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REDESIGNING AN EMERGENCY DEPARTMENT FOR INTERPROFESSIONAL TEAMWORK

A LONGITUDINAL EVALUATION OF THE IMPACT ON PATIENT FLOW AND TEAM BEHAVIOUR

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Cover picture
Interprofessional teamwork in a module: team members, work space and patient flow
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Redesigning an emergency department for interprofessional teamwork

A longitudinal evaluation of the impact on patient flow and team behaviour

THESIS FOR DOCTORAL DEGREE (Ph.D.)

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Heart to heart, mutual imprints

ABSTRACT

Objective

Crowding in emergency departments (EDs) has negative effects on patients and staff, whereas effective teamwork in healthcare has positive effects. Triage interventions and streaming of specific patient categories are common strategies used by EDs to reduce the negative effects of crowding, but few studies have evaluated interprofessional teamwork as a strategy to reduce ED crowding. This thesis evaluated the redesign of an ED for interprofessional teamwork with the aim of studying the impact on patient flow and team behaviour.

Methods

The project was conducted at an adult ED, where teamwork modules replaced the triage, fast track, and main ED sections in November 2014. Study I, II, and III were quantitative before-and-after studies using patient data, whereas study IV collected qualitative and quantitative data from health professionals for four years.

Study I and II used registry data from May 2012 to November 2015. Study I included all patient arrivals on weekdays from 8 am to 9 pm for three one-year periods and compared the first year of teamwork to two previous triage processes, nurse-led triage and physician-led triage. Study II included patients who presented limb injuries or back pain to the ED, where the first year of teamwork was compared to a previous period, when ambulant low acuity patients were streamed to the fast track. An equal number of non-orthopaedic presentations were also included to control for the impact on other patient categories. The waiting time to physician assessment and ED length of stay were outcome measures in both studies. We used multiple linear regression analysis to adjust the ED length of stay for differences in patient and background characteristics between the periods.

Study III included all patients 80 years or older arriving on weekdays during a pilot period in 2016, when a teamwork module was dedicated to older patients, and a corresponding period in 2015 with only regular teamwork modules for mixed age groups. The outcome measures were the ED length of stay and the total hospital admission rate within seven days.

Study IV included triangulated data from three staff sources; structured observations of team behaviours in June 2016 and June 2018, semi-structured interviews in June 2018, and a questionnaire of the perceived workload, collaboration, and patient satisfaction repeated from October 2014 through June 2018.

Results

Study I included 185 806 patient arrivals. The crude median ED length of stay was shortest for the teamwork period, 228 minutes (95% CI: 226.4 to 230.5) compared to 232 minutes (95% CI: 230.8 to 233.9) for the nurse-led triage period, and longest for the physician-led triage period, 250 minutes (95% CI: 248.5 to 252.6). The adjusted ED length of stay for the teamwork period was 16 minutes shorter than for the nurse-led triage period ($p<0.001$), and 23 min shorter

than for the physician-led triage period ($p<0.001$). The median waiting time to physician assessment was 74 minutes (95% CI: 73 to 75) for the teamwork period, 116 minutes (95% CI: 114 to 118) for the nurse-led triage period, and 56 minutes (95% CI: 55 to 57) for the physician-led triage period.

Study II included 22 551 orthopaedic patient presentations. In the fast track period, 70% were low acuity patients and 70% of these were dispositioned from the fast track. The crude median ED length of stay was shorter for the teamwork period compared to the fast track period, -13 minutes (95% CI: -18 to -8). The difference of the adjusted ED length of stay was -23 minutes (95% CI: -27 to -19). The mean waiting time to physician assessment was also shorter in the teamwork period, -57 minutes (95% CI: -60 to -54) compared to the fast track period. For the additional 21 780 non-orthopaedic presentations, the adjusted ED length of stay was also shorter in the teamwork period, -20 minutes (95% CI: -25 to -16), as was the mean waiting time to physician assessment, -30 minutes (95% CI: -33 to 26).

Study III included 4 584 presentations by patients 80 years or older and there was no difference in patient characteristics between the periods. In the intervention period, 27% (n=634) of the patients received care in the geriatric module, and the remaining patients in standard teamwork modules. The total hospital admission rate within seven days was lower in the intervention period, compared to the control period. However, the ED length of stay was longer in the intervention period.

Study IV included 50.5 hours of structured observations in 2016, when fidelity was observed for four of five key team behaviours. In 2018, fidelity remained only for one team behaviour and observation saturation was reached after 37.5 hours. Qualitative content analysis of 18 interviews in 2018 exposed several issues of the staff and context fidelity, for instance, team training and feedback were discontinued. In the questionnaire, positive ratings approximately doubled for items relating to the work experience when teamwork was introduced. However, in 2018 the ratings had deteriorated to pre-implementation levels.

Conclusions

Effective interprofessional teamwork reduced the waiting time to physician assessment and the ED length of stay for the patients. However, the fidelity to the teamwork process decayed over time and the positive outcomes were not sustained.

LIST OF SCIENTIFIC PAPERS

I. Liu J, Masiello I, Ponzer S, Farrokhnia N. Can interprofessional teamwork reduce patient throughput times? A longitudinal single-centre study of three different triage processes at a Swedish emergency department. BMJ Open. 2018 Apr 19;8(4):e019744. PubMed PMID: 29674366. PMCID: PMC5914774.

II. Liu J, Masiello I, Ponzer S, Farrokhnia N. Interprofessional teamwork versus fast track streaming in an emergency department – An observational cohort study of two strategies for enhancing the throughput of orthopaedic patients presenting limb injuries or back pain. PLoS One. 2019;14(7):e0220011. PubMed PMID: 31318942. PMCID: PMC6638969. Epub 2019/07/19.

III. Liu J, Palmgren T, Ponzer S, Masiello I, Farrokhnia N. Dedicated emergency team and area for older people can reduce the hospital admission rate – An observational pre- and post-intervention study. Submitted to BMC Geriatrics.

IV. Liu J, Ponzer S, Farrokhnia S, Masiello I. Evaluation of interprofessional teamwork implementation in an emergency department – A qualitative study of fidelity. Manuscript.

CONTENT

LIST OF ABBREVIATIONS

ATS	Australasian Triage Scale
CI	Confidence interval
CTAS	Canadian Triage and Acuity Scale
ED	Emergency department
ESI	Emergency Severity Index
METTS	Medical Emergency Treatment and Triage System
MTS	Manchester Triage System
N/n	Number
OR	Odds ratio
RETTS	Rapid Emergency Treatment and Triage System
SD	Standard deviation

1 INTRODUCTION

Emergency department (ED) crowding is a problem worldwide, as indicated by the position statements of emergency medicine societies in the USA (1), Canada (2), the United Kingdom (3), and Australia (4). ED crowding was also present in several European countries, though not yet a major problem in the Scandinavian countries, according to a report published in 2011 (5). However, the Swedish National Board of Health and Welfare found increasing waiting times for patients to be seen by a physician and longer stays in the ED by 2013 (6). The trend of increasing ED length of stay from 2009 to 2016 was verified by researchers at Karolinska University hospital in Stockholm, especially for patients 80 years or older and for patients admitted to inpatient care (7).

This thesis project started in 2013, when Södersjukhuset was one of three Swedish hospitals with the longest median ED length of stay in the national survey that year. The adult ED was the busiest in Sweden with an average of 300 patient arrivals per day. During the afternoon peak hours, there could be over 100 patients present in the ED, accompanied by relatives or friends. The ED facility was outdated and cramped so that patients lying on stretchers were lining the corridors in the crowded ED, which distressed the health professionals. For several years, plans to replace the ED facility had been repeatedly cancelled, but in early 2013 the Stockholm County Council finally decided to build a new ED.

As an emergency physician, I became engaged in an interprofessional group that assisted the architects in designing our new ED. Building a larger replica of the previous ED was not an option to the group, but initially we did not see how to the design the new ED despite study trips to other EDs. In October 2013, the hospital also decided to improve the ED patient flow by implementing interprofessional teamwork. Planning the teamwork process helped the group to see how the new facility should be designed. Interim changes for teamwork were made in the old ED until the new facility designed for teamwork finally opened in April 2020.

This thesis project is a mixed-methods evaluation of the implementation process, a complex intervention to redesign the ED for interprofessional teamwork spanning a period of nearly five years from October 2013. I started on a journey to gain evidence of improved patient throughput by teamwork in emergency care, but it gradually brought me to the fields of implementation science. There, I found the fascinating complexities of implementation practice, where clinical science enters the real world of healthcare.

From the thesis project, I have learnt how to conduct quantitative registry studies. The first two studies used patient throughput times and compared interprofessional teamwork to two common types of interventions to reduce ED crowding, triage and fast track streaming low acuity patients. I have studied two different patient categories in more detail, orthopaedic patients in study II and patients 80 years or older in study III. From the final study, I have learnt qualitative methods, structured observations, semi-structured interviews, and staff surveys. Most of all, I have learnt the importance of sustained fidelity to teamwork principles.

2 BACKGROUND

This chapter contains an overview of the existing knowledge of ED crowding and interventions related to this thesis project. It also summarizes our knowledge of two special patient categories, patients presenting orthopaedic complaints and older patients in emergency care. The chapter ends with an overview of implementation science and practice.

2.1 EMERGENCY DEPARTMENT CROWDING

2.1.1 Effects of crowding

ED crowding has negative effects on clinical outcomes and patient safety (8-11). ED crowding also reduces the quality of care, and the satisfaction of both patients and health professionals (12, 13). Crowding increases the length of the patient´s ED stay, but the increase depends on the chief complaint presented to the ED. Medical conditions that require time critical interventions tend to be treated timely regardless of crowding, if they can be identified at an early stage in the ED. Examples of such conditions are patients with acute myocardial infarction who require percutaneous coronary intervention (14), and stroke patients who need to receive thrombolysis within the stipulated timeframe (15). The increase of ED length of stay caused by crowding is therefore less for patients with more urgent conditions (16).

Furthermore, patients who are admitted from crowded EDs risk longer hospital stays at greater costs (17-22). Some studies indicate that they also have an increased mortality during the hospital stay (18, 20, 23-25), although this could not be established in other studies where the population had a lower mortality rate (21, 22). For patients discharged home from EDs, the risk of death within seven to ten days increases with increasing length of the ED visit (26, 27). The risk of being admitted to inpatient care within seven days of the ED discharge also increases with increasing length of the ED stay (26, 28).

2.1.2 Definition and measurements

Research on ED crowding has been complicated by a lack of consensus on terminology, definitions and measurement. For example, the Canadian and Australasian medical societies use the term *overcrowding* (2, 4), while the British society prefers *crowding* (29). The definitions of crowding according to some major emergency medicine societies are listed in Table 1.

Likewise, a systematic review identified a diversity of definitions in the medical literature from 1966 to 2002. The authors also found a lack of distinction between the definitions of crowding and its causes and effects (30). The research field was clarified by Asplin et al., who introduced a framework for describing the causes of ED crowding in 2003. This conceptual input-throughput-output model has gained broad acceptance (31). The input component includes any factor that contributes to the demand for ED services. The throughput component consists of the internal ED processes, i.e., triage, initial assessment, diagnostic evaluation, treatment, reassessment, and eventually disposition and discharge. The output component relates to the availability of inpatient beds for admitted patients, and follow-up care for discharged patients (Figure 1).

Table 1. Emergency department crowding/overcrowding – defined by medical societies.

Emergency department crowding/overcrowding
Crowding occurs when the identified need for emergency services exceeds available resources for patient care in the ED, hospital, or both - American College of Emergency Physicians (1).
ED overcrowding refers to the situation when ED function is impeded primarily because the number of patients waiting to be seen, undergoing assessment and treatment, or waiting for departure exceeds either the physical bed and/or staffing capacity of the ED - Australasian College of Emergency Medicine (32).
ED overcrowding is defined as a situation where the demand for emergency services exceeds the ability of the ED to provide quality care within appropriate time frames - Canadian Association of Emergency Physicians (2).
ED crowding is a situation where the number of patients occupying the ED is beyond the capacity for which the ED is designed and resourced to manage at any one time - The Royal College of Emergency Medicine (29).

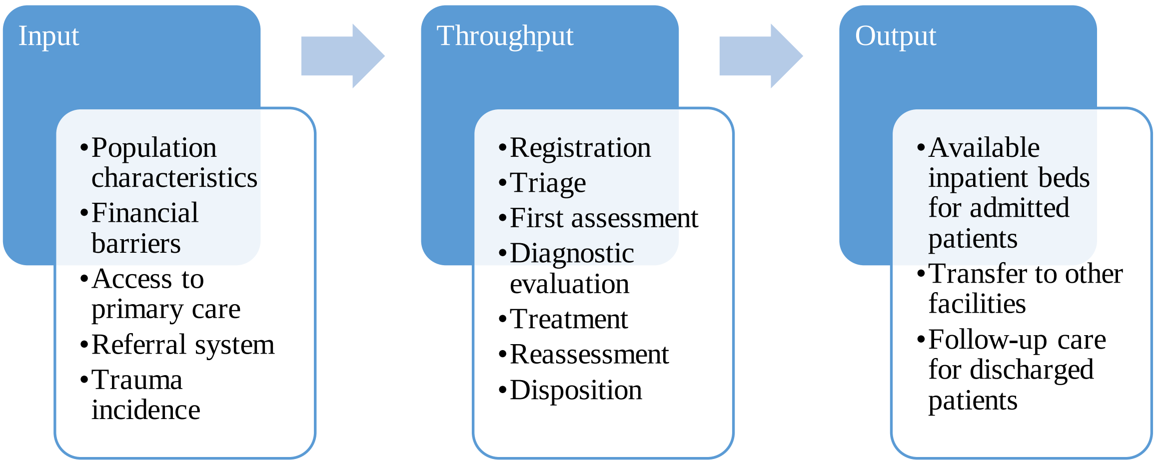

Figure 1. **Conceptual model of emergency department crowding** (31). Examples of contributing factors within each component.

Numerous ED crowding measures have been suggested, without a gold standard. A systematic review of the literature from 1966 to 2009 identified 71 unique crowding measures, which the authors classified into five groups: input, throughput, output, clinician opinion, and multidimensional indices (33). Multidimensional indices generate scores from statistical algorithms, which are derived from real-time opinions of attending physicians and charge nurses on the degree of ED crowding. For example, the Emergency Department Work Index is calculated from the number of patients in each triage category, the number of attending physicians, ED beds, and patients waiting for an inpatient bed (34). This complexity has restricted the use of multidimensional indices. Moreover, their transferability to different healthcare systems and ED settings is limited (35).

