Improving emergency department flow by introducing four interventions simultaneously

A quality improvement project

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Review

Improving emergency department flow by introducing four interventions simultaneously. A quality improvement project

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ABSTRACT

Background: Emergency department (ED) crowding is a widespread issue with adverse effects on patient care and outcomes.
Local problem: ED crowding exacerbates wait times and compromises patient care, prompting opportunities for internal process improvement.
Method: Over one week, the ED flow project team implemented four interventions, including an additional triage station, to optimize patient flow. We compared triage times, length of stay, crowding levels, and patient experiences with two control periods.
Results: During peak hours, waiting times to triage decreased significantly with a median of 20 min (IQR 15–30) in the project week and 26 min (IQR 18–37) in the control weeks. Self-referrals decreased, while general practitioner referrals remained unchanged. Individual patient length of stay was unaffected, but crowding reduced notably during the project week. We found no difference in patient experiences between the periods.
Conclusion: The interventions contributed to reduced crowding and improved patient flow. The dedication of the ED flow project team and the ED nurses was crucial to these outcomes. An additional triage station during peak hours in the ED was established as a structural change.

1. Background and problem statement

Emergency department (ED) crowding is a widespread issue [1] with adverse effects on patient care and outcomes [2–5]. It stems primarily from insufficient hospital capacity, in terms of beds and/or staff, and it often results in admitted patients staying in the ED [4]. Thus, crowding is not confined to the ED alone; it is a broader systemic problem affecting the entire hospital [5]. While various external factors contribute to crowding, there are opportunities for process improvement within the ED's input, throughput, and output phases [6].

To achieve this, we assembled an ED flow project team comprising two ED nurses, two emergency physicians, a surgeon, a radiologist, an ED nurse manager, and a quality officer. The latter served as the project leader, collaborating with the team to develop four interventions aimed at optimizing processes and reduce crowding. These interventions were then implemented and tested during a project week. Here are the interventions:

Abbreviations: CEN, Certified Emergency Nurse; CI, Confidence interval; ED, Emergency department; GP, General practitioner; GPC, General practitioner cooperative; HMC, Haaglanden Medical Center; IQR, Interquartile range; mNEDOCS, Modified National Emergency Department OverCrowding Score; NEDOCS, National Emergency Department OverCrowding Score; N, Number; NP, Nurse practitioner; SPSS, Statistical Package for the Social Sciences.

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To manage the peak influx of patients between 3 and 5 p.m., an additional triage station was introduced. This involved modifying a nurse's work schedule from the day shift. Originally scheduled from 7:30 a.m. to 4 p.m., ED management adjusted the shift timing 8:30 a.m. to 5 p.m., allowing two triage stations to operate simultaneously during peak hours.

In our routine scenario, patients undergo triage and then wait in the waiting room until a treatment room becomes available, where a medical specialist is called to assess the patient. During the project week, a new procedure was experimented with between 12 and 8 p.m. Instead of waiting in the waiting room, patients referred for surgery or traumatology as well as self-referrals with trauma-related issues, were promptly assessed by the on-duty surgeon during triage. The triage nurse called the surgeon, and the surgeon then assessed those patients immediately in the triage room. The aim was to determine the most suitable examination location, whether within the ED or at outpatient clinics.

Patients presenting with abdominal complaints between 12 and 8 p.m. underwent point of care testing (POCT) for C-reactive protein (CRP) during triage, in addition to the usual blood and urine sampling. Those with elevated CRP (15 or higher) received immediate ultrasound evaluation, streamlining the diagnostic process. The triage nurse performed these procedures and could also independently request an ultrasound, without involving a physician.

Patients not requiring a bed or monitoring were directed to a secondary waiting area until their results were available, minimizing unnecessary occupation of treatment rooms or beds. The doctor subsequently called them in for either an exit interview or treatment. Responsibility for patients awaiting results lies with the healthcare provider who ordered the tests.

