Nursing & Health Sciences

WILEY

Nursing & Health Sciences

RESEARCH ARTICLE

The Effect of a Nursing Triage Protocol for Minor Orthopedic Trauma in an Emergency Department: A Randomized Controlled Trial

Sanne Bombeek[1] | Rinaldo Lauwers[1] | Tom C. R. V. Van Zundert[2] | Filip Haegdorens[3]

[1]Emergency Department, AZORG Hospital, Aalst, East Flanders, Belgium | [2]Emergency Department, Holy Heart Hospital, Antwerp, Belgium | [3]Workforce Management and Outcome Research in Care Group, Centre for Research and Innovation in Care (CRIC), University of Antwerp, Antwerp, Belgium

Correspondence: Sanne Bombeek (sanne.bombeek@azorg.be)

Received: 20 December 2024 | **Revised:** 30 October 2025 | **Accepted:** 7 November 2025

Funding: The authors received no specific funding for this work.

Keywords: advanced triage protocol | emergency nursing | flow times | minor trauma | nursing triage protocol | patient satisfaction | treatment adjustment

ABSTRACT

More than 90% of patients with minor orthopedic injuries are categorized as non-urgent which can result in prolonged waiting times in the emergency department. A total of 220 adults presenting between March and May 2023 with non-urgent orthopedic distal limb injuries were included in this single center, unblinded, randomized, parallel-group, controlled trial. A nurse performed the physical examination and initiation of X-ray during triage in the intervention group while an emergency physician performed these after triage in the usual care group. The results of 108/110 (intervention) and 107/110 participants (usual care) were analyzed. The intervention group had a significantly lower flow time between emergency department registration and X-ray request. The usual care group had significantly lower flow time between X-ray request and emergency department discharge. There was no difference in total length of stay, patient satisfaction and treatment adjustment between groups. The nursing triage protocol reduced flow time between registration and request for X-ray but did not affect total length of stay.

1 | Introduction

Emergency departments (EDs) around the world are under increasing pressure. Growing patient volumes, limited resources, and rising expectations have made ED crowding a persistent global concern (Javidan et al. 2021). Among those contributing to this challenge are patients with minor orthopedic injuries—individuals who are stable, ambulatory, and typically triaged as low acuity.

In Belgium, similar trends are observed. In 2019, nearly half of all hospital contacts took place via an emergency department, and the total number of ED admissions increased by 23% between 2010 and 2019 (Farfan-Portet et al. n.d.) . The majority of ambulatory patients (82%) present to the ED without referral from a general practitioner (GP) (Farfan-Portet et al. n.d.). Over one third arrive after an accident or trauma, of which only 9% result in hospitalization, suggesting that most involve minor injury or trauma (Farfan-Portet et al. n.d.). Among adults with isolated limb trauma, 96% are assigned an emergency severity index (ESI) level of 4 or 5 (Vermeir 2024), representing non-urgent cases with limited need for additional diagnostic or therapeutic interventions (Figure 1) (Gilboy et al. 2005; Elshove-Bolk et al. 2007). Especially in EDs

Summary

- This study showed no difference in total length of stay between the nursing triage protocol and usual care groups. The potential for reduction of flow times in the emergency department by using a nursing triage protocol is, however, evident.
- Significantly more participants in the usual care group sought additional medical care elsewhere (i.e., registration at another emergency department, appointment with a general practitioner, ...).
- No significant difference in patient satisfaction scores for the physical exam between groups shows that trained triage nurses are perceived as qualified as emergency physicians by participants.

without team triage or rapid evaluation programs, these patients often experience prolonged waiting times before diagnostic imaging or treatment is initiated (Javidan et al. 2021; Kim and Cho 2017).

For patients with isolated limb trauma, the current triage process often results in delays in assessment and treatment (Gilboy et al. 2005). For example, a patient requiring radiological examination for a suspected fracture is first triaged by a nurse, followed by physician assessment, the diagnostic procedure (X-ray), further medical review, and finally treatment (Tambimuttu et al. 2002). These delays are mainly due to the time required for an emergency physician to become available to perform a physical examination, request appropriate investigations, and initiate treatment (Javidan et al. 2021; Lazarus et al. 2016; Erenler et al. 2016; Derksen et al. 2007).

The implementation of a nursing triage protocol (NTP) specifically aimed at patients with minor orthopedic injuries requiring medical imaging could be a possible solution to this problem by eliminating waiting time for an available emergency physician. Previous studies in other countries have shown that implementing NTPs can reduce total length of stay (TLOS) in the ED for this patient group (Derksen et al. 2007; Lindley-Jones and Finlayson 2000; Pedersen and Storm 2009; Sorensen et al. 2012; Allerston and Justham 2000; Al Abri et al. 2020). Other potential benefits of nurse-initiated X-rays include an improved perception of waiting and greater satisfaction with emergency services (Parris et al. 1997). In a climate of reduced healthcare resources, nurse-initiated X-rays represent one strategy that may improve both patient throughput and satisfaction with emergency care (Javidan et al. 2021; Tambimuttu et al. 2002).

It remains to be determined whether introducing an NTP provides added value for the treatment of patients with minor orthopedic trauma in an ED without team triage or rapid evaluation programs. The aim of this randomized controlled trial was to determine whether an NTP affects flow times in the ED. In addition, accompanying treatment adjustments and patient satisfaction outcomes were compared between the control and intervention groups.

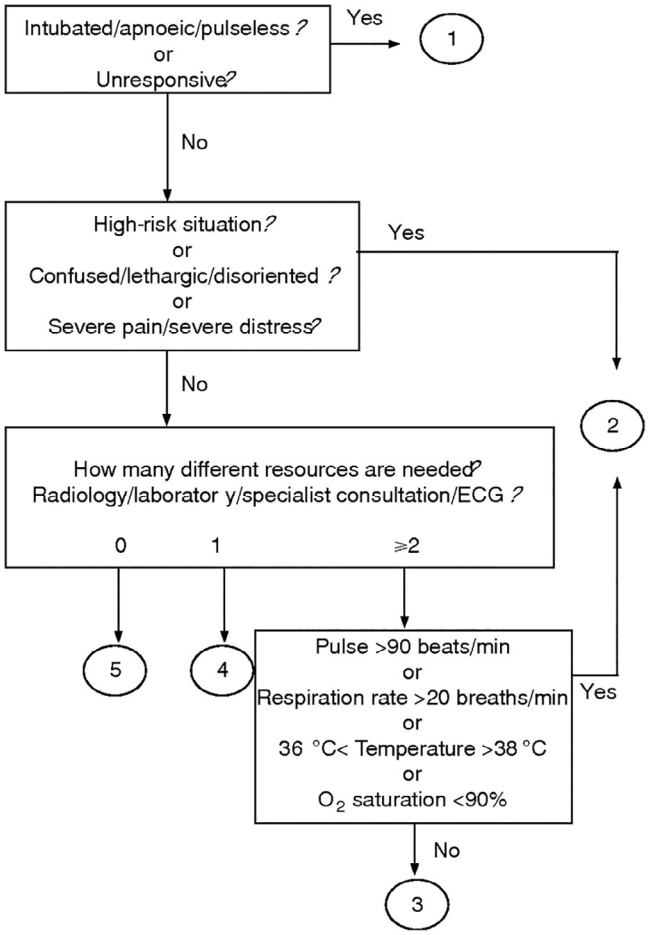

FIGURE 1 | Emergency severity index triage algorithm (Tambimuttu et al. 2002).