The authors of (33) further distinguished between two categories of crowding measures: patient flow measures (time intervals), and nonflow measures (counts or proportions). In Table 2, examples of crowding measures are categorized according to the input-throughput-output model of ED crowding.

Table 2. Emergency department crowding measures – common examples.

	Input	Throughput	Output
Patient flow	Time to triage Time to physician	Length of stay	Boarding time
Nonflow	Number of arrivals Number of patients in the waiting room	Number of patients in the ED ED occupancy rate	Number or proportion of patients admitted, boarding, or leaving without being seen Inpatient occupancy

2.1.3 Etiology

The causes of ED crowding are complex and can be found within the entire healthcare system. Some causes are universal, while others vary between countries and ED settings (12, 13, 36). In Table 3, some examples of crowding causes are categorized according to the input-throughput-output model of ED crowding.

Table 3. Causes of emergency department crowding – some examples.

Input	Throughput	Output
Increased ED volume (37) High acuity patients (38) Frequent ED users (39) Low-income areas (40)	Inadequate staffing (40) Reduction of ED beds (41) Delay of ancillary service (42) Use of advanced imaging (43, 44)	Boarding of inpatients (45) Reduction of hospital beds (46) Increased hospital occupancy (47, 48)

2.1.4 Strategies to reduce crowding

The multifactorial causes in different settings further complicate the research field by making it difficult to compare and transfer results. Examples of reported interventions to reduce ED crowding are listed in Table 4. This thesis project focuses on two types of throughput strategies for adult EDs, triage and streaming. However, it must be emphasized that a comprehensive approach, including hospital-wide and society-based interventions, is required to reduce ED crowding (49, 50).

Table 4. Strategies to reduce emergency department crowding – some examples.

Input	Throughput	Output
Ambulance diversions (51) Primary care providers (52) ED appointments (53) Online triage service (54)	Triage interventions Nurse-initiated x-ray (55) Fast track streaming Point-of-care testing (56) Four-hour target (57) Facility expansion (58)	Observation ward (59) In-hospital bed management (60, 61) Inpatient hallway boarding (62) Timing of hospital discharge (63)

2.2 TRIAGE

Though the historical records are scarce, it is believed that the Roman empire implemented categorization of injured soldiers for treatment on the battlefield as well as in field hospitals (valetudinaria) (64). In *De Medicina* by Celsus (65) from the first century AD, different wounds from weapons were categorized in detail depending on the likelihood of death or successful treatment. The introduction of triage in healthcare in modern times is usually attributed to Jean Dominique Larrey (66), a chief surgeon of Napoleon´s Imperial Guard, and his predecessor Pierre Francois Percy (67, 68). From the late 1950s, EDs began to adopt triage principles to manage increasing patient volumes (69).

2.2.1 Nurse-led triage

Triage was initially performed as a spot check by a nurse who greeted newly arrived patients and categorized them as emergent, urgent, or nonurgent. From the 1980s, comprehensive triage aided by acuity systems began to develop (69), with a subsequent increase from three to five acuity levels. Acuity is used as a synonym for urgency, which implies that a high acuity patient needs to be seen by a physician sooner than a patient triaged to a lower acuity level (70).

In 1993, Australia was first to implement a national triage system, the 5-level National Triage Scale (NTS) (71), which was refined and renamed the Australasian Triage Scale (ATS). It was modified again in the late 1990s to be the official triage system throughout Canada, the Canadian Triage and Acuity Scale (CTAS) (72). The CTAS was in turn modified in 2011 to the Taiwan Triage and Acuity Scale, replacing the mandatory 4-level Taiwan Triage Scale (73).

In the United Kingdom and other European countries, the Manchester Triage System (MTS) is the most commonly used triage system since 1997 (74). In the USA, the use of the Emergency Severity Index (ESI) increased following a policy statement by the American College of Emergency Physicians in 2010 (75). Many other triage systems have also been developed for different regions, for example, the South African Triage Scale (76) and the French Echelle Liégeoise d'Index de Sévérité à l´Admission (77).

2.2.1.1 Reliability

Although widely spread, the scientific evidence of the reliability of triage systems is insufficient (78-80). The reliability has mainly been evaluated in studies using low quality designs, such as case scenarios with 5 to 50 scenarios in each study (81-88), and reviews of 100 to 359 triage notes (89-93). A few studies have evaluated the reliability by simultaneous triage, but with small sample sizes, 167 patients for the MTS (94) and 386 for the ESI (95). For the CTAS, the study sample sizes were moderate, 569 and 693 patients (96, 97). Although some studies assessed the intra-rater agreement, most assessed the inter-rater agreement by reporting the kappa statistic κ. When the agreement is no better than chance, κ is 0, while κ=1 indicates a perfect agreement. The weighted κ accounts for the degree of disagreement by assigning higher weights to larger differences between the ratings (98). Table 5 shows that there is a large variation of the weighted κ within studies of the same triage system. Moreover, information is mostly absent of influencers on the magnitude of weighted κ, such as the choice of weighting scheme (99), which complicates the comparison between studies.

Table 5. Inter-rater agreement of triage systems

Triage system (review article)	Weighted κ	Reference
ATS (70, 100)	0.23 – 0.60	(86, 88, 89, 101)
CTAS (102)	0.36 – 0.80	(82-84, 96, 97)
ESI (103)	0.68 – 0.89	(90-93, 95, 104)
MTS (74, 105, 106)	0.40 – 0.95	(85, 94, 104, 107, 108)

2.2.1.2 Validity

Likewise, the evidence of the validity of triage systems is limited and a contributing factor is the lack of a gold standard to measure urgency. Most studies have assessed the construct validity of triage systems, for example, the ability to predict mortality (109). However, studies correlating triage levels to mortality have had a low number of deceased patients, from 26 to 618. Moreover, these studies used different endpoints of mortality, from death within the ED stay up to six months after the ED visit. Triage levels have also been correlated to the hospitalization rate (Table 6), resource consumption (92, 95, 110, 111), and the length of ED stay (92, 95). However, the broad variations even within studies of the same triage system raise questions of the external validity, when a triage system is transferred to different settings and healthcare systems. For example, the hospitalization rate of ATS level 4 and 5 was higher in the Netherlands than in Australia (112). The poor external validity contributes to the fact that many local and regional triage systems have been developed. A recent systematic review identified 33 different triage systems worldwide. Of these, 25 were only evaluated by a single publication (80).

Table 6. Validity assessment of triage systems. Overview of studies correlating triage levels to mortality endpoints and hospitalization rate.

Triage system	Mortality endpoints	Hospitalization rate	Reference
ATS (70)	Admitted patients ≤24h (113) In-hospital (114)	Category 1: 79% - 85% Category 2: 60% - 71% Category 3: 41% - 50% Category 4: 17% - 30% Category 5: 3% - 17%	(112-114)
CTAS	Within ED stay (110)	Level 1: OR 4.45 Level 2: OR 2.22 Level 3: OR 1 Level 4: OR 0.36 Level 5: OR 0.16	(110)
ESI	Within ED stay (115) ≤2 months (95) ≤6 months (116)	Level 1: 80% - 96% Level 2: 47% - 73% Level 3: 31% - 51% Level 4: 6% - 10% Level 5: 0% - 7%	(90, 92, 93, 95, 115, 117)
MTS (105)	Within ED stay (115) ≤30 days (94)	Red: 67% - 100% Orange: 45% - 73% Yellow: 31% - 37% Green: 5% - 13% Blue: 2% - 9%	(74, 94, 115)

Abbreviation: OR = Odds ratio.

In a survey from 2010, 97% of the Swedish EDs used a triage scale and 65% employed the Medical Emergency Treatment and Triage System (METTS) (118), developed in Sweden in 2006 and renamed the Rapid Emergency Treatment and Triage System (RETTS) (119). The evidence of the reliability of the adult version of RETTS is based on two published studies with discordant findings. The developers of the METTS reported a high inter-rater agreement with unweighted κ values of 0.76 to 0.90, from 132 patients observed in parallel by senior emergency physicians and triage nurses (119). By contrast, the inter-rater agreement was only moderate with an unweighted κ of 0.56 in the second study, where 28 registered nurses disagreed on 85% of 46 case scenarios. Furthermore, they triaged 46% of the scenarios across the boundary between stable and unstable patients (120). A similar inter-rater agreement with a κ value 0.60 was found for the Danish version RETTS–HEV (Hospital Unit West), when 146 patients were triaged simultaneously by two nurses (121).

The validity of METTS has only been assessed by correlating the triage levels to the in-hospital mortality and length of hospital stay for 8695 ED visits (119). The validity of the Danish version has been assessed by correlating the triage levels to mortality at several endpoints, hospital admission rate, and length of hospital stay. However, the study only included 4 680 ED visits (122).

The algorithm of most triage systems includes measuring certain vital signs, such as the respiratory rate, heart rate and pulse, level of consciousness, and body temperature to better differentiate the medical urgency of patients in crowded EDs and make their waiting time safer. However, according to a systematic review published in 2011, the association between specific vital signs and mortality has a limited evidence base, except for the respiratory rate (79). More recent studies of selected patient categories and patients admitted to inpatient care also support the use of respiratory rate to predict mortality (123-125). This was further confirmed by one study of unselected ED patients, where the authors also found associations between mortality and deviation from the normal range of several other vital signs. However, the odds of death within the same triage level varied, depending on which vital sign was abnormal (126).

2.2.1.3 Time saving aspects

Triage systems and protocols for the nurse-led triage process were not primarily developed to save time. This was demonstrated in a study of the MTS, where the waiting time was longer, treatment time shorter, and the total length of ED stay unchanged after implementation of the MTS (127). According to the Emergency Nurses Association in the USA, a comprehensive triage should be completed within two to five minutes, but for most patients this triage time limit was exceeded (128, 129). This may build an access block to triage and cause unsafe delays for high acuity patients (129). Moreover, some EDs have added screening tools and other activities, such as obtaining pre-defined test panels (130) and initiating x-ray in triage, in attempts to achieve a shorter ED length of stay. However, these activities may prolong the triage time (131) and increase resource consumption.

The scientific evidence of time saving of nurse-initiated x-rays has been summarized in several literature reviews (55, 56, 132, 133). Out of three randomised controlled and three prospective cohort studies on three continents, five found no significant reduction of the ED length of stay (134-138). However, two of these study centres chose to continue the practice of nurse-initiated x-ray due to improved staff satisfaction (135, 137). The only study reporting a shorter ED length of stay for various injury categories did not specify the significance levels of the findings (139). Moreover, unnecessary x-rays have been reported in 5.3% - 6.5% of nurse-initiated radiographs (134, 139), and 4% - 8% additional x-rays after the physician assessment (134, 135, 138, 139).

In recent years, some researchers have returned to the quick-look triage and compared it to formalised comprehensive triage. One study found that triage based on a quick-look had a comparable inter-rater agreement to a resource-intense triage system (140). Another study even found a quick-look of a phlebotomist superior to the comprehensive triage in predicting short-term mortality (141).

2.2.2 **Physicians in triage**

A common approach to reduce the bottle-neck effects of the comprehensive nurse triage and improve ED performance is to introduce physicians into the triage process. Again, a lack of consensus on quality indicators complicates the research field. Experts have sought to standardize performance measures and ED benchmarking (142-145) . The waiting time to see a physician and ED length of stay are the most studied performance indicators (146). However, the evidence base is low of most indicators.

2.2.2.1 Intervention categories

In the medical literature, physician in triage was first described in 1999 in Australia (147). The study was a before-and-after study with the aim to medically assess all patients within the waiting time standard for each triage category, a quality indicator used by the Australian Council of Healthcare Standards. The rapid assessment team increased the proportion of patients seen by a physician within the time standards from 39% to 59%, which was still far from the stipulated thresholds of 85% to 98% for the triage categories. However, it had no impact on the length of ED stay. The intervention was discontinued after three months due to a lack of resources and funds, although the authors claimed that the physicians in triage were drawn from the existing ED staff and no other resources were added.

This study has since been followed by at least 30 papers published in English, where most of the studies have had a single-centre before-and-after design, and only four were cluster randomised trials (148-151). The large diversity of interventions in the studies can be classified into three categories, where all included the initiation of diagnostic testing and treatment. When possible, patients were also rapidly discharged by the physician in triage. One category was the introduction of a triage liaison physician, who assisted the nurse-led triage process upon request for some patients (149). Another, the most common category, was the use of a physician in team triage, who screened all new patients (148). A third category was the introduction of a rapid assessment team dedicated to certain patient categories, typically the medium acuity patients, after they had passed the triage nurse (152).

2.2.2.2 Impact on patient throughput

Regardless of intervention type, all studies reported a shorter time to physician assessment compared to nurse-only triage, if it was measured as the time to first contact with the physician in triage. Of 14 studies reporting the proportion of patients who left without being seen by a physician, eight studies found a significant reduction. However, the base-line level varied from 2.0% to 10.7%, which indicated that there were considerable differences in study setting.

The impact on the ED length of stay differed and depended on the resources allocated in the studies of physicians in triage. Resources were added in most studies, unchanged in five studies, and not clearly stated in another five. A reduction of the ED length of stay was mainly observed in studies where resources were added. However, several studies with added resources found no significant reduction of the ED length of stay (148, 151, 153) and it was even increased in one study (154). Only three studies with unchanged resources reported the ED length of stay as an outcome measure, which was reduced in one study (155) and unchanged in the other two (147, 148). Moreover, the reduction of ED length of stay was mostly observed for patients who were immediately discharged by the physician in triage, whereas the length of stay was increased for patients who proceeded to see another physician in the main ED (156).

The use of physicians in triage has been evaluated in several reviews, including two meta-analyses (56, 132, 157-159). Three cluster randomised studies with adult populations (148-150) were included in a systematic review published in 2016 (158). The authors chose not to carry out a meta-analysis of the waiting time to physician assessment and the ED length of stay, due to a low evidence quality and different ways of reporting the outcome measures. Although the authors pooled the outcome data of patients who left the ED without being seen by a physician, the resulting risk ratio was inconclusive, with a confidence interval of 0.57 to 1.07 after adjusting for clustering. In summary, the authors found no conclusive evidence of physicians in triage being superior to nurse-only triage (158).

Another systematic review published in 2016 (157) included the three studies and a fourth cluster randomised study (151), together with a larger number of studies with other designs. These authors did not refrain from meta-analysing the waiting time to physician assessment and ED length of stay and concluded that physicians in triage improved all three outcome measures, including the proportion of patients who left without being seen by a physician. The authors also recommended cost effectiveness studies of physicians in triage.

