3-8,8)	4.5(3-6.8)

*: median and interquartile range

**: the separate diagnoses did not differ significantly between the groups

Patient-related outcomes

The primary outcome showed no significant differences in the quality of RRT interventions between the APP group and the MR group based on the MAELOR tool. (p=.06). In three cases, the APP left the patient on the standard nursing ward with treatment advice, followed by an EWS repeated RRT call after 24 hours. One of these patients had yet to be admitted to the ICU. All 3 patients survived. Mortality was 25% in the APP group versus 17.5% in the MR group, but this difference was not statistically significant. *(Table 2)*

Table 2. Patient- and process-related outcomes of patients treated by either APP or MR.

Patient-related outcome	**APP**	**MR**	**p-value (Chi-square)**
Mortality (30 day)	5/20 (25%)	7/40 (17.5%)	.73 (.117)
MAELOR positive	17	40	.59 (3.55)
Admission < 4h	13	25	na
No admission	6	15	na
Admission > 4h	1	0	na
Process-related outcome*	**APP Median (IQR)**	MR **Median (IQR)**	**p-value (u-value and z-score)**
Time between call and arrival	4:30 (2:45-9:30)	3:59 (2:00-6:00)	.28 (258.5, -1.07)
Time until respiratory exam	0:30 (0:00-1:00)	0:00 (0:00-1:00)	.25 (318.5, -1.14)
Time until circulation exam	2:00 (1:00-4:00)	1:00 (0:44-3:00)	.13 (289, -1.53)
Time until EMV exam	2:00 (1:00-4:00)	1:00 (0:00-3:00)	.91 (336, -.11)
Time until diagnosis	5:00 (3:00-10:00)	5:00 (3:00-8:00)	.72 (276.5, -.36)
Crisis management skills total	27 (25-28)	27 (26-28)	.59 (366.5, -.53)
MAYO observer	22 (22-24)	23 (22-24)	.34 (340.5, -.95)
GRS observer	6 (6-7)	6(6-7)	.96 (397.5, -.048)
MAYO ICU nurse	21 (19-24.5)	24 (20.7-25)	.22 (57.5, -1.22)
GRS ICU nurse	6 (6-6.5)	6 (6-6)	.44 (69.5, -.77)
CEX provider	7 (6-7.25)	7 (7-8)	.04 (233, -2.09)

*: All time data as minutes:seconds

Team-related outcomes

There were no statistical differences in time from call until arrival, time from call until assessment of airway, breathing, circulation, neurological evaluation and diagnosis and time from call until admission to the ICU. The results of the CEX provider scale showed that the MRs tended to rate themselves more highly than the APPs did (p=.037).

The outcomes of The Mayo High Performance Teamwork Scale and the Ottawa Global Rating Scale of the observer and the crisis management skills checklist showed no differences either. The outcomes of the CEX provider scale showed that the APPs tend to grade their performance more conservative than the residents. *(Table 2)*

Outcomes of the CEX recipient questionnaire showed that the APPs and MRs initially performed equally well, although the MRs had more outliers to the lower scores *(Figure 1)*. A separate comparison of equally experienced APPs and residents showed that with increased experience, the APPs performed significantly better in an increasing number of domains *(Figure 1-3)*. After 6 months, the CEX recipient scores on organization and judgement of the APPs were significantly better than those of the MRs *(Figure 2)*. When APPs and MRs had more than 1-year ICU experience, the APPs' overall accumulated CEX recipient questionnaire outcomes also were significantly higher than those of the MRs.

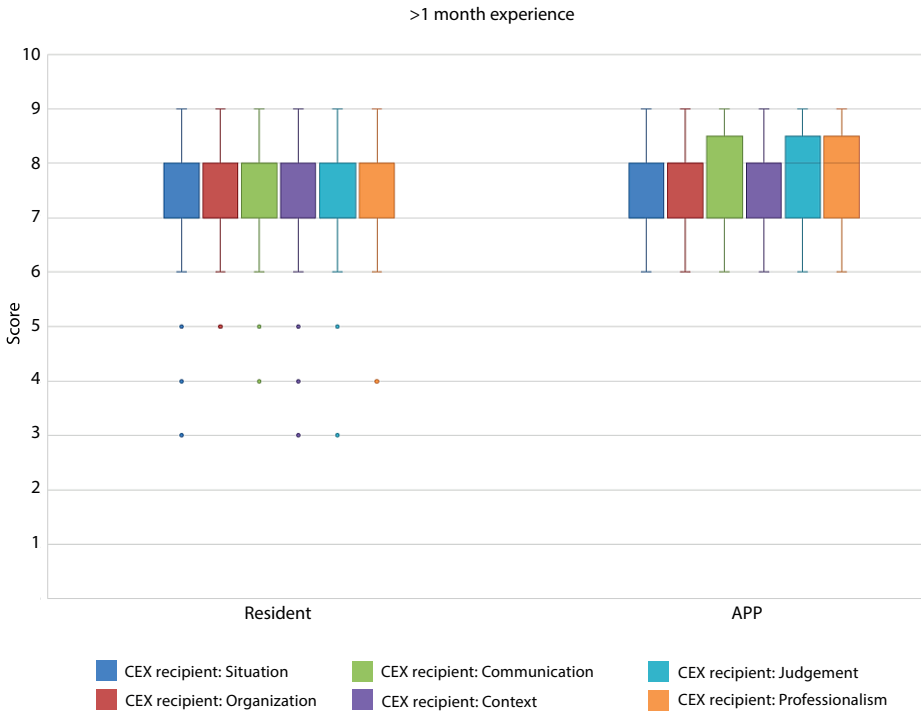

Figure 1. The handoff CEX recipient scores of MRs and APPs with more than 1 month experience
:p<.05*

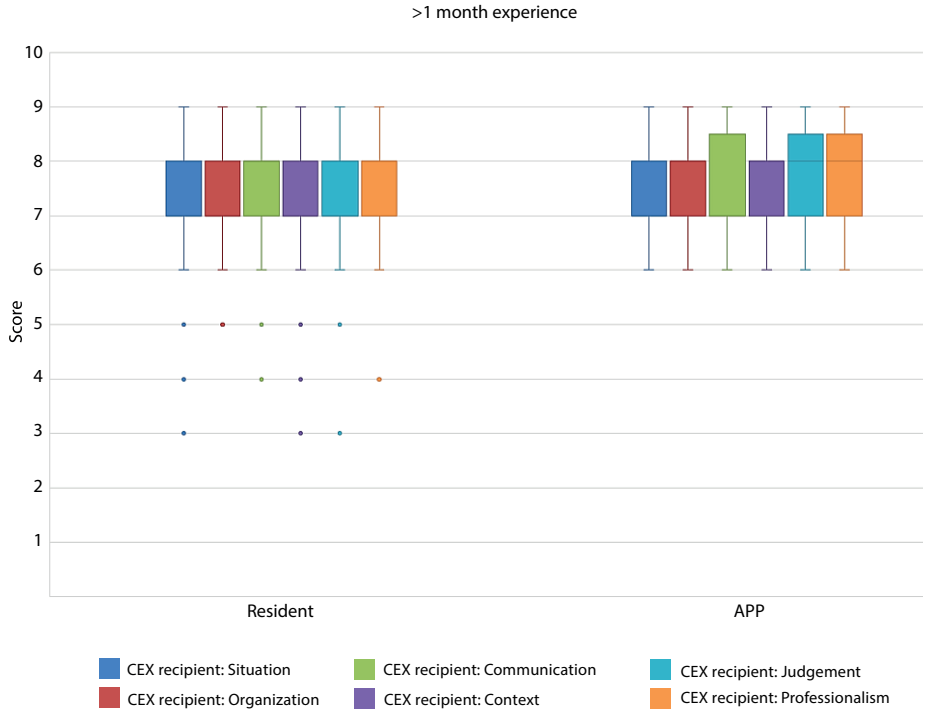

Figure 2. The handoff CEX-recipient scores of MRs and APPs with more than 6 months experience

***:*p<.05*

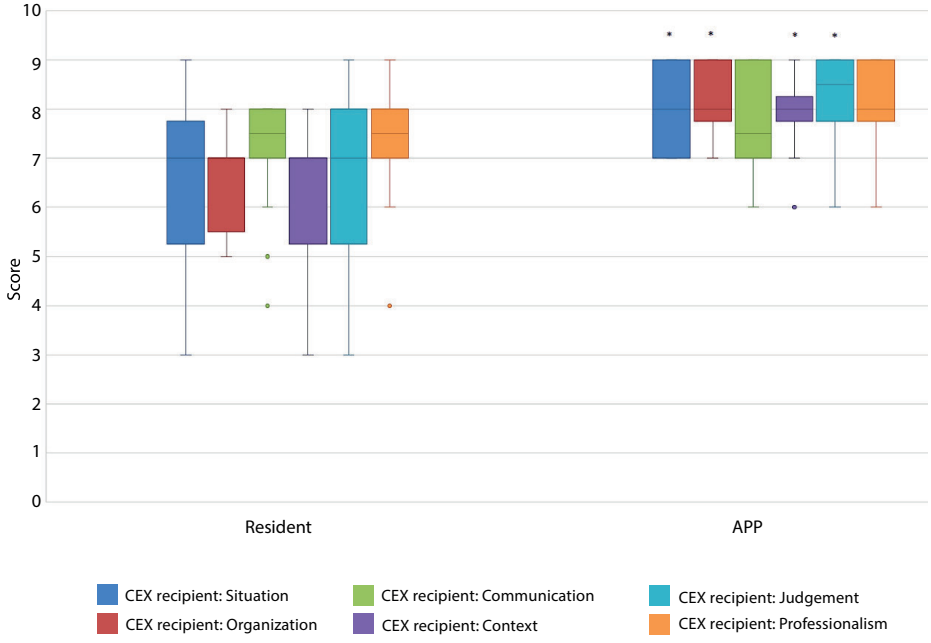

Figure 3. The handoff CEX recipient scores of MRs and APPs with more than 12 months experience

***:*p<.05*

Discussion

This study found no significant difference in the quality of the RRT visits between teams led by APPs or by MRs regarding patient-outcomes using mortality and the MAELOR-tool. Both types of teams seem to perform equally well and both teams are non-inferior to each other. The process outcomes like teamwork communication and general handling of the call, assessed by the Crisis management skills checklist, the Mayo High Performance Teamwork Scale, the Ottawa Global Rating Scale and assessed by the observers and nurses, also showed an equal performance of both groups.

The finding that patient related outcomes of APPs are non-inferior to those of physicians is in line with the literature. (3, 4) But when we assess the performance of APPs by process outcomes, the handoff CEX-recipient scale, an assessment of the RRT procedure in several domains like content, organization, judgement and communication as assessed by an experienced intensivist, did show a better performance of the APPs. This better performance of the APP led teams on the CEX-recipient scale is in line with a recent study which found improved performances in the non-technical skills of APPs compared to physicians. (17) The CEX-recipient scale outcome acknowledges the impression that an experienced APP performs on a higher level than an experienced resident. Considering that most critical care delivery is performed by junior physicians, this study suggests that the quality of critical care may be improved by APPs in rapid response teams.

Maybe also the urge of the resident to have a higher esteem of himself than the APP, as shown in the CEX-provider scale, raises the question whether the 'humbler' approach of the APP is also a factor in teamwork. Some literature supports this 'humble' approach hypothesis. (27)

For practical purposes this study can be used as a model in which an advanced practice provider provides continuity and therefore quality of care. Together with a consistent team these trainable and capable advanced practice providers can enhance the quality of rapid response teams which often encounter a variety of critical care situations. Their participation enables supervision of these teams without physical presence of specialists with a lot of other tasks at hand and guarantees quality of a rapid response team led by clinicians trained to cope with critical care situations.

Strengths and weaknesses:

This study is one of the few prospective studies comparing specific skills in APPs versus physicians and the first one for assessing their role as the leader in a rapid

response team. Moreover, it also is one of the few studies that measured both patient- as process-related outcomes. The patient-related outcomes of residents and APPs, both supervised by medical specialists, are already inherently good which makes it difficult to establish differences for these outcomes. The process-related outcomes may therefore be better outcomes to measure quality differences between APPs and residents.

The most apparent limitations are inherent to the study design and financial limitations. This was a single-center study because the clinical roles and tasks of APPs in critical care differ between ICUs. They also frequently do not participate in an RRT as leader. This makes it difficult to have a homogenous intervention group of APPs. In addition, a proper power analysis was not possible since literature guidance was scarce. Therefore, a random time period was chosen to include a minimum number of patients during day, evening and night shifts based on the retrospective evaluation. (4) Unfortunately, only 60 of the 247 RRTs could be observed during the study period, even though an voluntary attempt was taken by the three observers to cover multiple evening, night and weekend shifts. Funding for total coverage was not available. The limited funding combined with unplannable nature of RRT consultations and the variation of the clinical roles and responsibilities of APPs make it difficult to perform a multicenter trial about this topic. The RRT consultations that were observed are a random selection and do not introduce bias to the analysis. Therefore, we believe that the results of our single-center study are of value, especially for hospitals that experience difficulties with obtaining enough qualified and experienced physicians to cover all duties of their critical care departments and RRTs. Although the observers were trained to evaluate RRT consultation, they were medical students with limited clinical experience in these acute care scenarios. This limited experience might have influenced their observations in which certain valuable qualities have remained unnoticed. The better assessment by the experienced intensivist might be a result of these underestimated results. The qualities of the APP have its origin in the focus on critical care: they are often longer acquainted with the critical care environment and they are familiar with protocol and critical illness assessment in contrast to the medical resident who is often pursuing a career outside critical care. Although tried-and-tested assessment tools were used, other elements for example emotional control of the clinician and patient perception have not been tested. As these and other process related outcomes are important and may play a role, this can influence outcome.

Finally, the applied tools to assess the non-technical skills have not specifically been developed for RRT consultations, but for example for simulation studies. This could

have influenced the results since in real live it is difficult to assess the encountered acute clinical problems by strict rules.

Nevertheless, this study is in line with other studies about patient and technical skills outcomes. Although APPs often perform relative more technical and non-technical skills when comparing the number of APPs to the number MRs, this study underscores the difficulty of assessing the APP without its team and using the right tools to measure the added value of an APP. (12, 28-30)

Future research could zoom in on the non-technical skills required during these encounters with deteriorating patients and the assessment of these skills by experienced clinicians. Simulation environments maybe practical for these situations because they enable the APPs to boost their non-technical skills in a safe environment. Simulation environments can be adapted to suffice for a local situation but care must be taken to make these situations as practical and real as possible.

Conclusions

In this prospective observational study, we confirmed that APPs can provide non-inferior care compared to the medical resident during RRT visits. Moreover, the process outcome measures, evaluated by experienced clinicians, show that, even when the standard of care is high, an APP may still improve the quality of care.

References

1. Fry M. Literature review of the impact of nurse practitioners in critical care services. Nurs Crit Care. 2011;16(2):58-66.
2. Kreeftenberg HG, van Rosmalen J, Aarts JT, van der Voort PHJ. Physician assistants in intensive care units in the Netherlands: a narrative review with recommendations. Neth J Crit Care 2020;28:200-4
3. Kleinpell RM, Grabenkort WR, Kapu AN, Constantine R, Sicoutris C. Nurse Practitioners and Physician Assistants in Acute and Critical Care: A Concise Review of the Literature and Data 2008-2018. Crit Care Med. 2019;47(10):1442-9.
4. Kreeftenberg HG, Pouwels S, Bindels A, de Bie A, van der Voort PHJ. Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med. 2019;47(5):722-30.
5. Alexandrou E, Spencer TR, Frost SA, Mifflin N, Davidson PM, Hillman KM. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Crit Care Med. 2014;42(3):536-43.
6. Bevis LC, Berg-Copas GM, Thomas BW, Vasquez DG, Wetta-Hall R, Brake D, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. Am J Crit Care. 2008;17(4):357-63.
7. Rayo MF, Mount-Campbell AF, O'Brien JM, White SE, Butz A, Evans K, et al. Interactive questioning in critical care during handovers: a transcript analysis of communication behaviours by physicians, nurses and nurse practitioners. BMJ Qual Saf. 2014;23(6):483-9.
8. Burns SM, Earven S, Fisher C, Lewis R, Merrell P, Schubart JR, et al. Implementation of an institutional program to improve clinical and financial outcomes of mechanically ventilated patients: one-year outcomes and lessons learned. Crit Care Med. 2003;31(12):2752-63.
9. Collins N, Miller R, Kapu A, Martin R, Morton M, Forrester M, et al. Outcomes of adding acute care nurse practitioners to a Level I trauma service with the goal of decreased length of stay and improved physician and nursing satisfaction. J Trauma Acute Care Surg. 2014;76(2):353-7.
10. Sirleaf M, Jefferson B, Christmas AB, Sing RF, Thomason MH, Huynh TT. Comparison of procedural complications between resident physicians and advanced clinical providers. J Trauma Acute Care Surg. 2014;77(1):143-7.
11. Landsperger JS, Semler MW, Wang L, Byrne DW, Wheeler AP. Outcomes of Nurse Practitioner-Delivered Critical Care: A Prospective Cohort Study. Chest. 2016;149(5):1146-54.
12. Gershengorn HB, Xu Y, Chan CW, Armony M, Gong MN. The Impact of Adding a Physician Assistant to a Critical Care Outreach Team. PLoS One. 2016;11(12):e0167959.
13. Investigators A-CMd, Jones D, Drennan K, Hart GK, Bellomo R, Web SA. Rapid Response Team composition, resourcing and calling criteria in Australia. Resuscitation. 2012;83(5):563-7.
14. Moreira AAS, Ramos RO, Ligorio ABS, Junqueira KD, Correa KS. Rapid response team: what factors interfere with your performance? Invest Educ Enferm. 2018;36(2) doi: 10.17533/udea.iee.v36n2e05.
15. Daniele RM, Bova AM, LeGar M, Smith PJ, Shortridge-Baggett LM. Rapid response team composition effects on outcomes for adult hospitalised patients: A systematic review. JBI Libr Syst Rev. 2011;9(31):1297-340.
16. Gupta S, Balachandran M, Bolton G, Pratt N, Molloy J, Paul E, et al. Comparison of clinical outcomes between nurse practitioner and registrar-led medical emergency teams: a propensity-matched analysis. Crit Care. 2021;25(1):117.
17. Kreeftenberg HG, de Bie AJR, Subbe CP, van der Voort PHJ. Advanced practice providers in critical care improve team performances. A post-hoc analysis of the BASIC trial. Resuscitation. 2022;170:207-8.

