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Direct discharge from the Emergency Department of patients with simple stable musculoskeletal injuries

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VIRTUAL FRACTURE CARE

Direct discharge from the Emergency Department
of patients with simple stable musculoskeletal injuries

THIJS H. GEERDINK

VIRTUAL FRACTURE CARE

Direct discharge from the Emergency Department of patients with simple stable musculoskeletal injuries

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Virtual Fracture Care
Direct discharge from the Emergency Department of patients with simple stable musculoskeletal injuries.

This thesis was written at the Department of Trauma Surgery, OLVG Hospital, Amsterdam, the Netherlands.

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VIRTUAL FRACTURE CARE

Direct discharge from the Emergency Department of patients with simple stable musculoskeletal injuries

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. ir. P.P.C.C. Verbeek
ten overstaan van een door het
College voor Promoties ingestelde commissie,
in het openbaar te verdedigen in de Agnietenkapel
op 4 november 2022, te 10:00 uur

door

Thijs Hendrik Geerdink
geboren te Hengelo (Overijssel)

PROMOTIECOMMISSIE

Promotor:	prof. dr. J.C. Goslings	AMC-UvA
Co-promotores:	dr. R.N. van Veen	OLVG
	dr. J.M. van Dongen	Vrije Universiteit Amsterdam
Overige leden:	prof. dr. J.A.M. Kremer	Radboud Universiteit Nijmegen
	prof. dr. M.A.A.J. van den Bosch	Universiteit Utrecht
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	prof. dr. L. Witkamp	AMC-UvA

Faculteit der Geneeskunde

voor pap en mam
4 november 2022

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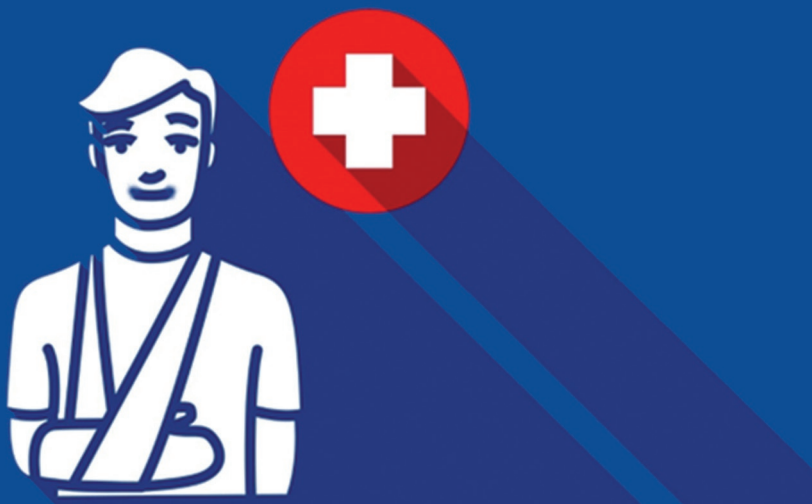

OUTLINE OF THE CURRENT ISSUES AND AIMS OF THIS THESIS

"How often we see plaster of Paris applied merely because X-ray examination has revealed a small crack or undisplaced fracture! On many such occasions the surgeon would probably have treated a case without plaster had he used his clinical sense alone (….) patients are frequently prevented from returning to work by plasters which are not essential but which are forced on them by surgeons who think only in terms of routine procedures and do not adjust their method to the demands of the individual problem (….) A popular impulse to apply plaster to practically anything in which the X-ray shows a fracture would seem to spring from an unvoiced belief that plaster is some sort of dressing which, when applied to the skin, accelerates the healing of the underlying bone."

- From the 1950's textbook "*The closed treatment of common fractures*", by Sir John Charnley.[1]

Sir John Charnley (29 August 1911 – 5 August 1982) was an English orthopaedic surgeon. He pioneered the hip replacement operation. Charnley also demonstrated the fundamental importance of bony compression in operations to perform arthrodesis (fuse) of joints, in particular the knee, ankle and shoulder. His 1950's textbook on conservative fracture treatment influenced generations of (orthopaedic) surgeons.

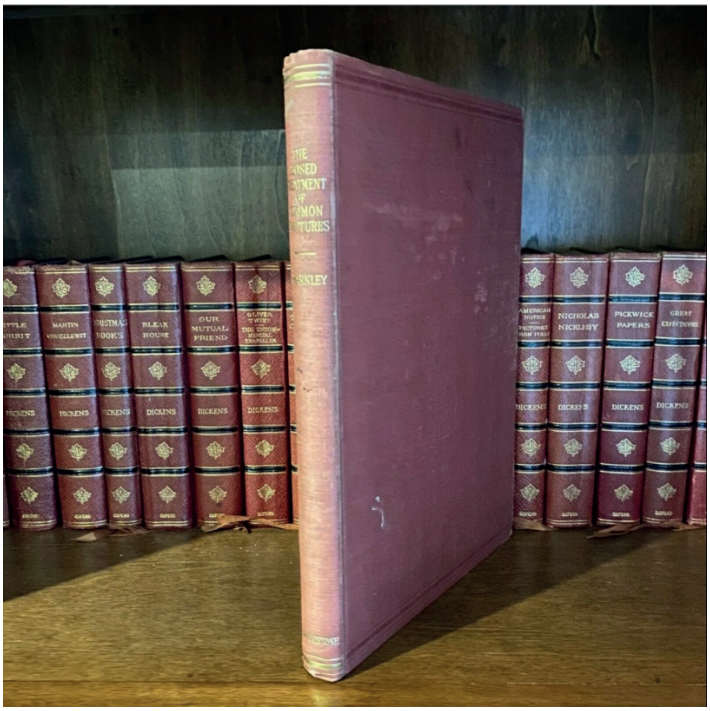

Figure 1 – First edition (1950) of "*The closed treatment of common fractures*" by Sir John Charnley

INTRODUCTION

In his 1950's book *"The closed treatment of common fractures"*, Sir John Charnley criticised the mere execution of medical dogma and routine by orthopaedic surgeons in the treatment of patients with common fractures.[1] Charnley claimed that many fractures recover quickly and adequately, even without the standard use of plaster. Therefore, he proposed treatment to be adjusted to the individual demands of each patient using clinical sense, rather than to blindly follow standard treatment protocols.

Despite his plea, today, more than 70 years later, the "traditional" treatment of the majority of patients with minor fractures still involves the standard application of a plaster cast, and subsequent routine review(s) in a fracture clinic at fixed moments during the weeks thereafter. Following Charnley's request for more tailored care, a more "on-demand" treatment approach might be direct discharge (DD) from the Emergency Department (ED), i.e. without routine follow-up, supported by the use of bandage or orthoses instead of plaster, and a telephone helpline in case of questions or concerns. This allows patients to receive the specific amount of care they need. The work in this thesis evaluates whether DD from the ED of patients with simple, stable injuries (SSIs) provides an effective, safe and acceptable alternative to routine follow-up.

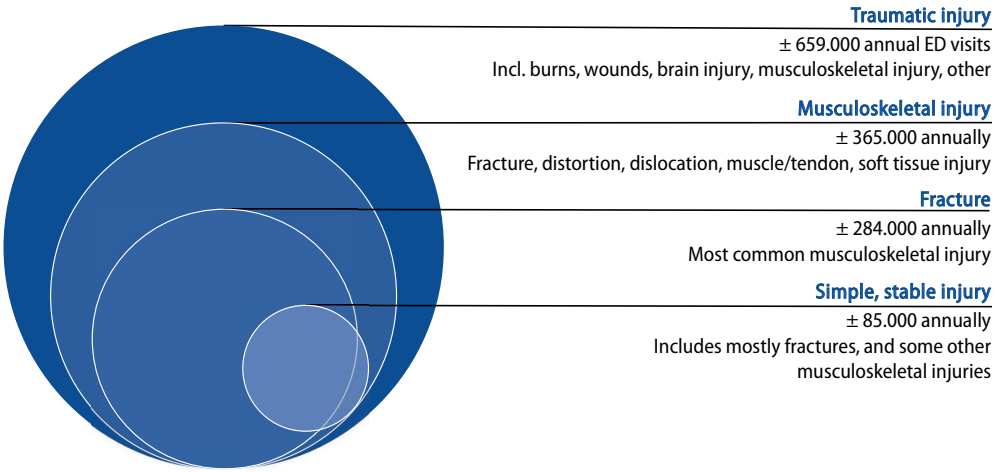

Figure 2 – Different types of injuries
Numbers of injuries based on the year 2019 in the Netherlands. Chart was not made to scale.
ED, Emergency Department

Types of injuries

Before going into more detail regarding the contents of this thesis, it is important to clarify the differences between traumatic injuries, musculoskeletal injuries, fractures and simple, stable injuries (SSIs).

The most common reason for an Emergency Department (ED) visit is a traumatic injury.[2] To illustrate this, in the Netherlands there were nearly two million ED visits in 2019, 659,000 (33%) of which concerned traumatic injuries.[2] Consequently, traumatic injuries are an important contributor to ED as well as outpatient clinic workload, where follow-up typically takes place. The economic impact of traumatic injuries is substantial as well, both from a societal and a healthcare perspective. In the Netherlands, for example, the total annual direct healthcare costs and lost productivity costs of traumatic injuries in 2019 were estimated at EUR 2.4 billion and EUR 1.4 billion, respectively.[2, 3]

The majority of traumatic injuries are musculoskeletal injuries (55.3%, **Figure 2**),[2] i.e. injuries of the musculoskeletal system. Other examples of traumatic injuries include wounds (6.9%), burns (0.7%), and brain injuries (8.9%).[2] Musculoskeletal injuries can be further divided into several subgroups, including amongst others, fractures (77.6%), distortions (8.5%), dislocations (7.4%) and muscle/tendon injuries (5.4%).[2]

Throughout this thesis, the term simple, stable injury (SSI) will be used to refer to a group of relatively minor musculoskeletal injuries with excellent prognosis, including fractures as well as several other musculoskeletal injuries. Examples of SSIs include paediatric buckle fractures of the forearm, non-displaced radial head fractures in adults, or fractures of the lesser toes. Typically, patients with SSIs are: 1) treated conservatively, 2) expected to fully recovery without residual pain, and 3) expected to return to functional outcome levels equal to pre-injury, while 4) complication rates (delayed/non-union) are very low. It is estimated that approximately 25-33% of all musculoskeletal injuries are SSIs, meaning that in the Netherlands alone more than 85.000 patients with SSIs visit an ED every year.[2]

Sustainability of Traditional Fracture Care

Following the traditional model of fracture care, fracture clinics are often characterized by the routine attendance of a large number of patients, many of whom have minor self-limiting injuries. This leads to long ED waiting times, recurrent unnecessary or untimely follow-up appointments, and a high workload that inevitably has consequences in terms of patient experience, staff morale, and quality of care.[4, 5]

Moreover, the incidence of musculoskeletal injuries increased during the past two decades following population growth as well as a change in population composition (i.e. younger and older age groups are increasing, while most injuries have a peak incidence in these age groups).[6] For example, the incidence of extremity fractures in

the Netherlands was 129,188 in 2004, 170,673 in 2010, and 260,800 in 2019.[2, 6] Another important trend is that the treatment of patients with musculoskeletal injuries gradually moves towards non-university hospitals.[6] Consequently, workload for non-university hospitals increases. If these trends continue, a change in capacity and resources might be warranted to keep being able to provide adequate, high-quality trauma care in the near future.[6] On top of that, there are several other reasons as to why alternative types of care should be considered.

First, recent studies indicate that a large proportion of patients with minor injuries would prefer optional follow-up, instead of routine follow-up. For example, in a study performed in 2016 by Finger et al., patients with relatively minor upper extremity fractures were offered either a scheduled or an optional follow-up appointment during the initial assessment in the ED. Of them more than halve (i.e. 53%) chose an optional appointment.[7] A few years later, Mackenzie et al. contacted patients with fractures of the fifth metacarpal neck, radial head, or base of the fifth metatarsal bone, six months after they were discharged from the ED without scheduling routine follow-up. They found that 75% of patients would like to receive the same kind of treatment in case they would sustain such an injury again.[8] Despite these numbers, offering optional follow-up for patients with SSIs is not part of routine care in most hospitals across the world, while today, in many fields of medicine, there is a clear shift towards promoting self-care, remote care and tailored care, and the "paternalistic" model of care has been replaced by the shared-decision making model to improve patient autonomy.[9]

Second, there are now randomized controlled studies that show that for several injuries, including fifth metacarpal neck fractures,[10] torus distal radius fractures[11] and minimally displaced distal radius fractures,[12, 13] casting offers no benefit over functional treatment in terms of pain or functional outcome. Moreover, various cohort studies show that minimally displaced proximal fifth metatarsal fractures,[14, 15] and non-displaced, stable Weber A and B ankle fractures,[16] recover equally well when only treated functionally using a bandage or an orthosis such as a brace. These materials allow for self-removal at home, which in turn would be beneficial for the patient in terms of reduced time off work, as well as costs for travel and parking.[4]

Third, most patients with SSIs are in follow-up for a relatively short period, i.e. between one and up to six weeks. It is very uncommon for follow-up appointments during this initial recovery period to lead to a change in treatment.[4] Moreover, routine imaging is usually not performed during these follow-up appointments, since secondary dislocations are not expected to occur. In the rare occasion of a delayed union or non-union, this is typically diagnosed at a later stage, when a patient returns with persisting problems after already being discharged from follow-up. Therefore, the added value of routine follow-up appointments in the first weeks after the ED visit might be questioned.

Hence, alternatives to the traditional model of fracture care should be further explored, acknowledging the preference and ability of the majority of patients with minor injuries for self-management,[7, 8] as well as the opportunity for a potential (partial) solution to the increased workload observed in fracture clinics.[6]

Virtual Fracture Care – a viable alternative

In 2006, Beiri et al. described a change in how the referrals to their fracture clinic were organized.[17] Prior to that, all patients attended the fracture clinic within a few days after their ED visit, for reassessment and definitive management. However, Beiri et al. argued that the ED was staffed by relatively inexperienced junior doctors, and that misinterpretation of X-rays was common, causing a delay in the diagnosis and/or adequate management of a patient's injury.[17] In an effort to improve care and to reduce misdiagnoses, they organized a daily, orthopaedic consultant-led meeting, during which the cases of all ED patients with musculoskeletal injuries who presented to the ED on the previous day were discussed. For each patient it was decided whether they required further follow-up, or not. Patients with minor musculoskeletal injuries requiring follow-up were referred to a nurse-led clinic, while the other patients were referred to a regular orthopaedic fracture clinic. They found this process to be more effective and efficient compared to their previous process, as it reduced the time per case needed for review as well as the number of resources consumed, delays and appointments.[17]

Five years later, colleagues in Glasgow Royal Infirmary used the principles of Beiri's model to develop their "Glasgow Fracture Pathway".[5] While Beiri's primary aim was to reduce misdiagnoses in the ED, the aim of the Glasgow Fracture Pathway was to optimize and streamline outpatient care for all patients with musculoskeletal injuries, and as a consequence thereof, to reduce unnecessary and untimely review of patients during follow-up.[5] Today, such a model is most often referred to as the "Virtual Fracture Clinic" (VFC) model,[18-37] although several United Kingdom (UK) based hospitals implemented comparable models of care using different names, such as the "Trauma Triage Clinic" (Edinburgh Royal Infirmary),[4, 8] and "Trauma Assessment Clinic" (Connolly Hospital Dublin).[38] Despite their differences in name, the basic principles of all these models are comparable, and for simplification all of these models will be referred to as the VFC model throughout the rest of this thesis. The VFC model comprises of two main parts: 1) DD from the ED of patients with SSIs and 2) a daily VFC review for all other patients with musculoskeletal injuries (**Figure 3**). Both parts will be discussed in further detail below.

The first part of the VFC model is DD from the ED of patients with SSIs.[5] Glasgow colleagues changed their treatment protocols in such a way that routine follow-up after the initial ED visit was no longer required for six types of SSIs (i.e. fifth metatarsal, fifth metacarpal, distal radius, torus, minor radial head/elbow fat pad sign, mallet finger, child's clavicle). These changes were made based on the aforementioned studies that

showed that functional treatment results in a recovery that is comparable to casting as well as on common sense. That is, they assumed that patients with these injuries require reassurance and information about their injury and expected recovery, but do not need to attend a fracture clinic routinely. These changes in the treatment protocols implicated that patients with these six SSIs were no longer scheduled for a routine fracture clinic follow-up appointment after their ED visit. This was supported by the use of self-removable orthoses and a telephone helpline that patients could contact in case of questions or concerns. Instructions were provided in the ED by the ED staff regarding the injury and recovery, which were also summarized in a comprehensive discharge leaflet.[5]

The second part of the VFC model concerns all other ED patients with musculoskeletal injuries who would normally be referred to the fracture clinic, but instead are now reviewed daily in a multidisciplinary orthopaedic consultant led meeting, before any appointments are scheduled.[5, 17] Like in Beiri's model, following VFC review, patients are either discharged "virtually", referred to a nurse-led clinic or referred to a specialty clinic. Patients are contacted afterwards to further discuss their treatment, and to schedule the appointment(s), if necessary. This allows an additional proportion of patients who would have otherwise attended a fracture clinic to be discharged "virtually". These are usually patients with minor injuries that do not fall under the DD treatment protocols. However, their injury is deemed minor enough by the VFC team to be treated without further follow-up. For all other patients, the VFC model is expected to ensure that they are seen at the right time by the right person, hence, reducing unnecessary or untimely reviews.

In 2018, our hospital (OLVG Hospital, Amsterdam, the Netherlands, Level 2 trauma centre and large teaching hospital) saw a rapid increase in the number of patients with musculoskeletal injuries presenting to our ED (approximately 30% increase in the number of patients), while the incidence of patients with musculoskeletal injuries had already been increasing for several years.[6] An important reason for this was the bankruptcy of a nearby hospital (i.e. Slotervaart Ziekenhuis), which shifted emergency care of many patients towards our ED. In a response, we explored the possibility to implement DD, and we visited Glasgow Royal Infirmary as well as the Royal Infirmary of Edinburgh to meet with Lech Rymaszewski and Tim White, respectively. They are both orthopaedic surgeons and were responsible for the implementation of the VFC model at their hospital. Based on the information they shared, several studies that were available at that time comparing DD to routine follow-up, consensus meetings, and expert opinions, the trauma team in our hospital agreed to implement DD for eleven types of SSIs as of May 2019. We agreed that in order for it to become standard care, DD had to be an effective, safe and acceptable alternative to routine follow-up, i.e. patient outcome, experience and complications would have to remain comparable to pre-DD standards. These terms served as the basis for the work in this thesis.

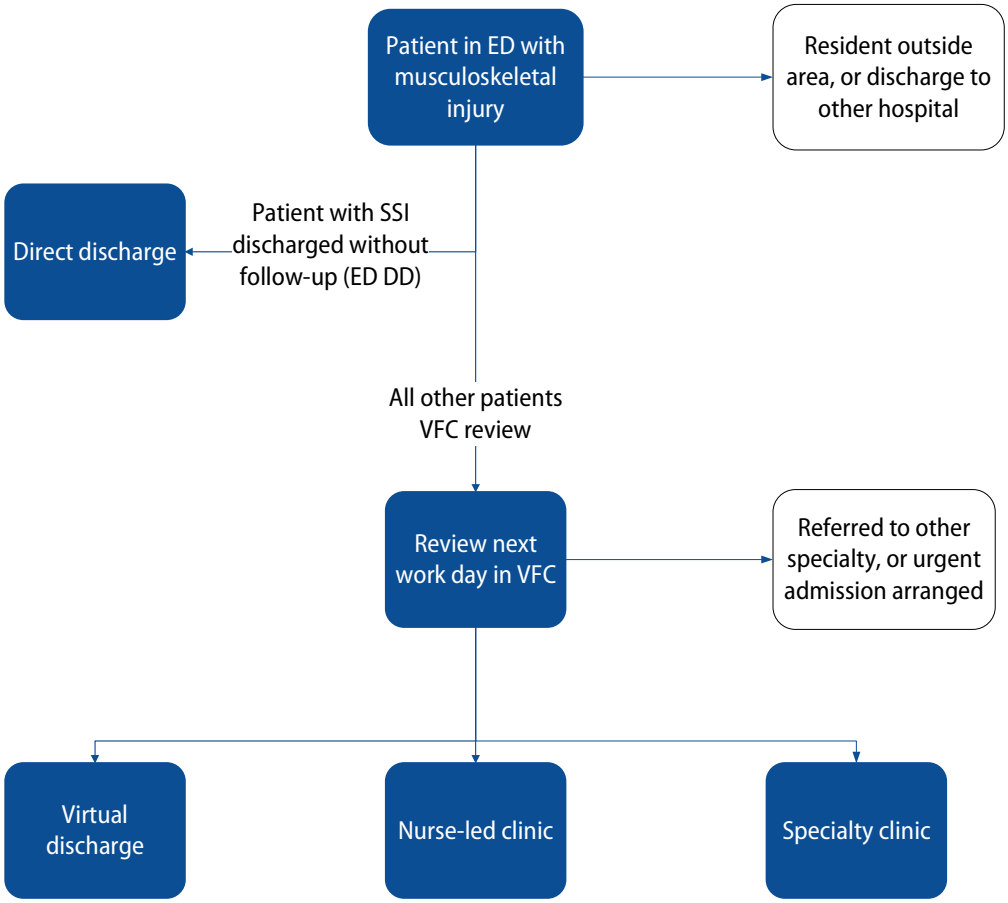

Figure 3 – Virtual Fracture Clinic model

THESIS OUTLINE

The primary aim of this thesis was to assess the potential benefits of DD from the ED of patients with SSIs, compared to routine follow-up, in the Netherlands. That is, in terms of reducing healthcare utilization and costs, while also assessing whether after DD there was a change in patient experience, patient outcome or complication rate.

Consequently, the work presented in this thesis mainly focuses on the first part of the VFC model within a Dutch hospital setting, i.e. DD from the ED of patients with SSIs. Prior to the work described in this thesis, the VFC model was studied mainly within UK hospitals, i.e. within one healthcare system only. Although the results of these studies were promising, it was unclear whether these results would be transferable to a different healthcare setting, such as a different country. Assessing the transferability

is an important step in the adoption of such a new model, since for instance, the patient's acceptance of a treatment like DD might be different in the Netherlands than in the UK. Furthermore, while Glasgow colleagues' might be appreciated for their pragmatic approach of changing treatment protocols for SSIs, many of the early UK studies regarding DD were limited by a lack of a control cohort, being retrospective and relatively small sample sizes.

Our hypothesis was that, like in the UK, Dutch patients with SSIs can be discharged safely (i.e. comparable patient outcome and complication rate) and effectively (i.e. reducing healthcare utilization and costs), and that Dutch patients would find this type of treatment an acceptable alternative to routine follow-up in terms of satisfaction with treatment. Provided this was the case, we assumed the work in this thesis to also provide an evidence-base for DD within the Netherlands specifically, in addition to the previous UK studies, which could possibly encourage other Dutch hospitals to consider the implementation of DD as well.

The thesis is divided into three parts.

Part I of this thesis consists of two chapters and aims to describe and summarize all available evidence regarding DD that was available prior to the implementation of DD in our hospital. Furthermore, it provides an evaluation of the extent to which DD of patients with SSIs has been adopted worldwide as an alternative to routine follow-up.

Part II focuses on the question of whether within a Dutch population, DD is a safe, acceptable and effective alternative to routine follow-up. This question is answered by comparing patients treated according to "previous" standards, i.e. routine follow-up in a fracture clinic, versus patients discharged directly from the ED. Part II of this thesis aims to provide an extensive evaluation of DD versus routine follow-up, focusing on logistic effects (number of follow-up appointments and follow-up imaging procedures), patient-reported outcomes (PROMs, functional outcome), patient-reported experiences (PREMs, including satisfaction with treatment), costs, and complication rates.

Part III is divided in two chapters. The first chapter focuses on the question of whether the results of our studies performed in a Dutch hospital are transferable to another Dutch hospital. The second chapter describes the implementation, potential value and use of a daily VFC review in the Netherlands (i.e. the second part of the VFC model).

PART I – CURRENT EVIDENCE AND USE OF DIRECT DISCHARGE OF SIMPLE STABLE INJURIES

Chapter 1: Direct discharge of patients with simple stable musculoskeletal injuries as an alternative to routine follow-up: a systematic review of the current literature

Since its inception in 2011, the VFC model has been introduced in several hospitals, mainly in the UK, as an alternative model of fracture care to regulate access to fracture clinics.[5, 39]

In this chapter, an overview is provided of all available evidence regarding the first part of the VFC model, i.e. DD from the ED of patients with SSIs (**Figure 3**). To this end, the literature is systematically reviewed for studies that include patients with SSIs who are discharged from further follow-up after their initial ED visit. Outcomes include logistic and financial outcomes, as well as PROMs (functional outcome), PREMs (satisfaction with treatment) and adverse outcomes (delayed/non-union and secondary surgeries).

Chapter 2: Adoption of direct discharge of simple stable injuries amongst (orthopaedic) trauma surgeons

The second chapter aims to evaluate the extent to which DD from the ED of patients with SSIs has been adopted across the world as an alternative to routine follow-up. Furthermore, the variation in treatment of common SSIs is assessed among (orthopaedic) trauma surgeons. To this end, an online survey is used, containing eleven hypothetical cases of patients with an SSI presenting to the survey respondent's ED. (Orthopaedic) Trauma surgeons across the world are asked to answer questions regarding the way they would treat the patient for each of the eleven cases, including the number of follow-up appointments, follow-up radiographs and whether patients would be referred to a physiotherapist, or not.

PART II – (Cost-)effectiveness of direct discharge of patients with simple stable injuries in the Netherlands

Chapter 3: Direct Discharge from the Emergency Department of patients with simple stable injuries: a Dutch pilot study (in Dutch)

Chapter 3 of this thesis is originally written in Dutch, and is translated to English in this thesis. It provides our preliminary experiences and results of DD in the Netherlands. Patients presenting to our ED with one of these SSIs in the three months prior to the implementation of DD in our hospital on 20 May 2019, are compared to patients with SSIs discharged directly from the ED in the three months thereafter. The chapter will include logistic effects (i.e. number of follow-up appointments and imaging procedures), as

well as primary healthcare utilization (i.e. general practitioner visits and physiotherapist visits), and patient experience (e.g. satisfaction with treatment).

Chapter 4: Direct discharge from the Emergency Department of simple, stable injuries: a propensity-score adjusted non-inferiority trial

In this chapter, primary healthcare utilization, secondary healthcare utilization, functional outcome, satisfaction with treatment and adverse outcomes is compared in patients with SSIs six months before and six months after implementing DD in our hospital. While secondary healthcare utilization is most likely reduced by implementing DD, this chapter also evaluates another important aspect of an intervention like DD. That is, it tests whether the directly discharged patients' functional outcome as well as their satisfaction with treatment is non-inferior to patients who were followed-up routinely, prior to implementing DD. Furthermore, when patients are no longer followed-up routinely in a hospital setting (secondary healthcare), this might lead to increased visits to a general practitioner and/or a physiotherapist (primary healthcare). Therefore, the primary healthcare utilization will be evaluated in this chapter as well.

Chapter 5: Cost-effectiveness of direct discharge from the Emergency Department of patients with simple, stable injuries in the Netherlands

Chapter 5 provides an economic evaluation of the data that is gathered as part of the study in chapter 4. Cost-effectiveness is assessed from a societal perspective and for four outcomes: generic health-related quality of life (HR-QoL), disease-specific HR-QoL (functional outcome), satisfaction with treatment, and pain. Amongst others, the chapter provides an estimation of the cost savings per patient, from a societal perspective as well as that of the Dutch healthcare sector.

PART III – Upscaling Virtual Fracture Care in the Netherlands and future steps in optimizing trauma care

Chapter 6: Healthcare utilization and satisfaction with treatment before and after direct discharge from the Emergency Department of simple stable musculoskeletal injuries in the Netherlands

In Chapter 6 it is evaluated whether effects of DD are similar with regard to healthcare utilization and satisfaction with treatment, both in a larger cohort within our own (pilot) hospital (Part II), as well as in an additional Dutch hospital. This is important to evaluate in order to indicate whether the concept of DD that was developed within a single Dutch hospital is scalable to other Dutch hospitals, i.e. providing similar results. This chapter also evaluates whether the effects of DD differed per SSI subgroup, in an attempt to identify whether DD might be more effective for some SSIs than for others.

Chapter 7: Optimizing orthopaedic trauma care delivery during the COVID-19 pandemic

When the coronavirus disease 2019 (COVID-19) pandemic was declared on 11 March 2020, the implementation of the second part of the VFC model was brought forward, i.e. a virtual review of all patients not discharged directly (**Figure 3**).

In this chapter, a closed-loop audit is performed to evaluate the potential use and added value of a VFC review within our hospital setting. The audit standards evaluated are: 1) all eligible patients should be referred for VFC review (i.e. compliance), 2) all patients should be contacted by telephone afterwards to discuss treatment, 3) whenever possible, patients should be "virtually" discharged in addition to the ED DD of patients with SSIs that was already in place prior to the VFC review, 4) appointments should be delivered remotely whenever possible.

The thesis is concluded by a general discussion of the work and proposed future perspectives, as well as a summary of the work in English and in Dutch.

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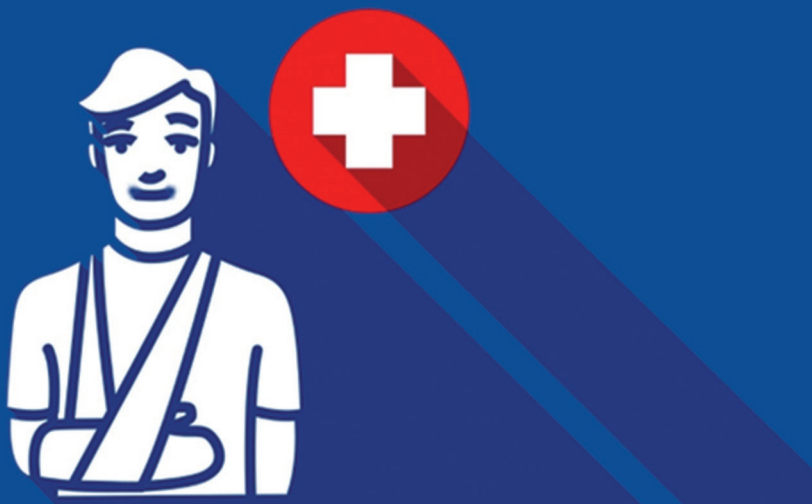
PART I

CURRENT EVIDENCE AND USE OF DIRECT DISCHARGE OF SIMPLE STABLE INJURIES



DIRECT DISCHARGE OF PATIENTS WITH SIMPLE STABLE MUSCULOSKELETAL INJURIES AS AN ALTERNATIVE TO ROUTINE FOLLOW-UP: A SYSTEMATIC REVIEW OF THE CURRENT LITERATURE

1

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ABSTRACT

Background

There is growing evidence that patients with certain simple stable musculoskeletal injuries can be discharged directly from the Emergency Department (ED), without compromising patient outcome and experience. This study aims to review the literature on effects of direct discharge (DD) of simple stable musculoskeletal injuries, regarding healthcare utilization, costs, patient outcome and experience.

Methods

A systematic review was performed in Medline, Embase, CINAHL, Cochrane Library and Web of Science using PRISMA-guidelines. Comparative and non-comparative studies on DD of simple stable injuries from the ED in an adult/paediatric/mixed population were included if reporting ≥1 of: 1) logistic outcomes: DD-rate (proportion of patients discharged directly); number of follow-up appointments; DD return-rate; 2) costs; 3) patient outcomes/experiences: functional outcome; treatment satisfaction; adverse outcomes; other.

Results

Twenty-six studies were included (92% conducted in the UK). Seven studies (27%) assessed functional outcome, nine (35%) treatment satisfaction, and ten (38%) adverse outcomes. A large proportion of studies defined DD eligibility criteria as injuries being minor/simple/stable, without further detail. ED DD-rate was 26.7-59.5%. Mean number of follow-up appointments was 1.00-2.08 pre-DD, vs. 0.00-0.33 post-DD. Return-rate was 0.0%-19.4%. Costs per patient were reduced by €69 to €210 post-DD. Functional outcome and treatment satisfaction levels were 'equal' or 'better' (comparative studies), and 'high' (non-comparative studies), post-DD. Adverse outcomes were low and comparable.

Conclusions

This systematic review supports the idea that DD of simple stable musculoskeletal injuries from the ED provides an opportunity to reduce healthcare utilization and costs without compromising patient outcomes/experiences. To improve comparability and facilitate implementation/external validation of DD, future studies should provide detailed DD eligibility criteria, and use a standard set of outcomes.

Systematic review registration number: 120779, date of first registration: 12/02/2019

INTRODUCTION

Rationale

Traditionally, all patients with musculoskeletal injuries are referred to a fracture clinic for further review and treatment, after initial assessment in an Emergency Department (ED). Consequently, fracture clinics are often characterized by the referral of large numbers of unselected patients, many of whom have minor injuries that do not require intervention. This leads to long waiting times, recurrent unnecessary reviews, and a high workload that inevitably has consequences for patient experience, staff morale, training, and quality of care.[1]

A Virtual Fracture Clinic (VFC) model has been introduced in several hospitals worldwide as an alternative model of fracture care to regulate access to fracture clinics.[2,3] This model is increasingly used in the United Kingdom (UK), but also in the Netherlands, Norway, Australia and New Zealand.[3] The VFC model comprises two main components.[2]

First, direct discharge (DD) of patients with relatively simple stable injuries. This means patients are discharged without subsequent review or repeated imaging, supported by self-removable orthoses, discharge leaflets, and a telephone helpline. Second, the establishment of an individualised management plan for all other patients during a daily consultant-led VFC review. This process should further streamline outpatient care and ensure that each patient is seen at the right time by the most appropriate person.[2]

The DD protocols were developed based on studies showing that for several minor self-limiting injuries, casting offers no benefit over functional treatment,[2] and on the assumption that patients with these injuries require reassurance and information, but do not need to attend a fracture clinic routinely. However, for DD to be a useful and acceptable alternative to routine follow-up, patient outcome, patient experience and complication rates should at least remain comparable, while healthcare utilizations and consequently costs are ideally reduced. Despite several independent studies that were conducted since DD was first established in 2011,[2] an overview of all current evidence regarding DD is not available.

Objective

The objective of this study was to systematically review the literature on the logistic and financial benefits of DD of patients with simple stable injuries, as well as their patient reported outcome, experience, and adverse outcomes.

Case example I – Torus/buckle fracture

A ten-year-old boy presents to the Emergency Department (ED) complaining of wrist pain after a fall from his bicycle. The patient is examined by an ED physician or Orthopaedic consultant. Radiographic imaging of the wrist reveals a torus/buckle type fracture of the distal radius, without any angulation.

Treatment before direct discharge	Treatment after direct discharge
• A plaster cast/splint is applied in the ED • A follow-up appointment is scheduled in the fracture clinic in 7 days • After 7 days, the cast/splint is removed. Bandage is applied and parents are instructed to remove the bandage in a few days as pain allows. No further imaging is performed. • The patient is then discharged from follow-up with instructions regarding sports, etc.	• A removable wrist orthosis is applied in the ED • Verbal instructions are provided in the ED with regard to the injury, recovery, when to remove the orthosis, when to contact the hospital etc. • This is also summarized in a discharge leaflet and/or smartphone application • No follow-up appointments are scheduled • It is allowed to remove the orthosis e.g. to take a shower, and parents are instructed to permanently remove the orthosis after 7 days. • If pain does not allow, then the orthosis can be used for another week • A special telephone helpline is available in case of any questions or concerns. If necessary, a face-to-face follow-up appointment is scheduled

METHODS

Protocol registration

This systematic review was planned, conducted, and reported using PRISMA guidelines.[4] A study protocol was registered with the PROSPERO register prior its commencement (registration number: 120779).[5]

Eligibility criteria

Both comparative (i.e. routine care before DD protocols were adopted compared to DD) and non-comparative studies (i.e. a DD cohort only) were considered if they featured DD of one or more musculoskeletal injuries in an adult, paediatric, or mixed population. Case reports and abstracts were excluded. There were no restrictions regarding the timing of the study, nor the duration of follow-up. Only articles reported in English were included.

Direct discharge was defined as scheduling no routine follow-up appointment after the ED visit. This could either take place directly after the ED visit (ED DD) or after a daily 'virtual' review (VFC DD, **Figure 1**). A single fracture clinic visit, shortly after attending the ED, was interpreted as ED DD if the sole purpose of this visit was application of a removable splint/orthosis. Studies were excluded if any further information or assessments were part of this visit. Studies were also excluded if reporting the potential effects of DD, without actually discharging patients directly. Both prospective and retrospective studies were included if reporting one of the following outcomes:

Logistic outcomes

Logistic outcomes included: 1) proportion of patients discharged directly, 2) number of follow-up appointments, and 3) number of repeat radiographs during follow-up. If the number of follow-up appointments was not reported, a study was also included if it reported a return rate instead (i.e. the proportion of patients that returned to the hospital despite being discharged directly).

Financial outcomes

Financial outcomes included any report on costs, for instance healthcare costs, societal costs etc.

Patient outcomes

Patient outcomes included any patient reported experience/outcome measures (PREMs/PROMs) and adverse outcomes.

Information sources

Medline, Embase, CINAHL, Cochrane Library and Web of Science databases were searched from inception to 15 January 2020. A limited update literature search was performed on 6 August 2020. Reference lists of included studies were scanned to ensure literature saturation.

Search

The electronic search strategy was developed by a health librarian and peer-reviewed by another librarian. Medical subject headings (MeSH) were used in Medline and complemented by text words related to DD and (virtual) fracture clinic redesign. This search strategy was then translated for the other databases. The PICO strategy and the full electronic search of Medline are reported in **Table S1** and **Table S2**, respectively.

Study selection

Two review authors (THG and JV) independently screened the titles and abstracts yielded by the search against the inclusion criteria. Full texts were obtained if studies appeared to meet the inclusion criteria, or in case of uncertainty. All reasons for exclusion were recorded. Reviewing authors were not blinded to the journal titles, study authors and institutions.

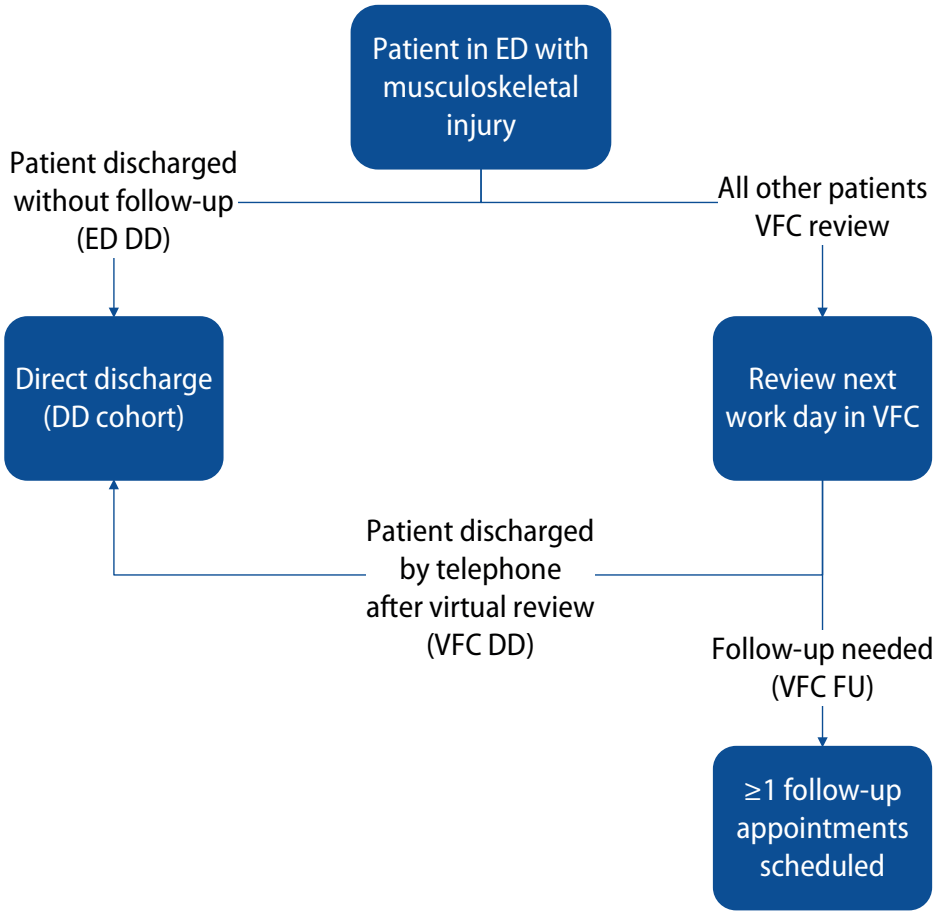

Figure 1 - Virtual Fracture Clinic model, explaining the difference between patients discharged directly from the Emergency Department (ED DD), or after virtual review (VFC DD). ED, Emergency Department; VFC, Virtual Fracture Clinic

Data collection process

A data extraction sheet was developed and pilot-tested on five randomly-selected included studies, and refined accordingly. Data from the included studies was extracted by one author (THG) and checked by another (JV).

Data items

The following data items were collected for all included studies: country; year; design; sample size; injury/injuries studied; eligibility criteria for DD; population (adult/paediatric); study period. If reported, the distribution of patients across the various parts of the VFC model (i.e. ED DD; VFC DD or VFC follow-up, **Figure 1**) was extracted and summarized in **Table S3**. Information on the type of immobilization used before and after DD protocols were implemented was extracted and summarized in **Table S4**.

The following data items were extracted if available: the proportion of patients discharged directly; number of follow-up appointments; return rate; number of repeat radiographs; costs; functional outcome score; any other PROMs or PREMs measured; any adverse outcomes reported. Method of assessment, timing and response rate (if applicable) were collected for all outcomes of interest. Missing information was scored as 'not reported'. Authors were contacted if further information or confirmation of data was required.

In some studies, only part of the intervention cohort consisted of patients who were discharged directly (e.g. if the effects of the whole VFC model as a whole was assessed, rather than the effect of DD in particular; **Figure 1**). For those studies, if possible, we extracted logistic outcome and adverse outcome data only for the patients who were discharged directly (DD cohort). If this was not possible, data was only extracted if >75% of patients within the intervention cohort were discharged directly. Costs and PREMs/PROMs data were extracted and only included in the main analysis if reported specifically for patients discharged directly (DD cohort).

Risk of bias in individual studies

Two reviewers (THG and JV) independently assessed risk of bias using the Cochrane risk-of-bias tool for randomized controlled trials,[6] and the Newcastle-Ottawa Quality Assessment Scale (NOS) for non-randomized studies.[7] A modified NOS was used to assess non-comparative studies. Following the manuals of the tools, studies were scored as either having a "low", "medium", "high" or "unclear" risk of bias.

Disagreements regarding study selection, data collection or risk of bias assessment were resolved through discussion or by consulting a third author (JCG).

Summary measures

To summarize the results, various outcome-specific summary measures were estimated based on the extracted data, including: 1) logistic outcomes: DD rate (proportion of patients discharged directly); mean number of follow-up appointments, and in case of a comparative study the mean reduction; mean repeat radiographs, 2) financial outcomes: costs as reported, and in case of a comparative study the difference in euro (€) and percentage (%), 3) patient outcomes: functional outcome score using a validated multi-item questionnaire; satisfaction with treatment; number and rate of adverse outcomes divided in non-union, secondary surgery, and other.

Synthesis of results

We chose not to pool data via meta-analysis due to high levels of clinical and methodological heterogeneity. For all outcomes, findings were therefore presented narratively and in summary tables.

RESULTS

Study selection

The search identified 5,872 unique records, 5,668 of which were excluded after screening title and abstract. A further 184 studies were excluded after reading full-texts. Six additional studies were included after scanning reference/citation lists and an updated search. **Figure 2** shows the selection process and an overview of the reasons for exclusion.

Two studies were based on the same cohort.[2, 8] In both studies, the only outcome relevant for this systematic review was the DD rate. Therefore, we did not exclude one as duplicate, but merged the results of these studies in the corresponding table. Another study described results for three types of injuries separately.[9] Therefore, the results of this study were summarized per injury separately in all tables.

Study characteristics

Ten studies (38%) compared DD to routine care,[8-17] whereas sixteen (62%) studies did not have a control cohort.[1, 2, 18-31] Twenty-four studies (92%) were conducted in the UK and two in New-Zealand (8%).[25, 26] The patient population was described in 22 studies (85%), whereas 4 (15%) did not describe the study population. One study included an adult population, seven a paediatric population, and fourteen a mixed population. Twelve studies included a single injury (46%) and fourteen (54%) multiple injuries. The 26 studies included a total of 38,506 patients, 3,832 of which were assessed before implementing any changes (control cohort) and 34,674 patients thereafter (intervention cohort). Of these 34,675 patients, 11,133 were discharged directly (DD cohort). A detailed description of the eligibility criteria for DD was reported in ten studies (**Table 1**).[9-11, 13, 16, 17, 25, 26, 28, 31]

Risk of bias within studies

Risk of bias was "low" in fifteen studies, "high" in four studies and "unclear" in the remaining seven studies (**Table S5**).