Patients were not involved in the project design or intervention selection.

To evaluate the project week, two researchers were involved (CL and NL) in determining outcome measures. Experiences of patients arriving between 12 and 8 p.m. during the intervention week and control weeks were captured through interviews conducted by students.

1.1. Project aim

This study aims to compare triage waiting times, individual ED length of stay, ED crowding, and patient experiences between the intervention (project) week and control weeks, with the goal of informing future improvements in patient care.

2. Methods

2.1. Context

The Haaglanden Medical Center is situated in The Hague, The Netherlands. This 26-bed ED functions as a regional level 1 trauma and acute neurovascular centre, receiving approximately 50,000 adult and paediatric patient visits annually, with a 30 % admission rate. The ED provides both highly complex and basic emergency care for adult and paediatric patients. Staffing typically includes emergency physicians (EPs) and EP residents available 24/7. Cardiology, neurology, surgery, internal medicine and radiology residents are in-house available 24/7 to provide patient care. Based on a previous project in which the effect of deploying additional medical specialists on patient flow was assessed, a cardiologist, an internal medicine specialist, a neurologist, a radiologist and a surgeon work alongside EPs and residents during peak hours (from 12 to 8 p.m.) [7]. Other medical specialists are available in the hospital during office hours and on-call outside office hours when needed. Nursing staff comprises certified emergency nurses (CENs) (75 %), nurse practitioners (NPs) (5 %) and registered nurses in training for CEN (20 %).

Upon arrival, self-referrals are directed to the General Practitioner Cooperative (GPC) unless emergency care is required, determined by triage performed by the GPC staff. The GPC, a facility where GPs work together to provide out-of-hours primary care services, is located adjacent to the ED.

The remaining patients are registered at the ED and triaged using the Manchester Triage System (MTS) [8], which categorizes patients into immediate (level 1), highly urgent (level 2), urgent (level 3), standard (level 4) and non-urgent (level 5) categories.

2.2. Measures

We conducted an observational study over three weeks in November 2022, one intervention week and two control weeks (before and after the intervention week). We compared triage times between patients arriving between 3 and 5 p.m. in the intervention week and patients arriving between 3 and 5 p.m. in the control weeks. We compared patients' length of stay, crowding levels and patient experiences between patients arriving between 12 and 8 p.m. in the intervention week with patients arriving between 12 and 8 p.m. in the control weeks. Data were extracted from the electronic health record system, including demographic details (age, sex), ED arrival and discharge times, triage information, and discharge disposition for each ED visit. Waiting times to triage (time from registration to triage level assignment) were calculated for patients arriving between 3 and 5 p.m. Additionally, ED length of stay (time from registration until departure) was assessed for all visits between 12 and 8 p.m., aligning with the planned interventions 2, 3, and 4.

ED crowding was measured using a modified version of the National Emergency Department Over Crowding Score (NEDOCS) [9,10], a multidimensional scale. The modified NEDOCS (mNEDOCS) incorporates variables automatically derived from the hospital information system every 15 min, including total ED and hospital beds, patient counts, admit times, and resuscitation activity. The mNEDOCS has been previously shown to correlate well with perceived crowding in this ED [10]. Crowding was defined as a mNEDOCS of > 100, with scores of 61 and higher indicating extreme busyness.

During the study period, research assistants were present at the ED from 12 to 8 p.m. to administer patient experience surveys based on the Patient Picker Experience [11]. Surveys included questions on waiting times, physician interactions, information provision, and overall satisfaction. Questions had 3 to 5 response options (Appendix). Overall patient experience (response to the question "Please rate your overall experience at our ED") and likelihood of recommendation (response to the question "How likely would you be to recommend this ED to friends and family?") were scored using a 10-point Likert scale. Patient identifiers were not collected to ensure anonymity. Patients redirected to the GPC or the Chest Pain Unit (CPU) were excluded from analyses.