2.2.2.3 Cost effectiveness

Among the few studies that have investigated the cost effectiveness of physicians in triage, one found that the improvements of patient flow came at a 62% increase of the cost per patient (160). Another study found an 11% increase of radiology use (154), and in the third study the authors argued that the cost would be better spent on solutions for the exit block to inpatient care (161). However, a fourth study projected that the initial expenses would break even with the revenues after 13 months (162).

The perspectives of ED health professionals and managers on physicians in triage were investigated in a qualitative study published in 2018 (163). Most participants doubted the added value of senior physicians at the ED front door, since the approach does not address other organisational issues, such as exit block. They identified several barriers to the physician in triage process. One was the lack of a standardised working procedure, which may lead to unrealistic expectations of the physician in triage. Another barrier was the lack of teamwork and effective communication, when the physician in triage was not supported by a team.

In fact, teamwork was a contributing factor to the improved efficiency in a 2016 study of physician-led team triage, where the authors argued that “*Another factor may have been the* *teamwork itself, because all of the team members received the same information simultaneously, thereby allowing them to work in a more coordinated manner"* (164). In the same year, another ED challenged the physician in triage model in use and compared it to rotational patient assignment. No significant difference between the processes was found in terms of ED length of stay and the proportion of patients leaving without being seen by a physician. The authors argued that the care transition and ambiguity about patient responsibility built into the physician in triage model was eliminated by a rotational patient assignment model (165).

2.3 STREAMING

Another strategy for enhancing ED throughput is the streaming of specific patient categories in separate processes. These are typically created for medical conditions requiring time critical interventions, for instance, for patients presenting symptoms of an acute stroke, where brain imaging is recommended within 25 minutes of the patient arrival to rule out haemorrhage and thrombolysis should start within 60 minutes for patients with ischemic stroke (166). Patients with acute myocardial infarction may even bypass the ED and be transferred directly to percutaneous coronary interventions after a prehospital electrocardiogram (167).

Streaming patients based on their likelihood of being admitted to inpatient care or discharged home from the ED is a broader strategy which has been investigated in two single-centre studies with a before-and-after design. The waiting time to see a physician for all patient categories was only reduced by 3 minutes in the study by Kelly et al. (168), and unchanged in the study by King et al. (169). Although the ED LOS was reduced in both studies, by 12 minutes and 48 minutes, respectively, the patient categories that benefitted most were different. Kelly et al. found that the separate streams for likely admission and discharge were more beneficial for low acuity patients, whereas the reduction of ED length of stay was larger for admitted patients in the other study.

2.3.1 Fast tracks for low acuity patients

A different category consists of the walk-in patients who present to the ED with minor injuries or illnesses. Many EDs have chosen to stream these low acuity patients to a designated area, where they are assessed and treated separately from the high acuity patients. Such a fast track was first described in 1988 in the USA. In this study, a registered nurse, a resident physician, and two examination rooms were dedicated to low acuity patients during 20 peak hours per weekend (170). Common discharge diagnoses at the fast track were viral syndrome, urinary tract infection, extremity sprain, low back pain, and pharyngitis. The mean ED length of stay for these patients was 94 minutes, compared to 161 minutes for similar patients previously treated in the main ED. Moreover, the satisfaction of the patients improved after the introduction of the fast track.

2.3.1.1 Impact on patient throughput

A reduced ED length of stay for patients seen in fast tracks has been consistently observed across study settings on different continents and in numerous countries, in the approximately 20 scientific papers published in English. Other consistent findings have been an improved or unaffected ED length of stay for the other patients seen in the main ED and fewer patients leaving the ED without being seen by a physician, even in studies with no added resources. These fast tracks have, for example, been called Minor Injury Unit (171), See and Treat (172), Rapid Assessment Clinic (173), and Super Track (174).

A fast track for low acuity patients has been declared to be the only intervention that is supported by moderately strong evidence in a 2011 systematic review of triage-related interventions (132) and an umbrella review of interventions to improve ED patient flow published in 2018 (175). An explanation suggested for the efficiency of a fast track is the reduced distraction of staff when the low acuity patients are seen in the order of registration by a dedicated staff in an area separated from the high acuity patients. In a mixed process, the low acuity patients may notice that patients arriving later are seen sooner and distract the staff with questions about the waiting time.

2.3.1.2 Provider types

Fast tracks may be staffed by senior physicians (173, 176), resident physicians (170, 177), physician assistants, emergency nurse practitioners, or a combination of these provider categories (178, 179). The positive effects on ED throughput were consistent across provider levels. An emergency nurse practitioner is a senior registered nurse with additional training to autonomously diagnose and treat predefined ED patient categories. A nine-month emergency nurse practitioner training program was first described in the USA in 1977 to compensate for medical staff shortage (180). Various training models and practice ranges for emergency nurse practitioners have followed in Australia, Canada and the United Kingdom. A 2007 systematic review of 36 studies (181) found that nurse practitioners tend to be more expensive than junior physicians, since a nurse practitioner arranged more follow-ups (182) and saw fewer patients per hour than a physician (183). However, patients seen by nurse practitioners reported higher satisfaction than patients seen by resident physicians.

2.3.1.3 Orthopaedic patients

Among the low acuity patients in EDs, almost one third are patients who present with limb injuries or back pain (184). If ambulatory, these patients are often streamed to the fast track section (173). To the best of our knowledge, only two studies have specified the proportion of patients presenting limb injuries in the fast track section (173, 184). However, none of the studies specified the outcomes of these patient categories.

2.4 OLDER PATIENTS

Older patients pose special challenges to emergency care, which require EDs to adapt the processes for these patients.

2.4.1 Challenges

2.4.1.1 Overrepresentation

The finding of a larger proportion of patients 65 years or older seen in EDs compared to their proportion of the general population is consistent across continents and countries (185). For example, people 80 years or older accounted for 15% of all ED visits in the Finnish city of Tampere in 2015 to 2016, though the proportion in the population was only 4.8% (186).

In 2018, 5.2% of the population was 80 years or older in Sweden (187). In Swedish EDs, patients 80 years or older accounted for 18% of all adult visits in 2018. Patients aged 70 to 79 years also accounted for 18% of the visits, but this age group was larger and constituted 9.4% of the Swedish population. In other words, older people use emergency care more frequently than younger people. The frequency for people 80 years or older was 65 ED visits per 100 individuals, 35 per 100 for individuals aged 70 to 79 years, and less than 20 per 100 for individuals younger than 60 years (188).

With the expected increase of life expectancy in Sweden (189) and globally (190), the demand for emergency care will escalate with the growing number and proportion of older people. Populations in all regions of the world are ageing faster than ever before, causing the World Health Organization to declare 2020–2030 as the Decade of Healthy Ageing to emphasize the need for urgent actions (191).

2.4.1.2 Resource use

A second aspect is the higher resource use for older patients in emergency care. Patients 65 years or older are more likely to arrive by ambulance, 30% – 55% compared to 9% – 24% for those younger than 65 years, according to studies included in a systematic review (185). Furthermore, older patients more often present medical conditions of higher urgencies. This means that they require more nursing care and earlier physician assessment than younger patients in the ED. In addition, more diagnostic testing, including imaging, is used for older patients and patients 65 years or older are more likely to be admitted to inpatient care, 32%–51% compared to 8%–18% for those younger than 65 years (185). Older patients also stay longer in the ED (185), which adds to the risk of pressure ulcers (192) and nutritional deficiencies. The nursing tasks required to prevent these adverse events further increases the work load of the ED staff.

2.4.1.3 Diagnostic issues

A third aspect is the higher risk of undetected or misdiagnosed medical conditions for older patients, despite more extensive diagnostic testing in the ED (185). There are several contributing factors to the diagnostic challenge. Comorbidity, measured as the number of simultaneous medical conditions, averaged 3.1 (SD 2.2) for patients 65 years or older in a Canadian study (193). Among these patients, the average number of drugs was 4.2 (SD 3.1) per patient. This polypharmacy, in combination with the physiological changes of old age, increases the risk of unintended adverse drug effects.

Furthermore, older patients have higher risks of serious conditions. At the same time, they are more likely to present with atypical symptoms. For example, acute myocardial infarction may be presented as nausea or shortness of breath, instead of chest pain (194). In addition, 13% to 21% of older non-trauma patients present to the ED with non-specific complaints of weakness, tiredness or decreased general condition (195, 196). Apart from a high number of comorbidities and prescribed drugs, most of these patients suffer from serious acute conditions that may be under-triaged and underestimated in the ED (196). Older patients with non-specific complaints have a higher mortality during an in-hospital stay with an odds ratio of 4.7 (95% CI: 3.9–5.8) (197). The mortality remains higher within 30 days of the ED visit with a hazard ratio of 1.7 (95% CI: 1.2–2.4) (195). Moreover, cognitive and hearing impairments cause communication difficulties, which may lead to incomplete or incorrect patient histories and suboptimal decision making.

2.4.1.4 Negative outcomes

A fourth aspect is the negative health outcomes for older patients after the ED visit. These include functional decline with a subsequent need for assistance in daily living activities or even moving to long-term care facilities, increased mortality, revisits to the ED, and subsequent admission to inpatient care. Contributing factors to these negative outcomes are communication problems and unrecognized geriatric syndromes, such as repeated falls, depression, and cognitive impairment (198).

2.4.2 Interventions

Interventions to meet the challenges described above have used several different approaches, in particular, staff education, embedded geriatric expertise, and community-based interventions.

2.4.2.1 Staff education

One approach addresses the perceived lack of geriatric competencies by ED professionals (199, 200). A recent systematic review included nine studies of geriatric education programs, including lectures and high-fidelity simulation training sessions, for emergency medical and nursing staff (201). Most of the studies used participant questionnaires to report perceived changes in knowledge or attitude as study outcomes. Only one study assessed patient benefits in terms of reduced inappropriate placements of a urinary catheter after a one-year geriatric curriculum for emergency medicine residents (202).

2.4.2.2 Embedded geriatric expertise

Another common approach consists of placing geriatric expertise within the ED. Ten such studies were identified in a recent systematic review (203). Five of the studies used comprehensive geriatric assessment as the study intervention, which was carried out in a dedicated zone of the ED in two studies (204, 205). Most studies used mortality, hospital admission rate and length of inpatient care as outcome measures. The ED length of stay was the outcome measure in only two studies, which assessed the addition of a geriatric nurse (206) and a pharmacist, respectively (207). Patients in the intervention group stayed 1 and 2.6 hours longer, respectively, compared to older patients who received standard care in the ED.

2.4.2.3 Community-based interventions

A third approach consists of interventions carried out in the community or at home, after discharge from the ED or inpatient care. Through phone calls or home visits, the identified needs of the older patients are followed up, so that they may be met by relevant service providers (203). Although most of the studies reported reduced numbers of ED revisits by the intervention group, the finding was contrasted by an increased number of revisits in one randomized controlled trial of nurse case management for frail older people (208).

2.4.2.4 Comprehensive geriatric assessment

All intervention approaches mentioned above may include comprehensive geriatric assessment, a cornerstone of geriatric care for early identification of older people who risk negative outcomes. Comprehensive geriatric assessment consists of a multidimensional assessment of the medical, functional, and social needs of the patient by a multidisciplinary team in order to arrive at a coordinated care plan. The assessment is flexible and may be carried out as screening or an in-depth management plan, by team members of various professions, and in different healthcare settings (209, 210).

The first randomized controlled trial was published in 1984 and studied a hospital unit specifically designated for comprehensive geriatric assessment (211). Several systematic reviews and meta-analyses have since been published, and the evidence supports that older patients discharged from the designated units are more likely to be alive in their own homes (212-214). Despite an overall heterogeneity, the evidence also supports that home assessment reduces functional decline and mortality (215, 216). By contrast, there is no clear evidence of positive outcomes of comprehensive geriatric assessment in EDs (210, 217, 218).

Comprehensive geriatric assessment is time consuming and may be difficult to carry out for every older patient in busy EDs. Therefore, a two-step approach has been suggested, where the first step consists of using a screening tool to identify the frail older patients at high risk of negative outcomes (219). However, there is a lack of standard definition of frailty and a lack of evidence supporting any of the screening instruments validated for EDs (220-222).

Consequently, new frailty screening instruments are still being developed and compared to the more established tools (223, 224). Even when comprehensive geriatric assessment is carried out only for selected patients, it may be too time consuming for EDs. Therefore, shorter assessment tools have been developed for use in EDs (219).

2.4.2.5 Geriatric guidelines

The Royal College of Emergency Medicine in the United Kingdom and the British Geriatrics Society jointly led a project and in 2012 published the document " Quality care for older people with urgent and emergency care needs", also called the Silver Book (225). It consists of best practice guidelines endorsed by many medical and nursing societies in the United Kingdom. In the USA the following year, collaborating medical and nursing societies jointly approved the Geriatric Emergency Department Guidelines (226). The Australasian College for Emergency Medicine followed in 2015 by approving the "Policy on the care of elderly patients in the emergency department" (227). These documents incorporate the main components of comprehensive geriatric assessment and call for older-friendly ED environments.

2.5 TEAMWORK

A team consists of at least two individual members who perform interdependent tasks to reach a common goal. Our knowledge of team performance originates from various research disciplines, for instance, human factors, psychology, organizational science, communication, and learning. Researchers have identified over 130 models of team performance. However, these models share a common concept of input, process, and output variables (228). Input variables characterize the individual members and the team, such as skills, resources, and tasks. Output variables are the team outcomes, satisfaction of members, and stability of the team. The output variables from one team episode influence the next episode, which allow teams to learn and improve. The process variables concern the communication, coordination, and decision-making skills of the team. Leadership, situation awareness and a shared mental model are also important process skills (Figure 2). These are called non-technical skills, as opposed to the technical skills of a pilot or the clinical skills of a surgeon in a team (229).