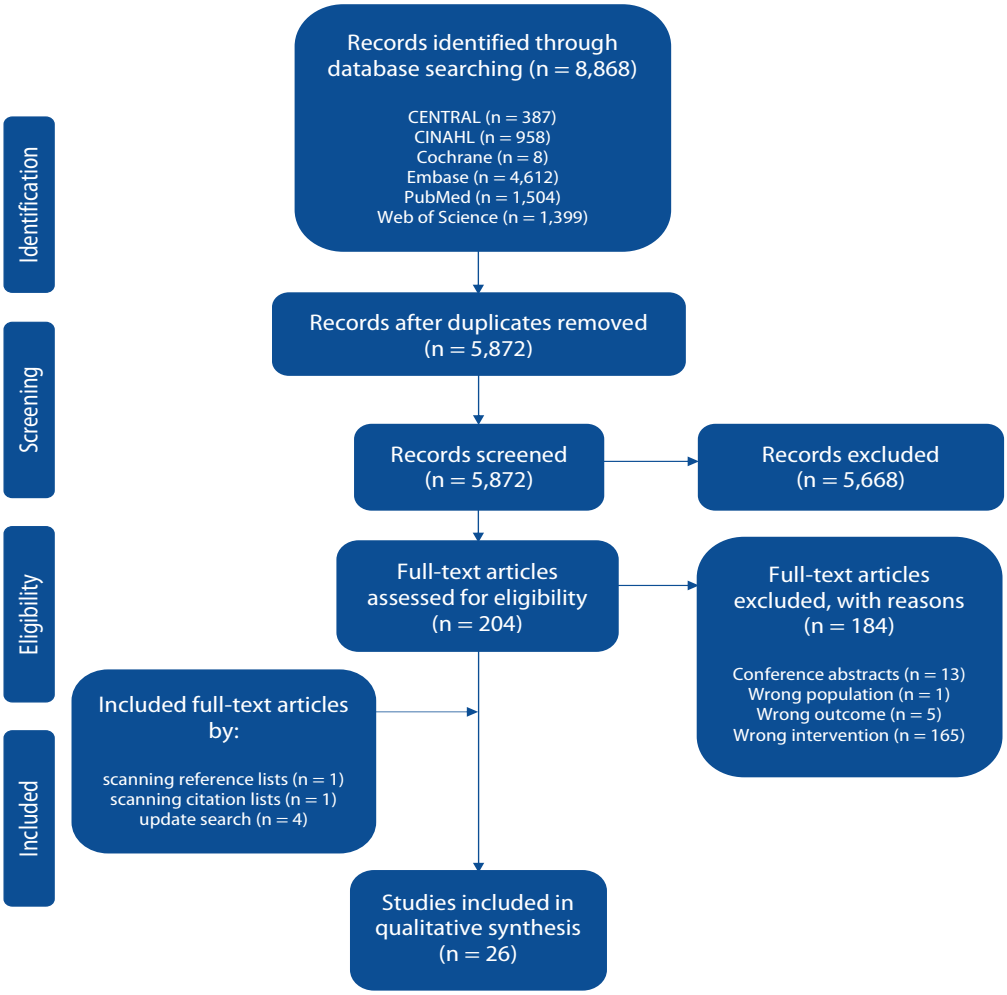

Figure 2 - Flowchart depicting article screening and inclusion

Table 1a - Baseline characteristics of included comparative studies

Study details				Sample size; n		Study population			Outcomes						
First author	Country	Year	Design	Control	Inter-vention	Injuries stud-ied	Described eligibility criteria for DD	Population	D	L	€	F	S	AO	Period; m
Comparative studies															
Abdelmalek[10]	England	2015	PPP	36	27	5MC neck Fx	Angulation <50°, no rotational deformity	A + P	+	+	-	-	-	-	6 vs. 6
Bansal[11]	England	2007	PPP	40	38	5MC neck Fx	Angulation <70°, no rotational deformity, no delay (<1w)	≥16y	-	+	-	+	+	-	NR
Ferguson[12]	Scotland	2015	RPP	279	339	5MT Fx	Not clearly defined	A + P	+	+	-	-	-	+	12 vs. 12
Hamilton[13]	England	2013	RCT	158	159	Stable forearm Fx	Torus/greenstick: <15° angulation; SH I/II: <5mm displaced	P ≥2y	-	+	+	+	+	-	34
Kelly[14]	Ireland	2019	RPP	NR	247	Multiple	Not clearly defined	A + P	+	-	-	-	-	-	6 vs. 6
Khan[15]	Ireland	2007	RCT	48	69	Torus Fx distal radius	Not clearly defined, described as 'stable'	P	-	-	-	-	+	-	3
Mackenzie[9]	Scotland	2018	RPP	108	88	5MC Fx	Isolated extra-articular Fx	A + P ≥13y	-	+	+	+	+	+	6 vs. 6
				111	87	5MT Fx	Any	A + P ≥13y	-	+	+	+	+	+	6 vs. 6
				118	114	Radial head/ neck Fx	Mason type 1 and 2	A + P ≥13y	-	+	+	+	+	+	6 vs. 6
Matthews[16]	England	2014	RPP	55	23	Clavicle Fx	Isolated single fragment midshaft Fx	P 1-15y	+	-	-	-	+	-	10 vs. 3
Seewoonarain[17]	England	2019	RPP	39	44	Torus Fx distal radius	No associated ulnar styloid Fx	P <16y	+	+	+	-	-	-	6. vs 6
Vardy[8]	Scotland	2014	RPP	2,840	6,385	All not requiring immediate inpatient treatment	Not clearly defined, included 5MC neck, paediatric greenstick/ torus, clavicle, mallet finger, radial head, 5MT Fx	A + P	+	-	-	-	-	-	12 vs. 12

Studies were included if they reported at least one of: D (proportion of patients discharged directly), L (logistic outcomes), € (financial outcomes), F (functional outcomes), S, (satisfaction with treatment); AO (Adverse outcomes). 5MC, fifth metacarpal; 5MT, fifth metatarsal; A, Adult; CS, Cohort study, not mentioned specifically if data were collected retrospectively or prospectively. DD, Direct Discharge; Fx, fracture; PCS, Prospective cohort study; PPP, Prospective pre-post study; m, months; MC, Metacarpal; mm, millimetre; NR, not reported; NZ, New-Zealand; P, Paediatric; RCS, Retrospective cohort study; ROM, range of motion; RPP, Retrospective pre-post study; SH, Salter-Harris; STI, Soft-tissue injury;

Table 2b - Baseline characteristics of included non-comparative studies

Study details				Sample size; n		Study population			Outcomes							
First author	Country	Year	Design	Control	Inter-vention	Injuries studied	Described eligibility criteria for DD	Popula-tion	D	L	€	F	S	AO	Period; m
Non-comparative studies															
Bhattacharyya[18]	Scotland	2017	RCS		138	Clavicle Fx	Not clearly defined, mostly Robinson 2a1 and 3a1	A + P	+	+	-	+	-	+	12
Breathnach[19]	Ireland	2018	RCS		157	'Orthopaedic Fx'	Not clearly defined, includes buckle Fx/STI of hand, foot, ankle	A + P	+	-	-	-	-	+	1.5
Brogan[20]	England	2017	CS		663	Suspected 5MT Fx	All 5MT Fx, but 'Jones' Fx' based on clinician's decision	A + P	+	+	-	-	-	+	24
Brooksbank[21]	Scotland	2014	PCS		47	Mallet finger	Not clearly defined	NR	+	+	-	+	+	-	12
Callender[22]	Ireland	2015	RCS		119	Wrist torus Fx	Not clearly defined	P	-	+	+	-	-	+	12
Evans[23]	England	2018	PCS		291	Hand and wrist injuries	'Simple tuft, 5MC neck, minor avulsion, volar plate and STI'	A + P	+	-	-	-	-	+	4.5
Gamble[24]	Scotland	2015	RCS		167	5MC Fx	Not clearly defined	A	-	+	-	+	+	-	6
Gleeson[25]–I	NZ	2016	RCS		61	Torus Fx radius/ ulna; clavicle Fx	Torus: <15° angulation; Clavicle: isolated Fx with bone contact	P >1y	-	+	+	-	+	-	12
Gleeson[26]–II	NZ	2016	RCS		33	5MC neck Fx; 5MT base Fx; Ankle Fx, Weber type A	5MC: <60° angulation, no rotation; 5MT: Zone 1 <2mm displaced, <10% angulation; Weber A: <4mm displaced, fragment <5mm	NR	-	-	+	-	-	-	9
Ibrahim[27]	Scotland	2018	CS		100	Acute closed STI/bony hand injuries	Not clearly defined, but excl. isolated carpal and wrist Fx	NR	+	-	-	-	-	+	1.5
Jayaram[28]	Scotland	2014	RCS		182	Radial head/neck Fx	Unilateral, Mason type 1 or 2 or fatpad sign, no other injuries	NR	+	+	-	-	-	+	12
Jenkins[2]	Scotland	2014	RCS		6,385	5MT, 5MC, distal radius, torus, radial head Fx, mallet finger, child clavicle Fx	Not clearly defined, described as 'simple, self-limiting stable Fx'	A + P	+	-	-	-	-	-	12

Table 2b - continued

Study details				Sample size; n		Study population			Outcomes						
First author	Country	Year	Design	Control	Inter-vention	Injuries studied	Described eligibility criteria for DD	Popula-tion	D	L	€	F	S	AO	Period; m
Little[29]	England	2020	PCS		3,709	Hand/wrist injuries	Stable STI/bony injury, no significant swelling or ROM problems	A + P	+	-	-	+	+	-	21
O'Reilly[30]	Ireland	2019	CS		2,704	Simple 5MC, 5MT, clavicle, radial head or torus Fx, mallet finger	Not clearly defined: 'simple injuries', mallet finger: no bony injury	A + P	+	-	-	-	-	-	19
Robinson[31]	England	2017	PCS		229	MC, phalanx hand, distal radius/ulna, elbow, clavicle, metatarsal, lateral malleolus Fx	Metacarpal: <60° angulation, no rotational deformity; phalanx: minor avulsion, wrist: undisplaced or torus, elbow: undisplaced/ fatpad (>5y); clavicle: un/ minor displaced, metatarsal: undisplaced; lateral malleolus: undisplaced (>5y)	P	-	+	-	-	-	+	6
White[1]	Scotland	2017	RCS		12,069	All patients with musculoskeletal injuries	Mallet finger with no bony injury, 5MC neck, radial head/neck Mason type I or II, 5MT base Fx or Fx of lesser toe	A + P	+	-	-	-	-	-	12

Studies were included if they reported at least one of: D (proportion of patients discharged directly), L (logistic outcomes), € (financial outcomes), F (functional outcomes), S, (satisfaction with treatment); AO (Adverse outcomes). 5MC, fifth metacarpal; 5MT, fifth metatarsal; A, Adult; CS, Cohort study, not mentioned specifically if data were collected retrospectively or prospectively. DD, Direct Discharge; Fx, fracture; PCS, Prospective cohort study; PPP, Prospective pre-post study; m, months; MC, Metacarpal; mm, millimetre; NR, not reported; NZ, New-Zealand; P, Paediatric; RCS, Retrospective cohort study; ROM, range of motion; RPP, Retrospective pre-post study; SH, Salter-Harris; STI, Soft-tissue injury;

Logistic outcomes

In ten studies, the intervention cohort consisted exclusively of patients discharged directly. Hence, a DD rate could not be estimated. In the remaining sixteen studies, the DD rate ranged from 18.2% to 97.9% (**Table 2**). Of these sixteen studies, three reported a DD rate as a proportion of all patients that attended the ED with a musculoskeletal injury. The DD rate in these studies was 26.7%, 59.5% and 33.3% respectively.[1, 8, 30]

The mean number of follow-up appointments was reported in eleven studies, and ranged from 1.00 to 2.08 in the control cohort versus 0.0 to 0.33 after implementing DD (**Table 3**). In the comparative studies, the mean reduction of follow-up appointments ranged from 1.00 to 1.78 appointments per patient.

Twelve studies determined a return rate of patients after DD. Brooksbank et al. found 19.7% of patients that sustained a mallet finger injury to return after DD.[21] All other studies reported a return rate of less than 10%.

The mean number of repeat radiographs was reported in five studies.[9, 10, 17, 22, 24, 25] Of the two comparative studies, Mackenzie et al. reported a mean reduction of 0.34, 0.17 and 0.79 radiographs per patient, in patients with fifth metacarpal neck, fifth metatarsal and radial head fractures, respectively.[9] Seewoonarain et al. found a mean reduction of 1.00 radiograph per patient with a torus wrist fracture.[17] In three non-comparative studies, the mean number of repeat radiographs in the DD cohort was 0.0 based on a return rate of 0%.[22, 24, 25]

Table 2 – Number of patients discharged directly in the intervention cohort

Study	Injury	DD cohort size; n	DD rate; %	Relative to all patients with
Comparative				
Abdelmalek [10]	5MC neck Fx	6	22.2	5MC neck fractures
Bansal [11]	5MC neck Fx	38	n/a	-
Ferguson [12]	5MT Fx	280	82.6	5MT fractures
Hamilton [13]	Paediatric forearm Fx	159	n/a	-
Kelly [14]	Multiple	45	18.2	Minor trauma injuries
Khan [15]	Torus Fx wrist	69	n/a	-
Mackenzie [9]	5MC Fx	88	n/a	-
	5MT Fx	87	n/a	-
	Radial head/neck Fx	114	n/a	-
Matthews [16]	Paediatric clavicle Fx	18	78.3	Paediatric zone 2 (midshaft) clavicle fractures
Seewoonarain [17]	Torus Fx wrist	33	75.0	Torus fractures of the distal radius
Vardy/Jenkins [2, 8]	Multiple	3,802	59.5	Musculoskeletal injuries in the ED not requiring immediate admission
Non-comparative				
Bhattacharyya [18]	Clavicle Fx	62	44.9	Clavicle fractures
Breathnach [19]	Multiple	42	26.8	Any type of fracture
Brogan [20]	5MT Fx	499	75.3	5MT fractures
Brooksbank [21]	Mallet finger	46	97.9	Mallet finger injuries
Callender [22]	Torus Fx wrist	119	n/a	-
Evans [23]	Hand/wrist injuries	54	18.6	Hand/wrist injuries
Gamble [24]	5MC Fx	167	n/a	-
Gleeson [25] – I	Torus Fx wrist; paediatric clavicle Fx	61	n/a	-
Gleeson [26] – II	5MC neck, 5MT base, Weber A Fx	33	n/a	-
Ibrahim [27]	Hand/wrist injuries	38	38.0	Hand/wrist injuries
Jayaram [28]	Radial head/neck Fx	182	90.1	Mason type 1 or 2 radial head/ neck fractures
Little [29]	Hand/wrist injuries	968	26.1	Hand injuries
O'Reilly [30]	Multiple	901	33.3	Musculoskeletal injuries in the ED
Robinson [31]	Multiple paediatric	229	n/a	-
White [1]	Multiple	3,222	26.7	Musculoskeletal injuries in the ED

If studies reported exclusively on outcomes in patients that were discharged directly, a direct discharge rate could not be determined (n/a/).
5MC, Fifth metacarpal; 5MT, Fifth metatarsal; DD; Direct Discharge; ED, Emergency Department; FU, Follow-up; Fx, fracture; n/a, not applicable; VFC, Virtual Fracture Clinic;

Table 3 – Logistic outcomes

		Number of appointments; mean			Returned after DD	Repeat radiographs; mean	
Study	**Injury**	**Control**	**DD**	**Mean reduction**	**Rate; %**	**Control**	**DD**
Comparative							
Abdelmalek[10]	5MC neck Fx	1.33	0.0	1.33	0.0	NR	0.0
Bansal[11]	5MC neck Fx	1.83	0.05	1.78	5.3	NR	NR
Ferguson[12]	5MT Fx	1.76	<0.30*	1.46	2.5	NR	NR
Hamilton[13]	Paediatric forearm Fx	1.05	0.02	1.03	1.3	NR	NR
Mackenzie[9]	5MC Fx	1.08	0.08	1.00	NR	0.4	0.06
	5MT Fx	2.08	0.33	1.75	NR	0.3	0.13
	Radial head/neck Fx	1.25	0.22	1.03	NR	1.1	0.31
Seewoonarain[17]	Torus Fx wrist	1.00	0.0	1.00	0.0	1.0	0.0
Non-comparative							
Bhattacharyya[18]	Clavicle Fx		0.02		1.6		NR
Brogan[20]	5MT Fx		<0.17**		NR		NR
Brooksbank[21]	Mallet finger		NR		19.4		NR
Callender[22]	Torus Fx wrist		0.0		0.0		0.0
Gamble[24]	5MC Fx		0.0		0.0		0.0
Gleeson[25]-I	Torus Fx wrist; clavicle Fx		0.0		0.0		0.0
Jayaram[28]	Radial head/neck Fx		NR		1.1		NR
Robinson[31]	Multiple		NR		9.2		NR

*5MC, fifth metacarpal; 5MT, fifth metatarsal; DD, Direct Discharge; Fx, fracture; NR, Not reported; *determined among 339 patients, 82.6% of which were discharged directly; **determined among 663 patients, 75.3% of which were discharged directly.*

Financial outcomes

Six studies estimated costs with reductions ranging from €69 to €210 per patient after implementing DD (**Table 4**).[9, 13, 17, 22, 25, 26]

Patient outcomes

Seven studies assessed functional outcome using a validated questionnaire, including four non-comparative and three comparative studies (**Table 5**). The three comparative studies found equal functional outcome scores before and after implementing DD.[9, 11, 13] Of them, Mackenzie et al. reported significantly better QuickDASH scores at six months within the DD subgroup of patients with fifth metacarpal fractures.[9] All four non-comparative studies reported good recovery in terms of functional outcome based on QuickDASH scores within the DD cohort.

Satisfaction with treatment was reported by nine studies, five of which were comparative and four were non-comparative (**Table 6**). Of the comparative studies, Bansal et al. found that patients with fifth metacarpal neck fractures were more satisfied after DD compared to patients that were followed-up (5.1 vs 7.0 on a 1 (very dissatisfied) to 10 (very satisfied) rating scale).[11] Three studies reported no difference in satisfaction before and after implementing DD, without providing any rates.[13, 15, 16] Mackenzie et al. found high satisfaction rates before and after implementing DD (95% vs. 98% using a yes/no "are you satisfied with treatment" question).[9] The four non-comparative studies all assessed satisfaction rates based on a Likert satisfaction scale, and satisfaction ranged from 84.9%-100%.[21, 24, 25, 29]

All other PROMs and PREMs that were reported in the individual studies are summarized in **Table S6**. These included, amongst others, satisfaction with recovery and whether patients had visited other clinicians such as their general practitioner for the treatment of their injury.

Non-union-rate was reported by three studies (**Table 7**), ranging from 0.0%-0.9% in the control cohort versus 0.0-2.3% in the DD cohort.[9, 12, 20] Secondary surgery rates were reported in two comparative studies and three non-comparative studies, ranging from 0.0%-1.1% in the control cohort,[9, 12 9, 12, 18, 20, 28] versus 0.0%-2.3% in the DD cohort.[9, 12, 18, 20, 28] Four non-comparative studies reported that 'no adverse outcomes' occurred.[22, 23, 27, 31]

Table 4 – Financial outcomes in three comparative and three non-comparative studies

Study	Injury	How were costs calculated	Costs per patient pre-DD	Costs per patient DD	Δ/patient; €	Δ/patient; %	Sig.
Comparative							
Hamilton[13]	Paediatric forearm Fx	Costs resulting from clinic visits, MIU visits, GP visits, telephone contacts, plaster room contact, use of immobilization materials	Mean GBP 261.04	Mean GBP 160.48	-€111,57	-38.5%	<0.001
Mackenzie[9]	5MC Fx	National Health Service secondary care cost analysis, including staffing, operation and radiology costs	Median GBP 139.83 (86.1 to 288.69)	Median GBP 12.17 (0.58 to 21.02)	-€141,64	-91.3%	NR
	5MT Fx	Similar	Median GBP 297.74 (210.39 to 385.15)	Median GBP 113.35 (4.48 to 316.72)	-€204,58	-61.9%	NR
	Radial head/ neck Fx	Similar	Median GBP 167.11 (127.16 to 257.23)	Median GBP 28.97 (9.82 to 44.23)	-€153,26	-82,7%	NR
Seewoonarain[17]	Torus Fx wrist	Costs resulting from clinic visits and material costs, staffing costs	Mean GBP 163.82	Mean GBP 101.60	-€69,03	-38,0%	NR
Non-comparative							
Gleeson[25]–I	Torus Fx wrist; Paediatric clavicle Fx	Financial savings as quantified by business analyst. Unclear description of exact calculation		NZD -379.88 per clavicle visit NZD -223.88 per buckle visit	-€210,28 -€129,93	-[a] -[a]	
Gleeson[26]–II	Multiple	Financial savings as quantified by business analyst. Unclear description of exact calculation		NZD -379.88 per visit	-€210,28	-[a]	
Callender[22]	Torus Fx wrist	Simple estimation of costs from outpatient clinic visits and soft cast material costs, compared to estimation of previous situation	Mean GBP 162.11	Mean GBP 5.50	-€173,76	-96,6%	

Studies that reported on costs within the DD cohort. The difference between the cohort before implementing DD and after implementing DD were calculated per patient. The conversion rates to EUR (€) at the time of calculation were: 1 GBP = EUR 1.10949 and 1 NZB = EUR 0.553554. 5MC, Fifth metacarpal; 5MT, Fifth metatarsal; DD, Direct Discharge; EUR; Euro's; Fx, fracture; GBP; Great Britain Pounds; GP, General Practitioner; MIU, Minor Injury Unit; NR, Not reported; NZD, New Zealand Dollars; RH, Sig., Significance level;

[a] Not reported as percentage as only post-DD costs, and no pre-DD costs were provided.

Table 5 - Functional outcome assessed by using a validated multi-item questionnaire

			Assessment			Control		DD		
Questionnaire	**Study**	**Injury**	**Reported as**	**How**	**When**	**Score**	**Resp. rate; %**	**Score**	**Resp. rate; %**	**Sig.**
Comparative										
DASH	Bansal[11]	5MC neck Fx	Mean score	Phone	12w	8.1 (SD 6.0)	NR	6.8 (SD 4.9)	NR	NS
FADI	Mackenzie[9]	5MT Fx	Median score	NR	6m	100 (95 to 100)	66.0	100 (97 to 100)	80.0	NS
CHAQ	Hamilton[13]	Paediatric forearm Fx	Mean change index score	Post	4w	-0.48 (SD 4.87)	67.1	0.48 (SD 4.02)	79.2	NS
QuickDASH	Mackenzie[9]	Radial head/neck Fx	Median score	NR	6m	0.0 (0 to 2.3)	80.0	0.0 (0 to 4.5)	80.0	NS
	Mackenzie[9]	5MC Fx	Median score	NR	6m	0.0 (0 to 7.9)	21.0	0.0 (0 to 0)	53.0	0.001
Non-comparative										
QuickDASH	Gamble[24]	5MC Fx	Median score	Post/phone	>1y			2.3 (0 to 6.8)	80.6	
	Brooksbank[21]	Mallet finger	Median score	Post	1y			2.27 (0 to 4.55)	77.0	
	Bhattacharyya[18]	Clavicle Fx	Mean score	Post	1y			16.1 (SD 25.2)	71.0	
QuickDASH modules Disability; Work; Sport	Little[29]	Hand/wrist injuries	Median module score	Post/phone	>6m			D: 4.4 (0 to 24) W: 14 (0 to 32) S: 14 (0 to 32)	92.0 89.0 38.0	

Studies that reported on any type of patient-reported functional outcome measure. 5MC, Fifth metacarpal; 5MT, Fifth metatarsal; A, Agreed; CHAQ, Childhood Health Assessment Questionnaire; DASH, Disabilities of the Arm, Hand and Shoulder; DD, Direct Discharge; FADI, Foot & Ankle Disability Index; Fx, fracture; m, months; NR, Not reported; NS, Not significant; P, Point; RH, Radial head; S, Satisfied; SA, Strongly agreed; SD, Standard deviation; Sig., Significance level; VS, Very satisfied; w, weeks; y, year(s)

Table 6 – Satisfaction with treatment before and/or after direct discharge

Experience measure	Study	Injury	Assessment			Control		DD		Sig.
			Assessed by	How	When	Score	Resp. rate; %	Score	Resp. rate; %	
Comparative										
Satisfaction with	Bansal[11]	5MC neck Fx	Scale 1 (VD) to 10 (VS)	Phone	12w	5.1 (SD 1.9)	NR	7.0 (SD 1.4)	NR	0.04
treatment	Hamilton[13]	Paediatric forearm Fx	Seven domain satisfaction, Likert	Post	6m	'No difference'	93.7	'No difference'	88.1	NS
	Matthews[16]	Clavicle Fx	NR	NR	>6m	NR	-	Majority satisfied	100	NR
	Khan[15]	Torus Fx wrist	Scale 1 (VD) to 10 (VS)	Phone	4-5w	Highly-satisfied	100	'Highly satisfied'	100	NR
	Mackenzie[9]	5MC, 5MT, RHFx	Yes/no question	NR	6m	95% S	56.4	98% S	72.3	NR
Non-comparative										
Satisfaction with	Gamble[24]	5MC Fx	Likert scale	Post/phone	>1y			84.9% VS or S	59.0	
treatment	Gleeson[25]–I	Torus Fx, clavicle Fx	Likert scale	Phone	3-6w			100% VS or S	45.9	
	Brooksbank[21]	Mallet finger	Likert scale	Post	1y			100% VS or S	77.0	
	Little[29]	Hand/wrist injuries	Likert scale	Post/phone	>6m			99,3% VS or S	94.0	

Studies that reported on satisfaction with treatment or treatment outcome. 5MC, Fifth metacarpal; 5MT, Fifth metatarsal; Fx, fracture; m, months; NR, Not reported; NS, Not significant; S, Satisfied; SD, Standard deviation; Sig., Significance level; VD, Very dissatisfied; VS, Very satisfied; w, weeks; y, year(s)

Table 7 - Adverse outcomes

Outcome	Study	Injury	Assessment		Outcome; n (%), reason if available		Sig.
			How	When	Control	DD	
Comparative							
Non-union rate	Ferguson[12]	5MT Fx	EPR	>1y	1 (0.4), zone 1 fracture*	2 (0.6); 1 Jones; 1 proximal diaphyseal fracture*	NS
	Mackenzie[9]	5MC Fx	EPR	3 y	0 (0.0)	0 (0.0)	-
		5MT Fx	EPR	3 y	1 (0.9)	2 (2.3)	NR
		Radial head/neck Fx	EPR	3 y	0 (0.0)	0 (0.0)	-
Secondary surgery	Ferguson[12]	5MT Fx	EPR	>1y	3 (1.1), 1 non-union, 2 refracture*	2 (0.6), both non-union*	NS
rate	Mackenzie[9]	5MC Fx	EPR	3 y	0 (0.0)	0 (0.0)	-
		5MT Fx	EPR	3 y	1 (0.9, non-union)	2 (2.3), both non-union	NR
		Radial head/neck Fx	EPR	3 y	0 (0.0)	0 (0.0)	-
Non-comparative							
Non-union rate	Brogan[20]	5MT Fx	EPR / PACS	>6m		8 (1.2) Jones type* 5 (0.75) asymptomatic zone 1 fractures in DD cohort	
Secondary surgery	Bhattacharyya[18]	Clavicle Fx	EPR	1y		0 (0.0)	
rate	Brogan[20]	5MT Fx	EPR / PACS	>6m		1 (0.15), symptomatic non-union	
	Jayaram[28]	Radial head/neck Fx	NR	>6m		1 (0.5) in DD cohort, malunion Mason II fracture	
Other	Breathnach[19]	Multiple	NR	18-24m		1 (0.64) poor clinical outcome, referred to physiotherapist	
	Callender[22]	Torus Fx wrist	NR	NR		'No adverse events or clinically significant complications'	
	Evans[23]	Hand/wrist injuries	Survey	NR		'No complications of treatment'	
	Ibrahim[27]	Hand injuries	Hand therapist	NR		'No adverse outcomes'	
	Robinson[31]	Multiple	EPR	>1m		'No serious adverse outcomes'	

*5MC, Fifth metacarpal; 5MT, Fifth metatarsal; d, days; DD, Direct Discharge; EPR, Electronic Patient Record evaluation; Fx, fracture; m, months; NR, Not reported; NS, Not significant; Sig., Statistically significant difference; w, weeks; y, year(s); *, it was not reported if these patients had initially been discharged directly.*

DISCUSSION

Summary of evidence

This systematic review supports the idea that patients with certain simple and stable injuries can be discharged directly from the ED without compromising patient outcome. This suggests that DD offers an opportunity to alleviate fracture clinic workload by reducing unnecessary appointments and consequently healthcare costs. This will allow physicians to spend more time on patients with more complex injuries, teaching, training, or improving standards of care.

Frequently, studies, including several systematic reviews performed recently,[32-34] report on the effects of the VFC model as a whole. This model includes both DD of musculoskeletal simple stable injuries, as well as a daily VFC review, consequently including more complex injuries that require follow-up (**Figure 1**).[1, 2, 8, 33] This limits the ability to independently assess the feasibility, efficacy and safety of DD of simple stable injuries as a solitary concept. To our knowledge this is the first systematic review to focus exclusively on DD of simple stable injuries. Herewith, it provides an extensive and critical evaluation of all evidence currently available.

Logistic outcomes

The DD rate as a proportion of all patients in the ED with a musculoskeletal injury ranged from 18% to 59.5%.[1, 2, 8, 14, 30] This is a remarkably large variation, and despite the studies' lack of detail on their DD eligibility criteria, this variation is most likely caused by a combination of: 1) differences in the definition of 'all musculoskeletal injuries' (i.e. including contusions, wounds, soft tissue injuries, or not), 2) differences in the kinds of injuries discharged directly, and 3) differences in the period since the DD protocols were first implemented.[31] Regardless of this variation, when implemented, DD will concern a large number of patients with musculoskeletal injuries that are seen frequently in an ED. This is an important factor to determine the logistic level of impact on a fracture clinic. Among the included comparative studies in this systematic review, the mean reduction in the number of follow-up appointments after DD ranged from 1.00 to 1.78 after DD.

Financial outcomes

All studies that estimated financial effects found DD to reduce healthcare costs. However, cost-analyses were limited to relatively simple estimations of fracture clinic costs, such as material costs, radiology costs and staffing costs. Hence, other important cost categories, such as other healthcare costs, (unpaid) productivity costs, and possibly informal care costs were not included. While it seems evident that healthcare costs reduce when healthcare utilization reduces, these results should be interpreted in a national context, as different healthcare payment systems are in place in each country. Furthermore, full

economic evaluations, preferably from a broader healthcare perspective or a societal perspective, are needed to estimate the cost-effectiveness of DD compared with usual practice.

Patient outcomes

All comparative studies reported 'as good' or 'better' functional outcome and satisfaction with treatment in the DD cohort compared to patients treated before DD protocols were implemented. The non-comparative studies also reported high levels of satisfaction and satisfactory functional outcome. Of the included studies, Bhattacharyya et al. reported a relatively high mean QuickDASH after DD of patients with a clavicle fracture,[18] but this is within the range of the normative values of this questionnaire.[35]

Non-union and secondary surgery rate were reported in fifth metatarsal fractures,[9, 12, 20] fifth metacarpal fractures,[9] radial head fractures,[9, 28] and clavicle fractures.[18] These rates were low and comparable in all cohorts. The DD model is established around the idea that a large proportion of patients are well able to manage their recovery independently, if adequately instructed This model also appreciates that some patients will have concerns or persisting pain, and an even smaller number might develop complications like non-union. However, these problems would have probably also occurred despite routine follow-up, and the majority of patients recover without any issues. Follow-up should therefore not solely serve as a safety net to identify those patients with concerns, or complications that might occur in 1-2%. Rather, our results emphasize the importance of instructing patients when to contact the hospital, and of providing an open access helpline in case of any concerns. This helpline should always be part of the DD model, with subsequent face-to-face review in a fracture clinic if necessary.

Limitations

This review should be regarded in light of the following limitations. First and foremost, there was high clinical and methodological heterogeneity amongst the included studies. As a consequence, we were not able to perform a meta-analysis.

Second, most studies were non-randomized and are therefore prone to selection bias, especially in retrospective cohort studies. Randomization at an individual patient level might not always be feasible for treatment redesigns like DD. However, other methods to reduce confounding effects of systematic differences in baseline characteristics were not used, including institutional cluster-randomization, or advanced statistical techniques such as a propensity score matching or weighting.

Third, only seven studies (27%) assessed functional outcome within the DD cohort using a validated questionnaire, only nine studies (35%) assessed patient satisfaction with treatment and only ten studies (38%) assessed adverse outcomes. Moreover, there was a large variety of other patient reported outcomes/experiences measured, with

methodology of assessment ranging from use of Likert scales, simple yes/no questions, and 1-10 rating scales. Furthermore, with regard to logistic outcomes, the extent to which the included studies assessed whether patients visited their GP or another hospital/clinician for further treatment was limited (Appendix **Table S6**). However, only non-comparative studies assessed this, while comparative studies would be needed to indicate whether DD increases GP visits or visits to another hospital/clinician.

Fourth, several studies have reported high numbers of patients discharged directly, but this far exceeds the number of patients in which logistic, financial and patient outcomes have actually been evaluated. To illustrate, Glasgow Royal Infirmary have discharged 3,802 patients in the first year alone,[2] while a later study reported that 30,000 patients were treated successfully since the implementation of their VFC pathway, 65% of which were discharged directly.[36] White et al. studied a cohort of 12,069 patients, 3,222 of which were discharged directly.[1] Despite these figures, this systematic review included 'only' 2,137 patients in the DD cohort to assess logistic outcomes, with even smaller sample sizes for patient outcomes. In other words, there appears to be a gap between clinical practice and evidence base. Additionally, in 62% of the included studies, a clear description of the eligibility criteria for DD was not included and often limited to 'simple', 'minor' or 'stable' injuries. Altogether, this complicates implementation and external validation of DD in other hospitals.

Fifth, most studies were conducted in the UK; hence the generalizability to other countries might be limited depending on the similarity of their healthcare system with that of the UK, e.g. whether extensive low-threshold public healthcare is available. Different baseline levels of effectiveness of care prior to DD, based on local protocols, might cause logistic outcomes to be different, and patient' mindset might result in different patient experiences or outcome, as well as patient's acceptance of DD without further care.

Last, most studies did not report a priori sample size calculations based on the minimal clinical important difference of a predefined primary outcome, such as satisfaction or function. Despite the significant reductions in appointments, sample sizes were often relatively small and therefore lacked statistical power to determine a change in patient experience, outcome or complications.

Future implications

Future studies on DD should be prospective, comparative and include subgroup analysis of each injury eligible for DD. We propose the minimum set of outcome variables of such studies to include: mean number of follow-up appointments, whether patients visited their GP or other hospital, functional outcome using a validated questionnaire, satisfaction using visual analogue scales as well as Likert point scales, and non-union/secondary surgery rates after at least one year.

Furthermore, future studies should also focus on fine-tuning the DD treatment protocols by assessment of outcomes within specific subgroups (i.e. based on age, comorbidity, injury subgroup etc.). If such analyses indicate that specific patient characteristics are predictive of, for example, high levels of return for follow-up, dissatisfaction or low functional outcome, the treatment protocols might be adjusted accordingly. Preferably, a multicentre database should be established to this end, as it is likely necessary to include relatively large sample sizes sufficient for subgroup analyses of these data.

Based on the high remodelling capacity and low rate of non-union in children,[37] it is highly likely that DD is also a safe alternative for several stable paediatric injuries. However, Robinson et al. were the only authors to report on DD of paediatric injuries, other than paediatric clavicle and torus wrist fracture, exclusively within a paediatric cohort.[31] Future studies could focus on the identification of additional minor and stable injuries that can be discharged directly, both in the adult and paediatric population.

Conclusions

Despite the clinical and methodological heterogeneity of the included studies in this systematic review, DD of several simple and stable injuries seems to be an effective alternative to routine follow-up, which does not seem to compromise patient outcome. Future studies on DD of those as well as other injuries should use a standard set of baseline and outcome variables to improve comparability and facilitate implementation and testing of external validity in other hospitals, especially in countries other than the UK with different healthcare systems.

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APPENDIX

Table S1 – Patient, Intervention, Control, Outcome (PICO) strategy used to develop search strategy

PICO	Criteria
Population	Patients of any age presenting to the ED with any type of musculoskeletal injury
Interventions	Direct discharge, either straight from the ED (ED DD) or after virtual review (VFC DD)
Comparison (if applicable)	No direct discharge (i.e. routine follow-up with at least one appointment)
Outcome	Patient direct discharge rate Logistic effects Financial effects Functional outcome Patient reported outcome/experience measures Adverse outcomes

DD, Direct Discharge; ED, Emergency Department; PICO, Patient, Intervention, Control, Outcome; VFC, Virtual Fracture Clinic

Table S2 – Search strategy in MEDLINE

No.	Query	Results
#6	(#1 OR #5)	1,504
#5	(#2 AND #3 AND #4)	958
#4	"Virtual Reality Exposure Therapy"[Mesh] OR "Telemedicine"[Mesh] OR "User-Computer Interface"[Mesh] OR "Remote Consultation"[Mesh] OR electronic referral*[tiab] OR remote consult*[tiab] OR teleconsult*[tiab] OR tele-consult*[tiab] OR virtual*[tiab] OR Re-design*[tiab] OR redesign*[tiab]	174,030
#3	"Patient Discharge"[Mesh] OR "Outpatient Clinics, Hospital"[Mesh] OR "Ambulatory Care Facilities"[Mesh] OR "Ambulatory Care"[Mesh] OR "Outpatients"[Mesh] OR "Appointments and Schedules"[Mesh] OR "Aftercare"[Mesh] OR outpatient*[tiab] OR discharge*[tiab] OR ambulatory[tiab] OR clinic visit*[tiab] OR aftercare*[tiab] OR follow-up[tiab] OR followup[tiab] OR "Referral and Consultation"[Mesh:NoExp] OR visit[tiab] OR visits[tiab] OR appointment*[tiab] OR referral*[tiab]	170,2013
#2	"Fractures, Bone"[Mesh] OR "Wounds and Injuries"[Mesh:NoExp] OR "Arm Injuries"[Mesh] OR "Athletic Injuries"[Mesh] OR "Fractures, Cartilage"[Mesh] OR "Hand Injuries"[Mesh] OR "Finger Injuries"[Mesh] OR "Hip Injuries"[Mesh] OR "Joint Dislocations"[Mesh] OR "Leg Injuries"[Mesh] OR "Multiple Trauma"[Mesh] OR "Shoulder Injuries"[Mesh] OR "Sprains and Strains"[Mesh] OR "Tendon Injuries"[Mesh] OR "injuries" [Subheading] OR fracture*[tiab] OR injur*[tiab] OR orthopedic*[tiab] OR orthopaedic*[tiab]	1,218,483
#1	Fracture clinic*[tiab] OR direct discharge*[tiab] OR ((trauma[tiab] OR fractur*[tiab] OR orthopaedic*[tiab] OR orthopedic*[tiab]) AND (triage clinic*[tiab] OR virtual clinic*[tiab] OR virtual triag*[tiab] OR clinic design*[tiab] OR clinic redesign*[tiab] OR clinic re-design*[tiab] OR service design*[tiab] OR service redesign*[tiab] OR service re-design*[tiab]))	581

Table S3 - Distribution of patients in intervention cohort

	Distribution of patients in intervention cohort; n (%)							
	ED DD		ED FU		VFC DD		VFC FU	
Author	n	%	n	%	n	%	n	%
Abdelmalek[1]	6	22.2	21	77.8				
Bhattacharyya[3]					62	44.9	76	55.1
Breathnach[2]					42	26.8	111	70.7
Brogan[12]					499	75.3	164	24.7
Brooksbank[14]	45	95.7			1	2.15	1	2.15
Evans[9]					54	2.15	228	78.4
Ferguson[4]	194	57.2			86	25.4	59	17.4
Ibrahim[17]					38	38.0	62	62.0
Jayaram[5]	137	67.8			45	22.3	20	9.9
Vardy/Jenkins[16, 18]	2,115	33.1			1,687	26.4	2,583	40.5
Kelly[8]					45	18.2	202	81.8
Little[21]					968	26.1	2,741	73.9
Matthews[13]	18	78.3	5	21.7				
O'Reilly[22]					901	33.3	1,803	66.7
Seewoonarain[15]					33	75.0	11	25.0
White[23]					3,222	26.7	8,847	73.3

Patient distribution in the intervention cohort, indicating whether all patients were discharged directly from the Emergency Department (ED DD), or after Virtual Fracture Clinic review (VFC DD)

Table S4 – Immobilization used before and after implementing direct discharge

Author	Pre-DD	Post-DD
Abdelmalek[1]	Neighbour strapping	Neighbour strapping
Bansal[6]	Plaster slab	Neighbour strapping
Bhattacharyya[3]	Sling	Sling
Breathnach[2]	Unclear	Unclear
Brogan[12]	Non-weightbearing cast	Blackboot
Brooksbank[14]	Unclear	Unclear
Callender[20]	Backslab	Softcast
Evans[9]	Variable	Variable
Ferguson[4]	Variable	Elastic bandage or Velcro boot
Gamble[19]	NR	Neighbour strapping
Gleeson[24] – I	Torus: POP cast; Clavicle: sling	Torus: Velcro wrist splint or soft cast back slab if <2y; Clavicle: sling
Gleeson[25] – II	5MC: ulnar gutter slab; 5MT: below knee back slab plaster cast; Weber A: below knee POP cast	5MC: neighbour strapping; 5MT: tubi grip; Weber A: removable orthosis
Hamilton[7]	Rigid cast	Soft cast
Ibrahim[17]	NR	NR
Jayaram[5]	NR	NR
Jenkins[18]	NR	Removable Velcro splints where required
Kelly[8]	NR	NR
Khan[10]	Rigid cast	Soft cast
Little[21]	NR	NR
Mackenzie[11] –MC5	Variable	Neighbour strapping with/without removable splint
Mackenzie[11] –MT5	Variable	Removable weight-bearing orthosis
Mackenzie[11]–radial head/neck	Variable	Collar and cuff
Matthews[13]	Broad arm sling	Broad arm sling
O'Reilly[22]	NR	Removable splint or cast
Robinson[26]	NR	Finger stall, wrist splint, collar & cuff, walking boot
Seewoonarain[15]	Plaster or Paris or splint	Cast, softcast or splint
Vardy[16]	Unclear	Unclear
White[23]	NR	Removable orthosis

DD, Direct discharge; 5MC, Fifth metacarpal; 5MT, Fifth metatarsal; NR, Not reported; POP, Position-of-protection; y, years;

Table S5 – Risk of bias assessment of the included studies

	Newcastle Ottawa Scale (cohort studies)			Cochrane Collaboration's Risk of Bias Tool (RCTs)							Assessment level
Author	**Selection**	**Compara-bility**	**Outcome**	**Random sequence generation**	**Allocation concealment**	**Blinding of participants/ personnel**	**Blinding of outcome assessment**	**Incomplete outcome data**	**Selective reporting**	**Other sources of bias**	**Risk of bias**
Comparative											
Abdelmalek[1]	***		***								Unclear
Bansal[6]	****		***								Low
Ferguson[4]	****		***								Low
Hamilton[7]				Low	Low	High	Low	High	Unclear	Low	High
Kelly[8]	***		**								Unclear
Khan[10]				Unclear	Unclear	High	High	High	Unclear	Unclear	High
Mackenzie[11]	****		***								Low
Matthews[13]	***		***								Unclear
Seewoonarain[15]	****		***								Low
Vardy[16]	****	*	***								Low
Non-comparative	**Selection**	**Exposure**	**Outcome**								
Bhattacharyya[3]	**	*	**								Low
Breathnach[2]		*	**								Unclear
Brogan[12]	**	*	***								Low
Brooksbank[14]	**	*	**								Low
Callender[20]	*	*	**								Unclear
Evans[9]	**	*	*								Unclear
Gamble[19]	**	*	**								Low
Gleeson[24] – I		*	*								High
Gleeson[25] – II		*	*								High
Ibrahim[17]	**	*	**								Low

Table S5 – Continued

	Newcastle Ottawa Scale (cohort studies)			Cochrane Collaboration's Risk of Bias Tool (RCTs)							Assessment level
Author	**Selection**	**Compara-bility**	**Outcome**	**Random sequence generation**	**Allocation concealment**	**Blinding of participants/ personnel**	**Blinding of outcome assessment**	**Incomplete outcome data**	**Selective reporting**	**Other sources of bias**	**Risk of bias**
Jayaram[5]	*	*	**								Unclear
Jenkins[18]	**	*	***								Low
Little[21]	**	*	***								Low
O'Reilly[22]	*	*	***								Low
Robinson[26]	**	*	***								Low
White[23]	*	*	***								Low

Risk of bias was assessed using the Newcastle-Ottawa Quality Assessment Scale for cohort studies (Selection, maximum four stars, Comparability, maximum two stars and Outcome, maximum three stars). Using the NOS, an overall score of 7 to 9 stars is considered as low risk of bias, 4 to 6 as unclear risk of bias, and 3 or less as high risk of bias. The NOS was adapted by the authors to be suitable to studies of non-comparative design (Selection, maximum two stars, Exposure, maximum one star, and Outcome, maximum three stars). For the adapted NOS an overall score of 5 to 6 stars is considered as low risk of bias, 3 to 4 as unclear risk of bias, and 2 or less as high risk of bias. Randomized controlled were assessed using Cochrane Collaboration's Risk of Bias Tool. Using this tool, the overall risk of bias is Low if all domains are rated as low, High if at least one domain is assessed as high, and Unclear if at least one domain is assessed as unclear and no domains are assessed as high.

Table S6 - Patient reported outcome- and experience measures

		Assessment				Control		DD		
Measure	**Author**	**Specification**	**Reported as**	**When**	**How**	**Score**	**Resp. rate; %**	**Score**	**Resp. rate; %**	**Sig.**
Satisfaction w/	Breathnach [2]	Information (in ED), Y/N	Proportion	18-24m	Phone			93% Yes	76.2	
support /	Bhattacharyya [3]	Information (leaflet), 4P Likert	Proportion	1y	Post			86.4% S	71.0	
information	Ferguson [4]	Information (written), 4P Likert*	Proportion	1y	NR	NR		79.6% S or VS	63.7	
	Jayaram [5]	Information (provided), 4P Likert*	Proportion	>6m	Post/Tel			95% S	77.0	
	Bansal [6]	Support, scale 1-10	Mean	12w	Phone	5.5 (SD 1.7)	NR	6.4 (SD 2.0)	NR	0.04
Satisfaction w/ treatment	Evans [9]	Process, Likert*	Proportion	NR	Phone			85% VS; 15% S	60.0	
(Satisfaction	Bansal [6]	Lack of terminal extension, Y/N	Proportion	12w	Phone	10% Yes	NR	2.6% Yes	NR	NS
w/) injury	Bhattacharyya [3]	Satisfaction with outcome, Likert	Proportion	1y	Post			91% VS or S	71.0	
outcome /	Breathnach [2]	Satisfaction with outcome, Likert	Proportion	18-24m	Phone			97% A or SA	76.2	
recovery	Ferguson [4]	Satisfaction w/ outcome*	4P Likert	1y	NR	NR		78% S or VS	63.7	
	Gamble [19]	Satisfaction with outcome, Likert	Proportion	>1y	Post/Tel			80.6% VS or S	59.0	
	Khan [10]	ROM compared to other side	NR	4-5w	Phone	All full recovery	100 (48)	All full recovery	100	-
	Matthews [13]	Back to normal activities	NR	>6m	NR	NR		All, no pain	100	NR
	O'Reilly [22]	Satisfaction with outcome, Likert	Proportion	NR	Phone			97% A or SA	3.6	
Treatment	Breathnach [2]	Would prefer face-to-face FU	Y/N	18-24m	Phone			28% Yes	76.2	
preference	Matthews [13]	Would prefer face-to-face FU	Y/N	>6m	NR	NR		22% Yes	100	NR
	Mackenzie [11] – all	Would prefer face-to-face or DD	Proportion			65% prefer DD	56.4	75% prefer DD	72.3	NR
	Khan [10]	Would prefer treatment again	Y/N	4-5w	Phone	6.3% yes	100	98.6% Yes	100	<0.01
Other clinician	Gamble [19]	Contacted GP	Y/N	>1y	Post/Tel			20.4% Yes	59.0	
	Bhattacharyya [3]	Visited GP	Y/N	1y	Post			15.9% Yes	71.0	

	Breathnach [2]	Visited GP	Y/N	18-24m	Phone			6.3% Yes	76.2	
	Gleeson [24] – I	Visited GP	Y/N	3-6w	Phone			0% Yes	45.9	
	Brooksbank [14]	Visited GP / other clinician	Y/N	1y	Post			19% Yes	77.0	
	O'Reilly [22]	Visited GP / other clinician	Y/N	NR	Phone			6% Yes	3.6	
	Jayaram [5]	Visited other clinician*	Y/N	>6m	Post/Tel			13% Yes	77.0	
	Ferguson [4]	Visited other hospital*	Y/N	1y	NR	NR		2.8% Yes	63.7	
Helpline use	Breathnach [2]	Aware of availability	Y/N	18-24m	Phone			38% Yes	76.2	
	Jayaram [5]	Aware of availability	Y/N	NR	Phone			94% Yes	3.6	
	Jayaram [5]	Satisfied with, if used, 4P Likert*	Proportion	>6m	Post/Tel			93% S	77.0	
	Bhattacharyya [3]	Used	Y/N	1y	Post			9.1% Yes	71.0	
	Ferguson [4]	Used*	Y/N	1y	NR	NR		15.7% Yes	63.7	
	Brooksbank [14]	Used	Y/N	1y	Post			25% Yes	77.0	
	Gamble [19]	Used	Y/N	>1y	Post/Tel			3.1% Yes	59.0	
Return to work	Bansal [6]		w, mean	12w	Phone	5.0 (SD 2.2)	NR	2.7 (SD 1.5)	NR	<0.01
	Mackenzie [11] – 5MC		w, median	6m	NR	0 (0 to 0)	21.0	0 (0 to 2.0)	53.0	NS
	Mackenzie [11] – 5MT		w, median	6m	NR	2.0 (0 to 4.0)	66.0	1.0 (0 to 2.0)	80.0	NS
	Mackenzie [11] – RH		w, median	6m	NR	0 (0 to 3.0)	80.0	1.0 (0 to 3.5)	80.0	NS
	Mackenzie [11] – RH		w, median	6m	NR	0 (0 to 3.0)	80.0	1.0 (0 to 3.5)	80.0	NS
Return to sport	Mackenzie [11] – 5MC		w, median	6m	NR	2.0 (0 to 4.0)	21.0	2.0 (0 to 4.0)	53.0	NS
	Mackenzie [11] – 5MT		w, median	6m	NR	6.0 (4.0 to 12.0)	66.0	6.0 (4.0 to 8.0)	80.0	NS
	Mackenzie [11] – RH		w, median	6m	NR	6.0 (3.8 to 8.0)	80.0	6.0 (4.0 to 8.0)	80.0	NS

*Studies that reported on any type of patient-reported outcome measure excluding functional outcome. 5MC, Fifth metacarpal; 5MT, Fifth metatarsal; DD, Direct Discharge; ED, Emergency Department; FU, follow-up; GP, General Practitioner; m, months; NR, Not reported; NS, Not significant; P, Point; ROM, Range of Movement; RR, Response rate; S, Satisfied; SD, Standard deviation; Sig., Significance level; Tel, Telephone; VS, Very satisfied; w, weeks; y, year(s). *there was no subgroup analysis exclusively of patients that were discharged directly.*

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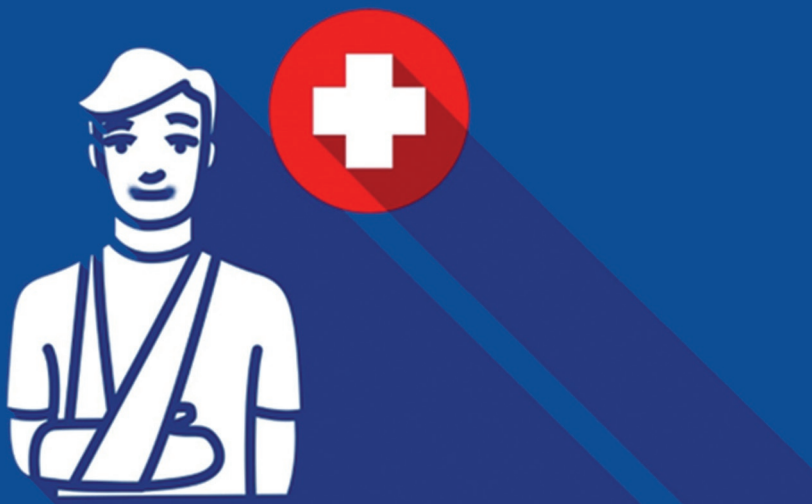

ADOPTION OF DIRECT DISCHARGE OF SIMPLE STABLE INJURIES AMONGST (ORTHOPAEDIC) TRAUMA SURGEONS

2

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ABSTRACT

Background

The importance of routine follow-up of several relatively simple stable injuries (SSIs) is questionable. Multiple studies show that direct discharge (DD) of patients with SSIs from the Emergency Department results in patient outcomes and experiences comparable to 'standard care' with outpatient follow-up. The purpose of this study was to evaluate to which extent DD of SSIs has been adopted amongst trauma and orthopedic surgeons internationally, and to assess the variation in the management of these common injuries.