2.3. Data analysis

Patient and visit characteristics: Triage levels 1, 2 and 3 were grouped as 'urgent', while levels 4 and 5 were grouped as 'non-urgent'. Descriptive statistics, chi-square tests, and Mann–Whitney U tests were employed as appropriate. Odds ratio and their 95 % confidence intervals were reported when applicable. Significance was determined at $p < 0.05$. Statistical analyses were conducted using SPSS (IBM Corp., IBM SPSS Statistics for Windows, version 26.0, Armonk, New York, USA).

Patient Experiences: Neutral responses were coded as "non-problem", while positive answers were also categorized as "non-problem." Remaining responses were labelled as "problems." Likelihood of recommendation was assessed using the Net Promotor Score (NPS), calculated by subtracting the percentage of detractors (respondents' score: 0–6) from the percentage of promoters (respondents' score: 9–10). The NPS ranges between -100 and $+100$, with a positive score indicating favourable feedback [12].

The study was exempted from review by the regional medical ethics committee and the institutional review board (METC-LDD, N22-095). We adhered to the SQUIRE (Standards for Quality Improvement Reporting Excellence) guidelines in the drafting of this article [13].

3. Results

Over the 21-day study period, 3120 patient visits were recorded, averaging approximately 149 visits per day. We excluded patients redirected to the GPC at triage (n = 146) and those assessed at the CPU (n = 328). Of the remaining 2646 patient visits, 1330 occurred between 12 and 8p.m., with 424 in the intervention week, and 906 in the control weeks (Fig. 1).

An average of 65 patients per day presented between 12 and 8 p.m. during the control period, compared to 61 patients per day during the intervention period. The number of daily presentations was similar between the intervention and control periods, except on Sundays, when significantly more patients presented during the intervention period (Table 1). There were no differences in patient visit characteristics between the intervention and control period, except for the percentage of patients presenting with extremity injuries and the percentage of self-referrals. During the intervention period, 13.9 % of the patients presented with extremity injuries, whereas this figure was 19.8 % during the control period. Additionally, 6.8 % of patients were self-referred to the ED during the intervention period, compared to 10.7 % during the control period. The percentage of self-referrals presenting with extremity injuries decreased from 36 % in the control period to 32.1 % in the intervention period.

Triage times

For this outcome measure, we analysed ED visits with an arrival time between 3 and 5 p.m., coinciding with the installation of an additional triage station during the intervention period. There were 347 ED visits between 3 and 5 p.m., with 113 occurring during the intervention period and 234 during the control period. Triage times were available for 318 ED visits, comprising 103 (91.2 %) in the intervention period and 215 (91.9 %) in the control period.

Triage times exhibited a significant decrease ($p < 0.001$), with a median of 20 min (IQR 15–30) in the intervention period compared to 26 min (IQR 18–37) in the control period. However, there was no difference in the number of patients triaged within 10 min.

Length of stay and emergency department crowding

For this outcome measure, we analysed ED visits with an arrival time between 12 and 8 p.m. Data on ED length of stay were available for 422 out of 424 ED visits (99.5 %) during the intervention period and for 902 out of 906 (99.6 %) during the control period. Our analysis revealed no statistically significant differences in ED length of stay between the two periods (Table 2).

A sub group of patients arriving from Monday to Friday was analysed to account for variability in the processes and availability of resources or personnel, which may differ between weekends and weekdays. For this sub group, the median length of stay was significantly shorter in the intervention period (168 min) compared to the control period (184 min, p = 0.02) (Table 3). Additionally, for patients referred by the GP to surgery and for self-referrals, the median length of stay was significantly shorter during the intervention period.

During the study period, we collected a total of 672 mNEDOCS measurements between 12 and 8 p.m. (21 days * 32 quarters).

