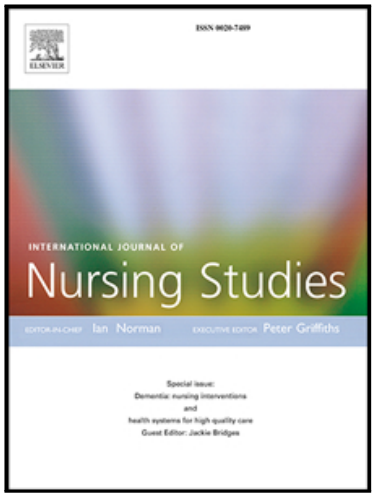
Journal Pre-proof



Implementation of advanced practice nursing for minor orthopedic injuries in the emergency care context – a non-inferiority study

Erika BOMAN , Elisabeth DUVALAND , Kim GAARDE , Alison LEARY , Auvo RAUHALA , Lisbeth FAGERSTRÖM

PII: S0020-7489(21)00048-1
DOI: https://doi.org/10.1016/j.ijnurstu.2021.103910
Reference: NS 103910

To appear in: *International Journal of Nursing Studies*

Received date: 8 June 2020
Revised date: 3 February 2021
Accepted date: 18 February 2021

Please cite this article as: Erika BOMAN , Elisabeth DUVALAND , Kim GAARDE , Alison LEARY , Auvo RAUHALA , Lisbeth FAGERSTRÖM , Implementation of advanced practice nursing for minor orthopedic injuries in the emergency care context – a non-inferiority study, *International Journal of Nursing Studies* (2021), doi: https://doi.org/10.1016/j.ijnurstu.2021.103910

Implementation of advanced practice nursing for minor orthopedic injuries in the emergency care context – a non-inferiority study

Running head: ANP for minor orthopedic injuries

Erika BOMAN[1,2]

Elisabeth DUVALAND[3]

Kim GAARDE[3]

Alison LEARY[1,4]

Auvo RAUHALA[5,6]

Lisbeth FAGERSTRÖM[1,5]

[1]Department of Nursing and Health Sciences, University of South-Eastern Norway, Drammen, Norway

[2]Department of Nursing, Åland University of Applied Sciences, Mariehamn, Finland

[3]Drammen Hospital, Vestre Viken HF, Drammen, Norway

[4]School of Health and Social Care, London South Bank University, London, UK

[5]Faculty of Education and Welfare Studies, Åbo Akademi University, Vaasa, Finland

[6] Vaasa Central Hospital, Vaasa, Finland

Corresponding author: Erika Boman, Neptunigatan 17, 22100 Mariehamn, Åland, Finland. E-mail: erika.boman@ha.ax. Phone: +358 18 537783

ABSTRACT

Aims: To evaluate the implementation of advanced practice nursing for patients with minor orthopedic injuries, including comparison of outcomes in relation to advanced practice nurse versus standard (physician-led) care models.

Design: A non-inferiority study was performed in an emergency department in Norway, where advanced practice nursing is in an initial stage of implementation. The non-inferiority design was chosen to test whether the new advanced practice nursing model does not compromise quality of care compared to the standard care model already in use.

Methods: Patients with minor orthopedic injuries were assessed and treated by either advanced practice nursing or standard (physician-led) care models. Participating patients were assigned to the professional available at presentation. In the nursing model, registered nurses worked at an advanced level/applied advanced practice nursing following in-house-training. Senior orthopedic specialists evaluated the diagnostic and treatment accuracy in both models. Data were collected in a tool developed for this study, from May to October, 2019.

Results: In total, 335 cases were included, of which 167 (49.9 %) were assessed and treated in the nursing model. Overall, correct diagnosis was found in 97.3 % (n = 326) of the cases, and correct treatment was found in 91.3 % (n = 306) of the cases. In comparison of missed diagnosis between advanced practice nurse and the standard (physician-led) care model showed inconclusive results (risk ratio: 0.29, 95% CI: 0.06-1.36). In comparison of treatment outcomes, the results showed that the advanced practice nursing model was non-inferior (risk ratio: 0.45, 95% CI: 0.21-0.97).

Conclusion: Advanced practice nursing care models can be used to diagnose and treat minor orthopedic injuries without compromising quality of care. Further implementation of the advanced practice nurse care model is encouraged.

Key words: Advanced practice nursing, Assessment, Emergency department, Emergency services, Non-inferiority study, Orthopedics, Treatment.

What is already known about the topic?

- Limited emergency care resources are an issue in Norway, as in many other countries around the world. Throughput of patients can be increased by implementing advanced practice nursing.
- It has been demonstrated that advanced practice nursing can be improve health care systems in a number of previous studies. Due to its recent introduction, research on advanced practice nursing in the Norwegian healthcare system is, to date, limited.

What this paper adds?