Methods

An online survey was sent to members of an international trauma- and orthopaedic surgery collaboration. Participants, all trauma- or orthopaedic surgeons, were presented with eleven hypothetical cases of patients with simple stable injuries in which they were asked to outline their treatment plan regarding number of follow-up appointments and radiographs, physiotherapy and when to start functional movement. The primary outcome was the proportion of surgeons selecting direct discharge (i.e. zero scheduled appointments), per injury. Secondary outcomes included clinical agreement (>80% of respondents answering similarly) on total number of follow-up appointments (0, 1 or ≥2), radiographs (0, 1 or ≥2), routine physiotherapy referral (yes/no) and when to start functional movement (weeks).

Results

138 of 667 (20.7%) surgeons completed the survey. Adoption of direct discharge ranged from 4-45% of case examples. In 10 out of 11 cases, less than 25% of surgeons selected direct discharge. Clinical agreement regarding number of appointments and when to start functional movement was not reached for any of the injuries. There was clinical agreement on number of radiographs for one injury and for four injuries regarding routine referral to a physiotherapist.

Conclusions

Despite available evidence DD of SSIs has not been widely adopted worldwide. Practice variation still exists even for these common injuries. This variation suggests inefficiency and consequently unnecessarily high healthcare costs. (Orthopaedic) trauma surgeons are encouraged to evaluate their current treatment protocols of SSIs.

INTRODUCTION

Approximately one third of all musculoskeletal injuries diagnosed in the Emergency Department (ED) are simple stable injuries (SSIs) with excellent prognosis.[1] Over the past few years, the added value of follow-up of patients with these injuries has been open to question. Several randomized trials show casting offers no benefit over functional treatment for fifth metacarpal neck fractures,[2,3] torus distal radius fractures[4] and minimally displaced distal radius fractures.[5,6] Several cohort studies show minimally displaced proximal fifth metatarsal fractures[7], radial head and neck fractures[8], and non-displaced, stable Weber A and B ankle fractures[9] do equally well with just functional treatment.

These studies raised the question if follow-up of patients with these SSIs is necessary at all. Consequently, more recent trials on the treatment of SSIs have compared routine follow-up to direct discharge (DD) from the ED without routine follow-up.[7,8,10–14] Direct discharge is supported by extensive verbal information in the ED, which is summarized in a discharge leaflet and/or smartphone application.[14] Patients are treated in the ED using self-manageable materials such as a brace or pressure bandage. A telephone helpline is available in case of questions or concerns.[1] Studies show that DD results in high patient satisfaction and functional outcome, comparable to 'standard care' with follow-up, while drastically reducing appointments, imaging, costs and re-attendance.[14,15]

Several hospitals in the United Kingdom as well as the Netherlands[14], Norway, Australia and New Zealand have already implemented DD for several injuries.[16] However, practice variation likely still exists and this may contribute to varying standards of care for these common conditions.[17] The purpose of this study was to evaluate to which extent DD of SSIs has been adopted internationally, and to assess the variation in the management of common SSIs amongst (orthopaedic) trauma surgeons.

METHODS

In November 2019 a description of the study and a link to access and complete an online survey was sent by e-mail to members of an international trauma- and orthopaedic surgery collaboration. All members are (orthopaedic) trauma surgeons from around the world. A reminder was sent after four weeks. The survey closed after eight weeks.

Survey

The survey was divided into two sections. The first section contained four baseline questions concerning general information of the surgeon: gender; age; years of experience as surgeon; and country of practice. The second section contained eleven

cases describing the hypothetical presentation of a patient with an injury to the ED of the responding surgeon (**Table 1**). The selection of these injuries was based on previous studies that illustrated direct discharge of these injuries is an effective and safe alternative to 'standard care' with follow-up.[1,3,7,8,13–15,18–20] An embedded DICOM viewer allowed respondents to review high-quality standard radiographic projections of each injury, comparable to daily practice. Respondents were asked to answer the following questions concerning management, with instructions to provide answers according to their current treatment protocols: 1) *Would you schedule follow-up appointment(s) after this ED visit?* If yes, a treatment plan could be outlined by selecting the total number of follow-up appointments the surgeon would normally deem necessary. Then, participants could indicate per appointment at which intervals in weeks these should be scheduled and if radiographic imaging should be performed, 2) *Would you routinely refer the patient to a physiotherapist (yes/no)?* and 3) *After how many weeks would you allow your patient to start functional movement of their injured extremity*?

Outcomes

The primary outcome was the proportion of surgeons selecting direct discharge (i.e. no follow-up appointments), per injury. If surgeons chose to schedule any follow-up appointments, the total number of appointments and radiographs was determined per injury. Clinical agreement, defined as >80% of the respondents answering similarly,[21] was evaluated for each injury regarding number of follow-up appointments (0, 1 or ≥2), radiographs (0, 1 or ≥2), physiotherapy referral (yes/no) and the number of weeks after which a patient should be allowed to start functional movement of their injured extremity (immediately, 1 week, 2 weeks, 3-4 weeks, 5-6 weeks, 7-8 weeks, 9-10 weeks).

Statistical analysis

Statistical analysis was performed using IBM SPSS 22.0 (SPSS Inc., Chicago, IL).[22] The answers of the surgeons that completed all eleven cases were analysed. Baseline characteristics of the surgeons were analysed using quantities and proportions. For age, mean and standard deviation (SD) was used. Years of experience were categorized into 0-5, 6-10, 11-15, 16-20 and >20 years), and country of practice was categorized into continents. Descriptive statistics were used in order to illustrate the variation in treatment amongst surgeons. All data were presented in quantities and proportions. No tests for statistical significance were used.

Table 1 - Eleven cases of simple and stable injuries used to describe hypothetical patients in this survey study.

Case details			Radiographic details		Immobilization options in addition to "No immobilization"
Type of injury	**Age**	**Additional details**	**Projections**	**Features**	
Pediatric clavicle fracture	10	No injury of the skin	PA, cephalic	Midshaft fracture, 2mm displaced	Figure-of-8 brace, sling, triangular brace
Radial head fracture	25	-	PA, lateral, Coyle's view	Mason type 1	Pressure bandage, removable elbow brace, above elbow backslab
Torus/Buckle type of the distal radius	5	-	PA, lateral	No angulation	Pressure bandage, removable wrist brace, plaster splint
Distal radius fracture	25	-	PA, lateral, oblique	Stable, non-displaced, extra-articular fracture	Pressure bandage, removable wrist brace, plaster splint
Fifth metacarpal neck fracture	25	No rotational deformity	PA, lateral, oblique	30 degrees volar angulation	Buddy tape, pressure bandage, removable brace ('Lucerne cast'), plaster splint in POP
Mallet finger	25	-	PA, lateral	No bony fragment	Stack splint (PIP joint free), aluminum splint (volar immobilization of PIP joint)
Avulsion fracture of base of fifth metatarsal bone	25	-	PA, lateral, oblique	Zone 1 with 2mm dislocation	Supportive shoe, pressure bandage, velcro boot (walker), plaster cast/splint
Ankle fracture Weber type A	25	-	PA, lateral, mortise	Lauge Hansen SA1, 1mm dislocation	Supportive shoe, removable ankle brace, pressure bandage, velcro boot (walker), lower leg splint/cast
Avulsion fracture of the ankle	25	-	PA, lateral, mortise	Avulsion fracture of the cuboid bone	Supportive shoe, removable ankle brace, pressure bandage, velcro boot (walker), lower leg splint/cast
Phalanx fracture of the foot	25	-	PA, oblique	Non-displaced fracture of middle phalanx of the fifth digit	Buddy tape, pressure bandage with Velcro cast shoe, supportive shoe, plaster toe spica, lower leg cast/splint
Fracture of first digit of foot	25	-	PA, oblique	Non-displaced extra-articular fracture of proximal phalanx	Buddy tape, pressure bandage with Velcro cast shoe, supportive shoe, lower leg cast/splint

PA, posterior – anterior; SA, supination – adduction; mm, millimeter. All patients were described as being otherwise healthy individuals.

RESULTS

Demographic data

A total of 667 online surveys were sent by email to (orthopaedic) trauma surgeons. After four weeks, 82 surgeons had completed the survey (**Table 2**). After sending a reminder, another 56 surgeons completed the survey (response rate 20.7%). Of all 138 respondents, 126 (91%) were male. The mean age was 47.8 years (SD 7.9). Most surgeons (92.0%) had more than 5 years of working experience, equally distributed among the categories 6-10 years (21.0%), 11-15 years (23.9%), 16-20 years (25.4%) and more than 20 years (21.7%). Surgeons most frequently practiced in Europe (64.5%) or North America (16.7%).

Table 2 - Demographic data of 138 responding (orthopaedic) trauma surgeons

Demographics	Respondents (n = 138)
Gender; n (%)	
Male	126 (91.3%)
Female	12 (8.7%)
Age; mean (SD)	47.8 (7.9)
Years of experience; n (%)	
0-5 years	11 (8.0%)
6-10 years	29 (21.0%)
11-15 years	33 (23.9%)
16-20 years	35 (25.4%)
Over 20 years	30 (21.7%)
Continent of practice; n (%)	
Europe	89 (64.5%)
North America	23 (16.7%)
South America	14 (10.1%)
Asia	8 (5.8%)
Australia	3 (2.2%)
Africa	1 (0.7%)

Direct discharge

The proportion of surgeons selecting direct discharge as preferred treatment ranged from 4-45% (**Figure 1**). Less than 10% of surgeons selected direct discharge as preferred treatment in case of a distal radius fracture (4%), pediatric clavicle fracture (6%), mallet finger (7%), radial head fracture (9%) and fifth metacarpal neck fracture (9%). The phalanx fracture was most frequently selected to be eligible for direct discharge (45% of surgeons). For the other injuries this ranged from 10-23%.

Follow-up

Clinical agreement regarding the total number of follow-up appointments was not reached for any of the injuries (**Figure 1**). For all injuries, most surgeons would schedule a single appointment, ranging from 45-75%. The proportion of surgeons that would schedule ≥2 appointments ranged from 10-27%. The uncategorized total number of scheduled appointments ranged from 1-3 or 1-4, depending on the type of injury (Appendix **Table A1**). To provide a complete overview of the treatment plan, we analysed at which interval in weeks surgeons would schedule their last outpatient follow-up appointment (Appendix **Table A2**), and if the immobilization that would be applied in the ED was self-removable, or not (Appendix **Table A3**).

Radiographic imaging

Clinical agreement on number of radiographs was only reached a mallet finger: 81% of surgeons agreed a radiograph was not required (**Figure 2**). **Figure 2** shows the proportion of surgeons choosing either 0, 1 or ≥2 radiographs during follow-up. Most frequently, surgeons would perform one or more radiographs during follow-up of a pediatric clavicle fracture (70%), fracture of first digit of the foot (73%), distal radius fracture (78%) and avulsion fracture of base (zone 1) of fifth metatarsal bone (79%).

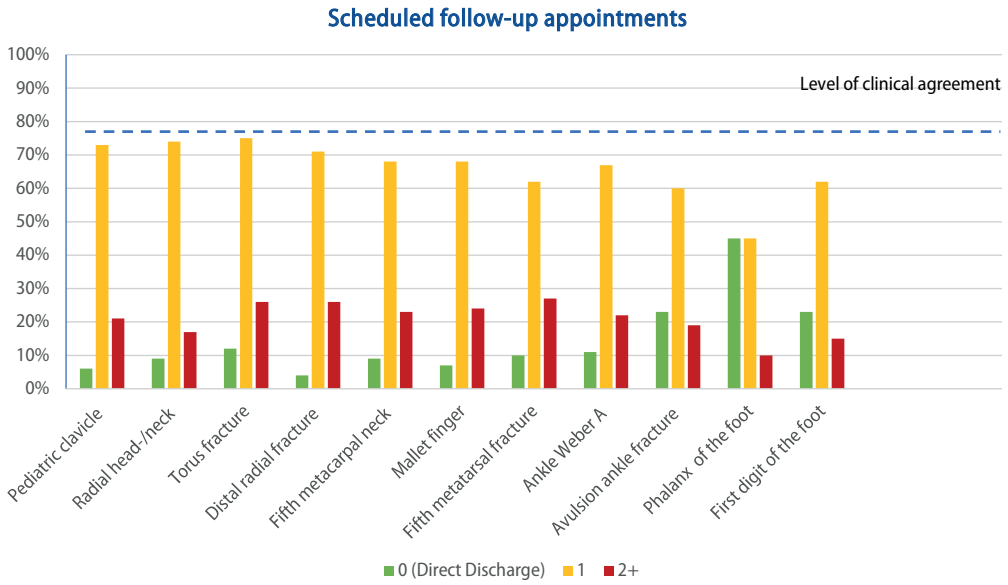

Figure 1 – Proportion of surgeons that would schedule 0 (direct discharge), 1 or > 2 follow-up appointments per injury. Line with dashes indicates threshold for clinical agreement.

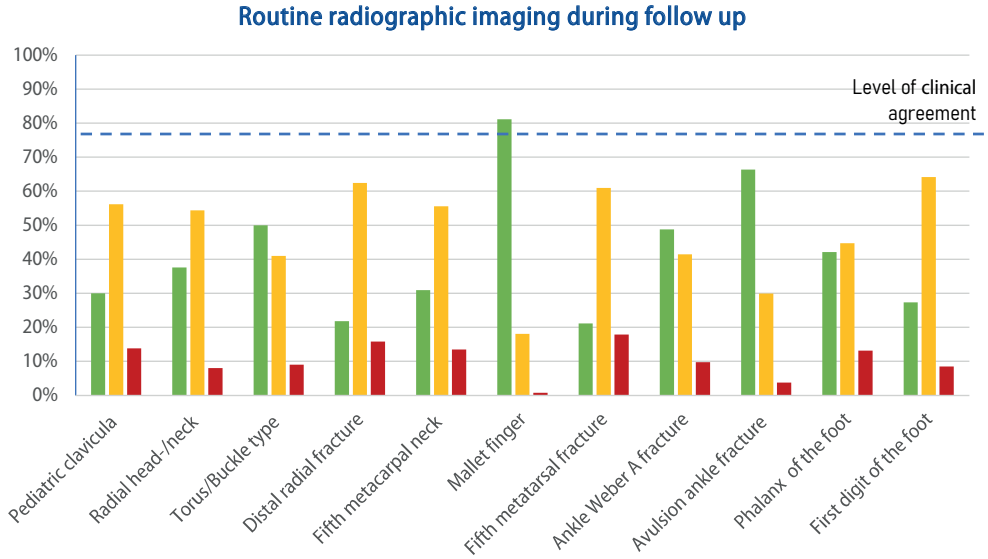

Figure 2 - Proportion of surgeons who would perform 0, 1 or ≥2 radiographic images during follow-up, if they would schedule one or more appointments

Routine referral to physiotherapist

Clinical agreement was reached in case of an avulsion fracture of the base of the fifth metatarsal bone, torus fracture of distal radius, fracture of first digit of foot and phalanx fracture of the foot. In these cases, respectively 82%, 92%, 93% and 95% of surgeons agreed this is not necessary. For none of the injuries there was clinical agreement that a patient must be routinely referred to a physiotherapist. The proportion of surgeons that would routinely refer the patient to a physiotherapist ranged from 5% (phalanx fracture of the toe) to 36% (avulsion fracture of the ankle, **Table 3**).

Table 3 - Routine referral for physiotherapy

	Routine referral to physiotherapist; n (%)	
Type of injury	**Yes**	**No**
Pediatric clavicle fracture	20 (15%)	118 (75%)
Radial head fracture	46 (33%)	92 (67%)
Torus/Buckle type of the distal radius	11 (8%)	127 (92%)
Distal radius fracture	40 (29%)	98 (71%)
Fifth metacarpal neck fracture	31 (23%)	107 (77%)
Mallet finger	41 (30%)	97 (70%)
Avulsion fracture of base of fifth metatarsal bone (zone 1)	25 (18%)	113 (82%)
Ankle fracture, Weber type A	41 (30%)	97 (70%)
Avulsion fracture of the ankle	50 (36%)	88 (64%)
Phalanx fracture of the foot	7 (5%)	131 (95%)
Fracture of first digit of foot	10 (7%)	128 (93%)

Functional movement

Clinical agreement was not reached regarding the number of weeks after which a patient should be allowed to start functional movement of their injured extremity (**Table 4**).

Table 4 - When would surgeons allow their patient to start functional movement of the injured extremity?

Type of injury	Immediately; n (%)	1 week; n (%)	2 weeks; n (%)	3-4 weeks; n (%)	5-6 weeks; n (%)	7-8 weeks; n (%)	9-10 weeks; n (%)
Pediatric clavicle fracture	44 (31.9%)	33 (23.9%)	31 (22.5%)	23 (16.7%)	7 (5.1%)	-	-
Radial head fracture	68 (49.3%)	25 (18.1%)	23 (16.7%)	18 (13.0%)	3 (2.2%)	1 (.7%)	-
Torus/Buckle type of the distal radius	32 (23.2%)	12 (8.7%)	34 (24.6%)	50 (36.2%)	10 (7.2%)	-	-
Distal radius fracture	31 (22.5%)	5 (3.6%)	10 (7.2%)	67 (48.6%)	25 (18.1%)	-	-
Fifth metacarpal neck fracture	39 (28.3%)	11 (8.0%)	15 (10.9%)	61 (44.2%)	12 (8.7%)	-	-
Mallet finger	13 (9.4%)	3 (2.2%)	3 (2.2%)	18 (13.0%)	58 (42.0%)	31 (22.5%)	12 (8.7%)
Avulsion fracture MT5 bone (zone 1)	69 (50.0%)	12 (8.7%)	11 (8.0%)	25 (18.1%)	21 (15.2%)	-	-
Ankle fracture, Weber type A	72 (52.2%)	16 (11.6%)	15 (10.9%)	20 (14.5%)	15 (10.9%)	-	-
Avulsion fracture of the ankle	85 (61.6%)	12 (8.7%)	15 (10.9%)	22 (15.9%)	4 (2.9%)	-	-
Phalanx fracture of the foot	105 (76.1%)	3 (2.2%)	12 (8.7%)	17 (12.3%)	1 (.7%)	-	-
Fracture of first digit of foot	86 (62.3%)	9 (6.5%)	18 (13.0%)	22 (15.9%)	3 (2.2%)	-	-

MT5, Fifth metatarsal;

DISCUSSION

The current study shows that, despite available evidence, direct discharge (DD) of simple stable injuries (SSIs) has not been widely adopted among (orthopaedic) trauma surgeons internationally. There is still a considerable practice variation in the treatment of these common injuries, with a low level of clinical agreement.

Previous studies have illustrated that practice variation in the treatment of injuries exists amongst (orthopaedic) trauma surgeons.[17] These studies mainly focus on the variation in operative versus conservative treatment. This is the first study to address international practice variation in the treatment of SSIs, established around the question of the added value of follow-up.

Reviewing a patient with an SSI at the outpatient clinic can be based on several motives such as hospital setting (i.e. rural or not), impeding patient characteristics, legal reasons or financial reasons, such as existing healthcare payment models that financially reward follow-up. Resolving these potentially perverse incentives is an important step in order to reduce variation and overtreatment. Promoting efficient care should be a prerequisite in any value-based healthcare system, supporting the adoption of strategies such as DD of SSIs. Other factors that might serve as a barrier to initiate change include the investment of time and costs needed to create a suitable direct discharge system. Promoting sharing of information and cooperation between hospitals will lower these barriers and increase the opportunity for other hospitals to adopt their own direct discharge system. Several institutions have already shared their information, knowledge and experiences online to be used as a basis for implementation in other hospitals.[23–25] Furthermore, a lack of high-level evidence, often sparse in orthopaedic trauma, might also contribute to variation.[26] Nevertheless, variability in treatment without a change in patient satisfaction and outcome may indicate inefficiency, consequently contributing to unnecessarily high healthcare costs. This is exactly opposite the purpose of value-based health care: to maximize or maintain patient outcome while minimizing costs.[27]

Depending on the type of injury, a notable number of surgeons indicated they would routinely refer their patient to a physiotherapist. For some of these injuries, a 'self-care protocol' has already been demonstrated to produce functional outcome comparable to follow-up.[12,13,28] Additionally, the current study shows that routine radiography of SSIs during follow-up is not unusual. However, there is growing evidence that this is of limited value.[29] This further raises the question if today, in contrast to routine care, rapid-access patient-initiated follow-up, imaging and/or physiotherapy might not better suit patient's needs, at reduced healthcare costs.

This study has several limitations. First, the survey used hypothetical cases and therefore it cannot be assured that the results completely represent what surgeons would actually do in their hospital setting based on their examination and the principles of shared-decision making. Second, we used an online survey which is prone to under-coverage and self-selection bias.[30] While the response rate is relatively low (20.7%), the absolute number of respondents is acceptable for the aim of this study. We believe a higher response rate or a larger number of respondents would not alter the conclusion nor the overriding message. Third, we did not explore possible surgeons' motives to schedule follow-up appointments (or not) or performing radiographic images (or not), such as hospital setting, financial or legal reasons, or expectedly higher patient satisfaction. This information could give more insight in why practice variation exists and therefore would be valuable in an attempt to reduce variation. Last, the categories used to determine clinical agreement were arbitrary. However, combining several categories would not lead to a proportional increase of clinical agreement.

Nevertheless, our study represents a useful evaluation of the variation in the treatment of common SSIs amongst (orthopaedic) trauma surgeons internationally, since the establishment of direct discharge as safe and effective alternative to follow-up.

Direct discharge of SSIs has not been widely adopted in current international clinical practice. Practice variation exists even for the most common type of injuries, consequently contributing to inefficient care. Orthopaedic trauma surgeons are encouraged to evaluate their current treatment protocols of SSIs in order to establish timely, efficient and (cost-)effective care.

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APPENDIX

Table S1 - Proportion of surgeons that would schedule 0, 1, 2, 3 or 4 appointments per injury

	Number of scheduled follow-up appointments; n (%)				
Type of injury	**Direct discharge**	**1**	**2**	**3**	**4**
Pediatric clavicle fracture	8 (6%)	101 (73%)	25 (18%)	3 (2%)	1 (1%)
Radial head fracture	13 (9%)	102 (74%)	20 (15%)	2 (1%)	1 (1%)
Torus/Buckle type of the distal radius	16 (12%)	103 (75%)	16 (12%)	16 (12%)	3 (2%)
Distal radius fracture	5 (4%)	98 (71%)	29 (21%)	5 (4%)	1 (1%)
Fifth metacarpal neck fracture	12 (9%)	94 (68%)	25 (18%)	4 (3%)	3 (2%)
Mallet finger	10 (7%)	94 (68%)	25 (18%)	7 (5%)	2 (1%)
Avulsion fracture of base of fifth metatarsal bone (zone 1)	14 (10%)	86 (62%)	32 (23%)	6 (4%)	-
Ankle fracture, Weber type A	15 (11%)	93 (67%)	22 (16%)	8 (6%)	-
Avulsion fracture of the ankle	31 (23%)	83 (60%)	18 (13%)	6 (4%)	-
Phalanx fracture of the foot	62 (45%)	62 (45%)	10 (7.2%)	4 (3%)	-
Fracture of first digit of foot	32 (23%)	86 (62%)	17 (12%)	3 (2%)	-

Table S2 - When would surgeons schedule their last outpatient follow-up appointment?

Type of injury	**Direct discharge; n (%)**	**1-2 weeks; n (%)**	**3-4 weeks; n (%)**	**5-6 weeks; n (%)**	**7-8 weeks n (%)**
Pediatric clavicle fracture	8 (5.8%)	55 (39.9%)	43 (31.2%)	27 (19.6%)	5 (3.6%)
Radial head fracture	13 (9.4%)	71 (51.4%)	25 (18.1%)	26 (18.8%)	3 (2.2%)
Torus/Buckle type of the distal radius	16 (11.6%)	52 (37.7%)	51 (37.0%)	16 (11.6%)	3 (2.2%)
Distal radius fracture	5 (3.6%)	53 (38.4%)	46 (33.3%)	31 (22.5%)	3 (2.2%)
Fifth metacarpal neck fracture	12 (8.7%)	53 (38.4%)	47 (34.1%)	20 (14.5%)	6 (4.3%)
Mallet finger	10 (7.2%)	31 (22.5%)	25 (18.1%)	44 (31.9%)	28 (20.3%)
Avulsion fracture of base of MT5 bone (zone 1)	14 (10.1%)	36 (26.1%)	25 (18.1%)	58 (42.0%)	5 (3.6%)
Ankle fracture, Weber type A	15 (10.9%)	44 (31.9%)	29 (21.0%)	45 (32.6%)	5 (3.6%)
Avulsion fracture of the ankle	31 (22.5%)	32 (23.2%)	33 (23.9%)	40 (29.0%)	2 (1.4%)
Phalanx fracture of the foot	62 (44.9%)	20 (14.5%)	33 (23.9%)	22 (15.9%)	1 (.7%)
Fracture of first digit of foot	32 (23.2%)	48 (34.8%)	30 (21.7%)	25 (18.1%)	3 (2.2%)

MT5, Fifth metatarsal;

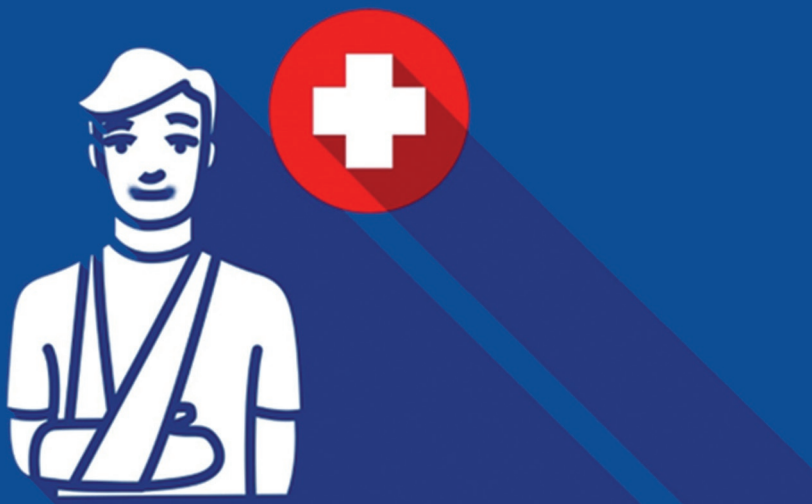
Table S3 - Proportion of surgeons that would use self-removable materials in the Emergency Department

	Immobilization could be self- removed at home; n (%)	
Type of injury	**Yes**	**No**
Pediatric clavicle fracture*	138 (100%)	-
Radial head fracture	110 (80%)	28 (20%)
Torus/Buckle type of the distal radius	38 (35%)	90 (65%)
Distal radius fracture	43 (31%)	95 (69%)
Fifth metacarpal neck fracture	59 (42%)	85 (62%)
Mallet finger*	138 (100%)	-
Avulsion fracture of base of fifth metatarsal bone (zone 1)	79 (57%)	59 (43%)
Ankle fracture, Weber type A	115 (83%)	23 (17%)
Avulsion fracture of the ankle	131 (95%)	7 (5%)
Phalanx fracture of the foot	132 (96%)	6 (4%)
Fracture of first digit of foot	125 (91%)	13 (9%)

**there were no options of immobilization materials that could not be self-removed at home.*

PART II

(COST-)EFFECTIVENESS OF DIRECT DISCHARGE OF SIMPLE STABLE INJURIES IN THE NETHERLANDS



DIRECT DISCHARGE FROM THE EMERGENCY DEPARTMENT OF PATIENTS WITH SIMPLE STABLE INJURIES A DUTCH PILOT STUDY

(original article in Dutch, translated to English)

3

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ABSTRACT

Background

To describe and study (a) the implementation of direct discharge from a Dutch Emergency Department (ED) for patients with relatively simple stable injuries (SSIs), (b) preliminary logistical and financial effects, and (c) patients' experiences.

Methods

Following the example of a healthcare reorganization in the United Kingdom, in May 2019 we changed the treatment protocols of eleven SSIs. Since that time, no standard follow-up appointment has been scheduled for these patients. Patients are given information about treatment and the recovery period, and a form of immobilization is applied which can easily be removed at home. This information is summarized in a discharge leaflet and a smartphone application. A telephone helpline is available for any concerns or questions. During the implementation phase we determined compliance with, and deviation from, the protocol daily for 3 months. To determine the logistical and financial effects we compared the healthcare utilization of all patients with SSIs three months before and after implementation. Patient satisfaction and the shift in treatment towards primary care were determined by means of questionnaires.

Results

In the three months before implementation 275 patients with an SSI presented to our ED, compared with 318 in the same period after implementation; 304 of the 318 patients were directly discharged (protocol compliance 95.6%). We found a significant reduction in follow-up appointments (-91%), radiological imaging (-72%), and costs. Patient satisfaction was comparable. There was no shift towards primary care in healthcare utilization.

Conclusions

In the Netherlands, direct discharge from the ED seems to be an effective and safe alternative to traditional treatment with outpatient follow-up. Further studies on patient-reported outcomes should determine if this process is in concordance with the principle of Value Based Health Care.

INTRODUCTION

In the Netherlands, 1.8 million patients visit an Emergency Department (ED) annually. Four in ten of these patients have a fracture.[1] The incidence of patients with fractures is rising, with an increased demand and workload as a result thereof.[2] In order remain able to offer adequate care to this growing patient group in the future, a change in how healthcare is provided in the Netherlands might be warranted.[2,3]

A new treatment method was developed in Glasgow in 2011 with the aim of providing efficient, effective and patient oriented care to patients with musculoskeletal injuries.[4,5] This method consists of two parts. The first part is direct discharge (DD) from the ED of patients with a relatively simple and stable injury (SSI). This means that follow-up appointments are not scheduled routinely after the ED visit. Patients are instructed after immobilization materials have been applied that are easily removed by the patients themselves.

The second part concerns a daily review of all other patients in a Virtual Fracture Clinic (VFC). During this VFC-review an individual treatment proposal is documented, which is discussed with the patient by telephone afterwards. Currently, multiple hospitals in the United Kingdom (UK) have already implemented a comparable reorganization.[6]

In our hospital, we are implementing a reorganisation of our trauma care, which is based on the method from the UK, and tailored to the Dutch healthcare system if necessary, while studying its effects. Recently we started the DD (part one) from the ED for several musculoskeletal injuries. A pilot of a VFC-review (part two) will follow shortly.

The aim of this study was to describe and assess: 1) the first three months of implementation of DD from the ED, 2) the initial logistical and financial effects and 3) the first results regarding patient experiences.

METHODS

Injuries, workflow and treatment

Prior to this study eleven SSIs were identified in agreement with Trauma Surgery, Orthopaedics and Emergency Departments (**Table 1**). This selection was based mostly on studies that suggest that patients with these injuries have satisfactory treatment outcome with early mobilisation and without routine follow-up or radiological imaging.[4,7–14]

On 20 May 2019 we changed our treatment protocols and DD of patients with these injuries from our ED became our standard of care. Our ED is part of a large Level 2 Trauma centre with two locations, where 75,000 patients are reviewed annually. All employees involved were informed prior to these changes using presentations, an e-learning, newsletters and a reference card.

Prior to the implementation of DD treatment (most often) involved (cast) immobilisation and one or multiple outpatient follow-up appointments. The hospital's local treatment protocol directed treatment. Since the implementation of DD patients are immobilized in the ED using materials that are easily self-removed at home. Instructions regarding the recovery and recovery period are provided in the ED as well. This information is summarized in a discharge leaflet in the Dutch or English language. This leaflet is also available in a smartphone application ("app") for iOS and Android. Additionally, this app contains video instructions of exercises to improve recovery, as well as video instructions on how to reapply the immobilization materials. In case of questions or concerns after DD a telephone helpline can be contacted. If the question or concern cannot be resolved by telephone, an outpatient follow-up appointment is scheduled.

In this study we included all patients with an SSI (**Table 1**). Exclusion criteria were: high energy trauma, more than one injury, treatment continued elsewhere, other reason than the SSI to be followed-up in an outpatient clinic, language barrier that complicated providing instructions to the patient in the ED.

Table 1 – Injuries eligible for direct discharge, criteria and immobilisation

Type of injury	Age category	Additional criteria	Immobilisation material
Paediatric clavicle #	≤14 years old	No indication for surgical treatment	Sling
Radial head # or radial neck # or positive fatpad sign	Adults	Head: Mason type 1 Neck: not dislocated	Pressure bandage and sling
Torus- and greenstick type # of distal forearm	Paediatric	Torus: isolated ulna- or radius #, or both # Greenstick: isolated ulna- or radius #, Acceptable angulation based on residual growth	Removable wrist brace, sling
Fifth metacarpal neck #	Adult	<70 degrees. volar angulation No rotational deviation	Buddy strap and pressure bandage, sling
Mallet finger	Adult	Either tendinous or bony No wound Treated conservatively	Mallet splint
Base of fifth metatarsal #	Adult	Zone 1 or Zone 2 <5mm dislocation	Walker boot
Weber A type ankle #	Adult	<3mm dislocation	Tubigrip and ankle brace
Distortion of ankle with minimal avulsion type #	Both	No additional criteria	Tubigrip and ankle brace
Bicycle spoke injury	Paediatric	Minimal wound (superficial / excoriation) No fracture	Pressure bandage
Isolated phalangeal # of the foot (lesser toe)	Both	No indication for surgical treatment	Buddy strap
Greater toe #	Both	Not dislocated	Spica pressure bandage and bandage shoe

#, fracture; mm, millimetre;

Implementation

During the implementation we assessed the protocol compliance and deviation on a daily basis. There was protocol compliance if a patient with an SSI was immobilized according to our new DD protocols and discharged directly, i.e. no routine outpatient follow-up appointment was scheduled. If these patients were treated according to our previous protocols, this was scored as non-compliance to the protocol. Deviation was defined as a patient being discharged directly incorrectly (i.e. the injury was not an SSI). Furthermore, we assessed how often the telephone helpline was contacted and the reason to do so.

Logistical and financial effects

The initial logistical and financial effects were assessed by comparing the following groups: 1) all patients with an SSI who presented to our ED three months prior to the implementation of DD (baseline measurement in pre-cohort), and 2) the patients who were discharged directly from the ED after implementation (DD-cohort). The following data were collected by a review of the electronic patient record (EPR): age, gender, type of injury, total duration of stay in the ED in minutes, total number of follow-up appointments, radiologic imaging during follow-up, physiotherapy referrals and the immobilisation material used. The total number of follow-up appointments was categorised into : 1, 2, 3 and >4 appointments. Costs were defined as the total costs as a result of follow-up appointments, radiologic imaging during follow-up and the materials used for immobilisation (both in the ED as well as during reapplication of new materials during follow-up appointments). For our calculation we used the tariffs provided in the guideline for economic evaluations in healthcare.[15] For the costs of the materials used for immobilisation we used the price purchase price.

Patient experience and primary healthcare utilization

Both before as well as after the implementation of DD all patients with an SSI were asked if they wanted to participate in a survey study regarding patient-related outcomes including satisfaction, functional outcome and quality of life. After obtaining informed consent, patients received a questionnaire one week and three months after their ED visit. To describe the initial effects on patient experience we used all the questionnaires that were completed to date, and we selected the questions regarding patient experience and shift of care towards primary healthcare that we deemed most relevant: satisfaction with treatment in the ED (on a 1-10 scale), which as assessed after one week, and satisfaction with their treatment in general (on a 1-10 scale), the total number of visits to the general practitioner and the total number of physiotherapist visits. Visits to the general practitioner were categorised in 0, 1, 2, and ≥3, physiotherapist visits were categorised in 0, 1-2, 3-5 and >5.

This study was approved by the hospital's local review committee for scientifical research (Adviescommissie Wetenschappelijk Onderzoek (ACWO), OLVG Hospital, Amsterdam, the Netherlands).

RESULTS

Number of patients and course of implementation

During the three months prior to the implementation of DD, 293 patients with an SSI presented to our ED, versus 340 patients in the three months thereafter (**Figure 1**). After applying the exclusion criteria, 275 patients remained in the pre-cohort and 318 patients in the DD-cohort (**Table 2**). Of these 318 patients, 304 were treated according to the new DD protocol (protocol compliance 95.6%). For the other 14 patients the treating physician did not think about the new treatment protocol.

One patient was treated according to the "Weber A type ankle fracture " DD protocol, while actually this was a Weber B type ankle fracture. This was noted during our daily review of all the radiologic ED images and the patient was contacted and scheduled for surgical treatment. The telephone helpline was contacted 42 times. In 50% of cases this was a patient with a base of fifth metatarsal fracture. Of all telephone contacts, pain was the most common reason for contact (38%), followed by questions regarding the treatment (24%), and questions regarding the immobilisation materials (19%).

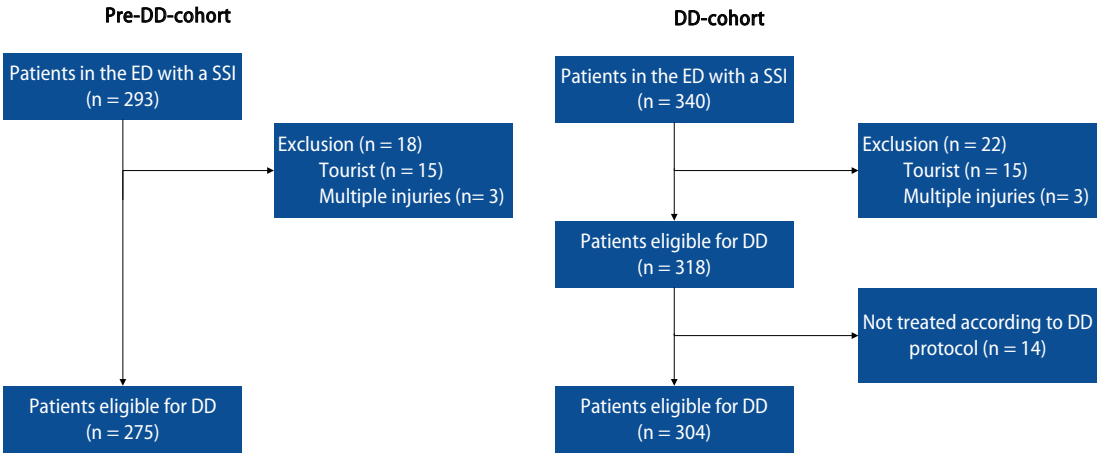

Figure 1 – Inclusion of patients in both cohorts
DD, Direct Discharge; ED, Emergency Department; SSI, Simple, stable injury

Table 2 – Characteristics of 579 patients with an SSI who visited our Emergency Department during six months

Characteristic	Pre-cohort (n = 275)	DD-cohort (n = 304)
Age†	23 (10 – 42)	28 (10 – 45)
Paediatric (<18 years); n (%)	123 (44.7)	119 (39.1)
Gender		
Male; n (%)	151 (54.9)	159 (52.3)
Female; n (%)	124 (45.1)	145 (47.7)
Type of injury		
Clavicle #; n (%)	12 (4.4)	10 (3.3)
Radial head/- neck #; n (%)	51 (18.5)	41 (13.5)
Paediatric forearm #; n (%)	56 (20.4)	51 (16.8)
Greenstick; n (%)	19 (6.9)	13 (4.3)
Torus; n (%)	37 (13.5)	38 (12.5)
Fifth metacarpal neck #; n (%)	17 (6.2)	17 (5.6
Mallet finger; n (%)	7 (2.5)	8 (2.6)
Base of fifth metatarsal #; n (%)	35 (12.7)	43 (14.1)
Weber A type ankle #; n (%)	11 (4.0)	8 (2.6)
Avulsion type ankle #; n (%)	27 (9.8)	35 (11.5)
Bicycle spoke injury; n (%)	14 (5.1)	32 (10.5)
Letter toe #; n (%)	18 (6.6)	30 (9.9)
Greater toe #; n (%)	27 (9.8)	29 (9.5)

DD, Direct Discharge; SSI, Simple, stable injury; #, fracture; Continuous data reported as † median (i.q.r.) or ‡ mean (s.d.). Numeric data reported as n (%). # Mann-Whitney U test, in other cases Chi-square test.

Logistical and financial effects

The total number of outpatient follow-up appointments in the pre-cohort was 356, versus 36 in the DD-cohort (**Table 3**, $p < 0.001$). There was a significant reduction in the total number of radiographs during follow-up, as well as in physiotherapist referrals. De total duration of stay in t he ED was comparable: mean 141 versus 143 minutes.

The total costs as a result of outpatient follow-up, imaging and material use in the pre-cohort were €31,090, versus €8,249 in the DD-cohort. This is equal to €113 versus €27 per patient (**Table 4**).

Table 3 – Secondary healthcare utilization in both cohorts

Outcome	Pre-cohort (n = 275)	DD-cohort (n = 304)	p-value
Outpatient follow-up appointments; n	356	36	<0.001*#
Outpatient follow-up appointments, categorized			<0.001*
No appointments; n (%)	65 (23.6)	278 (91.6)	
1 appointment; n (%)	96 (34.9)	17 (5.7)	
2 appointments; n (%)	93 (33.8)	6 (2.0)	
3 appointments; n (%)	14 (5.1)	1 (0.3)	
≥4 appointments; n (%)	7 (2.6)	1 (0.3)	
Radiographs during follow-up; n	77	24	<0.001*#
Physiotherapist referrals; n	35	4	<0.001*
Total duration of ED stay; minutes ‡	141 ± 66	143 ±73	0.709 (95% CI -13.63 – 9.28)

CI, Confidence interval; DD, Direct Discharge; ED, Emergency Department. Continuous data reported as † median (i.q.r.) or ‡ mean (s.d.). Numeric data reported as n (%). # Mann-Whitney U test, in other cases Chi-square test.

Table 4 – Costs in both cohorts and per patients as a result of outpatient follow-up, imaging and material use

Item	Pre-cohort (n = 275)	DD-cohort (n = 304)
Outpatient follow-up appointment costs[a]	€ 25,988	€ 2,628
Radiographic imaging costs[b]	€ 2,926	€ 912
Material costs	€ 2,176	€ 4,709
Total costs	€ 31,090	€ 8,249
Costs per patient	€ 113	€ 27

DD, Direct Discharge; [a], costs outpatient follow-up: €73; [b], mean costs radiograph: €38.[15]

Patient experiences and primary healthcare utilization

Table 5 shows the current response to the various questions we selected to describe the first effects of DD on patient experiences. Satisfaction with treatment in the ED as well as satisfaction with treatment in general (after three months) were comparable in both cohorts (7.8 versus 7.9 and 7.9 versus 7.9, respectively, **Table 5**). In the pre-cohort, 35 of 154 patients (22.7%) visited a general practitioner for the follow-up of their injury, versus 14 of 55 patients in the DD-cohort (25.5%, p = 0.682). The mean number general practitioner visits was 0.34 versus 0.38 in the pre-cohort and DD-cohort, respectively. In the pre-cohort, 40 patients visited a physiotherapist (26.0%), versus 8 patients in the DD-cohort (14.5%, p = 0.084). The mean number of physiotherapist visits was1.89 versus 0.89 in the pre-cohort and DD-cohort, respectively.

Table 5 – Patient-reported experiences and primary healthcare utilization

Outcome/experience	Response	Pre-cohort	DD-cohort	p-value
Satisfaction with treatment in ED; (1-10)‡	216 versus 123	7.78 ± 1.64	7.93 ± 1.53	0.425 (95% CI -0.50 – 0.21)
Satisfaction with treatment after three months; (1-10)‡	171 versus 55	7.91 ± 1.70	7.93 ± 1.43	0.936 (95% CI -0.54 – 0.50)
Visited general practitioner	154 versus 55			0.682
Yes; n (%)		35 (22.7)	14 (25.5)	
No; n (%)		119 (77.3)	41 (74.5)	
Total general practitioner visits; n	"	53	21	0.684#
General practitioner visits, categorized	"			0.919
No visits; n (%)		119 (77.3)	41 (74.5)	
1 visit; n (%)		23 (13.9)	9 (16.4)	
2 visits; n (%)		8 (5.2)	4 (7.3)	
≥3 visits; n (%)		4 (2.6)	1 (1.8)	
Visited physiotherapist	"			0.084
Yes; n (%)		40 (26.0)	8 (14.5)	
No; n (%)		114 (74.0)	47 (85.5)	
Total physiotherapist visits; n	"	291	49	0.096#
Physiotherapist visits, categorized	"			0.266
No visits; n (%)		114 (74)	47 (85.5)	
1-2 visits; n (%)		4 (2.5)	2 (3.6)	
3-5 visits; n (%)		13 (8.4)	1 (1.8)	
>5 visits; n (%)		23 (14.9)	5 (9.1)	

*CI, Confidence interval; DD, Direct Discharge; ED, Emergency Department; Continuous data reported as † median (i.q.r.) or ‡ mean (s.d.). Numeric data reported as n (%). # Mann-Whitney U test, in other cases Chi-square test. * signifance level p <0.05.*

DISCUSSION

Direct discharge might contribute to a limitation of the increased workload and care demand of patients with musculoskeletal injuries. Despite the available evidence indicating that patients with certain injuries can be discharged directly from the ED, to our knowledge currently no Dutch hospitals have implemented and studied DD on a large scale. Consequently, the (potential) medical, logistical and financial effects of DD in the Netherlands remain unclear.

To our knowledge, this is the first study to describe the implementation and potential effects of DD in the Netherlands. Our results indicate that it is possible to achieve a high protocol compliance within a relatively short time period. Our protocol compliance was two times higher compared to numbers reported in UK studies.[16] Like in the UK, DD in the Netherlands seems to be an effective alternative to the more 'traditional' treatment: after DD there are significant reductions in healthcare utilization and -costs as a consequence of decreased follow-up appointments, while currently patient satisfaction seems to remain comparable. The reductions in follow-up appointments (-91%), and imaging (-72%), are comparable to the results reported in the UK.[4,12,13,17]

Furthermore, there was no shift of care towards primary healthcare. Remarkably, the number of physiotherapist visits actually seems to decrease (while not statistically significant due to a low number of included patients). This might be explained due to the fact that the number of referrals decreased, or possibly patients with a brace start mobilization at an earlier stage which leads to less stiffness.

Limitations of this study include the relatively small subgroups in both cohorts. Consequently, it is currently not possible to assess patient satisfaction relative to a specific type of injury or age group. Furthermore, follow-up of patients was relatively short. Moreover, it is possible that patients visited a different hospital for follow-up of their injury. To assess a shift of care towards primary healthcare we used surveys, instead of data from the general practitioner of physiotherapist. In addition to the current study, our definitive study regarding patient-reported outcomes will also include other outcomes such as functional outcome, quality of life and work absenteeism. Inclusions for this study are not completed yet. Consequently, the post-DD-cohort is currently relatively small.

Future studies should assess the logistical and financial effects in larger (sub) cohorts, with a longer follow-up to assess complication rates. Our study regarding patient-reported outcomes, which will compare 385 patients before and after the implementation of DD, will indicate whether DD is in concordance with the principle of Value Based Healthcare, that is aimed at maximizing the value of care for the patient while reducing healthcare costs.[18] Based on the survey study and the logistical effects a cost analysis will be performed from different perspectives as well. Moreover it is valuable to assess the experiences of the employees involved with this project. Admittedly, the total duration of stay in the ED did not increase, but it was not assessed whether the treating physician spends more time – relatively – to provide instructions to the patient. A study measuring different sub-processes in the ED could provide more insight.

For the staging of this reorganization we used the NHS Scotland guideline **Figure 2**.[19] This guideline advises to implement DD prior to a daily Virtual Fracture Clinic (VFC) review. Our next step will be the development and implementation of a daily VFC-review for all trauma patients with an injury that is not eligible for DD. During the VFC-review a

treatment proposal is determined for each individual patient. Patients are contacted by telephone the day after their ED visit, to discuss their treatment proposal and establish a definitive treatment plan. The definitive treatment plan is developed in consultation with a specialist shortly after the ED visit, and ensures clarity for the patient as well as the healthcare providers who review the patient in an outpatient clinic. Moreover, we expect this to reduce treatment variation and unnecessary follow-up appointments and imaging.

In conclusion, like in the UK, DD from the ED of patients with an SSI in the Netherlands seems an effective and safe alternative to the more 'traditional' treatment with routine follow-up. If at least patient-reported outcomes remain comparable, DD might be considered by other hospitals in the Netherlands as well, in order to remain able to provide adequate care in the future, to the increasing number of patients with musculoskeletal injuries.