The ED experienced lower levels of crowding during the intervention period, with 30.4 % of the measurements indicating the ED was extremely busy, compared to 46.4 % during the control period (Table 4). Notably, crowding, defined as a mNEDOCS score above 100, did not occur during the intervention period.

Patient experiences

Research assistants collected a total of 109 patient experience surveys in patients arriving between 12 and 8 p.m. Our analysis revealed no differences in responses to the questions, patient satisfaction, or overall patient experience scores, with median scores of eight in both periods. The NPS was 81.8 in the intervention period and 58.8 in the control period, though this difference did not reach statistical significance (OR 2.59, 95 % CI 0.28 to 23.8).

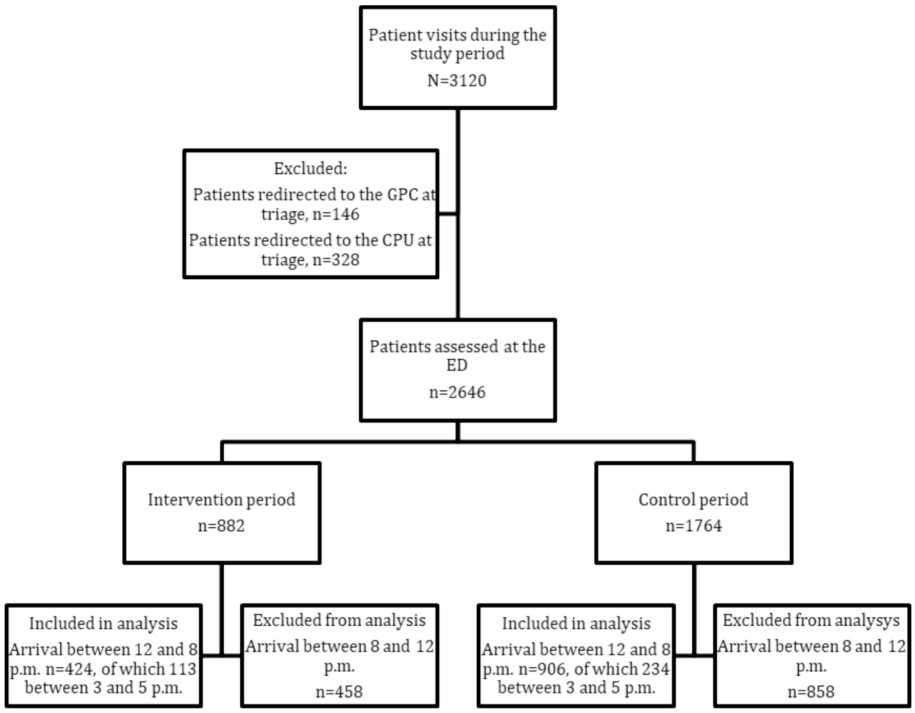

Fig. 1. Flow chart study participants. Abbreviations: CPU, chest pain unit; ED, emergency department; GPC, general practitioner cooperative; N, number; p.m., post meridiem.

Table 1
Baseline characteristics of patient presentations in the study periods.