2 | Materials and Methods

2.1 | Trial Design

This is a single center, unblinded, randomized (with a 1:1 allocation), parallel-group, controlled trial conducted in Belgium. Care provider allocation continued as usual: the triage nurse is assigned at the start of a shift; new patients are alternately assigned to an emergency physician using a 1:1 allocation between 10 a.m. and 9 p.m. every study day.

2.2 | Ethical Considerations

Written and signed informed consent was obtained from all patients. The study protocol was approved by the institutional and central ethics committees, ensuring that it conformed to the ethical guidelines of the 1975 Declaration of Helsinki (Project ID 5197—BUN B3002023000049—approved 20/02/2023).

2.3 | Trial Registration and Protocol

This trial is registered at a clinical trial registry (ClinicalTrials.gov, NCT05765045). Full details of the trial protocol can be obtained through the researchers upon request. The

CONSORT reporting guidelines for parallel group randomized trials (of nonpharmacologic treatments) were used throughout this report.

2.4 | Participants

A convenience sample of consecutive patients with minor peripheral orthopedic limb injuries was obtained from the ED of the Holy Heart hospital in Mol, Belgium from March 14 to May 22, 2023. The Holy Heart hospital is a regional hospital that treated approximately 15 000 patients in the ED in 2020, of which nearly 73% were outpatient contacts (Hartziekenhuis 2020).

All triage nurses that received an instructive PowerPoint presentation about the intervention were eligible to treat patients in the NTP group. There were no specific eligibility criteria for emergency physicians considering that there was no need for them to adjust their usual care. Eligible participants were patients who met the eligibility criteria with the inclusion criteria being:

- Adults (aged 18 or over);
- ESI 4 or ESI 5 (non-urgent);
- Recent trauma (< 10 days after initial trauma);
- Accidental trauma mechanism (e.g., fall, stumble);
- Peripheral orthopedic limb injury (Distal to the elbow: forearm, wrist, hand, finger OR distal to the knee: lower leg, ankle, foot, toe).

Exclusion criteria were:

- (Suspicion of) pregnancy;
- Additional, non-orthopedic, injuries (e.g., cuts, commotio cerebri);
- Reassessment of previously examined injury (i.e., increased, or continued pain, thigh plaster cast);
- Trauma due to an underlying somatic cause (e.g., vasovagal syncope, epileptic seizure)
- Atraumatic limb pain (e.g., joint pain without obvious traumatic cause).

2.5 | Intervention

An NTP was developed by the researchers based on the Ottawa Ankle rules for ankle and foot injuries (Beckenkamp et al. 2017; Gorbachova et al. 2020; Smith et al. 2020) and on the presence of obvious deformity, *functio laesa* and localized tenderness or edema for all other distal limb injuries (Bussières et al. 2008). The NTP was submitted for approval to the heads or their representatives of the ED, orthopedics department and radiology department. Subsequently a presentation was provided for the participating triage nurses in which the aim of the study and the protocol including the physical examination of peripheral limb injuries was explained. No measures were taken to assess or enhance adherence of care providers to the NTP or of participants to the study.

Patients in the intervention group were triaged using the NTP that is, physical examination and initiation of medical imaging by a nurse during triage. Participants allocated to the NTP group were sent directly from triage to the radiology department if medical imaging was deemed necessary. The control group received usual care (UC) that is, physical examination and initiation of medical imaging by the allocated emergency physician. Participants assigned to the UC group were to be directed to the waiting room or a treatment room after initial triage by a nurse. After medical imaging, both the NTP group and the UC group were treated the same.

2.6 | Outcomes and Data Collection

2.6.1 | Primary Outcomes

The primary outcomes of this study were flow times (in minutes) in the ED for patients with minor orthopedic limb injuries. Time variables to calculate flow times were collected retrospectively using the electronic patient file and are defined as:

- T_0: time of patient registration at the ED;
- T_1: time of triage by a nurse;
- T_2: time of digital request for medical imaging;
- T_3: time of execution of medical imaging;
- T_4: time of medical imaging protocol;
- T_5: time of discharge from the ED or the request of additional imaging (i.e., CT or ultrasound) by an orthopedic surgeon.

TLOS was defined in the study protocol as the time between patient registration at the ED (T_0) and discharge from the ED or the formal request of a bedside orthopedic advice. TLOS was defined as such because the request of an advice from an orthopedic surgeon, and any additional medical imaging (i.e., CT, ultrasound), can entail waiting times and is seen separately from the flow at the ED. However, after commencement of the trial, the electronic patient record, where data were retrospectively collected, was changed by the participating hospital. This change made it not feasible to objectively collect the formal time of request of an advice from an orthopedic surgeon. To maintain the integrity and consistency of the primary outcome measure across the study population, the definition of TLOS was adapted to the time between patient registration at the ED (T_0) and discharge from the ED or the time of request of additional imaging (i.e., CT or ultrasound) by an orthopedic surgeon (T_5). This revised endpoint was selected as a clinically and operationally relevant proxy to the original endpoint. Although this adjustment modifies the initial definition, it does not affect the actual clinical outcome or interpretation. The request for advanced imaging often coincides with or follows the orthopedic consultation, serving as a reliable surrogate marker for the transition of care away from the ED team. Furthermore, timestamps for imaging request are systematically and reliably recorded, ensuring data integrity and comparability across all participants.

Initially, the other primary outcome of this study was to determine the effect of the NTP on flow time between time of triage (T_1) and the digital request for medical imaging (T_2).

After commencement of the trial, flow time between triage and digital request for medical imaging was replaced by flow time between registration at the ED (T_0) and digital request for medical imaging (T_2). Furthermore, it was decided to add the flow time between the time of digital request for medical imaging (T_2) and discharge from the ED or the time of request of additional imaging (i.e., CT or ultrasound) by an orthopedic surgeon (T_5). For the purpose of this study, this change to the trial protocol better reflects the flow and waiting times in the ED and the effect of the NTP.

2.6.2 | Secondary Outcomes

Secondary outcome measures were the effect of the NTP on patient satisfaction, treatment adjustment and additional traditional X-rays requested by emergency physicians after the triage nurse deemed this unnecessary in the NTP group. Patient satisfaction was surveyed by 10-point Likert scales at ED discharge. More specifically, participants were asked to score their overall satisfaction concerning their stay at the ED, their overall satisfaction concerning waiting times at the ED and their satisfaction with the physical exam performed by the triage nurse in de NTP group or the emergency physician in the UC group. The scores were registered using a standardized data collection form.