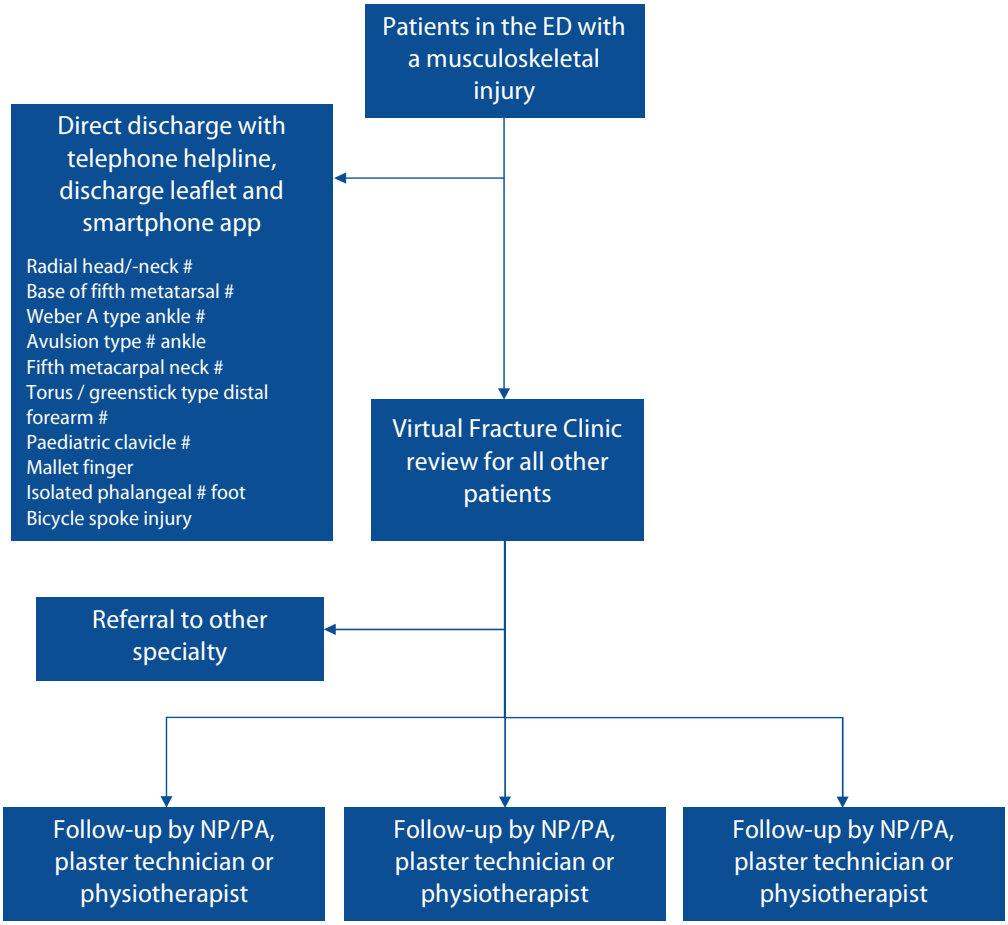

Figure 2 – Flowchart depicting the workflow and different steps of the project
Direct discharge is step 1, step 2 is the implementation of a Virtual Fracture Clinic review, step 3 is further optimization of follow-up by involvement of NP/PA/plaster technician/physiotherapist.
#, fracture; ED, Emergency Department; NP, Nurse Practitioner; PA,

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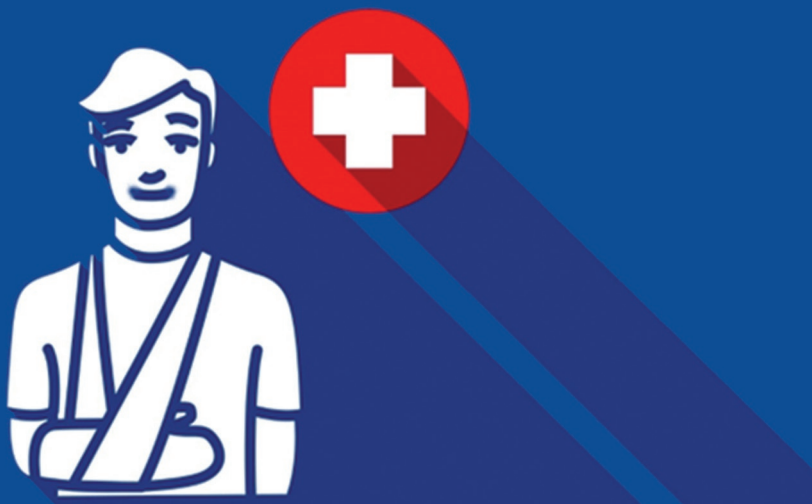

DIRECT DISCHARGE FROM THE EMERGENCY DEPARTMENT OF SIMPLE STABLE INJURIES A PROPENSITY-SCORE ADJUSTED NON-INFERIORITY TRIAL

4

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ABSTRACT

Background

Recent studies suggest a large proportion of musculoskeletal injuries are simple, stable injuries (SSIs).The aim of this study was to evaluate whether direct discharge (DD) from the Emergency Department (ED) of SSIs is non-inferior to "traditional care" regarding treatment satisfaction and functional outcome, and to compare other patient-reported outcomes (PROMs), experiences (PREMs), resource utilization and adverse outcomes before-and-after DD.

Methods

This trial compared outcomes for eleven SSIs, six months before-and-after the implementation of DDprotocols. Pre-DD, patients were treated according to local protocols. Post-DD patients were discharged directly using removable orthoses, discharge leaflets, smartphone app and telephone helpline. Participants received a three-month post-injury PROM/PREM survey to assess: treatment satisfaction (VAS); pain (VAS); functional outcome (four validated questionnaires); health-related quality-of-life (HRQoL, EQ-5D). Resource utilization included: general-practitioner (GP) visited (yes/no); physiotherapist visited (yes/no); return-to-work/school/sports (days); work/school absenteeism to visit hospital (yes/no); number of hospital visits and follow-up X-rays. Other outcomes included missed injuries (additionally to SSI); adverse outcomes (delayed-union, non-union). Between-group differences were assessed using propensity-score adjusted regression analyses. Non-inferiority was assessed for satisfaction and functional outcome using predefined margins.

Results

348 (pre-DD) and 371 patients (post-DD) participated, 144 (41.4%) and 153 (41.2%) patients completed the survey. Satisfaction and functional outcome post-DD was non-inferior to traditional care. Mean satisfaction was 8.13 pre-DD and 7.95 post-DD (mean difference:-0.16, p=0.408). Pain, HR-QoL, GP/physiotherapist visits and return-to-work/school/sports were comparable before-and-after DD. Work absenteeism was higher pre-DD (OR:0.110, p<0.001), as well as school absenteeism (OR:0.084, p<0.001). Post-DD, mean number of hospital visits and X-rays were reduced: -1.68 (p<0.001), and -0.26 (p<0.001). Missed injuries occurred once pre-DD versus twice post-DD. There were no adverse outcomes.

Conclusions

The results of this study confirm several SSIs can be discharged directly from the ED without compromising patient outcome/experience. Future injury-specific trials are needed to conclusively assess non-inferiority of DD.

INTRODUCTION

In the Netherlands, 656,000 of two million annual Emergency Department (ED) visits concern injuries, 40% of which are fractures.[1] Traditionally, patients with fractures are reviewed in a fracture clinic approximately one week after their initial assessment in the ED. Consequently, fracture clinics are often characterized by the referral of large numbers of unselected patients with minor injuries that do not (necessarily) require intervention.[2] This frequently leads to recurrent unnecessary reviews and a high workload that inevitably has consequences for patient experience, staff morale, training, and quality of care. Therefore, recently, a Virtual Fracture Clinic (VFC) model was introduced in several hospitals in the United Kingdom (UK) to optimize and streamline outpatient trauma care.[2-6]

The VFC model consists of two main components.[2, 4] The first component is direct discharge (DD) from the ED of patients with simple, stable injuries (SSIs). Direct discharge is based on the idea that most SSI patients require reassurance and information, but not routine review, as it is highly likely their injuries have excellent outcome with early mobilisation.[4] The second component is a 'virtual' review of all other ED patients with musculoskeletal injuries (i.e. not discharged directly).[2-6] During this consultant-led VFC review, patients are triaged to an appropriate patient-centred pathway, aiming to reduce unnecessary and untimely follow-up appointments. Typically, DD of SSIs is implemented prior to the implementation of a VFC review.[7]

Direct discharge has been studied for several SSIs within the UK, including amongst others, Mason type 1 radial head fractures,[8, 9] fifth metacarpal neck fractures,[8, 10, 11] base of fifth metatarsal fractures,[8, 12, 13] buckle type fractures of the distal radius and paediatric clavicle fractures.[14-18] These studies indicate that DD reduces follow-up appointments, imaging, no-shows and costs without compromising outcome and experience. To our knowledge, however, no studies have been performed outside the UK, whereas it is important to externally validate and evaluate effects in other settings, such as a different country.

The aim of this study was to evaluate whether DD of SSIs in a large urban district teaching hospital in the Netherlands was non-inferior to traditional care in terms of satisfaction with treatment and functional outcome, as well as to compare other patient-reported outcomes (PROMs), experiences (PREMs), adverse outcomes and resource utilization before and after the implementation of DD.

METHODS

Design

This was a prospective, non-inferiority before-and-after study performed in the OLVG West hospital, a level-2 trauma centre in Amsterdam, the Netherlands, between 15 November 2019 and 15 November 2020, comparing DD versus 'traditional' fracture care. Direct discharge protocols were implemented at the midpoint of this study (20 May 2019), dividing patients into a pre-DD-cohort and a DD-cohort.[19]

Direct discharge of simple stable injuries

Prior to the start of this study (October 2018), consensus was reached by our team of (orthopaedic) trauma surgeons, regarding the eligibility of injuries for DD and their corresponding treatment (**Table 1**). For most injuries this was based on previous studies.[2-6, 8-17, 20-22] The isolated 'greenstick-type' distal radius fracture, avulsion fracture of the ankle and bicycle spoke injury were deemed eligible based on expert opinion.

Table 1 – Simple and stable injuries, criteria and immobilization

Injury	Paediatric/ adult	Criteria	Immobilization after DD
Paediatric clavicle Fx	Paediatric	Age ≤14 No indication for surgical treatment	Sling
Radial head-/neck Fx	Adult	Head: Mason type 1, neck: undisplaced, or Positive fatpad sign	Pressure bandage, sling
Greenstick or torus/ buckle type Fx of the distal radius	Paediatric	Acceptable angulation based residual growth Torus/buckle type: isolated ulna Fx, isolated radius Fx or both Greenstick type: isolated ulna Fx or isolated radius Fx	Removable wrist brace
Fifth metacarpal neck Fx	Adult	Volar angulation <70 degrees No rotational deviation	Buddy strap and pressure bandage
Mallet finger	Adult	Either bony or tendinous Treated conservatively	Mallet splint
Weber A type ankle Fx	Adult	Dislocation <2mm No signs of stage 2 supination-adduction type injury	Tubigrip and ankle brace
Avulsion type ankle Fx	Adult	Either lateral or medial malleolus or tarsal bones	Tubigrip and ankle brace
Fx of fifth metatarsal base	Adult	Fx located in either zone 1 or zone 2 Dislocation ≤4 mm	Walker boot
Fx of greater toe	Both	Either proximal or distal phalanx Fx Undisplaced	Spica pressure bandage and bandage shoe
Fx of lesser toe	Both	Any isolated Fx No indication for surgical treatment	Buddy strap
Bicycle spoke injury	Paediatric	No Fx based on radiograph Superficial wound	Pressure bandage

DD, Direct Discharge; Fx, fracture; mm, millimetre.

Treatment

Traditional care

Before implementation of DD (pre-DD-cohort), all patients with SSIs were treated in the ED according to local protocols. This often involved casting or splinting in the ED and at least one follow-up appointment in the fracture clinic after approximately one week.

Direct discharge

After implementation of DD (DD-cohort), all patients with SSIs were treated in the ED using removable immobilization such as a bandage or brace (**Table 1**). In the ED, physicians provided extensive verbal instructions and information relating to the injury and the expected recovery. This information was also summarized in a discharge leaflet. A smartphone application was available for iOS and Android, containing digital versions of the discharge leaflets, videos of physical exercises to improve recovery, and videos explaining how to reapply immobilization after removal. A telephone helpline was available during mornings of weekdays in the event of questions, concerns, or if the patient requested review. Eligibility for DD was reassessed the next morning by an (orthopaedic) trauma surgeon and radiologist during a daily review of cases and X-rays of all ED patients. This daily assessment was already part of our treatment process prior to the implementation of DD and acts as safety netting to identify missed injuries or patients treated incorrectly. In case patients were discharged directly incorrectly (i.e. the injury was not an SSI), further face-to-face follow-up was scheduled by telephone. In case a patient with an SSI was not discharged directly, the patient was treated according to previous standards.

Recruitment and consent

During the study period all consecutive patients that presented to our ED with an isolated SSI were asked to participate. Patients were included only after obtaining written informed consent. Exclusion criteria were: inability to understand/complete a Dutch survey; initial treatment in the ED of a different hospital; multiple injuries; reason for follow-up other than the SSI (e.g. social care reasons); Eye/Motor/Verbal-score <15 at presentation, high-energy trauma; treatment continued in different hospital (e.g. closer to home); alcohol/drug intoxication.

Outcomes

Primary outcomes of interest were satisfaction with treatment and functional outcome. For these outcomes, non-inferiority of DD versus traditional care was assessed using predefined non-inferiority margins (minimal clinically important difference, MCID, **Table 2**).[23-26] All outcomes were categorized into: "PROMs and PREMs", "Resource utilization", and "Safety and use of DD protocols" (**Figure 1**).

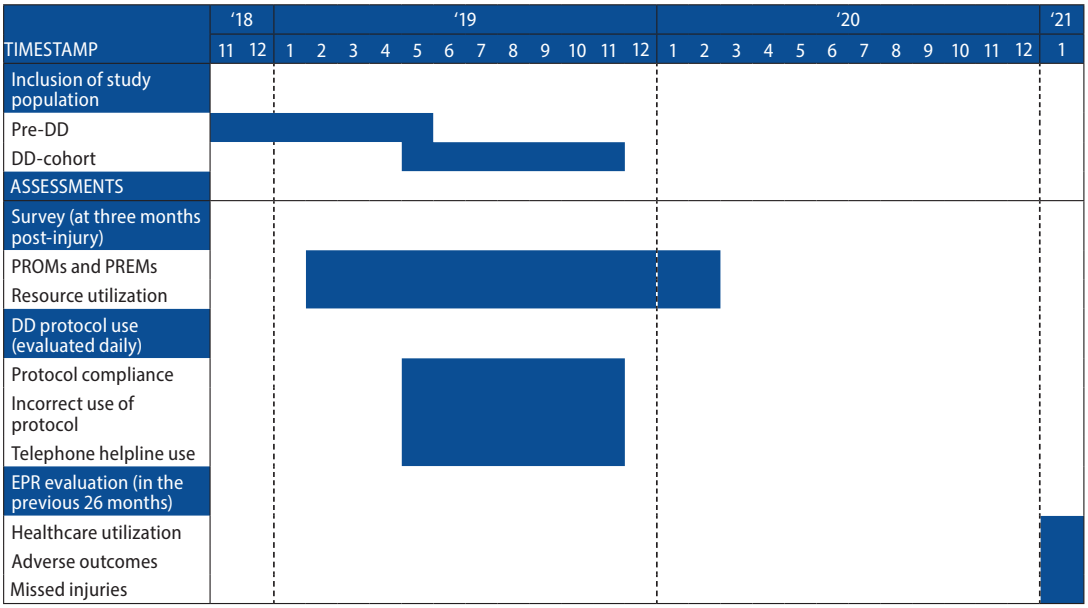

Figure 1 - Timeline depicting patient inclusion and assessments of outcomes.
DD, Direct Discharge; EPR, Electronic Patient Record; PREM, Patient-Reported Experience Measure; PROM, Patient-Reported Outcome Measure.

PROMs and PREMs

All PROMs and PREMs were assessed using a three-month post-injury survey, administered either online through CastorEDC,[27] or by postal mail. In case of non-response, two reminders were sent, followed by one telephone reminder. Satisfaction with treatment was assessed using a visual analogue scale (VAS), ranging from 0 (very dissatisfied) to 100 (very satisfied), and using a 5-point Likert scale. Pain was assessed on a VAS from 0 (no pain) to 100 (extremely painful). The VAS satisfaction and VAS pain scores were converted from a 0–100 scale to a 0–10 scale. The 5-point Likert satisfaction scale was dichotomized into "dissatisfied" ("very dissatisfied", "dissatisfied") and "not-dissatisfied". Functional outcome was assessed using four different validated questionnaires: Shortened version of the Disability of the Arm, Shoulder and Hand (QuickDASH),[28] Lower Extremity Functional Scale (LEFS),[29] Short Form of the Patient-Reported Outcomes Measurement Information System Upper Extremity (PROMIS UE-SF), and Short Form of the PROMIS Mobility.[30] The specific kind of functional outcome questionnaire per patient was based on the region of their injury and their age (**Table 2**). These separate functional status scores were also converted to one 0–100 scale to allow analysis of this outcome for the whole study population. Health-related quality of life (HR-QoL) was assessed using the EuroQol-5D (EQ-5D) questionnaire and the EQ-VAS.[31] Proxy versions of the questionnaires were used for children age 4-7, and children

age 8-17 received either a self-complete version or a proxy version based on their preference. More detailed information about the administered questionnaires, outcome ranges, and non-inferiority margins can be found in **Table 2**. Treatment preference was assessed by explaining the principles of traditional care versus DD in text, and asking which treatment the patient would prefer.

Summary scores were calculated using the guideline of each corresponding questionnaire. Normative Dutch values of the EQ-5D-5L were used to calculate the EQ-5D-5L index scores, and normative values of the EQ-5D-3L were used to calculate the EQ-5D-Youth index scores. * Indicates best outcome score. EQ-5D, EuroQol-5D; LEFS, Lower Extremity Functional Scale; MCID, Minimal Clinically Important Difference; N/A, Not Available; No., number; PROMIS, Patient-Reported Outcomes Measurement Information System; QoL, Quality of Life; QuickDASH, Shortened version of the Disability of the Arm, Shoulder and Hand; Ref., Reference; SD, Standard Deviation; SF, Short Form; T-score; 50 points equal to mean score of ref. population and -10 equal to mean score of -1 SD compared to ref. UE; Upper Extremity; VAS, Visual Analog Scale.

Table 2 – Different questionnaires used to assess satisfaction, functional outcome and quality of life

Outcome	Extremity	Age category	No. of items	Summary score	Non-inferiority margin (MCID)
Satisfaction w/ treatment	Either	All participants	1-item; 0-100 VAS	Rating scale 0 – 10	-0.7 points
Functional outcome					
No questionnaire	Either	0 – 3			
PROMIS UE SF	Upper	4 – 17	8-item; 5P-Likert	T-score	Not available
PROMIS Mobility SF	Lower	4 – 17	8-item; 5P-Likert	T-score	-3.0 points
QuickDASH	Upper	≥18	11-item; 5P- Likert	Total (100 – 0*)	+15.91 points
LEFS	Lower	≥18	20-item; 5P-Likert	Total (0 – 80*)	-9.0 points
Health-related QoL					
No questionnaire	Either	0 – 3			
EQ-5D-Youth	Either	4 – 11, and 12 – 17 (if proxy)	5-items; three-level 1 item; 0-100 VAS	Index (0 – 1*) VAS score (0 – 100*)	
EQ-5D-5L	Either	≥18, and 12-17 (self complete)	5-items; three-level 1 item; 0-100 VAS	Index (0 – 1*) VAS score (0 – 100*)	

*Summary scores were calculated using the guideline of each corresponding questionnaire. Normative Dutch values of the EQ-5D-5L were used to calculate the EQ-5D-5L index scores, and normative values of the EQ-5D-3L were used to calculate the EQ-5D-Youth index scores. * Indicates best outcome score. EQ-5D, EuroQol-5D; LEFS, Lower Extremity Functional Scale; MCID, Minimal Clinically Important Difference; N/A, Not Available; No., number; PROMIS, Patient-Reported Outcomes Measurement Information System; QoL, Quality of Life; QuickDASH, Shortened version of the Disability of the Arm, Shoulder and Hand; Ref., Reference; SD, Standard Deviation; SF, Short Form; T-score; 50 points equal to mean score of ref. population and -10 equal to mean score of -1 SD compared to ref. UE; Upper Extremity; VAS, Visual Analog Scale.*

Resource utilization

The three-month post-injury survey was also used to assess the number of times patients visited their general practitioner (GP) and physiotherapist for the treatment of their injury (during the previous three months); and if applicable: the number of days after which they returned to work (return-to-work), school (return-to-school) and sports (return-to-sports), as well as work and school absenteeism (i.e. the number of missed workdays or schooldays to attend (a) follow-up appointment(s)). All these outcomes were dichotomized into "yes" and "no".

The participants' EPRs were accessed by author THG during the second and third week of January 2021, i.e. the follow-up for these data differed per patient, ranging from 14 months for patients included in November 2019, to 26 months for patients included in November 2018. Data were extracted on patients' healthcare utilization, including: total number of hospital visits (categorized into 'with physician' or 'with plaster technician for cast/brace issues') and imaging (number of X-rays, CT-scans, MRI-scans).

Safety and use of DD protocols

The EPR evaluation was also used to assess if adverse outcomes of treatment of the SSI had occurred, including: delayed-union and non-union, and if this was the case: treatment outcome and whether secondary surgery was performed (yes/no). Furthermore, we assessed whether any missed injuries were identified during follow-up (i.e. in addition to the SSI).

During the first six months after which DD protocols were implemented (i.e. 20 May 2019 – 15 November 2019), a researcher (either THG or SA) was present during the daily review of all X-rays to assess protocol-compliance, which was defined as the proportion of patients with an SSI that were actually discharged directly. Incorrect use of DD protocols was assessed as well, defined as the number of patients that were discharged directly by the ED, but recalled based on the daily X-rays review. Additionally, the total number of telephone helpline contacts was recorded during this period using a simple paper registration sheet.

Using EPRs and the aforementioned survey various baseline characteristics were assessed, including age (years); gender; type of SSI (see **Table 1**); employment status (work/school/none).

Statistical analysis

Statistical analysis was performed using SPSS version 27.0 and STATA v16.[32, 33] Analyses were performed for two groups separately. That is, healthcare utilization, missed injuries and adverse outcomes were assessed for all patients that provided informed consent to access their EPR, survey outcome measures were analysed only for patients that completed the survey. Baseline characteristics were reported using descriptive statistics

for both groups separately, using mean with standard deviation (SD) or median with interquartile range (IQR) as appropriate.

Differences between the pre-DD-cohort and DD-cohort were assessed using regression models, adjusted for the patients' propensity-score to deal with the non-randomized nature of this study. A propensity-score indicates the probability of a patient being assigned to an intervention group, given a set of baseline characteristics.[34] In our study, the propensity-score was estimated using: cohort (pre-DD-cohort/DD-cohort), age, gender, injury type, using the pscore package in STATA. For continuous data, linear regression was performed using the patients' cohort and propensity-score as independent variable and outcome as dependent variable, resulting in a mean adjusted between-group difference, corresponding 95% confidence intervals (CIs), and p-value. In case of non-normally distributed continuous data, Bias Corrected and Accelerated bootstrapping was performed using 5,000 replications to estimate uncertainty. For dichotomous or categorical data, binary logistic regression was performed in a similar manner. For DD to be considered non-inferior to 'traditional' care in terms of satisfaction and functional outcome, the predefined non-inferiority margins (**Table 2**) should not be included in the corresponding 95% CIs. For all other comparisons, a p-value of <0.05 was considered statistically significant.

Patient and public involvement

Patients were not involved in the design, intervention, research question, or outcome measures of the current study.

Ethics

The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethical committee of the OLVG hospital (Ref.no. 18.071), and by its board of directors.

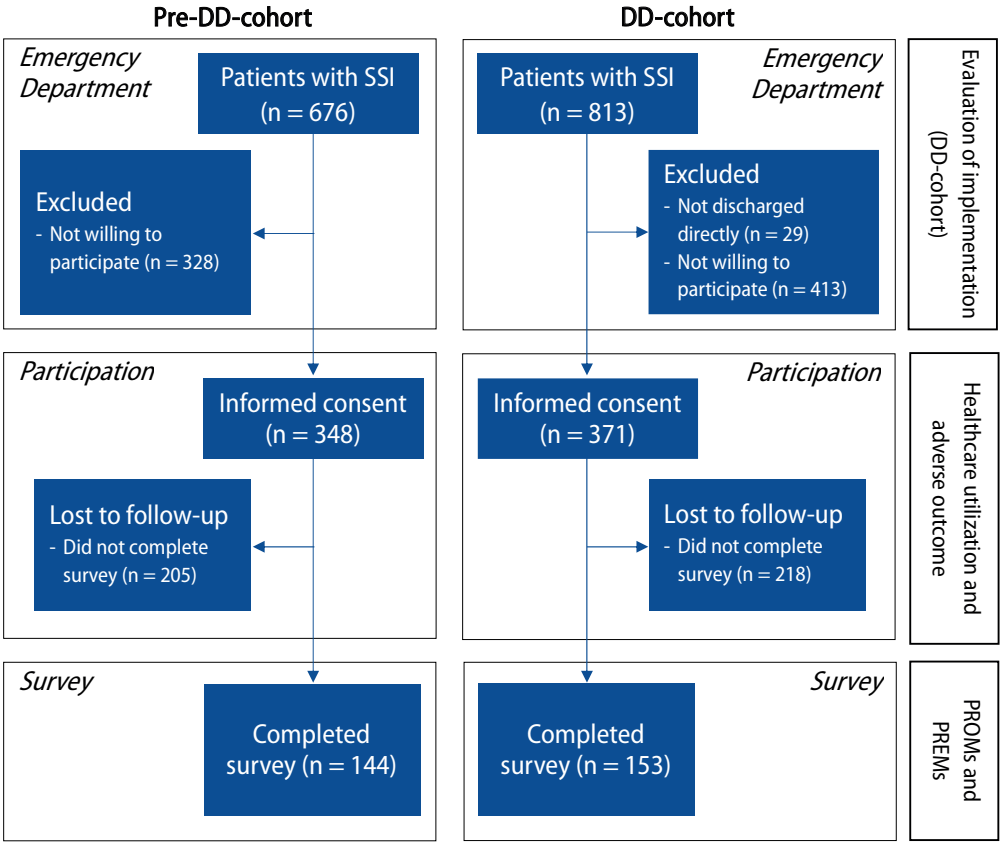

Figure 2 – Flowchart depicting the inclusion of patients.
In the DD-cohort, patients in the Emergency Department with a simple stable injury were used to assess implementation. Patients that provided informed consent were used to assess healthcare utilization, patients that completed the survey were used to assess patient-reported outcomes and experiences. DD, Direct Discharge; PREM, Patient-Reported Experience Measure; PROM, Patient-Reported Outcome Measure; SSI, Simple stable injury.

RESULTS

Before implementation of DD, 676 patients presented to our ED with an SSI and were treated according to local protocols (pre-DD-cohort). After implementation of DD,784 patients were discharged directly from our ED with an SSI (DD-cohort). Of these patients, 348 and 371 patients agreed to participate, in the pre-DD-cohort and DD-cohort, respectively (**Figure 2**). The three-month post-injury survey was completed by 144 and 153 patients in the pre-DD-cohort and DD-cohort, respectively (response-rates 41.4% and 41.2%). **Table 3** provides the patients' baseline characteristics.

Table 3 – Baseline characteristics of participating patients

	Provided informed consent (n = 719)		Completed the survey (n = 297)	
Characteristic	**Pre-DD (n = 348)**	**DD (n = 371)**	**Pre-DD (n = 144)**	**DD (n = 153)**
Age; median (IQR)	24 (10 – 45)	28 (10 – 48)	26 (11 – 55)	36 (13 – 54)
Age <18; n (%)	142 (40.8)	135 (36.4)	59 (41.0)	48 (31.4)
Gender male; n (%)	194 (55.7)	197 (53.1)	76 (52.8)	68 (44.4)
Type of injury; n (%)				
Paediatric clavicle Fx	13 (3.7)	17 (4.6)	8 (5.6)	8 (5.2)
Radial head-/neck Fx	61 (17.5)	56 (15.1)	24 (16.7)	28 (18.3)
Paediatric Fx distal radius				
Greenstick	47 (13.5)	25 (6.7)	15 (10.4)	9 (5.9)
Torus	58 (16.7)	48 (12.9)	21 (14.6)	18 (11.8)
Fifth metacarpal neck Fx	25 (7.2)	11 (3.0)	6 (4.2)	1 (0.7)
Mallet finger	19 (5.5)	8 (2.2)	6 (4.2)	4 (2.6)
Weber A type ankle Fx	20 (5.7)	21 (5.7)	11 (7.6)	14 (9.2)
Avulsion type ankle Fx	10 (2.9)	32 (8.6)	8 (5.6)	12 (7.8)
Fx of fifth metatarsal base	46 (13.2)	51 (13.7)	17 (11.8)	20 (13.1)
Fx of greater toe	19 (5.5)	36 (9.7)	10 (6.9)	11 (7.2)
Fx of lesser toe	16 (4.6)	34 (9.2)	10 (6.9)	18 (11.8)
Bicycle spoke injury	14 (4.0)	32 (8.6)	8 (5.6)	10 (6.5)
Region – age category – functional outcome questionnaire; n (%)				
UE – age 0-3 – none	7 (2.0)	11 (3.0)	3 (2.1)	4 (2.6)
LE – age 0-3 – none	2 (0.6)	4 (1.1)	0 (0.0)	1 (0.7)
UE – paediatric – PROMIS UE	112 (32.2)	81 (21.8)	41 (28.5)	31 (20.3)
LE – paediatric – PROMIS Mob	21 (6.0)	39 (10.5)	15 (10.4)	12 (7.8)
UE – adult – QuickDASH	104 (29.9)	73 (19.7)	36 (25.0)	33 (21.6)
LE – adult – LEFS	102 (29.3)	163 (43.9)	49 (34.0)	72 (47.1)
Employment status; n (%)				
Going to work	-	-	58 (40.3)	73 (47.7)
Going to school	-	-	59 (41.0)	44 (28.8)
No work/school	-	-	27 (18.8)	36 (23.5)

DD, Direct Discharge; Fx, fracture; IQR, interquartile range; LEFS, Lower Extremity Functional Scale; Mob, Mobility; PROMIS, Patient-Reported Outcomes Measurement Information System; QuickDASH, Shortened version of the Disability of the Arm, Shoulder and Hand; UE, Upper Extremity.

PROMs and PREMs

The predefined non-inferiority margins (see **Table 2)** for satisfaction and functional outcome were not included in the 95% CIs surrounding the point estimates of these outcomes, hence, non-inferiority was met. To illustrate, the predefined non-inferiority margin for satisfaction (-0.70) is not included in the 95% CI, which ranges from -0.53 to

0.21. The mean satisfaction with treatment on a VAS was 8.13 (pre-DD-cohort) and 7.95 (DD-cohort, **Figure 3**).

Pre-DD, 5 patients (3.5%) were dissatisfied with treatment on the 5-point Likert scale, versus 11 patients post-DD (7.2%, OR 2.05, p=0.197). There were no statistically significant differences in VAS pain scores (mean score 1.4 versus 1.5, mean difference 0.078, p=0.727) or EQ-5D index- and VAS scores. In the DD-cohort, 81.7% of patients indicated to prefer DD over 'traditional' care, versus 39.6% pre-DD. Mean differences of the functional outcome scores, as well as all other PROMs/PREMs can be found in **Table 4**.

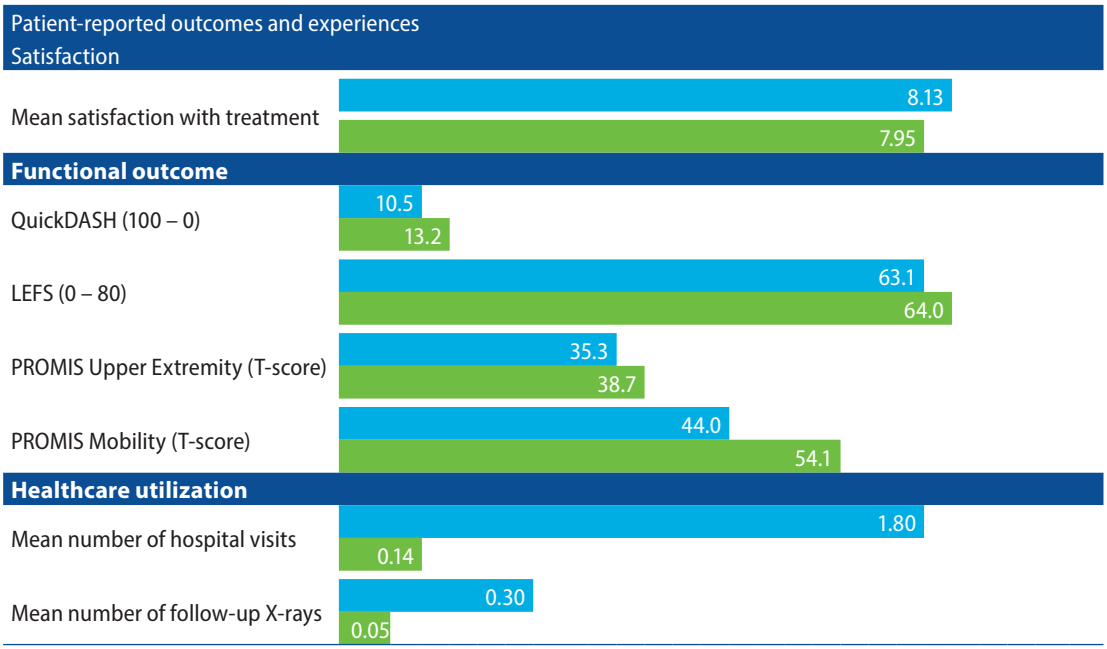

Figure 3 - Depiction of differences in satisfaction with treatment, functional outcome, and healthcare utilization before and after direct discharge
DD, Direct Discharge; LEFS, Lower Extremity Functional Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; QuickDASH, Shortened version of the Disability of the Arm, Shoulder and Hand.

Table 4 – Patient-reported outcomes and experiences at three months

Outcome	Response; n		Descriptive outcome		Effect (regression DD vs. pre-DD)		Non-inferior
	Pre-DD	DD	Pre-DD	DD	Diff.; mean (95% CI)	Sig.	
Continuous data; mean (SD)							
Satisfaction (VAS 0-100)	144	153	8.13 (1.5)	7.95 (1.7)	-0.16 (-0.53 – 0.21)	0.408	Yes
Pain (VAS 0-100)	144	153	1.40 (2.1)	1.52 (1.9)	0.078 (-0.37 – 0.53)	0.727	-
Functional outcome	141	148	77.4 (26.4)	81.0 (21.9)	3.98 (-1.56 – 9.37)	0.166	-
QuickDASH	36	33	10.5 (12.2)	13.2 (14.8)	4.15 (-2.00 – 10.50)	0.231	Yes
LEFS	49	72	63.1 (16.4)	64.0 (15.4)	1.06 (-4.56 – 6.81)	0.716	Yes
PROMIS UE	41	31	35.3 (14.7)	38.7 (13.6)	3.79 (-3.40 – 10.88)	0.270	n/a
PROMIS Mobility	15	12	44.0 (12.5)	54.1 (7.4)	10.79 (2.78 – 19.67)	0.019	Yes
Health-related QoL							
EQ-5D-5L index	85	105	0.839 (0.189)	0.852 (0.139)	0.014 (-0.032 – 0.062)	0.553	-
EQ-5D-5L VAS	85	105	80.2 (16.7)	80.3 (13.1)	0.19 (-4.1 – 4.4)	0.932	-
EQ-5D-Y index	56	43	0.874 (0.242)	0.949 (0.148)	0.076 (0.003 – 0.156)	0.052	-
EQ-5D-Y VAS	56	43	92.3 (9.6)	94.7 (7.5)	2.4 (-1.0 – 5.8)	0.169	-
Dichotomous data; n (%)					**Odds Ratio (95% CI)**		
Dissatisfied w treatment (Likert)	144	153	5 (3.5)	11 (7.2)	2.05 (0.69 – 6.09)	0.197	-
Treatment preference DD	144	153	57 (39.6)	125 (81.7)	6.72 (3.95 – 11.41)	<0.001	-

Propensity-score adjusted linear regression was performed to analyse continuous data with bootstrapping for non-normally distribution, and binary logistic to analyse dichotomous data. Non-inferiority margins: satisfaction -0.7; QuickDASH +15.91; LEFS -9.0; PROMIS Mob -3.0; CI, Confidence Interval; DD, Direct Discharge; Diff., Difference; LEFS, Lower Extremity Functional Scale; PROMIS, Patient-Reported Outcomes Measurement Information System; QoL, Quality of Life; QuickDASH, Shortened version of the Disability of the Arm, Shoulder and Hand; SD, Standard Deviation; Sig. Significance (p-value); UE, Upper Extremity; VAS, Visual Analog Scale; Y, Youth.

Resource utilization

Return-to-sports, return-to-work and return-to-school were comparable before and after DD, as well as the proportion of patients that visited their GP or physiotherapist for the treatment of their injury (**Table 5**). Of the patients going to school, 57.6% missed one or more schooldays to attend a follow-up appointment in the pre-DD-cohort, versus 11.4% in the DD-cohort (OR 0.084; 95%CI 0.023-0.253; p<0.001). Of the patients going to work, 44.8% missed one or more workdays to attend a follow-up appointment in the pre-DD-cohort, versus 8.2% in the DD-cohort (OR 0.110; 95% CI 0.041-0.295; p<0.001).

The mean number of hospital visits was 1.80 in the pre-DD-cohort versus 0.14 in the DD-cohort (mean difference -1.68, p<0.001). This included a mean reduction of 0.13 in plaster-technician visits, e.g. due to issues with a cast/brace/sling (p<0.001). The mean number of X-rays during follow-up was 0.30 in the pre-DD-cohort, versus 0.05 in the DD-cohort (mean difference -0.26, p<0.001). A CT-scan was performed once in the DD-cohort

to assess if there were any missed injuries in a patient with a fifth metatarsal fracture. No MRI-scans were performed. There were 9 no-shows in the pre-DD-cohort (2.6%) versus 0 in the DD-cohort.

Table 5 – Resource utilization

	Patients; n		Descriptive outcome		Effect (regression DD vs. pre-DD)	
Outcome	**Pre-DD**	**DD**	**Pre-DD**	**DD**	**Diff.; mean (95% CI)**	**Sig.**
At three months (survey)						
Return-to-sports (days); mean (SD)	90	80	29.2 (24.7)	26.6 (25.3)	-3.49 (-10.61 – 3.97)	0.372
Return-to-work (days); mean (SD)	58	73	13.3 (21.0)	9.1 (14.8)	-0.165 (-4.91 – 1.44)	0.313
Return-to-school (days); mean (SD)	59	44	2.3 (3.4)	1.9 (2.1)	-0.43 (-0.17 – 0.59)	0.456
					Odds Ratio (95% CI)	
Visited general practitioner; n (%)	144	153	34 (23.6)	40 (26.1)	1.08 (0.63 – 1.85)	0.784
Visited physiotherapist; n (%)	144	153	38 (26.4)	32 (20.9)	0.70 (0.41 – 1.21)	0.197
Missed school for follow-up; n (%)	59	44	34 (57.6)	5 (11.4)	0.084 (0.028 – 0.253)	<0.001
Missed work for follow-up; n (%)	58	73	26 (44.8)	6 (8.2)	0.110 (0.041 – 0.296)	<0.001
EPR evaluation (range 14 – 26 months)					**Diff.; mean (95% CI)**	
Number of hospital visits; mean (SD)	348	371	1.80 (1.13)	0.14 (0.47)	-1.68 (-1.81 – -1.55)	<0.001
With physician			1.62 (0.94)	0.11 (0.44)	-1.53 (-1.65 – -1.42)	<0.001
With plaster technician			0.18 (0.51)	0.05 (0.26)	-0.13 (-0.19 – -0.07)	<0.001
Imaging during follow-up; mean (SD)	348	371				
X-ray			0.30 (0.65)	0.05 (0.32)	-0.26 (-0.33 – 0.18)	<0.001
CT-scan			0.0	0.01 (0.07)	NP	-
MRI-scan			0.0	0.0	NP	-
No-shows; n (%)	348	371	9 (2.6)	0.0	NP	-

Propensity-score adjusted linear regression performed to analyse continuous data with bootstrapping for non-normally distribution, and binary logistic to analyse dichotomous data. CI, Confidence Interval; DD, Direct Discharge; Diff., Difference; NP, Not performed as number of observations were too small to perform bootstrapping (if applicable) and subsequent regression; SD, Standard Deviation; Sig. Significance (p-value).

Safety and use of DD protocols

Delayed/non-unions and secondary surgeries of SSIs did not occur based on the EPR evaluation of all 719 participants. However, a 'missed injury' (in addition to the SSI) was diagnosed during follow-up in three cases, one in the pre-DD-cohort and two in the DD-cohort. In the pre-DD-cohort, a patient with an avulsion-type fracture of the medial malleolus and navicular bone had further imaging eight weeks after the ED visit (during regular follow-up). This revealed a proximal fracture of the fibula, which was treated surgically. In the DD-cohort, one patient contacted the telephone helpline one week after a Weber A fracture due to persisting high-levels of pain, and was scheduled for

review the next morning. Despite our daily X-ray review, radiographic imaging revealed a Weber B-type ankle fracture supination-external rotation stage 4. This was treated surgically. The other patient in the DD-cohort was treated with an ankle brace after a Weber A fracture and contacted the telephone helpline twice, complaining of pain after starting weight-bearing. Further imaging revealed an additional fifth metatarsal base fracture that was treated conservatively by switching immobilization from an ankle brace to a walker boot.

During the six months after implementation of DD, there were 813 patients in our ED with an SSI, 784 of which were discharged directly (protocol compliance 94.6%). During the same period, the telephone helpline was contacted 84 times. Furthermore, an additional 15 patients were initially discharged directly by the ED, but were recalled based on the daily screening of all X-rays by an (orthopaedic) trauma surgeon and radiologist. This included 12 children treated as per adult DD protocols, one patient with a dislocated zone 2 fifth metatarsal fracture that exceeded our limit of 4 millimetres, and two patients with a zone 3 fifth metatarsal fracture.

DISCUSSION

This first study on DD from the ED of patients with SSIs performed outside the UK shows that, in terms of satisfaction with treatment and functional outcome, DD is non-inferior to 'traditional' care with routine follow-up. Other patient outcomes, including pain and HR-QoL return-to-sports, return-to-work, and return-to-school all were comparable before and after DD. Furthermore, there were no adverse outcomes before and after implementation of DD. Hence, our findings support the idea that the SSIs included in this study can be discharged from the ED safely, i.e. without compromising patient outcome and experience.

In previous studies on DD assessing satisfaction, it was often unclear whether this was related to the injury treatment or the DD/VFC process.[35] In our study, patients were asked specifically to rate satisfaction with our treatment of their injury. We were of the opinion that this is a key parameter: i.e. patients should retain comparable satisfaction-levels with our services, in addition to a comparable functional outcome, and regardless of the reduction of healthcare utilization.

The methods used to assess satisfaction in previous studies ranged from using either Likert scales,[5, 11, 14, 22] simple yes/no questions,[8] or 1–10 VAS.[10, 15] All have advantages and disadvantages. For instance, the chances of acquiescence bias and ceiling effects are smaller using VAS,[36, 37] while children might prefer Likert scales.[38] In the current study parents/caregivers were allowed to (help their child to) complete the survey. For these reasons, we used VAS as well as Likert scales to assess (dis)satisfaction. Both before and

after DD, satisfaction with treatment was high, as is shown by the high mean satisfaction rate (VAS), as well as the low rate of dissatisfied patients (Likert). Moreover, a large proportion of the patients that were discharged directly indicated they prefer DD over traditional care (81.7%), which is more or less comparable with Mackenzie et al. studying DD of three SSIs (75%).[8]

Although the aim of this study was to assess non-inferiority, it is noteworthy that the mean PROMIS Mobility Tscore was 10 points higher in the DD-cohort (indicating better outcome), while the MCID for this questionnaire is 2-3 points.[26] It must be noted that the sample-size for this questionnaire was small. Future studies are therefore needed to reassess this. As this was a remarkable finding we also performed a post-hoc analysis assessing treatment satisfaction of this particular subgroup, and found that all patients rated their treatment ≥8.0 (VAS), and none indicated to be dissatisfied (Likert). The three other functional outcome scores were non-inferior after DD, and the mean summary scores of each individual questionnaire indicate that the majority of patients with these SSIs have a good functional outcome three months post-injury.

Furthermore, our study indicates that adverse outcome rates are low, as was also shown in previous studies,[8, 9, 12, 13, 20]. However, it also emphasizes the importance of safety netting to include an available telephone helpline for questions and concerns, as well as the reassessment of X-rays of all DD patients by an (orthopaedic) trauma surgeon before definitive treatment. One DD patient had surgery following a misdiagnosis (Weber B-type ankle fracture) one week post-injury. In the Netherlands this is within the normal window for this procedure to be performed.

The reduced work/school absenteeism to attend a follow-up appointment indicates DD is also likely to be beneficial from a societal perspective. Furthermore, in our hospital, DD has drastically reduced healthcare utilization, and it is worth emphasizing that this study found no shift towards primary care (i.e. GP or physiotherapist). In the Netherlands, approximately 256,000 fractures are diagnosed annually in EDs,[1] 85,000 of which are estimated to be SSIs (33%).[4] Our mean reduction of 1.68 hospital visits per patient after DD is in line with previous comparative studies on DD of, for example, fifth metacarpal neck fractures (-1.78),[10] fifth metatarsal fractures (-1.46),[12] and the study by Mackenzie et al. (-1.26).[8] Based on our results, if DD would become standard-of-care for these SSIs in the Netherlands, the national reduction of hospital visits is estimated at 142,800 visits per year. Therefore, DD provides an excellent opportunity to reduce the fracture clinic workload and healthcare costs.

Unfortunately, in many previous studies on DD, the classification of an SSI was limited to “minor”, “stable” or “self-limiting”, or even unclassified.[35] This complicates comparison with our results, as well as implementation and external validation of DD in other settings. Roughly speaking, however, studies on DD can be divided into two

groups: 1) studies at the institutional-level, and 2) patient-level follow-up studies. The majority of the studies at an institutional-level are non-comparative process evaluations of implementing (parts of) the VFC model.[2-6] These studies typically include relatively large numbers of patients, and provide information on the distribution of patients across the VFC model. Data regarding patients' outcomes and experiences typically is limited, and therefore, conclusions regarding the safety, effectiveness and efficacy of DD for each individual injury cannot be drawn.

An important strength of this study is that a wide range of outcomes were evaluated in a before-and-after design, including: hospital visits, imaging, satisfaction, functional outcome using validated questionnaires, and adverse outcomes. Consequently, our study provides both institutional-level information (e.g. number of patients, protocol-compliance and telephone helpline use), as well as patient-level data of DD regarding the patients' healthcare utilization, PROMs and PREMs. Apart from the study by Mackenzie et al. on DD of radial head-, fifth metacarpal and fifth metatarsal fractures,[8] patient-level follow-up studies typically include only some of these outcomes. Furthermore, many of these studies did not directly compare DD with traditional care,[9, 11, 13, 20-22] and often patient outcome was not measured using validated questionnaires. Furthermore, while randomization at an individual patient-level for treatment redesigns like DD might not always be feasible, to our knowledge no previous studies on DD have attempted to reduce the chances of "selection bias" due to the non-randomized nature of their studies using methods such as the propensity-score adjustment that was used in the current study. To our knowledge, this is also the first study on DD to specifically assess non-inferiority of DD versus traditional care, using predefined margins.

This study has several limitations. First, we studied the concept of DD, including multiple SSIs, and consequently, subgroups of the included injuries were too small to analyse outcomes per injury. Second, numbers of patients far exceeding our numbers would have been needed to adequately assess differences in adverse outcomes like non-union. Third, as this was a before-and-after study, we did not include a-priori non-inferiority sample size calculations of a predefined primary outcome. Fourth, PROMs and PREMs were assessed only once: at three months. Fifth, while part of DD, the patients discharged directly were not contacted routinely after a few weeks or months to assess their outcome and experience. This is a limitation especially for patients that did not complete the survey. We have evaluated all participants' EPRs and found no adverse outcomes. This assumes patients experiencing any problems during their recovery would have returned to our hospital. However, we cannot be certain patients did not visit a different hospital for any issues. Furthermore, however in keeping with what might be expected, the survey response rate in this study was fairly low, despite sending multiple reminders. Last, we asked patients after how many days they returned to work,

school or sports. While based on our results we expect no between-group differences, we did not assess if patients had not yet returned to work/school or sports, at all.

Future studies on this topic should also assess the cost-effectiveness of DD versus traditional care. While some relatively large injury-specific cohorts have been studied before, it is likely necessary to perform adequately powered studies for some of the other SSIs included in the current study, before non-inferiority of DD can be assessed conclusively. Our smartphone app is now increasingly used by other hospitals in the Netherlands, and this might offer an opportunity to gather data in a collective and standardized way, allowing us to perform studies in much larger cohorts. Furthermore, these data can then be used to perform stratified analyses of outcomes per injury, allowing more fine-tuning of the DD protocols, e.g., if these results would indicate certain patient characteristics (e.g. higher age, cognitive impairment, language barrier) predict worse outcome. In the current study, 18% of DD patients indicated they would prefer traditional care. Future studies should further explore these patients' motives. Last, future studies should evaluate if DD is suitable for other injuries, including paediatric injuries.

In conclusion, the results of this study on DD of SSIs confirm DD is an effective and safe alternative to traditional care with routine follow-up, that does not compromise patient outcome and experience. This first study on this topic performed outside the UK indicates that direct discharge is likely to produce satisfactory results in other countries as well. A large number of SSIs are diagnosed each year and consequently DD offers an opportunity to reduce healthcare costs and fracture clinic workload. The results of our study should be confirmed and strengthened by future larger injury-specific cohort studies. A collective (national) data registry could be established to accelerate this process, which should also encourage uniform data collection across multiple hospitals using validated and standardized outcome measures to improve comparability and strengthen findings.