18. Kreeftenberg HG, De Bie AJR, Mestrom EHJ, Bindels A, van der Voort PHJ. Advanced practice providers versus medical residents as leaders of rapid response teams: A 12-month retrospective analysis. PLoS One. 2022;17(8):e0273197.
19. Sidani S, Doran D, Porter H, et al. Outcomes of nurse practitioners in acute care: an exploration. Internet J Adv Nurs Pract 2005:8;1-7. http://ispub.com/IJANP/8/1/12232
20. Ludikhuize J, Brunsveld-Reinders AH, Dijkgraaf MG, Smorenburg SM, de Rooij SE, Adams R, et al. Outcomes Associated With the Nationwide Introduction of Rapid Response Systems in The Netherlands. Crit Care Med. 2015;43(12):2544-51.
21. van Galen LS, Dijkstra CC, Ludikhuize J, Kramer MH, Nanayakkara PW. A Protocolised Once a Day Modified Early Warning Score (MEWS) Measurement Is an Appropriate Screening Tool for Major Adverse Events in a General Hospital Population. PLoS One. 2016;11(8):e0160811.
22. Kim J, Neilipovitz D, Cardinal P, Chiu M. A comparison of global rating scale and checklist scores in the validation of an evaluation tool to assess performance in the resuscitation of critically ill patients during simulated emergencies (abbreviated as "CRM simulator study IB"). Simul Healthc. 2009;4(1):6-16.
23. Malec JF, Torsher LC, Dunn WF, Wiegmann DA, Arnold JJ, Brown DA, et al. The mayo high performance teamwork scale: reliability and validity for evaluating key crew resource management skills. Simul Healthc. 2007;2(1):4-10.
24. Morris A, Owen HM, Jones K, Hartin J, Welch J, Subbe CP. Objective patient-related outcomes of rapid-response systems - a pilot study to demonstrate feasibility in two hospitals. Crit Care Resusc. 2013;15(1):33-9.
25. Horwitz LI, Dombroski J, Murphy TE, Farnan JM, Johnson JK, Arora VM. Validation of a handoff assessment tool: the Handoff CEX. J Clin Nurs. 2013;22(9-10):1477-86.
26. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373-83.
27. Thomas EJ, Sexton JB, Helmreich RL. Discrepant attitudes about teamwork among critical care nurses and physicians. Crit Care Med. 2003;31(3):956-9.
28. Kreeftenberg HG, Aarts JT, Bindels A, van der Meer NJM, van der Voort PHJ. Procedures Performed by Advanced Practice Providers Compared With Medical Residents in the ICU: A Prospective Observational Study. Crit Care Explor. 2020;2(4):e0101.
29. Pirret AM. The role and effectiveness of a nurse practitioner led critical care outreach service. Intensive Crit Care Nurs. 2008;24(6):375-82.
30. van Vught A, van den Brink G, Hilkens M, van Oers JAH. Analysis of the level of clinical skills of physician assistants tested with simulated intensive care patients. J Eval Clin Pract. 2018;24(3):580-4.

Part IV

Chapter 8

A Survey in the Netherlands about ways of implementation, and advantages and barriers for employing APPs.

A survey on implementation of physician assistants in ICUs in the Netherlands

Neth J Crit Care 2022;30:124-30

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Abstract

Background: In several countries, the advanced practice provider (APP) is positioned as a clinician in an acute care setting. In the Netherlands, physician assistants (PAs), the equivalent of the APP, are increasingly being employed in ICUs. It is unknown to what extent PAs are present in Dutch ICUs, what they do and how they are appreciated. To provide a general overview, we conducted a survey.

Methods: The survey was sent to intensivists and PAs working in ICUs in the Netherlands. The survey focused on familiarity with the PA, the underlying reasons for implementation and their tasks.

Results: Sixty-five intensivists (representing 85% of all hospitals) and 43 of the 55 (78%) Dutch PAs responded. Twenty ICUs employed PAs and eight were considering doing so. In these ICUs, both intensivists and PAs were satisfied about their performance. Quality improvement and continuity of care were the main reasons mentioned for implementation. In 60% of the ICUs, the PAs performed medium complex tasks such as inserting central venous catheters, in 20% PAs performed complex tasks like treatment of unstable patients with intubation. The main reasons for not implementing PAs were: 'the intensivist performed the care without residents', 'ICU care is too complex for PAs', 'no need for additional personnel, enough residents available' and 'too expensive'.

Conclusion: ICUs in the Netherlands are recognising the potential of a PA on the ICU. Especially larger ICUs are already implementing PAs. Despite this, the majority of ICUs do not yet employ PAs. Presumptions about the profession sometimes inhibit acceptance of these professionals, although PAs are highly appreciated in the ICUs were they do work.

Introduction

Physician assistants (PAs) are increasingly being implemented in Dutch intensive care units (ICUs). Internationally, these PAs, often designated as advanced practice providers, have been trained to operate in the medical domain of intensive care and to facilitate and evaluate the daily medical problems together with an intensivist and ICU nurses. Because PA is a relatively new profession, the current status of implementation and the tasks delegated to PAs in Dutch ICUs is unclear. Several international studies about implementation have been performed and it is clear that the Dutch ICUs are frontrunners.[1] We conducted a survey among intensivists and PAs working in ICUs to gain insight into the current status of the acute care PA in the Netherlands.

Methods

The survey was sent to all 73 Dutch ICUs by email via the Netherlands Intensive Care Society (NVIC). A reminder for response was sent after four weeks. Eventually, the non-responders from the Dutch survey were approached by telephone. In addition, all PAs working on the ICUs in the Netherlands were asked by email to complete the survey. A reminder was sent to the PAs via Whatsapp-messenger after six weeks.

The survey

The survey consisted of questions about the baseline characteristics of the hospital and ICU such as number of beds, type of hospital and ICU, and number of residents and PAs. The second part consisted of questions about acquaintance with and the position of PAs in the ICU. Additionally, the survey addressed the underlying reasons for either implementing or not implementing this profession and the extent of the tasks of the PA. A flowchart representing the survey is presented in *figure 1*. In questions about amounts, a number had to be filled, in questions about motivation of choices, up to seven predetermined options could be filled in, and for binary questions yes or no could be filled.

Based on the Dutch national guidelines of the Central Committee on Research Involving Human Subjects (the CCMO), ethical approval was not necessary because the survey involved non-patient data and the participation of intensivists and PAs was voluntary.

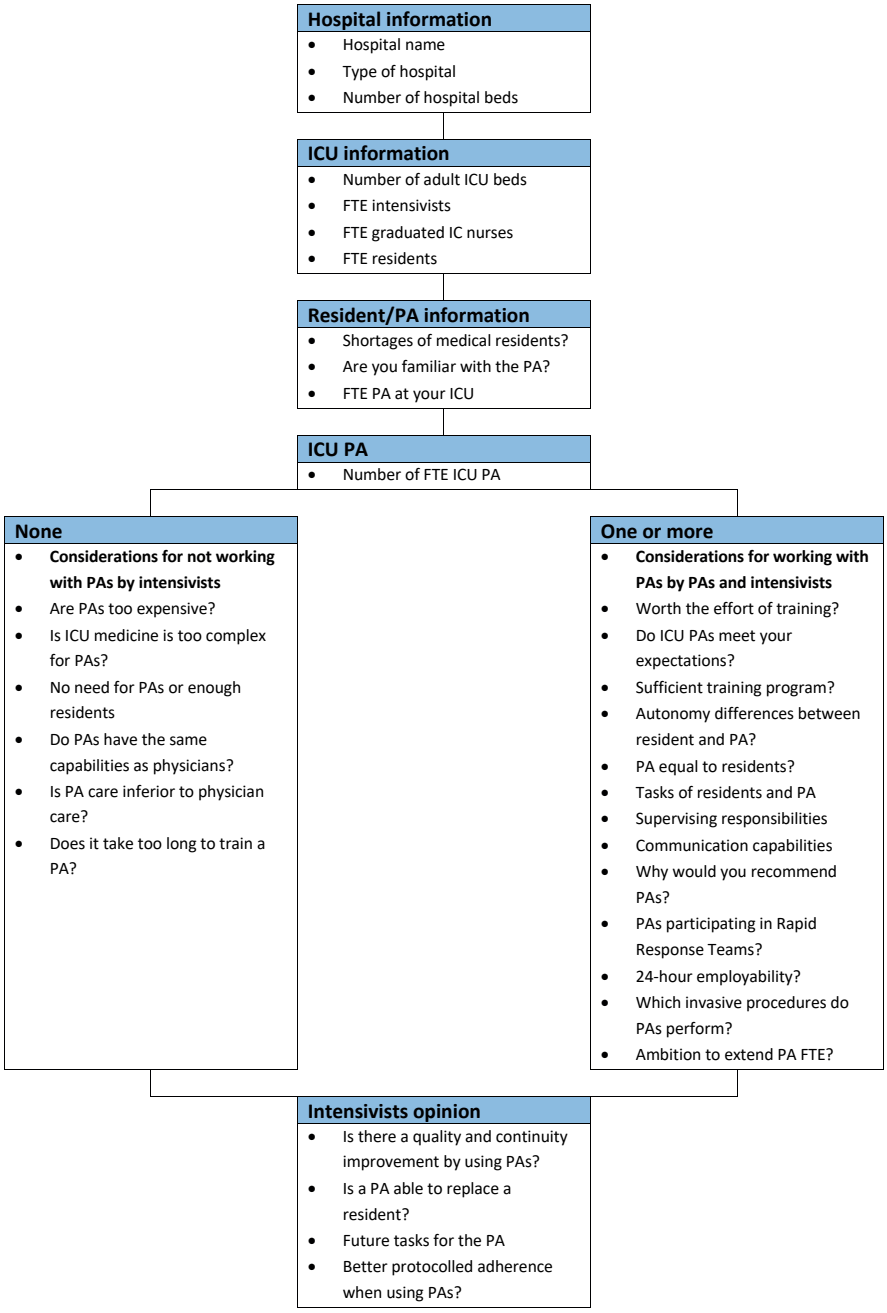

Figure 1. Flowchart representing an overview of the questionnaire. FTE: full-time equivalent

Analysis

The analysis was conducted with Excel for Windows 2013 (©2013 Microsoft Corporation) and SPSS 25 (IBM Corporation, Armonk, NY, USA). Results are presented in absolute numbers and percentages. Non-parametric continuous data were analysed with the Mann-Whitney test. The distribution was given with the interquartile range (IQR). Correlation was calculated by the Spearman correlation coefficient for non-parametric data. Dichotomous data were analysed with the Chi-square test with Yates continuity correction and when distributions were less than five, the Fisher's exact test was used.

Results

Survey among intensivists

Intensivists from 65 hospitals in the Netherlands responded (85%). Twenty of the 65 participating hospitals had already implemented or are implementing PAs on the ICU. In eight ICUs, use of a PA was under consideration. Thirty-seven hospitals reported not implementing PAs on the ICU. Together, the ICUs employed 51 full time equivalent (FTE) PAs (55 persons).

Of the 20 hospitals working with PAs, 13 were large teaching hospitals and university medical centres (UMCs), which is half of the total number of responding large teaching hospitals. The other seven hospitals that used PAs were general hospitals. Eight hospitals are in the process of or considering using PAs, five of these are general hospitals.

Of the UMCs, three of the eight were already using PAs on the ICU, and three were starting to employ PAs. Two UMCs reported having enough residents to guarantee continuity of care without PAs *(figure 2)*.

There was no significant difference in implementation of PAs between UMCs and other large teaching hospitals (p=1.00) or general hospitals (p=0.11). The number of PAs implemented in large teaching hospitals compared with general hospitals was significantly higher (p=0.03).

There was a significant correlation between the size of an ICU and implementation of PAs (r=0.361, p<0.001) which implies that the larger ICUs employ more PAs than the smaller ICUs.

Figure 3 summarises the reasons for ICUs to consider working with PAs. The reasons were: solving physician shortage (n=12), improvement in continuity of care (n=20), improvement in quality of care (n=15), career perspective for ICU nurses (n=20) and workload relief by delegating tasks from physicians to the PA (n=7).

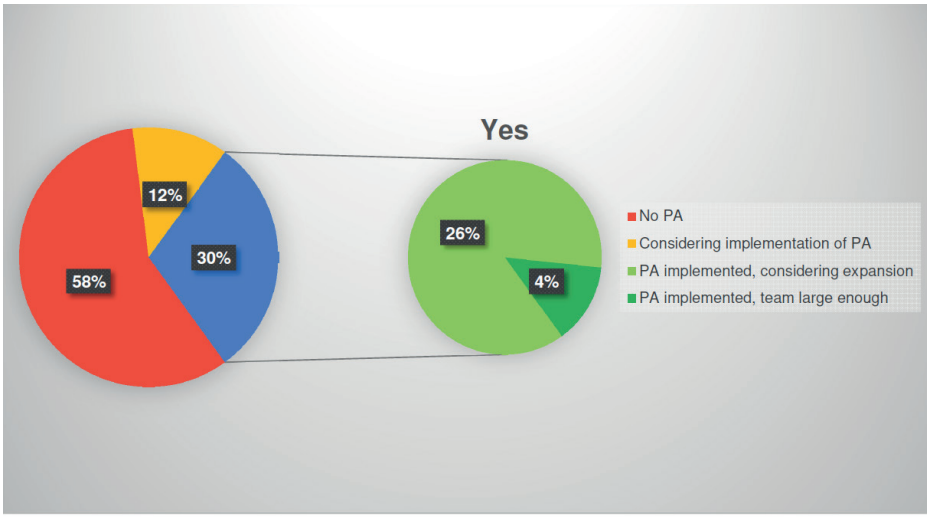

Figure 2. Overview of implementation rates in Dutch ICUs (n=65)

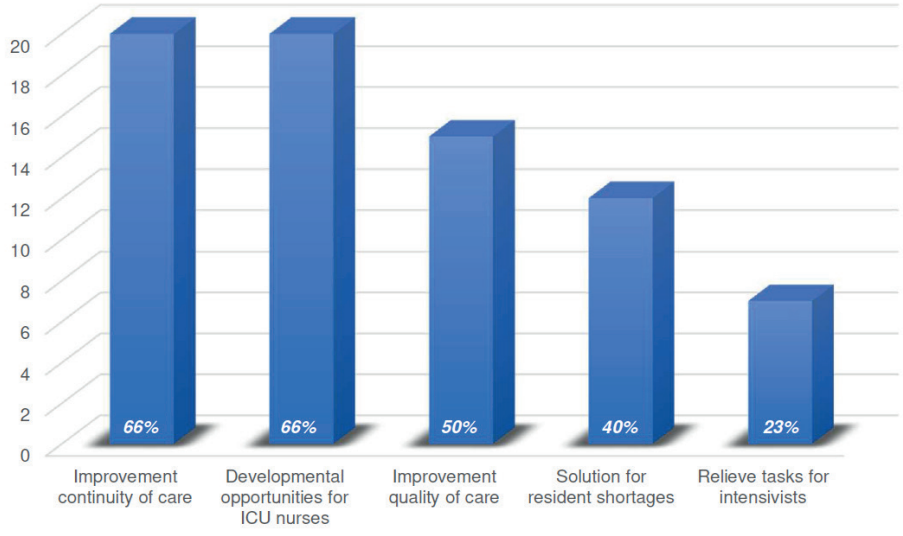

Figure 3. considerations for employing PAs in the ICU (number of respondents):

Nine of the participating ICUs were unfamiliar with PAs and did not work with them. The reasons for not having PAs were: no need because there were no shortages in residents (n=3); care provided by non-physicians is inferior to care provided by physicians (n=2); no reason (n=1); not yet discussed within group (n=1). Two ICUs worked with intensivists only, so without residents or PAs.