For this study, treatment adjustment was defined as whether the treatment initiated by the emergency physician at the ED was adjusted at a later stage. For participants who made a follow-up appointment at the orthopedics department after 7–14 days, this was checked retrospectively in the electronic patient file. Participants without follow-up appointment were contacted by telephone to inquire whether they sought additional medical care elsewhere in a period of 2 weeks after their visit to the ED (i.e., registration at another ED with medical imaging, appointment with a general practitioner, ...). After contacting participants twice without response, they were considered lost to follow-up.

Participants in the NTP group who, according to the NTP, did not need medical imaging were physically examined by an emergency physician after triage. If the emergency physician determined that traditional X-rays were indicated for the participant (i.e., based on clinical expertise, inadequate use of the NTP, ...) a note was made on the study documents. The same approach was used for participants in the NTP group who got additional traditional X-rays after physical examination by an emergency physician. For this participant subgroup, the results of the medical imaging were retrospectively reviewed and reported separately (i.e., number of missed fractures in the NTP group).

Additionally, demographic characteristics (age and gender), pain score according to the visual analogue scale (VAS), result of the medical imaging protocol and information on the type of X-rays requested, were collected retrospectively using the electronic patient file.

2.7 | Sample Size

An a priori sample size calculation was performed to detect a difference between the intervention and control group. A two-tailed α of 0.05 and a power $(1-\beta)$ of 0.80 were used to detect a 15% difference in flow times between groups.

This estimate was based on a previous systematic reviews (Considine et al. 2019; Gottlieb et al. 2021) exploring the effect of nurse-initiated X-rays in patients with extremity injuries on reduction in TLOS which proved a decrease of approximately 4–45 min (Thurston and Field 1996; Sorensen et al. 2012). Although the overall quality of evidence was rated low to very low due to risk of bias, indirectness, and imprecision, these findings support the plausibility of moderate improvements in flow times following such interventions.

Given the heterogeneity of study designs and populations in the existing literature, a precise expected effect size could not be derived directly. Therefore, the 15% threshold was chosen as a clinically meaningful estimate, grounded in both the approximate magnitude of effect observed in prior studies and expert consensus among the research team.

A minimum sample size of 100 participants per group was deemed necessary to demonstrate a significant difference. Considering an expected dropout rate of 10%, a sample size of 220 participants in total was calculated.

A 4-week inclusion period was planned to recruit the required number of participants. However, patient inclusion was continued until the target sample size was achieved.

2.8 | Randomization and Blinding

Patients who were eligible to participate in the study were randomly assigned following simple randomization to the NTP group or the UC group. For allocation of the participants, a computer-generated list of random numbers was used with a 1:1 allocation ratio. The allocation sequence was concealed from the triage nurses enrolling and assigning the participants in sequentially numbered, opaque, sealed envelopes. These envelopes were prepared by an investigator with no clinical involvement in the trial and kept at the triage desk.

The study was unblinded because all participants, emergency nurses, physicians, and outcome assessors were aware of radiographic test requests by triage nurses who implemented the NTP.

2.9 | Statistical Methods

All collected data were imported and analyzed using IBM SPSS Statistics version 28.0 for MAC OS. Independent *t*, Pearson's chi-squared or Fisher's exact tests were used for baseline comparison of participant characteristics. Descriptive statistics, including percentage, mean and standard deviation (SD) were used to summarize the data. The normality of the data was checked using z-scores and the Shapiro–Wilk test.

Flow times in the ED were compared using the Mann–Whitney *U* test (MWU) and reported by giving the median, interquartile range (IQR) and effect size (*r*). Patient satisfaction scores were analyzed using MWU tests and reported using median, IQR and effect size (*r*). Descriptive statistics and the Fisher's exact test were used to compare treatment adjustment between the two groups and for further subgroup analysis. Subgroup analysis was performed for participants in the NTP group who got no or additional traditional X-rays after physical examination by an emergency physician by using descriptive statistics. To account for potential multiplicity within the flow time outcomes (T_5–T_0, T_2–T_0, T_5–T_2), we used a Bonferroni correction ($\alpha = 0.05/3 = 0.0167$). Two-tailed p values of < 0.05 were considered significant for all statistical tests. Intention-to-treat analysis was used to maintain the effect of randomization.

3 | Results

3.1 | Participant Flow and Characteristics

Eligible participants were recruited from March 14 till May 22, 2023, at which time the pre-calculated sample size was reached. The diagram of participant flow is shown in Figure 2. No data was collected for the number of participants who were assessed for eligibility. The omission resulted from logistical constraints during the implementation of the trial in a busy ED environment, where pre-screening was performed informally by triage staff without systematic documentation.

As a result, it is not possible to precisely quantify the number of patients screened but not enrolled, which limits our ability to fully assess the presence of selection bias or evaluate the representativeness of the study sample.

Ultimately, a total of 220 participants was randomized in the NTP ($n = 110$) or UC ($n = 110$) groups. The intervention was discontinued in one participant in the UC group who left the ED after triage but before physical examination by an emergency physician. One participant failed to mention an earlier visit to another ED for the same injury but was still included in further analysis despite not meeting the eligibility criteria for the intervention (reassessment of previously examined injury) considering the intention-to-treat approach.

To minimize the risk of data loss, standardized procedures were implemented, including the use of secure, study-specific paper documentation stored in designated folders within the ED, as well as regular data entry into an electronic trial database by trained research staff. Despite these measures, the study documents of five participants (2%) were irretrievably lost after randomization, prior to complete data extraction. These cases occurred sporadically and without clustering in either treatment group, suggesting the loss was likely due to logistical factors (e.g., misplaced paper forms during shift transitions or incomplete transfers to the data collection system) rather than systematic error.

The results of 108 participants in the NTP group and 107 participants in the UC group were analyzed for the primary outcome measures ($N = 215$).

Nonresponse was the main reason for lack of follow-up for the secondary outcome measure patient satisfaction (37/215, 17%). No phone number was available for two participants (2/215, 0.01%). This resulted in system missing data for which no imputation techniques were used. The results of 178/220 participants were analyzed for the secondary outcome measure patient satisfaction (NTP: 84/110, UC: 94/110). The results of 215