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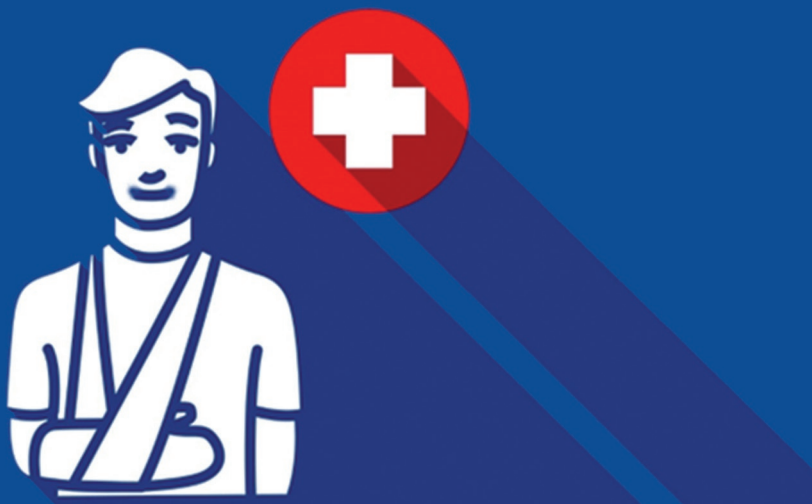

5

COST-EFFECTIVENESS OF DIRECT DISCHARGE FROM THE EMERGENCY DEPARTMENT OF PATIENTS WITH SIMPLE STABLE INJURIES IN THE NETHERLANDS

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ABSTRACT

Background

Approximately one third of musculoskeletal injuries are simple, stable injuries (SSIs). Direct discharge (DD) from the Emergency Department (ED) of patients with SSIs reduces healthcare utilization, without compromising patient outcome and experience, when compared to ´traditional´ care with routine follow-up. This study aimed to determine cost-effectiveness of DD compared to traditional care from a societal perspective.

Methods

Societal costs, including healthcare-, work-absenteeism- and travel costs were calculated for patients with an SSI, six months before (pre-DD-cohort) and after implementation of DD (DD-cohort). The pre-DD-cohort was treated according to local protocols. The DD-cohort was treated using orthoses, discharge leaflet, smartphone app and telephone helpline, without scheduling routine follow-up. Effect measures included: generic health-related quality-of-life (HR-QoL, EQ-5D); disease-specific HR-QoL (functional outcome, different validated questionnaires, converted to 0-100 scale); treatment satisfaction (visual analogue scale (VAS), 1-10); pain (VAS, 1-10). All data were assessed using a three-month post-injury survey and electronic patient records. Incremental cost-effectiveness ratios were calculated, and uncertainty was assessed using bootstrapping techniques.

Results

Before DD, 144/348 participants completed the survey, versus 153/371 patients thereafter. There were no statistically significant differences between the pre-DD-cohort and DD-cohort for generic HR-QoL (0.03; 95%CI [-0.01]–[0.08]), disease-specific HR-QoL (4.4; 95%CI [-1.1]–[9.9]), pain (0.08; 95%CI [-0.37]–[0.52]), and treatment satisfaction (-0.16; 95%CI [-0.53]–[0.21]). Total societal costs were lowest in the DD-cohort (-€822; 95%CI -€1719 to -€67), including healthcare costs (-€168; 95%CI [-€205]–[-€131]) and absenteeism costs (-€645; 95% CI [-€1535]–[€100]). The probability of DD being cost-effective was 0.98 at a willingness-to-pay of €0 for all effect measures, remaining high with increasing willingness-to-pays for generic HR-QoL, disease-specific HR-QoL, pain, and decreasing with increasing willingness-to-pays for treatment satisfaction.

Conclusions

Direct discharge from the ED of patients with SSIs seems cost-effective from a societal perspective. Future studies should test generalizability in other healthcare systems and strengthen findings in larger injury-specific cohorts.

INTRODUCTION

In the Netherlands, 659,000 of two million annual Emergency Department (ED) visits concern musculoskeletal injuries, such as fractures (43%), soft tissue injuries (15%), distortions (5%), dislocations (4%) and tendon injuries (3%).[1] Their economic impact is substantial. That is, in the Netherlands, total annual direct healthcare costs and lost productivity costs following injuries are estimated at EUR 2.4 billion and EUR 1.4 billion, respectively.[1] Epidemiological studies show that the incidence of injuries is increasing.[2] To illustrate, e.g. for extremity fractures in the Netherlands, in 2004 the total number was 129,188, versus 170,673 in 2010, and 260,800 in 2019.[1, 2] A change in healthcare capacity and resources is warranted in anticipation of a further increasing demand, and in order to maintain high-quality trauma care.[2]

Traditionally, the majority of patients with musculoskeletal injuries are reviewed in a fracture clinic within one week after initial ED assessment, and at regular fixed periods in the weeks thereafter. Consequently, these clinics are characterized by the routine attendance of large numbers of unselected patients, who often have relatively minor injuries with excellent prognosis and that do not require intervention.[3, 4]

Recent studies indicate that a large proportion of musculoskeletal injuries are simple, stable injuries (SSIs) that require reassurance and information, but not routine review.[3, 4] There is growing evidence that suggests that direct discharge (DD) from the ED of patients with these SSIs is a safe and effective alternative to "traditional" care with routine follow-up, that reduces healthcare utilization (i.e. hospital visits and imaging), without compromising patient outcome (e.g. functional outcome) and experience (e.g. satisfaction with treatment).[5-24]

While a relatively small number of previous studies included cost-estimations before and after DD,[7-11] to our knowledge currently no studies have been performed regarding the cost-effectiveness. Therefore, the aim of this study was to determine whether DD from the ED of patients with SSIs is cost-effective from a societal perspective, compared to 'traditional' care with routine follow-up.

METHODS

Design

This cost-effectiveness analysis (CEA) was based on data from a prospective non-inferiority trial for eleven SSIs, performed in the OLVG hospital, a level-2 trauma centre and teaching hospital in Amsterdam, the Netherlands.[25]

Participants

All consecutive ED patients with an isolated SSI were asked to participate during a one-year period (15 November 2018 – 15 November 2019).[25] DD was implemented at the midpoint (20 May 2019), dividing participants into a pre-DD-cohort and DD-cohort. Exclusion criteria were: inability to understand/complete Dutch survey; initial treatment in ED of different hospital; other reason for follow-up (e.g. social care reasons); Eye/Motor/Verbal-score <15 at presentation, high-energy trauma; treatment continued elsewhere (e.g. closer to home); alcohol/drug intoxication.[25]

All patients who were willing to participate provided written informed consent in the ED, and received a three-month post-injury survey containing questions regarding employment status, education level, health-related quality of life (HR-QoL), functional outcome, satisfaction, pain, primary healthcare use and work absenteeism. Furthermore, the electronic patient record (EPR) of all participants was evaluated after one year to assess secondary healthcare use, including hospital visits, imaging (e.g. X-ray, CT-scan, MRI-scan), and adverse outcomes.

Treatment

Traditional care

Before DD, all SSI patients were treated using local protocols. This usually involved application of a cast/splint/bandage and review in the fracture clinic one week post-injury. Frequently, one or multiple subsequent visits followed in the weeks thereafter for the assessment of functional outcome and/or removal of cast material.

Direct discharge

The implementation of DD standardized the immobilization of SSIs to bandage or removable orthoses (**Table 1**). Follow-up appointments are no longer scheduled routinely. Instead, ED physicians provide information about the SSI and expected recovery, which is also summarized in discharge leaflets. These leaflets are available on paper as well as digitally by means of a smartphone application for iOS and Android, that also contains videos of physical exercises to improve recovery, and videos explaining how to reapply immobilization after removal (e.g. after taking a shower). Patients are instructed to contact our telephone helpline in case of questions or concerns. The X-rays of all ED patients, including patients with SSIs, are reviewed daily by an orthopaedic trauma surgeon and radiologist. If based on this review, an injury is not deemed suitable for DD (e.g. the injury is not an SSI), a face-to-face appointment is scheduled.

Table 1 – Simple and stable injuries, criteria and immobilization

Injury	Paediatric/ adult	Criteria	Immobilization after DD
Paediatric clavicle Fx	Paediatric	• Age ≤14 • No indication for surgical treatment	Sling
Radial head-/neck Fx	Adult	• Head: Mason type 1, neck: undisplaced, or • Positive fatpad sign	Pressure bandage, sling
Greenstick or torus/ buckle type Fx of the distal radius	Paediatric	• Acceptable angulation based residual growth • Torus/buckle type: isolated ulna Fx, isolated radius Fx or both • Greenstick type: isolated ulna Fx or isolated radius Fx	Removable wrist brace
Fifth metacarpal neck Fx	Adult	• Volar angulation <70 degrees • No rotational deviation	Buddy strap and pressure bandage
Mallet finger	Adult	• Either bony or tendinous • Treated conservatively	Mallet splint
Weber A type ankle Fx	Adult	• Dislocation <2mm • No signs of stage 2 supination-adduction type injury	Tubigrip and ankle brace
Avulsion type ankle Fx	Adult	• Either lateral or medial malleolus or tarsal bones	Tubigrip and ankle brace
Fx of fifth metatarsal base	Adult	• Fx located in either zone 1 or zone 2 • Dislocation ≤4 mm	Walker boot
Fx of greater toe	Both	• Either proximal or distal phalanx Fx • Undisplaced	Spica pressure bandage and bandage shoe
Fx of lesser toe	Both	• Any isolated Fx • No indication for surgical treatment	Buddy strap
Bicycle spoke injury	Paediatric	• No Fx based on radiograph • Superficial wound	Pressure bandage

DD, Direct Discharge; Fx, fracture; mm, millimetre.

Effect measures

Cost-effectiveness was assessed for four outcomes: 1) generic HR-QoL, 2) disease-specific HR-QoL, 3) satisfaction with treatment, and 4) pain. Questionnaires used to assess generic and disease-specific HR-Qo were only available for patients ≥4 years old. Therefore, these outcomes were not assessed for participants <4 years old.

Generic HQ-QoL was assessed using the EuroQol five-dimensional questionnaire (EQ-5D). The five-level version (EQ-5D-5L) was completed by all participants ≥18 years old and also by children ≥12 years old if self-completing the questionnaire.[26] The youth version (EQ-5D-Y) was used for all other children 4-17 years old.[27] Proxy versions were used if a parent/caregiver completed the survey. The participants' EQ-5D-5L or EQ-5D-Y health states were converted to utility values using the Dutch EQ-5D-5L and EQ-5D-3L value sets, respectively.[28, 29] Utility values indicate the preference or desirability of a certain health state on a scale anchored at 0 (equal to death) to 1 (equal to optimal health).

Disease-specific HR-QoL was assessed in participants ≥4 years old, using four different validated functional outcome questionnaires based on age and type of injury (**Appendix A**): 1) Shortened version of the Disability of the Arm, Shoulder and Hand (QuickDASH),[30] 2) Lower Extremity Functional Scale (LEFS),[31] 3) Short Form of the Patient-Reported Outcomes Measurement Information System Upper Extremity (PROMIS UE-SF), and 4) Short Form of the PROMIS Mobility.[32, 33]. To compare disease-specific HR-QoL for all participants, the individual functional outcome scores were converted to a single scale ranging from 0 (worst functional outcome) to 100 (best functional outcome).[34]

Satisfaction with treatment was assessed using a visual analogue scale (VAS), ranging from 0 (very dissatisfied) to 100 mm (very satisfied).[25] Pain was assessed on a VAS from 0 (no pain) to 100 mm (extremely painful). Both scores were converted from a 0–100 scale to a 0–10 scale.

Cost measures

Costs were assessed from a societal perspective, including: healthcare costs, work absenteeism costs, and travel costs.

Healthcare costs included primary healthcare costs (e.g. visits to the general practitioner (GP) or physiotherapist for the follow-up of the SSI), and secondary healthcare costs (e.g. ED visits, immobilization materials used, follow-up appointments, no-shows, and imaging).[35] Healthcare costs were valued using Dutch standard costs, and if unavailable, prices from professional organizations and hospital accounting records (**Appendix B**).

Work absenteeism costs were based on patient absenteeism and parent absenteeism. Patient absenteeism were estimated using the number of days patients had to take leave from work after sustaining their injury, as well as the number of hours patients had to take leave from work to attend their fracture clinic appointment(s). Parent absenteeism costs were estimated using the number of hours parents had to take time off from work to accompany their child during a hospital visit. For patient absenteeism, costs were calculated using the Friction Cost Approach (FCA) and gender-specific price weights. The FCA assumes that costs are limited to the friction period, i.e. the period needed to replace a sick worker, which is 12 weeks in the Netherlands. If applicable, absenteeism costs were therefore truncated at 12 weeks. In case of parent absenteeism, the accompanying parent's gender was unknown, and consequently, gender-specific price weights could not be used. Therefore, these costs were calculated using the average productivity costs rate of all Dutch adults.[35]

Travel costs per hospital visit were assessed using previously collected hospital survey data on the type of transport and the average distance from a patient's home to the nearest hospital in the Netherlands, and valued using Dutch standard prices (**Appendix B**).[35]

All costs were converted to Euros 2019 using Dutch consumer price indices.

Discounting of costs was not necessary, because follow-up was not more than 12 months.[35-39]

The following baseline characteristics were assessed: age, gender, education level (low/middle/high),[40] school/work status and type of injury.

Statistical analysis

Statistical analysis was performed using SPSS version 27.0 (IBM Corp, NY, USA) and STATA v16 (StataCorp, TX, USA).[41, 42] As children <4 years old did not receive EQ-5D and functional outcome questionnaires, analyses were performed for two groups separately. That is, the CEAs for satisfaction with treatment and pain were based on data of all participants, while the CEAs for generic HR-QoL and disease-specific HR-QoL were based on data of participants ≥4 years old only.

Aggregate and disaggregate cost differences were estimated using linear regression analyses adjusted for the patients' propensity-score and work status (yes/no). A propensity-score indicates the probability of a patient being assigned to an intervention group, given a set of baseline characteristics.[43] In our study, the propensity-score was estimated using: cohort (pre-DD-cohort/DD-cohort), age, gender and injury type, using the pscore package in STATA.

Seemingly unrelated regression (SUR) analyses were performed to estimate the differences in costs (ΔC) and effects (ΔE). Cost-differences were adjusted for the propensity-score and work status, whereas effect-differences were adjusted for the propensity-score. Incremental cost-effectiveness ratios (ICERs) were calculated by dividing the differences in total societal costs by the differences in effects (i.e., ΔC/ΔE). 95% confidence intervals (CIs) around all cost differences were estimated using bias-corrected and accelerated (BCA) bootstrapping, with 5,000 replications. BCA bootstrapping was also used to graphically illustrate the uncertainty surrounding the ICER by plotting bootstrapped incremental cost-effect pairs (CE-pairs) on cost-effectiveness planes (CE-planes).[44, 45]

A summary measure of the joint uncertainty of costs and effects was presented using cost-effectiveness acceptability curves (CEACs), providing an indication of the probability of DD being cost-effective in comparison with traditional care at different values of willingness-to-pay (WTP). WTP is defined as the maximum amount of money decision makers are willing to pay per one extra unit of effect.[46] For the differences in costs and effects, a p-value of <0.05 was considered statistically significant.

Sensitivity analyses

Three sensitivity analyses were performed to test the robustness of the results of our main analyses: 1) applying the healthcare perspective (SA1), 2) absenteeism costs valued using both age- and gender-specific price weights (SA2), and 3) using an alternative

propensity-score, which was estimated using cohort, age, gender, injury type and education level (SA3). Both SA2 and SA3 were adjusted for the same covariates as the main analysis, i.e. propensity-score and work status, while SA1 was adjusted for the propensity-score only.

Patient and public involvement

Patients were not involved in the design, intervention, research question, or outcome measures of the current study.

Ethics

The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethical committee of the OLVG hospital (Ref.no. 18.071), and by its board of directors.

RESULTS

Before DD, 348 of 676 ED patients with SSIs were willing to participate (pre-DD-cohort), versus 371 of 784 patients thereafter (DD-cohort). Of them, 144 and 153 participants completed the three-month post-injury survey in the pre-DD-cohort and the DD-cohort, respectively (**Figure 1**, **Table 2**). The median age in the pre-DD-cohort was 26, versus 36 in the DD-cohort. There were more employed participants in the DD-cohort (47.7%) compared to the pre-DD-cohort (40.3%). There was no missing data.

Effect measures

There were no statistically significant effect differences between the pre-DD-cohort and the DD-cohort for generic HR-QoL, disease-specific HR-QoL, satisfaction with treatment, and pain (**Table 3**).

Cost measures

On average, total societal costs were €2,181 in the pre-DD-cohort, versus €1,672 in the DD-cohort. After adjusting for the propensity-score and work status, costs were €822 lower in the DD-cohort compared with the pre-DD-cohort (95% CI: -€1,719 to €67; **Table 4**). As for the disaggregate cost differences, there were statistically significant reductions in total healthcare costs (-€168), secondary healthcare costs (-€152), parent absenteeism (-€47) and travel costs (-€7) in the DD-cohort compared to the pre-DD-cohort, while there were non-significant reductions in primary healthcare costs (-€16), total absenteeism costs (-€645) and patient absenteeism costs (-€598).

Table 2 - Baseline characteristics

Characteristics	Pre-DD-cohort (n = 144)	DD-cohort (n = 153)	Significance
Age; median (i.q.r.)	26 (11 – 55)	36 (13 – 54)	0.370ǂ
Gender; n (%)			
Male	76 (52.8)	68 (44.4)	0.151*
Type of injury; n (%)			0.557*
Paediatric clavicle Fx	8 (5.6)	8 (5.2)	
Radial head-/neck Fx	24 (16.7)	28 (18.3)	
Paediatric Fx distal radius			
Greenstick type	15 (10.4)	9 (5.9)	
Torus type	21 (14.6)	18 (11.8)	
Fifth metacarpal neck Fx	6 (4.2)	1 (0.7)	
Mallet finger	6 (4.2)	4 (2.6)	
Weber A type ankle Fx	11 (7.6)	14 (9.2)	
Avulsion type ankle Fx	8 (5.6)	12 (7.8)	
Fx of fifth metatarsal base	17 (11.8)	20 (13.1)	
Fx of greater toe	10 (6.9)	11 (7.2)	
Fx of lesser toe	10 (6.9)	18 (11.8)	
Bicycle spoke injury	8 (5.6)	10 (6.5)	
Education level; n (%)[a]			0.568*
Low	70 (48.6)	60 (39.2)	
Middle	23 (16.0)	30 (19.6)	
High	51 (35.4)	63 (41.2)	
Work/school status; n (%)			0.061*
Going to work	58 (40.3)	73 (47.7)	
Going to school	59 (41.0)	44 (28.8)	
No work/school	27 (18.8)	36 (23.5)	

DD, Direct Discharge; Fx, Fracture; i.q.r., interquartile range;
[a] According to the education levels by the Dutch Central Agency for Statistics (CBS)[40] ǂ Mann-Whitney-U test
** Chi-square test*

Cost-effectiveness

The main analyses for generic HR-QoL indicated that total societal costs were lower in the DD-cohort compared to the pre-DD-cohort (mean -€845; 95% CI -€1,781 to -€88). The ICER was -26,022, indicating that on average, a 1-point improvement in utility in the DD-cohort was associated with a societal cost saving of €26,022 compared to the pre-DD-cohort. The majority of cost-effect pairs (CE-pairs) were located in the south-east quadrant (87%), indicating that, on average, DD was less costly while being more effective than traditional care (**Table 3**; **Figure 2-1a**).[47] The CEAC in **Figure 2-1b** indicates

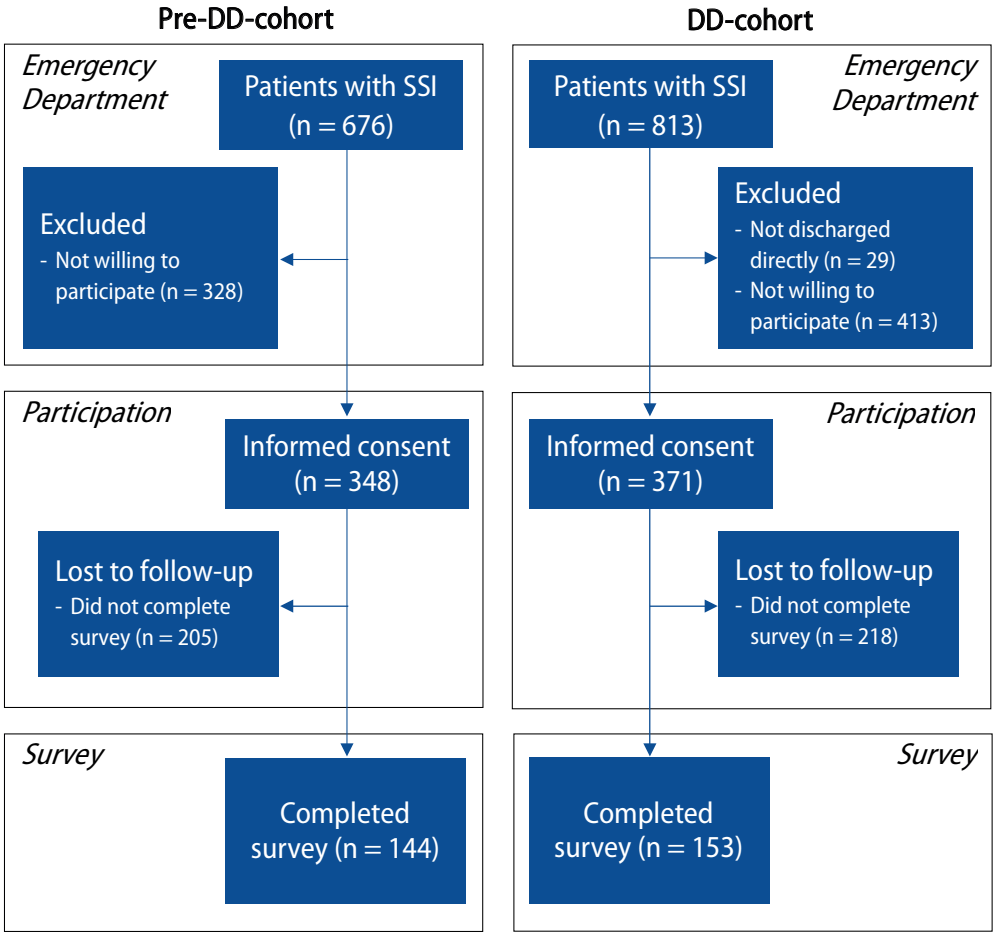


Figure 1 – Flowchart depicting the inclusion of patients.
In the DD-cohort, patients in the Emergency Department with a simple stable injury were used to assess implementation. Patients that provided informed consent were used to assess healthcare utilization, patients that completed the survey were used to assess patient-reported outcomes and experiences.

that the probability of DD being cost-effective compared to traditional care is 0.98 at a WTP of 0€/1-point improvement, increasing to a maximum of 0.99 for higher values of WTP.

For disease-specific HR-QoL, the ICER was -193, and 88% of CE-pairs were located in the south-east quadrant, indicating that DD dominated traditional care (i.e. less costly and more effective than traditional care (**Table 3**; **Figure 2-2a**). The probability of DD being cost-effective was 0.98 at a WTP of 0€/1-point improvement on the 1-100 functional outcome scale, slightly decreasing to 0.95 at a WTP of €3,000 per point improvement (**Figure 2-2b**).

The ICER for satisfaction with treatment was 5,213, suggesting that, on average, a 1-point decrease on the 1-10 VAS was associated with a societal cost saving of €5,213 (**Table 3**). The majority of CE-pairs (74%) were located in the south-west quadrant, indicating that on average, DD was less costly and less effective than traditional care (**Figure 2-3a**). The CEAC indicates that the probability of DD being cost-effective compared to traditional care was 0.98 at a WTP of 0€/1-point improvement, decreasing with increasing values of WTP (0.92 at €1,000, 0.69 at €3,000 and a minimum of 0.23 at €30,000; **Figure 2-3b**).

The ICER for pain was -10,517 and 61% of CE-pairs were located in the south-east quadrant, suggesting that on average DD dominated traditional care (**Table 3**; **Figure 2-4a**). At a WTP of 0€/1-point improvement on the 1-10 VAS, the probability of DD being cost-effective compared to traditional care was 0.98 (**Figure 2-4b**). This probability slightly decreased with increasing values of WTP, to 0.91 at a WTP of €3,000.

Sensitivity analyses

In accordance with the main analysis, total costs were statistically significantly lower in the DD-cohort compared with the pre-DD-cohort when applying the healthcare perspective (SA1), but the magnitude of this effect was smaller. When absenteeism costs were valued using age and gender-specific price weights (SA2), and when an alternative propensity-score was used (SA3), results regarding costs, effects, ICERs and CEACs were comparable to those in the main analysis, albeit differences in costs were no longer statistically significant.

Table 3 - Differences in costs and effects, incremental cost-effectiveness ratios, and cost-effectiveness planes

Analysis[a]	Sample size; n		Outcome*	ΔC; € (95% CI)[b]		ΔE; point (95% CI)		ICER; €/ point	Distribution CE-plane; (%)			
	Pre	DD							NE	SE	SW	NW
Main analysis	141	148	Generic HR-QoL (0 – 1)[c]	-845	(-1,781 to -88)	0.03	(-0.01 to 0.08)	-26,022	0.07	0.87	0.06	0.00
	141	148	Disease-specific HR-QoL (0 – 100)[d]	-852	(-1,777 to -96)	4.4	(-1.1 to 9.9)	-193	0.07	0.88	0.05	0.00
	144	153	Treatment satisfaction (0 – 10)	-821	(-1,711 to -75)	-0.16	(-0.53 to 0.21)	5,213	0.06	0.19	0.74	0.01
	144	153	Pain (0 – 10)	-822	(-1,710 to -77)	0.08	(-0.37 to 0.52)	-10,517	0.07	0.61	0.32	0.00
SA1 Healthcare perspective	141	148	Generic HR-QoL (0 – 1)[c]	-169	(-206 to -130)	0.03	(-0.01 to 0.08)	-5,190	0.06	0.88	0.05	0.00
	141	148	Disease-specific HR-QoL (0 – 100)[d]	-169	(-206 to -130)	4.4	(-1.1 to 9.9)	-38	0.06	0.89	0.05	0.00
	144	153	Treatment satisfaction (0 – 10)	-168	(-206 to -132)	-0.16	(-0.53 to 0.21)	1,068	0.06	0.19	0.75	0.00
	144	153	Pain (0 – 10)	-168	(-206 to -132)	0.08	(-0.37 to 0.52)	-2,153	0.05	0.62	0.33	0.00
SA2 Absenteeism costs valued using age and gender-specific price weights	141	148	Generic HR-QoL (0 – 1)[c]	-721	(-1,666 to 6)	0.03	(-0.01 to 0.08)	-22,203	0.09	0.85	0.06	0.00
	141	148	Disease-specific HR-QoL (0 – 100)[d]	-729	(-1,587 to 36)	4.4	(-1.1 to 9.9)	-162	0.09	0.86	0.05	0.00
	144	153	Treatment satisfaction (0 – 10)	-700	(-1,567 to 33)	-0.16	(-0.53 to 0.21)	4,445	0.06	0.19	0.72	0.03
	144	153	Pain (0 – 10)	-701	(-1,566 to 33)	0.08	(-0.37 to 0.52)	-8,969	0.09	0.59	0.32	0.00
SA3 Propensity-score including education level	141	148	Generic HR-QoL (0 – 1)[c]	-758	(-1,732 to 53)	0.03	(-0.01 to 0.07)	-24,045	0.09	0.84	0.06	0.01
	141	148	Disease-specific HR-QoL (0 – 100)[d]	-762	(-1,736 to 46)	3.44	(-2.06 to 8.93)	-222	0.09	0.81	0.09	0.01
	144	153	Treatment satisfaction (0 – 10)	-741	(-1,661 to 35)	-0.12	(-0.49 to 0.24)	6,065	0.07	0.23	0.67	0.03
	144	153	Pain (0 – 10)	-741	(-1,664 to 35)	0.07	(-0.37 to 0.52)	-9,883	0.08	0.58	0.33	0.01

*ΔC, Difference in costs; CE-plane, cost-effectiveness plane; CI, confidence interval; ΔE, Difference in effects; ICER, incremental cost-effectiveness ratio; NE, The northeast quadrant of the CE plane, indicating that DD is more effective and more costly than standard care; NW, The northwest quadrant of the CE plane, indicating that DD is less effective and more costly than standard care; SA, sensitivity analysis; SE, The southeast quadrant of the CE plane, indicating that DD is more effective and less costly than standard care; SW, The southwest quadrant of the CE plane, indicating that DD is less effective and less costly than standard care; * higher value indicates better outcome.*

[a] *Main analysis, SA2 and SA3 were adjusted for propensity-score and work status (yes/no), while SA1 was adjusted for propensity-score only.*

[b] *All costs are expressed in Euros 2019.*[35, 36]

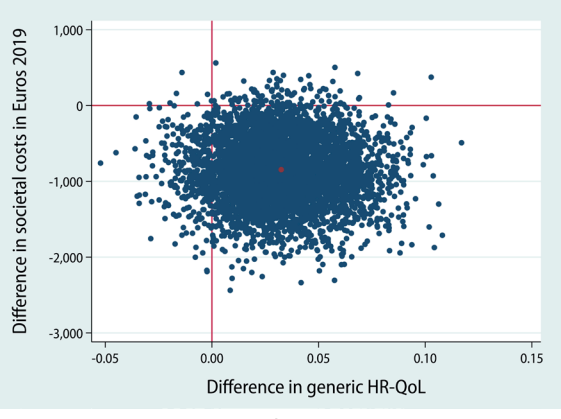
[c] *Assessed in participants ≥4 years old, using the EuroQol five-dimensional questionnaire.*[26, 27]

[d] *Assessed in participants ≥4 years old, using four different validated functional outcome questionnaires,*[30-33] *all converted to a 0 – 100 scale for comparison.*[34]

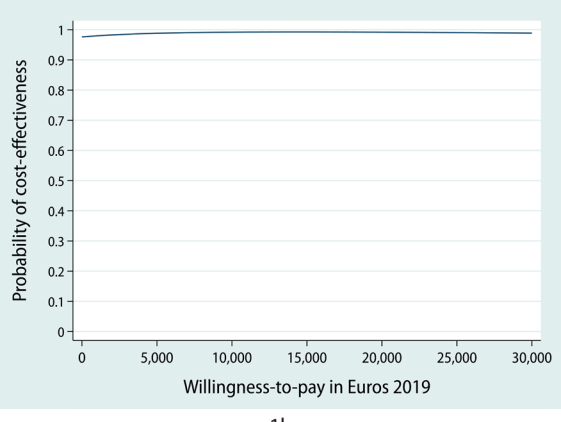
Table 4 - Mean costs and mean cost differences in Euro

Cost category	Costs in €; mean (SEM)				Cost difference in €; mean (95% CI)[c]			
	Pre-cohort (n = 144)		DD-cohort (n = 153)		Unadjusted		Adjusted[d]	
Healthcare – total[a]	522	(16)	361	(11)	-162	((-200 to -124)	-168	(-205 to -131)
Primary healthcare	67	(10)	53	(9)	-14	(-39 to 13)	-16	(-41 to 11)
Secondary healthcare	456	(11)	307	(4)	-148	(-174 to -127)	-152	(-179 to -132)
Absenteeism - total	1648	(348)	1306	(275)	-341	(-1232 to 476)	-645	(-1535 to 100)
Patient absenteeism[a]	1591	(350)	1301	(275)	-289	(-1182 to 537)	-598	(-1492 to 148)
Parent absenteeism[b]	57	(10)	5	(3)	-52	(-75 to -34)	-47	(-69 to -31)
Travel	11	(0)	5	(0)	-7	(-8 to -6)	-7	(-8 to -6)
Total	2181	(353)	1672	(277)	-510	(-1411 to 323)	-822	(-1719 to -67)

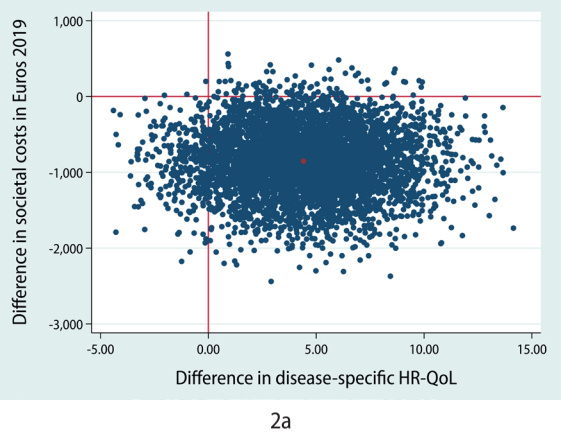
CI, confidence interval; SEM, Standard Error of the Mean.
[a] Including work absenteeism in the days after sustaining the injury (return-to-work), as well as work leave for the purpose of a hospital follow-up visit.
[b] Work leave of a parent to accompany a child to the hospital follow-up visit.
[c] Cost differences were calculated using regression models using bias-corrected and accelerated (BCA) bootstrapping, with 5,000 replications.
[d] Cost differences adjusted for propensity-score, and additionally, absenteeism costs were adjusted for work status (yes/no) as well.
All costs are expressed in Euros 2019.[35, 36]


Difference in societal costs in Euros 2019
1,000
0
-1,000
-2,000
-3,000
-0.05
0.00
0.05
0.10
0.15
Difference in generic HR-QoL

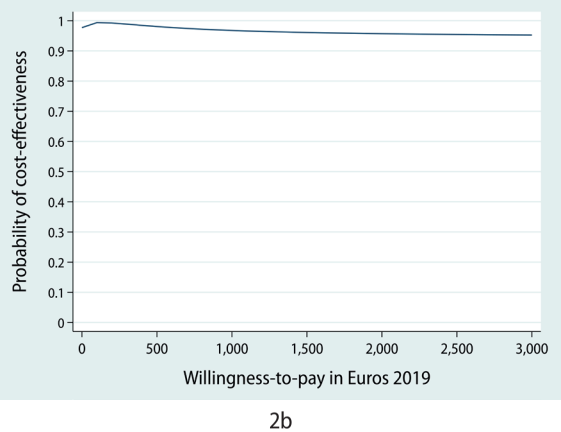
1a


Probability of cost-effectiveness
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5,000
10,000
15,000
20,000
25,000
30,000
Willingness-to-pay in Euros 2019

1b


Difference in societal costs in Euros 2019
1,000
0
-1,000
-2,000
-3,000
-5.00
0.00
5.00
10.00
15.00
Difference in disease-specific HR-QoL

2a


Probability of cost-effectiveness
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1,000
1,500
2,000
2,500
3,000
Willingness-to-pay in Euros 2019

2b

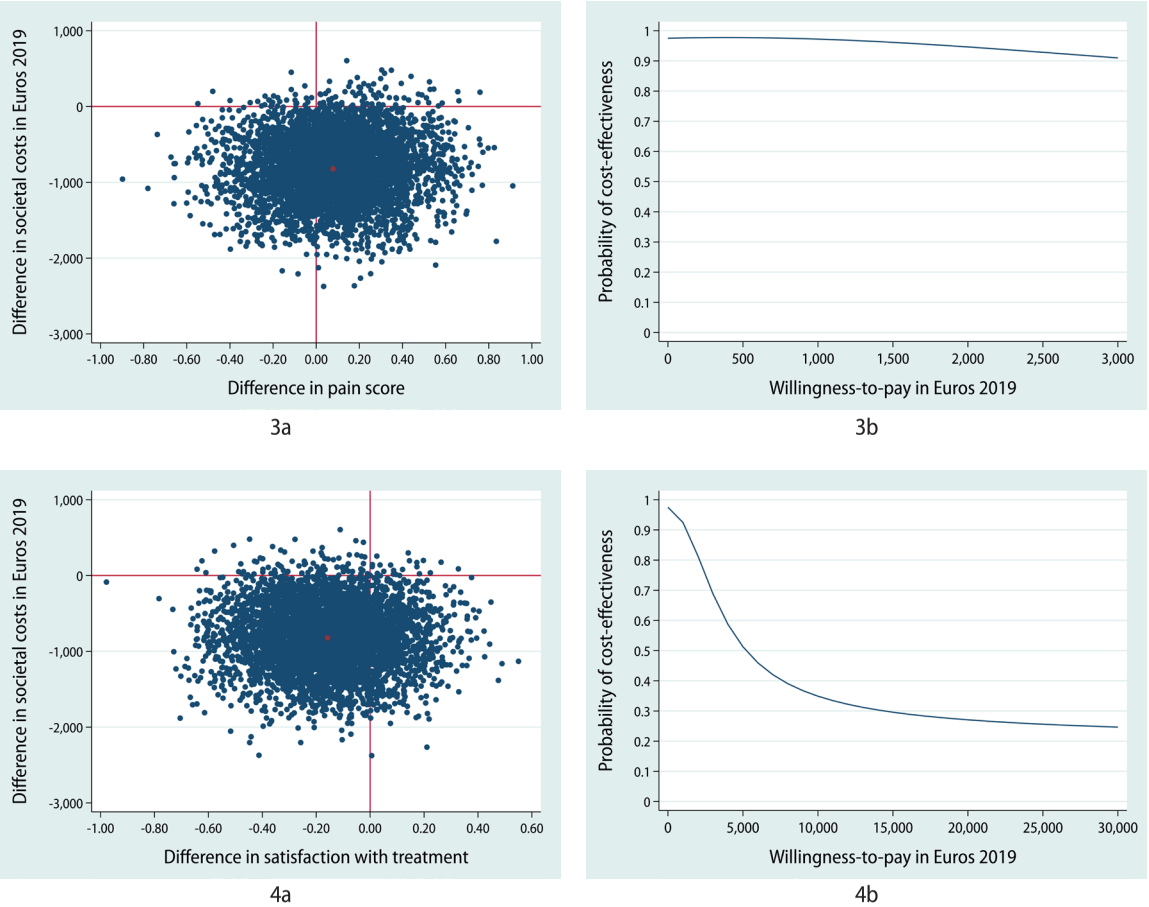


Figure 2 – Cost-effectiveness
(1) Cost-effectiveness planes indicating the distribution of incremental cost-effect pairs around its four quadrants and (2) cost-effectiveness acceptability curves indicating the probability of direct discharge being cost-effective in comparison with standard care for different values (€) of willingness-to-pay for (a) generic HRQoL,
(b) disease-specific HR-QoL, (c) pain, and (d) treatment satisfaction.

DISCUSSION

The results of this study suggest that DD from the ED of patients with SSIs is likely to be cost-effective compared to 'traditional' care with routine follow-up, both from a societal perspective as well as a health care perspective, for all four effect measures. That is, DD dominates traditional care for generic HR-QoL, disease-specific HR-QoL and pain, i.e. for these outcomes, on average, DD was less costly and more effective. For satisfaction with treatment, on average, DD was less costly, but also less effective compared with traditional care. It is noteworthy however, that the mean difference in satisfaction with treatment was 0.16 on a 0-10 scale in favor of the pre-DD-cohort,[25] which is far from clinically relevant as the minimally clinical important difference for this outcome is estimated at 0.7. Furthermore, in both cohorts there were relatively high levels of satisfaction, e.g. the mean satisfaction with treatment in the DD-cohort was 7.95.[25]

For all outcomes, the CEACs indicate that DD has a high probability of being cost-effective compared with traditional care. For generic HR-QoL, disease-specific HR-QoL and pain these probabilities remained the same or only slightly decreased with increasing values of WTP. For satisfaction with treatment, this probability slightly decreased with reasonable increasing values of WTP. This decrease in WTP was caused by the fact that satisfaction with treatment was on average lower for DD compared with traditional care, but as mentioned, this difference was far from clinically relevant.

Although the aim of this study was to assess cost-effectiveness, our results also suggest that DD is likely to reduce costs across all included cost categories, i.e. absenteeism-, primary healthcare-, secondary healthcare- and travel costs. Based on previous studies, we estimate that approximately 85,000 annual ED visits concern SSIs,[1, 3, 4] and based on the results of the current study, if DD would become the standard of care in the Netherlands, this could potentially result in a national societal cost saving of EUR 70 million per year. This includes an annual reduction of EUR 14 million in direct healthcare costs and EUR 54.8 million lost productivity costs. While this is a relatively small proportion of the total annual societal costs of injuries (EUR 3.8 billion),[1] it is also important to consider the additional logistic benefits of DD, i.e. in our study on effectiveness of DD we estimated that national adoption of DD would prevent approximately 142,800 outpatient visit clinics per year.[25]

Several previous studies on DD of SSIs have attempted to quantify healthcare cost-differences before and after DD, including several non-comparative studies that modelled pre-DD costs based on several assumptions with regards to healthcare utilization, rather than actually measuring pre-DD data.[10, 11, 18] Furthermore, several previous comparative studies only assessed healthcare costs, most frequently limited to secondary healthcare costs, and did not assess cost-effectiveness.[7-9] To our knowledge, the current study is the first to assess costs and cost-effectiveness from the broader societal perspective, including both primary healthcare costs and secondary healthcare

costs, as well as work absenteeism costs and travel costs. The societal perspective is recommended by the Dutch guidelines for economic evaluations in healthcare.[48]

As a result of this, the comparison of our results to previous studies is limited to comparing healthcare cost-differences. It must be noted however, that the ability to directly compare these differences is further limited by the differences in healthcare (payment) systems across countries as well as the variety of variables used to calculate the cost differences and the costs per item. To illustrate, Seewoonarain et al. (Great-Britain) valued one fracture clinic appointment at £154, while Mackenzie et al. valued this at £99 (Scotland), versus €85 in the current study based on Dutch reference prices (Appendix B).[8, 9] Moreover, in our study, on average, primary and secondary healthcare costs were reduced by €16 and €152 per patient, respectively. Hamilton et al. reported a mean reduction in healthcare costs of £100 (€116) after DD, in a comparative study among paediatric patients with a forearm fracture.[7] In this study however, healthcare costs only included clinic visit-, GP visit-, and immobilization material costs. Seewoonarain et al. compared patients with a torus fracture of the distal radius before and after DD, and found a mean reduction of £62 (€72) in healthcare costs per patient after DD. Their costs only included clinic costs and immobilization costs, which might explain why their total cost reduction was smaller than ours.[9] Mackenzie et al. estimated secondary health care costs of three types of SSIs before and after DD. Costs included staffing costs, operation costs and radiology costs. The median reduction per patient was £128 (€148) for fifth metacarpal fractures, £84 (€97) for fifth metatarsal fractures and £138 (€160) for radial head fractures.[8]

This study has several strengths. Most importantly, this is the first study to evaluate the cost-effectiveness of DD compared to traditional care from a societal perspective. Second, cost-effectiveness was analysed using SUR. This regression technique allows for the correction of the possible correlations between costs and effects.[49] Third, this study was based on an extensive survey, which allowed a wide range of variables to be included in our total societal cost estimates. Fourth, while randomization might be infeasible for studying redesigns such as DD, our study deals with the non-randomized nature of the study using propensity-score adjustments. Last, there was no missing data amongst the participants that responded to the survey.

This study also has several limitations. First, both cohorts were relatively small and consequently the 95% CIs surrounding the cost-differences are relatively wide. However, we do not expect our analyses to be extremely underpowered, because even our total cost differences were found to be statistically significant, whereas costs are typically underpowered due to their relatively skewed nature. Second, however in keeping with what might be expected, the survey response rate was relatively low, but there were no major differences in baseline characteristics between responding and non-responding participants.[25] Third, eleven types of SSIs were included and this limits the ability to draw injury-specific conclusions regarding (cost-)effectiveness of DD versus traditional care.

Preliminary post-hoc analyses per injury are provided in Appendix C for societal costs, healthcare costs, and the four effect measures that were used in our study. These analyses indicate that DD reduces both societal costs as well as healthcare costs for all injury subgroups, while there were no remarkable differences in patient outcomes or patient experiences before and after implementing DD for each injury. However, these injury subgroups are relatively small and therefore lack statistical power, hence, future studies should be conducted to assess this into more detail. Fourth, in this cost-effectiveness analysis we did not consider the one-time investment that is required to implement DD in a hospital (e.g. staffing, resources). However, we have shared our protocols and discharge leaflets with other Dutch hospitals, and these hospitals typically require approximately three months to prepare the implementation. Therefore, the associated costs for preparing implementation are relatively low and in our opinion should not refrain hospitals from implementing this model of care. Fifth, outcomes were only measured at a single point in time. Hence, we were unable to include quality-adjusted life years (QALYs) as outcome measure. Sixth, most data were collected prospectively by self-report. While we do not expect this to differ severely between cohorts, this may have caused socially desirable answers and/or recall bias, e.g. for number of GP visits or work absenteeism. Last, patient absenteeism was valued using age- and gender-specific price weights, but parent absenteeism was valued using average wage, as the gender and age of the parent accompanying the child during follow-up was unknown.

Future studies should focus on the generalizability of our results in other countries with different healthcare systems, as well as the eligibility of other injuries for DD and associated (cost-)effectiveness. Additionally, studies including larger cohorts should be conducted to strengthen the results, and these cohorts should be large enough to perform subgroup analysis for each injury. Currently multiple hospitals in the Netherlands are implementing DD, and therefore this might be achieved by performing multicentre studies in which data is collected in a cooperative and standardized manner. Last, researchers could explore the options to shift the treatment of patients with SSIs from secondary healthcare to primary healthcare (e.g., treatment via GP without visiting the ED at all) in order to further reduce healthcare and societal costs.

In conclusion, the results of this first CEA to compare DD of SSIs with traditional care, suggest that DD is likely to be cost-effective compared to ´traditional´ care with routine follow-up, for generic- and disease-specific HR-QoL, satisfaction with treatment, and pain, both from a societal perspective as well as from a healthcare perspective. As a large proportion of musculoskeletal injuries are SSIs, the implementation of DD offers an opportunity to respond to increasing demands, high workloads and costs. This is necessary to guarantee future high-quality trauma care. Future studies should be performed in larger cohorts to strengthen current findings, as well as to test generalizability in other countries.

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APPENDIX

Appendix A - Effect measures

Table A1 – Assessment of effect measures

Effect measure	Summarized as	Age category	Questionnaire
Health-related QoL	Index score 0 – 1 (optimal health)	0 – 3	No questionnaire
		4 – 11, and 12 – 17 (if proxy)	EQ-5D-Youth
		≥18, and 12-17 (self-complete)	EQ-5D-5L
Disease-specific QoL	Scale 0 (worst) – 100 (best functional outcome)	0 – 3	No questionnaire
		4 – 17	PROMIS UE SF
		4 – 17	PROMIS Mobility SF
		≥18	QuickDASH
		≥18	LEFS
Satisfaction w/ treatment	Scale 0 (very dissatisfied) – 10 (very satisfied)	All participants	Single question
Pain	Scale 0 (no pain) – 10 (extremely painful)	All participants	Single question

Summary scores were calculated using the guideline of each corresponding questionnaire. Normative Dutch values of the EQ-5D-5L were used to calculate the EQ-5D-5L index scores, and normative values of the EQ-5D-3L were used to calculate the EQ-5D-Youth index scores. EQ-5D, EuroQol-5D; LEFS, Lower Extremity Functional Scale; MCID, PROMIS, Patient-Reported Outcomes Measurement Information System; QoL, Quality of Life; QuickDASH, Shortened version of the Disability of the Arm, Shoulder and Hand; Ref., Reference; SD, Standard Deviation; SF, Short Form;

Appendix B - Cost measures

Table B1 - Costs per cost unit for primary healthcare, secondary healthcare and absenteeism costs

Cost unit	Unit	Standard calculation values; EUR
Primary healthcare costs		
General practitioner visit	One unit	35.24
Physiotherapist visit	One unit	35.24
Secondary healthcare costs		
Outpatient / fracture clinic visit	One unit	85.44
No show	One unit	85.44
Emergency Department visit	One unit	276.61
X-ray	One unit	53.03
CT-scan	One unit	133.56
Absenteeism costs[a]		
Work absenteeism – gender specific – male	Hour	40.48
Work absenteeism – gender specific – female	Hour	33.75
Parent absenteeism – average Dutch wage	Hour	37.11

EUR; Euro expressed in Euros 2019[1, 2]

Table B2 - Costs for immobilization material per type of injury

	Immobilization costs; EUR	
Type of injury	**Pre-DD-cohort**	**DD-cohort**
Fifth metatarsal base fracture	26.80	51.00
Fifth metacarpal neck fracture	14.63	1.33
Greenstick or torus/buckle type fracture of the distal radius	14.63	23.83
Radial head- and -neck fracture	9.09	1.29
Mallet finger	4.29	2.29
Clavicle fracture	1.00	0.83
Isolated phalangeal fracture of the foot	0.03	0.03
Fracture of the hallux	15.65	7.96
Weber A type ankle fracture	41.38	22.46
Minor avulsion fracture of the ankle	6.30	22.46
Bicycle spoke ankle injury	7.80	0.46

DD; Direct discharge; EUR; Euro expressed in Euros 2019[1, 2]; DD; direct discharge;

Table B3 - Costs per kilometre by means of transport

Means of transport	Unit	Standard calculation values; EUR
Car	costs per kilometre	0.20
Car parking	costs per visit	3.20
Motorbike / scooter	costs per kilometre	0.10
Bike	-	0.00
Walking	-	0.00
Public transport		
Train	costs per kilometre	0.20
Bus	costs per kilometre	0.20
Tram	costs per kilometre	0.20

EUR; Euro expressed in Euros 2019[1, 2]

Table B4 - Average travel costs based on means of transport data

Means of transport	Number of patients; n	Average costs; EUR	Total costs; EUR
Car	72	6.00	432.00
Motorbike	3	1.40	4.20
Scooter	2	1.40	2.80
Train	39	2.80	109.20
Bus	2	2.80	5.60
Tram	2	2.80	5.60
Bike	18	0.00	0.00
Walking	5	0.00	0.00
Total	**143**	**Sum** **Average per visit**	**559.40** **3.91**

EUR; Euro expressed in Euros 2019[1, 2]
The average distance to the nearest hospital in the Netherlands is 7 kilometres, travel distance for one visit was therefore estimated at 14 kilometres (return).[1] Means of transport was based on a previous survey with 143 respondents.