- Diagnostic and treatment accuracy were high in both the advanced practice nursing care model and in the standard (physician-led) care model.
- The study demonstrates that the advanced practice nursing care model was non-inferior in treatment accuracy compared to the standard (physician-led) care model.
- The study supports further implementation of the advanced practice nursing in orthopedic service. However, some caution is necessary regarding rarely observed diagnoses and/or diagnoses with lower treatment accuracy.

1. INTRODUCTION

Emergency department (ED) presentations have been shown to be increasing both in Norway (Bjornsen, Uleberg, & Dale, 2013) and in other countries such as Sweden (af Ugglas et al., 2020), Australia (Burkett et al., 2017) and the United States (Greenwood-Ericksen & Kocher, 2019). Delays to care are a common problem that can compromise patient safety (af Ugglas et al., 2020; Morley et al., 2018; Velt et al., 2018). Advanced practice nursing is one approach to meeting this increased demand and ED throughput may be increased by expanding nursing roles and the scope of nursing practice (Elder, Johnston, & Crilly, 2015; Wilson, Zwart, Everett, & Kernick, 2009). The study objective was to compare the quality of care provided for patients with minor orthopedic injuries in terms of diagnostic and treatment accuracy between advanced practice nursing versus standard (physician-led) care models. The study was set in the emergency care context in Norway, where advanced nursing practice is in an initial stage of implementation.

1.1 Background

All Norwegian residents have access to a public healthcare system, covered by the National Insurance Scheme. The municipalities organize the primary healthcare, including general practitioner service (*fastlege*) and 24-h urgent care service (*legevakt*), while the state is in charge of hospitals and the ambulance services (Sandvik & Hunskaar, 2018). Access to specialist healthcare, including ED presentation, is generally referral based. Patients cannot meet at hospital emergency rooms without a prior contact with prehospital healthcare. The urgent care centers in Norway provide a pre-hospital level of care but do not have full diagnostic resources. Therefore, if a patient is evaluated as needing further treatment, for example, radiography services, they will be referred on to specialist health services such as the ED (Ringard, Sagan, Sperre Saunes, & Lindahl, 2013). Applying this, so-called gatekeeper system, means that the

majority of the patients have a preliminary diagnosis prior to ED presentation (Blinkenberg et al., 2019).

In Norway, the health care services have been assessed to be of high quality and most patients are well cared for. However, patients' need for coordinated services may not be adequately met (Ministry of Health and Care Services, 2009). As a result, there has been an initiative for better coordination of services, including offering appropriate treatment, at the right place and time. In order to achieve this one approach, the Government has approved the introduction of advanced practice nursing (Ministry of Health and Care Services, 2009). Advanced practice nursing involves, "nurses working in advanced roles beyond the standard registered nurses' (RN) scope-of-practice, after additional training" (Maier & Aiken, 2016). Advanced practice nursing can be applied by formally educated advanced practice nurses (APNs) or nurse practitioners (NPs). It is recommended that these nurses have added skills and knowledge derived from clinical experience and post-basic education at Master's level (International Council of Nurses, 2020). Advanced practice nursing can also be applied by registered nurses in advanced roles without master education, including certain elements of the advanced scope of practice, but do not practice to the same level of complexity as APNs or NPs (Maier, Aiken, & Busse, 2017).

Previous studies have shown advanced practice nursing to be equivalent to or better than physician-led care in some cases in terms of outcomes (Cooper, Lindsay, Kinn, & Swann, 2002; Roche, Gardner, & Jack, 2017; Wilson et al., 2009). Nurse-led care has been shown to have a positive impact on wait times (Hiza, Gottschalk, Umpierrez, Bush, & Reisman, 2015; Jennings, Clifford, Fox, O'Connell, & Gardner, 2015), patient satisfaction (Cooper et al., 2002; Jennings et al., 2015; Martinez-Gonzalez et al., 2014) and quality of care (Jennings et al., 2015; Martinez-Gonzalez et al., 2014). Additionally, previous research has shown that APN is convenient for

non-urgent emergency care patients (Jennings, McKeown, O'Reilly, & Gardner, 2013; Li, Westbrook, Callen, Georgiou, & Braithwaite, 2013; van der Linden, Reijnen, & de Vos, 2010; Wilson et al., 2009). However, it has been suggested that more research on the subject is required (Jennings et al., 2015; Martinez-Gonzalez et al., 2014).

Due to its recent introduction, research on advanced practice nursing in the Norwegian healthcare system is limited. This study adds to knowledge base on the quality of care provided by advanced practice nursing models in comparison to physician-led care for minor orthopedic injuries, i.e., injuries and/or closed fractures in the elbow and/or distal of elbow or knee and/or distal of knee (Appendix S1). The results are expected to be applicable if introducing similar advanced practice nursing services elsewhere. Also, to add knowledge on advanced practice nursing in emergency care in general.