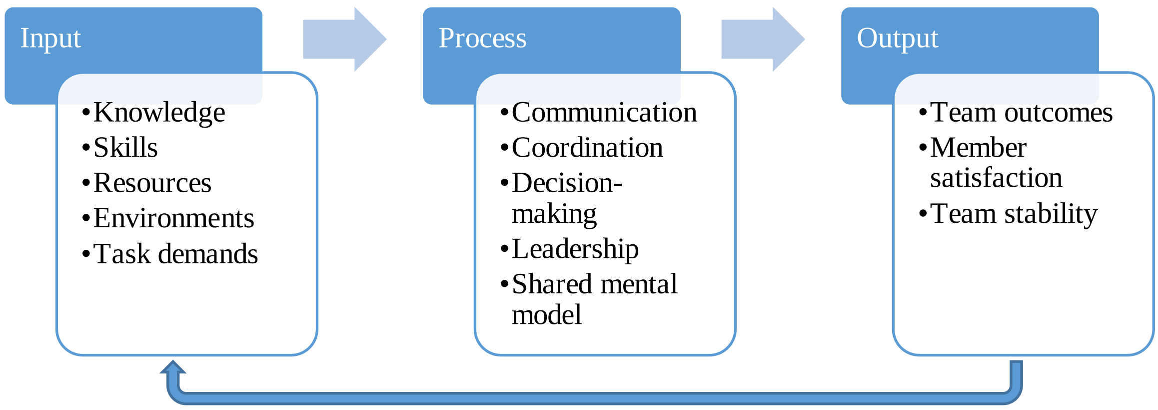

Figure 2. Input-Process-Output model of team performance

2.5.1 Healthcare teams

There are many different types of healthcare teams, for example, primary care teams for specific chronic diseases, hospital-based home care teams for elderly patients, breast cancer teams, and hospital-wide critical care outreach teams. Reviews of healthcare team effectiveness published in 2006 and 2014 found that, across healthcare settings, care delivered by teams improves clinical outcomes and patient satisfaction, compared to uncoordinated sequential care (230, 231). Furthermore, improved job satisfaction was correlated to perceived team effectiveness. The authors concluded that future research should focus on how to create and sustain high-functioning teams in different healthcare settings. Similar conclusions were drawn in a 2017 update of a Cochrane review on interprofessional collaborative practice. The authors recommended that future studies should use mixed quantitative and qualitative methods and longer follow-up to conceptualize and measure the collaboration (232).

2.5.2 Patient safety

Patient safety was once considered a matter of clinically skilled physicians and nurses who expect perfect performances of themselves. Errors in medicine were mostly regarded as personal failures of individual clinicians and were dealt with by correction or more training. As a consequence, similar errors recurred with other clinicians being blamed for not being careful or skilful enough. However, it was recognized from lessons in the aviation industry and research in cognitive psychology and human factors that errors lie in the human nature. There are different types of human errors: Slips are un-intentional actions, lapses are inactions, and mistakes result from incorrect intentions. These appear especially when the attention is diverted by various distractions in the system (233).

Reports of substantial numbers of patients in hospitals who were harmed or died from errors have been published since the 1960s. Most of the errors were preventable. In the mid-1990s, voices were raised for a change of the patient safety culture towards an approach of designing safer systems (234). However, errors occur even in high reliability systems and such errors are recovered by human adjustments in a resilient organization (235). In 2000, the Institute of Medicine (now the National Academy of Medicine) in the USA published the report *To Err is Human – Building a Safer Health System* (236). One of the recommendations was to establish interdisciplinary team training programs, including simulation, for personnel in areas such as the ED. This recommendation was repeated by the Institute of Medicine in 2001 and 2003 (237, 238).

2.5.3 Team training

The recommendation was built on the recognized importance of teamwork for safe healthcare and on the methods of team training in commercial aviation. The training is known as crew resource management and has been successful in reducing flight accidents. Black boxes in the cockpits revealed that flight accidents were mostly caused by failures of communication, decision-making, and leadership. This led to the development of crew resource management modules, where aircrews were trained in simulated crisis scenarios with instructor feedback from 1979 and onward (239). The approach was first adopted into the healthcare services as the Anaesthesia Crisis Resource Management in the 1990s (240).

Although high-fidelity simulation training based on crisis resource management is widespread and appreciated by health professionals as a learning experience, the evidence is still limited of the impact on patient outcomes (239, 241, 242). More recently, in situ simulations have been described. The simulation is conducted in actual care units by using existing equipment and resources. This has been promoted as a better way to detect latent safety threats in the system than simulation in high-fidelity training centres. For example, in situ simulations has been conducted as unannounced video-recorded training sessions of ten-minute duration, followed by a ten-minute debriefing in a paediatric ED (243). Didactic team training integrated with practice scenarios is a different approach provided by TeamSTEPPS® (Team Strategies and Tools to Enhance Performance and Patient Safety), developed jointly by the US Department of Defense and the Agency for Healthcare Research and Quality. The TeamSTEPPS® course material, implementation guide and measurement tools are available online at no cost (244). A review of team training programs and tools in healthcare is available from the Canadian Patient Safety Institute (245).

2.5.3.1 Interprofessional education

Already in 1972, the Institute of Medicine hosted the *Conference on the Interrelationships of Educational Programs for Health Professionals* (246). But interprofessional education, where members of more than one healthcare profession learn together to improve interprofessional collaboration and quality of care, was slow to develop (247). In 2010, the World Health Organization released the *Framework for Action on Interprofessional Education & Collaborative Practice* (248) and interprofessional education is now progressively being incorporated in the undergraduate curriculum for healthcare programs. Examples of interprofessional education are the student-led ward (249) and the clinical educational emergency department (250). The second update in 2013 of a Cochrane review (247), originally published in 1999 and first updated in 2008, showed that the number of interprofessional education studies reporting various positive outcomes has grown. However, the authors concluded that more research is needed using larger samples and better randomization procedures. More appropriate control groups than those that received no educational intervention were also recommended. Interprofessional education improves knowledge, skills, and attitudes about collaborative teamwork according to a systematic review and meta-analysis of 12 more recent pre-post studies (251).

2.5.4 Emergency teams

As in the case of commercial aviation, teamwork failure of the ED staff was the main contributor to errors in a review of malpractice claims from eight hospitals (252, 253). The staff in the ED performs multiple concurrent tasks in an environment of dynamic plans, uncertainty, high work load, time pressure, and interruptions. Flexibility is required for efficient teamwork in the ED, more than in the aviation industry and other healthcare settings.

2.5.4.1 Teamwork principles

Researchers have suggested principles of teamwork to improve patient safety in emergency care (229, 252, 254), which can be summarized in five items: 1. Highly motivated and task-oriented team leaders, whose behaviours promote coordination and collaboration; 2. Team members with clear roles and responsibilities, who know what to expect from teammates but can still adapt to new situations and back up team members when needed; 3. A shared understanding and awareness of the task and situation of teammates, in order to monitor the progress and adjust when needed; 4. A discipline of pre-briefing and debriefing, where the team leader clarifies roles, goals, and strategies before the team performance and afterwards summarizes the lessons learned to improve team skills; 5. The development of trust and confidence to promote a sense of collective efficiency and psychological safety.

Training of closed-loop communication, situation awareness, coordination, and leadership skills is recommended. However, further research on training of these skills is needed, which requires better real-time measurements that are validated for use in ED settings (255-258) .

2.5.4.2 Patient safety in the ED

Few studies have investigated teamwork in emergency care. Of these, the MedTeams™ project has been the major contributor. This was a patient safety research project supported by the US Department of Defense and involved nine EDs which self-selected into the experimental or the control group (259). From 1996 to 1998, an expert panel of designated physician-nurse pairs from each of the participating EDs and behaviour scientists developed a curriculum, the Emergency Team Coordination Course. It consisted of 48 team behaviours in five learning modules and was conducted as lectures and discussions aided by video vignettes, where actors illustrated good and poor teamwork.

During five months in 1998, all 684 clinicians in the six experimental EDs received 8 hours of training in mixed groups of physicians, nurses and technicians. The groups were led by the designated physician-nurse pairs in the expert panel. Training was delayed until the completion of data collection in March 1999 for the three EDs in the control group. After the training, ED staffing was adapted to create work teams, each containing at least one physician-nurse pair and up to ten health professionals. The most experienced physician in the work team was designated as team leader. Members of a work team worked together during a shift to deliver care for the patients assigned to the team, but the teams were composed of different individuals from one day to another.

Observations of clinical errors and teamwork quality were conducted during one period before the training and two periods after the training. A reduction of clinical errors was observed only for the experimental group of EDs, from 30.9% to 4.4%. The teamwork quality was observed using the Team Dimension Rating Form, validated in military aviation research. Improved teamwork quality was observed only for the experimental EDs, where the mean score increased from 30.4 before to 57.0 after the training (259).

In addition to the standard 8-hour didactic training, two work teams from one experimental ED were randomized to receive an additional 8-hour simulator training session containing three scenarios. Team observations before and after the training showed no significant difference in improvement of teamwork quality (p=0.07) between the work teams with additional simulator training and the work teams randomized to only receiving the didactic training. However, the authors argued that the p-value indicated a trend towards greater improvement in the group receiving both didactic and simulator training (260).

2.5.4.3 Staff perception

The perception of the job environment in the MedTeams™ project was evaluated in a cross-sectional survey conducted from 2009 to 2012 (261), more than ten years after the Emergency Team Coordination Course. A convenience sample of the staff in four EDs that practiced teamwork after the training and four other EDs with no training was invited. During one week in each ED, 191 staff members from EDs in the experimental group and 307 from the control group completed two questionnaires, the Healthcare Team Vitality Instrument (262) and the Revised Nurse Work Index (263). In both groups, 87% of the respondents were nurses and 13% were physicians. The authors found an improved perception of job environment, autonomy, and control over practice among the staff of experimental EDs, compared to EDs in the control group (261).

2.5.4.4 Patient throughput

Few studies have investigated the impact of teamwork on patient throughput in EDs. The following examples indicate a development from assigning patients to physician-led teams towards focusing on principles of interprofessional teamwork.

A large ED in Hong Kong evaluated a small team assignment system in 1994, which replaced a common pool of patients for doctors to see. After triage, patients waited in four different queues, one for each team. A team consisted of one medical officer, but the nursing staff was not specified. Two teams covered the Walking section and two teams the Cubicle section. A total of 2583 patient presentations were sampled and analysed retrospectively. The mean waiting time to physician assessment was reduced from 35 to 22 minutes after the small team intervention. The ED length of stay was not reported (264).

In 2002, a single-centre study in the USA assigned ED patients to physician-led teams consisting of one physician, two nurses, and usually one technician. Over 30 000 patient presentations during one year after the intervention were compared to an equivalent number of patient presentations during the previous one-year period. The mean time to physician assessment was reduced from 71.3 to 62.8 minutes, but the mean ED length of stay increased from 249 to 257 minutes after the intervention (265).

An Australian single-centre study of team-based care in 2013 reported an increase from 54% to 71% of ED patients admitted to inpatient care or discharged within four hours, a national emergency access target. The intervention assigned the medical staff to discrete teams of 3 to

4 physicians per team, with one team covering the low acuity fast track unit and two teams covering the other patients. A leading senior physician was involved early in the patient assessment. Two additional ED consultants were employed in this ED, which had 73 000 visits per year. The mean time from triage to departure from the ED was reduced from 264 to 227 minutes after the intervention (266). However, the work process before and after the intervention was not described in detail, nor the collaboration between medical and nursing staff or whether the staff received any team training.

In Sweden, a team-based system was introduced during a 2-month test in 2007 at the orthopaedic section of an ED. Each team had three dedicated examination rooms and was staffed by one doctor and at least three nursing staff. The doctor alternated between patients and carried out the paperwork in the examination rooms, which were equipped with a computer and recorder for dictation. The sample size was approximately 3000 patient presentations in each period of two months immediately before and after the team-based intervention. The mean waiting time to physician assessment was reduced from 124 to 114 minutes and the mean ED length of stay from 268 to 245 minutes (267).

Later, a 4-hour target of ED length of stay was also introduced in Sweden and another ED launched a project in 2010 to meet the target, the TEPPP (Teamwork on Efficiency, Patient safety, Patient satisfaction, and Personnel work environment) project. The project introduced multi-professional teams consisting of one physician, one registered nurse and one nursing assistant, and each team shared a dedicated office near the examination rooms. Initially, the new work process was introduced at the medicine section of the ED, where all employees participated in a half-day workshop and received a handbook along with a flashcard before the implementation. Data collected from the medicine section immediately before and one year after full implementation showed an increase from 59% to 71% of patients meeting the 4-hour target, a reduction of the median waiting time to physician assessment from 53 to 42 minutes, and a 39-minute reduction of the adjusted ED length of stay (268).

2.5.4.5 Team behaviour

Observations of key team behaviours were conducted during the second week after the implementation of the TEPPP project. With two simultaneous observers, the observation time totalled 50 hours and team encounters with 44 patients were observed (269). The observers focused on four key team behaviours: 1. *Take patient history with the whole team present*; 2. *Design and communicate plan within the team*; 3. *Collaborate and cooperate around patient needs by working in parallel with individual tasks*; and 4. *Rapid execution of plan.*

Adherence to the planned behaviours varied from one day to the next and the patient history was taken with all team members present for only 36% of the observed patients. The physicians seldom discussed the plan and mainly communicated the next immediate step. Once the team members left the examination room, they had trouble finding each other and proceeded on their own. For patients whose history was taken without all team members present, teamwork was not observed at all. The authors suggested applying "*more general principles for successful* *implementation of teamwork, such as institutional level incentives to train and multi-professional training of staff in their units*".

2.5.4.6 Implementation matters

One year later, new observations were conducted in May and June 2011 at the medicine section and the surgery section, where the new work process had been introduced in January 2011 (270). The observations were stopped after saturation, which was reached after 68 patients at the medicine section and eight at the surgery section. The new observations focused on five revised key team behaviours, which were: 1. *Assembling when tasks have been performed*; 2. *Communicating decision to change plan*; 3. *Coordinating work*; 4. *Working in parallel*; and 5. *Communicating the work plan*.

At the medicine section, three or more key team behaviours were observed for 50% of the observed patients, compared to 0% at the surgery section. Semi-structured interviews of 11 staff and managers were also conducted, enabling the authors to conclude that the observed differences between the ED sections were due to different implementation approaches. At the medicine section, a change team of ED nurse managers and a full-time physician facilitator actively supported the staff during shifts, gave clear directions, provided feedback on team performance, and carried out the necessary adaptations during the first three months. At the surgery section, the senior medical manager supported the implementation only for two work shifts and no structured coordination with the ED nurse managers took place. Directions were unclear and deviations from the work process remained uncorrected.

2.5.4.7 Sustainability issues

The TEPPP project was further evaluated in 2013 by new observations and a multi-professional group interview at the medicine section (271). The proportion of observations with three or more key team behaviours had decreased from 50% to 23%. Working schedules were no longer synchronized between the medical and nursing staff, so that some physicians only worked during a part of a team shift, while other shifts had a surplus of physicians. Work rooms were used by other staff members than the designated teams. The interviewed staff had different views of whether teamwork was still the formal work process and what it was comprised of. No individuals took over the tasks of the change team after it was dissolved and the debriefings at the end of shifts no longer took place. Without feedback of the fact that the teamwork process was faster for the patients, the staff experienced that they did less and worked more slowly.