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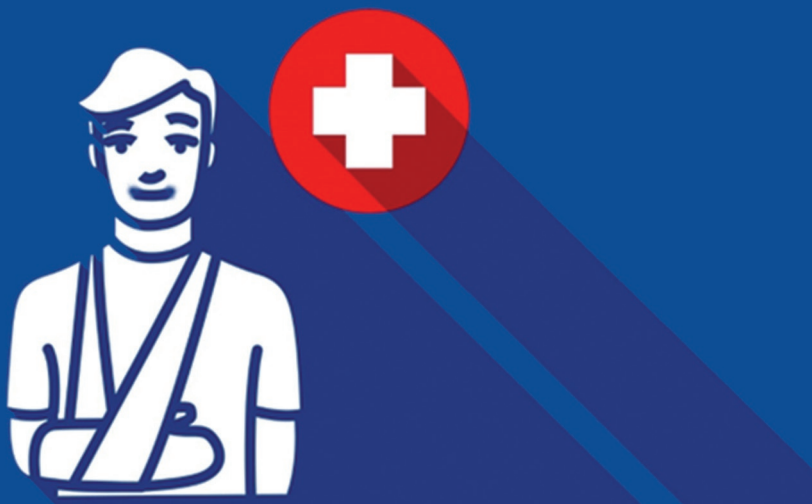
PART III

UPSCALING VIRTUAL FRACTURE CARE AND FUTURE STEPS IN OPTIMIZING TRAUMA CARE



HEALTHCARE UTILIZATION AND SATISFACTION WITH TREATMENT BEFORE AND AFTER DIRECT DISCHARGE FROM THE EMERGENCY DEPARTMENT OF SIMPLE STABLE MUSCULOSKELETAL INJURIES IN THE NETHERLANDS

6

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ABSTRACT

Purpose

To evaluate healthcare utilization and satisfaction with treatment before and after implementing direct discharge (DD) from the Emergency Department (ED) of patients with simple, stable musculoskeletal injuries.

Methods

Patients with simple, stable musculoskeletal injuries were included in two Dutch hospitals, both level-2 trauma centres: OLVG and Sint Antonius (SA), before (pre-DD-cohort) and after implementing DD (DD-cohort). With DD, no routine follow-up appointments are scheduled after the ED visit, supported by information leaflets, a smartphone application and a telephone helpline. Outcomes included: secondary healthcare-utilization (follow-up appointments and X-ray/CT/MRI); satisfaction with treatment (scale 1-10); primary healthcare-utilization (general practitioner (GP) or physiotherapist visited, yes/no). Linear regression was used to compare secondary healthcare-utilization for all patients and per SSI subgroup. Satisfaction and primary healthcare-utilization were analysed descriptively.

Results

A total of 2,033 (OLVG=1,686; SA=347) and 1,616 (OLVG=1,396; SA=220) patients were included in the pre-DD-cohort and DD-cohort, respectively. After DD, the mean number of follow-up appointments per patient reduced by 1.06 (1.13–0.99; $p<0.001$) in OLVG and 1.07 (1.02–0.93; $p<0.001$) in SA. Follow-up appointments reduced significantly for all injury subgroups. Mean number of follow-up X-rays per patient reduced by 0.17 in OLVG ($p<0.001$) and 0.18 in SA ($p<0.001$). Numbers of CT/MRI-scans were low and comparable. In OLVG, mean satisfaction with treatment was 8.1 (pre-DD-cohort) versus 7.95 (DD-cohort), versus 7.75 in SA (DD-cohort only). In OLVG, 23.6% of pre-DD-cohort patients visited their GP, versus 26.1% in the DD-cohort, versus 13.3% in SA (DD-cohort only). Physiotherapist use was comparable.

Conclusions

This study performed in a large population and additional hospital confirms earlier pilot results, i.e. that DD has the potential to effectively reduce healthcare utilization, while maintaining high levels of satisfaction.

INTRODUCTION

There is growing evidence that direct discharge (DD) from the Emergency Department (ED) of patients with certain simple, stable musculoskeletal injuries is a safe and effective alternative to 'traditional' care with routine follow-up. That is, DD reduces secondary healthcare utilization, i.e. number of follow-up appointments and radiographs, without a shift to primary healthcare utilization (i.e. visits to a general practitioner (GP) or physiotherapist), while patient-reported outcomes (e.g. functional outcome), experiences (e.g. satisfaction) are non-inferior, and adverse outcomes (e.g. non-unions, delayed-unions and secondary surgeries) are comparable.[1-6]

DD from the ED of a large proportion of patients with simple, stable musculoskeletal injuries was first described by Jenkins et al. in 2011.[1] After DD had been well-established within the United Kingdom (UK), it was implemented in the OLVG hospital in the Netherlands in May 2019.[7] Currently, one previous pilot study was performed in the Netherlands.[8] While results indicated that effects of DD in the Netherlands are comparable to earlier UK results, this was a single-centre study with relatively small sample size. Furthermore, no stratified analyses were performed to assess the effects of DD per injury subgroup. Nevertheless, based on this first Dutch pilot study, and accelerated by the increased demand for remote care during the coronavirus pandemic, there was a rapid rise in the number of Dutch hospitals adopting DD in 2020 and the beginning of 2021[9-13]

The aim of the current study was to assess whether effects of DD are similar with regard to healthcare utilization and satisfaction with treatment, both in a larger cohort within the pilot hospital (OLVG) as well as a second Dutch hospital. Additionally, it was evaluated whether effects of DD on secondary healthcare utilization differed per injury subgroup.

METHODS

Design

This was a before-and-after study comparing DD versus 'traditional' fracture care for patients with simple, stable musculoskeletal injuries in two hospitals: 1) the OLVG hospital (OLVG): a level-2 trauma centre with two locations in Amsterdam, the Netherlands, and 2) the Sint Antonius hospital (SA): a level-2 trauma centre with two locations in Utrecht and Nieuwegein, the Netherlands.

After visiting Glasgow Royal Infirmary in 2018, the trauma team of OLVG decided to change treatment protocols and implement DD from the ED for eleven types of simple,

stable musculoskeletal injuries. Table 1 provides all the criteria for a patient's injury to be eligible for DD according to these treatment protocols. Apart from the criteria mentioned in **Table 1**, the protocols did not contain any other predefined restrictions regarding age, comorbidities, cognitive impairment, language barrier, medication use etc. However, the ED staff were instructed to evaluate whether DD was the most suitable treatment for each patient, for instance, if a language barrier did not allow the ED physician to provide adequate instructions, a follow-up appointment with a translator might be scheduled for this purpose.

The DD treatment protocols took effect in May 2019 in OLVG, location West, and in September 2019 in OLVG, location Oost. The same treatment protocols were shared with SA and were implemented in August 2020

Table 1 – Simple and stable injuries, criteria and immobilization

Injury	Paediatric/ adult	Criteria	Immobilization after DD
Paediatric clavicle Fx	Paediatric	• Age ≤14 • No indication for surgical treatment	Sling
Radial head-/neck Fx	Adult	• Head: Mason type 1, neck: undisplaced, or • Positive fatpad sign	Pressure bandage, sling
Greenstick or torus/ buckle type Fx of the distal forearm	Paediatric	• Acceptable angulation based residual growth • Torus/buckle type: isolated ulna Fx, isolated radius Fx or both • Greenstick type: isolated ulna Fx or isolated radius Fx	Removable wrist brace
Fifth metacarpal neck Fx	Adult	• Volar angulation <70 degrees • No rotational deviation	Buddy strap and pressure bandage
Mallet finger	Adult	• Either bony or tendinous • Treated conservatively	Mallet splint
Weber A type ankle Fx	Adult	• Dislocation <2mm • No signs of stage 2 supination-adduction type injury	Tubigrip and ankle brace
Avulsion type ankle Fx	Adult	• Either lateral or medial malleolus or tarsal bones	Tubigrip and ankle brace
Fx of fifth metatarsal base	Adult	• Fx located in either zone 1 or zone 2 • Dislocation ≤4 mm	Walker boot
Fx of greater toe	Both	• Either proximal or distal phalanx Fx • Undisplaced	Spica pressure bandage and bandage shoe
Fx of lesser toe	Both	• Any isolated Fx • No indication for surgical treatment	Buddy strap
Bicycle spoke injury	Paediatric	• No Fx based on radiograph • Superficial wound	Pressure bandage

DD, Direct Discharge; Fx, fracture; mm, millimetre.

Treatment

Traditional care

Before the implementation of the DD treatment protocols, patients with simple, stable musculoskeletal injuries were treated according to local protocols (pre-DD-cohort). Immobilization consisted of either bandage material, a splint or a cast. Generally, at least one follow-up appointment was scheduled approximately one week after the ED visit for review and definitive management.

Direct discharge

After implementation of the DD treatment protocols, patients with simple, stable musculoskeletal injuries were discharged directly from the ED (DD-cohort). That is, no routine follow-up appointments were scheduled. This was supported by the use of removable immobilization such as an orthosis or bandage (**Table 1**). ED physicians provided extensive information regarding the injury and expected recovery, which was also summarized in a discharge leaflet. Patients were also advised to download a smartphone application containing a digital version of these leaflets, videos of exercises to improve recovery and videos with instructions on how to reapply immobilization. Furthermore, a telephone helpline was available on weekdays for questions or concerns. Eligibility for DD was reassessed each day by an (orthopaedic) trauma surgeon and radiologist, during a routine daily review of all cases and X-rays of patients that presented to the ED on the previous day. Subsequently, patients who were discharged directly incorrectly (e.g. the injury was not a simple, stable injury) were contacted by telephone to schedule a face-to-face follow-up appointment.

Outcomes

Outcomes included "secondary healthcare utilization", "satisfaction with treatment", and "primary healthcare utilization". To assess these outcomes, OLVG data were prospectively collected from 15 November 2018 - 29 February 2021. DD was implemented on 20 May 2019 in OLVG, location West, and on 2 September 2019 in OLVG, location Oost, dividing all OLVG patients into a pre-DD-cohort and a DD-cohort. SA data were collected prospectively during the first three months after implementing DD in August 2020 (DD-cohort), and retrospectively during the same period in the previous year (pre-DD-cohort). Consequently, the periods during which patients were included in each cohort differed per hospital, location, and outcome type (**Figure 1**).

Secondary healthcare utilization

Secondary healthcare utilization was evaluated by the total number of follow-up appointments with a physician after visiting the ED, as well as the total number of follow-

up radiographs, CT scans, and MRI scans. Data on these outcomes were derived from electronic patient records (EPRs).

Satisfaction with treatment and primary healthcare utilization

Satisfaction with treatment was assessed on a scale ranging from 0 (very dissatisfied) to 10 (very satisfied). Primary healthcare utilization was evaluated by the number of GP visits and the number of physiotherapist visits related to the simple, stable injury, both dichotomized into "yes" or "no". Data on these outcomes were assessed at three months post-injury. In OLVG, this was part of a survey study and patients received a survey via e-mail or post. In SA, this was part of a clinical audit conducted after implementing DD (i.e. there were no pre-DD-cohort data), and data were collected by a telephone call three months after the ED visit. In case a child was not able to answer these questions, a parent/caregiver was also allowed to respond.

In both hospitals, the following patient characteristics were collected from EPRs: age (years); gender; type of injury (**Table 1**). Furthermore, for patients with a simple stable musculoskeletal injury in the DD-cohort, who were not discharged directly by the ED, the reason was recorded for not following the new DD treatment protocols.

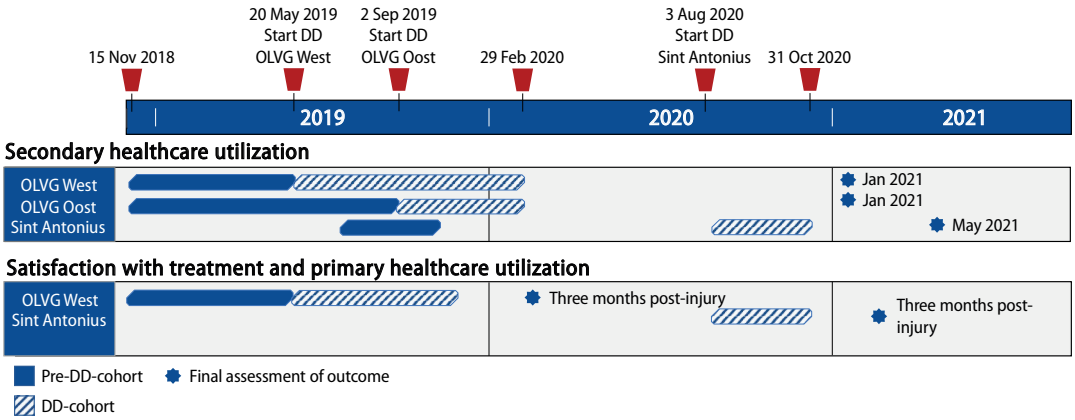


Figure 1 - Inclusion periods of both cohorts in the different centres, to assess healthcare utilization and satisfaction.
DD, Direct Discharge.

Recruitment and consent

For the current study, we included all patients presenting to the ED of the two participating hospitals with an isolated simple, stable musculoskeletal injury according to the criteria mentioned in **Table 1**. Exclusion criteria were: initial treatment in the ED of a different hospital; multiple injuries; reason for follow-up other than the injury (e.g.

social care reasons); Eye/Motor/Verbal-score <15 at presentation, high-energy trauma; treatment continued in different hospital (e.g. closer to home); alcohol/drug intoxication. Since these outcomes were assessed by means of a survey, an additional exclusion criterium for the assessment of "satisfaction with treatment" and "primary healthcare utilization" was: inability to understand/complete a Dutch survey.

In both hospitals, for the assessment of secondary healthcare utilization within the pre-DD-cohort, all consecutive ED patients with simple, stable musculoskeletal injuries were included, while the DD-cohort included all consecutive ED patients with simple stable musculoskeletal injuries who were discharged directly from the ED. In OLVG, assessments of primary healthcare utilization and satisfaction with treatment were part of a previous survey study conducted in OLVG, location West.[8] Participants for this survey were enrolled in the ED and provided written informed consent and received a survey after three months. In SA, assessments of primary healthcare utilization and satisfaction was part of a clinical audit that was conducted after implementing DD, i.e. for these outcomes there was no pre-DD data. Participants for this clinical audit were contacted by telephone after three months and provided verbal informed consent.

Statistical analysis

Statistical analysis was performed using SPSS version 27.0 and STATA v16.[14, 15] Baseline characteristics were reported descriptively using numbers and proportions for categorical variables, and mean with standard deviation (SD) or median with interquartile range (IQR) as appropriate.

To assess secondary healthcare utilization before and after DD in both hospitals, between-group differences were assessed for the DD-cohort versus the pre-DD-cohort for both hospitals separately, and per injury subgroup. Between-group differences were assessed using linear regression models, adjusted for the patients' propensity-score to account for the non-randomised nature of this study. A propensity-score indicates the probability of a patient being assigned to an intervention group, given a set of baseline characteristics.[16] In our study, the propensity-score was estimated using: cohort (pre-DD-cohort/DD-cohort), age, gender, and injury type, using the pscore package in STATA. In case of non-normally distributed data, Bias Corrected and Accelerated bootstrapping was performed using 5,000 replications to estimate uncertainty. A p-value of <0.05 was considered statistically significant. Satisfaction with treatment and primary healthcare utilization were analysed descriptively.

Patient and public involvement

Patients were not involved in the design, intervention, research question, or outcome measures of the current study.

Ethics

The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethical committee of OLVG (Ref.no. 18.071), and SA (Ref.no. W21.122).

RESULTS

The number and flow of the included patients per hospital and outcome type is shown in **Figure 2**. In OLVG, 1,686 patients presented to the ED with a simple stable musculoskeletal injury before the implementation of DD (pre-DD-cohort), versus 1,492 patients thereafter. Of these 1,492 patients, 1,369 (91.8%) were discharged directly according to the DD treatment protocols (DD-cohort). In SA, 347 patients with a simple, stable injury were included in the pre-DD-cohort, and 256 patients presented to the ED with a simple, stable injury after implementing DD. Of these 256 patients, 220 patients (85.9%) were discharged directly (DD-cohort). This means that DD protocols were not followed in 123 and 36 patients with simple, stable musculoskeletal injuries, in OLVG and SA, respectively. In both hospitals, the most common reason for not discharging a patient directly after DD treatment protocols were implemented was "non-compliance to the protocol" (86/123 (69.9%) patients in OLVG, and 33/36 (91.7%) patients in SA). Other reasons included a language barrier, a patient insisting a cast to be applied, or cognitive impairment (**Figure 2**).

Table 2 provides an overview of the included patients' baseline characteristics. In SA, the proportion of children with a forearm fracture in the DD-cohort was relatively large, resulting in a slightly lower median age compared to the pre-DD-cohort. Furthermore, a relatively large proportion of patients had an avulsion type ankle fracture in OLVG, compared to SA. Data of all of these patients were used to evaluate the effect of implementing DD on secondary healthcare utilization.

In OLVG, location West, 144 (pre-DD-cohort) and 153 participants (DD-cohort) completed the survey at three months post-injury. In SA, 173 of 220 DD-cohort patients participated in the clinical audit. Baseline characteristics of these patients can be found in Appendix **Table A1**. Data of all of these patients were used to evaluate the effect of implementing DD on satisfaction and primary healthcare utilization.

Secondary healthcare utilization

In OLVG, in the pre-DD-cohort, the mean number of follow-up appointments was 1.29 (SD 1.18) per patient, versus 0.22 (SD 0.68; **Table 3**) in the DD-cohort (mean difference -1.06; $p<0.001$). In SA, the mean number of follow-up appointments per patient was 1.19 (SD=1.04) and 0.13 (SD=0.52) in the pre-DD-cohort and DD-cohort, respectively (mean difference -1.07; $p<0.001$).

In OLVG, the mean number of follow-up X-rays per patient was 0.22 (SD 0.60) in the pre-DD-cohort, versus 0.05 (SD=0.31) in the DD-cohort (mean difference -0.17, p<0.001). In SA, the mean number of follow-up X-rays was 0.19 (SD=0.49) and 0.01 (SD=0.10) in the pre-DD-cohort and DD-cohort, respectively (mean difference -0.18; p<0.001). The mean number of CT and MRI scans were relatively low and comparable across all cohorts. **Table 3** also shows the difference in number of follow-up appointments before and after DD per injury subgroup.

Satisfaction with treatment and primary healthcare use

In OLVG, the mean satisfaction with treatment was 8.1 (SD 1.5) in the pre-DD-cohort, versus 7.95 (SD 1.7; **Table 4**) in the DD-cohort. In SA, the mean satisfaction with treatment in the DD-cohort was 7.75 (SD 1.7). In OLVG, the proportion of patients that visited their GP for the treatment of their injury in the pre-DD-cohort was 23.6%, versus 26.1% in the DD-cohort. In SA, this proportion was 13.3% in the DD-cohort. In OLVG, the proportion of patients that visited a physiotherapist in the pre-DD-cohort was 26.4%, versus 20.9% in the DD-cohort. In SA, this proportion was 21.4% in the DD-cohort.

Figure 3 provides an infographic summarizing several relevant outcomes of this study

Table 2 – Baseline characteristics of included patients

	OLVG Hospital (n = 3,055)		Sint Antonius Hospital (n = 567)	
Characteristic	**Pre-DD (n = 1,686)**	**DD (n = 1,369)**	**Pre-DD (n = 347)**	**DD (n = 220)**
Age; median (IQR)	30 (13 – 50)	28 (12 – 48)	27 (11 – 52)	22 (9 – 50)
Age <18; n (%)	501 (29.7)	437 (31.9)	136 (39.2)	95 (43.2)
Gender male; n (%)	878 (52.1)	718 (52.4)	170 (49.0)	105 (47.7)
Type of injury; n (%)				
Paediatric clavicle Fx	78 (4.6)	49 (3.6)	42 (12.1)	16 (7.3)
Radial head-/neck Fx	320 (19.0)	215 (15.7)	46 (13.3)	24 (10.9)
Paediatric forearm Fx	215 (12.8)	210 (15.3)	60 (17.2)	57 (25.9)
Fifth metacarpal neck Fx	98 (5.8)	48 (3.5)	17 (4.9)	10 (4.5)
Mallet finger	84 (5.0)	61 (4.5)	22 (6.3)	14 (6.4)
Weber A ankle Fx	93 (5.5)	78 (5.7)	19 (5.5)	13 (5.9)
Avulsion Fx ankle	246 (14.6)	208 (15.2)	11 (3.2)	16 (7.3)
Fx of fifth metatarsal base	149 (8.8)	135 (9.9)	29 (8.4)	23 (10.5)
Fx of greater toe	176 (10.4)	145 (10.6)	32 (9.2)	14 (6.4)
Fx of lesser toe	135 (8.0)	91 (6.6)	50 (14.4)	20 (9.1)
Bicycle spoke injury	92 (5.5)	129 (9.4)	19 (5.5)	13 (5.9)

DD, Direct Discharge; Fx, fracture; IQR, interquartile range.

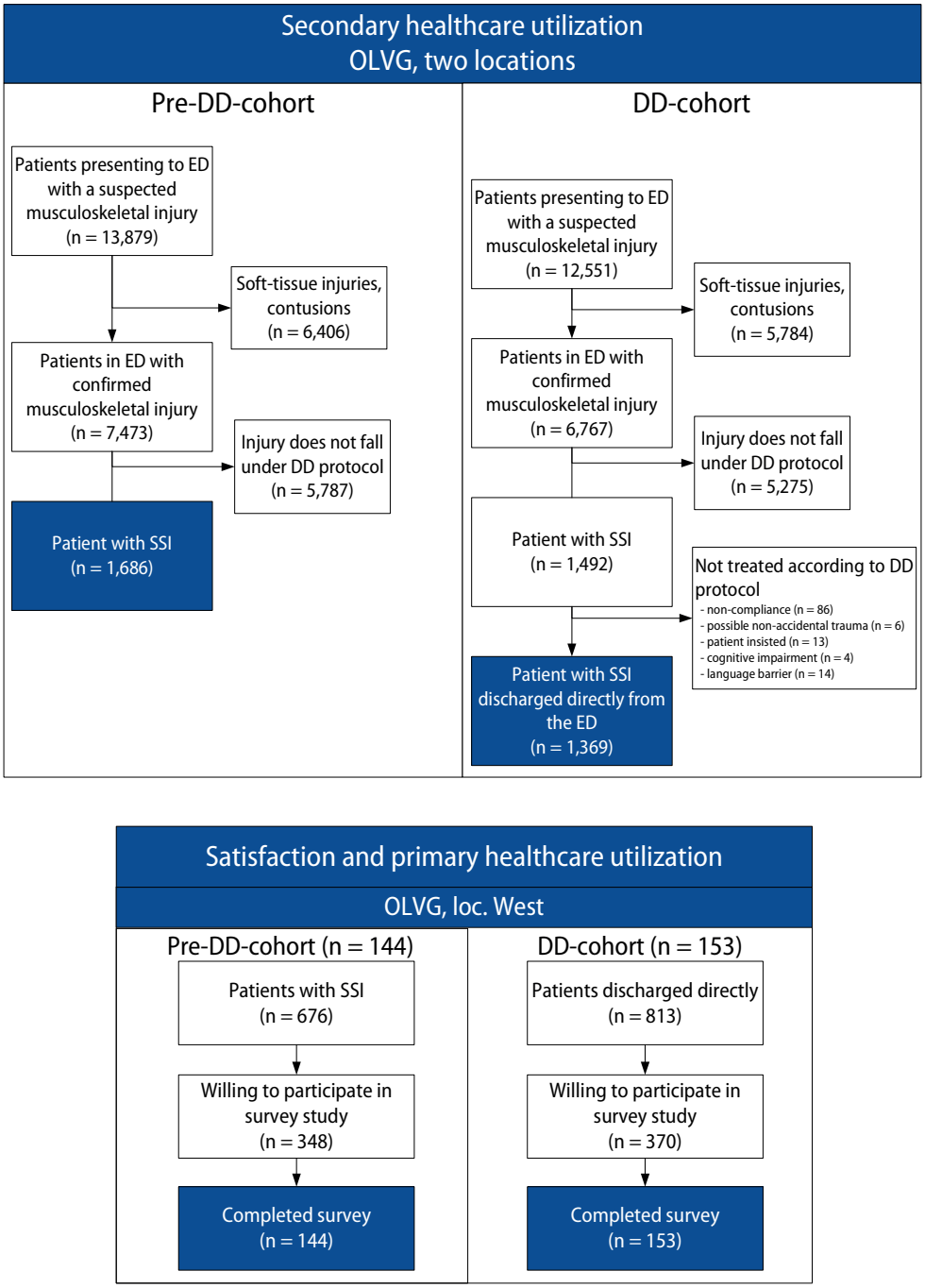
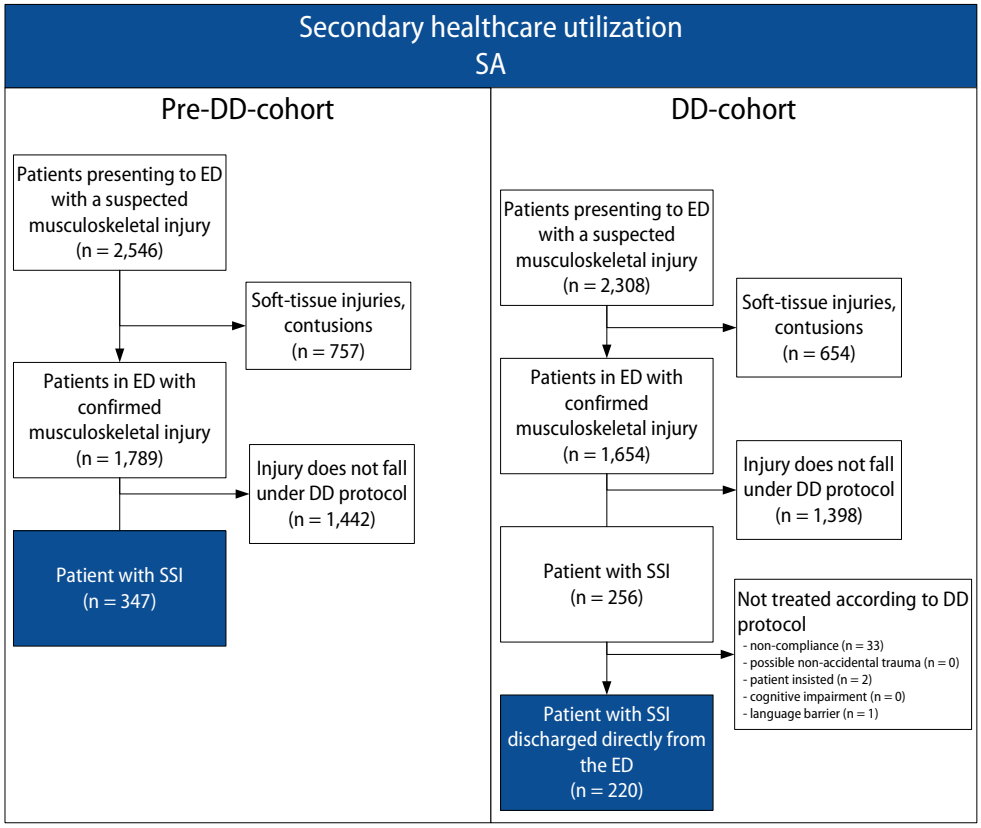


Figure 2-a – Depiction of number and flow of the patients included in OLVG, and outcome type.
DD, Direct discharge; loc., location; SSI, Simple stable injury.



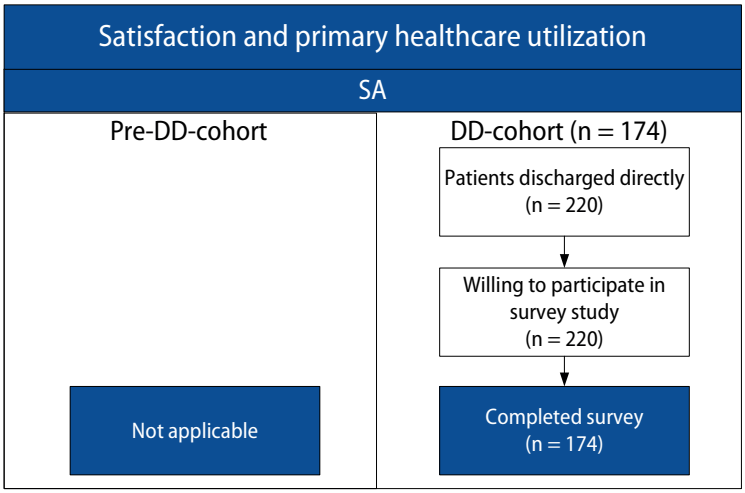


Figure 2-b – Depiction of number and flow of the patients included in Sint Antonius, and outcome type.
DD, Direct discharge; loc., location; SSI, Simple stable injury.

Table 3 – Secondary healthcare utilization

	Descriptive outcome; mean (SD)				Difference (regression DD vs. pre-DD); mean (95% CI)			
	OLVG hospital		Sint Antonius hospital		OLVG hospital		Sint Antonius hospital	
Outcome	**Pre-DD (n = 1,686)**	**DD (n = 1,369)**	**Pre-DD (n = 347)**	**DD (n = 220)**	**Difference**	**Sig.**	**Difference**	**Sig.**
Whole cohort								
Follow-up appointments	1.29 (1.18)	0.22 (0.68)	1.19 (1.04)	0.13 (0.52)	-1.06 (-1.13 – -0.99)	<0.001	-1.07 (-1.02 – -0.93)	<0.001
Follow-up imaging								
X-ray	0.22 (0.60)	0.05 (0.31)	0.19 (0.49)	0.01 (0.10)	-0.17 (-0.20 – -0.13)	<0.001	-0.18 (-0.23 – -0.12)	<0.001
CT-scan	0.02 (0.14)	0.01 (0.13)	0.00	0.00	-0.004 (-0.013 – 0.006)	0.44	NP	-
MRI-scan	0.01 (0.06)	0.00	0.01 (0.09)	0.01 (0.07)	-0.004 (-0.007 – -0.001)	0.021	NP	-
SSI subgroup								
Follow-up appointments								
Paediatric clavicle Fx	1.45 (0.75)	0.20 (0.54)	1.10 (0.53)	0.06 (0.25)	-1.29 (-1.49 – -1.09)	<0.001	-1.03 (-1.24 – -0.80)	<0.001
Radial head-/neck Fx	1.29 (1.01)	0.10 (0.42)	1.50 (0.98)	0.13 (0.61)	-1.17 (-1.29 – -1.05)	<0.001	-1.42 (-1.80 – -1.04)	<0.001
Paediatric forearm Fx	1.44 (0.64)	0.10 (0.38)	1.17 (0.49)	0.04 (0.27)	-1.34 (-1.44 – -1.24)	<0.001	-1.13 (-1.26 – -0.98)	<0.001
MC5 neck Fx	1.94 (0.21)	0.21 (0.54)	2.00 (1.37)	0.00	-1.73 (-1.98 – -1.46)	<0.001	-1.95 (-2.68 – -1.38)	<0.001
Mallet finger	2.50 (1.64)	1.89 (1.44)	1.00 (0.62)	0.57 (1.09)	-0.60 (-1.10 – -0.10)	0.019	-0.43 (-0.96 – -0.30)	0.21
Weber A ankle Fx	1.32 (1.24)	0.22 (0.66)	1.79 (1.08)	0.31 (0.75)	-1.09 (-1.38 – -0.81)	<0.001	-1.45 (-2.09 – -0.83)	<0.001
Avulsion Fx ankle	0.94 (1.22)	0.26 (0.61)	1.45 (0.93)	0.06 (0.25)	-0.68 (-0.86 – -0.51)	<0.001	-1.37 (-1.92 – -0.79)	0.005
Fx of MT5 base	2.20 (1.26)	0.22 (0.61)	2.55 (1.43)	0.35 (0.83)	-1.98 (-2.20 – -1.75)	<0.001	-2.29 (-2.86 – -1.72)	<0.001
Fx of greater toe	0.78 ((1.01)	0.11 (0.58)	0.63 (0.83)	0.00	-0.68 (-0.85 – -0.51)	<0.001	-0.62 (-0.95 – -0.35)	0.005
Fx of lesser toe	0.26 (0.77)	0.03 (0.18)	0.12 (0.33)	0.05 (0.22)	-0.22 (-0.38 – -0.08)	0.016	-0.08 (-0.21 – 0.08)	0.27
Bicycle spoke injury	0.91 (0.74)	0.06 (0.35)	1.11 (0.66)	0.00	-0.85 (-1.02 – -0.69)	<0.001	-1.09 (-1.40 – -0.81)	0.002

Propensity-score adjusted linear regression performed with bootstrapping for non-normally distribution. CI, Confidence Interval; DD, Direct Discharge; MC5, Fifth metacarpal; MT5, Fifth metatarsal; NP, Not performed as number of observations were too small to perform bootstrapping and subsequent regression; SD, Standard Deviation; Sig. Significance (p-value).

Table 4 – Satisfaction with treatment and primary healthcare use

	OLVG Hospital		Sint Antonius Hospital
Outcome	**Pre-DD (n = 144)**	**DD (n = 153)**	**DD (n = 173)**
Satisfaction w/ treatment; mean (SD)	8.1 (1.5)	7.95 (1.7)	7.75 (1.7)
Visited general practitioner; n (%)	34 (23.6)	40 (26.1)	23 (13.3)
Visited physiotherapist; n (%)	38 (26.4)	32 (20.9)	37 (21.4)

DD, Direct Discharge; SD, Standard deviation
OLVG data were collected as part of a previous study.[8]

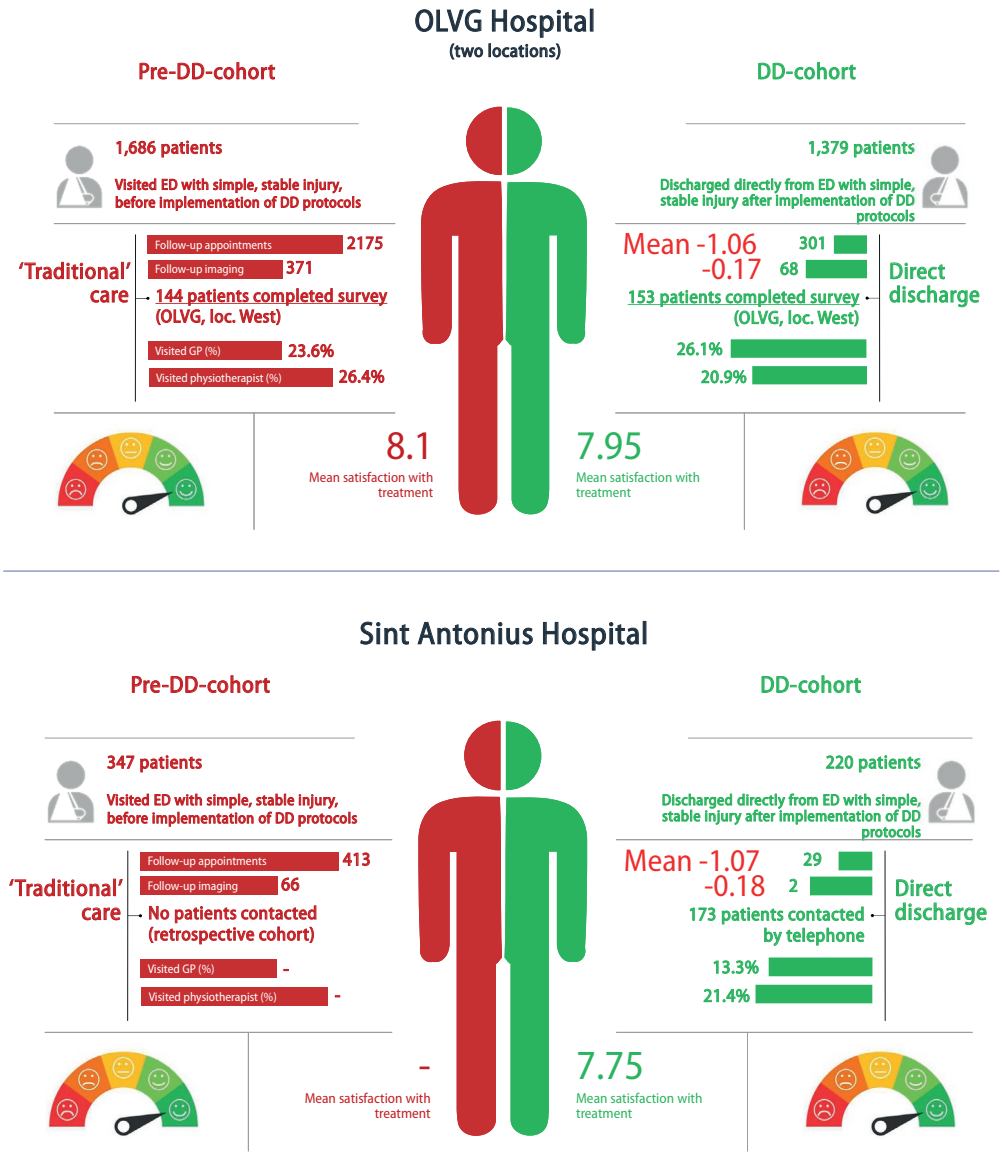


Figure 3 – Infographic providing a summary of the results of this study.
Patients were included in two hospitals before and after changing treatment protocols for eleven types of simple, stable musculoskeletal injuries. After treatment protocols were changed, patients with these injuries were no longer followed-up routinely, but discharged directly from the Emergency Department instead using self-removable orthoses and an available telephone helpline in case of questions or concerns. In Sint Antonius hospital, the pre-DD-cohort was included retrospectively and consequently it was not possible to assess primary healthcare utilization and satisfaction with treatment.
DD, Direct discharge; ED, Emergency Department; GP, General Practitioner; loc., location

DISCUSSION

The results of this study conducted in two Dutch hospitals confirm the results of the previous Dutch pilot study, i.e. that DD of patients with simple, stable musculoskeletal injuries from the ED reduces secondary healthcare utilization, without increasing primary healthcare utilization, while maintaining relatively high levels of satisfaction with treatment (i.e. mean ≥7.75). The reductions in follow-up appointments and imaging as well as the satisfaction with treatment scores were comparable in both hospitals, increasing the likelihood that DD will produce similar results in other (Dutch) hospitals as well. Moreover, our results indicate that DD works outside the UK, in a different healthcare system altogether. The authors therefore encourage clinicians worldwide to evaluate if treatment of simple, stable musculoskeletal in their hospital includes routine follow-up, and if so, to consider if DD might be a feasible alternative in their particular healthcare system.

This study builds on a previous study performed in OLVG, location West, and parts of the data of this previous study were reused in order to compare outcomes between two hospitals.[8] Herewith, we aimed to evaluate whether the concept of DD as developed initially by OLVG, provides comparable results if implemented in another Dutch hospital, i.e. a different hospital setting and different patient population. This is an important step, as various Dutch hospitals have accelerated the implementation of DD, or are currently preparing the implementation of DD, following the rapid increase in demand for remote care during the coronavirus pandemic, while the initial OLVG results had not yet been validated in a different Dutch hospital setting.[9-13] The current study also provides data regarding secondary healthcare utilization in both OLVG locations, and over a longer period of time compared to our previous study, hence within a much larger cohort, which in turn allowed for injury subgroup analysis. To illustrate, in our previous study, secondary healthcare utilization was assessed in 348 and 371 patients within the OLVG pre-DD-cohort and DD-cohort, respectively, while in the current study 1,686 and 1,369 patients were included in these two OLVG cohorts, respectively.

To our knowledge, apart from Mackenzie et al., no previous multi-injury study assessed the effects of DD on secondary healthcare utilization stratified per injury subgroup.[5] This is important, however, because a relatively high mean number of appointments for a specific injury would indicate that DD might not be as feasible for that specific type of injury. Our stratified analyses show that DD reduces secondary healthcare utilization for all injury subgroups, and that the mean number of follow-up appointments after DD was very low for all types of simple, stable musculoskeletal injuries. In both hospitals, this reduction was greatest among patients with a fifth metacarpal neck fracture or base of fifth metatarsal fracture, while the reduction was smallest for patients with a lesser fracture of the toe or mallet finger injury. For the mallet finger injury, a possible

explanation for the relatively high number of follow-up appointments in the DD-cohort is that patients are instructed to contact our telephone helpline in case their mallet splint needs replacement, either due to loosening of the splint following decreased swelling, or for hygienic purposes. For the lesser toe fracture, the fairly small reduction in appointments is most likely a result of the fact that patients with these injuries were already often, but not consistently, discharged from the ED without follow-up.

While this was not the aim of the current study, our stratified analyses per injury also provide the opportunity to directly compare the effects of DD on secondary healthcare utilization between the UK and the Netherlands. For example, in the study by Mackenzie et al., the mean number of follow-up appointments of patients with a fifth metatarsal base fracture in the pre-DD-cohort was 2.08, versus 0.33 after DD.[5] In our study, similar reductions were found. That is, in the pre-DD-cohort, the mean number of follow-up appointments was 2.20 and 2.55 for OLVG and SA, respectively, versus 0.22 and 0.35 appointments in the corresponding DD-cohorts. For radial head fractures, Mackenzie et al. reported a mean number of follow-up appointments of 1.25 before DD and 0.22 after DD, which is more or less comparable to our results: 1.29 (OLVG) and 1.50 (SA) in the pre-DD-cohort, versus 0.10 and 0.13 in the DD-cohort.[5] For fifth metacarpal fractures, Mackenzie et al. reported a mean number of follow-up appointments of 1.08 (pre-DD-cohort) versus 0.08 (DD-cohort), while in our study this was 1.94 and 2.00 (pre-DD-cohort) versus 0.21 and 0.00 in the OLVG and SA DD-cohorts, respectively.[5] This illustrates that DD is likely to produce comparable results in hospitals in other countries, even if healthcare systems are different.

Remarkably, the proportion of DD patients visiting a GP for the treatment of their injury in SA was nearly twice as low compared to OLVG. This might be attributed to the baseline difference in the types of injuries between both hospitals, which in turn was likely (at least partly) caused by a change in incidence of certain injuries while lockdown measures were in effect due to the coronavirus pandemic (i.e. only the SA DD-cohort was included during this period). To illustrate, the proportion of patients with paediatric fractures was higher in the SA DD-cohort, and we assume that these paediatric patients visit their GP less frequently, for example when compared to adult patients with a Weber A or avulsion type ankle fracture. It must also be noted that the lockdown itself might also be a reason for less frequent face-to-face GP visits. Nevertheless, primary healthcare utilization within the SA DD-cohort was low.

Strengths of the current study include that it assessed whether the effects of DD remain comparable within a larger cohort, as well as within another hospital that was not involved in the development of the concept, whereas sample sizes of the previous Dutch pilot study was relatively small (i.e. <800 patients) and performed in a single-centre.[7, 8] This indicates that the concept is scalable and this is an important step towards the

adoption of DD as standard-of-care.[17] Furthermore, to account for the non-randomised nature of this study, all effect measures were adjusted for the patients' propensity-score using regression models, in order to prevent confounding by indication.

This study also has several limitations. First, data regarding satisfaction and primary healthcare utilization were not available for the SA pre-DD-cohort. Consequently, for SA, it could not be assessed whether these outcomes changed following the implementation of DD. Second, data regarding satisfaction and primary healthcare utilization were available for a relatively small proportion of all patients and consequently no injury subgroup analyses could be performed for these outcomes. Moreover, while most effects were statistically significant, the injury subgroups of the SA cohorts were relatively small to perform stratified analyses of secondary healthcare utilization. Third, in OLVG, the last patient in the DD-cohort presented to the ED eleven months prior to the assessment of secondary healthcare utilization by EPR evaluation, while this was only six months in SA. However, we do not expect the conclusions of this study to change if these data would be reassessed in six months, as the vast majority of patients are no longer in follow-up after six months.

Future studies should focus on the comparison of adverse outcomes in the pre-DD-cohort and DD-cohort, including delayed union, non-union and secondary surgery rates, preferably per specific type of simple, stable injury. Furthermore, multiple hospitals are currently implementing DD, allowing standardized collection of data across these hospitals regarding, for example, satisfaction with treatment and functional outcome. Preferably, a multicentre/national database should be established to this end, as it is likely that this will be necessary to increase sample sizes to numbers that provide sufficient levels of power for subgroup analyses of patient-reported outcome and experience measures. These data could then be used to optimize treatment protocols, e.g. when indicating that, on average, patients within a certain age group return more frequently or have relatively low levels of satisfaction, after being discharged directly. A more qualitative approach in assessing patient experience might also help to further optimize DD, e.g. with regard to patient information and expectation management.

In conclusion, this study shows that DD from the ED of patients with simple, stable musculoskeletal injuries is likely to produce comparable results across multiple hospitals. That is, after implementing DD, secondary healthcare utilization of patients with simple, stable musculoskeletal injuries will likely reduce, without increasing primary healthcare utilization, while the patients' satisfaction levels with treatment remain high. Future studies should focus on tailoring the optimal treatment strategy to each individual patient by assessing if certain patient characteristics are predictive of (dis)satisfaction, levels of return for review, or adverse outcomes. This might be achieved more easily if multiple hospitals collect data cooperatively, and in a standardized manner.

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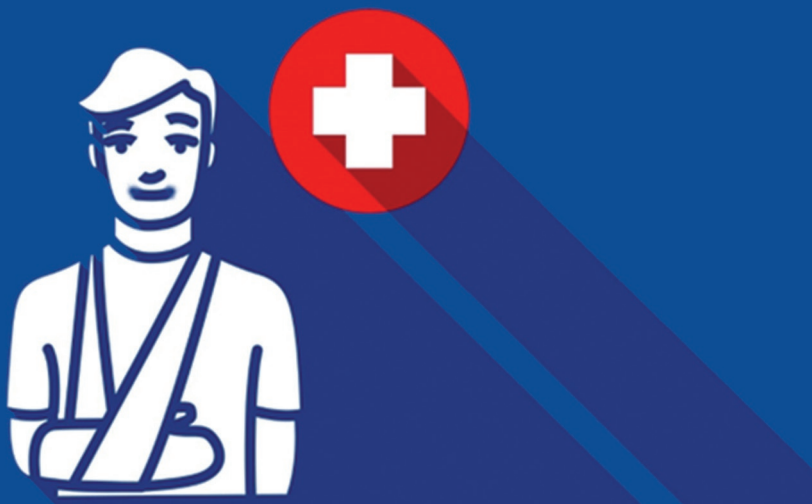
APPENDIX

Table A1 – Baseline characteristics of participants included in patient-reported experience outcome

	OLVG Hospital		Sint Antonius Hospital	
Characteristic	**Pre-DD (n = 144)**	**DD (n = 153)**	**Pre-DD (n = 0)**	**DD (n = 173)**
Age; median (IQR)	26 (11 – 55)	36 (13 – 54)	-	22 (9 – 51)
Age <18; n (%)	59 (41.0)	48 (31.4)	-	74 (42.8)
Gender male; n (%)	76 (52.8)	68 (44.4)	-	81 (46.8)
Type of injury; n (%)				
Paediatric clavicle Fx	8 (5.6)	8 (5.2)	-	14 (8.1)
Radial head-/neck Fx	24 (16.7)	28 (18.3)	-	21 (12.1)
Paediatric Fx distal radius	36 (25.0)	27 (17.7)		43 (24.9)
Fifth metacarpal neck Fx	6 (4.2)	1 (0.7)	-	6 (3.5)
Mallet finger	6 (4.2)	4 (2.6)	-	12 (6.9)
Weber A type ankle Fx	11 (7.6)	14 (9.2)	-	9 (5.2)
Avulsion type ankle Fx	8 (5.6)	12 (7.8)	-	13 (7.5)
Fx of fifth metatarsal base	17 (11.8)	20 (13.1)	-	19 (11.0)
Fx of greater toe	10 (6.9)	11 (7.2)	-	10 (5.8)
Fx of lesser toe	10 (6.9)	18 (11.8)	-	17 (9.8)
Bicycle spoke injury	8 (5.6)	10 (6.5)	-	9 (5.2)

DD, Direct Discharge; Fx, fracture; IQR, interquartile range.



OPTIMIZING ORTHOPAEDIC TRAUMA CARE DELIVERY DURING THE COVID-19 PANDEMIC

A closed-loop audit of implementing a virtual fracture clinic and fast-track pathway in a Dutch level 2 trauma center

7

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ABSTRACT

Background

Guidelines concerning outpatient management of patients during the coronavirus pandemic required minimized face-to-face follow-up, and increased remote-care. In response, we established a Virtual Fracture Clinic (VFC)-review for Emergency Department (ED) patients with musculoskeletal injuries, meaning patients are reviewed "virtually" the next workday by a multidisciplinary team, instead of routine referral for face-to-face fracture clinic review. Patients wait at home and are contacted afterwards to discuss treatment. Based on VFC-review, patients with minor injuries are discharged, while for other patients an extensive treatment plan is documented using injury-specific care-pathways. Additionally, we established an ED orthopaedic trauma fast-track to reduce waiting time. This study aimed to evaluate the extent to which our workflow supported adherence to national guidelines, and effects on ED waiting time.

Methods

A closed-loop audit was performed during two four-week periods, using predefined standards: 1) all eligible ED orthopaedic trauma patients are referred for VFC-review; 2) and reached afterwards; follow-up is 3) patient-initiated, or 4) performed remotely, whenever possible. Total ED waiting time, time-to-review; time-for-review; time-after-review were assessed during both audit periods and compared to previous measurements.