2. THE STUDY

2.1 Aim and objective

The aim was to evaluate the implementation of advanced practice nursing for patients with minor orthopedic injuries.

The study objective was to compare the quality of care provided for patients with minor orthopedic injuries in terms of diagnostic and treatment accuracy between advanced practice nursing versus standard (physician-led) care models. The study took place in the emergency care context in Norway, where advanced nursing practice is at an initial stage of implementation.

2.2 Design

A quasi-experimental non-inferiority study. Patients with minor orthopedic injuries were referred to either advanced practice nursing or standard (physician-led) care model to evaluate if advanced practice nursing model is not worse than standard model of care.

This research is part of a larger project entitled, "Providing person-centered healthcare – by new models of advanced nursing practice in cooperation with patients, clinical field and higher education". A study protocol has been published prior to this study (Boman, Duvaland, Gaarde, Leary, & Fagerström, 2020).

2.3 Setting

The study was performed in an emergency department in South-East Norway providing 24-hr care. The hospital serves approximately 170,000 inhabitants, and the proposed ED unit receives about 30,300 annual patient visits. The region is socio-economically below-average with a high proportion of immigrants.

Traditionally, all patients presenting with minor orthopedic injuries has been assessed, diagnosed and treated by a medical intern (*LIS-1*), here called 'standard (physician-led) care model'. At the time, there were 13 medical interns rotating in this service. In parallel, an advanced practice nursing model has been implemented. In the advanced practice nursing model, patients with minor orthopedic injuries are being assessed, diagnosed (including analysis of radiographs), treated and/or deemed in need of surgery by a RN, working at an advanced level/applying advanced practice nursing following in-house-training. At the time, there were 9 nurses rotating in the service. Five were in the final stage of NP education or recently graduated, two were RNs with orthopedic (plaster) technician education and two were nurse specialists (postbasic nurse

education). All had worked more than 5 years in the emergency department and had a special interest in orthopedics.

The nurses participated in a 1-day in-house education program and additional self-studies. The training program included diagnostics (including radiograph reading) and treatment of minor orthopedic injuries, and training on how to document in patient records. When needed, both the nurses and the medical interns can consult the orthopedic surgeon on duty to support hands on support and instruction.

2.4 Sample/Participants

Patients with minor orthopedic injuries were eligible. The inclusion criteria were patients with suspected fractures/orthopedic injuries to the elbow and/or distal of elbow and/or distal of knee (Appendix S1) who could be treated in either the advanced practice nursing or standard (physician-led) care models in the outpatient clinic. There were no age limit regarding patients' age: the professionals at service were instructed to undertake the first patient on the list that they felt confident to serve.

The study objective was to compare the quality of care provided for patients with minor orthopedic injuries in terms of diagnostic and treatment accuracy between advanced practice nursing versus standard (physician-led) care models. To estimate number of patient presentations in each model, power calculation was performed in sealed envelope™ (https://www.sealedenvelope.com/power/ binary-noninferior/) and was set by: $\alpha = 5\%$; $1 - \beta = 90\%$; percentage success (both groups) = 90%; $\delta = 10\%$; an estimation based on results from previous studies (Aitkenhead & Lee, 2019; Lee et al, 2014). According to power calculation, data from 310 (155 in each group) was to be collected.

2.5 Data collection

To assess clinical accuracy, a data collection tool was developed (Appendix S1). One of the evaluators, a senior orthopedic specialist, tested and assessed the data collection tool regarding the assessment of diagnosis and treatment accuracy prior to data collection commencing and found the data collection tool to be applicable after some minor revisions.

The data collection tool was used by senior orthopedic specialists to evaluate the diagnostic and treatment accuracy of the care provided for patients with minor orthopedic injuries in either the advanced practice nursing or standard (physician-led) care models. In total, three senior orthopedic specialists took part in the study. They were all three (or at least two) taking part in each of the evaluation sessions, ensuring consistency in ratings. When assessing diagnostic and treatment accuracy in the two models, the senior orthopedics had information on applied model (not blinded).

Background characteristics collected included patients' age, gender and diagnosis. The accuracy of the recorded diagnosis and treatment was then scored by the senior orthopedic specialists. An answer of "No" to the question "Correct diagnosis?" was scored 0 and an answer of "Yes" was scored 1. Answers to the question "Correct treatment?" were scored in similar way.

Data were collected from May 15, 2019 until October 30, 2019. At that point data from 349 patients had been collected.

2.6 Data analysis

During the analysis process, some treatment episodes with incomplete information were identified: lack of information on profession (n = 8), diagnosis (n = 1), treatment (n = 2), and lack of injury and diagnosis and treatment (n = 3). These 14 cases were excluded from the

analysis. There were also two cases missing data on the patient's gender. These were included. To assess risk of selection bias, a direct standardization by injury and by age group was performed.