Patients arriving between 12 and 8 p.m., N=1330	Intervention period N=424	Control period N=906	Odds Ratio (95 % CI)
Weekday % (n)			
Monday	65 (15.3)	152 (16.8)	0.90 (0.65, 1.23)
Tuesday	67 (15.8)	128 (14.1)	1.14 (0.83, 1.57)
Wednesday	53 (12.5)	137 (15.1)	0.80 (0.57, 1.13)
Thursday	59 (13.9)	130 (14.3)	0.97 (0.69, 1.35)
Friday	67 (15.8)	147 (16.2)	0.97 (0.71, 1.33)
Saturday	53 (12.5)	124 (13.7)	0.90 (0.64, 1.27)
Sunday	60 (14.2)	88 (9.7)	1.53 (1.08, 2.18) *
Median age in years (IQR)	49 (25–69)	51 (28–71)	0.19**
Self-referred % (n)	6.8 (29)	10.7 (97)	0.61 (0.40–0.94) *
Patients referred by GP to surgery % (n)	17.0 (72)	15.8 (143)	1.09 (0.80 – 1.49)
Arrival by ambulance % (n)	29.0 (123)	27.9 (253)	1.06 (0.82–1.36)
Acuity level % (n)			
Urgent	73.5 (285)	75.1 (626)	0.92 (0.70–1.21)
Presenting problem % (n)[b]			
Abdominal pain	21.4 (83)	17.9 (149)	1.25 (0.93–1.69)
Chest pain and collapse	4.6 (18)	4.1 (34)	1.15 (0.64—2.05)
Ear/nose/throat/eye	1.3 (5)	1.8 (15)	0.71 (0.26–1.98)
Headache and head injury	7.7 (30)	7.7 (64)	1.01 (0.64–1.58)
Injuries of an extremity	13.9 (54)	19.8 (165)	0.66 (0.47–0.92) *
Psychiatric disorders	2.8 (11)	3.8 (32)	0.73 (0.37–1.47)
Severe trauma and falls	11.6 (45)	8.9 (74)	1.35 (0.91–1.99)
Shortness of breath	7.0 (27)	7.8 (65)	0.89 (0.56–1.41)
Unwell patient	14.2 (55)	15.7 (131)	0.89 (0.63–1.25)
Wounds and local infections	9.8 (38)	7.1 (59)	1.43 (0.93–2.19)
Other presenting problem[c]	5.7 (22)	5.5 (46)	1.03 (0.61–1.74)
Hospital admission % (n)	28.5 (120)	31.3 (282)	0.88 (0.68–1.13)

Abbreviations: CI, confidence interval; ED, emergency department; IQR, interquartile range.
*Statistically significant.
***p* values were calculated using the Mann-Whitney *U* test.
[b] Based on 1222 patient presentations, due to 108 missing.
[c] Other presenting problem, presenting problem occurring less than 40 times during the study period: allergy, back pain, diabetes, facial problems, irritable child, neck pain, sexually acquired infections.

4. Discussion

This study aimed to evaluate the impact of four interventions proposed by the ED flow project team on optimizing ED processes. These interventions included (1) installing an additional triage station from 3 to 5 p.m., (2) redirecting some self-referrals and GP-referred patients to outpatient clinics by involving the surgeon in the triage process, (3) implementing POCT for CRP and immediate ultrasound in patients with abdominal complaints and elevated CRP levels, and (4) utilizing a second waiting room for exit interviews. We hypothesised that triage times between 3 and 5 p.m. and the number of self-referrals and GP-referred patients for surgery to the ED would decrease, along with a reduction in patients' ED length of stay, particularly for those with abdominal complaints.

Our findings indicated a decrease in waiting times to triage and the number of self-referrals, but no significant effect on the number of patients referred by GPs. Regarding individual patients' ED length of stay, there was no difference between the intervention period and the control period. When excluding the weekend arrivals in our sub analysis, a statistical significant reduction in length of stay during the intervention week was evident. We hypothesized that the interventions were more successful during weekdays because there are fewer staff members or less experienced staff available on weekends, which can reduce efficiency. Additionally, the higher number of patient arrivals on Sunday

Table 2
Patients' ED length of stay, total study population, N=1330.