2.5.4.8 Patient satisfaction

Two studies assigning ED patients to physician-nurse teams reported improvements of the patient satisfaction by 3.1–4.5 percentage points from a level of 63%–78% (265, 272). However, the response rate of the mailed Press, Garney survey in the first study was only 9%–10%. The second study used the quarterly delivered scores from the Kaiser Permanente member survey, which had a 45% response rate, but the proportion of ED patients with a membership was not reported. A third study (273) used an adapted version of the Group

Development Questionnaire and showed that patients who perceived a high team effectiveness were more likely to report a high satisfaction.

2.6 IMPLEMENTATION

Issues of initial adoption and sustainability of teamwork behaviour are neither new nor unique. A new research field, implementation science, has evolved to fill the gap from evidence to routine practice. Evidence-based practice emphasizes the use of the latest knowledge, but an average time lag of 17 years for scientific discoveries to be translated into clinical practice has often been quoted (274). This time lag consists of a minimum of 6.3 years from publication to review papers or textbooks, and another 9.3 years to implementation. In 2015, a review of 23 papers in translational research found that broad variations of the time lag remained, and that standardized definitions, key stages and measures were needed to better quantify and improve time lags (275).

2.6.1 Definitions

A standardized terminology is also needed for implementation science (276), which is the scientific study of methods to facilitate the systematic uptake of evidence-based health interventions into routine practice (277). The research field deals with behaviour change, system transformation, and organizational restructuring, and has overlaps with other research disciplines, such as behaviour science, quality improvement, management, and knowledge dissemination. For instance, many terms used by implementation researchers were introduced 1962 by Rogers in the classical *Diffusion of innovation* model (278). Examples are the stages of dissemination, adoption, implementation, evaluation, and institutionalization of an innovation. However, the diffusion literature covers only the initial stages and implementation research the remaining stages. An implementation process usually starts by exploring whether a decision to adopt the innovation should be made (279, 280).

2.6.1.1 Innovation versus intervention

According to Rogers, an innovation is an idea, practice or object that is perceived as new by an individual, but is not necessarily new to others (278). In implementation research, the innovation is often an evidence-based practice or guidelines that have passed the dissemination stage. While clinical trials rigorously control the contexts to measure the health outcomes of an innovation, implementation research investigates how the innovation is processed in the real world and answers questions such as: To what extent is the innovation used, by whom, when, and in which context? A method or technique used to facilitate the uptake of an innovation is an implementation intervention, while an implementation strategy is a package of selected interventions to address identified barriers to the uptake (281). In clinical trials, the term intervention is used for the innovation under investigation, something which often causes confusion.

2.6.1.2 Fidelity at several levels

In implementation practice, a trade-off is often necessary between installing an innovation with fidelity and adapting it locally to the specific context where it is to be used. Finding the right balance of what must be maintained of the innovation to achieve the desired health outcomes is often the first fidelity decision to make. However, fidelity also refers to the degree to which the clinicians are using the innovation as intended, which often diminishes over time if not carefully monitored. Moreover, fidelity at the organizational level is also needed to ensure that prerequisites, such as staffing and other resources, for the clinicians' use of the innovation are in place (279).

2.6.2 Theories and frameworks

Initially, implementation research was mainly empirical and has been described as "*an expensive version of trial-and-error*" in 2005 (282). However, theory-based research has been encouraged and numerous frameworks are now available. Theories have the capacity to predict outcomes and to explain causal mechanisms of implementation, while models or frameworks only describe and categorize empirical phenomena. The terms model and framework are used interchangeably.

2.6.2.1 Process models

Models that describe or guide the process from research to practice are categorized as process models, where action models constitute a subtype. Action models guide the implementation process by providing checklists for deliberate planning and management, especially for the early stages of an implementation process. The Quality Implementation Framework is an action model developed in 2012 from a synthesis of 25 existing frameworks. This meta-framework contains 14 critical steps in four phases, with eight steps in the first phase, *Initial consideration regarding the host setting* (Figure 3) (280). Published study protocols illustrate the usefulness of the Quality Implementation Framework for guidance in empirical research (283, 284).

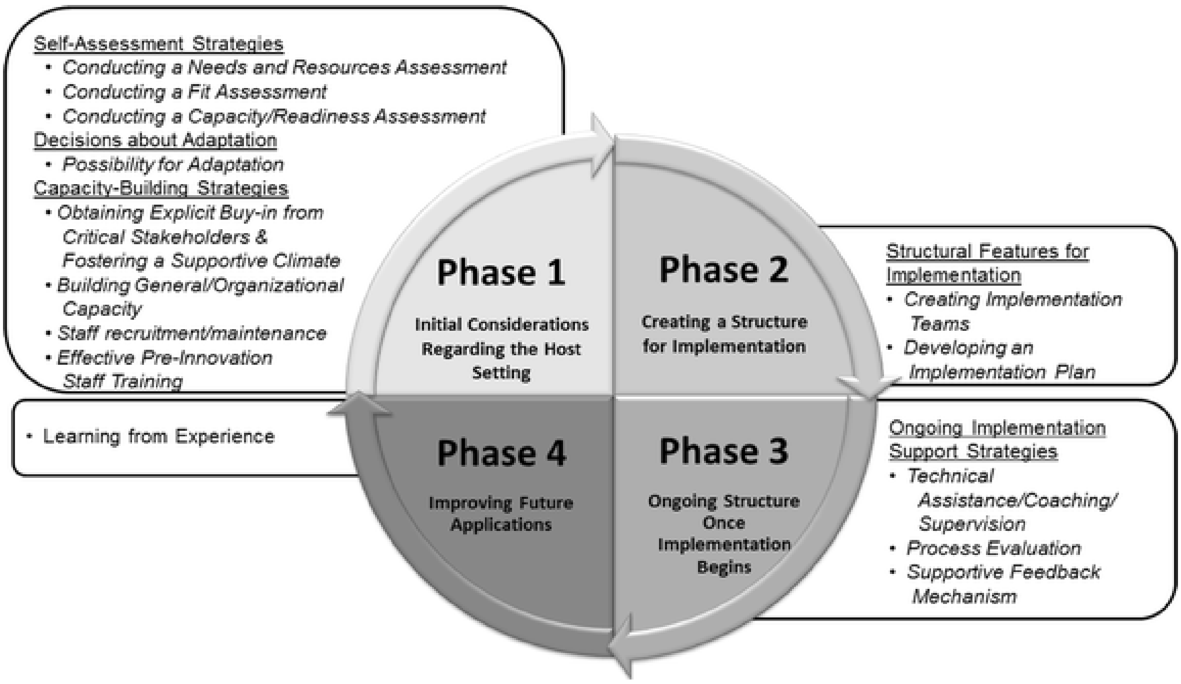

Figure 3. The Quality Implementation Framework: a synthesis of critical steps in the implementation process. Reproduced with permission from (280).

2.6.2.2 Theories

Implementation researchers may choose to apply classic theories from other research disciplines, such as theories of psychological behaviour change, organizational learning, and leadership. Nevertheless, specific theories for certain aspects of implementation have been developed, for example, Implementation Climate, Organizational Readiness, Normalization Process Theory, and COM-B (Capability, Opportunity, Motivation, and Behaviour) (276).

The COM-B is the behaviour system that constitutes the hub of the Behaviour Change Wheel framework published in 2011 (285). Motivation directs behaviour, but capability and opportunity are necessary additional factors for a behaviour to occur. Capability is the individual's physical and psychological capacity to perform the behaviour, which includes the necessary skills and knowledge. Opportunity refers to the social and physical factors outside the individual that make the behaviour possible. The performed behaviour may in return influence the motivation, either automatic or reflective, but also the capability and opportunity components (Figure 4). In the Behaviour Change Wheel, the COM-B hub is surrounded by an inner circle of nine intervention functions and an outer circle of seven policy categories, which were synthesized from 19 existing behaviour change frameworks (Figure 5).

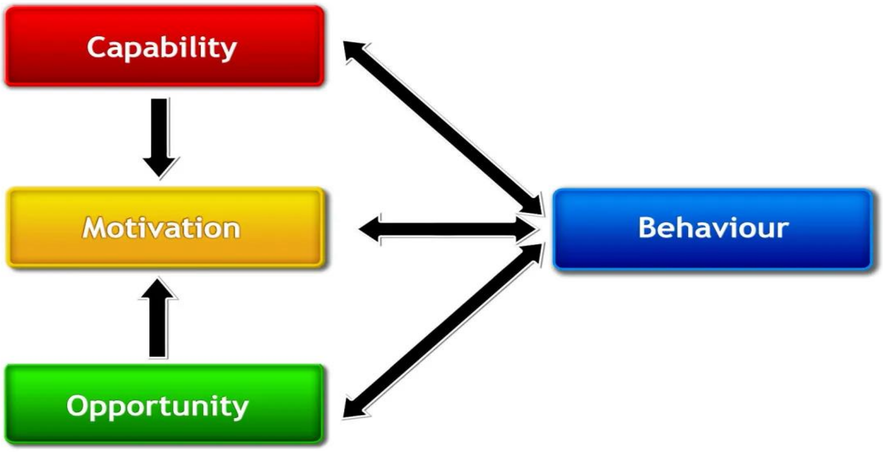

Figure 4. The COM-B system – a framework for understanding behaviour**.** Reproduced with CC BY licence from (285).

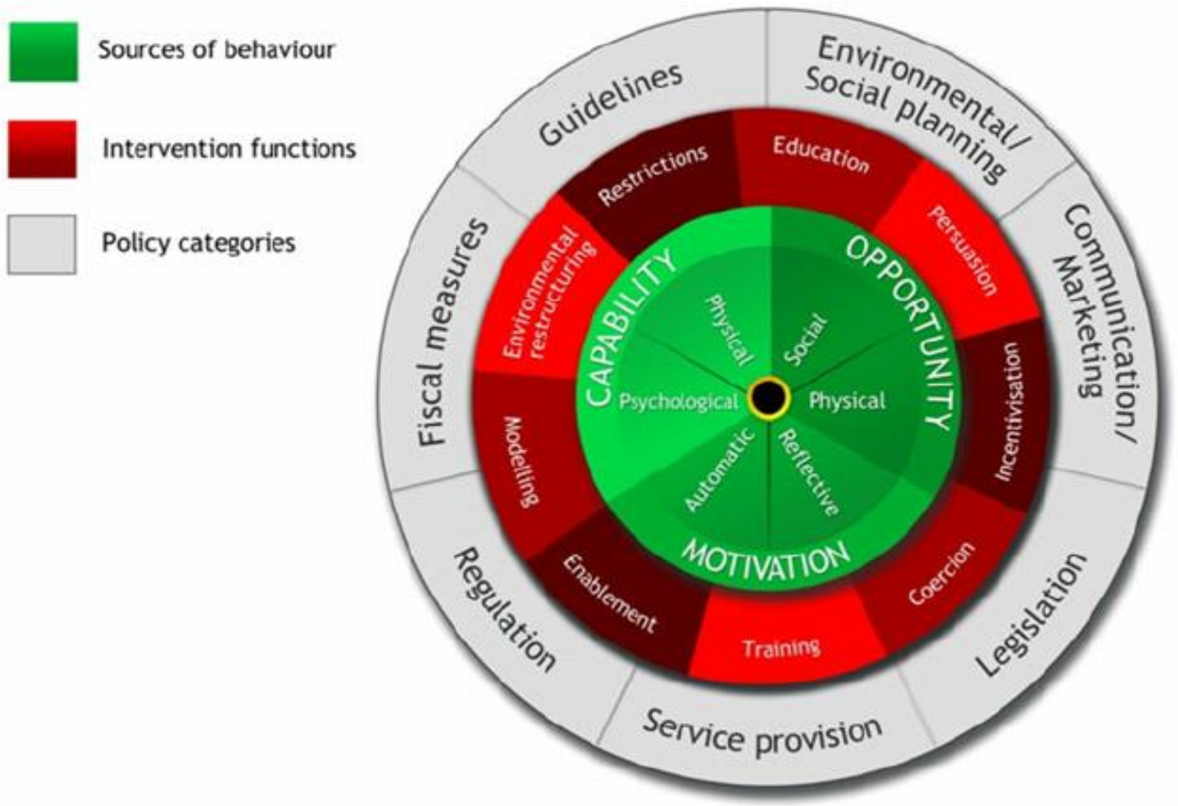

Figure 5. The Behaviour Change Wheel. Reproduced with CC BY licence from (285).

2.6.2.3 Determinant frameworks

Another category consists of the frameworks which describe determinants that influence the implementation outcome. Many of these frameworks identify multi-level determinants that interact with each other, implying an integrated approach to the whole system. In contrast to theories, determinant frameworks do not explain the causal mechanisms of change (276). Examples of determinant frameworks are PARIHS (Promoting Action on Research Implementation in Health Services), the Theoretical Domains Framework, and Active Implementation Frameworks (286).

The Theoretical Domains Framework was synthesized from 33 psychological behaviour change theories by a consensus group of health psychology theorists and health service implementation researchers. The 128 identified constructs were simplified into 12 domains, each accompanied by examples of interview questions. The resulting framework was validated by 30 other health psychologists at a national conference and published in 2005 (287). In 2012, a refined Theoretical Domains Framework was published after a new validation by behaviour change researchers (288). The refined framework contained 84 constructs in 14 domains and was found to fit well with the Behaviour Change Wheel, with 100% agreement in designing interventions. The authors recommended starting with a COM-B analysis to select the domains most important to investigate. The Theoretical Domains Framework has been the guide for exploring and measuring barriers and facilitators to specified behaviours in numerous implementation studies. A formal guide to using the framework is also available (289).

In contrast to the focus on behaviour change, the Active Implementation Frameworks are multi-dimensional and contain six frameworks: Usable Innovations, Implementation Stages, Implementation Drivers, Implementation Teams, Improvement Cycles, and Systemic Change (286). The Active Implementation Frameworks are based both on reviews of literature and "things that apparently matter" from decades of implementation practice. Assessment of fidelity at several levels is emphasized in the Active Implementation Frameworks. Starting with Usable Innovations, where essential elements to achieve the intended health outcomes are specified and practical fidelity assessments are designed during the exploration stage. In the installation stage, staff and organization are prepared and resources acquired. From the initial implementation stage, fidelity is achieved by the effective use of eight implementation drivers: three of competency, two of leadership, and three organizational. Each driver interacts dynamically with the others and continuous monitoring is required. An implementation team is selected to support and be accountable for the effective use of the innovation. Improvement Cycles are used for rapid problem-solving, while Systemic Change guides the work to create a context with enabling structures to sustain the use of innovation.

In conclusion, more than one theory or framework may be chosen to address different aspects of an implementation process.