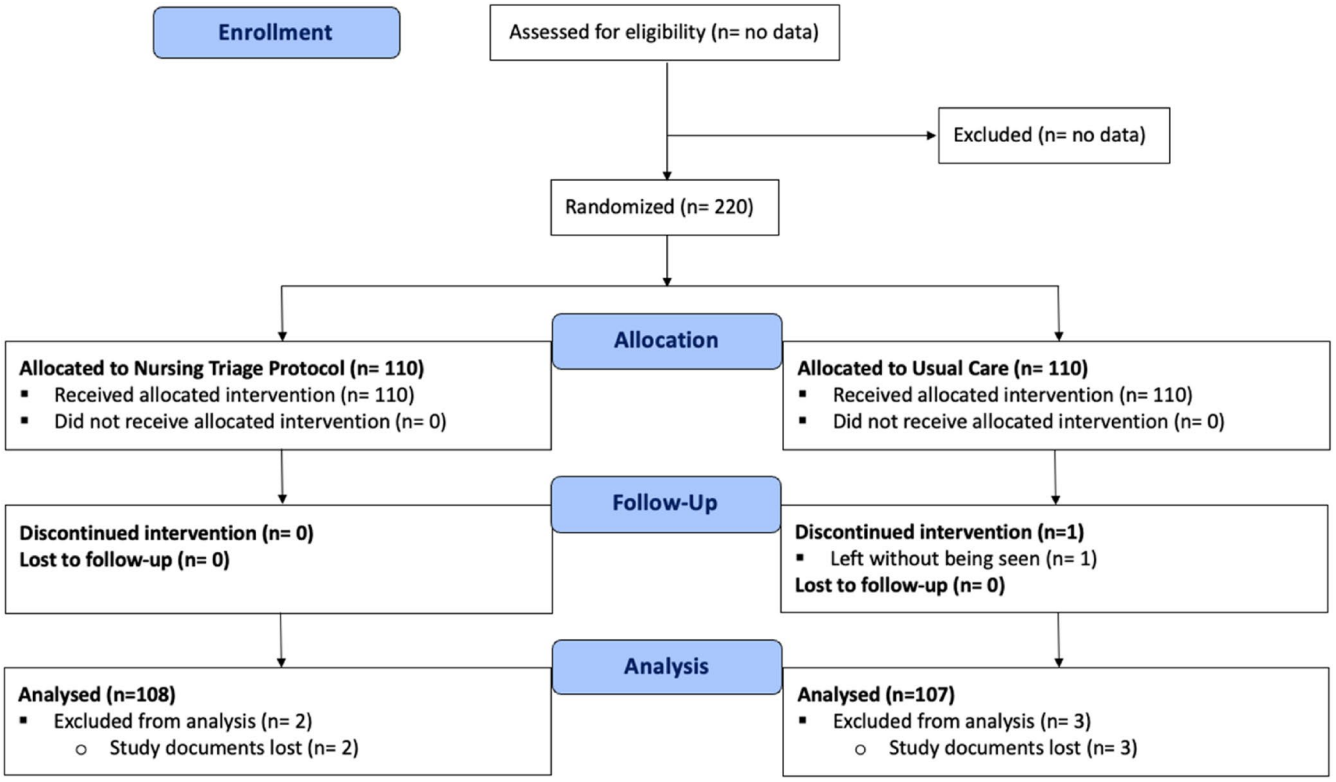

FIGURE 2 | Participant flow diagram for primary outcome measures based on the CONSORT guidelines.

TABLE 1 | Participants' characteristics.

Characteristics		Usual care ($n=107$)	Nursing triage protocol ($n=108$)	p
Gender, *n* (%)	Male	47 (44)	46 (43)	0.89[a]
	Female	60 (56)	62 (57)	
Age in years, mean (SD)	18–92	44 (17)	43 (18)	0.84[c]
VAS-score, mean (SD)	0–10	3 (2)	3 (2)	0.33[c]
Site of injury, *n* (%)	Upper limbs	48 (45)	50 (46)	0.55[b]
	Lower limbs	59 (55)	56 (52)	
	Upper and lower limbs	0 (0)	1 (1)	
	Left	48 (45)	47 (44)	0.89[b]
	Right	55 (51)	58 (54)	
	Left and right	4 (4)	3 (3)	
Number of X-rays requested, *n* (%)	Finger	16 (15)	13 (12)	0.56[a]
	Hand	24 (23)	25 (23)	1.00[a]
	Scaphoid	3 (3)	4 (4)	1.00[a]
	Wrist	17 (16)	24 (22)	0.30[a]
	Forearm	4 (4)	7 (7)	0.54[a]
	Toe	8 (8)	9 (8)	1.00[a]
	Foot	44 (42)	37 (35)	0.33[a]
	Ankle	38 (36)	36 (34)	0.78[a]
	Lower leg	1 (1)	4 (4)	0.37[a]
Fracture identified, *n* (%)	Yes	39 (36)	46 (43)	0.57[b]
	No	66 (62)	61 (57)	
	No X-ray	2 (2)	1 (1)	
Patient disposal, *n* (%)	Admitted	4 (4)	2 (2)	0.45[a]
	Discharged	103 (96)	106 (98)	

Abbreviation: SD, standard deviation.
[a]Fisher's exact test.
[b]Pearson chi-square.
[c]Independent *t* test.

participants were analyzed for the secondary outcome measure treatment adjustment, but subgroup analysis proved difficult due to nonresponse.

The UC and NTP groups were comparable for gender, mean age, VAS-score on admission, site of injury, identified fractures and patient disposal (Table 1).

3.2 | Outcomes

3.2.1 | Primary Outcome: Flow Times

Normality of continuous variables was assessed using both *Z*-scores for skewness/kurtosis and the Shapiro–Wilk test. All primary time-based outcome measures (T_5-T_0, T_2-T_0, T_5-T_2) were non-normally distributed ($p<0.01$), justifying the use of non-parametric tests. Mann–Whitney *U* tests were performed to evaluate whether flow times differed by group (Table 2).

The results indicated that there was no significant difference ($z=-1.26$, $p=0.21$) between TLOS (T_5-T_0) of the NTP group and the UC group with a small effect size ($r=0.09$). The median (IQR) for the NTP group was 90 (63–120) and 97 (66–133) for the UC group as shown in Figure 3.

The NTP group had significantly lower flow times (in minutes) between registration at the ED and digital request for medical imaging (T_2-T_0) ($z=-7.50$, $p<0.01$) with a large effect size ($r=0.51$). The median (IQR) for the NTP group was 17 (11–27) and 38 (22–66) for the UC group as shown in Figure 4.

The UC group had significantly lower flow times between digital request for medical imaging and time of discharge from the ED or request of additional imaging by an orthopedic surgeon (T_5-T_2) ($z=-3.58$, $p<0.01$) with a small-to-medium effect ($r=0.24$). The median (IQR) for the NTP group was 67 (47–95) and 54 (34–74) for the UC group as shown in Figure 5. A drop in sample size from 215 participants to 212 participants is noted

TABLE 2 | Comparison of median flow times between usual care and nursing triage protocol groups in minutes.

		Total sample ($n=215$)	Usual care ($n=107$)	Nursing triage protocol ($n=108$)	p	Effect size (r)	U
TLOS (T_5–T_0), min	Median (IQR)	91 (65–128)	97 (66–133)	90 (63–120)	0.21[a]	0.09	5205[a]
Registration to X-ray request (T_2–T_0), min	Median (IQR)	24 (15–45)	38 (22–66)	17 (11–27)	<0.01[a]	0.51	2270[a]
X-ray request to discharge (T_5–T_2), min	Median (IQR)	62 (40–85)	54 (34–74)	67 (47–95)	<0.01[a]	0.24	4021[a]

Abbreviations: IQR, interquartile range; SD, standard deviation; TLOS, total length of stay.
[a]Mann–Whitney U test.