LENGTH OF STAY[a]	Intervention period 12 to 8p.m.	Control period 12 to 8p.m.	*p* value[b]
Total patients	N=422 (99.5 % of 424)	N=902 (99.6 % of 906)	
Median length of stay in minutes (IQR)	166 (103–238)	174 (111–247)	0.21
Weekday, median length of stay in minutes (IQR)			
Monday	146 (89–230)	173 (111–243)	0.32
Tuesday	166 (115–258)	212 (126–291)	0.19
Wednesday	160 (77–204)	180 (131–260)	0.75
Thursday	184 (132–288)	176 (122–250)	0.72
Friday	170 (104–250)	192 (119–276)	0.08
Saturday	132 (77–182)	131 (78–215)	0.96
Sunday	184 (123–236)	139 (85–212)	0.08
Self-referrals	N=29	N=97	
Median length of stay in minutes (IQR)	91 (73–157)	122 (68–212)	0.2
Patients referred by GP to surgery	N=72	N=142	
Median length of stay in minutes (IQR)	132 (101–179)	155 (89–218)	0.31
Patients with abdominal complaints	N=83	N=149	
Median length of stay in minutes (IQR)	197 (143–266)	200 (146–289)	0.9
Admitted patients	N=120	N=282	
Median length of stay in minutes (IQR)	213 (154–283)	230 (181–321)	0.32
Discharged patients	N=301	N=620	
Median length of stay in minutes (IQR)	147 (89–218)	143 (90–212)	0.54

Abbreviations: CI, confidence interval; ED, emergency department; GP, general practitioner; IQR, interquartile range.
[a] Length of stay based on 1324 measures due to 2 missing in the intervention period and 4 missing in the control period.
[b] *p* values were calculated using the Mann-Whitney *U* test.

Table 3
Patients' ED length of stay, subgroup of patients arriving Monday to Friday, N=1005.

LENGTH OF STAY[a]	Intervention period 12 to 8 p.m.	Control period 12 to 8 p.m.	*p* value[b]
Total patients Monday to Friday	N=311	N=694	
Median length of stay in minutes (IQR)	168 (105–246)	184 (122–260)	0.02*
Self-referrals	N=19	N=62	
Median length of stay in minutes (IQR)	80 (52–120)	127 (72–197)	0.04*
Patients referred by GP to surgery	N=45	N=102	
Median length of stay in minutes (IQR)	156 (106–198)	184 (121–251)	0.04*
Patients with abdominal complaints	N=62	N=116	
Median length of stay in minutes (IQR)	210 (145–280)	218 (152–289)	0.92
Admitted patients	N=88	N=227	
Median length of stay in minutes (IQR)	229 (155–295)	237 (184–332)	0.55
Discharged patients	N=221	N=463	
Median length of stay in minutes (IQR)	150 (93–223)	158 (103–223)	0.49

*Statistically significant.
Abbreviations: CI, confidence interval; ED, emergency department; GP, general practitioner; IQR, interquartile range.
[a] Length of stay based on 1000 measures due to 1 missing in the intervention period and 4 missing in the control period.
[b] *p* values were calculated using the Mann-Whitney *U* test.

Table 4
Emergency department crowding.

ED CROWDING[a]	Intervention period 12 to 8p.m.	Control period 12 to 8p.m.	95 % CI	*p* value[b]
Mean mNEDOCS (95 % CI))	51 (48–53)	59 (57–61)	4.98, 11.59	<0.001
Extremely busy % (n)	30.4 (68)	46.4 (208)	0.36, 0.71	<0.001
Crowding % (n)	0 (0)	8 (1.8)	–	0.04

Abbreviations: CI, confidence interval; mNEDOCS, modified National ED OverCrowding Score.

[a] mNEDOCS based on 672 measures; mNEDOCS 61–100 means extremely busy, and mNEDOCS>100 means crowding.

[b] *p* values were calculated using the Independent Samples *t*-test for mean mNEDOCS, and the Chi-square test for Extremely busy and Crowding.

during the intervention period compared with the control period may have reduced efficiency.

There was a significant reduction in crowding during the intervention week. This reduction can be attributed to the diversion of some self-referrals and referred patients to the GPC and to the outpatient clinic, consequently decreasing the number of patients at the ED and the mNEDOCS.