3 AIMS

The introduction of interprofessional teamwork in healthcare has progressed slowly, despite repeated recommendations from health organizations during two decades. Effective teamwork is advocated mainly for its potential to improve patient safety and clinical outcomes, but it also improves the satisfaction of patients and staff. However, studies of interprofessional teamwork in emergency care are few. The overall aim of this thesis project was to evaluate the implementation of interprofessional teamwork in a large crowded ED. Our hypothesis was that well-coordinated care delivered by effective ED teams improves the patient throughput, in terms of waiting time to physician assessment and length of ED stay. These are widely used as proxy measures of crowding and are among the most studied of ED performance indicators (146).

More specific aims of the individual studies were:

I. To compare the patient throughput of interprofessional teamwork to that of two common triage-related strategies to reduce ED crowding.

II. To compare the patient throughput of interprofessional teamwork to that of a fast track streaming low acuity patients, which is also a widespread strategy to reduce ED crowding.

III. To evaluate the streaming of older patients to a dedicated ED team in terms of inpatient admission rate and ED length of stay.

IV. To evaluate the implementation process and learn about the fidelity and improve the sustainability of interprofessional teamwork.

4 ETHICS

We obtained approval of the Regional Ethical Review Board of Stockholm, reference number 2016/109-31/5. The interprofessional teamwork intervention was justified by the need for more evidence from ED settings, the potential of positive effects from effective teamwork, and the minimal risks for participating patients and health professionals. Several measures were also taken to protect their integrity and confidentiality.

The hospital administration granted access to de-identified registry data from the electronic tracking system of the ED. Data were retrieved for the study period from 2012 to 2016 and stored in a dedicated research folder of a hospital server, to which only the project members were given access. Since all ED visits to the adult ED during the study period were included and each patient was managed according to the ED processes at the time of visit, we did not obtain the patients' consent to participate. Nor did we obtain the patients' consent to publish, because the results were only reported at an aggregated level where the risk of identifying individual patients was negligible.

Written consent to participate and publish was given by all staff who were observed or interviewed. Each was informed that participation was voluntary and that he or she had the right to withdraw without any explanation. Data from the observations and interviews were also de-identified and stored in the same research folder as the quantitative data. We removed all names from the interview transcripts and only reported data in a manner that minimized the risk of identification.

The Regional Ethical Review Board also approved an amendment for accessing additional registry data from the Stockholm County Council of patients 80 years or older, reference number 2018/541-32. The additional data were also de-identified, stored in the same research folder as the original data, and reported at an aggregated level with a minimal risk of identification.

5 MATERIAL AND METODS

5.1 STUDY DESIGN

The thesis project is a single-centre evaluation of the implementation of interprofessional teamwork in emergency care. Mixed methods were used, with a quantitative pre-post design in three of the studies, whereas the fourth study used triangulated data from structured observations, semi-structured interviews, and a staff questionnaire. The relation in time of the four studies from 2012 to 2018 is visualized in Figure 6.

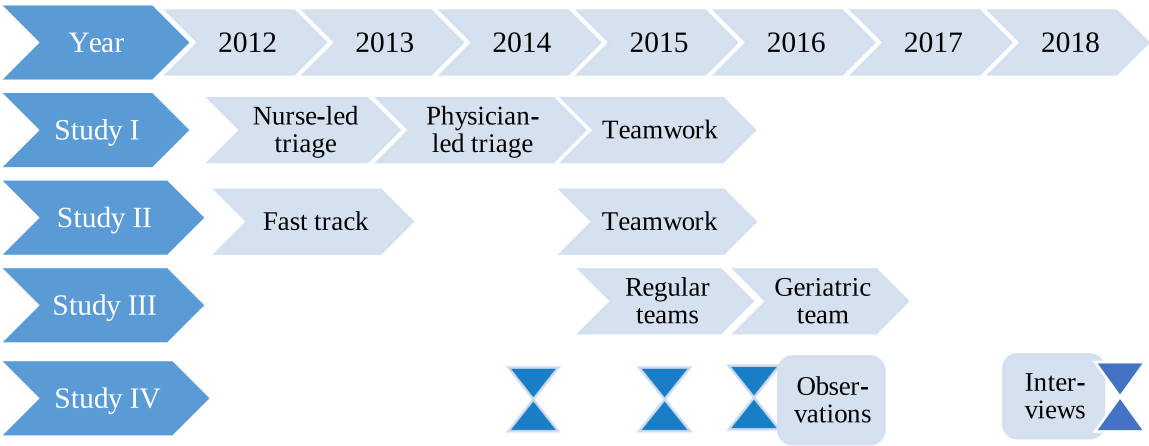

Figure 6. Relation in time of study I to IV. The first three studies were quantitative studies using patient data, while the final study used staff data from team observations, interviews, and a repeated questionnaire as indicated by the ⧗ symbol.

5.2 STUDY POPULATION

The studies were conducted at the adult ED of Södersjukhuset, a 600-bed urban teaching hospital in Stockholm, Sweden. During the study period from May 2012 to June 2018, approximately 110 000 patient arrivals were registered each year at the ED. All nursing staff, consisting of approximately 120 registered nurses and 60 nursing assistants, were ED employees that rotated between all sections in the ED.

The situation of physicians was more complicated. In most Swedish EDs in 2012, the medical staff consisted mainly of junior physicians on rotation from other departments of the hospital. They were not ED employees and only worked some of their shifts in the ED. However, the study hospital was the first in Sweden to introduce a residency program in emergency medicine and had approximately 60 physicians who were full-time employees of the ED. Of these physicians, only ten were specialists when the study period started. These physicians mainly served patients presenting orthopaedic or other surgery complaints in one corridor of the main

ED and the fast track See & Treat for mixed low acuity patients. Physicians on rotation from the internal medicine and cardiology departments served only patients with non-surgical complaints in the other corridor of the main ED. More than 400 physicians per year were on rotation to the ED, including interns and primary care residents.

5.3 REDESIGN FOR INTERPROFESSIONAL TEAMWORK

In October 2013, the hospital management decided to improve the patient throughput in the ED by introducing interprofessional teamwork. Five department managers each assigned one senior physician for engagement 20% of full-time in the ED improvement groups. A total of 60 hospital employees formed three ED improvement groups, consisting of physicians, registered nurses, nursing assistants, and section managers. The groups initially focused on different patient categories: surgery, internal medicine, and cardiology, respectively. Facilitated by an external consultant, the improvement groups conducted ten Plan-Do-Study-Act cycles (290) within the first year and prepared for the implementation of interprofessional teamwork, hereafter referred to as teamwork.

The ED facility, including the triage area and See & Treat, was reorganized into teamwork modules. A module had dedicated rooms, bays, a waiting area, and a team area. It was staffed by two care teams and a leading flow team. Each team consisted of a physician and a registered nurse, with the most senior pair in the flow team. A nursing assistant helped all team members (Figure 7).

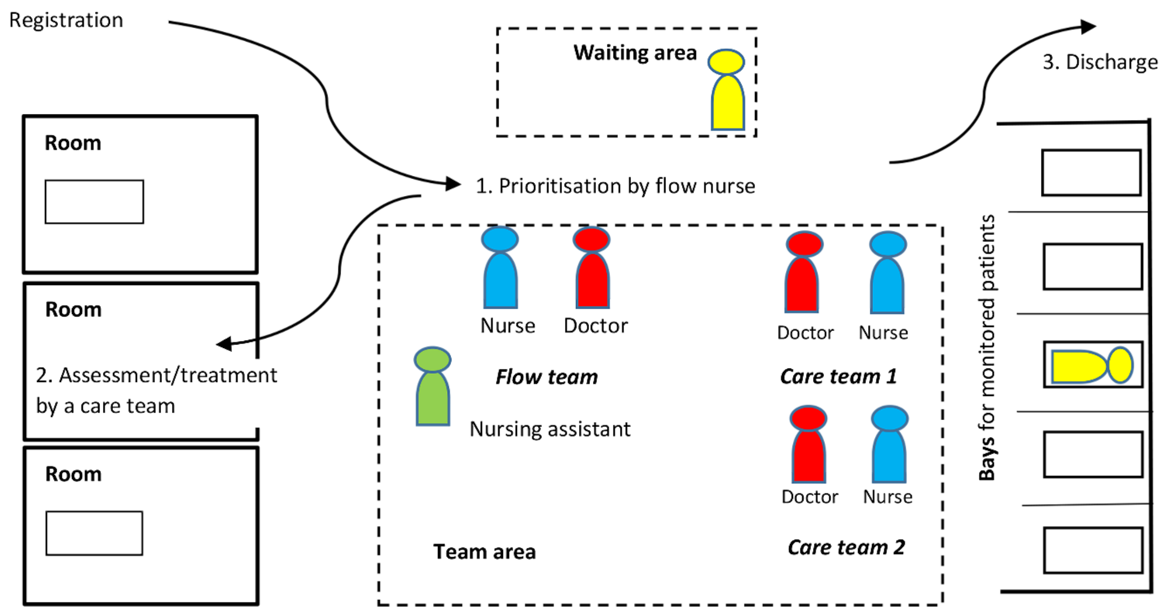

Figure 7. Interprofessional teamwork module. A teamwork module had dedicated rooms, bays, a waiting area, and a team area. It was staffed by two care teams and one leading flow team. Each team consisted of a physician and a registered nurse, with the most senior pair in the flow team. A nursing assistant helped all team members. Reproduced with CC BY-NC 4.0 license from (291).

Doctors moved from back offices to a shared team area, where each team member had a dedicated workplace next to his or her teammate. Some rooms were fitted with large windows and converted to team areas, where all team members had a good view over their patients. The spacious waiting room in the triage section was emptied and waiting patients were distributed to different teamwork modules, where they were greeted and prioritized by the flow team nurse.

The work schedules of physicians from different departments and the ED nursing staff were synchronized to allow all team members to start and end a shift together, although a teamwork module consisted of new members from one shift to the next. Previously, physicians belonging to different departments had different work shifts, which also differed between the medical and nursing staff belonging to the ED.

In November 2014, teamwork was formally implemented on weekdays from 8 am to 9 pm. After further Plan-Do-Study-Act cycles, it was also introduced on weekday nightshifts in November 2015 and on weekends in February 2016.

5.3.1 Pre-training

In September 2014, all medical and nursing staff of the ED participated in a one-day workshop, which consisted of a didactic lecture and practical scenarios where health professionals played team roles. Improvement group leaders facilitated during the scenarios and held debriefings after each scenario. Starting with routine patient scenarios, the facilitators also allowed team members to suggest scenarios that they expected to be challenging. In the fall, physicians from other departments were invited to a lunch containing a two-hour version of the pre-training where approximately 200 participated.

Staff members were trained to start a work shift with a pre-briefing and end it together with a debriefing. Team members had clear roles and responsibilities. After registration, the patient was assigned to a module, where the flow team nurse prioritized among the waiting patients and was responsible until a care team started the first assessment. Doctor and nurse in the care team carried out the patient history, physical examination, and decided on a plan together with the patient. The flow team doctor supported the care teams in deciding the correct plan and briefly joined the first assessment. The care team executed all activities in the plan, such as the diagnostic workup and treatment, in an immediate sequence before preparing the room for the next patient. The care team was responsible until the patient left the ED. In the team area, the flow team doctor supported the flow team nurse with prioritization when needed and monitored the progress of patient plans among care teams. When possible, the flow team doctor managed low acuity patients together with the nursing assistant.

5.3.2 Continuous training

In collaboration with the hospital Clinical Training Centre, a training package was developed to ensure that efficient teamwork was sustained despite staff turnover. It combined an e-course for individual learning with practical team training sessions on a regular basis. First, Delphi rounds were conducted, where representatives of the health professions defined the key team behaviours of each team role. Then, facilitators of practical scenarios were trained in a 1-week instructor course and the interactive e-course for individual learning was finalized. The training package was launched in January 2017, when team members scheduled for the evening shift were invited to participate in a practical training session one hour before they started working together.

5.4 CONTROL PERIODS & OUTCOME MEASURES

5.4.1 Study I

All patient arrivals on weekdays from 8 am to 9 pm in the first year of the teamwork process were compared to the corresponding patient arrivals during one-year periods of two previous processes at the ED, nurse-led triage using RETTS and physician-led triage (Figure 8). The ED length of stay was the primary outcome measure, while the secondary outcome measures were the waiting time to physician assessment and the proportion of patients who left the ED without being seen by a physician.

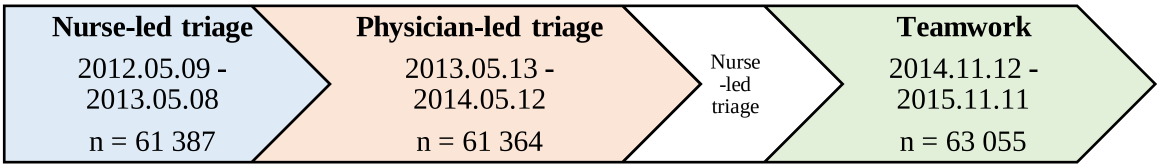

Figure 8. Teamwork compared to two previous work processes in study I. All patient arrivals on weekdays from 8 am to 9 pm in the first year of the teamwork process were included and compared to the corresponding patient arrivals during one-year periods of nurse-led triage and physician-led triage.

5.4.2 Study II

A teamwork module dedicated to patients presenting orthopaedic complaints had a different staff composition. In the care team, a nursing assistant who was certified or trained in casting techniques replaced the registered nurse, while a registered nurse replaced the nursing assistant who helped all team members. During the operation hours, daily from 8 am to 9 pm, all orthopaedic patients were treated in this teamwork module.

Patients presenting limb injuries or back pain and arriving on weekdays from 8 am to 9 pm during the first year of the teamwork process were compared to the corresponding patient arrivals during a one-year period preceding the intervention, when ambulatory low acuity patients were streamed to the fast track See & Treat and the remaining patients received care in the main ED (Figure 9). In addition, 21 780 patients presenting six non-orthopaedic complaints in both periods were included to control for the impact on other patient categories. The outcome measures were the waiting time to physician assessment and the ED length of stay.