The results are presented in frequencies and percent of total population, and within advanced practice nursing and standard (physician-led) care models, respectively. Differences in diagnostic and treatment accuracy between advanced practice nursing model and the standard (physician-led) model were analyzed by means of Fisher's exact test (2-sided). A p-value of < 0.05 was considered statistically significant. For non-inferiority testing, to assess if advanced practice nursing model was no worse than standard (physician-led) care model, the upper bound of the 95% confidence interval of an observed risk ratio of missed diagnosis or treatment between advanced practice nursing and standard care models should not exceed 1.10 (Head et al., 2012). The analyses were conducted with SPSS version 26 (IBM SPSS Statistics for Windows, Version 22.0, IBM Corp., Armonk, NY, USA) and R (Package "fmsb") (R Core Team, 2020).

2.7 Ethical considerations

The study protocol and data, shared with the research team, contained anonymized data (only patients' age, gender, diagnosis and treatment). The Regional Committees for Medical and Health Research Ethics (2019/173) approved the study.

Preliminary results were shared with key stakeholders at the study ED in January 2020 to allow for changes to the organization, routines and/or training to be made to minimize future errors.

3 RESULTS

The results include 335 cases of which 167 (49.9 %) had been assessed and treated in the advanced practice nursing care model and 168 (50.1) in the standard (physician-led) care model.

There was an equal gender distribution of the patients in total (male: 49.2 %), and in the compared care models (advanced practice nursing, male: 53.7 %; standard, male: 46.3 %). The median age of the patients was 26.0 (q1 = 14.0; q3 = 46.0).

Missed diagnosis and treatment was explored, in total, in different groups of injuries, and in the compared care models (Table 1). In total, the most commonly presented injuries were ankle contusion, followed by hand, wrist and foot contusion.

INSERT TABLE 1 ABOUT HERE.

Diagnostic accuracy was high overall: correct diagnosis was found in 97.3 % (n = 326) of the cases. The senior orthopedic specialists revised the primary diagnosis in only 2.7% (n = 9) of the cases. Treatment accuracy was also high overall though somewhat lower than diagnostic accuracy: correct treatment was found in 91.3 % (n = 306) of the cases. The senior orthopedic specialists revised suggested/initiated treatment in 29 (8.7 %) of the cases. Of these 29 revised suggested/initiated treatments 20 (69.0 %) occurred in the standard (physician-led) care model. Overall, correct diagnosis and treatment was seen more frequently in the advanced practice nursing care model (98.8 % and 94.6 %, respectively) than the standard (physician-led) care model (95.8 % and 88.1 %, respectively).

No statistically significant difference was found between the advanced practice nursing and standard (physician-led) care models in terms of performance, but the p-value was just at the limit value of significance in the comparison of treatment groups (Table 2). In further non-inferiority testing, the comparison of missed diagnosis showed inconclusive results. In comparison of treatment outcomes, the results showed that the advanced practice nursing model was non-inferior (Table 2). To assess the possibility of selection bias, the treatment outcome risk

ratio (0.45) was also performed after direct standardization by injury and age. The standardized ratios proved to be almost unchanged, 0.48 and 0.46, respectively.

INSERT TABLE 2 ABOUT HERE.

4 DISCUSSION

In both care models, diagnostic accuracy was high. There were only two cases of missed diagnosis in the advanced practice nursing care model, compared to seven in the standard (physician-led) care model. Treatment accuracy was also high, but still somewhat lower than diagnostic accuracy. There were nine cases of missed treatment in the advanced practice nursing care model, compared to twenty in the standard (physician-led) care model. The advanced practice nursing model was found to be non-inferior in comparison of treatment accuracy. In fact, the results indicate that the advanced practice nursing care model even may be superior in treatment accuracy (as the confidence interval of risk ratio did not even include the value 1.00, but were entirely below 1.00, which is a requirement for superiority trials (Head et al., 2012)). The results are in line with previous research (Lau, Kerr, Law, & Ritchie, 2013; McClellan, Cramp, Powell, & Benger, 2012; Sakr, 1999; van der Linden, 2010). Although the results was inconclusive in diagnostic accuracy, there was only a 1.2 % risk of being wrongly diagnosed in the nursing model and it is suggested that the advanced practice nursing care model can be used to diagnose minor orthopedic injuries in the elbow and/or distal of elbow, and/or distal of knee. The results also support that an advanced practice nursing model can be established to treat such injuries, albeit with some caveats.

Analysis showed that some injuries were rarely represented and some were more challenging to treat (for example, malleolar fractures, toe phalanx fractures, scaphoid fractures and collum/caput radii fractures). As a result, it is reasonable to suggest that the treatment of injuries linked to lower treatment accuracy in this study, irrespective of care model, should be confirmed by consulting senior orthopedic specialists on-site.