Results

Results are reported for first and second audit, respectively: 162 (88.0%) and 302 (98.4%) of eligible ED patients were referred for VFC-review, 98.1% and 99.0% were reached afterwards. Of the referred patients,17.9% and 13.6% were discharged "virtually", while 45.0% and 41.1% of scheduled follow-up appointments were remote. Median total ED waiting time reduced by -36 minutes ($p<0.001$) and -33 minutes ($p<0.001$). During the second audit, median time-to-review reduced by -13 minutes ($p<0.001$), as well as time-for-review: -10 minutes ($p=0.019$).

Conclusions

In line with national guidelines, our VFC-review allowed time-effective review and triage of the majority of ED orthopaedic trauma patients, supporting patient-initiated and remote follow-up, whenever possible. ED waiting time reduced following implementation of the VFC-review and orthopaedic trauma fast-track.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic was declared on 11 March 2020.[1] The guidelines that were implemented for the outpatient management of patients as a result of this pandemic,[2,3] required considerable and pragmatic revisions of established treatment protocols in orthopaedic trauma. This included patient-initiated follow-up to be the default, as well as minimizing the number of face-to-face appointments using tele- or video communication.[2,3]

The guidelines also prescribed that an attending physician should assess the medical indication and necessity of follow-up appointments, and indicate if these appointments should be conducted remotely or face-to-face.[2] However, this was not routine prior to the pandemic, since the majority of ED orthopaedic trauma patients were typically referred to a fracture clinic for further face-to-face review within a few days after their initial ED visit. After this appointment, a physician (often a junior resident) would then decide if and when a subsequent appointment was scheduled, using local protocols.

The Virtual Fracture Clinic (VFC) model was first established in 2011 in an effort to streamline outpatient management of orthopaedic trauma patients. The VFC model concerns all ED patients with musculoskeletal injuries who do not require acute admission. It consists of two main parts.[4,5] First, direct discharge from the ED of patients with simple stable injuries. This is supported by removable orthoses, a discharge leaflet and a telephone helpline. Second, all other patients with musculoskeletal injuries, are discharged to home and referred for a VFC-review on the next day. This is in contrast to the routine referral of all ED patients for face-to-face review at the fracture clinic. During the VFC-review on the next work day, all patients are reviewed "virtually". That is, the patient waits at home while a multidisciplinary team led by an orthopaedic consultant evaluates their case and outlines his or her treatment. The possible outcomes of the VFC-review include "virtual" discharge (i.e. no additional follow-up appointments), or follow-up in a nurse-led clinic or subspecialty clinic. All patients are contacted by telephone after VFC-review, to discuss their treatment and to schedule the corresponding appointments if applicable.[4,5]

Prior to the COVID-19 pandemic, our hospital had already implemented the first part of the VFC model, i.e. direct discharge from the ED of patients with simple stable injuries. During the first month of the coronavirus pandemic, our hospital accelerated the implementation of the second part of the VFC model, i.e. the VFC-review, since we anticipated the VFC-review to provide an opportunity to effectively adhere to the aforementioned coronavirus-related guidelines.[2,3] That is, if a proportion of the patients can be discharged "virtually", and a complete treatment plan is outlined during VFC-review for all patients, this might reduce the number of unnecessary and untimely (face-to-face) follow-up appointments. Additionally, to further alleviate the increasing

workload for our ED staff, and to minimize ED waiting-time for orthopaedic trauma patients, an orthopaedic trauma fast-track pathway was implemented in the ED. This involved the use of fast-track rooms adjacent to the ED and a dedicated fast-track team.

The aim of the current study was to evaluate whether implementation of a VFC-review supported our adherence to the guidelines for the outpatient management of patients during the coronavirus pandemic. Additionally, we evaluated the compliance to our new workflow (i.e. both VFC-review and ED fast-track pathway), and its effects on waiting-time in the ED, by performing a closed-loop audit.

METHODS

The Standards for Quality Improvement Reporting Excellence checklist was used while writing this manuscript.[6]

Design

This was a closed-loop audit performed in a Level-2 Trauma centre and teaching hospital in Amsterdam, the Netherlands.

Workflow

Table 1 and **Figure 1** provide information on the differences in workflow before and after implementing a VFC-review and ED orthopaedic trauma fast-track pathway. These changes were prepared during three weeks in March 2020, and implemented on 6 April 2020.

In our hospital, the following four categories of ED orthopaedic trauma patients are generally encountered and determine what steps are required by the ED staff before patients leave the ED: 1) patients requiring immediate admission to the ward (e.g. for surgery or for social care reasons; 2) patients requiring scheduled operative treatment (i.e. not immediately, but within the coming days/week); 3) conservatively treated patients requiring follow-up; 4) conservatively treated patients who do not require further follow-up (i.e. direct discharge from the ED).

Pre-change workflow

If immediate admission to the ward was required, the on-call orthopaedic consultant was contacted by the ED staff to admit the patient. If scheduled operative treatment was deemed necessary, the orthopaedic consultant was contacted as well, and management was decided and discussed in the ED. For these patients, follow-up appointments were scheduled post-operatively. Conservatively treated patients requiring follow-

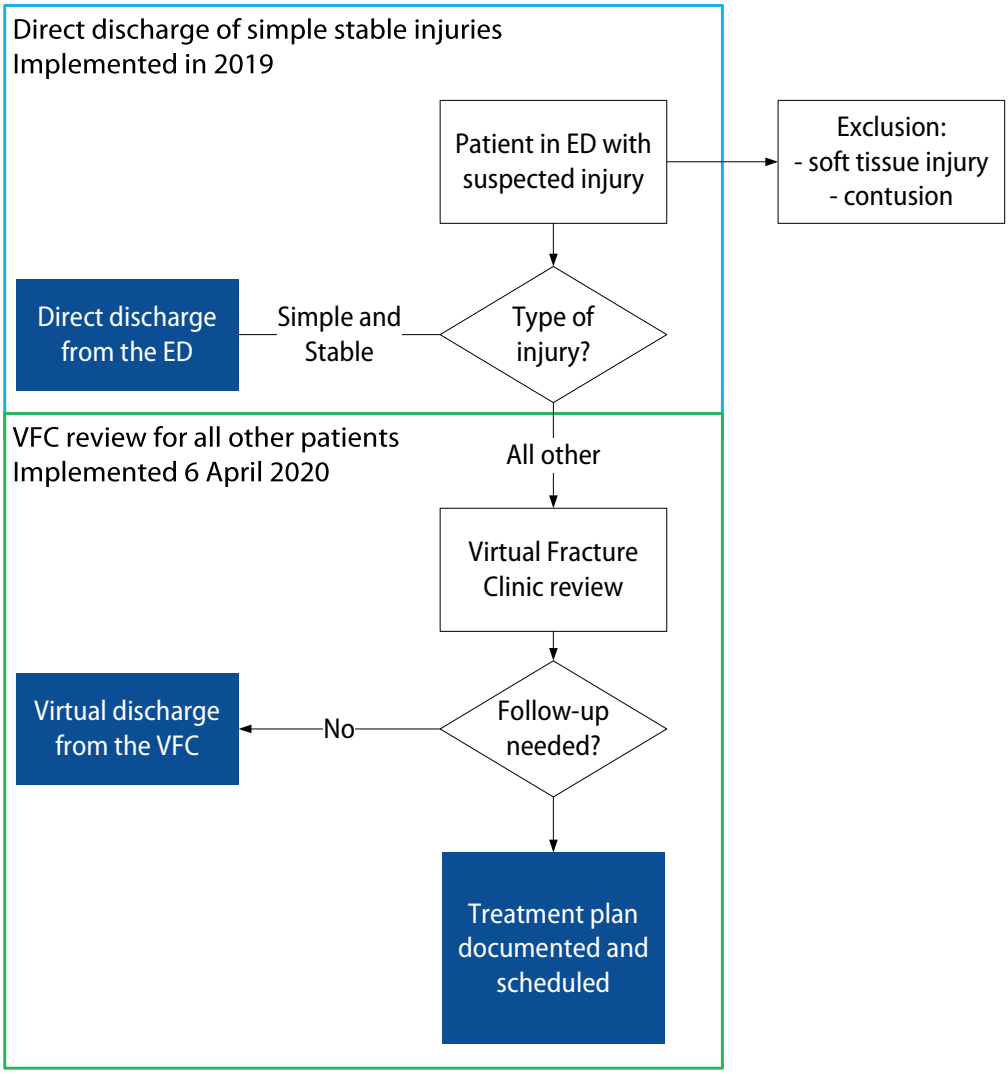

Figure 1 – Virtual Fracture Clinic model
ED, Emergency Department; VFC, Virtual Fracture Clinic. Blue square: direct discharge of patients with simple stable injuries from the ED. Green square: VFC-review of all other patients.

up were routinely referred to our fracture clinic, for face-to-face review and definitive management within approximately one week. For these patients, if necessary, any further follow-up appointments were scheduled after each subsequent follow-up appointment. Conservatively treated patients with injuries that did not require follow-up were discharged directly from the ED (**Figure 1**).

New workflow

If immediate admission to the ward was required, workflow did not change. If scheduled operative treatment was deemed necessary, patients were immobilized, discharged to home, and referred for VFC-review on the next workday. Conservatively treated patients requiring follow-up were also discharged to home and referred for VFC-review, instead of the routine referral of these patients to our fracture clinic for face-to-face review. For patients with injuries that did not require follow-up, workflow did not change.

During the VFC-review a multidisciplinary team evaluated the cases of all referrals. Possible outcomes of the VFC-review were: 1) "virtual" discharge for patients with relatively minor injuries. 2) conservative treatment, requiring follow-up, and 3) scheduled surgery within one to several days.

In its original UK version, the VFC team either "virtually" discharges patients or refers patients to a nurse-led clinic or subspecialty clinic for further treatment, where further follow-up appointments are scheduled after each subsequent follow-up appointment, i.e. a complete treatment plan is not documented.[4,5] However, our aim was to outline an extensive and complete supervised treatment plan during the VFC-review as well, since this was in line with national guidelines for the management of orthopaedic trauma patients during the coronavirus pandemic (i.e. to assess the necessity and indication of all follow-up appointments by an attending physician).[2] To this end, we integrated all our treatment protocols as care pathways into our electronic patient record (EPR) system. Our trauma team had reached consensus on these pathways by organizing consensus meetings shortly after national measures took effect in March 2020, using the national guidelines for the outpatient treatment of patients during the coronavirus pandemic, which required minimized face-to-face consultations and remote-care whenever possible.

During VFC-review, if necessary, the VFC team could make individual changes for each patient. This resulted in the documentation of an extensive, individual and supervised treatment plan for all patients who were not discharged "virtually", including an overview of the characteristics of all appointments; e.g. date, mode (face-to-face or remote review), radiological imaging (yes/no), instructions (e.g. specific assessments required and if or when supervision should be sought). If necessary, this treatment plan was updated based on the course of events throughout the patient's treatment.

After evaluation of all referrals was completed, patients were contacted by telephone to discuss and to reach agreement on their treatment plan. If applicable, admission and surgery was scheduled as well. If unable to reach the patient, a voicemail was recorded, and a letter was sent to the patient and their General Practitioner (GP).

An additional change was the implementation of an orthopaedic trauma fast-track pathway to minimize waiting-time in the ED. If deemed eligible for fast-track review and treatment by the triaging ED nurse, patients with suspected musculoskeletal injuries took place in a special fast-track waiting room. These patients were reviewed and

treated by a dedicated fast-track team in one of four 'fast-track' rooms adjacent to the ED. These rooms were used specifically for the rapid review and treatment of patients with suspected musculoskeletal injuries.

Table 1 – Changes to existing workflow

Name	Previous situation	Change
Treatment protocols	Local protocols based on national guidelines.	Local protocols were changed based on expert-opinion in consensus meetings using the following principles: face-to-face appointments are minimized; remote consultations are increasingly used; and follow-up imaging is performed only in case of a possible significant change in management.
Decision-making in the ED	In case of any uncertainty or concern, the ED staff contacts the orthopaedic consultant. Patients possibly requiring surgical treatment are always discussed with an orthopaedic consultant. All non-operative patients in the ED are immobilized and an appointment is scheduled for face-to-face review in the fracture clinic after approximately one week.	In case of uncertainty about the need for acute admission, or in case of any concern or questions that cannot wait until the next workday, the ED staff contacts the orthopaedic consultant. Patients that require acute admission for surgical treatment are always discussed with an orthopaedic consultant. Patients that require surgical treatment, but not acute admission, are referred for VFC-review on the next work day to be scheduled. All trauma patients are immobilized in the ED and referred for VFC-review on the next work day.
Virtual Fracture Clinic treatment plan	During the first fracture clinic appointment, the patient is assessed by a physician. Based on the assessment and the local protocols the physician decides if imaging is performed, if and when the next appointment will take place, and if further immobilization or change in management is necessary. This is repeated until discharge from follow-up.	A multidisciplinary specialist-led team documents an extensive treatment plan for each patient referred to the Virtual Fracture Clinic, using the protocols mentioned under 1) Treatment protocols. This includes all appointments, duration of immobilization, instructions on imaging and specific examination per appointment, if applicable.
Fast-track pathway in the ED	Patients are triaged by the ED triaging nurse and then take place in the ED waiting room. There is one ED team that reviews patients according to urgency priority order.	Four ED rooms are used as dedicated fast-track rooms, adjacent to the ED. Patients take place in a separate fast-track waiting room. The dedicated fast-track team continuously screens the waiting room for patients eligible for fast-track treatment.

ED, Emergency Department; VFC, Virtual Fracture Clinic;

Evaluation

To evaluate the level of compliance to our new workflow, a closed-loop audit was performed during two periods of four weeks (**Figure 2**). An audit is a quality improvement process that seeks to improve patient care through the systematic review of care against explicit standards, and the implementation of change.[7] It includes setting standards, testing practice against standards (first audit), and correcting practice where it falls short. The loop is then 'closed' by a re-audit (second audit) to confirm whether standards are met.[8]

Audit

Based on our consensus meetings and the guidelines for outpatient management during the pandemic,[2,3] the following audit standards were predefined:

- Standard 1: All eligible ED trauma patients should be referred to the VFC, allowing the VFC team to review, triage and outline an extensive treatment plan for all patients.
- Standard 2: After VFC-review, all patients should be contacted to discuss their individual treatment plan.
- Standard 3: If deemed possible by the VFC team, patient-initiated follow-up should be the default.
- Standard 4: Follow-up appointments should be delivered by telephone or video if possible.

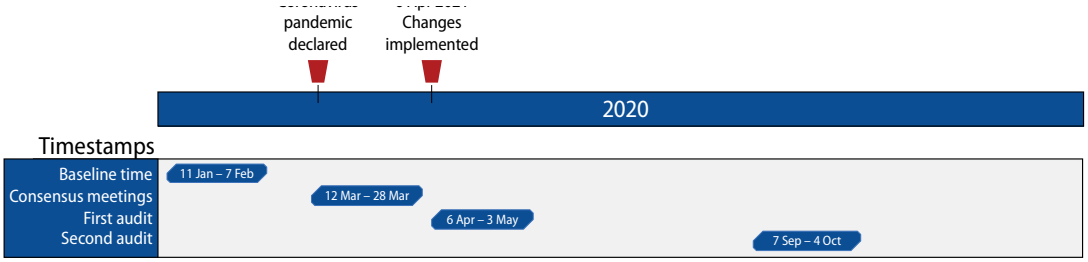

Figure 2 – Timeline of relevant dates and audit periods

All ED patients diagnosed with a fracture were considered for the audit. Exclusion criteria were: simple stable injury discharged directly from by the ED staff based on protocols that were in place prior to the pandemic (**Figure 1**); acute admission; and follow-up in a different hospital.

The first audit was performed between 6 April 2020 and 3 May 2020 and the second audit between 7 September 2020 and 4 October 2020. To assess the extent to which our audit standards were met during both audit periods (i.e. compliance), all patients presenting to our ED with a suspected fracture were reviewed daily.

Waiting-times

Prior to the pandemic, i.e. in January 2020 (**Figure 2**), two researchers performed stopwatch waiting-time measurements of ED patients with a suspected fracture, including measurements on four weekdays and one day in the weekend. Patients provided verbal consent upon arrival. One patient was followed at a time. Per patient, the total ED waiting-time, as well as three subprocesses were recorded (**Table S1**). Timestamps of the subprocesses were: 1) time from entering the ED until the patient's

first contact with physician (time to review); 2) time from the patient's first contact with a physician until the formulation of the final decision and the start of immobilization (time for review and decision-making); and 3) time from the start of immobilization until leaving the ED (time after review). These time measurements served as baseline.

During both audit periods, time measurements were performed similarly (i.e. on four weekdays and one day in the weekend, following one patient at a time). To assess the effects of implementing the VFC-review and orthopaedic trauma fast-track pathway on ED waiting-time, we compared the waiting-times of the first and second audit to the baseline measurements (i.e. those conducted prior to the pandemic), respectively.

Additionally, per patient, the total time needed for VFC-review, including contacting the patient by telephone afterwards, was measured during both audit periods.

Evaluation in between audits

After the first audit, staff of all involved departments were invited to attend a meeting to evaluate the new workflow based on their experiences and the gathered data. This was used to define further optimizations of the workflow prior to the second audit.

Statistical analysis

Statistical analysis was performed using SPSS version 21. Descriptive statistics were used to assess compliance to our new workflow, and the extent to which our predefined audit standards were met. Waiting-times were reported as median. Both audit periods were compared to the baseline measurements using the Mann-Whitney U test. A p-value of <0.05 was considered statistically significant.

Patient and public involvement

Patients were not involved in design, intervention, research question, or outcome measures.

Ethics

Ethics review was not sought because the study was deemed an improvement activity and not human subjects research.

RESULTS

First audit – April 2020

In total, 184 patients with a fracture were eligible for VFC-review during the first audit.

- First standard: 162 of 184 eligible patients (compliance: 88.0%) were referred for VFC-review by the ED staff. More information (e.g. additional imaging) was needed in six patients (3.3%) before a treatment plan could be made.
- Second standard: after VFC-review, nineteen of 162 patients (11.7%) could not be contacted immediately. Of these patients, sixteen (9.9%) contacted the VFC team after being requested to do so via voicemail. The other three patients (1.9%) could not be reached. A letter was sent to the patient and their GP, requesting to contact the hospital.
- Third standard: of the 162 patients reviewed, the VFC team discharged 29 patients (17.9%, **Table 2**).
- Fourth standard: the treatment plans of all patients totalled 291 appointments, 137 (45.0%) of which to be conducted remotely.

Table 2 – Patients 'virtually' discharged after VFC-review during first audit

Injury	Number of patients; n	Proportion of all (n = 162); %
Misdiagnosed fracture (e.g. contusion)	4	2.5
Acromio-clavicular luxation Tossy type 1 or 2	5	3.1
Avulsion fracture of the distal radius	1	0.6
Avulsion fracture of the finger	4	2.5
Distorted knee	2	1.2
Primary dislocation of the shoulder	10	6.2
Volar plate injury	3	1.9
Total	29	17.9

Waiting-time

Of all patients presenting to our ED with a suspected fracture, 88% were treated in the fast-track rooms. Waiting-time was measured in 77 patients during the first audit, and compared to baseline measurements performed in 131 patients prior to the pandemic. The median total time per patient, from entering the ED until leaving the ED was 95 minutes during the audit, compared to 131 minutes in January (**Figure 3** and **Table S2**; $p < 0.001$). Time to review was 30 minutes during the audit, compared to 60 minutes in January ($p < 0.001$). Time for review was 42 minutes during the audit, and 45 minutes in January ($p = 0.506$). During the first audit, the median time needed for VFC-review was 9 minutes per patient.

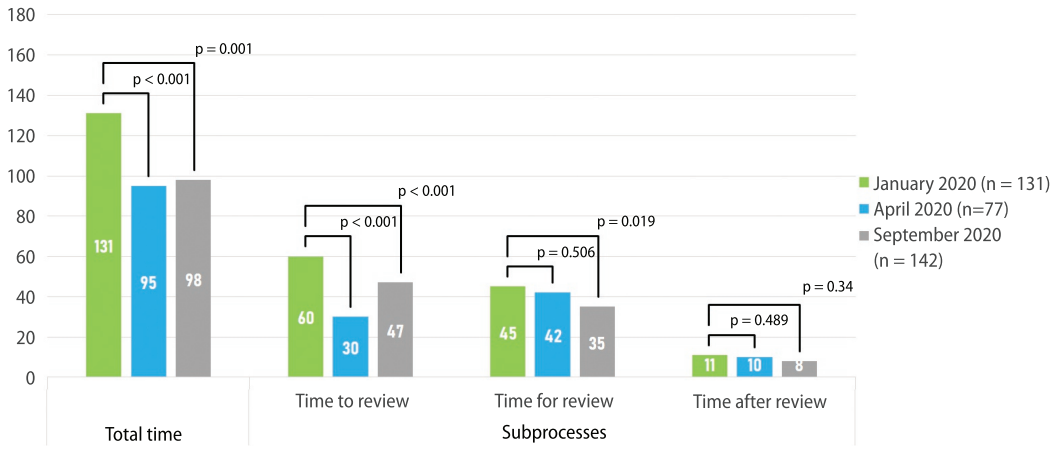

Figure 3 – Median time spent in the ED in minutes during baseline, first audit and second audit period
Mann-Whitney U test was used to compare the first audit in (April 2020, orange bars) and the second audit period (September 2020, grey bars) to baseline (January 2020, blue bars), respectively. A p-value <0.05 was deemed statistically significant.

Optimizations after evaluation of first audit

ED staff were invited to be present during the VFC-review if their time allowed. We expected this would improve the completeness of their documentation in the ED, as well as their compliance (e.g. only 88% of eligible patients were referred for VFC-review while the standard was 100%), as feedback could be provided directly. Furthermore, we expected the VFC workflow would postpone the often-lengthy process of decision-making and supervision of orthopaedic trauma patients in the ED. However, time for review and decision-making did not decrease. The ED staff noted it was not always clear if a case should be referred for VFC-review, or discussed directly. Therefore, multiple presentations were held explaining the workflow, and posters depicting the workflow were provided in the ED. An information leaflet was developed and provided to the patient at discharge, which requested patients to contact the hospital if not contacted by 3pm on the next work day.

Furthermore, we expected our time comparisons were biased by the low volume of patients in April 2020 (**Figure S1**). Therefore, we wanted to perform the second audit once the patient volume was more comparable to January 2020, hence also more representative of a non-COVID situation. We evaluated patient volume monthly and found patient volume in August 2020 to be comparable to 2019 (**Figure S1**). Therefore, the second audit started on 7 September 2020. To illustrate, in September 2019 there were 1,123 trauma patients that presented to our ED with suspected injuries, compared to 1,069 in September 2020 (**Figure S1**).

Second audit – September 2020

In total, 305 patients with a fracture were eligible for VFC-review during the second audit.

- First standard: 302 of 305 (compliance: 98.4%) eligible patients were referred for VFC-review by the ED staff. More information (e.g. additional imaging) was needed in eleven patients (3.6%), before a definitive treatment plan could be made.
- Second standard: after VFC-review, thirteen of 305 patients (4.3%) could not be contacted immediately. Of these patients, ten (3.3%) contacted the VFC team after being requested to do so via voicemail. The other three patients (1.0%) could not be reached. A letter was sent to their GP, and to the patient requesting to contact the hospital.
- Third standard: of the 302 patients reviewed, the VFC team discharged 41 patients (13.6%, **Table 3**).
- Fourth standard: the treatment plans of all patients totalled 436 appointments, 179 of which (41.1%) to be conducted remotely.

Table 3 – Patients 'virtually' discharged after VFC-review during second audit

Injury	Number of patients; n	Proportion of all (n = 302); %
Misdiagnosed fracture (e.g. contusion)	3	1.0
Acromio-clavicular luxation Tossy type 1 or 2	2	0.7
Avulsion/minor fracture of the finger	5	1.7
Avulsion/minor fracture of a metacarpal bone	3	1.0
Avulsion fracture of the ankle	1	0.3
Avulsion fracture after luxation of a toe	3	1.0
Bicycle spoke injury	3	1.0
Primary dislocation of the shoulder	15	5.0
Mason type 2 radial head fracture	1	0.3
Salter-Harris type 1 or 2 fracture of the distal radius	2	0.7
Salter-Harris type 1 fracture of the proximal humerus	1	0.3
Volar plate injury	2	0.7
Total	41	13.6

Waiting-time

Of all patients that presented to our ED with a suspected fracture during the second audit, 92% were treated in the fast-track rooms. Waiting-time was measured in 142 patients during the second audit. Total time was 98 minutes per patient (-33 minutes, $p = 0.001$ compared to January 2020). Time to review was 47 minutes (-13 minutes, $p < 0.001$ compared to January 2020). Time for review was 35 minutes during the second audit, compared to 45 minutes in January ($p = 0.019$). During the second audit, the median time needed for VFC-review was 7 minutes per patient.

DISCUSSION

This study showed that once the new workflow had settled in, the implementation of a Virtual Fracture Clinic (VFC) review on work days allowed the VFC team to review, triage and outline a treatment plan for 98.4% of ED orthopaedic trauma patients. Prior to the implementation of the VFC-review, all of these patients would have been referred for face-to-face review in our fracture clinic.[2] Instead, the VFC team discharged 17.9% and 13.6% of these patients "virtually", and therefore seems to have reduced the number of unnecessary face-to-face reviews of these patients during the first and second audit, respectively. Moreover, an extensive treatment plan was documented for all other patients, which is in line with national guidelines for the outpatient management of patients during the coronavirus pandemic.[2,3] Hence, our study indicates that a VFC-review can be established in three weeks with a relatively high level of compliance.

To our knowledge, this is the first study conducted outside the United Kingdom (UK) to describe the implementation and effects of a VFC-review.[9] According to the original UK VFC model, the VFC team either discharges patients "virtually", or refers patients to a nurse-led clinic or subspecialty clinic for further treatment.[4,5] The reviewing nurse or physician then decides on further follow-up during that subsequent clinic visit. However, we were of the opinion that such a set-up is prone to high levels of treatment variation. Furthermore, national guidelines for the outpatient treatment of patients during the pandemic, required the necessity and mode (e.g. face-to-face or remote) of each follow-up appointment to be evaluated by an attending physician. For these reasons, in addition to the original UK VFC model, our VFC-review included the documentation of an extensive and complete treatment plan for each patient. To this end, we established special care pathways shortly after the coronavirus pandemic was declared, that were based on the principles in the national guidelines, i.e. requiring minimized consultations and increased remote care during the pandemic.[2,3]

Previous studies have reported "virtual" discharge rates ranging from 11.1% to 26.4%.[4,5] Our virtual discharge rate was 17.9% and 13.6% during the first and second audit, respectively. Differences in these numbers across hospitals are most likely caused by a difference in the number of simple stable injuries that are discharged directly by ED staff,[10] i.e. the larger the number of injuries discharged directly from the ED, the smaller the number of injuries that can be discharged "virtually" after VFC-review. Furthermore, the extent to which removable immobilization is used in the ED also determines whether patients can be "virtually" discharged, or not. When revising our treatment protocols based on national guidelines, we did not make any changes to the immobilization materials used in the ED. Therefore, in the future, increased use of removable orthoses in the ED can further eliminate the need of cast removal, which in turn might allow even more patients to be discharged "virtually" after VFC-review.

For all these reasons, our VFC-review supported the adherence to national guidelines for the outpatient treatment of patients during the coronavirus pandemic. To illustrate, we evaluated the necessity of each (face-to-face) appointment by documenting an extensive VFC treatment plan for each patient, and we minimized face-to-face review whenever possible through the VFC treatment plan as well as by "virtually" discharging patients with minor injuries. Moreover, while not part of the current study, we assume that the documentation of an extensive treatment plan also reduces treatment variation and untimely or unnecessary appointments and imaging during further follow-up.

It is worth noting that, while numbers were low, a small proportion of patients could not be contacted after VFC-review. Despite the safety netting that includes a discharge leaflet, voicemail and letter to the GP, one patient (male, clavicle fracture) had not contacted our hospital at all, a few weeks after the last VFC-review in September 2020. It is also important to consider that the number of patients that cannot be reached after VFC-review might be higher in other countries (i.e. compared to the Netherlands or UK), particularly those with limited cellular phone saturation. If this would be the case, a possible solution would be to refer the patient to the fracture clinic for face-to-face review, while a VFC team would still document an extensive treatment plan for all patients on the first work day after the ED visit. This would eliminate the need for a telephone call after VFC-review, while we expect that the documentation of an extensive treatment plan would then still reduce treatment variation and unnecessary appointments.

Another aim of the VFC-review (i.e. postponing decision-making to the next work day) and the orthopaedic trauma fast-track pathway, was to alleviate ED workload and minimize ED waiting-time. We found that the total time spent by the patient in the ED was decreased by 36 minutes and 33 minutes during the first and second audit, respectively, compared to baseline measurements performed before any changes were in effect. Time to review was reduced from 60 minutes (baseline) to 30 minutes during the first audit. Once patient volume was comparable during the second audit, this increased to 47 minutes. However, this is still a statistically significant median reduction of 13 minutes per patient compared to the baseline measurements.

Furthermore, during the second audit, the time spent by the ED physician for review and decision-making decreased by 10 minutes (from 45 minutes to 35 minutes) compared to the baseline. The median time needed for VFC-review on the next work day was 7 minutes per patient. Hence, the VFC pathway is time-effective compared to direct supervision in the ED, with the benefit of an extensive treatment plan that is explained to the patient in detail. This also allows ED physicians to spend time on reviewing other patients or performing different tasks.

This study has several limitations. First, time measurements were performed during the COVID-19 pandemic. While we performed the second audit once patient volume normalized, it is unclear if the time-effectiveness will be comparable to a non-COVID scenario. Second, this was a study focusing on the compliance to our new workflow and its effects on waiting-time in the ED. Therefore, we did not study if the treatment plans were followed in the subsequent months, nor did we study patient outcome or experience. Last, workflow, treatment protocols or cellular phone usage might be different in other countries or even across hospitals within a country, and therefore generalizability of our results should be tested. We do expect, however, that the documentation of an extensive and tailored treatment plan for each individual patient shortly after the initial ED assessment is a generalizable concept that will improve care in most current settings.

Based on these first results, our hospital will continue to use and evaluate this new workflow. Future studies should assess the extent to which the VFC treatment plans are followed throughout the patient's treatment, and whether the documentation of this extensive plan reduces treatment variation, as well as untimely and unnecessary follow-up appointments and imaging. Furthermore, studies should assess patient outcome and experience, ultimately providing evidence on the model's (cost-)effectiveness.

In conclusion, this is the first study outside the UK to describe the use of the VFC model to streamline outpatient trauma care during the coronavirus pandemic. Without previous experience, the VFC was implemented with high compliance, despite being established in a quick response to national guidelines. The VFC allowed us to review, triage, and outline an extensive treatment plan using agreed upon care pathways for the majority of ED orthopaedic trauma patients during the coronavirus pandemic, under direct supervision of the attending physician, while being time-effective. This supported adherence to national guidelines for the outpatient treatment of patients during the coronavirus pandemic. We assume this process will also reduce treatment variation and will minimize unnecessary or untimely appointments and imaging, that is likely to also be of value in a post-pandemic scenario. Future comparative studies, including follow-up of the patients reviewed, are needed to further assess this.

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APPENDIX

Table S1 – Recorded timestamps before and during the audit

Process	Timestamp	Comment
Total time from arrival until leaving the hospital	Total waiting time	
Subprocesses		
Time from arrival in the Emergency Department to first contact with physician	Time to review	This included registration and triage. After triage the patient takes place in the waiting room until a clinician is ready to review the patient.
Time from first contact with physician until decision- making complete, and immobilization started	Time for review and decision-making	
Time from immobilization started until leaving the hospital	Time after review	

Table S2 – Median time spent in the ED during baseline, first audit and second audit period

	First audit; minutes			Second audit; minutes	
Timestamp	January 2020; (n = 131)	April 2020; (n = 77)	Sig.	September 2020; (n = 142)	Sig.
Total time; median (i.q.r.)	131 (96 – 165)	95 (64 – 128)	<0.001	98 (73 – 133)	0.001
Subprocesses					
Entering – first contact with physician	60 (34 – 87)	30 (19 – 44)	<0.001	47 (25 – 63)	<0.001
First contact – start immobilization	45 (23 – 80)	42 (22 – 70)	0.506	35 (20 – 60)	0.019
Start immobilization - leaving	11 (4 – 24)	10 (6 – 16)	0.489	8 (3 – 16)	0.34

Mann-Whitney U test was used to compare time measurements of April to January and September to January. i.q.r., interquartile range; Sig., Significance.

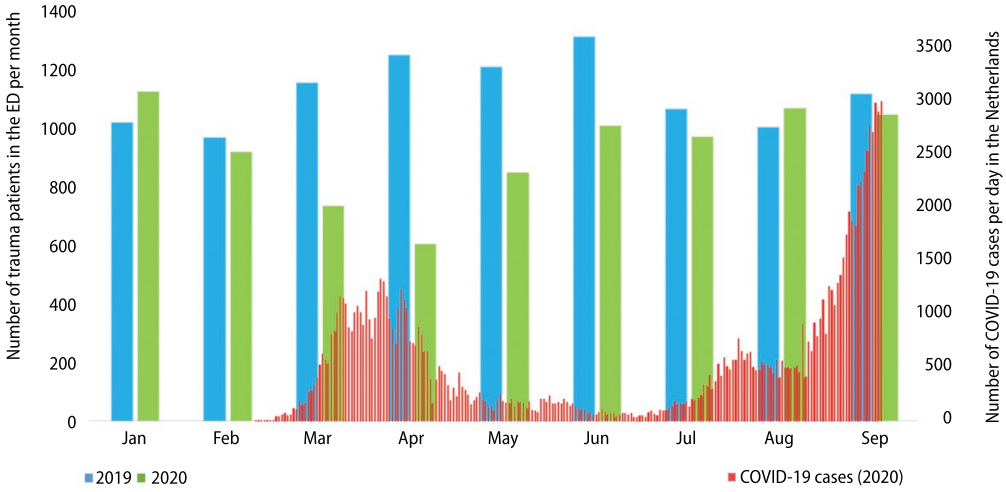
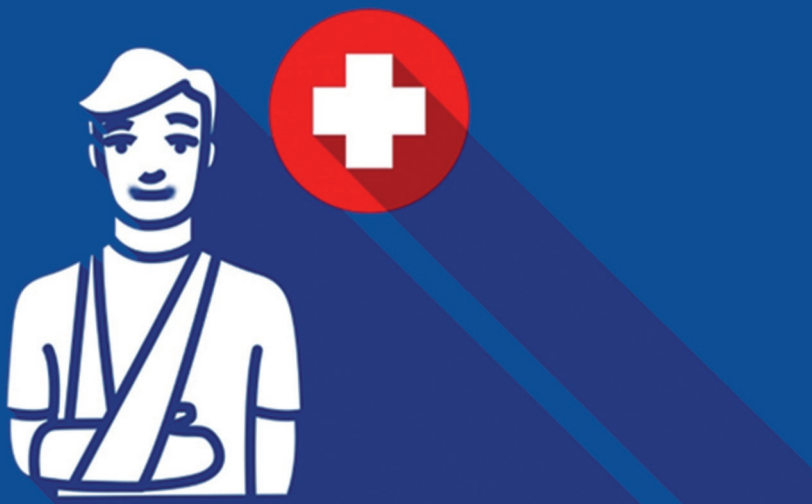


Figure S1 – the number of patients with suspected injuries presenting to our ED in 2019 and 2020 per month, and COVID-19 cases per day in the Netherlands. Blue bars, number of presentations in 2019; Green bars, number of presentations in 2020; Red bars, number of COVID-19 cases per day; ED, Emergency Department.



CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS FOR FUTURE RESEARCH AND PRACTICE

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS FOR FUTURE RESEARCH AND PRACTICE

To ensure that high-quality healthcare can still be provided in the future, a change in healthcare capacity and resources is warranted.[1] However, with the current shortage of healthcare staff, which is expected to increase even further in the near future, a simple workforce expansion is not an option to meet these demands. Consequently, across all medical fields of medicine initiatives are implemented with the aim to change the way our healthcare is provided, i.e. these initiatives promote patient-centred and patient-initiated care that is virtual whenever appropriate, ambulatory, supported by medical technology, and value-based.[2] An important step towards "future-proof" healthcare is likely best achieved by policies that promote providing only healthcare if and when it is necessary, i.e. at the right place and at the right time. In other words, by evaluating whether low-value care – or healthcare services and practices that are of limited or no benefit to patients – can be de-implemented from our current systems.[3]

This thesis was centred around the efficiency and effectiveness of the treatment and follow-up of patients with musculoskeletal injuries in the Netherlands. The primary aim of this work was to assess whether Dutch patients with relatively simple, stable musculoskeletal injuries can be treated more effectively and efficiently, by implementing a direct discharge (DD) system for eleven simple, stable injuries in the Netherlands (SSIs). That is, after implementing DD patients with these injuries are discharged from the Emergency Department (ED) without scheduling any further routine follow-up appointments. We assessed the potential benefits of DD by comparing DD to routine follow-up in terms of healthcare utilization and costs, while also assessing whether after DD there was a change in patient experience, patient outcome or complication rate.

Moreover, to optimize treatment of all other patients with musculoskeletal injuries (i.e. patients with injuries not eligible for DD), a daily consultant-led Virtual Fracture Clinic (VFC) review is introduced in the last chapter of this thesis. In our opinion, this review could play a pivotal role in a future reorganization of trauma care in our country. This will be further outlined in the recommendations for future research and clinical practice.

This discussion is divided in two parts. The first part is about DD from the ED of patients with SSIs. The second part is about the VFC-review.

DIRECT DISCHARGE FROM THE EMERGENCY DEPARTMENT OF PATIENTS WITH SIMPLE, STABLE INJURIES

Part I – Current evidence and use of direct discharge of simple stable injuries

Traditionally, in the Netherlands, patients with minor musculoskeletal injuries are usually followed-up one or two times in an outpatient clinic. This might have various reasons, including cast replacement or removal, providing instructions, answering questions, monitoring recovery, fear of litigations, and/or financial incentives. However, recent studies suggested that the functional outcome of patients with minor musculoskeletal injuries who are treated using bandage or an orthosis, is comparable to that of patients with similar injuries treated with a cast.[4-9] Other studies indicated that the majority of patients with minor injuries would prefer optional follow-up instead of routine follow-up.[10, 11] A next step would be to study whether routine follow-up of patients with these injuries is necessary at all. This is based on the assumption that patients who require additional guidance and/or patients who have persisting issues with their injury will contact the hospital themselves if necessary.

Chapter 1 provided a summary of all studies available prior to the work in this thesis, regarding the DD from the ED of patients with SSIs. The study focussed on logistic outcomes, functional outcome, patient satisfaction and costs. We identified twenty-six studies and concluded that DD of several SSIs seems to be an effective alternative to routine follow-up, which does not seem to compromise patient outcome. That is, DD seems to reduce the number of follow-up appointments and costs, while levels of patient's satisfaction, functional outcome and adverse outcomes remain the same compared to patients who are followed-up routinely in a fracture clinic. In other words, it is in concordance with VBHC.

The results of **Chapter 1** suggest that studies on DD can be divided into two groups: 1) studies at the institutional-level, and 2) patient-level follow-up studies. The majority of the studies at an institutional-level are non-comparative process evaluations assessing the implementation of (parts of) the Virtual Fracture Clinic (VFC) model.[12-16] These studies typically included relatively large numbers of patients, and only provided descriptive process-related information, such as on the distribution of patients across the VFC model (e.g. the proportion of all ED patients discharge directly), without providing any process-related outcomes, such as number of follow-up appointments, or patient-reported outcomes, such as satisfaction with treatment or functional outcome.

When adding up all patients in the 26 studies that were identified in our systematic review, 'only' 2,137 patients were included in the DD cohort to assess patient-level outcomes such as number of follow-up appointments, with even smaller sample sizes for patient-reported outcomes, such as satisfaction with treatment or functional outcome. This is in contrast to the number of patients reported in the institutional-level studies.

For example, Glasgow Royal Infirmary reported to have discharged 3,802 patients with SSIs directly from their ED in the first year alone,[17] while a later study reported that 30,000 patients were treated successfully since the implementation of their "Virtual Fracture Clinic" (VFC) pathway, 65% of which were discharged directly. No patient-level data such as number of appointments or satisfaction was reported.[18] This is similar to a study by White et al., who reported to have discharged 3,222 of 12,069 patients directly (26.7%), without providing patient-level data.[16] In other words, despite the relatively small amount of patient-level data that can be found in the literature, it seems that relatively large numbers of patients are already treated by DD. However, more extensive patient-level data including patient-reported outcomes and experiences are needed to strengthen the evidence of the safety and feasibility of DD, and in order for policymakers to consider changing their treatment protocols, especially in countries other than the UK.

It must also be noted that there was a high level of clinical and methodological heterogeneity in the studies included in **Chapter 1**. That is, while some studies included a single type of injury, others included multiple injuries. On top of that, many studies did not have a control cohort, and a large proportion of the included studies lacked a clear description of the criteria for a patient's injury to be eligible for DD (e.g. "minor", "stable"). Moreover, only one study assessed all of our predefined outcomes of interest, i.e. logistic outcome, functional outcome, patient satisfaction and costs,[11] while all other studies only reported some of them. On top of that, there was a large variety in how other patient-reported outcomes/experiences were measured, with assessment instruments ranging from Likert scales, simple yes/no questions, and 1-10 rating scales. Furthermore, the majority of the studies were performed in the UK. Altogether, from a scientific point of view this hampered the generalizability and pooling of our results, while from a practical point of view it complicates implementation and external validation of DD in other hospitals, especially in countries other than the United Kingdom (UK) with different healthcare systems. This might be one of the reasons why in **Chapter 2** we found that DD has not been widely adopted among (orthopaedic) trauma surgeons internationally. Moreover, based on the data in this chapter we can conclude that there is still a considerable practice variation in the treatment of these common injuries, with a low level of clinical agreement. This variation might indicate that care is provided inefficiently and hence that healthcare costs might be unnecessarily high, and it suggests that it is currently not clear how to optimally treat patients with SSIs.

There might also be several other reasons or considerations for reviewing a patient with an SSI at the outpatient clinic, such as hospital setting (i.e. rural or not), impeding patient characteristics, legal reasons or financial reasons, such as existing healthcare payment models that financially reward follow-up. We did not study the respondents' motives and considerations, while this information could have given us more insight into

why practice variation exists and therefore would have been valuable in an attempt to reduce variation.

Other factors that might serve as a barrier to initiate the changes necessary for a successful implementation of DD include the investment of time and costs needed to create a suitable DD system. Promoting sharing of information and cooperation between hospitals will lower these barriers and increase the opportunity for other hospitals to adopt their own DD system. Several UK institutions have already shared their information, knowledge and experiences online to be used as a basis for implementation in other hospitals (e.g. www.fractureclinicredesign.org). The preparation and implementation of DD in our hospital took approximately nine months. Based on our experiences, we developed a Dutch guide that can be used by other Dutch hospitals to implement DD. This also includes the sharing of all our treatment protocols, discharge leaflets etcetera. Currently, thirteen hospitals have already implemented DD using the information provided by us, and on average, implementation in these hospitals took approximately three months.

Part II – (Cost-)effectiveness of direct discharge of patients with simple stable injuries in the netherlands

Chapter 3 reports on the preliminary results of our pilot. These results were promising in that they indicated that DD could be implemented with a high level of protocol compliance, that DD had relatively large effects on secondary healthcare utilization (e.g. -92% outpatient clinic visits), and that a large proportion of patients were satisfied with this type of treatment. To our knowledge, this was the first study regarding DD of SSIs performed in the Netherlands.

In **Chapter 3** we measured outcomes in ED patients with SSIs three months before and after the implementation of DD in our hospital, amongst two relatively small cohorts and a follow-up duration that was – unfortunately – not long enough to assess adverse outcomes or complications. **Chapter 4** is based on similar data, but on a more extensive set of outcomes, a larger cohort, and a longer follow-up duration, which – amongst others enabled us to assess adverse outcomes. Using pre-defined non-inferiority margins we concluded that in our Dutch hospital, DD from the ED of patients with SSIs was non-inferior to "traditional" care with routine follow-up in terms of patients' satisfaction and functional outcome. To our knowledge, this is the first study to do so. Furthermore, while randomization at an individual patient-level might be infeasible when assessing the impact of new care models like DD, to our knowledge no previous non-randomized studies on DD have attempted to reduce the impact of "selection bias" using statistical methods such as the propensity-score adjustment that was used in the current study.

An important strength of this study is that a wide range of outcomes was evaluated using a before-and-after design, including hospital visits, imaging, satisfaction, functional

outcome, and adverse outcomes. Consequently, our study provides both institutional-level information (e.g. number of patients, protocol-compliance and telephone helpline use), as well as patient-level data of DD regarding the patients' healthcare utilization, PROMs and PREMs. This is in contrast to the majority of previous studies (see **Chapter 3**).

As explained before, we implemented DD for eleven types of SSIs. In this study we were able to assess all of these injuries as one group. We had to do so because injury subgroups were too small to perform subgroup analyses. Based on the results of **Chapter 3** we therefore cannot indefinitely conclude that DD is effective and safe for each of the eleven individual SSIs that were included in this study. Therefore, an important recommendation provided in this chapter was that future studies should include a larger number of patients to confirm the feasibility of DD for each injury. To include the required number of patients for such analyses we deemed it to be necessary to perform multicentre studies. If injury subgroups are large enough, stratified analyses could be performed based on, for example, age or co-morbidities. This might allow more fine-tuning of the DD protocols, i.e. if these analyses indicate that patients above a certain age need more guidance during recovery. Last, future studies should evaluate if DD is suitable for other injuries, including paediatric injuries.

Chapter 5 was based on the same data as **Chapter 4,** but the aim of this chapter was to assess the cost-effectiveness of DD versus traditional care with routine follow-up. Four effect measures were used (i.e. health-related quality of life (HR-QoL assessed by the EQ-5D tool), disease specific HR-QoL (assessed using validated functional outcome questionnaires), satisfaction with treatment (VAS 1-10) and pain (VAS 1-10)). Costs were estimated from the societal perspective. Our results indicated that DD is cost-effective when compared to "traditional" care with routine-follow-up for HR-QoL disease specific HR-QoL and pain. For satisfaction with treatment, on average, DD was less costly, but also less effective compared with traditional care. It is noteworthy however, that the mean difference in satisfaction with treatment was 0.16 on a 1-10 scale in favour of the pre-DD-cohort,[19] which is far from clinically relevant as the minimally clinical important difference for this outcome is estimated at 0.7. Furthermore, in both cohorts there were relatively high levels of satisfaction, e.g. the mean satisfaction with treatment in the DD-cohort was 7.95.[19]

The results of **Chapter 5** also indicated that DD can reduce absenteeism, primary healthcare, secondary healthcare, and travel costs. If DD would become the standard of care in the Netherlands, this could potentially result in a national societal cost saving of EUR 70 million per year. This includes an annual reduction of EUR 14 million in direct healthcare costs and EUR 54.8 million lost productivity costs. While this is a relatively small proportion of the total annual societal costs of injuries (EUR 3.8 billion),[20] it is also important to consider the additional logistical benefits of DD. That is, in our study on the effectiveness of DD we estimated that national adoption of DD would prevent approximately 142,800 outpatient clinic visits per year.[19]

In conclusion, as a large proportion of musculoskeletal injuries are SSIs, the implementation of DD offers an opportunity to respond to the increasing demands, high workloads, and costs in healthcare and orthopaedic trauma in particular. This is in line with the VBHC concept, and might be necessary to guarantee future high-quality trauma care. After the studies in this chapter were performed, our next aim was to assess whether the DD concept as developed in our hospital (i.e. OLVG) would also be transferable to other hospitals in the Netherlands.

Part III (a) – Upscaling virtual fracture care

Chapter 6 is the last chapter in this thesis regarding DD of SSIs. In this chapter, we studied the effects of DD within a larger cohort of patients in our own hospital, and in another Dutch hospital. By doing so, we assessed the transferability of our concept to other Dutch hospitals, which is important because various Dutch hospitals have accelerated the implementation of DD, or are currently preparing the implementation of DD. Amongst others, this was an effect of the rapid increase in demand for remote care during the coronavirus disease 2019 (COVID-19) pandemic.[21-25]

Overall, this chapter strengthened the results of the previous chapters. That is, in our hospital within a large cohort of patients, the results regarding the reduction of healthcare utilization were comparable to the results found in our previous studies. Moreover, the reductions in healthcare utilization found in the second Dutch hospital were more or less comparable to the reductions in our hospital, and this was also the case for the patients' satisfaction with treatment. This indicates that the DD concept is transferable to other Dutch hospitals, which reduces healthcare utilization without compromising patient outcome and experience.

The larger cohorts also allowed us to perform stratified analyses per injury for secondary healthcare utilization. These analyses indicated that DD reduced secondary healthcare utilization in all SSI subgroups, and that the mean number of follow-up appointments after DD was very low for all types of SSIs as well. Unfortunately, however, data regarding satisfaction and primary healthcare utilization were only available for a relatively small proportion of all SSI patients. Consequently no SSI subgroup analyses could be performed for these outcomes. While the low mean number of follow-up appointments for each individual injury suggest that DD works for every SSI, studies with a larger sample size have to be performed to assess the (cost-)effectiveness of DD compared with traditional care per injury subgroup.