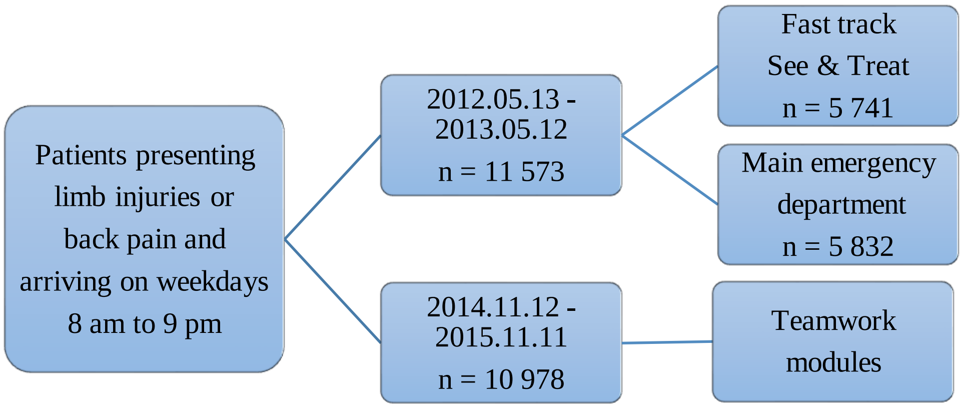

Figure 9. Teamwork compared to fast track streaming of low acuity patients in study II. Patients presenting limb injuries or back pain and arriving on weekdays from 8 am to 9 pm in the first year of teamwork were compared to the corresponding patient arrivals for one year when low acuity patients were streamed to the fast track See & Treat.

5.4.3 Study III

A geriatric pilot project was conducted in the fall of 2016, when older patients could be streamed to a dedicated teamwork module in an older-friendly ED area. The geriatric module was staffed on weekdays from 8 am to 9 pm by an emergency physician or a resident, a junior physician, a registered nurse, two nursing assistants, and a specialist nurse who had expertise in discharge planning for older patients and networked with geriatric hospitals. These specialist nurses were also available for the regular ED teams, but as consultants rather than team members. Another difference to the regular teamwork modules was that the geriatric module had no flow team and no queue. Instead, the geriatric module nurse recruited queueing patients from the registration nurse or flow team nurse in the regular teamwork modules. The geriatric module did not have capacity for all older patients, nor did it have resources for patients needing immediate treatment or continuous monitoring of unstable vital signs.

All ED arrivals by patients 80 years or older during 45 weekdays of the pilot project were compared to the corresponding weekdays in 2015 (Figure 10). The proportion of patients admitted to inpatient care within one week of the ED visit and the ED length of stay were used as the outcome measures.

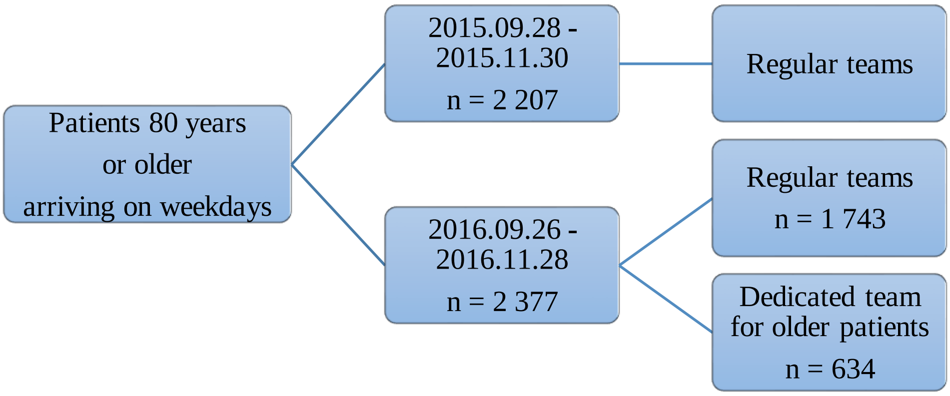

Figure 10. Dedicated emergency team for older patients in study III. All patients 80 years or older arriving on 45 weekdays during the pilot period in 2016 were compared to patient arrivals on corresponding weekdays in 2015.

5.4.4 Study IV

Structured observations of team behaviours were conducted in June 2016 and repeated in June 2018. Semi-structured interviews about the experiences from the teamwork innovation and the implementation process were conducted from May to June 2018 with a purposeful sample of staff and managers. A staff questionnaire about the perceived work load, interprofessional collaboration, and patient satisfaction was distributed at intervals from October 2014 to June 2018 (Figure 6).

5.5 DATA COLLECTION & ANALYSIS

5.5.1 Quantitative methods

In the quantitative studies, we used registry data from the electronic ED tracking system and retrieved the independent variables age, gender, arrival mode, main complaint, and disposition of each patient arrival. We also retrieved the time of arrival, when the first physician signed in, and the time of departure to calculate the outcome measures waiting time to physician assessment and ED length of stay. Additional registry data from the Stockholm County Council was used in study III to calculate the hospital admission rate within one week of the ED visit for patients 80 years or older.

We collected further data from potential sources of bias. The inpatient bed occupancy rate was calculated from the daily number of inpatients and available beds at wards receiving patients from the adult ED by using the hospital inpatient registry. We used the work schedules of medical and nursing staff to calculate the daily staffing hours during each period. We also retrieved time stamps from the radiology department to calculate the imaging processing times for patients in study II.

5.5.1.1 Statistics

The retrieved data were imported to R (The R Foundation for Statistical Computing, Vienna) and IBM SPSS Statistics version 25. We used the Chi-squared test to compare proportions and the Mann-Whitney-Wilcoxon test to compare mean values. However, the distributions of waiting time to physician assessment and ED length of stay are heavily skewed. The times are short for most patients but very long for a small number of patients, which was also the case for the imaging times in study II. Therefore, we used the median values to compare these measures. The p-values were calculated using Mood's median test and the 95% confidence intervals of medians were obtained by carrying out bootstrap simulations in R. We conducted multiple linear regression analyses using predefined predictor variables to adjust the ED length of stay for differences in background characteristics between the periods. We used histograms, scatterplots, normal probability plots, and Cooke's distance to check that model assumptions were met. The statistical significance level at a two-tailed p-value of 0.05 was set for all outcomes.

5.5.2 Qualitative and mixed methods

The author of the thesis conducted structured observations both in June 2016 and June 2018. Team members performed their tasks without being disturbed during the observations. Different teams on both day and evening shifts, on weekdays and weekends, were observed. A protocol consisting of the essential behaviours of each team role identified from the Delphi rounds was used. The team behaviours were either dichotomic or assessed on a Likert scale from 1 to 5. The team scored 5 if the observer assessed that the behaviour was clearly present and scored 1 if the behaviour was not observed at all.

The author of the thesis also conducted semi-structured interviews from May to June 2018. The purposeful sample of informants consisted of staff and section managers who had experienced the implementation process. The interview guide consisted of four open-ended questions. First, the researcher asked the informant about the experiences of the new teamwork process. This was followed by a question about the experiences of each phase in the implementation process: planning, implementation, and follow-up. The voice recordings were transcribed verbatim and read by four researchers. We conducted an inductive qualitative content analysis as described by Graneheim and Lundman (292, 293).

A staff questionnaire was also distributed at intervals from October 2014 to June 2018. It contained five statements about the work shift: *I had an acceptable work load, I had enough time to carry out my tasks, I experienced a good collaboration of doctors, nurses and nursing assistants, I experienced that my patients were satisfied,* and *In summary I had a good work shift.* Each statement was rated on a Likert scale from 0 to 5, where 0 meant strongly disagree and 5 strongly agree. The questionnaire also contained space for a free comment. We compared the ratings between periods through mean values and by using a Chi-squared test for differences in proportions.

6 RESULTS

6.1 STUDY I

We included a total of 185 806 patient arrivals during the three one-year periods in study I. The details are published in BMJ Open (291). The teamwork period had the largest number of patient arrivals and the oldest patients. The mean hospital bed occupancy rate increased gradually during the study period, from 93% in the nurse-led triage period to 98% in the teamwork period. Despite this, the crude median ED length of stay was shortest for the teamwork period and longest for the physician-led triage period. The difference was more pronounced for patients who were discharged home, compared to patients admitted to inpatient care. As expected, the median waiting time to physician assessment was shortest for the physician-led triage period, and longest for the nurse-led triage period. However, the proportion of patients who left without being seen by a physician was largest for the teamwork period (Table 7a).

The mean daily number of staffing hours was approximately constant, except in the ED corridor staffed by physicians from the departments of internal medicine and cardiology where it increased from one period to the next. To obtain an accurate comparison between the periods, we performed subgroup analyses of patients dispositioned from the ED sections where the number of staffing hours was approximately constant. For this subgroup, the crude median ED length of stay was also shortest for the teamwork period and longest for the physician-led triage period. The patterns of the secondary outcome measures were also similar to those for the entire population (Table 7b).

The primary outcome measure ED length of stay was adjusted for six predictors: age, female gender, arrival with ambulance, arrival with prehospital alert, daily total number of patient arrivals, and daily hospital bed occupancy rate. For the subgroup with constant staffing resources, the adjusted ED length of stay for the teamwork period was 16 min shorter than for the nurse-led triage period ($p<0.001$), and 23 min shorter than for the physician-led triage period ($p<0.001$).

Table 7a. Crude outcome measures for the entire study population in study I.

Triage process	1.Nurse-led triage			2.Physician-led triage			3.Interprofessional teamwork		
Period	2012.05.09 – 2013.05.08		**Period 1 vs 2**	2013.05.13 – 2014.05.12		**Period 2 vs 3**	2014.11.12 – 2015.11.11		**Period 3 vs 1**
Median length of stay	**min**	**95% CI**		**min**	**95% CI**		**min**	**95% CI**	
Overall	226	224.5 – 227.6	*p<0.001*	239	236.9 – 240.0	*p<0.001*	223	221.9 – 224.0	*p<0.001*
Discharged home	210	208 – 211	*p<0.001*	223	221 – 224	*p<0.001*	198	197 – 200	*p<0.001*
Median time to physician	98	97.4 – 99.5	*p<0.001*	54	53.7 – 54.8	*p<0.001*	66	65.0 – 67.1	*p<0.001*
	n	**%**		**n**	**%**		**n**	**%**	
Left without being seen	1 594	2.6%	*p<0.001*	1 366	2.2%	*p<0.001*	2 321	3.7%	*p<0.001*

Table 7b. Crude outcome measures for the subgroup with approximately constant staffing resources.

Triage process	1.Nurse-led triage			2.Physician-led triage			3.Interprofessional teamwork		
Median length of stay	**min**	**95% CI**		**min**	**95% CI**		**min**	**95% CI**	
Overall	232	230.8 – 233.9	*p<0.001*	250	248.5 – 252.6	*p<0.001*	228	226.4 – 230.5	*p=0.006*
Discharged home	212	210 – 214	*p<0.001*	229	226 – 232	*p<0.001*	200	197 – 203	*p<0.001*
Median time to physician	116	114.4 – 117.5	*p<0.001*	56	54.5 – 56.6	*p<0.001*	74	72.7 – 74.8	*p<0.001*
	n	**%**		**n**	**%**		**n**	**%**	
Left without being seen	597	1.9%	*p<0.001*	368	1.2%	*p<0.001*	933	3.2%	*p<0.001*

6.2 STUDY II

We included 22 551 patients who presented limb injuries or back pain to the ED, here referred to as the orthopaedic patients. These patients were also older in the teamwork period, when the mean hospital bed occupancy rate was higher. All patients in study II were dispositioned from the sections of the ED where the staffing resources remained approximately constant between the periods. In the fast track period, 70% of the orthopaedic patients had a low acuity, comprising of a green or blue triage level according to RETTS. Of these patients, 70% were dispositioned from the fast track See & Treat. Therefore, it seemed adequate to study these orthopaedic patients when comparing teamwork and streaming of low acuity patients to a fast track. The details of study II are published in PLOS One (294).

6.2.1 Imaging

Since the orthopaedic patients often require diagnostic imaging, we also studied their imaging times during both periods. Conventional radiographs or ultrasound were requested for a smaller proportion of the patients in the teamwork period, 51.4% compared to 52.8% in the fast track period (-1.4%, p=0.033). In contrast, computed tomography was requested for a larger proportion of the patients in the teamwork period, 5.9% compared to 4.8% in the fast track period (1.1%, p<0.001). The median time from the request to a result of computed tomography was longer in the teamwork period, 139.0 minutes compared to 113.5 in the fast track period (+25.5 minutes; 95% CI: 16.0 to 36.0). Most of the increase was due to a longer delay to imaging start in the teamwork period, 75.5 minutes compared to 58.0 in the fast track period (+17.5 minutes; 95% CI: 6.5 to 25.0). However, the median time from request to start for radiographs and ultrasound remained constant.

6.2.2 Outcome measures

The ED length of stay for the orthopaedic patients was shorter in the teamwork period, with a median of 217 minutes compared to 230 in the fast track period (-13 minutes; 95% CI: -18 to -8). The reduction was largest for patients presenting a hand or arm injury, with a median of 180 and 210 minutes in the respective period (-30 minutes; 95% CI: -36 to -23). The waiting time to physician assessment was also shorter in the teamwork period, 70 minutes compared to 127 in the fast track period (-57 minutes; 95% CI: -60 to -54). In addition to the six predictors of study I, we also included two predictors relating to imaging in the multiple linear regression analysis of the orthopaedic patients. The adjusted ED length of stay was shorter in the teamwork period (-23 minutes; 95% CI: -27 to -19) than in the fast track period. The reduction was larger for orthopaedic patients who were discharged to home (-29 minutes; 95% CI: -33 to -24).

We found no indication of impairments for the 21 780 non-orthopaedic patients who were also included in both periods. On the contrary, the adjusted ED length of stay was also shorter for these patients in the teamwork period (-20 minutes; 95% CI: -25 to -16). The crude mean waiting time to physician assessment also improved for the non-orthopaedic patients (-30 minutes; 95% CI: -33 to 26).

6.3 STUDY III

In contrast to the first two studies, teamwork was implemented during both periods of study III and was not the study object. Instead, we evaluated the streaming of older patients to a dedicated team in a separate area of the ED, here referred to as the geriatric module. All patients 80 years or older arriving on weekdays during the period in 2016, when a geriatric module was in operation, were compared to patients of the same age category who arrived during a control period in 2015 with only regular ED teams.

A total of 4 584 presentations by patients 80 years or older were included and there was no difference in general patient characteristics between the periods. In the intervention period, 27% of the patients 80 years or older received care in the geriatric module (Figure 9). This was a convenience sample of older patients in the ED, since the geriatric module did not have enough capacity. However, patients in need of immediate treatment or continuous monitoring of unstable vital signs were not eligible, which means that the distribution of main complaints differed between the geriatric module and the regular teams.

6.3.1 Outcome measures

The proportion of patients who were admitted to inpatient care from the ED was lower in the intervention period, compared to the control period. Using registry data from the Stockholm County Council, we added all unplanned inpatient care initiated at other hospitals within seven days of the ED visit. We found that a lower hospital admission rate remained for the intervention period, which indicated that the number of failed discharges from the study ED did not increase despite a lower direct admission rate.