Figure 4 summarises the reasons for not working with PAs. Thirty ICUs were familiar with PAs but did not actually work with them. Their considerations for not working with PAs: no need for PAs because there is no shortage in residents (n=11); no need for working with residents or PAs (n=11); too expensive (n=2); time investment is too great (n=1); ICU care is too complex for PAs (n=2); have not considered it yet (n=3). Not all respondents who did not implement PAs stated a reason.

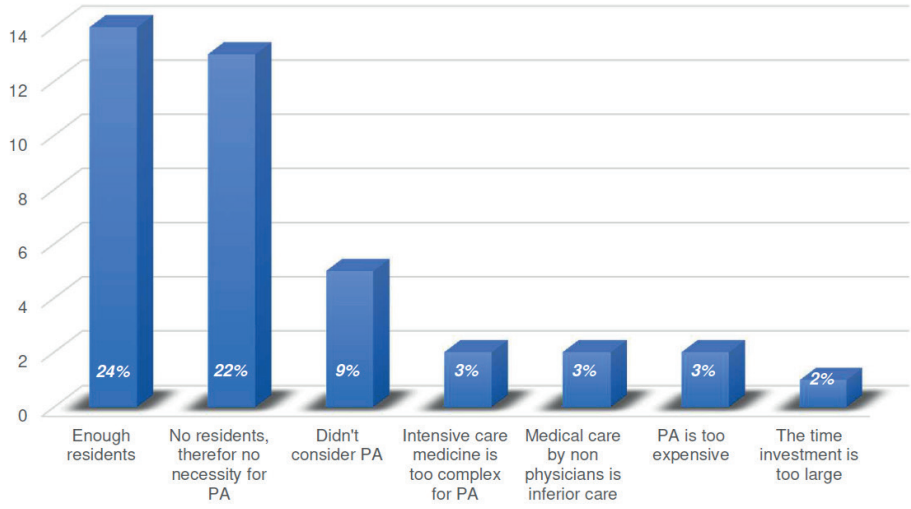

Figure 4. Considerations for not using PAs in the ICUs (number of respondents). The respondents were allowed to give multiple answers.

Survey among PAs

Of the 55 PAs working on Dutch ICUs, 43 responded to the survey (78%). Eleven of these PAs are still in training. The previous job of most PAs was ICU nurse (n=41, 95%), one was a physiotherapist and one was an anaesthetist nurse. The mean age of the group was 44 (IQR 12) years. The median time of employment was six years (IQR 7). The PAs are predominantly employed in larger hospitals with the minimum number of beds being 10 (median 15.5 beds). These hospitals implemented a mean of 2.0 (IQR 2) FTE PAs. The main reason for working with PAs was providing continuity of

care (n=42, 95%) and high quality of care (n=28, 65%). Other reasons were providing career opportunities for ICU nurses (n=25, 58%) and alleviating the workload of the intensivists (n=14, 33%).

Communication of PAs as assessed by intensivists

Three out of the 23 intensivists who reported on communication of the PA thought that their communication with patients was as good as that of the intensivist (13%). Six intensivists reported they considered the communication of the PA less proficient than both resident and intensivist (26%) and 13 intensivists considered the communication of the PA less proficient than the intensivist but more proficient than residents (57%). One intensivist considered the communication of the PA more proficient than both resident and intensivist.

Regarding communication with other attending physicians, one intensivist considered communication with PAs to be equal to intensivists, nine intensivists considered it less proficient than the intensivist and resident (39%) and 13 intensivists considered it less than the intensivist but better than a resident (57%).

Communication assessed by PAs

All 32 certified PAs felt that their communication toward patients and family was adequate. Eighteen respondents felt that their communication with patients was equal in quality compared with residents and intensivists (56%). Twelve respondents felt that they communicated less proficiently than the intensivist but more adequately than the resident (38%) and two PAs graded themselves better in communication than both intensivist and resident (6%).

Eleven of the certified PAs felt that their communication towards the attending physicians was as good as the communication of the intensivists themselves (34%). Twenty felt that their communication was less effective than intensivists but more effective than residents (63%) and one felt that the communication of the PA was more proficient than both intensivist and resident (3%).

Shifts and other tasks assessed by intensivists

Of the 20 ICUs with certified PAs, the PAs did not work night shifts in five ICUs (25%). In eight of the ICUs the PA did not participate in the rapid response team (40%). All 20 ICUs reported that PAs performed low-complex tasks such as arterial catheter placement or treatment of the uncomplicated postoperative patient. Twelve (60%) reported that the PAs performed medium-complex tasks such as placement of central venous catheters or supervising electrical cardioversion performed by residents. Four of the 20 ICUs

(20%) reported that PAs performed high-complex tasks such as consultation in the emergency department or unsupervised treatment of unstable patients.

Shifts and other tasks assessed by PAs

All 32 certified PAs responded to have supervision assignments and responsibilities, 26 supervised inexperienced residents (81%) and 20 supervised invasive procedures (63%). Twenty-nine (81%) PAs reported they participated in evening, night and weekend shifts.

Interventions assessed by intensivists

All 20 ICUs reported that certified PAs inserted arterial lines (100%). Eighteen of the 20 ICUs (80%) reported that PAs inserted central venous catheters and performed electrical cardioversions unsupervised. Seventeen ICUs (75%) reported that the PA performed complex intra-hospital transport. Intubations performed by PAs were reported in 12 of the 20 ICUs (60%).

Interventions assessed by PAs

All of the certified PAs reported inserting both arterial catheters and central venous catheters. Twenty-five of the 32 certified PAs reported performing intubations (78%), 28 reported performing electrical cardioversion and intra-hospital transportation with mechanically ventilated patients (88%) and 14 reported inserting thoracostomy tubes (44%). Twenty-seven PAs experienced a shift of the performance of invasive procedures from residents towards PAs (84%).

Employment and international cooperation

Seven intensivists expected the PA to stay on the same ICU for more than 10 years, six of them expected them to stay for five to ten years and one ICU expected them to stay two to five years. Seventeen ICUs want to expand the number of PAs. Moreover, 17 ICUs think that international cooperation would benefit the implementation and expansion of the profession. Eight ICUs do not think that international cooperation would benefit the integration of the PAs on Dutch ICUs.

Thirty-one out of 32 of the responding certified PAs think they would benefit from a more ICU-centred training or acute care training after their graduation to PA. Of the 32 certified PAs, three of them felt that they continuously had to live up to expectations and three PAs felt they were limited in their performance because their expertise was underestimated. One PA would have liked to expand research activities but did not have the opportunity to do so.

Discussion

The results of this Dutch survey provide a general overview about the use of PAs in the ICUs in the Netherlands. It shows that PAs are predominantly working in high-volume ICUs. Of the Dutch ICUs, 42% are considering or have already implemented PAs to improve the quality and continuity of care. When the smaller ICUs with only intensivists and without additional personnel are excluded, up to 58% have implemented PAs in their ICUs, either on top of existing formation or by replacing some of the residents by PAs. Next to quality and continuity of care, also career opportunities for employees is considered an argument to implement PAs.

When focusing on the specific tasks of the PA, such as communication or procedures, not much has been reported in the literature about evaluation of communication of acute care PAs. One study described perceptions of nurses, PAs and physicians regarding each other's communication. PAs communicated adequately, which is in line with the results from our survey.[2] Three intensivists thought that the communication skills were equal between PAs and intensivists. Intensivists also agreed that the communication skills of the PA were better than those of the residents. However, PAs tend to assess their skills on patient and attending physician communication better than intensivists do. Intensivists and PAs both reported that PAs were able to perform the most common procedures. More difficult procedures such as insertion of central venous catheters or intubation but also participation in a rapid response team are not always undertaken by PAs, although there is evidence that these procedures can safely be performed by other care providers than intensivists.[3-9] Moreover, the legal foundations in the Netherlands allow them to do so.[10]

The majority of ICUs do not yet work with PAs (58% vs 42%). The main reported reason is a policy decision, mainly in the smaller ICUs, to employ only intensivists and no other physicians or non-physician care providers. This budget containment is in contrast with a recent review about the cost-effectiveness of the PA and discusses financial and quality advantages.[11] If residents are readily available, there is also no incentive to explore the profession of the PA. Of the ICUs, 10% presume that quality issues will arise when employing PAs, although they did not actually use PAs. ICUs which do implement PAs, however, do not recognise these quality issues. These two contrasting opinions may partly be explained by misconceptions about the capabilities of PAs, possibly amplified by the time it takes to train a PA.

Alongside this Dutch survey, a European survey was distributed (unpublished results) which returned very limited results and showed that most European countries are unacquainted with this profession. This confirms the finding in the literature that the profession of PAs working in critical care has matured significantly in only a few countries: the United States of America, the Netherlands, Australia and the United Kingdom.[12]

This study has strengths and weaknesses. The high response rate from the Dutch survey together with agreement with the limited available literature and the accordance between intensivists and PAs, provides credibility and paints the picture of a relatively unknown profession with diverse potential. However, a weakness of every survey is the number of unanswered questions when zooming in on opinions of respondents. This may reflect unfamiliarity with the PA or differences in understanding and interpretation of the questions. In addition, the survey is not a validated questionnaire which implies that the questions might be multi-interpretable. Therefore, an acquiescence bias could be present: although the answers did provide negative answers and the survey was distributed by the NVIC and not by an individual person, bias could have been introduced because of the tendency to answer questions positively to avoid conflict. Furthermore, because some questions could be answered with more than one item, the response order effect could play a role. The number of questions with multiple items was, however, limited.

International cooperation will be helpful to expand acquaintance with PAs and to improve general awareness. Also, in the Netherlands, qualitative research into this profession will generate evidence which will standardise implementation and possibly convince the critics that PAs are a respected additional workforce in the critical care setting.

Conclusion

We have shown that familiarity of working with PAs in the critical care setting is increasing but not extensive in Dutch ICUs. In ICUs which have implemented PAs both intensivists and PAs are satisfied about their performance. PAs perform most tasks that are usually done by residents. Presumptions about the profession are barriers to the implementation of PAs.

References

1. Kreeftenberg HG, van Rosmalen J, Aarts JT, van der Voort PHJ. Physician assistants in intensive care units in the Netherlands: a narrative review with recommendations. Neth J Crit Care.2020;28:200-4.
2. Aslakson RA, Wyskiel R, Shaeffer D, et al. Surgical intensive care unit clinician estimates of the adequacy of communication regarding patient prognosis. Crit Care. 2010;14:R218.
3. Bevis LC, Berg-Copas GM, Thomas BW, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. Am J Crit Care. 2008;17:357-63.
4. Sirleaf M, Jefferson B, Christmas AB, Sing RF, Thomason MH, Huynh TT. Comparison of procedural complications between resident physicians and advanced clinical providers. J Trauma Acute Care Surg. 2014;77:143-7.
5. Kreeftenberg HG, Aarts JT, Bindels A, van der Meer NJM, van der Voort PHJ. Procedures Performed by Advanced Practice Providers Compared With Medical Residents in the ICU: A Prospective Observational Study. Crit Care Explor. 2020;2:e0101.
6. Gershengorn HB, Xu Y, Chan CW, Armony M, Gong MN. The Impact of Adding a Physician Assistant to a Critical Care Outreach Team. PLoS One. 2016;11:e0167959.
7. Gupta S, Balachandran M, Bolton G, et al. Comparison of clinical outcomes between nurse practitioner and registrar-led medical emergency teams: a propensity-matched analysis. Crit Care. 2021;25:117.
8. Scherr K, Wilson DM, Wagner J, Haughian M. Evaluating a new rapid response team: NP-led versus intensivist-led comparisons. AACN Adv Crit Care. 2012;23:32-42.
9. Stempek S, Wozniak J, Janz D, et al. Outcomes of ICU intu-bations performed by advanced practice providers compared to physicians. Crit Care Med. 2019;474:479
10. Gnirrep I, van Tilburg-van Hedel SW, Kreeftenberg HG, Lasut W, van Rosmalen J, Kerkhoven C, Aarts JT. Consensusdocument taakherschikking Intensivist – Physician Assistant-IC. https://nvic.nl/sites/nvic.nl/files/%3Cem%3ENieuws%3C/em%3E%20Consensusdocument%20Physician%20Assistants%20%3Cem%3Ebewerken%3C/em%3E/20181210%20concept%20consensusdocument%20NVIC-NAPA.pdf Accessed 01 11 2022.
11. van den Brink G, Hooker RS, Van Vught AJ, Vermeulen H, Laurant MGH. The cost-effectiveness of physician assistants/associates: A systematic review of international evidence. PLoS One. 2021;16:e0259183.
12. Kreeftenberg HG, Pouwels S, Bindels A, de Bie A, van der Voort PHJ. Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med. 2019;47:722-30.

Chapter 9

Practical implementation implications and review applied to the Dutch situation.

Physician Assistants in Intensive Care Units in the Netherlands: a narrative review with recommendations.

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Abstract

This review is an overview of the current status of the advanced practice provider (APP) working in critical care. After describing the history of the profession, the paper focuses on the literature available. Although a lot of literature is available, the papers are often heterogeneous and comparison with other clinicians remains difficult. The paper zooms in on the situation in the Netherlands and describes the training courses for the physician assistant (PA), the equivalent of the APP, together with the legislation in place. Furthermore, the review elaborates on the potential superimposed value of the PA for the ICU. Because of the limited amount of studies performed in the Dutch situation this review finishes with the conclusions of 15-year-experience and the possible issues which could arise when implementing a PA on the ICU.

Introduction and rationale

The number of Physician Assistants (PAs) working in Dutch Intensive Care Units (ICUs) is rising. The reasons for including PAs in the organization of an ICU, however, differ. Sometimes a PA is a solution for physician shortages and sometimes PAs are more convenient than the ever changing medical residents who consider their mandatory ICU internship as a springboard for their future career. Sometimes passing residents even seem to have limited consideration with intensive care. Besides a solution for above-mentioned issues, the PAs currently practicing in the ICU can solve the knowledge and continuity deficit present in the group of medical residents. The current work-hour restrictions for residents dictate a continuous rotating schedule during their short duration. As such, an increasing number of ICU's recognize that the PA could be an efficient solution for the delivery of continuous and high quality day and night intensive care. PAs are after all often familiar with the local protocols to which they already were exposed during their ICU nursing career and have learned effective communication techniques as nurse. This paper describes the current status of the acute care PA and provides recommendations for ICUs that consider implementing PAs.

History

The history of the profession goes back to the United States of America in the 1960s when both nurse practitioners (NPs) and PAs received a legalized diploma after following official recognized courses for these specialties. A concise overview of the history can be found in a review article of Kleinpell et al. (1) In the years to follow both professions spread out through several specialties of medicine including the relative new profession of intensive care medicine. In the United States it was the NP, originally registered as ICU nurse, who initiated the first recognized subspecialty in ICU nursing: the Acute Care Nurse Practitioner (ACNP). The NP is a qualified nurse with a Master's degree in Advanced Nursing Practice, in which the entire medical ICU skill-set is taught including technical interventions like intubation and intravascular catheterization. His/her colleague, the physician assistant, has a Bachelor's degree in a science or healthcare related subject and two years of practical experience in patient care before receiving on the job training in the ICU.(2) Both professions perform the same tasks, which are comparable to the ones residents, fellows and intensivists have to perform in the Netherlands. The responsibilities often extend beyond the ICU and also comprise the entire area of acute and emergency medicine including research, development of protocols and educating medical residents.

A decrease in resident work-hours implemented in 2003 by the Accreditation Council for Graduate Medical Education (ACGME) gave the nurse practitioners as well as the PA a boost.(3) In addition, a publication in 2001 from the Committee on Manpower for Pulmonary and Critical Care Societies predicted a shortfall of intensive care medicine specialists of 22% by the year 2020 and 35% by 2030.(4) Both events caused an increasing visibility of the two specialties in the ICUs. Nowadays some ICU's in the United States are completely run by ACNPs and PAs with remote supervision by intensivists. Because the differences in practice between the PA and ACNP are negligible they are often both referred to as advanced practice providers (APP).

Literature

A fair number of studies on the subject of the advanced practice provider in critical care have been published but most of these studies are descriptive. Especially in the beginning of this young profession the experiences of teams and individuals were shared. Studies published after 2000 started to address implementation in a standardized way and retrospectively or prospectively evaluated cohorts of patients treated by APPs. These cohort studies tried to identify the reasons for success of this profession and tried to elaborate on the potentially present, superimposed value of the APP for critical care. The studies can be divided in those that tried to demonstrate the value of APP's by determining either mortality benefit (5-9) or a decrease in length of stay (5, 7, 8, 10-13) and studies that investigated more subtle parameters in which the APP was presumed to excel, such as communication or protocol adherence. (13-16) All of these retrospective and prospective studies showed either APPs being non-inferior to residents or attending physicians (7-9, 12) or APPs having an additional benefit over physicians. (5, 11, 13) Most of these studies had a cohort design which is probably the most practical design in this research area. (1, 17) Further analysis however, also revealed problems. Often the studies were small and single-centered and the comparison between clinicians was diverse because APPs were either compared with residents, or fellows or even with specialists. Moreover, attending physicians always supervised the APP-initiated treatment. These confounders obviously mitigated the results. (17) One prospective study stands out because it evaluated a large patient group (n=9066) in a prospective cohort. This study showed a mortality benefit as well as a reduced hospital length of stay in the group of patients treated by APPs. (5) The other studies performed on subtle outcomes like communication (14, 15), protocol adherence (13, 16), patient satisfaction (18), the effectiveness of registering the mandatory ICU scoring systems and even one which scored the amount of laboratory requests, often showed a somewhat better performance of the APP. (19, 20)

The literature also tells us that several other tasks are delegated to PAs. In-depth research has been performed regarding the APP as leader of the critical care outreach team (21-23) and the APP performing invasive interventions. (24-27) In these studies the comparison of the APP with the less experienced medical resident and the implementation of APPs in already well performing teams, obviously has its drawbacks. Recently, a published review and meta-analysis on the subject of the APP in critical care, showed non-inferiority of APPs compared to other clinicians. (17) This meta-analysis did not show survival benefit or a shortened length of stay in patients treated by the APP group. In a lot of areas, where the APP is active, however, not enough literature was available to draw a solid conclusion about the position and value of the APP.