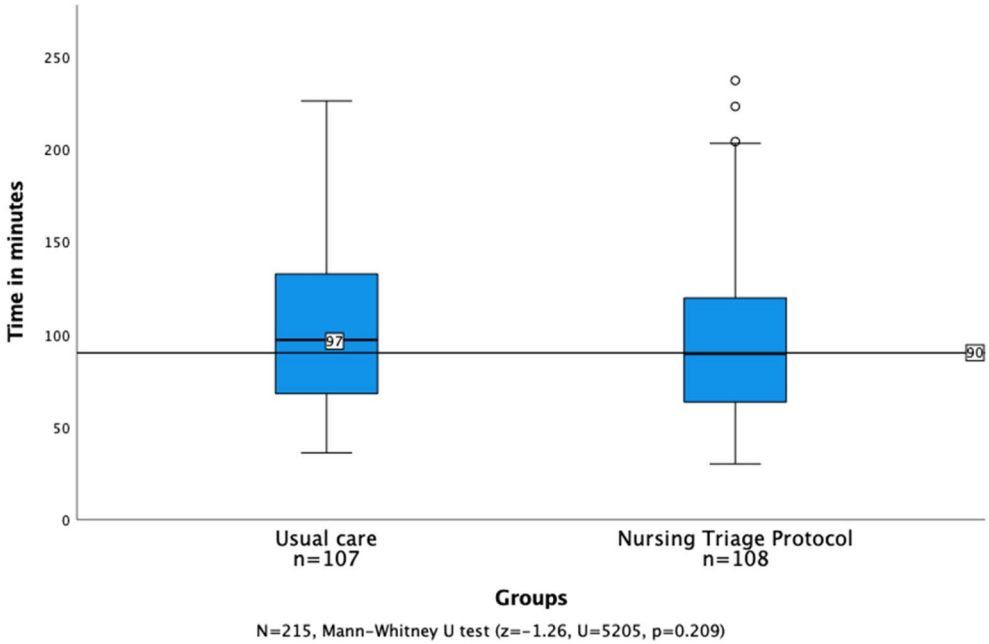

FIGURE 3 | Boxplot of the difference in total length of stay (in minutes) (T_5–T_0) between the usual care and nursing triage protocol groups.

in both flow times seeing that 3 participants did not receive an X-ray.

3.2.2 | Secondary Outcomes

3.2.2.1 | Patient Satisfaction. The results of 178/220 (81%) participants were analyzed for the secondary outcome measure patient satisfaction with 84/110 (76%) participants in the NTP group and 94/110 (86%) participants in the UC group (Table 3). The discrepancy in numbers compared to the primary outcome analysis reflects missing or incomplete questionnaire data.

All satisfaction scores showed a skewed distribution after assessing for normality using both Z-scores and the Shapiro–Wilk test ($p<0.01$), justifying the use of non-parametric tests.

A Mann–Whitney U test indicated that there was no significant difference between overall satisfaction scores between the UC group and the NTP group ($z=-1.67$, $p=0.10$) with a small effect size ($r=0.13$). The median (IQR) for both groups was 9 (8–10) for overall satisfaction scores.

Satisfaction scores for waiting times and the physical exam performed by the triage nurse in the NTP group, or the emergency physician in the UC group showed a skewed distribution. Mann–Whitney U tests were performed. Satisfaction scores showed no significant difference between the NTP group and the UC group for waiting times ($z=-1.28$, $p=0.20$, $r=0.10$) or physical exam ($z=-0.44$, $p=0.66$, $r=0.03$). The median (IQR) for both groups was 8 (7–9) for waiting times and 9 (8–10) for physical exam.

3.2.2.2 | Treatment Adjustment. A Fisher's exact test showed a significant difference ($p=0.01$) in number of participants who had a follow-up appointment at the orthopedics department (Table 4). Of the participants who did not receive follow-up at the orthopedics department 11 participants indicated that they sought additional medical care elsewhere (i.e., registration at

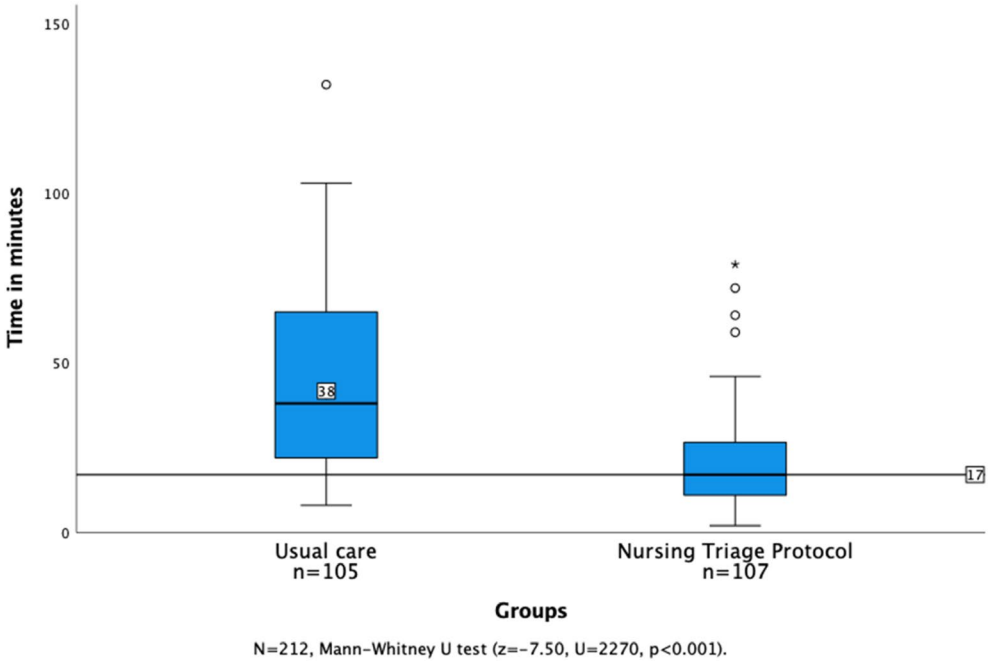

FIGURE 4 | Boxplot of the difference in flow time (in minutes) between registration at the ED and digital request for medical imaging (T_2–T_0) between the usual care and nursing triage protocol groups.