However, the median ED length of stay was longer for the intervention period, compared to the control period. Patients receiving care in the geriatric module had a longer median length of stay, compared to older patients who received care in regular ED teams. The detailed data are provided in the submitted manuscript.

6.4 STUDY IV

6.4.1 Structured observations

Structured observations were conducted during 50.5 hours in June 2016 and stopped after 37.5 hours in June 2018, when saturation was reached. Fidelity was observed for 4 out of 5 key team behaviours in June 2016 but remained only for a single behaviour in 2018 (Table 1 in the manuscript).

6.4.2 Semi-structured interviews

The contents of 18 interviews were coded and categorized into two separate domains, teamwork innovation and implementation process. Both domains had a positive and a negative main category, each consisting of several subcategories. Fidelity issues were expressed in both domains. Passive flow team doctors, slow care teams, flow team nurse overload, and pointless debriefings were negative categories of the staff fidelity to the teamwork innovation. Regarding context fidelity, the competency mix was not met, technical support withdrawn, team training discontinued, team compositions adapted to budget changes, and increasing hospital bed occupancy not sufficiently addressed (Table 2 in the manuscript).

6.4.3 Staff questionnaire

When teamwork was first introduced, the proportion of positive ratings, 4 (agree) or 5 (strongly agree) on the Likert scale, increased from 45% to 87% for the item *Acceptable work load,* from 47% to 88% for *Enough time*, and from 48% to 87% for *A good work shift*. The mean score of these items increased from 3.0, 3.1, and 3.2, respectively, to 4.5, 4.5 and 4.4. The mean rating score increased from 4.0 to 4.6 for the item *Good collaboration* and from 3.6 to 4.4 for the item *Satisfied patients*. However, the ratings in June 2018 had deteriorated to pre-implementation levels, except for *Good collaboration* (Table 3 in the manuscript).

7 DISCUSSION

This thesis project has evaluated the redesign of an ED for interprofessional teamwork, which started in 2013. We investigated the impact on patient throughput and team behaviour up to 2018. Our main finding was that the adjusted ED length of stay was shortest for the teamwork period. It was 16 minutes shorter than for the nurse-led triage period, 23 minutes shorter than for the physician-led triage period, and 23 minutes shorter than for the fast track period. Another main finding was that the median waiting time to physician assessment for the teamwork period was 42 minutes shorter than for the nurse-led triage period, and 57 minutes shorter than for the fast track period. We also found a lower hospital admission rate for patients 80 years or older in the period when a teamwork module was dedicated to older patients.

Few studies have investigated teamwork in EDs and even fewer have evaluated the impact on patient throughput times. The earlier studies assigned patients to individual physicians or physician-led teams but did not describe the teamwork process in any detail. For instance, Lau and Leung replaced a common patient pool for all doctors by assigning patients to each doctor in an intervention in 1994 (264). The waiting time to physician assessment was reduced from 35 to 22 minutes, but the ED length of stay was not reported. In 2002, Patel and Vinson assigned patients to physician-led teams, each consisting of a physician, two nurses, and usually a technician (265). The mean waiting time to physician assessment was reduced from 71 to 62 minutes, but the mean ED length of stay increased from 249 to 257 minutes. On the other hand, the average time from triage to ED departure was reduced from 264 to 227 minutes in a team-based redesign by Dinh et al. in 2013 (266). The authors only specified the medical staff, which was 3 to 4 ED doctors in each team. One team covered a low acuity fast track unit and two teams the remaining patients.

By contrast, Larsson et al. described the principles of a team-based intervention at the orthopaedic section of a Swedish ED in 2007 (267). The authors found a reduction of the mean ED length of stay from 268 to 245 minutes and the mean waiting time to physician assessment from 124 to 114 minutes. The sample size can be estimated to a total of 6 000 patient arrivals. Teamwork principles were also described in another Swedish project introducing multidisciplinary teams in 2010 at the internal medicine section of an ED (269). The adjusted ED length of stay was 17 and 39 minutes shorter in the first month and after 16 months, respectively. However, the sample of 1 728 patients was collected from five periods, each consisting of only 287 to 384 patients, and the ED length of stay after 6 and 12 months did not differ from the pre-intervention period (268).

Compared to these previous studies, we found a similar reduction of ED length of stay but the reduction of the median waiting time to physician assessment was larger in this project. One may consider that nurse-led physician-assisted triage and streaming of low acuity patient are being carried out within the teamwork module by the flow team nurse and doctor. Instead of a standardized formal triage, it is only performed when the teamwork module has a queue and the measurement of vital signs is individualized according to the patients' needs. However, this demands clinical skills but also skills of the flow team to effectively communicate and coordinate with each other and to lead the care teams.

According to the teamwork innovation, the care plan is discussed in the room by the care team doctor and nurse, the flow team doctor, and decided on together with the patient. In this way, all health professionals involved share the same goal of the patient's ED stay, while the patient knows which staff members are responsible and whom to interact with. The challenge for the care team members and flow team doctor is to coordinate their separate tasks and yet assemble in a timely manner, which also requires skills in communication and situation awareness (229, 254).

The present project differs from earlier teamwork studies in that we used practical multi-professional team training as suggested by Mazzocato et al. (269), who found a great discrepancy between the planned and the observed team behaviours in 2010. As a consequence of the pre-implementation team training we initially observed a better adherence to the key team behaviours. However, the planned continuous team training and feedback were discontinued in 2017. Subsequently, only one of five key team behaviours, start the shift with a briefing, was sustained to 2018.

A contributing factor to the discontinuation of team training was that physicians failed to attend the training sessions, which is not unique in the literature (295). Researchers have interviewed emergency and intensive care doctors about what it takes to achieve good teamwork (296). The authors reported that physicians emphasized clear roles and team stability, whereas interdependent tasks and a shared goal were less prominent features of the physicians' conceptualization of teamwork. Traditional hierarchy and professional culture, such as expectations of infallibility and autonomy also pose challenges to interprofessional teamwork (297).

We found leadership issues at the flow team level, but also at the management level regarding facilitation and support after the initial implementation, as did Frykman et al. (270). Although leadership has been recognized as an important determinant of successful implementations, the literature offers little practical guidance. A systematic review found that leadership was poorly defined and inconsistently described in implementations of evidence-based practice (298). In a recent systematic review of sustainability frameworks for healthcare contexts (299), one of seven identified themes was leadership and management. According to most frameworks, sustainability was described as an ongoing process of "continued delivery/use" and "evolution/adaption", or as expressed by Frykman et al., "*The work is never ending*" (271).

Future teamwork implementation projects need to be planned, introduced, sustained, and evaluated using several frameworks to address different aspects at various levels of an implementation process. For instance, the Quality Implementation Framework to complete all necessary steps, the COM-B (Capability, Opportunity, Motivation, and Behaviour) theory and the Theoretical Domains Framework to analyse and plan behaviour change, and the Active

Implementation Frameworks to sustain a high fidelity. Nonetheless, implementing and sustaining teamwork in EDs will continue to be a challenging complex endeavour.

During the period when a teamwork module was dedicated to older patients, the hospital admission rate for patients 80 years or older was reduced by the same magnitude as that reported of other studies providing comprehensive geriatric assessment (204, 300, 301). The geriatric module can be considered as a first step towards interventions recommended by the geriatric ED guidelines or as an alternative approach with smaller resource requirements. We found an increase of the median ED length of stay, which was also in line with several other studies of geriatric interventions. One single study has reported a shorter ED length of stay (302).

7.1 LIMITATIONS

Study I to III had a pre-post design that cannot claim a causality between the intervention and the outcomes. However, this was necessary due to the complex redesign of the ED. We have taken measures to minimize potential bias by using large samples from each period, choosing control periods without other process changes, and adjusting for potential confounders in study I and II. An alternative approach could have been a stepped wedge design with only one or two teamwork modules in the beginning. This would have made it possible to randomize patients to a teamwork module or to the regular ED process. Randomization of older patients to the geriatric module or regular teamwork module would have been preferable in study III.

Since this was a single-centre project, the transferability and generalizability are limited to similar ED settings. Nevertheless, teamwork principles for EDs are generalizable and each implementation project need to be tailored to the specific context.

8 CONCLUSIONS

Effective interprofessional teamwork reduced the waiting time to physician assessment and the ED length of stay for the patients. However, the fidelity to the teamwork process decayed over time and the positive outcomes were not sustained. In retrospect, a systematic use of implementation theories and frameworks could have helped to sustain a high fidelity to the teamwork process.

9 SAMMANFATTNING (SUMMARY IN SWEDISH)

9.1 SYFTE

Patienter och personal påverkas negativt av trängsel på akutmottagningar, medan effektivt teamarbete inom sjukvården har positiva effekter. Triage och separata flöden för särskilda patientgrupper är vanliga strategier som akutmottagningar använder för att minska de negativa effekterna av trängsel, men få studier har utvärderat interprofessionellt teamarbete som en möjlig strategi för att minska trängseln. Pojektet utvärderade omformningen av en stor akutmottagning för interprofessionellt teamarbete och syftet var att studera effekterna på patientflöden och teambeteenden.

9.2 METODIK

Projektet genomfördes vid en akutmottagning för vuxna, där triage, snabbspår och övriga sektioner ersattes av moduler för teamarbete i november 2014. Delarbete I, II och III var före-och-efter studier där kvantitativa patientdata användes, medan delarbete IV samlade kvalitativa och kvantitativa personaldata under fyra år.

Delarbete I och II använde registerdata från maj 2012 till november 2015. Delarbete I inkluderade alla patientankomster under vardagar från kl. 8 till 21 under tre ettårsperioder. Första året med teamarbete jämfördes med perioder med två tidigare arbetsprocesser, triage som leddes av sjuksköterskor respektive läkare. Delarbete II inkluderade patienter som sökte till akutmottagningen för extremitetsskada eller ryggsmärta. Första året med teamarbete jämfördes med en tidigare period, då uppegående patienter med mindre brådskande tillstånd behandlades i ett separat snabbspår. För att undersöka hur andra patientgrupper påverkades inkluderade vi ungefär lika många patienter som sökte till akutmottagningen för icke-ortopediska tillstånd. Utfallsmåtten var väntetiden till läkarbedömning och totala vistelsetiden på akutmottagningen i båda delarbetena. Vi justerade även vistelsetiden med multipel linjär regression för patientkaraktäristika och bakgrundsfaktorer som skilde sig åt mellan perioderna.

Delarbete III inkluderade alla patienter som var 80 år eller äldre och som ankom på vardagar under ett pilotprojekt 2016, då en teammodul enbart ägnade sig åt äldre patienter. Kontrollgruppen utgjordes av patienter inom samma åldersgrupp som anlände under en motsvarande period året innan med enbart vanliga teammoduler för blandade åldersgrupper. Utfallsmåtten var vistelsetiden på akutmottagningen och totala inläggningsfrekvensen inom sju dygn efter akutbesöket.

Delarbete IV samlade data från tre olika personalkällor: strukturerade observationer av teambeteenden i juni 2016 och juni 2018, semi-strukturerade intervjuer i maj och juni 2018 och även en enkät om upplevd arbetsbelastning, samarbetsgrad och patientnöjdhet som upprepades från oktober 2014 till juni 2018.

9.3 RESULTAT

Delarbete I omfattade 185 806 patientankomster. Medianvistelsetiden på akutmottagningen var kortast för perioden med teamarbete, 228 minuter (95% CI: 226,4 till 230,5) jämfört med 232 minuter (95% CI: 230,8 till 233,9) för triage av sjuksköterskor. Den var längst för triage av läkare, 250 minuter (95% CI: 248,5 till 252,6). Den justerade vistelsetiden för perioden med teamarbete var 16 minuter kortare jämfört med triage av sjuksköterskor ($p<0,001$) och 23 minuter kortare jämfört med triage av läkare ($p<0,001$). Medianväntetiden till läkarbedöming var 74 minuter (95% CI: 73 till 75) för perioden med teamarbete, 116 minuter (95% CI: 114 till 118) för triage av sjuksköterskor och 56 minuter (95% CI: 55 till 57) för triage av läkare.

Delarbete II omfattade 22 551 ortopediska patientbesök. Under perioden med snabbspår bedömdes 70% av de ortopediska patienterna ha mindre brådskande tillstånd och av dessa behandlades 70% vid snabbspåret. Medianvistelsetiden på akutmottagningen var kortare för perioden med teamarbete jämfört med snabbspårsperioden, -13 minuter (95% CI: -18 till -8). Den justerade vistelsetiden skilde med -23 minuter (95% CI: -27 till -19) mellan perioderna. Medianväntetiden till läkarbedömning var också kortare för perioden med teamarbete, -57 minuter (95% CI: -60 till -54) jämfört med snabbspårsperioden. Även för de 21 780 icke-ortopediska patienterna var den justerade vistelsetiden kortare under perioden med teamarbete, -20 minuter (95% CI: -25 till -16), likaså deras skillnad i medianväntetiden till läkarbedömning på -30 minuter (95% CI -33 till -26).

Delarbete III omfattade 4 584 akutbesök av patienter som var 80 år eller äldre. Ingen skillnad i patientkaraktäristika sågs mellan de båda perioderna. Under interventionsperioden 2016 behandlades 27% (n =634) av patienterna i äldre-modulen och de övriga patienterna i vanliga teammoduler. Vi fann en lägre total inläggningsfrekvens inom sju dygn efter akutbesöket för interventionsperioden, men medianvistelsetiden på akutmottagningen var kortare under kontrollperioden 2015.

Delarbete IV omfattade 50,5 timmars observation under 2016, då god följsamhet till fyra av fem nyckelbeteenden kunde observeras. Under 2018 återstod god följsamhet till ett enda nyckelbeteende och observationerna var mättade efter 37,5 timmar. Den kvalitativa innehållsanalysen av 18 intervjuer under 2018 visade flera problem både hos personalen och i organisationen att upprätthålla teamarbetet, bl.a. avbröts teamträningen och återkopplingen. Andelen positiva skattningar avseende upplevelsen av arbetet i personalenkäten nära fördubblades vid införandet av teamarbete, men 2018 hade skattningarna åter försämrats till nivån före införandet.

9.4 SLUTSATSER

Effektivt teamarbete minskade väntetiden till läkarbedömning och vistelsetiden på akutmottagningen för patienterna i projektet, men följsamheten till teamarbetet minskade över tid och de positiva effekterna avtog. Teorier och ramverk från implementeringsforskningen bör användas som guide i framtida projekt.

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