In Norway, the Government has approved the introduction of advanced practice nursing. As shown in this study, and elsewhere (for example in Maier and Aiken, 2016, and in Maier, Köppen, Busse, & Munros team, 2018), advanced practice nursing can be applied by registered nurses in advanced roles without master education. However, there is a support for formalizing advanced practice nursing: regulatory bodies that specify levels of advanced practice based on education and skills can update scope-of-practice faster (Maier & Aiken, 2016). In Norway, the first NP educational program started in 2011 and there are now several NP Master's level programs throughout the country (Henni, Kirkevold, Antypas, & Foss, 2018). In 2020, national guidelines for master's education in advanced clinical general nursing were published (Lovdata, 2020). The learning outcomes are divided into four areas: Clinical assessments, decision-making and competence to act; Health conditions/diseases, and patient education and guidance; Leadership and coordination of care; Evidence-based professional development, quality improvement and innovations.

This study was set in an emergency care context in Norway, a country with a "gatekeeper" care system. The vast majority of all patients have a preliminary diagnosis when entering that ED. Nonetheless, the results reveal that advanced practice nursing care models are a promising care model for minor orthopedic injuries. In further studies, it would be of interest to explore more quality outcomes such as patient satisfaction and how an advanced practice nursing care model

affects patient flow and/or improves capacity. It would also be of interest to study the implementation of advanced practice nursing in gatekeeper care systems in the urgent care center context, to see if advanced practice nursing models can further decrease pressure on advanced practice nursing capacity.

4.1 Limitations

We did not perform any interrater reliability across the evaluators. The evaluators were not blinded, that is, the senior orthopedic specialists had information on the model applied. This is regarded as a potential source of bias in this study.

One can also claim selection bias. This, as randomization was not applied; the professionals at service were instructed to undertake the first patient on the list that they felt confident to serve. It could be claimed that, for example the nurses, strategically chose patients with injuries that are assumed to be easier to assess and treat. However, there are no indications on that nurses in the APN model, in general, have avoided one or more group of patients (see Table 1) and though direct standardization we found that differences between groups in the treatment comparisons could not be explained by age nor injury. Thus, the risk of selection bias was assessed to be low. Nonetheless, none of the professionals (nurses nor medical interns) should take on the responsibility to assess and treat patients if they do not find themselves confident; as stated in the manuscript, both the nurses and the medical interns could and should consult the orthopaedic surgeon on duty to give hands on support and instructions. This, to not jeopardizing patient safety. It can also be added that no patients asked to be transferred to another professional/other model of care.

In the comparison of diagnostic accuracy, the result became inconclusive. A non-significant p-value and a wide confidence interval can be explained by the fact that diagnostic accuracy was higher than expected in power calculations, and the sample size proved to be insufficient.

Also, the number of studied variables were limited. In similar studies, durance of appointment and data on patient satisfaction has for example been collected. Results from previous studies show that nurse-led care has a positive impact on patient satisfaction, but nurses tend to use longer time for consultations (Maier et al., 2017). We do not find any reason to consider that the situation would differ in the Norwegian context. However, further research to study the impact of nurse-led care regarding patient satisfaction and cost-effectiveness in the Norwegian health care system is emphasized.

The study was performed in Norway and caution will therefore be needed in generalizing the results to other countries with different care systems and potential cultural differences. Also, the study is a single center study. Thus, further studies are needed to verify the results.

5 CONCLUSION

The study was performed in the emergency care context in Norway, where advanced practice nursing is at an initial stage of implementation. It can be concluded that advanced practice nursing care models can be used to diagnose and treat minor orthopedic injuries without compromising quality of care. However, a well-functioning system for collegial backing from senior orthopedic surgeons, and a quality assurance system, is imperative in both advanced practice nursing and standard (physician-led) care model. This, to secure patients safety, but also for advanced practice nurses and medical interns to enhance their competence. Further implementation of the advanced practice nursing care model is encouraged.

DECLARATIONS

- Ethics approval and consent to participate

The Regional Committees for Medical and Health Research Ethics (2019/173) approved the study. For data collection from patient records, no consent was collected.

- Consent for publication

Not applicable.

- Availability of data and material

The datasets used and/or analyzed during the current study will be available from the corresponding author on reasonable request.

- Competing interests

The authors declare that there is no conflict of interest regarding the publication of this article.

- Funding

Funding has been received from the Norwegian Research Council's PraksisVel program for the project entitled, "Providing person-centered healthcare – Development of new models of advanced nursing practice in cooperation with patients, clinical field and higher education". This study is performed in line with the project plan.

- Authors' contributions

All authors meet the ICMJE recommended criteria. All authors have made substantial contributions to the design of the manuscript. EB drafted the manuscript and all of the other

authors have substantively revised it. AL was responsible for power calculations, ED and KG for planning the data collection in the ED. LF was the principal investigator.