Situation in Europe and the Netherlands

Health care systems differ between countries, and even the way hospitals are organized within a country differs. The position of the APP in critical care varies accordingly. (28) The health care system in the USA with its specific reimbursement facilitates a strong position of the APPs. Moreover, the shortages in physicians are more evident in the USA than in Europe. (3, 29, 30)

However , there are shortages in Europe too. Several rural areas experience shortages of physicians and the accompanying increase quality requirements in health care together with the ageing population will lead to increasing demand for physicians. (31-35)

In Europe, except for the United Kingdom, there is lack of awareness that APPs in the ICUs can be a solution for problems such as physician shortages or continuity and quality of care. The literature about APPs published in Europe, underpins this situation. (36) At this moment only three comparative cohort studies originate from Europe, two from the Netherlands and one from the United Kingdom. (9, 37, 38)

The increasing health care costs and the need for containment of these costs, play a role in the way budgets are spent. In the Netherlands this has resulted in task redirection towards APPs. Arguments like continuity and quality of care as well as costs probably prevail over physician shortages as an argument for implementation of the APP. Although in the northern and eastern part of the Netherlands the physician shortages seem to play a larger role. (39)

Legalization in the Netherlands

In the year 2001 the first official courses for NPs in the Netherlands started. The official courses for PAs followed shortly thereafter. Two courses for PAs at the university of applied sciences in Utrecht and in Nijmegen were officially recognized in 2003.(40) In the meantime ICUs began implementing PAs and NPs. It became apparent that the PA was better equipped to support medical care than the nurse practitioner. In contrast to the NPs, the PAs were trained in several medical sub-specialties. As a consequence, the PAs gained an increased popularity in the entire medical domain but their official status was uncertain.

Due to the increase in health care expenses and the aim to reduce this spending, the Ministry of Health, Welfare and Sport in the Netherlands started a project called 'task reshuffling' (translated from 'taakherschikking'). The purpose was to organize health care more efficiently and effectively by improving the use of the existing health care capacity and by adapting the system to an increasing and changing health care demand. In short, the goal was to increase the quality of care and to reduce costs. One of the tools that the ministry of healthcare used was to implement opportunities by which medical care could be directed to PAs. The ministry anchored this profession legally by temporarily adding it under Article 36a of the Healthcare Professional Act (wet BIG) in January 2012. (41) This provided the PAs with the authorization of autonomously performing activities within the medical domain. The evaluation after a period of five years showed the profession to be opportune and efficient without an increase in costs and lawsuits. This in turn resulted in the addition of this profession to Article 3 of the 'BIG' Act, the part which describes the responsibilities of professions listed in the BIG registry. (42)

In the meantime, PAs were participating in intensive care medicine at quite a few ICUs. Following this development, the Netherlands Society of Intensive Care (NVIC) and the Netherlands Association of Physician Assistants (NAPA) developed a consensus document which describes the rights and responsibilities of physician assistants and ICU organizations. (43)

Education

The Dutch PA follows a joint theoretical and practical course to gain a Master's degree. The duration of this course is two and a half years and the course is completed by a Master's thesis: a literature study on an ICU relevant subject. (44)

The theoretical part consists of lessons in several specialties regarding physiology and pathophysiology. The practical side of the course is provided in hospital, during internships at several different wards. After obtaining a master degree, the generic fundamentals for exercising the PA profession are present. Specific knowledge of ICU pathophysiology and ICU skills like airway management and vascular access have to be acquired on the job.

Superimposed value to the ICU team

In 2020 there are 51 physician assistants currently working on ICUs in the Netherlands. The specific APP of acute care as an entity, like in the USA, does not yet exist. In the Dutch situation, most of the PAs working in acute care are based in ICUs and not in adjacent areas like the emergency department. The often-heard reasons for implementing PAs on ICUs in the Netherlands are: either the PA functions as a replacement equivalent for the medical resident in case of shortages or the PA addresses continuity of care. We do not yet know how the Dutch ICUs evaluate their PAs but in general discussions the PAs are often perceived as having a positive impact on several aspects of ICU care.

One of the important values of the PA mentioned, they are able to take over tasks normally assigned to the intensivist. (17, 45) Because PAs are often already settled in an area during their nursing career and have a network or family in place, there is no urge to change to another job or employer which in turn facilitates the cooperation. The time investment of learning the PA certain skills, thus pays off.

The continuity of the PA translates to the fact that the PA has the in-depth knowledge of the intensive care and local protocols from the period as an ICU registered nurse. Together with the social attitude it makes the PA an easy to cooperate, autonomous clinician which bridges the gap between nurses and physicians. It also makes the PA the ideal person to familiarize new residents with the ICU protocols and educate the resident and nurses in ICU pathology. Their experience facilitates other residents during the shifts or educational sessions.

Because the PA can perform several technical and invasive procedures autonomously it is easy for the team to delegate these tasks to the PA which in turn generates a lot of exposure. Because of this exposure, the PA becomes skillful in these procedures. For the PA to practice these skills without any supervision, however, requires an extra time effort from the ICU team because these skills have to be taught on the job.

One other remark seems appropriate: when an ICU considers implementing PAs, the ICU staff has to bear in mind that the collective labor agreement in the Netherlands provides the right to refrain from night shifts after an age of 57.

Considerations when implementing PAs: a single center experience

Guidelines on how to implement PAs in the Dutch system are not available. Even the general information on the PA in the ICU in the Netherlands is limited. (37, 38) This section covers the practical issues which were encountered when starting with PAs in a single center ICU. In 15 years of experience several issues keep returning when training PAs. **Table 1** is a list of issues and required actions from the perspective of the staff of the ICU and the PA. Recognition of these issues may help in successfully implementing PAs in the ICU.

Table 1. list of issues and actions.

	Issue	**Action**
Perspective of staff	Future position within ICU team	Clear understanding why a PA is implemented in the ICU.
	Capability of the PA	Selecting ICU nurses accustomed to your ICU and already completed several projects
	Limited ICU knowledge	Allow for a period of 4-5 years until final judgment: 2.5 years general education and 2 years building experience
	ICU too small for a PA	Consider implementing PA in the entire area of emergency care.
Perspective of PA	The difficult transition from nursing domain to medical domain	Support and facilitate PA as much as possible.
	Sharing experiences	Training of more PAs at once.
	Interacting with former nursing colleagues	Guidance regarding attitude to nurses and the medical staff displaying confidence towards the PA
	Low patient exposure	Collaboration with high-volume centers during training and thereafter.

Before employing PAs, the ICU staff and management should decide which problem the PA has to solve. It should be clear whether the PA has to perform specific tasks, is implemented because of resident shortages or for quality improvement. This is essential for the development of the PA because PAs experience a lot of changes during their training and will more easily adapt knowing what to expect.

Also, the selection of new PA students requires a few considerations. During this process it is important to assess the cognitive capabilities of the PA, which have to be on an academic level. During the training the PA has to be able to process a lot of new information in a short time frame and eventually function like a resident. The PA has to be able to operate on both an operational and strategic level. Although the entry requirements for acceptance to the Master course are graduation from a university of applied sciences, the period during which the applicant functions as a nurse can be used to assess personality trades like cooperation and determination. An assessment might be part of the selection process.

A sometimes-heard presumption is that the PA is not up to the task because of lack of specific knowledge about ICU pathology. This is certainly true during training, but also during the two years after graduation. Like everyone, the PA has to gain experience. This time investment takes four to five years, two and a half during official training and two years on the job. After this investment the PA can alleviate the tasks of an intensivist: invasive procedures are performed autonomously and because of the relative long cooperation between intensivist and PA, the consultation moments are easy.

A high level of exposure to patients and their problems is crucial. Low volume ICU's therefore, need to consider cooperating with a high volume ICUs during PA-training and possibly, intermittently during the following years. On a low volume ICU the problem may arise that the PA is not satisfied due to the absence of enough challenges, or that the PA is not cost-effective from hospital point of view. Therefore, smaller hospitals might consider deployment of the PA on multiple critical care wards (coronary care unit, ICU, stroke unit and emergency department) or even the normal wards. In our experience, this will increase the satisfaction of both the PA and the hospital. In contrast to the smaller ICUs the academic centers have larger ICUs with often enough fellows and experienced medical residents. Even in these centers the continuity and the quality proves to be advantageous. Besides their high quality clinical work, the PA can mentor the starting clinicians and guide and support them during their acquaintance with ICU medicine.

The PA experiences a transition from the well demarcated situation of the ICU nursing domain to a more creative problem-solving environment of the medical domain. Easily answered questions like whether to start diuretics in patients are suddenly handled with a lot more difficulty than an easy remark by the nurse during the rounds. The responsibilities and increasing understanding of pathophysiology which accompany this transition, have to be coped with. The diagnostic uncertainty is something to which the PA has to adapt. In addition, leaving the peer group of ICU nurses means leaving behind professional colleagues and obtaining a place within the relative unknown medical staff. If an ICU has no experience with PAs, its nursing team and physician team have to get used to the entity PA and the accompanying changes in daily practice. This will be experienced as barrier by the PA. Therefore, it is important to support and facilitate the PA during the entire training and the years thereafter, until the PA and team are accustomed to each other.

Regarding this professional development it helps when the PA takes his or her first practical steps together with another PA with whom experiences can be shared and reflected on.

Conclusions

The recognition of PAs as a valuable team member in daily ICU practice is increasing. In the Netherlands, support of the government and agreement between the NVIC and the NAPA effectively removed the barriers for implementation. This arrangement opens up opportunities for both critical care medicine and the PA and results in a front-runner position in Europe regarding this profession. The in depth training of the PA facilitates opportunities for hospitals to consider deployment of the PA on other wards than the ICU, such as the coronary care units, emergency departments, or even the normal wards. Irrespective of these opportunities, care has to be taken to preserve the quality of this provider by safeguarding its selection process. When fully trained, the ICU staff has a capable, well trained professional which sustains quality and continuity in the management of every critically ill patient.

References

1. Kleinpell RM, Ely EW, Grabenkort R. Nurse practitioners and physician assistants in the intensive care unit: an evidence-based review. Crit Care Med. 2008;36(10):2888-97.
2. Gershengorn HB, Johnson MP, Factor P. The use of nonphysician providers in adult intensive care units. Am J Respir Crit Care Med. 2012;185(6):600-5.
3. Pastores SM, O'Connor MF, Kleinpell RM, Napolitano L, Ward N, Bailey H, et al. The Accreditation Council for Graduate Medical Education resident duty hour new standards: history, changes, and impact on staffing of intensive care units. Crit Care Med. 2011;39(11):2540-9.
4. Pingleton SK. Committee on Manpower of Pulmonary and Critical Care Societies: a report to membership. Chest. 2001;120(2):327-8.
5. Landsperger JS, Semler MW, Wang L, Byrne DW, Wheeler AP. Outcomes of Nurse Practitioner-Delivered Critical Care: A Prospective Cohort Study. Chest. 2016;149(5):1146-54.
6. Hoffman LA, Tasota FJ, Zullo TG, Scharfenberg C, Donahoe MP. Outcomes of care managed by an acute care nurse practitioner/attending physician team in a subacute medical intensive care unit. Am J Crit Care. 2005;14(2):121-30; quiz 31-2.
7. Kawar E, DiGiovine B. MICU care delivered by PAs versus residents: do PAs measure up? JAAPA. 2011;24(1):36-41.
8. Scherzer R, Dennis MP, Swan BA, Kavuru MS, Oxman DA. A Comparison of Usage and Outcomes Between Nurse Practitioner and Resident-Staffed Medical ICUs. Crit Care Med. 2017;45(2):e132-e7.
9. Skinner H, Skoyles J, Redfearn S, Jutley R, Mitchell I, Richens D. Advanced care nurse practitioners can safely provide sole resident cover for level three patients: impact on outcomes, cost and work patterns in a cardiac surgery programme. Eur J Cardiothorac Surg. 2013;43(1):19-22.
10. Gershengorn HB, Wunsch H, Wahab R, Leaf DE, Brodie D, Li G, et al. Impact of nonphysician staffing on outcomes in a medical ICU. Chest. 2011;139(6):1347-53.
11. Gillard JN, Szoke A, Hoff WS, Wainwright GA, Stehly CD, Toedter LJ. Utilization of PAs and NPs at a level I trauma center: effects on outcomes. JAAPA. 2011;24(7):34, 40-3.
12. Burns SM, Earven S, Fisher C, Lewis R, Merrell P, Schubart JR, et al. Implementation of an institutional program to improve clinical and financial outcomes of mechanically ventilated patients: one-year outcomes and lessons learned. Crit Care Med. 2003;31(12):2752-63.
13. Russell D, VorderBruegge M, Burns SM. Effect of an outcomes-managed approach to care of neuroscience patients by acute care nurse practitioners. Am J Crit Care. 2002;11(4):353-62.
14. Rudy EB, Davidson LJ, Daly B, Clochesy JM, Sereika S, Baldisseri M, et al. Care activities and outcomes of patients cared for by acute care nurse practitioners, physician assistants, and resident physicians: a comparison. Am J Crit Care. 1998;7(4):267-81.
15. Rayo MF, Mount-Campbell AF, O'Brien JM, White SE, Butz A, Evans K, et al. Interactive questioning in critical care during handovers: a transcript analysis of communication behaviours by physicians, nurses and nurse practitioners. BMJ Qual Saf. 2014;23(6):483-9.
16. Gracias VH, Sicoutris CP, Stawicki SP, Meredith DM, Horan AD, Gupta R, et al. Critical care nurse practitioners improve compliance with clinical practice guidelines in "semiclosed" surgical intensive care unit. J Nurs Care Qual. 2008;23(4):338-44.
17. Kreeftenberg HG, Pouwels S, Bindels A, de Bie A, van der Voort PHJ. Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. Crit Care Med. 2019;47(5):722-30.
18. Sidani S, Doran D, Porter H, LeFort S, O'Brien-Pallas LL, Zahn C, et al. Processes of care: comparison between nurse practitioners and physician residents in acute care. Nurs Leadersh (Tor Ont). 2006;19(1):69-85.
19. Butler KL, Calabrese R, Tandon M, Kirton OC. Optimizing advanced practitioner charge capture in high-acuity surgical intensive care units. Arch Surg. 2011;146(5):552-5.

20. Jefferson BK, King JE. Impact of the acute care nurse practitioner in reducing the number of unwarranted daily laboratory tests in the intensive care unit. J Am Assoc Nurse Pract. 2018;30(5):285-92.
21. Pirret AM. The role and effectiveness of a nurse practitioner led critical care outreach service. Intensive Crit Care Nurs. 2008;24(6):375-82.
22. Gershengorn HB, Xu Y, Chan CW, Armony M, Gong MN. The Impact of Adding a Physician Assistant to a Critical Care Outreach Team. PLoS One. 2016;11(12):e0167959.
23. Scherr K, Wilson DM, Wagner J, Haughian M. Evaluating a new rapid response team: NP-led versus intensivist-led comparisons. AACN Adv Crit Care. 2012;23(1):32-42.
24. Alexandrou E, Murgo M, Calabria E, Spencer TR, Carpen H, Brennan K, et al. Nurse-led central venous catheter insertion-procedural characteristics and outcomes of three intensive care based catheter placement services. Int J Nurs Stud. 2012;49(2):162-8.
25. Alexandrou E, Spencer TR, Frost SA, Mifflin N, Davidson PM, Hillman KM. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Crit Care Med. 2014;42(3):536-43.
26. Bevis LC, Berg-Copas GM, Thomas BW, Vasquez DG, Wetta-Hall R, Brake D, et al. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons. Am J Crit Care. 2008;17(4):357-63.
27. Sirleaf M, Jefferson B, Christmas AB, Sing RF, Thomason MH, Huynh TT. Comparison of procedural complications between resident physicians and advanced clinical providers. J Trauma Acute Care Surg. 2014;77(1):143-7.
28. Fry M. Literature review of the impact of nurse practitioners in critical care services. Nurs Crit Care. 2011;16(2):58-66.
29. Edkins RE, Cairns BA, Hultman CS. A systematic review of advance practice providers in acute care: options for a new model in a burn intensive care unit. Ann Plast Surg. 2014;72(3):285-8.
30. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J, Jr., Committee on Manpower for P, et al. Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: can we meet the requirements of an aging population? JAMA. 2000;284(21):2762-70.
31. Kreeftenberg HG, Pouwels S, van der Voort PHJ. Efficient organisation of intensive care units with a focus on quality: the non-physician provider. Crit Care. 2017;21(1):118.
32. Murias G, Sales B, Garcia-Esquirol O, Blanch L. [Telemedicine: Improving the quality of care for critical patients from the pre-hospital phase to the intensive care unit]. Med Intensiva. 2010;34(1):46-55.
33. Durupt M, Bouchy O, Christophe S, Kivits J, Boivin JM. Telemedicine in rural areas: general practitioners' representations and experiences. Sante Publique. 2016;28(4):487-97.
34. Ward NS, Afessa B, Kleinpell R, Tisherman S, Ries M, Howell M, et al. Intensivist/patient ratios in closed ICUs: a statement from the Society of Critical Care Medicine Taskforce on ICU Staffing. Crit Care Med. 2013;41(2):638-45.
35. Hnilicova H, Vavreckova J, Dobiasova K. [Migration trends of Czech physicians]. Cas Lek Cesk. 2008;147(1):49-54.
36. Maier CB, Barnes H, Aiken LH, Busse R. Descriptive, cross-country analysis of the nurse practitioner workforce in six countries: size, growth, physician substitution potential. BMJ Open. 2016;6(9):e011901.
37. van Vught A, van den Brink G, Hilkens M, van Oers JAH. Analysis of the level of clinical skills of physician assistants tested with simulated intensive care patients. J Eval Clin Pract. 2018;24(3):580-4.
38. Kreeftenberg HG, Aarts JT, de Bie A, Bindels A, Roos AN, van der Voort PHJ. An alternative ICU staffing model: implementation of the non-physician provider. Neth J Med. 2018;76(4):176-83.