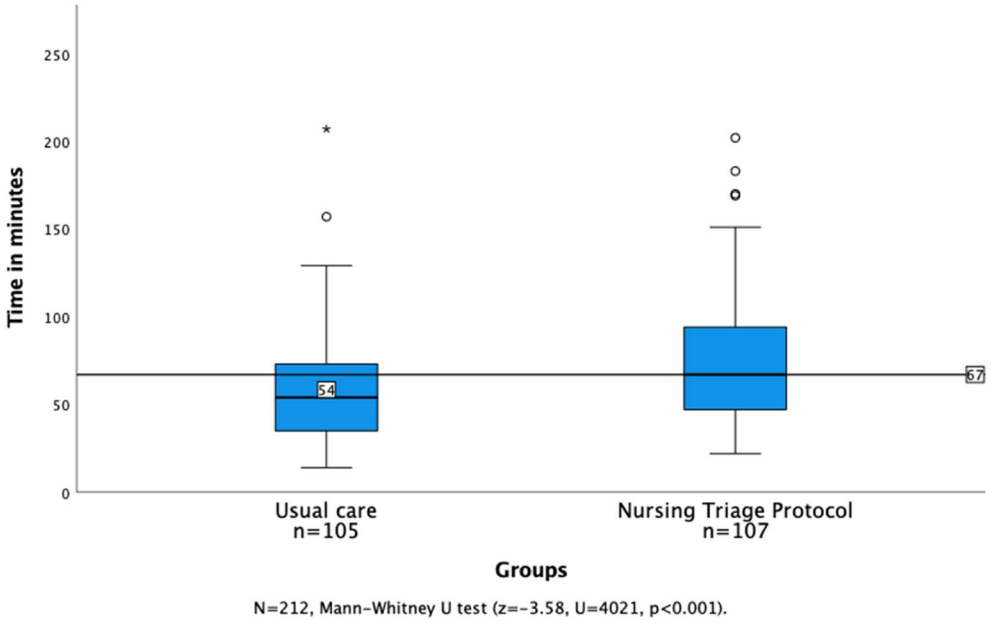

FIGURE 5 | Boxplot of the difference in flow time (in minutes) between digital request for medical imaging and discharge from the department or the time of request for additional imaging (i.e., CT or ultrasound) by an orthopedic surgeon (T_5–T_2) between the usual care and nursing triage protocol groups.

another ED, appointment with a general practitioner, ...) in the UC group versus 1 participant in the NTP group ($p = 0.02$).

Comparing the proportions of participants that had their initial treatment adjusted (19/119, 16%), either at the orthopedics department or elsewhere, showed no significant difference ($p = 1.00$) between the UC or NTP group. Subgroup analysis of participants who received follow-up at the orthopedics department showed no significant difference ($p = 0.58$) for the adjustment of the initiated treatment at the ED.

Subgroup analyses regarding treatment adjustments, particularly among participants who did not receive follow-up at the orthopedics department, involved very small cell sizes (e.g., 4 in the UC group and 0 in the NTP group). The resulting p values ($p = 1.00$) may not reflect true lack of effect but rather the inability to detect differences due to insufficient sample size.

These small groups should be interpreted with caution, and no definitive conclusions can be drawn regarding treatment adjustment differences based on these findings alone.

TABLE 3 | Median for satisfaction scores for overall satisfaction, waiting times and physical exam performed by the triage nurse in the nursing triage protocol group versus an emergency physician in the usual care group.

		Usual care ($n=94$)	Nursing triage protocol ($n=84$)	p	Effect size (r)
Overall satisfaction	Median (IQR)	9 (8–10)	9 (8–10)	0.10[a]	0.13
Waiting times satisfaction	Median (IQR)	8 (7–9)	8 (7–9)	0.20[a]	0.10
Physical exam satisfaction	Median (IQR)	9 (8–10)	9 (8–10)	0.66[a]	0.03

[a]Mann–Whitney U test.

TABLE 4 | Treatment adjustment between the usual care and nursing triage protocol groups.

		Usual care ($n=107$)	Nursing triage protocol ($n=108$)	p
Received follow-up at orthopedics department, n (%)	No	63 (59)	45 (42)	0.01[a]
	Yes	44 (41)	63 (58)	
		Usual care ($n=44$)	**Nursing triage protocol ($n=63$)**	**p**
Subgroup analysis: participants who received follow-up at the orthopedics department				
Initial treatment adjusted, n (%)	No	39 (87)	53 (84)	0.58[a]
	Yes	5 (11)	10 (16)	
		Usual care ($n=63$)	**Nursing triage protocol ($n=45$)**	**p**
Subgroup analysis: participants who did not receive follow-up at the orthopedics department				
Nonresponse, n (%)	No	26 (41)	16 (36)	
	Yes	37 (59)	29 (64)	
Sought additional medical care elsewhere, n (%)	No	15 (58)	15 (94)	0.02[a]
	Yes	11 (42)	1 (6.3)	
Initial treatment adjusted, n (%)	No	7 (64)	*1 (100)*	1.00[a]
	Yes	4 (36)	*0 (0)*	

Note: Subgroup comparisons involving small cell sizes ($n<5$) were included for completeness but should be interpreted with caution due to limited power and increased risk of Type II error (in italics).
[a]Fisher's exact test.

3.2.2.3 | X-Rays Requested by an Emergency Physician in the NTP Group. In one participant (1/108, 1%) the triage nurse deemed medical imaging unnecessary based on the NTP. An X-ray was requested by the emergency physician based on clinical expertise which did not identify a fracture.

Additional X-rays were requested by emergency physicians for 2/108 (2%) participants in the NTP group. In one case (1/108, 1%) the NTP was not followed correctly, and a fracture was missed. In the other case (1/108, 1%) the emergency physician requested an additional X-ray based on clinical expertise which did not show a fracture.

3.2.3 | Harms

No important adverse events occurred.

4 | Discussion

The implementation of a NTP did not affect the TLOS of participants in the ED in this study. Earlier studies concerning nurse-initiated X-rays focus mainly on the use of the Ottawa ankle rules (OAR) by triage nurses for patients with ankle or foot injuries. The results in these studies (Sorensen et al. 2012; Allerston and Justham 2000; Al Abri et al. 2020; Lee et al. 2016; Ho et al. 2018; Fan and Woolfrey 2006) and other studies, where participants with other distal limb injuries were included (Parris et al. 1997; Thurston and Field 1996), ranged from a non-significant reduction of TLOS of 4 min (Thurston and Field 1996) (MD = −4, $p=0.10$) to a significant reduction of 45 min (Sorensen et al. 2012) (MD = −45, $p<0.03$). However, definition of TLOS and eligibility criteria differed between these studies and methodologic quality was moderate to very low as confirmed by recent systematic reviews (Considine et al. 2019; Gottlieb et al. 2021).

A significant difference in flow times between registration at the ED and digital request for medical was reported in favor of the NTP group. This is a logical consequence of requesting X-rays at the time of triage and was also reported in other studies (Bliss et al. 1971; Matteucci and Roos 2003). However, the significant difference, in favor of the UC group, in flow times between the time of patient registration at the ED and discharge from the department or request of additional imaging by an orthopedic surgeon, was unexpected. Informal interviews with care providers involved in the study were performed to determine a possible cause for this result: involved emergency physicians argued that it is possible that they are more aware of patients' presence when they themselves request X-rays and therefore are more inclined to expedite discharge once the X-ray is executed.

Furthermore, only one participant (1/108, 1%) in the NTP group did not receive an X-ray. This could be a sign of the NTP being too rigid. However, only two participants (2/108, 2%) did not

receive an X-ray in the UC group. Even though X-rays are useful to identify fractures in patients with orthopedic injuries, standard execution is not recommended. It increases health expenditure, radiation exposure of patients and TLOS (Mendelson and Bairstow 2010).