• Acknowledgements

We would like to thank the senior orthopedic specialists who assisted with the evaluation and Joukko Kunnunen at Åland Statistics and Research for support with the statistics.

CRediT author statement

Erika Boman: Conceptualization, Data curation, Formal analysis, Writing - Original Draft, Project administration

Elisabeth Duvaland & Kim Gaarde: Conceptualization, Validation, Investigation, Writing - Review & Editing

Alison Leary: Conceptualization, Methodology, Writing - Review & Editing

Auvo Rauhala: Formal analysis, Visualization, Writing - Review & Editing

Lisbeth Fagerström: Conceptualization, Funding acquisition, Supervision, Writing - Review & Editing

Declaration of interests

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

REFERENCES

Af Ugglas, B., Djärv, T., Ljungman, P., & Holzmann, M. J. (2020). Association Between Hospital Bed Occupancy and Outcomes in Emergency Care: A Cohort Study in Stockholm Region, Sweden, 2012 to 2016. *Annals of Emergency Medicine, 76*(2), 179–190. doi: 10.1016/j.annemergmed.2019.11.009

Aitkenhead, A., & Lee, G. A. (2019). The accuracy of paediatric limb radiograph interpretation by nurse practitioners in a single centre. *International Emergency Nursing, 45*, 36–42. doi-org.proxy.ub.umu.se/10.1016/j.ienj.2019.03.001

Bjornsen, L. P., Uleberg, O., & Dale, J. (2013). Patient visits to the emergency department at a Norwegian university hospital: variations in patient gender and age, timing of visits and patient acuity. *Emergency Medicine Journal, 30*(6), 462-466. doi:10.1136/emermed-2012-201191

Blinkenberg, J., Pahlavanyali, S., Hetlevik, Ø., Sandvik, H., & Hunskaar, S. (2019). General practitioners' and out-of-hours doctors' role as gatekeeper in emergency admissions to somatic hospitals in Norway: registry-based observational study. *BMC Health Services Research, 19*(568). doi: 10.1186/s12913-019-4419-0

Boman, E., Duvaland, E., Gaarde, K., Leary, A., & Fagerström, L. (2020). Implementation of advanced practice nursing for orthopaedic patients in the emergency care context – A study protocol for outcome studies. *Journal of Advanced Nursing, 76*(4), 1069-1076. doi: 10.1111/jan.14299

Burkett E., Martin-Khan, M.G., Scott J., Samanta M., Gray, L.C. (2016). Trends and predicted trends in presentations of older people to Australian emergency departments: effects of demand

growth, population aging and climate change. *Australian Health Review, 41*(3), 246-253. doi: 10.1071/AH15165

Cooper, M. A., Lindsay, G. M., Kinn, S., & Swann, I. J. (2002). Evaluating emergency nurse practitioner services: a randomized controlled trial. *Journal of Advanced Nursing, 40*(6), 721-730.

Elder, E., Johnston, A. N., & Crilly, J. (2015). Review article: systematic review of three key strategies designed to improve patient flow through the emergency department. *Emergency Medicine Australasia, 27*(5), 394-404. doi:10.1111/1742-6723.12446

Greenwood-Ericksen, M.B., & Kocher, K. (2019). Trends in emergency department use by rural and urban populations in the United States. *JAMA Network Open, 2*(4), e191919. doi:10.1001/jamanetworkopen.2019.1919

Head, S. J., Kaul, S., Bogers, A. J., & Kappetein, A. P. (2012). Non-inferiority study design: lessons to be learned from cardiovascular trials. *European Heart Journal, 33*(11), 1318–1324. doi.org/10.1093/eurheartj/ehs099

Henni, S. H., Kirkevold, M., Antypas, K., & Foss, C. (2018). The role of advanced geriatric nurses in Norway: A descriptive exploratory study. *International Journal of Older People Nursing, 13*(3):e12188. doi:10.1111/opn.12188

Hiza, E. A., Gottschalk, M. B., Umpierrez, E., Bush, P., & Reisman, W. M. (2015). Effect of a dedicated orthopaedic advanced practice provider in a Level I Trauma Center: Analysis of length of stay and cost. *Journal of Orthopeadic Trauma, 29*(7), e225-230. doi:10.1097/bot.0000000000000261

International Council of Nurses (2020). *Guidelines on advanced practice nursing 2020.* Retrieved April 21, 2020 from https://www.icn.ch/system/files/documents/2020-04/ICN_APN%20Report_EN_WEB.pdf

Jennings, N., Clifford, S., Fox, A. R., O'Connell, J., & Gardner, G. (2015). The impact of nurse practitioner services on cost, quality of care, satisfaction and waiting times in the emergency department: a systematic review. *International Journal of Nursing Studies*, *52*(1), 421-435. doi:10.1016/j.ijnurstu.2014.07.006