39. http://www.tubantia.nl/enschede/tekort-aan-artsen-voor-ziekenhuizen-mst-en-zgt~a77a1cca/ Accessed 012420
40. zorgbalans/druk1/ING: Bohn Stafleu van Loghum, 2006
41. https://wetten.overheid.nl/BWBR0006251/2020-01-01#HoofdstukIV Accessed 012420
42. https://wetten.overheid.nl/BWBR0006251/2020-01-01#HoofdstukII Accessed 012420
43. https://www.napa.nl/wp-content/uploads/2019/10/Consensusdoucment-taakherschikking-Intensivist-Physician-Assistant_.pdf Accessed 012420
44. https://www.han.nl/opleidingen/master/physician-assistant/duaal/index.xml Accessed 012420
45. Kleinpell RM, Grabenkort WR, Kapu AN, Constantine R, Sicoutris C. Nurse Practitioners and Physician Assistants in Acute and Critical Care: A Concise Review of the Literature and Data 2008-2018. Crit Care Med. 2019;47(10):1442-9.

Part V

Chapter 10

Summary and Discussion

Introduction

This thesis focuses on the value and feasibility of deploying non-physician providers (NPP), later called advanced practice providers (APP), in critical care settings. As described in [**chapter 1**], introducing APPs in critical care has been reported to be valuable and economically feasible. The current opinion is that APPs are able to improve quality of care and provide continuity of care and that they provide a solution for physician shortages in rural areas. At the same time, the Netherlands Society of Intensive Care (NVIC) struggles with the position of the APPs designated as Physician Assistants (PA) in the Intensive Care (ICU) because of the lack of evidence regarding these advantages. The current guideline of the NVIC does not recommend APPs in Dutch critical care (1)

Exploration of the evidence on employing APPs in critical care

The value of the APP/PA has been mentioned in publications by several physicians in critical care, based on their experience while working with members of this profession. To provide scientific evidence, we conducted a review of the literature concerning APPs. [**chapter2**] In this review, we also generated a meta-analysis based on the aggregated results. We included studies with sufficient methodologic quality as assessed with the Newcastle Ottawa scale. The general findings were that although a significant amount was written about the implementation of APPs, most papers were opinion papers that expressed subjective opinions about the profession. This subjectivity also hampered the meta-analysis. Of the 30 comparable studies, the quality was medium to good, but the designs differed. For example, the clinicians with whom the APPs were compared were diverse, varying from medical residents to attending physicians or consultants. Due to these differences, the only data that could be pooled were the patient outcome measures length of stay and mortality. We demonstrated that APPs were not inferior to whatever group of physicians was chosen, but the supposed added value of this profession, which was often assumed, could not be demonstrated. In addition, the research mainly originated from four countries: the United States of America, Australia, the Netherlands and the United Kingdom. This suggests that many other countries are not familiar with APPs, although some initiated similar approaches, such as implementing specialist nurses to cope with physician shortages or to address the required quality improvements. (2)

An exploration of the tasks of the APP in a common ICU in a large teaching hospital in the Netherlands showed the scope of the APPs profession. [**chapter 3**] The implementation described in this chapter shows that part of the group of APPs is operating independently regarding all the necessary daily tasks. Technical and non-technical skills are often performed without supervision, depending on the APP's level of experience. The APPs appeared to be well embedded and accepted in the ICU-team. Coordinated treatment of each patient is guaranteed because the APPs work in conjunction with intensivists and attending physicians.

In this setting, it can be advantageous to have additional experience in critical care before taking on the profession of APP. The APPs' years of experience in critical care as an ICU nurse may contribute to their clinical judgement and probably enhances the quality of these professionals. Additional tasks covered by the APPs included the education of rotating residents and making them acquainted with the critical care environment. Together with the intensivists, this coaching role of the APP provides a safe environment for the rotating residents to learn intensive care medicine. In addition, while the APPs tasks exceed those of the residents, in the Dutch health care system their salary is equal to that of the residents. This cost effectiveness is in line with the findings of studies from other countries; even if APPs' salaries are higher, delegating diverse other tasks such as charge capture to APPs can still make their employment cost effective. (3)

Technical skills in the ICU performed by APPs

In the absence of convincing evidence to explain the additional value of employing APPs in a critical care environment in a developed country, the study in [**Chapter 4**] was initiated to address one of the described domains in which the APP could excel: technical interventions. This prospective cohort study showed the differences in technical skills between APPs and residents. Notably, APPs performed and supervised more procedures per person than residents (and intensivists). In a country with a high-quality health care system according to the commonwealth fund and the European indicators and in an ICU with a high quality of care according to the NICE database, the APPs' complication rates were non-inferior to those of rotating residents who were supervised by specialists. They even outperformed the residents when results were measured in number of attempts before success of a procedure and in success rate at first attempt of a procedure. Patient outcome parameters did not differ significantly and APPs as well as residents had low complication rates compared to the literature (4-7) No explanation has been demonstrated for the

difference in numbers of procedures per clinician, but experience probably plays a role; the median number of years of experience years of the APPs exceeded those of the residents.

These findings show that in principle, clinicians with experience and frequent exposure to critical care procedures can perform these procedures safely regardless of their education. These findings are supported by similar results of earlier reports on the technical skills of APPs. (7-9)

Non-technical skills in the ICU performed by APPs

To compare the performances of APPs and residents regarding non-technical skills, a retrospective study was undertaken on patient outcomes and mandatory reaction times of Rapid Response Teams (RRTs) led either by a resident or by an APP. [**chapter 5**] Again, this comparison showed that both groups were non-inferior to each other. Patient outcome measures were assessed to identify differences in performances. Along with the scores on a validated MAELOR tool, which measures the performance results of a rapid response team, these outcome parameters were well within established parameters, which is in contrast to some reports in the literature that found that the time between visit and admission was long. (10) Assessing the contribution of the APP alone remains problematic because despite the fact that several studies on this subject intended to assess the contribution of an APP, the assessment of patient outcome parameters often resulted in assessing an entire team. A comparable issue arose in our study, since outcome parameters were influenced by the fact that the intensivists had the final say before admission. A recent retrospective study described the performance of an APP-led rapid response team by evaluating patient outcome measures. However, they used propensity score matching to establish a reduced hospital length of stay, which once again introduced factors of influence outside the rapid response team. After all, the hospital length of stay can be considered an assessment of the entire hospital cure and care process instead of an assessment of the leaders of the rapid response team, which was what the study intended to measure. (11) Therefore, all these retrospective studies concluded that APPs and medical residents (MRs) perform well in an rapid response team when their performance was measured in terms of patient outcome measures. In countries with a high-quality healthcare system such as the Netherlands, all these factors make it difficult to measure the added value of an APP in critical care. The retrospective design of these studies also does not contribute to the evaluation of sole team members. However, the non-inferiority of APPs compared to residents is a meaningful outcome.

To address the disadvantages of the retrospective study designs and to measure the performances of individual APPs instead of those of the teams, [**chapter 6**] describes a study in a simulation environment focusing on critical care scenarios. During the design phase of the study, APPs were included to be able to evaluate their performance in simulated critical care situations like the ones encountered during a rapid response team visit. Although simulation situations make assessing patient outcomes difficult, they do enable measuring the performance of individual team members by using process performance outcomes. The scenarios are comparable to an environment in which critical care medicine is practiced by rotating residents who often are relatively young. In contrast to the residents, APPs do not rotate as much and therefore they gain considerable experience in critical care medicine. This study showed that APPs should be considered as members of rapid response teams because their higher level of experience appeared to increase the adequacy of their judgements.

To deepen the insight into the performance of APPs by means of process outcomes, we designed a prospective study in which the performance of APPs in a rapid response team was assessed by external observers and team members. [**chapter 7**] The evaluation showed that the external observers and team members were unable to recognize the added value of the APP in a complicated clinical situation; according to their interpretation, the performance of the APPs was non-inferior to that of the residents. However, when the performance of the rapid response team was assessed by experienced clinicians, the performance of the APPs was judged to be better than that of the residents in several process domains, such as judgment, overview and professionalism. The difference increased with increasing years of experience of both APPs and residents. These findings were in line with the findings in chapter 6, which also concluded that the main advantage of APPs over residents consists in the APPs' higher level of experience in dealing with the specific challenges of critical care.

The conclusion of the subsequent chapters therefore is once again that APPs are valuable team members in critical care and non-inferior to residents. The effect of their previous work experience as ICU nurses has not been established yet but appears to be advantageous. Patient outcome measures are not the preferred outcome measure for establishing the supposed added value of APPs in a high-quality healthcare system. A better way to assess their value in critical care is to measure process outcomes of teams that comprise an APP. Because of their often considerable experience, APPs seem better equipped to handle critical care situations than junior residents. In addition, their experience makes them particularly suited for performing other tasks

that contribute to quality improvement, such as guiding inexperienced residents, education, supervision and protocol development.

Experiences with APPs in Dutch ICUs

The Netherlands appears to be one of the frontrunners in implementing APPs in critical care. Taking advantage of this fact, we conducted a survey on the implementation of APPs in Dutch ICUs and the experiences and on ICU managers' reasons for implementing or not implementing APPs. [**chapter 8**] The results show that a minority of Dutch ICUs has implemented this profession and that larger hospitals appear to be the first to do so. The usual tasks of APPs involve technical and non-technical skills, but in some ICUs, the tasks of APPs are limited to simple skills. This confinement to simple tasks resulted from a lack of familiarity with this profession, which also proved to be a barrier for the implementation of APPs. Limited expectations of intensivists often inhibit the utilization of the full skill set of an APP. Another barrier for implementation of APPs in the ICU that was mentioned by intensivists is the time investment before the APP acquires sufficient experience. Mastering the entire process of critical care requires time and effort of both the APP and the intensivist. One of the additional wishes mentioned by APPs themselves in this survey was a post-graduation critical care training to optimize their performance, which may in turn reduce the required time investment.

[**Chapter 9**] presents a further in-depth review of the literature and an assessment of the applicability of this literature to the Dutch situation. Some general opinions and experiences are described to illustrate the position of ICU-APPs in Dutch ICUs. The review describes the most difficult part in the training of an APP: the transformation from delivering care (for example as an ICU nurse) to delivering the cure that is usually delivered by a clinician operating in the medical domain. After this transformation, and after the graduation to the position of APP, the APP has the same knowledge as a graduated physician, but experience has yet to be acquired. The employment of APPs is an important opportunity for ICUs which are struggling with the rise of health care costs and the limited availability of qualified medical clinicians. In the 'task reallocation' proposed by the Dutch government, these issues will be addressed without loss of quality and at equal costs by delegating tasks in critical care to APPs.

In the discussion of the results of this thesis, it is important to mention that the studies in chapter 3 to 7 of this thesis were performed in a single center and

included a group of APPs who previously worked in specialized functions as ICU nurses. These aspects influence the generalizability of the study outcomes.

The included APPs' former occupation facilitated their insight into intensive care problems. This pre-education made it easier to integrate these APPs into critical care after their general APP training than it would be to integrate APPs who lack this experience. This circumstance and the fact that our APP group is large compared to the number of APPs in other hospitals makes this a suitable group for studying the potential capabilities of APPs. Moreover, because the ICU in the Catharina Hospital is a large ICU and the hospital is a tertiary referral center, the pathology covers many aspects of critical care, which makes it a suitable environment to attribute to the development of this standardization and guidelines for implementation of this profession in critical care.

Since the profession of APP is young and has not yet been adopted by and implemented in many countries, the organizational structure in which APPs are embedded differs substantially between countries and between hospitals within the same country. These differences make it difficult to compare the performance of APPs in multicenter studies. This difficulty is corroborated by the survey in chapter 8, which describes the implementation of APPs in the Netherlands, showing that the majority of hospitals did not yet implement APPs. However, this survey also showed that there is a positive attitude towards the profession, which will probably lead to an increased deployment of APPs; the implementation and duties of APPs are dynamic and evolving, and we noticed that the adoption of APPs is increasing. We also noted a development in the capabilities, integration and implementation of APPs in Dutch ICUs, which in turn will lead to a better understanding of the tasks that can be delegated to APPs.

An additional barrier for designing a multicenter trial about the profession of APPs is the lack of financial means for large projects in an area of research which is not very well recognized. An example is shown in chapter 7: although the independent observers did try to evaluate all rapid response team calls, many calls were not evaluated due to the absence of an observer. Without the financial means to ensure the availability of observers to cover all shifts, a large number of rapid response calls had to be excluded from assessment. In the future, it may hopefully be possible to organize a multicenter trial when nation-wide mandatory performance requirements for the ICU-APPs have been established.

A final aspect of this thesis that might require clarification is the fact that APPs were compared to residents. The main reason for this choice is that critical care APPs perform tasks that are also performed by residents in the Dutch healthcare system. In contrast, several observational studies have compared APPs to other physicians. Moreover, the survey of chapter 8 showed that APPs do perform other tasks besides their daily clinical care, such as training and protocol management. These additional tasks and the differences in clinical experience make the comparison of APPs with residents difficult. At the same time, however, these differences inherently contribute to the advantages of employing APPs in critical care.

The results of the studies presented in this thesis led to the compilation of a consensus document: 'Task reallocation Intensivist – Physician Assistant'. This document was written in cooperation with the Netherlands Association of Physician Assistants (NAPA) and the Dutch Society of Intensive Care (NVIC). It describes the integration of the ICU-APP within critical care parallel to the addition of the profession in article 3 of the Dutch law on 'professions in health care', and it specifies the tasks the APP is allowed to perform in a Dutch ICU. Moreover, this document addresses the limited availability of evidence mentioned in the introduction of this thesis and provides a format for the implementation of APPs in Dutch ICUs.

Future directives

The conclusion that critical care delivered by APPs is non-inferior to that delivered by residents opens opportunities for ICU managers, hospital directors and for countries that face increasing healthcare costs. In addition, the findings are relevant for regions with shortages of physicians. APPs can guarantee the daily ICU care, and their supervision may not even require the direct presence of an intensivist, since the APPs might be supervised by intensivists in other ways for example by telemedicine. These opportunities may be especially beneficial for smaller ICUs which are not able to contract intensivists nor residents. Hence the deployment of APPs is fully coherent with the Dutch government's policy goal of 'task reallocation' and can save costs in an environment with increasing technical possibilities.