Patient satisfaction scores did not differ significantly between the NTP and UC groups. These results are in line with earlier studies (Fan and Woolfrey 2006; Sakr et al. 1999). No significant difference in patient satisfaction scores for the physical exam between groups shows that trained triage nurses are perceived as qualified as emergency physicians by participants. Furthermore, the shift in waiting times (after request for X-ray in the NTP group and before request for X-ray in the UC group) did not seem to affect the satisfaction scores for waiting times. However, the lack of use of a validated patient satisfaction model (Ye et al. 2022; Sun et al. 2001) is a limitation in this study.

Significantly more participants in the NTP group received follow-up at the orthopedics department. A follow-up appointment at the orthopedics department was offered to all participants but was not mandatory for participation in the study. Of the participants who did not receive follow-up, significantly more participants in the UC group sought additional medical care elsewhere (i.e., registration at another ED, appointment with a general practitioner, ...). These results could potentially indicate a study effect (where the NTP group was better informed by a nurse to book a follow-up appointment during informed consent). However, for patients who were lost to follow-up, treatment adjustment could not be assessed. This nonresponse caused an important reduction in sample size for this outcome; therefore, the results should be interpreted with caution.

Another limitation for this study is the lack of data collected for participants assessed which reduces external validity and could mask selection bias during recruitment of participants. To address this in future trials, we recommend conducting a pilot test for data collection procedures to assess feasibility and ensure the ability to track eligibility assessments reliably, even in fast-paced clinical environments. Moreover, a single center study design, with a specific patient population, ED design, staffing and patient flow characteristics limits generalizability to other EDs where nurse-initiated X-rays may have differing effects. Additionally, the study was performed in Belgium and caution will therefore be needed in generalizing the results to other countries with different care systems and potential cultural differences. Finally, one participant was included in the analysis despite a protocol deviation related to eligibility (a prior ED visit for the same injury). While this was consistent with the intention-to-treat approach, no separate per protocol analysis was conducted given the minimal expected impact on study outcomes; this nonetheless represents a minor limitation in protocol adherence.

Staff satisfaction was not assessed, but informal interview revealed both nurses and emergency physicians welcomed the use of nurse-initiated X-rays in expanding the nursing role. The acceptance of such nurse-initiated practices by the emergency physicians has important benefits for inter-professional staff development. Expanding the scope of practice of triage nurses by allowing them to order tests has been suggested to improve the triage process (Javidan et al., n.d.). The addition of nurse-initiated X-rays at triage may increase workload for triage nurses, resulting in delay in triage for other ED patients. We did not specifically observe the added time needed for assessment and ordering of X-rays at triage.

Further research relating to nurse-initiated X-rays is required to ensure that expanding the role of the triage nurse increases staff satisfaction and retention rates in the ED. In addition, further research is needed to determine if the introduction of a NTP is of added value. It should be linked to the introduction of nurse practitioners who have the autonomy to discharge patients which could shorten the length of stay and improve follow-up (Javidan et al., n.d.).

5 | Conclusions

The study did not show a significant reduction in TLOS for patients with minor orthopedic trauma following the implementation of the NTP. The results showed a significant reduction in flow times between registration at the ED and digital request for medical imaging for participants in the NTP group. Participants in the UC group had significantly lower flow times between digital request for medical imaging and time of discharge from the ED or request of additional imaging by an orthopedic surgeon. The potential for reduction of flow times throughout the ED is, however, evident. In addition, patient satisfaction and treatment adjustment results did not differ significantly between both groups.

6 | Relevance for Clinical Practice

This study shows that the implementation of a nursing triage protocol specifically aimed at patients with minor orthopedic injuries that require medical imaging can reduce flow times in the ED.

Author Contributions

S.B. (corresponding author) contributed to conceptualization, investigation, methodology development, validation, software and visualization tasks, and formal analysis. S.B. drafted the original manuscript, managed project administration, and performed data curation. R.L. contributed to manuscript review and editing and provided supervision. T.V.Z. contributed to the investigation, data curation, and manuscript review and editing, and also provided supervision. F.H. contributed to the conceptualization of the study, validation of the methodology, formal analysis, data curation, and manuscript review and editing. F.H. also supervised the project.

Ethics Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by a central Ethics Committee of the University (Hospital) of Antwerp (Project ID 5197—BUN B3002023000049—approved 20/02/2023) for studies involving humans.

Consent

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Al Abri, F. H., J. K. Muliira, and H. Al Awaisi. 2020. "Effect of Triage Nurse-Led Application of the Ottawa Ankle Rules on Number of Radiographic Tests and Length of Stay in Selected Emergency Departments in Oman." *Japan Journal of Nursing Science* 17: e12270. https://doi.org/10.1111/jjns.12270.

Allerston, J., and D. Justham. 2000. "A Case-Control Study of the Transit Times Through an Accident and Emergency Department of Ankle Injured Patients Assessed Using the Ottawa Ankle Rules." *Accident and Emergency Nursing* 8: 148–154. https://doi.org/10.1054/aaen.2000.0104.

Beckenkamp, P. R., C. C. Lin, P. Macaskill, Z. A. Michaleff, C. G. Maher, and A. M. Moseley. 2017. "Diagnostic Accuracy of the Ottawa Ankle and Midfoot Rules: A Systematic Review With Meta-Analysis." *British Journal of Sports Medicine* 51: 504–510. https://doi.org/10.1136/bjsports-2016-096858.

Bliss, A., L. Decker, and W. O. Southwick. 1971. "The Emergency Room Nurse Orders X-rays of Distal Limbs in Orthopedic Trauma." *Nursing Research* 20: 440–443.

Bussières, A. E., C. Peterson, and J. A. Taylor. 2008. "Diagnostic Imaging Guideline for Musculoskeletal Complaints in Adults—An Evidence-Based Approach—Part 2: Upper Extremity Disorders." *Journal of Manipulative and Physiological Therapeutics* 31: 2–32. https://doi.org/10.1016/j.jmpt.2007.11.002.

Considine, J., R. Z. Shaban, K. Curtis, and M. Fry. 2019. "Effectiveness of Nurse-Initiated X-Ray for Emergency Department Patients With Distal Limb Injuries: A Systematic Review." *European Journal of Emergency Medicine* 26: 314–322. https://doi.org/10.1097/mej.0000000000000604.

Derksen, R. J., F. C. Bakker, E. S. de Lange-de Klerk, et al. 2007. "Specialized Emergency Nurses Treating Ankle and Foot Injuries: A Randomized Controlled Trial." *American Journal of Emergency Medicine* 25: 144–151. https://doi.org/10.1016/j.ajem.2006.06.011.

Elshove-Bolk, J., F. Mencl, B. T. van Rijswijck, M. P. Simons, and A. B. van Vugt. 2007. "Validation of the Emergency Severity Index (ESI) in Self-Referred Patients in a European Emergency Department." *Emergency Medicine Journal* 24: 170–174. https://doi.org/10.1136/emj.2006.039883.