Jennings, N., McKeown, E., O'Reilly, G., & Gardner, G. (2013). Evaluating patient presentations for care delivered by emergency nurse practitioners: a retrospective analysis of 12 months. *Australasian Emergency Nursing Journal*, *16*(3), 89-95. doi:10.1016/j.aenj.2013.05.005

Lau, L. H., Kerr, D., Law, I., & Ritchie, P. (2013). Nurse practitioners treating ankle and foot injuries using the Ottawa Ankle Rules: a comparative study in the emergency department. *Australasian emergency nursing journal: AENJ*, *16*(3), 110–115. https://doi.org/10.1016/j.aenj.2013.05.007

Lee, G. A., Chou, K., Jennings, N., O'Reilly, G., McKeown, E., Bystrzycki, A., & Varma, D. (2014). The accuracy of adult limb radiograph interpretation by emergency nurse practitioners: A prospective comparative study. *International Journal of Nursing Studies*, *51*(4), 549–554. doi.org/10.1016/j.ijnurstu.2013.08.001

Li, J., Westbrook, J., Callen, J., Georgiou, A., & Braithwaite, J. (2013). The impact of nurse practitioners on care delivery in the emergency department: a multiple perspectives qualitative study. *BMC Health Services Research*, *13*, 356. doi:10.1186/1472-6963-13-356

Lovdata. (2020). *Forskrift om nasjonal retningslinje for masterutdanning i avansert klinisk allmennsykepleie [Regulations on national guidelines for master's education in advanced clinical general nursing]*. Retrieved September 7, 2020. https://lovdata.no/dokument/LTI/forskrift/2020-01-03-45

Maier, C. B., & Aiken, L. H. (2016). Task shifting from physicians to nurses in primary care in 39 countries: a cross-country comparative study. *European Journal of Public Health, 26*(6), 927-934. doi:10.1093/eurpub/ckw098

Maier, C. B., & Aiken, L. H. (2017). *Nurses in advanced roles in primary care: Policy levers for implementation.* Paris: OECD Health Working Papers No. 98. OECD Publishing. doi: doi.org/10.1787/a8756593-en

Maier, C. B., Köppen, J., Busse, R., & MUNROS team. (2018). Task shifting between physicians and nurses in acute care hospitals: cross-sectional study in nine countries. *Human Resources for Health*, *16*(1). doi: 10.1186/s12960-018-0285-9

Martinez-Gonzalez, N. A., Djalali, S., Tandjung, R., Huber-Geismann, F., Markun, S., Wensing, M., & Rosemann, T. (2014). Substitution of physicians by nurses in primary care: a systematic review and meta-analysis. *BMC Health Services Research, 14*, 214. doi:10.1186/1472-6963-14-214

Ministry of Health and Care Services (2009). *Samhandlingsreformen. Rett behandling – på rett sted – til rett tid. St.meld. nr. 47. (2008-2009). [The Coordination Reform— Proper treatment – at the right place and right time Report No. 47 to the Storting (2008-2009)]*. Retrieved June 14, 2020.

https://www.regjeringen.no/contentassets/d4f0e16ad32e4bbd8d8ab5c21445a5dc/no/pdfs/stm200820090047000dddpdfs.pdf

McClellan, C. M., Cramp, F., Powell, J., & Benger, J. R. (2012). A randomised trial comparing the clinical effectiveness of different emergency department healthcare professionals in soft tissue injury management. *BMJ open, 2*(6), e001092. doi:10.1136/bmjopen-2012-001092

Morley, C., Unwin, M., Peterson, G. M., Stankovich, J., & Kinsman, L. (2018). Emergency department crowding: A systematic review of causes, consequences and solutions. *PloS one, 13*(8), e0203316. doi: org/10.1371/journal.pone.0203316

O'Keeffe, C., Mason, S., Jacques, R., & Nicholl, J. (2018). Characterising non-urgent users of the emergency department (ED): A retrospective analysis of routine ED data. *PLoS One, 13*(2), e0192855. doi:10.1371/journal.pone.0192855

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.R-project.org/

Roche, T. E., Gardner, G., & Jack, L. (2017). The effectiveness of emergency nurse practitioner service in the management of patients presenting to rural hospitals with chest pain: a multisite prospective longitudinal nested cohort study. *BMC Health Services Research, 17*(1), 445. doi:10.1186/s12913-017-2395-9

Ringard, Å., Sagan, A., Sperre Saunes, I., & Lindahl, A.K. (2013). Norway: health system review. *Health Systems in Transition, 15*(8), 1–162.