References

1. Adviescommissie Kwaliteit van het Zorginstituut, bijlagen bij kwaliteitsstandaard Organisatie van IC Onderbouwingsdocument 2016;07. https://www.zorginzicht.nl/binaries/content/assets/zorginzicht/kwaliteitsinstrumenten/Bijlagen+bij+kwaliteitsstandaard+Organisatie+van+IC+Onderbouwingsdocument.pdf.
2. Fukuda Id T, Sakurai H, Kashiwagi M. Impact of having a certified nurse specialist in critical care nursing as head nurse on ICU patient outcomes. 2020 Available from: https://doi.org/10.1371/journal.pone.0228458
3. Butler KL, Calabrese R, Tandon M, Kirton OC. Optimizing Advanced Practitioner Charge Capture in High-Acuity Surgical Intensive Care Units. Arch Surg. 2011;146(5).
4. Brass P, Hellmich M, Kolodziej L, Schick G, Smith AF. Ultrasound guidance versus anatomical landmarks for subclavian or femoral vein catheterization. The Cochrane database of systematic reviews . 2015 Jan 9;1(1). Available from: https://pubmed.ncbi.nlm.nih.gov/25575245/
5. Brass P, Hellmich M, Kolodziej L, Schick G, Smith AF. Ultrasound guidance versus anatomical landmarks for internal jugular vein catheterization. Cochrane Database of Systematic Reviews. 2015 Jan 9;2017(6).
6. Landsperger JS, Wheeler AP. Central venous catheter insertion by advanced practice nurses: Another demonstrated competency. Critical Care Medicine. 2014 Mar;42(3):731–2.
7. Alexandrou E, Spencer TR, Frost SA, Mifflin N, Davidson PM, Hillman KM. Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service*. Critical care medicine [Internet]. 2014 Mar [cited 2022 Feb 6];42(3):536–43. Available from: https://pubmed.ncbi.nlm.nih.gov/24145843/
8. Outcomes of tube thoracostomies performed by advanced practice providers vs trauma surgeons - PubMed [Internet]. [cited 2022 Feb 6]. Available from: https://pubmed.ncbi.nlm.nih.gov/18593835/
9. Sirleaf M, Jefferson B, Christmas AB, Sing RF, Thomason MH, Huynh TT. Comparison of procedural complications between resident physicians and advanced clinical providers. Journal of Trauma and Acute Care Surgery. 2014;77(1):143–7.
10. Gershengorn HB, Xu Y, Chan CW, Armony M, Gong MN. The Impact of Adding a Physician Assistant to a Critical Care Outreach Team. 2016;
11. Gupta S, Balachandran M, Bolton G, Pratt N, Molloy J, Paul E, et al. Comparison of clinical outcomes between nurse practitioner and registrar-led medical emergency teams: a propensity-matched analysis. Critical Care [Internet]. 2021 Dec 1 [cited 2022 Feb 6];25(1):1–10. Available from: https://ccforum.biomedcentral.com/articles/10.1186/s13054-021-03534-4

Publiekssamenvatting

De gezondheidszorg in Nederland staat onder druk. Aan de ene kant is het personeelsgebrek een probleem aan de andere kant zijn de toenemende kosten een probleem. Ook op de Nederlandse intensive-cares (ICs) heeft men te kampen met een dergelijk probleem: In sommige regio's zijn behoudens verpleegkundigen ook arts-assistenten moeilijker te bewegen om op ICs te komen werken en hebben families en patiënten een toenemende hoeveelheid eisen ten opzichte van vroeger. Bovendien wordt op de IC vaak technisch ingewikkelde zorg bedreven waarbij allerlei innovaties om de hoek komen kijken. Anticiperend op dit probleem heeft de regering ingezet op taakherschikking. Hierbij worden taken die artsen doen, overgenomen door physician assistants (PAs) en nurse practitioners (NPs): personen die na een HBO opleiding een extra master opleiding gevolgd hebben om PA of NP te worden. Op verschillende ICs in Nederland worden dergelijke professies in toenemende mate ingezet vanwege ofwel continuïteitsproblemen ofwel vanwege artsentekorten. Hierbij vult deze beroepsgroep de basisartsen aan, die normaal worden gebruikt om het dagelijkse reilen en zeilen op ICs te regelen. Hoewel de ervaringen soms veelbelovend zijn, is er bij aanvang van dit promotieonderzoek nog geen duidelijkheid over inzetbaarheid en de uitgebreidheid van taken die een PA zou kunnen uitvoeren. Zo staat in de kwaliteitsstandaard Organisatie van Intensive Care 2016 te lezen dat de positie van IC-PA onduidelijk is omdat specifieke literatuur omtrent dit vak ontbreekt. Vanuit met name Amerikaanse literatuur zijn er wel aanwijzingen dat een PA of NP voordelen heeft en de continuïteit en kwaliteit op een IC zou kunnen verbeteren. Dit promotieonderzoek bestaat uit een aantal onderzoeksprojecten om duidelijkheid te scheppen over de kwaliteit, de inzetbaarheid en de problemen waarvoor PAs een oplossing zouden kunnen bieden binnen de ICs in Nederland. Deze inleiding is gepubliceerd in een aangepast vorm in het tijdschrift Critical Care.

Omdat op ICs in Nederland, PAs en NPs voor vaak overlappende taken ingezet worden, hebben we ze in dit onderzoeksproject aangeduid met de algemene term Non Physician Providers (NPP) en Advanced Practice Provider (APP).

Onderzoek naar inzetbaarheid van APPs bij de behandeling van een kritiek zieke patiënt:

Hoofdstuk 2 beschrijft de huidige stand van zaken met betrekking tot de implementatie van APPs in de spoedzorg. Het hoofdstuk is een literatuurstudie waarbij alle literatuur

die gepubliceerd is over de inzet van APPs in de spoedzorg, is geanalyseerd om te kijken waar en hoe deze groep is gepositioneerd en welke taken zij beter of slechter dan andere beroepsgroepen kunnen uitvoeren. Allereerst viel op dat er veel beschrijvende literatuur voorhanden was maar veel minder vergelijkende literatuur met name wat betreft de kwaliteit of kwantiteit van APPs ten opzichte van andere clinici. We hebben uiteindelijk 30 studies geselecteerd waarbij de APP vergeleken werd met andere clinici met dezelfde taken. De kwaliteit van deze studies, beoordeeld volgens de Newcastle-Ottawa schaal die gevalideerd is om dit soort onderzoeken te beoordelen, varieerde van matig tot goed, waarbij het aantal domeinen waarbij de groepen werden vergeleken zoals bijvoorbeeld uitgevoerde interventies of dagelijkse beleidsvoorstellen, divers was. De tweede vraag die we hebben geprobeerd te beantwoorden was, of de kwaliteit van geleverde zorg van deze APPs beter of slechter was dan de andere clinici. In studies die qua parameters ongeveer hetzelfde meten, konden we over de duur van opname en de mortaliteit van de patiëntengroepen een meta-analyse maken waarbij geen verschil gevonden werd tussen de soorten clinici: de kwaliteit zoals die geleverd werd door de APPs deed niet onder voor die van de medici. Gedeeltelijk is deze uitkomst terug te voeren op het feit dat vaak de prestaties van een team met APP werd geanalyseerd in plaats van de prestatie van de APP zelf. De robuuste meetwaarden, overlijden en duur van opname representeerden hierbij niet nauwkeurig genoeg de bijdrage van de individuele teamleden. Een tweede kanttekening bij dit onderzoek was, dat de literatuur afkomstig was uit een beperkt aantal landen waarbij Nederland, Amerika en Australië het meest prominent naar voren kwamen. Dit suggereert dat, omdat het een relatief nieuwe beroepsgroep is, er een relatieve onbekendheid met deze beroepsgroep bestaat. De inzet van dit soort clinici zou echter wel een oplossingen voor continuïteitsproblemen binnen de zorg kunnen bieden.

Hoofdstuk drie is een beschrijvende studie over het functioneren van PAs op een grote IC van een tertiair centrum in Nederland. Hierin worden de taken beschreven die gealloceerd worden naar de PAs zoals begeleiding van nieuwe assistenten, onderwijs en protocollen, waarbij de intensivist zelf meer toe komt aan superviserende en management taken. De PAs zijn van origine allemaal IC-verpleegkundigen uit het verpleegkundig team op de IC waar zij nu de functie van een PA hebben. Al deze factoren lijken ten goede te komen aan continuïteit en kwaliteit van zorg. Aan de hand van de interventies als inbrengen centrale lijnen en complicaties blijkt dat ook dit soort van specifieke IC interventies veilig en in toenemende mate uitgevoerd wordt door de PA op de IC. Tot slot worden de salaris schalen van de PA benoemd waarbij te zien is dat hun functieschaal 60 qua salariëring ongeveer overeenkomt met dat van een arts-assistent wat gezien de hoeveelheid taken die ze uitvoeren zeker kosteneffectief lijkt.

Technische procedures uitgevoerd door de APP

Hoofdstuk 4 beschrijft een studie die arts-assistenten met PAs vergelijkt wat betreft technische interventies op de IC. Prospectief zijn de procedures: inbrengen centrale lijnen, inbrengen arterielijnen, en intuberen bekeken. Het aantal complicaties dat voorkwam was laag in zowel de groep van de gesuperviseerde assistenten als de groep PAs, zelfs lager dan het gemiddelde aantal complicaties beschreven in de literatuur. De PAs brachten ook lijnen in zonder het gebruik van echografie als hulpmiddel en hadden hierbij eveneens een minder aantal complicaties dan in de literatuur wordt vermeld. De APPs hadden minder pogingen nodig voordat de procedure succesvol was afgerond en rondden de procedure vaker in een keer succesvol af dan de arts-assistent. Er werden duidelijk meer procedures per APP uitgevoerd dan per arts-assistent waarbij waarschijnlijk ervaring en het gemak waarmee procedures uitgevoerd werden, een rol speelde. Concluderend lijkt het erop dat het niet uitmaakt welke clinicus de procedure uitvoert maar de ervaring een des te grotere rol speelt bij het succes van de procedure.

Niet-technische procedures uitgevoerd door de APP

Hoofdstuk 5 focust zich op de prestatie van arts-assistenten en PAs binnen een rapid response team of spoed interventie team. Hierbij leidt een van deze clinici een spoed team dat wordt ingezet om kritiek zieke patiënten op de verpleegafdelingen te bezoeken, behandelingen te adviseren of initiëren en zo nodig de patiënt mee te nemen naar de IC. In dit hoofdstuk zijn de data retrospectief geanalyseerd. Hierbij is gezocht naar adequate parameters om de prestaties van de verschillende clinici als leider van zo'n rapid response team, te scoren. Omdat zoals we in hoofdstuk 2 al hebben gezien, studies vaak naar uitkomstmaten als opname duur en overlijden kijken en hier geen verschil tussen clinici wordt gevonden, hebben we gezocht naar parameters die wel een verschil tussen groepen zouden kunnen aantonen. We hebben hiervoor een verzameling van parameters genomen: de standaard gebruikte parameters: duur van opname en mortaliteit maar ook tijden vanaf het bezoek van het rapid response team tot aan procedures zoals het inbrengen van arteriële of centrale lijnen, het intuberen of bijvoorbeeld een verandering in antibiotica beleid en als laatste de gevalideerde MAELOR tool. Deze tool meet of de prestatie van het spoed interventie team binnen acceptabele grenzen ligt. Er werden geen verschillen gevonden tussen de parameters van de groep APPs en de groep arts-assistenten. De parameters die ook gebruikt worden in de literatuur om de prestaties van zo'n team te meten waren vergelijkbaar met de prestaties die wij vonden, wat weergeeft

dat het team op niveau heeft gefunctioneerd. Evenals te zien is bij andere studies over ditzelfde onderwerp, valt met het meten van deze parameters wederom geen uitspraak te doen over de extra toegevoegde waarde van een APP binnen een team. Wel kan opnieuw gezegd worden dat de APP non-inferieur is aan een arts-assistent. Opnieuw blijft de vraag wat de maatstaven zijn om de bijdrage van de APP goed te meten. Deze moeilijkheid wordt nog duidelijker geschetst aan de hand van een van de in dit hoofdstuk aangehaalde onderzoeken: waarbij na correctie voor allerlei factoren in de groep patiënten bezocht door een team geleid door een APP uiteindelijk een kortere ziekenhuis opname duur gemeten kan worden ten opzichte van een door een arts-assistent geleid team. Deze uitkomst leidt tot discussie omdat tussen de opname in het ziekenhuis en het ontslag uit het ziekenhuis van een patiënt, dermate veel andere personen betrokken zijn, dat het meten van de bijdrage van de IC APP moeilijk is.

Om de nadelen van een retrospectieve studie te tackelen is de studie gedaan die is beschreven in hoofdstuk 6. Dit is een studie in een simulatie omgeving die zich focuste op acuut zieke patiënten. Gedurende de ontwerpfase hebben we de APPs als aparte groep geïmplementeerd om beoordeeld te worden als leider van een klein team verpleegkundigen in een spoed situatie. Hieruit bleek dat naarmate de APPs meer ervaren waren zij beter in staat waren in allerlei domeinen als beoordeling overzicht, beslissingsvaardigheid en communicatie leiding te geven aan een groep en het probleem van een kritiek zieke patiënt adequaat op te lossen. Ook was er verschil te zien in praktische handelingen en waren de APPs die allen IC-verpleegkundige geweest waren, sneller spontaan in staat simpele opdrachten te geven zoals het adviseren om extra zuurstof toe te dienen.

Hierbij is waarschijnlijk wederom de ervaring en het feit dat de PAs eerder IC-verpleegkundige waren belangrijk. Met name het belang van ervaring moet gewogen worden in een ziekenhuis setting waarbij kritieke zorg vaak uitgevoerd wordt door een relatief onervaren assistent.

Hoofdstuk 7 beschrijft een prospectieve studie waarbij of arts-assistenten of APPs zelf beoordeeld werden als leiders van een spoed interventie team. Door externe beoordelaars die een korte opleiding kregen, werd volgens verschillende protocollair te scoren teamwork- en prestatiebeoordelingsschalen de APP ten opzichte van een assistent gemeten. Deze onafhankelijke beoordelaars waren wederom niet instaat verschillen tussen de clinici aan te tonen. In harde uitkomst maten als duur van opname en mortaliteit werden ook geen verschillen gevonden. Echter uit de evaluatie van ervaren clinici, die ook gevraagd werden een beoordeling in te

vullen, bleek dat zij de inschattingen van de APPs over de klinische situatie als beter beoordeelden dan die van een arts-assistent. Zelfs als beide spoed interventie team clinici even veel ervaring hadden, werd er toch een voordeel gezien van de APP. Mogelijk dat hier behoudens de ervaring en het klinisch inzicht ook een rol speelt dat mensen die langer met elkaar werken beter op elkaar zijn ingespeeld.

Wederom is aangetoond dat APPs waardevolle medewerkers zijn die niet onder doen voor arts-assistenten maar zelfs in de beoordeling van kritiek zieke patiënten een stapje voor lijken te hebben vanwege bekendheid met het team, de supervisor, maar ook als eerdere IC-verpleegkundige en nu APP, met kritiek zieke mensen. Kortom zij bieden continuïteit.

Ervaringen met APPs op Nederlandse IC's

Kijkende naar de literatuur lijkt het erop dat in Nederland qua implementatie van APPs een van de voorlopers is in de wereld. Om de situatie in Nederland te evalueren hebben we via de Nederlandse Vereniging voor Intensive Care een survey gedaan onder alle ICs in Nederland met vragen over de huidige en toekomstige inzet van APPs (in Nederland PA's) en de meningen over PAs op de IC. Deze survey hebben we ook door IC PA's laten invullen. Deze survey liet zien dat de minderheid van de Nederlandse ICs, op het moment van uitvoeren, PAs heeft geïmplementeerd en dat met name de grotere ziekenhuizen meer geneigd zijn dit te doen. Indien PA's op ICs geïmplementeerd zijn, worden ze vaak volledig ingezet als arts-assistent met alle dagelijkse taken die op een IC te doen zijn, inclusief invasieve interventies. De keuze voor een PA wordt vaak gemaakt vanwege continuïteit maar ook vanwege kwaliteitsverbetering. Verdere argumenten voor implementatie zijn: het bieden van een carrièreperspectief aan IC-verpleegkundigen. Sommige ICs limiteren de taken van de PA uit onbekendheid met de capaciteiten van de PAs. Deze onbekendheid met de capaciteiten was ook vaak een genoemde redenen om PAs helemaal niet in te zetten. Verdere barrières voor implementatie waren de forse tijdsinvestering van 2,5 jaar om de PA op te leiden en de aanvullende tijdsinvestering na diplomering om de PA ervaring te laten krijgen. Ook PAs zelf meldden dat zij na diplomering graag een aanvullende IC opleiding zouden willen volgen om de benodigde diepgang te verkrijgen in de IC geneeskunde.

Hoofdstuk 9 is een verdere verdieping van de literatuur en een evaluatie van de PA binnen de Nederlandse ICs. Behalve een aantal algemene opinies en ervaringen wordt ook het meest moeilijke deel van de opleiding tot PA beschreven: de

transformatie van verpleegkundige naar medicus clinicus. De inzet van de PA is te overwegen voor ICs die worstelen met voldoende continuïteit van zorg en hier een kosteneffectieve oplossing voor willen.

Dit onderzoek heeft uiteindelijk geleid tot een 'consensus document': Taakherschikking op de IC en is bekrachtigd door de Nederlandse Vereniging voor Intensive Care en de Nederlandse Associatie Physician Assistants. Hierbij is deze thesis een aanvulling op de beperkt voorhanden zijnde literatuur zeker binnen het Nederlandse gezondheidszorg model en voorziet in een voorbeeldmodel voor implementatie van PAs op Nederlandse ICs.

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Curriculum Vitae

Herman Gerhard Kreeftenberg was born on Oktober 28th 1972 in Groningen. He graduated from his high school "Willem Lodewijk gymnasium" in Groningen in 1991. He finished his study medicine at the " Rijks Universiteit Groningen" in 1998 and enrolled in the Royal Dutch Flight Academy and graduated for his airline transport pilot license (ATPL) in 1999. In 2000 he started his specialty training to become an internist in the University Medical center Utrecht. In 2006 he graduated to internist and intensivist and received his theoretical and practical European diploma for intensive care the same year.