It's important to acknowledge that due to the diversion policy, there were slight differences in patient populations between the intervention and control periods. Specifically, there were fewer patients presenting with limb problems and fewer self-referrals in the intervention period, likely as a result of the interventions. The surgeon promptly consulted all self-referrals, redirecting some to outpatient clinics or the patient's GP. Notably, self-referrals redirected at triage were not included in our analysis, which contributed to the decrease in patients presenting with limb problems.

While we observed a non-significant decrease in length of stay for the total patient group, there was a significant reduction in length of stay for self-referrals during the intervention period. We had anticipated a more pronounced impact on length of stay for patients with abdominal pain due to expedited diagnostics, but our analysis did not reveal a significant difference between the intervention and control weeks. Further investigation into the utilization of POCT and immediate ultrasound referrals is warranted.

The reduction in mNEDOCS during the intervention week suggests a positive effect on ED crowding, primarily due to patient diversion by the surgeon. However, sustaining this effect may prove challenging without effective management of departmental discharges [2,5,15]. Despite the absence of statistical significance, the reduction in length of stay for specific patient groups holds clinical relevance and shows promise for both patients and staff. The decrease in length of stay in specific patient groups is promising.

While the decrease in length of stay of 17 min for patients requiring hospital admission did not reach statistical significance, it remains clinically significant for both patients and ED capacity. Similarly, for patients referred to surgery and self-referrals, although the length of stay may not be significantly shorter, experiencing a reduction in wait time by 23 and 31 min, respectively, is meaningful for both patients and staff. This reduction represents a substantial improvement considering the overall short duration of the average stay in the ED and may translate into a shift from 'extremely busy' and 'moderately busy' conditions at the ED.

Moreover, it is crucial to recognize that when 30 % of ED patients require admission, the majority, 70 %, do not. Given the heightened congestion stemming from difficulties in admitting patients to the clinic, directing attention towards interventions for the non-admission group presents significant opportunities for improvement.

5. Limitations

Our study has several limitations. Firstly, its observational design prevents causal inference, so our findings should be interpreted as hypothesis-generating rather than conclusive. Additionally, we did not account for potential confounding factors, such as ED nurse workload and resource utilization. However, by comparing one intervention week with two control weeks (before and after the interventions), we reduce the risk that the results are solely due to chance variations or specific events during a single control reduces.

Secondly, our study was conducted at a single ED, limiting the generalizability of the findings to other settings.

Thirdly, during the intervention period, the ED team was aware of being observed, which may have introduced a Hawthorne effect – a behavioural change induced by the study itself. However, it is important to note that there was a deliberate effort to enhance operational efficiency and effectiveness during the intervention period.

Despite these limitations, our study provides valuable insights and recommendations for improving ED patient flow.

Overall conclusion

Engaging frontline nursing staff in brainstorming potential interventions to alleviate crowding and enhance patient flow enabled us to test four interventions with a highly motivated team. This initiative resulted in the structural modification of implementing an additional triage station during peak hours in the ED. Furthermore, we intend to conduct a more comprehensive investigation into the POCT CRP intervention. Based on the findings, we will proceed with its implementation accordingly.

CRediT authorship contribution statement

M.C. (Christien) Van der Linden: Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Data curation, Conceptualization. **M. (Merel) Van Loon-van Gaalen:** Writing – review & editing. **S.A.G. (Sven) Meylaerts:** Writing – review & editing. **H.M.E. (Jet) Quarles Van Ufford:** Writing – review & editing. **A. (Annemarie) Woldhek:** Writing – review & editing. **G. (Geesje) Van Woerden:** Writing – review & editing. **N. (Naomi) Van der Linden:** Writing – review & editing, Supervision, Formal analysis, Conceptualization.

Declaration of competing interest

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

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Authors' contributions.

All authors have participated in the research as well as contributed to the drafting and approval of the final version of the manuscript.

Ethics approval and consent to participate.

This study was performed according to the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. The ethical review committee of Southwest Holland (METC-LDD) granted approval and exemption (METC-LDD, N22.095). Patient consent was not required.

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