Sakr, M., Angus, J., Perrin, J., Nixon, C., Nicholl, J., & Wardrope, J. (1999). Care of minor injuries by emergency nurse practitioners or junior doctors: a randomised controlled trial. *Lancet, 354*(9187),1321–1326. doi:10.1016/s0140-6736(99)02447-2

Sandvik, H., & Hunskaar, S. (2018). Frequent attenders at primary care out-of-hours services: a registry-based observational study in Norway. *BMC Health Services Research, 18*(1). doi: 10.1186/s12913-018-3310-8

van der Linden, C., Reijnen, R., & de Vos, R. (2010). Diagnostic accuracy of emergency nurse practitioners versus physicians related to minor illnesses and injuries. *Journal of Emergency Nursing, 36*(4), 311-316. doi:10.1016/j.jen.2009.08.012

Velt, K. B., Cnossen, M., Rood, P. P. M., Steyerberg, E. W., Polinder, S., & Lingsma, H. F. (2018). Emergency department overcrowding: a survey among European neurotrauma centres. *Emergency Medicine Journal, 5*(7), 447-448. doi:10.1136/emermed-2017-206796

Wilson, A., Zwart, E., Everett, I., & Kernick, J. (2009). The clinical effectiveness of nurse practitioners' management of minor injuries in an adult emergency department: a systematic review. *International Journal of Evidence-Based Healthcare, 7*(1), 3-14 12p.

Table 1. Presentation of cases within compared care models, including missed diagnosis and missed treatment.

Injury	Cases within compared care models			Missed diagnosis			Missed treatment		
	Total	APN	Standard	Total	APN	Standard	Total	APN	Standard
	n (%)	n (%)	n (%)	n	n	n	n	n	n
Ankle contusion	89 (26.6)	52 (31.1)	37 (22.0)	0	0	0	1	0	1
Medial malleolar fracture	3 (0.9)	2 (1.3)	1 (0.6)	0	0	0	1	0	1
Lateral malleolar fracture	7 (2.1)	3 (1.8)	4 (2.4)	0	0	0	1	0	1
Bimalleolar fracture	1 (0.3)	0	1 (0.6)	0	0	0	1	0	1
Foot contusion	34 (10.1)	16 (9.6)	18 (10.7)	0	0	0	0	0	0
Tarsal fracture	1 (0.3)	1 (0.6)	0	0	0	0	0	0	0
Metatarsal fracture	11 (3.3)	5 (3.0)	6 (3.6)	1	0	1	3	1	2
Toe phalanx fracture 1	10 (3.0)	6 (3.6)	4 (2.4)	0	0	0	3	2	1
Toe phalanx fracture 2-5	7 (2.1)	5 (3.0)	2 (1.2)	0	0	0	2	1	1
Wrist contusion	31 (9.3)	15 (9.0)	16 (9.5)	2	1	1	3	1	2
Dislocated wrist fracture	18 (5.4)	3 (1.8)	15 (8.9)	1	0	1	2	0	2
Undislocated wrist fracture	17 (5.1)	10 (6.0)	7 (4.2)	1	0	1	2	1	1
Greenstick fracture	3 (0.9)	2 (1.2)	1 (0.6)	0	0	0	0	0	0
Hand contusion	36 (10.7)	16 (9.6)	20 (11.9)	2	1	1	3	2	1
Scaphoid fracture	4 (1.2)	1 (0.6)	3 (1.8)	1	0	1	2	0	2
Thumb fracture	7 (2.1)	4 (2.4)	3 (1.8)	0	0	0	1	0	1
Finger fracture 2-5	21 (6.3)	13 (7.8)	8 (4.8)	0	0	0	0	0	0
Metacarpal fracture 1	1 (0.3)	1 (0.6)	0	0	0	0	0	0	0
Metacarpal fracture 2-5	13 (3.9)	6 (3.6)	7 (4.2)	0	0	0	1	1	0
Elbow contusion	10 (3.0)	4 (2.4)	6 (3.6)	0	0	0	0	0	0
Elbow luxation	1 (0.3)	0	1 (0.6)	0	0	0	0	0	0
Olecranon fracture	1 (0.3)	0	1 (0.6)	0	0	0	0	0	0
Colum/caput radii fracture	7 (2.1)	1 (0.6)	6 (3.6)	1	0	1	3	0	3
Antebrachial fracture	1 (0.3)	0	1 (0.6)	0	0	0	0	0	0
Distal humerus fracture	1 (0.3)	1 (0.6)	0	0	0	0	0	0	0
Total	335 (100)	167 (100)	168 (100)	9	2	7	29	9	20

Table 2. Number and percentage of missed diagnosis and treatment within models and comparison between models.

Outcome	Total		Advanced practice nursing care model (APN)			Standard (physician-led) care model (standard)			P-value	APN vs. standard model	
	n	%	n	%	Risk	n	%	Risk		Risk ratio	95% CI
Missed diagnosis	9	2.7	2	1.2	0.012	7	4.2	0.042	0.174	0.29	0.06-1.36
Missed treatment	29	8.7	9	5.4	0.054	20	11.9	0.119	0.050	0.45	0.21-0.97