From 2006 until now he works at the Catharina Ziekenhuis Eindhoven as an intensivist. From 2007 – 2013 he was member of the board of the partnership Internal Medicine/ Gastroenterology in the Catharina Ziekenhuis, from 2010 -2013 he participated as member of the board of the staff partnership in the Catharina Ziekenhuis, and from 2013 until now he is member of the financial committee of the partnership Internal Medicine/Gastroenterology. Since 2016 he is also employed as an intensivist in the St Anna Ziekenhuis Geldrop and since 2021 he is medical manager of the intensive care in the St Anna Hospital.

Publications

Scrotal hematoma, anemia and jaundice as manifestations of an adrenal neuroblastoma in a newborn. Kreeftenberg HG jr, Zeebregts CJAM, Tamminga RYJ, de Langen ZJ, Zijlstra RJ.
Journal of Pediatric Surgery 1999;34(12):1856-8

Accurate Quantification of Liver Iron Concentration with MRI by combining T1-and T2-weighted Spin Echo Sequences and a Gradiënt Echo Sequence. Kreeftenberg HG jr, Mooyaart EL, Huizenga RJ, Sluiter WJ, Kreeftenberg HG sr.
Neth J Med. 2000;56(4):133-7

Condition on arrival of transferred ICU patients. Kreeftenberg HG jr, Ligtenberg JJ, Arnold LG, van der Werf TS, Tulleken JE, Zijlstra JG. Intensive Care Med. 1999;25:Suppl 1: S1-183

Condition on arrival of transferred critically ill patients. Kreeftenberg HG Jr, Ligtenberg JJ, Arnold LG, van der Werf TS, Tulleken JE, Zijlstra JG.
Neth J Med. 2000;57(5):180-4.

Pulmonary vasculitis may obscure large cell lung carcinoma. A case report. Kreeftenberg HG jr, Ligtenberg JJM, van der Werf TS, Timens W, Cohen Tervaert JW.
Clin Exp Rheum 2001;19:731-4

Methemoglobinemia after low-dose prilocaine in an adult patient receiving barbiturate comedication. Kreeftenberg HG jr, Nauta P, Braams R. Anesth Analg. 2007 Feb;104(2):459-60

Faster differentiation of S. aureus versus Coagulase Negative Staphylococci from blood culture material: a comparison of different bacterial DNA isolation methods. Anne JM Loonen, Wendy LJ Hansen, Arjan Jansz, Herman Kreeftenberg, Cathrien A Bruggeman, Petra FG Wolffs, Adriaan JC van den Brule. Critical Care 13(4): 1-1

Acceleration of the direct identification of Staphylococcus aureus versus coagulase-negative staphylococci from blood culture material: a comparison of six bacterial DNA extraction methods. AJM Loonen, AR Jansz, H Kreeftenberg, CA Bruggeman, PFG Wolffs.
European journal of clinical microbiology & infectious diseases 30 (3), 337-342 2011

Cholesterol in the ICU: a cheap and reliable marker for illness severity? HG Kreeftenberg, AN Roos, A Bindels, V Scharnhorst. Neth J Crit Care 2015; 20:17-20

Gaston, de elektronische ondersteuning voor zorgprofessionals. M. van Berkel, A. Wasylewic, H.G. Kreeftenberg en A.-K. Boer. Ned Tijdschr Klin Chem Labgeneesk 2015; 40: 26-29

Succesvolle introductie van beslisondersteuning is meer dan een goed algoritme – het heparinepomp protocol op de intensive care als voorbeeld. AK Boer, HG Kreeftenberg, AJGH Bindels, AN Roos, S Houterman, HHM Korsten, EAT van Dijk – v Berkel. Ned Tijdschr. Klin Chem Labgeneesk. 2015;40:105-6

Beslissingsondersteuning is meer dan een algorithme: heparinapomp protocol op de intensive care. AK Boer, H Kreeftenberg, A Bindels, A Roos, S Houterman, E Korsten, M. van Dijk – van Berkel. Ned Tijdschr Klin Chem Labgeneesk. 2015; 40: 211-212

Early treatment with intravenous lipid emulsion in a potentially lethal hydroxychloroquine intoxication. Ten Broeke R, Mestrom E, Woo L, Kreeftenberg H. Neth J Med. 2016 Jun;74(5):210-4.

Use of Postoperative Peak Arterial Lactate Level to Predict Outcome After Cardiac Surgery. Haanschoten MC, Kreeftenberg HG, Arthur Bouwman R, van Straten AH, Buhre WF, Soliman Hamad MA. J Cardiothorac Vasc Anesth. 2017 Feb;31(1):45-53. doi: 10.1053/j.jvca.2016.04.017.

Utility of the cold pressor test to predict future cardiovascular events. S Pouwels, ME Van Genderen, HG Kreeftenberg, R Ribeiro, C Parmar.
Expert review of cardiovascular therapy 17 (4), 305-318

Total cholesterol and Intensive Care survival in patients treated with Veno-Arterial Extracorporeal Life Support; A preliminary single-centre experience. M de Haan, M Haanschoten, H Kreeftenberg, P Lanen, S Houterman, B van Straten, M Soliman Hamad. Authorea Preprints

Efficient organisation of intensive care units with a focus on quality: the non-physician provider. Kreeftenberg HG, Pouwels S, van der Voort PHJ. Crit Care. 2017 Jul 27;21(1):118. doi: 10.1186/s13054-017-1703-4.

An alternative ICU staffing model: implementation of the non-physician provider. Kreeftenberg HG, Aarts JT, de Bie A, Bindels AJGH, Roos AN, van der Voort PHJ. Neth J Med. 2018 May;76(4):176-183.

Impact of the Advanced Practice Provider in Adult Critical Care: A Systematic Review and Meta-Analysis. HG Kreeftenberg, S Pouwels, AJGH Bindels, AJR de Bie, PHJ van der Voort.
Critical Care Medicine 2019 ;Volume 47: 722-30

Procedures in the ICU performed by Advanced Practice Providers compared to Medical Residents: a prospective observational study. HG Kreeftenberg, JT Aarts, AJGH Bindels, NJM van der Meer, PHJ van der Voort. Crit Care Explor. 2020; 2: e0101. doi: 10.1097/CCE.0000000000000101

Physician Assistants in Intensive Care Units in the Netherlands : a narrative review with recommendations. HG Kreeftenberg, J van Rosmalen, J Aarts, PHJ van der Voort. Neth J Crit Care 2020:Vol 28;200-4

A survey on implementation of physician assistants in ICUs in the Netherlands. H.G. Kreeftenberg, J.T. Aarts, C. Kerkhoven, J. van Rosmalen, A.J.G.H. Bindels, P.H.J. van der Voort
Neth J Crit Care 2022;30:124-30

Advanced practice providers in critical care improve team performances. A post-hoc analysis of the BASIC trial. HG Kreeftenberg, AJR de Bie, CP Subbe, PHJ van der Voort. Resuscitation. 2022;170:207-8. https://doi.org/10.1016/j.resuscitation.2021.12.012

Advanced practice providers versus medical residents as leaders of rapid response teams: A 12-month retrospective analysis. HG Kreeftenberg, AJR de Bie, EHJ Mestrom, AJGH Bindels, PHJ van der Voort. Plos One;2022;08: https://doi.org/10.1371/journal.pone.0273197

Advanced Practice Providers as leaders of a Rapid Response Team: a prospective cohort study. Kreeftenberg HG, de Bie AJR, Aarts JT, Bindels AJGH, van der Meer NJM, van der Voort PHJ. Healthcare 2022, 10,2122:1-11. https://doi.org/10.3390/healthcare10112122

Appendix A

Table S1. Search strategy for each database

Pubmed	((((((((((critical) AND care)) OR (((critical) AND care) AND unit)) OR (((critical) AND care) AND units)) OR (((intensive) AND care) AND unit)) OR (((acute) AND care) AND unit)) OR ((acute) AND care)) OR ((intensive) AND care))) AND ((((((((((((((((nonphysician) AND provider)) OR ((nonphysician) AND providers)) OR ((nurse) AND practitioner)) OR ((nurse) AND practitioners)) OR ((physician) AND assistant)) OR ((((acute) AND care) AND nurse) AND practitioner)) OR ((((acute) AND care) AND nurse) AND practitioners)) OR ((nonphysician) AND staffing)) OR ((midlevel) AND practitioner)) OR ((midlevel) AND practitioners)) OR (((clinical) AND nurse) AND specialist)) OR (((clinical) AND nurse) AND specialists)) OR ((nonphysician) AND staff)) OR ((physician) AND assistants))
The Cochrane Library	#1- MeSH descriptor: [Critical Care] explode all trees #2 - acute care ti,ab,kw (Word variations have been searched) #3 - nonphysician provider:ti,ab,kw (Word variations have been searched) #4 - MeSH descriptor: [Nurse Practitioners] explode all trees #5 - MeSH descriptor: [Physician Assistants] explode all trees #6 - acute care nurse practitioner ti,ab,kw (Word variations have been searched) #7 - acute care nurse practitioners ti,ab,kw (Word variations have been searched) #8 - nonphysician staff:ti,ab,kw (Word variations have been searched) #9 - nonphysician staffing ti,ab,kw (Word variations have been searched) #10 - midlevel practitioner:ti,ab,kw (Word variations have been searched) #11 - clinical nurse specialist ti,ab,kw (Word variations have been searched) #12 - clinical nurse specialists ti,ab,kw (Word variations have been searched) #13 - #1 or #2 #14 - #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 #15 - #13 and #14
Embase	#1 critical care.mp. or intensive care #2 acute care.mp. or emergency care #3 intensive care unit.mp. or intensive care/ or intensive care unit/ #4 nurse practitioner.mp. or nurse practitioner/ #5 physician assistant.mp. or physician assistant/ #6 acute care nurse practitioner.mp. or acute care nurse practitioner/ #7 nonphysician staff.mp. #8 nonphysician staffing.mp. #9 midlevel practitioner.mp #10 clinical nurse specialist.mp. or clinical nurse specialist/ #11 1 or 2 or 3 #12 4 or 5 or 6 or 7 or 8 or 9 or 10 #13 11 and 12

Table S1. Continued.

CINAHL	S14 (S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11) AND (S12 AND S13) S13 S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 S12 S1 OR S2 OR S3 S11 clinical AND nurse AND specialist S10 nonphysician AND provider S9 midlevel AND provider S8 nonphysician AND staffing S7 nonphysician AND staff S6 acute AND care AND nurse AND practitioner S5 nurse AND practitioner S4 physician AND assistant S3 acute AND care S2 critical AND care S1 intensive AND care

Appendix B

Table S2. Overview of the included studies.

Author	Study	Time	Group	Subject	Conclusion
Alexandrou et al. 2012 (40)	Comparative Cohort Retrospective	12 months	760 catheters. NP on ICU and 3 nurse specialists in 3 hospitals observed	Pneumothorax, Arterial puncture, Catheter bloodstream infection	Pneumothorax 1% Arterial Puncture 1% Bloodstream infection 1%
Alexandrou et al. 2014 (41)	Comparative Cohort Retrospective	13 years	4560 catheters/ 3 ACNPs	All complications, Catheter bloodstream infection	Pneumothorax 0,4% Arterial puncture depending on site, Bloodstream infections 0,1-0,8 per 1000 catheter days
Bevis et al. 2008 (42)	Comparative Cohort Retrospective	6 months	51 patients, placement of thoracotomies/ advanced practice providers from ICU versus surgeons, in the ICU and emergency dept.	All complications, placement quality indicators	No difference between complications or quality indicators between advanced practice providers and surgeons
Burns et al. 2003 (33)	Comparative Cohort Prospective intervention compared to retrospective data	12 months prospective, 18 months retrospective	510 patients protocolled weaning and sedation supervised by advanced practice nurses compared to 595 controls	Ventilator days ICU LOS Hospital LOS, General mortality rate and costs	Ventilator days reduced 10 to 9 (p =.0001) ICU LOS reduced 15 to 12 (p=.0008) Hospital LOS reduced 22 to 20 (p=.00001) Lower mortality rate 38% to 31% (p=.02), cost savings > 3 million
Butler et al. 2011 (49)	Comparative Cohort Prospective	36 months	3 ICU's 1-year collection 2004 ICU admissions adequate charge capture after implementation of educational program and documentation. Execution by 33 advanced practice providers and PAs in ICU	Adequate charge capture	48% increase in adequate charge capture with extension of 3 beds during this period

Table S2. Continued.

Christmas et al. 2005 (35)	Comparative Cohort Prospective	36 months	Three time periods compared (2 Physician extenders were implemented in the trauma team) 2001 Before 2002 During 2003 After Sample size unknown	Hospital length of stay, ICU length of stay, Patient mortality	Significant decrease in Hospital length of stay (12 vs 9 days), ICU length of stay (18 vs 12 days) and general care LOS (7 vs 3 days) Mortality and costs per patient remained unchanged
Collins et al. 2014 (36)	Comparative Cohort Retrospective	12 months	Team with NP implemented in trauma service (n= 3053 in 2012) compared with two years before.(2010: n= 2559 and 2011: n= 2671)	Hospital length of stay, costs	Data from 2010 and 2011 were averaged and the mean LOS for the entire trauma service was 7.2 days. After adding an experienced ACNP, the average LOS decreased to 6.4 days, a 0.8 day reduction. Per patient, there was a $ 9,111.50 savings in hospital charges, for a reduction of $27.8 million dollars in hospital charges over the 12-month pilot program.
Costa et al. 2014 (32)	Comparative Cohort Retrospective	12 months compared to previous 12 months	Teams with NP and PA participation in 29 mixed medical-surgical ICU's, 39541 patients	Difference in mortality between groups treated by a team with and without a physician assistant	No difference in mortality
Dubaybo et al. 1991 (27)	Comparative Cohort Retrospective	24 months	2 years of 2 PAs on an ICU compared with 2 years house officers. Sample size unknown	Difference in monthly mortality, occupancy and complications	No differences in mortality, occupancy and complications
Gershengorn et al. 2011 (25)	Comparative Cohort Retrospective	12 months	590 medical ICU admissions, 288 to the ICU with physician residents and 302 to ICU with NP and PAs.	Difference in hospital mortality, ICU LOS, hospital LOS and discharge facility	No difference in Mortality, LOS or sort of discharge facility

Table S2. Continued.

Gershengorn et al. 2016 (37)	Comparative Cohort Retrospective	9 months	Critical care outreach teams in two hospitals 3099 patients. One hospital with and one hospital without Critical Care trained PA (without n= 839 patients, with n= 1114 patients) Two: Normal outreach team (n= 1387 patients)	Difference in hospital mortality, hospital length of stay Time to transfer to ICU	No difference in hospital length of stay or hospital mortality 19.2% reduction in transfer time to the ICU (p=0.002)
Gillard et al 2011 (28)	Comparative Cohort Retrospective	26 months	Period before adding midlevel practitioner in a trauma center (2004-2005 n= 1216 patients) Period after adding midlevel practitioner (2005-2006 n= 1585 patients)	Difference in hospital mortality, hospital length of stay, ICU length of stay Occurrence of complications	No differences in hospital length of stay Significant decrease in ICU LOS from 4.08 ± 0.27 days (Pre intervention) to 3.28 ± 0.28 days (Post intervention) (p= 0.019)
Gracias et al. 2008 (45)	Comparative Cohort Prospective	12 months	1380 surgical intensive care admissions. Two teams, one with and one without a PA	Difference in adherence to clinical practice guidelines: venous thrombosis prophylaxis, stress ulcers prophylaxis and anemia management	Thrombosis prophylaxis prescription improvement with ACNP: 93% to 98% (p<.001), stress ulcers prophylaxis prescription improvement with ACNP 51% to 91%(p<.001), improvement with anemia management 67% to 93%(p<.001)
Hoffman et al. 2003 (47)	Comparative Cohort Prospective	19 months	2 groups of ACNP with increasing experience (6 vs. 12 months) compared with physicians in training scored with the clinicians activities tool	Clinicians' activity tool: time in routine patient management, coordination of care, non-unit activities. 5 and 10 minutes observation intervals were used	No difference between two groups of ACNP's in all endpoints, No difference time spent on routine patient management, ACNP spent more time in activities related to coordination of care (p<.001) and less in non-unit activities(p<.001)

Table S2. Continued.