Erenler, A. K., S. Akbulut, M. Guzel, et al. 2016. "Reasons for Overcrowding in the Emergency Department: Experiences and Suggestions of an Education and Research Hospital." *Turkish Journal of Emergency Medicine* 14: 59–63. https://doi.org/10.5505/1304.7361.2014.48802.

Fan, J., and K. Woolfrey. 2006. "The Effect of Triage-Applied Ottawa Ankle Rules on the Length of Stay in a Canadian Urgent Care Department: A Randomized Controlled Trial." *Academic Emergency Medicine* 13: 153–157. https://doi.org/10.1197/j.aem.2005.07.041.

Farfan-Portet, M., C. Dubois, P. Mistiaen, et al. n.d. "Naar een geïntegreerd systeem voor de behandeling van ernstige trauma's." Accessed October 15, 2021. https://kce.fgov.be/nl/naar-één-geïntegreerd-systeem-voor-de-behandeling-van-ernstige-traumas.

Gilboy, N., P. Tanabe, D. A. Travers, A. M. Rosenau, and D. R. Eitel. 2005. *Emergency Severity Index, Version 4: Implementation Handbook*. Agency for Healthcare Research and Quality.

Gorbachova, T., E. Y. Chang, A. S. Ha, et al. 2020. "ACR Appropriateness Criteria Acute Trauma to the Foot." *Journal of the American College of Radiology* 17: S2–s11. https://doi.org/10.1016/j.jacr.2020.01.019.

Gottlieb, M., D. A. Farcy, L. A. Moreno, G. M. Vilke, and J. A. Guittard. 2021. "Triage Nurse-Ordered Testing in the Emergency Department Setting: A Review of the Literature for the Clinician." *Journal of Emergency Medicine* 60: 570–575. https://doi.org/10.1016/j.jemermed.2020.11.004.

Hartziekenhuis, H. 2020. "*Jaarverslag*." Mol.

Ho, J. K., J. P. Chau, J. T. Chan, and C. H. Yau. 2018. "Nurse-Initiated Radiographic-Test Protocol for Ankle Injuries: A Randomized Controlled Trial." *International Emergency Nursing* 41: 1–6. https://doi.org/10.1016/j.ienj.2018.04.001.

Javidan, A. P., K. Hansen, I. Higginson, P. Jones, and E. Lang. 2021. "The International Federation for Emergency Medicine Report on Emergency Department Crowding and Access Block: A Brief Summary." *Emergency Medicine Journal* 38: 245–246. https://doi.org/10.1136/emermed-2020-210716.

Javidan, A. P., I. Higginson, P. Jones, et al. n.d. "Report from the Emergency Department Crowding and Access Block Task Force." Accessed July 20, 2023. https://www.ifem.cc/resource-library/.

Kim, J. Y., and E. Cho. 2017. "Evaluation of a Self-Efficacy Enhancement Program to Prevent Pressure Ulcers in Patients With a Spinal Cord Injury." *Japan Journal of Nursing Science* 14: 76–86.

Lazarus, B., Y. Chen, F. P. Wilson, et al. 2016. "Proton Pump Inhibitor Use and the Risk of Chronic Kidney Disease." *JAMA Internal Medicine* 176: 238–246. https://doi.org/10.1001/jamainternmed.2015.7193.

Lee, W. W., L. Filiatrault, R. B. Abu-Laban, A. Rashidi, L. Yau, and N. Liu. 2016. "Effect of Triage Nurse Initiated Radiography Using the Ottawa Ankle Rules on Emergency Department Length of Stay at a Tertiary Centre." *CJEM* 18: 90–97. https://doi.org/10.1017/cem.2015.67.

Lindley-Jones, M., and B. J. Finlayson. 2000. "Triage Nurse Requested X Rays—Are They Worthwhile?" *Journal of Accident & Emergency Medicine* 17: 103–107. https://doi.org/10.1136/emj.17.2.103.

Matteucci, M. J., and J. A. Roos. 2003. "Ottawa Knee Rule: A Comparison of Physician and Triage-Nurse Utilization of a Decision Rule for Knee Injury Radiography." *Journal of Emergency Medicine* 24: 147–150. https://doi.org/10.1016/s0736-4679(02)00716-3.

Mendelson, R., and P. Bairstow. 2010. "Inappropriate Imaging: Why It Matters, Why It Happens, What Can Be Done." *Journal of Medical Imaging and Radiation Oncology* 54: 173–177. https://doi.org/10.1111/j.1754-9485.2010.02173.x.

Parris, W., S. McCarthy, A. M. Kelly, and S. Richardson. 1997. "Do Triage Nurse-Initiated X-Rays for Limb Injuries Reduce Patient Transit Time?" *Accident and Emergency Nursing* 5: 14–15. https://doi.org/10.1016/s0965-2302(97)90056-4.

Pedersen, G. B., and J. O. Storm. 2009. "Emergency Department X-Rays Requested by Physicians or Nurses." *Ugeskrift for Laeger* 171: 1747–1751.

Sakr, M., J. Angus, J. Perrin, C. Nixon, J. Nicholl, and J. Wardrope. 1999. "Care of Minor Injuries by Emergency Nurse Practitioners or Junior Doctors: A Randomised Controlled Trial." *Lancet* 354: 1321–1326. https://doi.org/10.1016/s0140-6736(99)02447-2.

Smith, S. E., E. Y. Chang, A. S. Ha, et al. 2020. "ACR Appropriateness Criteria Acute Trauma to the Ankle." *Journal of the American College of Radiology* 17: S355–s366. https://doi.org/10.1016/j.jacr.2020.09.014.

Sorensen, E. L., A. Keeling, A. Snyder, and S. Syverud. 2012. "Decreasing ED Length of Stay With Use of the Ottawa Ankle Rules Among Nurses." *Journal of Emergency Nursing* 38: 350–352. https://doi.org/10.1016/j.jen.2011.02.014.

Sun, B. C., J. G. Adams, and H. R. Burstin. 2001. "Validating a Model of Patient Satisfaction With Emergency Care." *Annals of Emergency Medicine* 38: 527–532. https://doi.org/10.1067/mem.2001.119250.

Tambimuttu, J., R. Hawley, and A. Marshall. 2002. "Nurse-Initiated x-Ray of Isolated Limb Fractures in the Emergency Department: Research Outcomes and Future Directions." *Australian Critical Care* 15: 119–122. https://doi.org/10.1016/s1036-7314(02)80052-2.

Thurston, J., and S. Field. 1996. "Should Accident and Emergency Nurses Request Radiographs? Results of a Multicentre Evaluation." *Journal of Accident & Emergency Medicine* 13: 86–89. https://doi.org/10.1136/emj.13.2.86.

Vermeir, B. 2024. "Jaarverslag 2024*: Urgentiegeneeskunde*; AZORG."

Ye, F., L. Parast, R. D. Hays, et al. 2022. "Development and Validation of a Patient Experience of Care Survey for Emergency Departments." *Health Services Research* 57: 102–112. https://doi.org/10.1111/1475-6773.13853.