Hoffman et al. 2005 (22)	Comparative Cohort Prospective	28 months	526 admissions in a medical subacute ICU. (ACNP n= 250, fellows n= 276). 28 months, (total study time 31 months) 7 months care by physician and ACNP and 7 months care by physician and fellow intermittently.	Rate of readmission, mortality, duration of mechanical ventilation, length of stay, limitations in treatment, reintubation and time allocated to direct patient care	No difference in readmission, mortality, length of stay, duration of mechanical ventilation. Higher acute physiology score day 1 with ACNP, more direct patient care with ACNP, more reintubations in fellow care.
Hoffman et al. 2006 (29)	Comparative Cohort Prospective	28 months	192 patients on mechanical ventilation with tracheostomy. 7 months care by physician and ACNP and 7 months care by physician and fellow intermittently	LOS, days on mechanical ventilation, discharge weaning status, readmission and deaths.	No differences in LOS, days on mechanical ventilation, discharge weaning status, readmissions and death.
Jefferson et al. 2018 (50)	Comparative Cohort Prospective	2 weeks	81 patients (41 in comparison and 40 in intervention group. NP addressing necessity for lab orders	Number of laboratory test, number of adverse events	Significant increase lab tests (mainly specific individual tests), significant decrease in costs; no adverse events
Kapu et al. 2014 (39)	Retrospective Single Cohort	24 months	5 NP led inpatients teams: Neuro ICU, SICU, CVICU,MICU and trauma stepdown	LOS, financial impact	Gross collections and expenses for 4 teams were 62%, 36%, 47% and +32%. And absolute estimated reduction of 9111 per case and a total of 27.8 million dollars for the stepdown unit. LOS decreased after adding NP and also resource usage decreased
Kawar et al. 2011 (23)	Comparative Cohort Retrospective	36 months	5346 patients admitted to either a unit supported by physician residents (n= 3971) or a unit supported by PAs (n= 1375)	Hospital LOS and ICU LOS. Mortality ICU and hospital and 28 day	No differences in LOS or mortality

Table S2. Continued.

Landsperger et al. 2016 (21)	Comparative Cohort Prospective	12 months	9066 ICU admissions in 2 years care for by either an ACNP team (n= 2366) or a physician resident team (n= 6700)	90 day mortality, ICU mortality, LOS ICU and LOS hospital	ICU mortality lower with ACNP (OR 0.77 p<0.001) LOS hospital lower ACNP (OR 0.87 p<.001). No difference in hospital mortality or ICU LOS
Matsushima et al. 2016 (31)	Comparative Cohort Prospective	8 months	289 patients, Implementation of NPs during four night shifts.	Lactate clearance, transfusions, mortality; Hospital length of stay, ICU length of stay,	Median lactate clearance rate within 24 hours of admission was similar between study groups (10.0% vs 9.1%; P = .39). Advanced practitioners and RPs transfused patients requiring massive transfusion with a similar blood product ratio (packed red blood cells fresh frozen plasma) (2.1:1 vs 1.7:1; P = .32). In a multiple logistic regression analysis, AP coverage was not associated with any clinical outcome differences
Pirret 2008 (38)	Comparative cohort prospective with retrospective control	12 months	Implementation of a NP led critical care outreach service for referral patients (n= 133)	Prevention of (re)admission to ICU	Reduction in readmissions of patients staying < 72h (28 vs 9) and a reduction in ICU LOS (5 vs 3 days) No increase in complications.
Rayo et al. 2014 (44)	Comparative Cohort Prospective	12 months	Analysis of 133 patient handovers of physician residents, attending physicians, registered nurses and ACNPs.	Communication interactions between experienced and not experienced group:	Less interjections of experienced clinicians (also ACNP)(3.1/min vs. 1/min, p<.001), less explain requests with experienced clinicians (62,9% vs. 24%, p<.001) More collaborative cross-checks with experienced clinicians (6,5% vs. 27%, p<.001)

Table S2. Continued.

Rudy et al. 1998 (26)	Comparative Cohort Prospective	14 months	Analysis of activities of 16 ACNPs or PAs, and 50 physician residents. And analysis of 389 patients cared for by either ACNPs/PAs (n= 187) or physician residents (n= 202).	Daily activities of care takers and ICU LOS, Hospital LOS and hospital mortality.	Significant difference between ACNPs/PAs and physician residents in the activities: Conference, administration, off-unit activities, communication, discharge and daily activities of living. Non-significant difference between ACNPs/PAs and physician residents in hospital LOS (10.5 days vs. 10.0 days), in ICU LOS (8.2 days vs. 6.7 days) and hospital mortality (9 deaths vs. 17 deaths)
Russell et al. 2002 (34)	Comparative Cohort Prospective with ACNP compared to retrospective without ACNP	6 months ACNP and 12 months without ACNP	524 patients total, 402 patients admitted under the care of ACNP (outcome mangers) on a neurosurgical intensive care with identification of clinical pathways compared to random retrospective admissions without ACNP and without identification of clinical pathways	Clinical parameters: incidence of urinary tract infections, skin breakdown and pneumonia, tracheostomy placement and removal, duration mechanical ventilation, duration to placement from the ICU after written order to do so. Financial parameters, ICU and hospital LOS	With ACNP: Less skin breakdown (0% vs. 2% p<.05) less urinary tract infection (2% vs. 6% p<.05), LOS ICU shorter (8 vs. 11, p<.005), Savings of 2.47 million dollar. No differences in tracheostomy placement and de-cannulation, pneumonia, discontinuation of Foley catheter,
Scherzer et al. 2017 (24)	Comparative cohort Retrospective	12 months	NP-MICU vs. physician resident-MICU. 1157 admissions. NP: n= 221, physician resident: n= 936	ICU-mortality, in hospital mortality, ICU-LOS, hospital LOS	No differences in outcomes, ICU LOS in the NP run ICU longer due to disease severity of patients
Sidani et al. 2005 (46)	Comparative Cohort Prospective questionnaire Retrospective baseline situation	Duration unknown	ACNP vs. physician residents. 123 patients ACNP: n= 78, physician residents n= 45	Satisfaction of care, functional status, symptom resolution, sense of well-being	Satisfaction and functional status higher with ACPN Symptom resolution and sense of well-being no significant difference.

Table S2. Continued.

Sirleaf et al. 2014 (43)	Comparative Cohort Retrospective	12 months	1 year retrospective review of invasive procedures (arterial and venous lines, tracheostomy, Broncho alveolar lavage and percutaneous gastrostomy) in 1404 patients; comparison between ACNP and physician residents, both under supervision	Complications, LOS ICU and hospital, mortality	No differences in complications
Skinner et al. 2013 (30)	Comparative Cohort Prospective	24 months	Change in working hour directive: situation on cardiac intensive care before: 8 resident doctors and 7 NP during 1 year vs. situation after 5 resident doctors who were non-resident at night and 7 full-shift NP during 1 year	Acceptable situation if no mortality differences, no increase in adverse outcomes, same management of cardiac arrests and no delay in support of doctors was present when they were called Measurement of surgical trainee attendance in theatre and costs	Non-significant decrease in mortality with NP on watch, cardiac arrests same outcome, no delay in doctor attendance. Theatre attendance before 69% vs. after 80% p<.0001 Cost before: £933344 after £764691.
Van Vught et al 2018 (48)	Comparative Cohort Prospective	12 months	11 PAs compared to 10 physician residents. Filmed patient scenarios with performance measurements of the scenario scores.	Performance of skills	No difference in performance of PAs and physician residents.

ACNP=acute care nurse practitioner, APP = advanced practice provider, LOS=length of stay, ICU=intensive care unit, NP nurse practitioner, PA=physician assistant.

Appendix C:

C1. Crisis Management Skills Checklist

Action	Yes (2 points)	With Prompting (1 point)	No (0 points)
Problem solving			
Promt ABC assessment			
Implements concurrent management approach (4 points)			
Situational awareness			
Avoids fixation error (4 points)			
Re-assesses and re-evaluated situation (4 points)			
Resource Utilazation			
Calls for help when indicated			
Delegates and directs appropriately			
Leadership			
Maintains calm demeanor			
Acts decisively and maintains control of crisis			
Maintains global perspective			
Communication			
Communicates clearly and concisely			
Closes the loop and uses names			
Listens to team input			
Total score (30 points)			

EVALUATION CRITERIA:

This evaluation scale is directed towards assessing competence in crisis management (CM) skills and care of critically ill patients. The standard of competence has been set at the senior resident level, i.e. the third-year resident who has had prior ICU experience, and through experience as a senior housestaff physician, has previous experience in managing crises. As there exists a requisite base of medical knowledge required to effectively manage crises, this will also be evaluated. However, the focus of evaluation will be on crisis management skills. The skills listed below comprise essential aspects of crisis management. In the simulator case scenario sessions, performance in each of these areas will be assessed, in addition to the amount of prompting or guidance required during the case scenario sessions.

The following criteria will be evaluated:

LEADERSHIP SKILLS
Stays calm and in control during crisis
Prompt and firm decision-making
Maintains global perspective ("Big picture")

SITUATIONAL AWARENESS
Avoids fixation error
Reassesses and re-evaluates situation constantly
Anticipates likely events

COMMUNICATION SKILLS
Communicates clearly and concisely
Uses direct verbal/non-verbal communication
Listens to team input

PROBLEM SOLVING
Organized and efficient problem solving approach (ABC's)
Quick in implementation (Concurrent management)
Considers alternatives during crisis

RESOURCE UTILIZATION
Calls for help appropriately
Utilizes resources at hand appropriately
Prioritizes tasks appropriately

OVERALL

Resident #: _____ **Date:** _____

Staff: _____ **Time:** _____

1	2	3	4	5	6	7
Novice; all CM skills require significant improvement		Advanced novice; many CM skills require moderate improvement		Competent; most CM skills require minor improvement		Clearly superior; few, if any CM skills that only require minor improvement

I. LEADERSHIP SKILLS

1	2	3	4	5	6	7
Loses calm and control for most of crisis; unable to make firm decisions; cannot maintain delay; global perspective		Loses calm/control frequently during crisis; delays in making firm decisions (or with cueing); rarely maintains global perspective		Stays calm and in control for most of crisis; makes firm decisions with little delay; usually maintains global perspective		Remains cal m and in control for entire crisis; makes prompt and firm decisions without delay; always maintains global perspective

II. PROBLEM SOLVING SKILLS

1	2	3	4	5	6	7
Cannot implement ABC's assessment without direct cues; uses sequential management despite cues; fails to consider any alternative in crisis		Incomplete or slow ABC assessment; mostly uses sequential management approach unless cued; gives little consideration to alternatives		Satisfactory ABC assessment; without cues; mostly uses concurrent management approach with only minimal cueing; considers some alternatives in crisis		Thorough yet quick ABC without cues; always uses concurrent management approach; considers most likely alternatives in crisis

1 2	3 4	5 6	7
Becomes fixated easily despite repeated cues; fails to re-assess and re-evaluate situation despite repeated cues; fails to anticipate likely events	Avoids fixation error only with cueing; rarely reassesses and re-evaluates situation without cues; rarely anticipates likely events	Usually avoids fixation error with minimal cueing; reassesses re-evaluates situation frequently with minimal cues; usually anticipates likely events	Avoids any fixation error without cues; constantly reassesses and re-evaluates situation without cues; constantly anticipates likely events

IV. RESOURCE UTILIZATION SKILLS

1 2	3 4	5 6	7
Unable to use resources & staff effectively; does not prioritize tasks or ask for help when required despite cues	Able to use resources with minimal effectiveness; only prioritizes tasks or asks for help when required with cues	Able to use resources with moderate effectiveness; able to prioritize tasks and/or ask for help with minimal cues	Clearly able to utilize resources to maximal effectiveness; sets clear task priority and asks for help early with no cues

V. COMMUNICATION SKILLS

1 2	3 4	5 6	7
Does not communicate with staff; does not acknowledge staff communication, never uses directed verbal/non-verbal communication	Communicates occasionally with staff, but unclear and vague; occasionally listens to but rarely interacts with staff; rarely uses directed verbal/ non-verbal communication	Communicates with staff clearly and concisely most of time; listens to staff feedback; usually uses directed verbal/ non-verbal communication	Communicates clearly and concisely at all times, encourages input and listens to staff feedback; consistently uses directed verbal/ non-verbal communication

C3. Mayo High Performance Teamwork Scale

TABLE 1. Mayo High Performance Teamwork Scale

Use the following scale to rate the team on each dimension:

0	1	2
Never or rarely	**Inconsistently**	**Consistently**

Please rate conservatively. Most teams that have not worked extensively together do not consistently demonstrate many of the qualities described in the scale.

Always rate items 1–8.

_____ (1) A leader is clearly recognized by all team members.

_____ (2) The team leader assures maintenance of an appropriate balance between command authority and team member participation.

_____ (3) Each team member demonstrates a clear understanding of his or her role.

_____ (4) The team prompts each other to attend to all significant clinical indicators throughout the procedure/intervention.

_____ (5) When team members are actively involved with the patient, they verbalize their activities aloud.

_____ (6) Team members repeat back or paraphrase instructions and clarifications to indicate that they heard them correctly.

_____ (7) Team members refer to established protocols and checklists for the procedure/intervention.

_____ (8) All members of the team are appropriately involved and participate in the activity.

Items 9–16 may be marked "NA (not applicable)" if no situations occurred in which these types of responses were required.

_____ (9) Disagreements or conflicts among team members are addressed without a loss of situation awareness.

_____ (10) When appropriate, roles are shifted to address urgent or emergent events.

_____ (11) When directions are unclear, team members acknowledge their lack of understanding and ask for repetition and clarification.

_____ (12) Team members acknowledge—in a positive manner—statements directed at avoiding or containing errors or seeking clarification.

_____ (13) Team members call attention to actions that they feel could cause errors or complications.

_____ (14) Team members respond to potential errors or complications with procedures that avoid the error or complication.

_____ (15) When statements directed at avoiding or containing errors or complications do not elicit a response to avoid or contain the error, team members persist in seeking a response.

_____ (16) Team members ask each other for assistance prior to or during periods of task overload.

C4. Handoff CEX provider and recipient evaluation form

Handoff PROVIDER Evaluation Form

Evaluator: _____ Evaluatee: _____ Unit: _____ Date: _____

Evaluatee experience: ○ < 1 year ○ 1-2 years ○ 3-5 years ○ >5 years Situation: ○ end of shift ○ transfer between services ○ Admission

Setting (○ not observed)			
≥ 5 interruptions; Noisy, chaotic	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	No interruptions; silent
Organization/efficiency (○ not observed)			
Disorganized; Rambling	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	Standardized sign-out; concise
Communication skills (○ not observed)			
Not face-to-face; Understanding not confirmed; No time for questions; Responsibility for tasks unclear; Vague language	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	Face-to-face sign-out; Confirms understanding; Elicits questions; Assigns responsibility for tasks; Concrete language
Content (○ not observed)			
Information omitted or irrelevant; Omits clinical condition; 'to dos' lack plan, rationale	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	Includes all essential information describes clinical condition 'to dos' have plan, rationale
Clinical judgment (○ not observed)			
No recognition of sick patients; No anticipatory guidance	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	Sick patients identified; Anticipatory guidance provided with plan of action
Humanistic qualities/professionalism (○ not observed)			
Hurried, inattentive Inappropriate comments re: pts, family, staff	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	Focused on task appropriate comments re: patients, family, staff
Overall sign-out competence (○ not observed)				
	1 2 3 | Unsatisfactory	4 5 6 | Satisfactory	7 8 9 | Superior	

Evaluation time: Observing: _____min Providing feedback: _____min

Evaluator satisfaction with evaluation:

Low 1 2 3 | 4 5 6 | 7 8 9 High

Evaluatee satisfaction with evaluation:

Low 1 2 3 | 4 5 6 | 7 8 9 High

Comments: _____

Figure 1 Handoff provider assessment tool.

Handoff RECIPIENT Evaluation Form

Evaluator: _____ Evaluatee: _____ Unit: _____ Date: _____

Evaluatee experience: ○ < 1 year ○ 1-2 years ○ 3-5 years ○ >5 years Situation: ○ end of shift ○ transfer between services ○ Admission

Setting (○ not observed)

≥ 5 interruptions; Noisy, chaotic	1	2	3	4	5	6	7	8	9	*No interruptions; Silent*
	Unsatisfactory			Satisfactory			Superior			

Organization/efficiency (○ not observed)

Disorganized; Ill-prepared	1	2	3	4	5	6	7	8	9	*Prepared for note-taking; takes notes*
	Unsatisfactory			Satisfactory			Superior			

Communication skills (○ not observed)

No interaction; No questioning; No read-back; No acceptance of responsibility for tasks; Vague language	1	2	3	4	5	6	7	8	9	*Face-to-face sign-out; Asks questions; Read-back of assigned tasks; Accepts responsibility; Concrete language*
	Unsatisfactory			Satisfactory			Superior			

Clinical judgment (○ not observed)

No recognition of sick patients; No request for anticipatory guidance	1	2	3	4	5	6	7	8	9	*Sick patients recognized; Anticipatory guidance requested*
	Unsatisfactory			Satisfactory			Superior			

Humanistic qualities/professionalism (○ not observed)

Hurried, inattentive Inappropriate Comments re: pts, family, staff	1	2	3	4	5	6	7	8	9	*Focused on task; appropriate comments re: patients, family, staff*
	Unsatisfactory			Satisfactory			Superior			

Overall sign-out competence (○ not observed)

	1	2	3	4	5	6	7	8	9	
	Unsatisfactory			Satisfactory			Superior			

Evaluation time: Observing: _____min Providing feedback: _____min

Evaluator satisfaction with evaluation:

Low 1 2 3 | 4 5 6 | 7 8 9 High

Evaluatee satisfaction with evaluation:

Low 1 2 3 | 4 5 6 | 7 8 9 High

Comments: _____

Figure 2 Handoff recipient assessment tool.