By increasing sample sizes in future studies, data could also be used to evaluate whether certain patient characteristics are predictive of increased satisfaction levels, reduced levels of return for review, and/or adverse outcomes. Examples of such characteristics are age, comorbidity, language barrier, socioeconomic status, smoking status etc. If certain characteristics are found to predict worse outcome, DD

protocols should be further tailored to the specific needs of certain patient groups. Increased sample sizes might be achieved more easily if multiple hospitals collect data cooperatively, and in a standardized manner. To this end, a multicentre/national database could be established, and implementation of DD is then preferably linked to participation to this cohort study/database. A more qualitative approach in assessing patient experience might also help to further optimize DD. For example, when such studies indicate that specific information is missing from the discharge leaflets, or perhaps information is too extensive, this can then be used to further optimize the information that is provided to the patients. A mixed-method study design could be used in hospitals implementing the DD model, evaluating both quantitative data (i.e. the extent to which the DD model is adopted) as well as qualitative data (i.e. barriers and facilitators to its implementation). These data can be valuable in future adoption of DD in other hospitals as well as the implementation of other new models in general.

This thesis aimed to assess the feasibility, safety, and (cost-)effectiveness of DD from the ED for patients with SSIs in the Netherlands. The results of previous UK-based studies already indicated that DD might be an effective form of treatment for several SSIs, however, a relatively large proportion of these studies lacked methodological quality, an adequate sample size and/or a control cohort. Moreover, the majority of these studies were performed in the UK. The conclusions drawn in this thesis are based on a fairly extensive database that was established before and after the implementation of DD in a Dutch hospital. Our results indicate that in the Netherlands, DD from the ED of patients with SSIs is an effective alternative to routine follow-up, which does not compromise patient outcome and reduces healthcare costs. That is, after implementation of DD, healthcare utilization is drastically reduced, while patient satisfaction and functional outcome for patients who were discharged directly remained comparable to that of patients who were routinely followed-up. Hence, costs are reduced while patient outcomes were maintained, which is in turn in concordance with VBHC.

An overarching limitation of all the work in this thesis was that the focus was on DD as an individual concept. That is, effects of DD were analysed for all kinds of injuries simultaneously, instead of per injury. Unfortunately, injury subgroups were too small to perform subgroup analyses per injury for patient-reported outcomes and patient-reported experiences. This limits the ability to draw firm conclusions regarding the feasibility and (cost-)effectiveness of DD for every individual injury. However, it must also be noted that since the publication of the studies included in this work, several other Dutch hospitals have also implemented DD. Amongst others, this was accelerated by the COVID-19 pandemic, and at the time of writing this discussion, at least thirteen Dutch hospitals have implemented DD. Not all of these hospitals have gathered extensive individual patient data (yet), but all of them have reported to be satisfied with their new

workflow (i.e. DD). Moreover, like in our hospital, preliminary evidence from some of these hospitals suggests that patients were satisfied with the care provided as well.

For many of the SSIs included in our DD protocols, national guidelines do often not specifically include recommendations regarding the required number of follow-up appointments and radiographs. This means that, in the Netherlands, these injuries are treated according to local hospital protocols. Consequently, there has been a relatively large practice variation regarding the treatment of such injuries across the country indicating inefficiency, and for many years the standard has been to review patients with these injuries at least once or twice. A pitfall of the relatively fast pace at which DD is currently being implemented in the Netherlands, is that the opportunity is missed to gather a solid evidence-base with the amount of pre-DD and post-DD data. This would result in a scenario that is more or less comparable to the UK scenario discussed earlier, where many hospitals report large numbers of patients being discharged directly, while only small amounts of patient level-data are available. These data will be needed to make recommendations in national guidelines for the treatment of individual SSIs. Therefore, we propose multiple Dutch hospitals to collect data cooperatively, in a standardized manner, and implementation of DD is preferably linked to participation to this database. This might be achieved by expanding the cooperation that was established as part of the adoption of DD in several other Dutch hospitals following our Dutch implementation guide as well as our smartphone application. In explanation, as part of our DD treatment strategy, we developed a smartphone application ("Virtual Fracture Care application") that provides patients with all information regarding their injury and the expected recovery. A large number of the hospitals that have already implemented DD are also using this application. Our hospital is already closely working together with these hospitals by organizing consensus meetings every few months, to improve the patient information provided in the app, e.g. by adding extra information or recording new video instructions. This also allows us to standardize patient information across multiple Dutch hospitals, which will in turn ensure that patients receive comparable information, regardless of where in the country they are treated. It seems that the VFC app plays an important role in this cooperation and a next step might be to routinely collect the necessary standardized multicentre patient data in all participating hospitals, as mentioned in the previous paragraph.

This majority of this thesis centred around DD of patients with SSIs from the ED. A next step worth exploring would be moving the process of diagnosis and initial treatment of patients with musculoskeletal injuries completely out of the hospital, i.e. not in the ED. This would reduce ED workload, and very likely also ED crowding as well as healthcare costs. There might be various ways to do this.

For example, a general practitioner (GP) could order a radiograph for patients with suspected injuries to be performed in an outpatient radiology clinic, and forward the patient's information and radiograph to a nearby hospital operating a daily VFC review to receive treatment advice. If the injury is an SSI, patients could be treated following the DD protocols, without ever visiting the hospital. However, there are various problems that might arise. For example, this would only work for SSIs that are immobilized using a prefabricated orthosis, since GPs are not trained and do not have the resources nor time to apply immobilization such as casts, splints or bandage. Consequently, the majority of patients would still have to be referred to a fracture clinic for immobilization. Moreover, if VFC meetings take place in the morning, patients would have to wait until the next work day before advice is provided. This might be inconvenient and also result in unnecessary pain.

Another more feasible option could be the establishment of "musculoskeletal injury hubs" across the country. These hubs should be staffed by radiology technicians, specialized nurses who are trained to diagnose and initiate treatment of patients with suspected musculoskeletal injuries, and plaster technicians. Patients could either be referred by their GP to one of these hubs, in order to maintain the GP's gatekeeper function. However, to reduce GP workload, it might also be worth considering allowing patients to contact these hubs directly. In any case, an advantage of this system would be that patients can be scheduled for an appointment later that day, which might be assumed to lead to much shorter waiting times compared to the waiting time that is typically experienced by patients with minor injuries in a hospital's crowded ED.

The specialized nurse would be responsible for the diagnosis of the injury and initiation of treatment according to the injury's corresponding treatment protocol. If necessary, the nurse should be able to consult an (orthopaedic) trauma surgeon for advice. Patients with more complex injuries, such as open fractures, fractures or dislocations that need reduction, acute surgery, admission or further imaging (e.g. a CT-scan), should still be referred to a hospital as soon as possible or, in the case of additional imaging, as soon as necessary. All of the cases of the patients treated in this musculoskeletal injury hub should then be discussed during a VFC review the next work day to establish a definitive treatment plan. It might be an option that (parts of) this follow-up takes place within these hubs as well, and that patients are only referred to a hospital if problems arise during follow-up or in case recovery deviates from its expected course.

Discussing all potential barriers that might arise during the set-up of such hubs, taking into account the current organization of Dutch healthcare, will not be part of the current discussion. However, it is worth mentioning that it is highly likely that the way a Dutch patient's treatment is paid for should be reconsidered and redesigned. In short, in the Netherlands patients do not settle each component of their treatment, but

rather one price is paid for their entire care path. In case of an injury, the price of this care path is determined by the average costs associated with this form of injury. Since the proposed treatment of patients in musculoskeletal injury hubs would be transmural, and might partly take place within the hub and in some cases also (partly) within a hospital. For these reasons, the Dutch healthcare payment system might have to be partly rearranged. Another barrier might be the current regulations that are in effect as a result of the European Union (EU) General Data Protection Regulation. A prerequisite for the "hubs concept" is that the data of patients who are treated within these hubs can be shared easily with nearby hospitals in order to refer them for VFC review. It should be further explored how this can be organized most efficiently while still following these EU regulations. Possible solutions might be to operate these hubs as part of, or as an extension of a hospital. If this is not possible, patients visiting such hubs will probably have to provide consent to share their data as a prerequisite for being treated in such hubs. These are two possible solutions, probably amongst many others, and this needs further exploration.

VIRTUAL FRACTURE CLINIC REVIEW

Part III (b) – Future steps in optimizing trauma care

The second step in the VFC model is to conduct a daily orthopaedic consultant let VFC-review to discuss all ED patients who were not discharged directly (i.e. with injuries other than SSIs). The implementation of such a VFC-review was accelerated in our hospital by the COVID-19 pandemic. **Chapter 7** showed that once this new workflow had settled in, the implementation of a VFC-review on work days allowed the VFC team to review, triage and outline a treatment plan for 98.4% of ED orthopaedic trauma patients. Prior to the implementation of the VFC-review, all of these patients would have been referred for face-to-face review in our fracture clinic. After implementation of the VFC-review, the VFC team were able to discharge a relatively large proportion of these patients "virtually", reducing the number of unnecessary face-to-face reviews of these patients, and hence their associated healthcare costs. In the future, increased use of removable orthoses in the ED can further eliminate the need of cast removal, which in turn might will enable the "virtual" discharge of an additional proportion of patients after VFC-review.

To our knowledge, this was the first study conducted outside the UK to describe the implementation and effects of a VFC-review. According to the original UK VFC model, the VFC team either discharged patients "virtually", or referred patients to a nurse-led clinic or subspecialty clinic for further treatment.[4,5] The reviewing nurse or physician then decides on further follow-up during that subsequent clinic visit. However, we were of the opinion that such a set-up is prone to high levels of treatment variation

and unnecessary visits, because follow-up is then still very much dependent on the healthcare provider who is reviewing patients in the outpatient clinic. Therefore, in addition to the original UK VFC model, our VFC-review included the documentation of an extensive and complete treatment plan for each patient. This facilitates treatment of patients according to our local protocols during the whole patient journey, which can then be further tailored to the patient's individual needs, if necessary.

Based on these results, our hospital decided to continue the use and evaluation of this new VFC-review workflow. Future studies should assess the extent to which the VFC treatment plans are followed throughout the patient's follow-up, and whether the documentation of this extensive plan reduces treatment variation and the occurrence of unnecessary follow-up appointments and imaging. Furthermore, studies should assess patient outcome and experience, ultimately providing evidence on the model's (cost-) effectiveness. Such (cost-)effectiveness analyses should also take into account possible disadvantages of this model, such as the time needed for the VFC-review including calling patients afterwards, information that is lacking resulting in a patient who needs to return for further examination or imaging, not being able to reach patients after VFC-review, etcetera.

Healthcare delivery has transformed rapidly over the past decade. Driven by the pursuit of efficient and patient-centred care, there have been initiatives across all fields of medicine to redesign and rearrange the way our healthcare is provided. The ubiquity of the smartphone in everyday life has also contributed to a change in consumer's demands, with patients expecting to be able to change their appointments, check medical records and/or renew medication online, while having access to healthcare information at one's fingertips. These developments have also served as a catalyst for the shift of in-hospital care to more ambulatory, remote and on-demand care supported by medical technology or *e-Health*. This effect has compounded at an exponential pace since the coronavirus disease 2019 (COVID-19) pandemic. Changes that would typically encompass months of planning, education, testing, evaluation were suddenly compressed into days or weeks.[26] Many of these changes are likely here to stay.

For chronic diseases there are numerous examples of such developments, e.g. home-monitoring of blood glucose in patients with diabetes, or electrocardiogram monitoring in patients with cardiac arrhythmias. It has not been and will not be easy to come up with such solutions for more acute care, such as orthopaedic trauma. Nevertheless, it is important that we seek to improve our care in line with these developments in orthopaedic trauma as well. We believe that the VFC-review described in the last chapter might be an important step in this direction.

The implementation of a daily VFC-review, allowed us to document an extensive treatment plan for all our orthopaedic trauma patients who were not discharged

directly from the ED. We assume that this documentation improves compliance to our local treatment protocols, consequently reducing treatment variation and unnecessary follow-up appointments for these patients. However, future studies are needed to assess if this assumption is correct.

We also believe that the VFC-review could play an important role in increasing our ability to provide more tailored orthopaedic trauma care in the future. That is, the VFC-review allows us to initiate care pathways for patients, based on their injury and/or patient characteristics, supervised by the attending (orthopaedic) trauma surgeon. We propose that in future orthopaedic trauma care, the assessment of functional outcome at fixed moments during the course of treatment becomes part of these care pathways, hence part of standard care (e.g. at 2 weeks, 6 weeks, 3 months, 6 months). This functional outcome should be measured using validated questionnaires for each of the corresponding injury locations (e.g. the QuickDASH questionnaire that was used throughout this thesis to measure functional outcome for upper extremity injuries). When such data are collected consistently and on a large scale, these can be used to plot charts of a "normal" recovery for specific injury types and/or patient characteristics. This would be more or less comparable to children's growth curves, with standard deviations etc. Once these charts are available, these can be used to identify patients with a recovery that is better than average. Their follow-up appointment could then be skipped. Patients who deviate from "normal" recovery can be identified as well, and for them additional physiotherapy or follow-up could be initiated at an early stage.

Conclusions and recommendations for future research and practice

Based on this thesis the following conclusions and recommendations for future research and practice are given:

- There is still a large practice variation regarding the treatment of patients with fairly common, simple, stable injuries, indicating inefficiency and potentially unnecessarily high healthcare costs.
- DD from the ED of patients with SSIs seems to be a feasible alternative to routine follow-up, which reduces healthcare utilization without compromising patient satisfaction and outcome.
- The concept of DD seems to be transferable to other hospitals, both nationally and internationally.
- The DD model appreciates that while the majority of patients recover without any issues, some patients will have concerns or persisting problems. We recommend that an easily accessible telephone helpline is always part of the DD model, with subsequent face-to-face review in a fracture clinic if necessary.

- Future studies regarding DD should focus on:
  - Improving comparability by using a standard set of outcome variables.
  - Assessing the feasibility of DD for additional SSIs.
  - Strengthening the evidence base of DD for individual injuries by increasing sample sizes that allow injury subgroup analyses, in order to make recommendations in national guidelines. It is likely that multi-centre databases are needed to achieve this.
  - Tailoring DD protocols by examining whether certain patient characteristics predict worse outcome/satisfaction, e.g. age or co-morbidities.
  - Improving the DD concept using qualitative research methods, for example by a mixed-method study in hospitals implementing the DD model, evaluating both quantitative data (i.e. the extent to which the DD model is adopted) as well as qualitative data (i.e. barriers and facilitators to its implementation from both the patient's and the healthcare provider's perspective).
- Healthcare costs might be further decreased if patients with SSIs can be diagnosed and treated outside the hospital's walls, i.e. in primary healthcare or in musculoskeletal injury hubs
- The second part of the VFC model, i.e. the daily VFC-review, provides the opportunity to review all ED patients before any follow-up appointments are made. This allows the VFC-team to discharge an additional proportion of patients virtually.
- Increased use of orthoses in the ED might allow more patients to be discharged after VFC-review.
- Future studies should focus on the effects of the VFC-review on healthcare utilization to assess its (cost-)effectiveness.
- Routine assessment of recovery, e.g. by using validated questionnaires for functional outcome, at fixed times during follow-up, might provide a quantifiable way to monitor recovery, and this might be used to further tailor a patient's treatment during follow-up. This is in line with developments towards the future of care: patient-centred and patient-initiated, virtual when possible, tailored to a patient's needs, and value-based.

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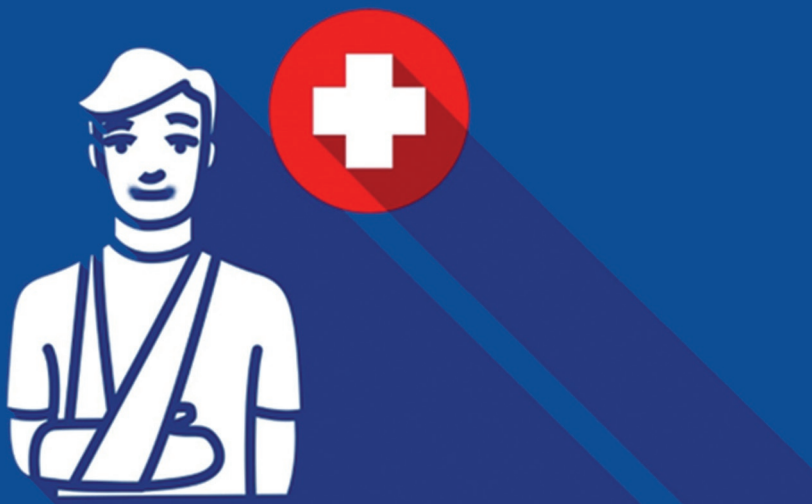


SUMMARY IN ENGLISH
NEDERLANDSE SAMENVATTING

SUMMARY IN ENGLISH

VIRTUAL FRACTURE CARE

Direct discharge from the Emergency Department of patients with simple, stable musculoskeletal injuries

Traditionally, all patients with musculoskeletal injuries are reviewed in a fracture clinic during the first weeks to months after their initial visit to an Emergency Department (ED). Depending on the type of injury, this routine review might have several reasons, including cast replacement/removal, providing information, monitoring functional outcome, or radiographic imaging to assess adequate position and/or to monitor the healing process of the bone.

The term "simple, stable injury" (SSI) is used in this thesis to refer to a group of musculoskeletal injuries with excellent prognosis, including fractures and other musculoskeletal injuries such as distortions or tendon injuries. Patients with SSIs are expected to recover to pre-injury functional outcome levels, while complication rates, including delayed-union or non-union of SSIs are very low. Examples of SSIs include Mason type 1 radial head fractures, torus or greenstick fractures of the distal radius, fifth metacarpal neck fractures and base of fifth metatarsal fractures.

Patients with SSIs typically attend one or two fracture clinic appointments before being discharged from further follow-up. This means that most of these patients are in follow-up for approximately one to six weeks, depending on the specific type of injury. Follow-up usually does not include radiographic imaging, since secondary dislocations are not likely to occur and complications, such as delayed union or non-union are not diagnosed within the follow-up timeframe. Consequently, SSI patients' treatment initiated in the ED is very unlikely to change based on the assessments made during the follow-up appointments.

Currently, many patients with SSIs are immobilized using plaster casts, which will in turn result in an inevitable appointment for cast removal. This is in contrast to recent studies that indicate that functional treatment (e.g. orthoses or bandage) provides comparable outcomes in terms of functional outcome. Other studies also indicate that the majority of patients with minor injuries would prefer optional follow-up instead of routine follow-up. That is, they would rather opt for self-management based on instructions provided in the ED than having to routinely attend a fracture clinic appointment to monitor their recovery.

Based on the aforementioned studies, the orthopaedic trauma team in Glasgow Royal Infirmary took a fairly pragmatic approach and decided to change their treatment protocols for several SSIs in 2011. They argued that routinely reviewing all patients with musculoskeletal injuries in a fracture clinic, including patients with relatively minor

injuries, was no longer sustainable, since the resulting high workload at the fracture clinic negatively influenced patient experience, staff morale and quality of care. What followed was the implementation of direct discharge (DD) from the ED of six SSIs (i.e. fifth metatarsal, fifth metacarpal, distal radius, torus, minor radial head/elbow fat pad sign, mallet finger, child's clavicle), meaning that for these six injuries routine follow-up appointments were no longer scheduled after the initial ED visit. This change of standard care was supported by the use of removable orthoses/bandage, discharge leaflets, and a telephone helpline in case of questions or concerns. In the years thereafter, many other UK-based hospitals followed their example and implemented DD for several (sometimes other) SSIs as well.

This thesis mainly focussed on DD from the ED of patients with SSIs. However, it is important to note that DD is only the first step of a more extensive model of care, and that this model of care is not limited to patients with SSIs. The more extensive model is most often referred to as the Virtual Fracture Clinic (VFC) model, and aims to streamline and optimize care for all patients with musculoskeletal injuries (Figure 1).

The VFC model comprises two main parts, with the first being DD from the ED of patients with SSIs. The second part concerns all patients with musculoskeletal injuries who are **not** discharged directly from the ED. Prior to the implementation of the VFC model, all of these patients were routinely referred for face-to-face review in the fracture clinic, sometimes leading to unnecessary or untimely appointments. Following the implementation of the VFC model, these patients are first referred to be reviewed during a daily orthopaedic consultant-led review before any appointments are scheduled. Possible outcomes of the VFC review are 1) virtual discharge 2) referral to a nurse-led clinic, or 3) referral to a specialty clinic. Injuries might be discharged "virtually" if the ED physician is unsure whether the injury is eligible for DD or when the injury does not fall under the DD protocol, but is deemed minor enough to be treated without further review by the VFC team. After the VFC review, all patients are contacted by telephone to discuss their treatment plan and schedule appointments, if necessary.

In 2018, the trauma team of our own hospital (OLVG, Amsterdam, the Netherlands) saw a rapid rise in the number of patients with musculoskeletal injuries presenting to our ED (approximately 30% increase compared to the previous year), while the incidence of patients with musculoskeletal injuries had already been increasing for several years. An important reason for this rapid rise was the bankruptcy of a nearby hospital (MC Slotervaart), shifting care of many patients from the bankrupt hospital towards OLVG. In a response, we explored the possibility to implement DD in our hospital, and visited Glasgow Royal Infirmary as well as the Royal Infirmary of Edinburgh to meet with Lech Rymaszewski and Tim White, respectively. They are both orthopaedic surgeons and were in charge of the implementation of the VFC model in their hospital. Based on the

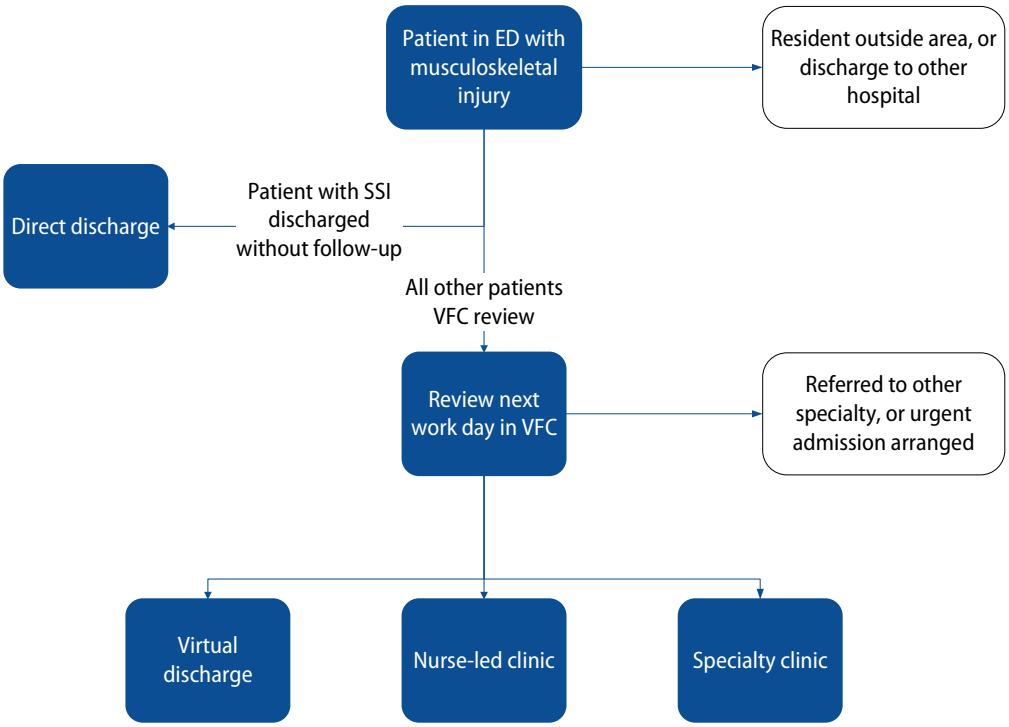


Figure 1 – Virtual Fracture Clinic model
ED, Emergency Department; SSI, Simple, stable injury; VFC, Virtual Fracture Clinic

information they shared, several studies that were available at that time, consensus meetings, as well as expert opinions, the trauma team in our hospital agreed to implement DD for eleven types of SSIs (Table 1) as of May 2019.

Prior to the work described in this thesis, the concept of DD had not yet been evaluated extensively outside the UK. However, results regarding its effectiveness, as well as patient expectation, experience, satisfaction and possibly outcome might not be directly transferrable across healthcare settings and/or patient populations. While we expected DD to drastically reduce secondary healthcare utilization based on the previous UK studies (this was one of the main reasons to consider the implementation in the first place), our predefined conditions for DD to be a safe and acceptable alternative, and hence our conditions for implementing it as the standard-of-care, also included maintaining high levels of patient satisfaction and patient outcome, i.e. comparable to pre-DD care, and low rates of missed injuries and complications. Furthermore, ideally DD should not shift care of patients towards primary healthcare, e.g. by increased visits to a general practitioner.

Table 1 – Simple and stable injuries, criteria and immobilization

Injury	Paediatric/ adult	Criteria	Immobilization after DD
Paediatric clavicle Fx	Paediatric	Age ≤14 No indication for surgical treatment	Sling
Radial head-/neck Fx	Adult	Head: Mason type 1, neck: undisplaced, or Positive fatpad sign	Pressure bandage, sling
Greenstick or torus/ buckle type Fx of the distal radius	Paediatric	Acceptable angulation based residual growth Torus/buckle type: isolated ulna Fx, isolated radius Fx or both Greenstick type: isolated ulna Fx or isolated radius Fx	Removable wrist brace
Fifth metacarpal neck Fx	Adult	Volar angulation <70 degrees No rotational deviation	Buddy strap and pressure bandage
Mallet finger	Adult	Either bony or tendinous Treated conservatively	Mallet splint
Weber A type ankle Fx	Adult	Dislocation <2mm No signs of stage 2 supination-adduction type injury	Tubigrip and ankle brace
Avulsion type ankle Fx	Adult	Either lateral or medial malleolus or tarsal bones	Tubigrip and ankle brace
Fx of fifth metatarsal base	Adult	Fx located in either zone 1 or zone 2 Dislocation ≤4 mm	Walker boot
Fx of greater toe	Both	Either proximal or distal phalanx Fx Undisplaced	Spica pressure bandage and bandage shoe
Fx of lesser toe	Both	Any isolated Fx No indication for surgical treatment	Buddy strap
Bicycle spoke injury	Paediatric	No Fx based on radiograph Superficial wound	Pressure bandage

DD, Direct Discharge; Fx, fracture; mm, millimetre.

Therefore, this thesis focused on the (cost-)effectiveness, safety and patient's experience and outcome, of DD from the ED of patients with SSIs within the Netherlands, as compared to the more "traditional" treatment with routine follow-up in a fracture clinic. Herewith, we aimed to assess the transferability of this concept to a country different than the UK and to establish an evidence base for the implementation of DD across the rest of the Netherlands. The thesis was divided into three parts.

Part I focused on summarizing the evidence regarding DD that was available prior to this work, while identifying possible evidence gaps that could serve as the basis for our future studies. This part also included an evaluation of the extent to which DD for SSIs is currently implemented across the world, and an assessment of the treatment variation for these fairly common and self-limiting injuries. **Part II** includes three studies that were based on data that were collected prospectively before and after the implementation of

DD in our hospital, and focused on secondary healthcare utilization, primary healthcare utilization, patient experience, patient outcome, adverse events and cost-effectiveness. **Part III** evaluates whether the results of our initial studies are reproducible in another Dutch hospital. Furthermore, the coronavirus disease 2019 (COVID-19) pandemic accelerated the implementation of the second step of the VFC model, i.e. a daily consultant-led VFC review (Figure 1). The last chapter of this thesis therefore describes our experiences with- and the potential added value of the implementation of the second step of the VFC model in the Netherlands.

PART I – CURRENT EVIDENCE AND USE OF DIRECT DISCHARGE OF SIMPLE STABLE INJURIES

Direct discharge of patients with simple stable musculoskeletal injuries as an alternative to routine follow-up: a systematic review of the current literature

The aim of **Chapter 1** was to provide an overview of all available evidence regarding DD of SSIs prior to the work described in this thesis, by performing a systematic review. The review was focused on logistic outcomes (e.g. number of follow-up appointments), financial benefits, functional outcome, patient satisfaction, and adverse events.

Twenty-six studies were included, 92% of which were based on data from UK hospitals. Ten studies (38.5%) compared outcomes in two groups: a DD-cohort and a pre-DD control cohort (i.e. patients with a similar injury treated prior to implementation of DD). The other sixteen studies (61.5%) only assessed outcomes in a DD-cohort, meaning that they did not provide any comparisons to a pre-DD situation. Ten studies (38.5%) included a clear description of the eligibility criteria for an injury to be discharged directly, whereas sixteen studies (61.5%) did not. Seven studies (26.9%) assessed functional outcome, nine studies (34.6%) assessed the patients' treatment satisfaction and ten studies (38.5%) assessed adverse outcomes. There was only one study (3.8%) that evaluated all of our predefined outcome measures.

In the studies that included a control cohort, the mean number of appointments ranged from 1.00 to 2.08 per patient pre-DD, depending on the type of injury or types of injuries included within that particular study. The mean number of follow-up appointments in the DD-cohort ranged from 0.00 to 0.33. Cost reductions ranged from 69€ to €210 per patient. In all studies that evaluated functional outcome or patient satisfaction, these outcomes were found to be comparable (for studies with a pre-DD cohort), or reported to be "satisfactory" (for studies without control cohort). Adverse outcomes were low and/or comparable (i.e. to pre-DD rates) in all of the ten studies that assessed this.

This systematic review supports the idea that DD provides a safe and effective alternative that does not compromise patient outcome or experience, especially for the UK population. Based on the findings of this review, we recommended that future studies should be conducted outside of the UK, and that all future studies, regardless of their country of origin, should clearly describe the criteria that were applied for deciding whether injuries could be discharged directly and to use a standard set of outcome variables. Both recommendations were made to improve future studies' comparability and the assessment of the transferability of their results to other settings.

Adoption of direct discharge of simple stable injuries amongst (orthopaedic) trauma surgeons

Our systematic review identified a fair number of studies evaluating DD of SSIs, but most of them were conducted in the UK. The aim of **Chapter 2** was therefore to evaluate the extent to which DD of SSIs has been adopted amongst trauma and orthopaedic surgeons internationally, and to assess the clinical agreement in the management of these common injuries.

To this end, we developed an online survey that included case descriptions and X-rays of eleven minor musculoskeletal injuries. For all of these injuries at least one or multiple studies regarding DD had been published previously. Each case described the hypothetical presentation of a patient to the ED of the respondent. Trauma- and orthopaedic surgeons of an international collaboration were invited and were asked to outline their treatment plan regarding the number of follow-up appointments and radiographs, physiotherapy and when to start functional movement. Adoption of DD was estimated per injury based on the proportion of surgeons who decided that zero follow-up appointments were required. Clinical agreement was predefined as >80% of surgeons to answer similarly.

A total of 138 of 667 (20.7%) invitees completed the survey. The majority of respondents practiced in Europe or North America. Of all the eleven cases, direct discharge was selected most often in case of the lesser toe fracture (45% of respondents selected zero appointments), while this was the least for the distal radius fracture in an adult patient (4% of respondents selected zero appointments). Clinical agreement regarding total number of appointments as well as when to start functional movement was not reached for any of the injuries. There was clinical agreement on the number of radiographs for one injury (mallet finger) and for four injuries regarding the routine referral of patients with these injuries to a physiotherapist.

Based on these findings, we concluded that DD of SSIs has not been widely adopted worldwide, despite available evidence. Moreover, there is still a large practice variation that indicates inefficiency, even for these common and minor injuries.

PART II – (COST-)EFFECTIVENESS OF DIRECT DISCHARGE OF PATIENTS WITH SIMPLE STABLE INJURIES IN THE NETHERLANDS

Direct Discharge from the Emergency Department of patients with simple stable injuries: a Dutch pilot study

Chapter 3 provides a preliminary analysis of the potential logistical and financial effects of DD from a Dutch ED for patients with SSIs. To this end, data were analysed of all the patients with one of the eleven predefined SSIs (Table 1), three months before and three months after the implementation of DD in our hospital. A survey was used to assess patient satisfaction and a potential shift to primary healthcare (visits to a general practitioner or physiotherapist). All data were assessed at three months post-injury.

In the three months before implementation, 275 patients with an SSI presented to our ED compared to 318 patients in the three months after implementation. During the first three months of DD, 304 out of the 318 patients with SSIs were discharged directly (protocol compliance 95.6%). One patient with an assumed Weber A type ankle fracture was discharged directly by the ED staff. However, during daily screening of all ED radiographs this patient was found to have a Weber B type fracture and was therefore recalled and treated accordingly.

We found DD to result in a significant reduction in follow-up appointments (-91%), radiological imaging (-72%), and costs. Patient satisfaction was comparable before and after the implementation of DD. There was no shift towards primary care. Based on these preliminary results, DD from the ED seems to be an effective and safe alternative to traditional treatment with outpatient follow-up in the Netherlands as well.

Direct discharge from the Emergency Department of simple, stable injuries: a propensity-score adjusted non-inferiority trial

Chapter 4 evaluated whether DD from the ED of SSIs is non-inferior to "traditional" care with routine follow-up, in terms of satisfaction with treatment and functional outcome, whilst also evaluating other patient-reported outcomes like health-related quality of life (EQ-5D-5L for adults and EQ-5D-Youth for children), return to work, school and sports, work absenteeism and school absenteeism, secondary healthcare utilization (follow-up appointments and imaging), primary healthcare utilization (general practitioner and physiotherapist visits), adverse outcomes (delayed union and non-union), and the number of missed injuries in the ED in addition to the SSI. Predefined non-inferiority margins were used for satisfaction with treatment (visual analogue scale 1-10), and functional outcome (assessed by one of four validated questionnaires based on location of injury and age).

In this study, we included all patients who provided informed consent during their initial visit to our ED with one of the eleven SSIs, six months before (pre-DD-cohort) and

six months after the implementation of DD (DD-cohort). Patient-reported outcomes and experiences were assessed by a survey that was sent to the patients at three months post-injury. All other data were collected by means of evaluation of the electronic patient record at least 14 months after the ED visit.

A total of 348 (pre-DD-cohort) and 371 patients (DD-cohort) participated, of whom 144 (41.4%) and 153 (41.2%) completed the survey, respectively. Satisfaction and functional outcome in the DD-cohort was non-inferior to the pre-DD-cohort. Mean satisfaction, for example, was 8.13 (pre-DD-cohort) and 7.95 (DD-cohort, mean difference: -0.16, p=0.408). Pain, quality of life, the number of general practitioner/physiotherapist visits and return-to-work/school/sports were comparable before and after the implementation of DD. Work absenteeism was higher in the pre-DD-cohort (OR:0.110, p<0.001), as was school absenteeism (OR:0.084, p<0.001). After DD, the mean number of hospital visits and X-rays were reduced: -1.68 (p<0.001), and -0.26 (p<0.001) per patient, respectively. Missed injuries occurred once in the pre-DD-cohort versus twice in the DD-cohort. There were no adverse outcomes in both cohorts.

The results described in this chapter confirm that several SSIs can be discharged directly from the ED without compromising patient outcome or experience. Based on our estimation that approximately 85,000 patients visit a Dutch ED with SSIs annually, adoption of DD across the Netherlands could potentially lead to an annual reduction of 142,800 outpatient clinic visits. However, since injury subgroups are relatively small, future injury specific trials might be needed to assess non-inferiority per injury.

Cost-effectiveness of direct discharge from the Emergency Department of patients with simple, stable injuries in the Netherlands

In **Chapter 5**, an economic evaluation was conducted using the data of the patients that had completed the three-month post-injury survey, comparing DD to "traditional" care with routine follow-up. This analysis was conducted from a societal perspective, and a sensitivity analysis was conducted to assess DD's cost-effectiveness from a healthcare perspective as well.

Total societal costs included healthcare-, work-absenteeism- and travel costs, all of which were valued using Dutch standard costs. Effect measures included generic health-related quality-of-life (HR-QoL, EQ-5D-5L or EQ-5D-Youth); disease-specific HR-QoL (functional outcome, different validated questionnaires, converted to 0-100 scale); treatment satisfaction (visual analogue scale (VAS), 1-10); and pain (VAS, 1-10).

There were no statistically significant differences between the pre-DD-cohort and DD-cohort for generic HR-QoL (0.03; 95%CI [-0.01]–[0.08]), disease-specific HR-QoL (4.4; 95%CI [-1.1]–[9.9]), pain (0.08; 95%CI [-0.37]–[0.52]), and treatment satisfaction (-0.16; 95%CI [-0.53]–[0.21]). Total societal costs were lower in the DD-cohort compared to the pre-DD-cohort (-€822; 95%CI -€1719 to -€67), and this was also the case for the

disaggregate cost categories healthcare costs (-€168; 95%CI [-€205]–[-€131]) and work absenteeism costs (-€645; 95% CI [-€1535]–[€100]). The probability of DD being cost-effective was 0.98 at a willingness-to-pay of €0 for all effect measures, remaining high for increasing willingness-to-pays for generic HR-QoL, disease-specific HR-QoL, pain, and slightly decreasing with increasing willingness-to-pays for treatment satisfaction. The previous chapter already indicated that the between-group differences in satisfaction were far from our predefined clinically relevant margins.

Based on these findings we concluded that, in addition to being effective, safe, and acceptable, DD from the ED of patients with SSIs also seems to be cost-effective compared with routine follow-up from a societal perspective. Based on our estimation of approximately 85,000 patients with SSIs presenting to a Dutch ED annually, adoption of DD across the Netherlands, implementation of DD could potentially lead to an annual reduction of EUR 14 million in direct healthcare costs and EUR 54.8 million in lost productivity costs.

PART III – UPSCALING VIRTUAL FRACTURE CARE AND FUTURE STEPS IN OPTIMIZING TRAUMA CARE

Healthcare utilization and satisfaction with treatment before and after direct discharge from the Emergency Department of simple stable musculoskeletal injuries in the Netherlands

Chapter 6 is the last chapter in this thesis that concerns DD of SSIs and this chapter aims to strengthen our findings in two ways: 1) by evaluating whether the results of our initial study in chapter 4 remain the same within our own hospital (OLVG) after a longer period of time, and hence including a larger number of patients, and 2) whether these results are comparable in a second Dutch hospital, the Sint Antonius hospital (SA). Outcomes included secondary healthcare utilization, satisfaction with treatment and primary healthcare utilization.

A total of 2,033 (OLVG=1,686; SA=347) and 1,616 (OLVG=1,396; SA=220) patients were included in the pre-DD-cohort and DD-cohort, respectively. After implementing DD, the mean number of follow-up appointments per patient reduced by 1.06 (1.13–0.99; p<0.001) in OLVG and 1.07 (1.02–0.93; p<0.001) in SA. In addition to our previous studies, in which all outcomes were analysed for all SSIs together, the larger cohorts of the current study also allowed us to analyse the number of follow-up appointments, and reductions thereof, per injury. After DD, follow-up appointments reduced significantly for all SSI subgroups. Mean number of follow-up X-rays per patient reduced by 0.17 in OLVG (p<0.001) and 0.18 in SA (p<0.001). In OLVG, mean satisfaction with treatment was 8.1 (pre-DD-cohort) versus 7.95 (DD-cohort), versus 7.75 in SA (DD-cohort only). In OLVG, 23.6% of the pre-DD-cohort patients visited their GP, versus 26.1% in the DD-cohort,

versus 13.3% in SA (DD-cohort only). Physiotherapist visits among SSI patients were comparable before and after the implementation of DD.

Based on this chapter, we concluded that the results of DD remained the same over a longer period of time in a larger cohort within our own hospital, and that DD provided comparable results in a different Dutch hospital. This shows that the DD concept as implemented in our hospital is transferable to other hospitals as well, which could help to encourage other Dutch hospitals to consider the implementation of DD in the near future.

Optimizing orthopaedic trauma care delivery during the COVID-19 pandemic

In **Chapter 7**, we evaluated the implementation and potential added value of a daily VFC review within the Netherlands. As described earlier, the VFC model consists of two parts, 1) DD of patients with SSIs, and 2) a daily review of all other patients with musculoskeletal injuries (Figure 1). While this thesis was initially supposed to be completely focused on DD, the implementation of the daily VFC review was accelerated and brought forward in a response to the coronavirus disease 2019 (COVID-19) pandemic. The guidelines for the outpatient treatment of patients during the COVID-19 pandemic prescribed minimizing face-to-face appointments and to increase remote care. We anticipated the VFC review to provide an opportunity to effectively adhere to these guidelines. That is, if a proportion of the patients can be discharged "virtually", and a complete treatment plan is outlined during VFC-review for all patients, this might reduce the number of unnecessary and untimely (face-to-face) follow-up appointments.

In its original UK version, the VFC team either "virtually" discharged patients or referred them to either a nurse-led clinic or subspecialty clinic for further treatment. Further follow-up appointments were scheduled after each subsequent follow-up appointment, i.e. a complete treatment plan from first to last appointment is not clear after the VFC review. As we were of the opinion that such a set-up might result in practice variation and unnecessary visits, we extended the VFC review to also include the documentation of a complete treatment plan for every patient reviewed, i.e. including all appointments, imaging etc.

Additionally, we streamlined ED trauma care by implementing an orthopaedic trauma fast-track pathway in our ED, in an attempt to alleviate ED workload during the pandemic as well as to limit long ED waiting times as a consequence of large numbers of patients presenting with suspected COVID-19.

The implementation of all of these changes were evaluated by a closed-loop audit that was performed during two four-week periods, using four predefined standards: 1) all eligible ED orthopaedic trauma patients are referred for VFC-review; 2) reached afterwards; and follow-up is 3) patient-initiated, or 4) performed remotely, whenever possible. Total ED waiting-time, time-to-review; time-for-review; time-after-review were

assessed during both audit periods and compared to previous measurements. A closed-loop audit includes setting standards, assessing these standards during a first audit, evaluating outcomes and use these to improve where possible, and then close the loop by a second audit.

During both audit periods, the majority of eligible ED patients were referred for VFC-review (1st: n=162[88.0%]; 2nd: n=302[98.4%]), and reached afterwards (1st: 98.1%; 2nd: 99.0%). Of all referred patients, 17.9% and 13.6% were discharged "virtually" during first and second audit, respectively, while 45.0% and 41.1% of scheduled follow-up appointments were remote. Median total ED waiting-time reduced (1st; -36 minutes, ($p<0.001$): 2nd; -33 minutes, ($p<0.001$)). During the second audit, median ED time-to-review reduced by -13 minutes ($p<0.001$), as well as time-for-review: -10 minutes ($p=0.019$).

This chapter shows the potential value of a VFC review, instead of the routine referral of all patients for a fracture clinic appointment. That is, in addition to the patients with SSIs who were already discharged directly from the ED, a relatively large number of patients with other minor injuries can be discharged "virtually" based on the VFC review. During our VFC review a complete treatment plan is documented for every patient. We expect this to reduce practice variation and consequently unnecessary or untimely visits and hence, costs. However, this was not assessed as part of this study. Future studies should therefore explore the effects of a VFC review on outcomes such as treatment variation, number of follow-up appointments and imaging procedures, in addition to patient-reported outcomes and experiences.

Virtual Fracture Care is (also) a valuable concept in the treatment of patients with musculoskeletal injuries in the Netherlands. DD of patients with SSIs offers an effective and efficient alternative to the more traditional treatment with routine follow-up on the one hand, while on the other hand the daily VFC review offers the opportunity to document a complete treatment plan for all other patients. This should reduce treatment variation and unnecessary follow-up appointments and imaging. In the future the VFC concept might be expanded, with more emphasis on treatment that is tailored to the individual patient. For example, by collecting patient-reported outcomes such as functional outcome at fixed moments during follow-up.

NEDERLANDSE SAMENVATTING

VIRTUAL FRACTURE CARE

Direct ontslag vanaf de Spoedeisende Hulp voor patiënten met simpele, stabiele letsels van het steun- en bewegingsapparaat

Het is gebruikelijk dat patiënten met een letsel van het steun- en bewegingsapparaat gecontroleerd worden op de polikliniek, in de eerste weken tot maanden na het initiële bezoek aan de Spoedeisende Hulp (SEH). Afhankelijk van het specifieke type letsel kunnen er verschillende redenen zijn voor deze routinematige controle, waaronder vervangen/verwijderen van gipsmateriaal, informatie geven, functionele uitkomst monitoren, of radiologische beeldvorming om de stand en/of het genezingsproces van het bot te controleren.

In dit proefschrift wordt de term “simpel, stabiel letsel” (SSL) gebruikt om te verwijzen naar een groep letsels van het steun- en bewegingsapparaat, waaronder fracturen en andere letsels zoals verstuikingen of peesletsels, die een uitstekende prognose hebben. Patiënten met een SSL komen over het algemeen na een periode van herstel terug op hun oude functionaliteitsniveau, en complicaties waaronder een vertraagde botgenezing of uitblijven van botgenezing komen nauwelijks voor. Voorbeelden van SSLs zijn een Mason type 1 radiuskop fractuur, een torus of greenstick fractuur van de distale radius, een subcapitale metacarpale V fractuur of een basis metatarsale V fractuur.

Gemiddeld genomen worden patiënten met een SSL één à twee keer poliklinisch gecontroleerd voordat zij worden ontslagen uit verdere controle. Dat betekent dat zij over het algemeen tussen de één tot zes weken onder controle zijn, e.e.a. afhankelijk van het specifieke type letsel. Tijdens controle wordt meestal geen radiologische beeldvorming verricht, omdat het erg onwaarschijnlijk is dat fractuurdelen verplaatsen, en omdat complicaties zoals vertraagde genezing of geen genezing niet gediagnosticeerd worden binnen deze initiële periode van slechts enkele weken. Als gevolg hiervan is het erg onwaarschijnlijk dat de behandeling die op de SEH werd gestart nog verandert tijdens deze poliklinische controles.

Bij de immobilisatie van patiënten met SSLs wordt vaak gebruik gemaakt van gipsmateriaal, waardoor er altijd een poliklinische controle nodig is voor het verwijderen hiervan. Recente studies laten echter zien dat, als het gaat om het herstel van functie, een functionele behandeling (bijv. met een orthese of verband) een vergelijkbare uitkomst geeft met gipsbehandeling. Andere studies laten zien dat het merendeel van de patiënten met klein letsel de voorkeur heeft voor een optionele poliklinische controle, in plaats van een routinematige poliklinische controle.

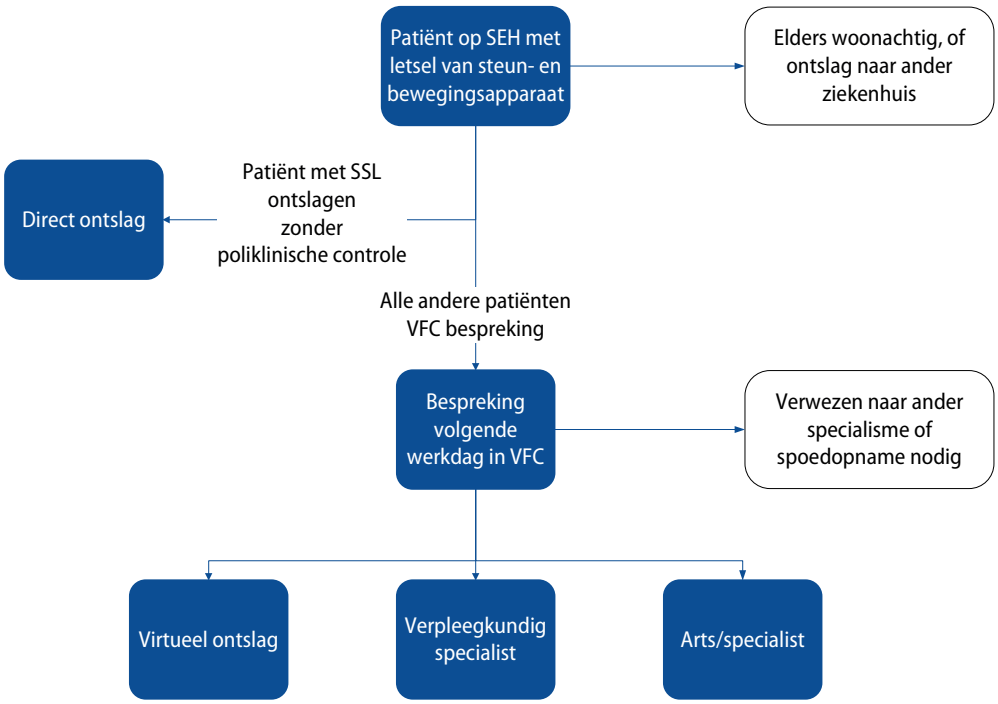
Op basis van deze studies nam het traumateam in Glasgow Royal Infirmary in 2011 een vrij pragmatisch besluit door hun behandelprotocollen voor verschillende SSLs te

veranderen. Zij vonden het niet langer houdbaar om alle patiënten met letsels van het steun- en bewegingsapparaat poliklinisch te controleren, omdat de hoge werkdruk die hierdoor ontstond een negatieve invloed had op de patiëntervaring, het moreel van de medewerkers en de kwaliteit van zorg. Hierop besloten zij Direct Ontslag (DO) van de SEH voor patiënten met één van zes verschillende SSLs te implementeren (fracturen van metatarsale V, metacarpale V, distale radius, torus fracturen, radiuskop fracturen, mallet vinger en clavicula fracturen bij kinderen). Dit betekende dat patiënten met een van deze letsels niet langer standaard terugkwamen op de polikliniek na hun bezoek aan de SEH. Deze verandering van standaardzorg werd ondersteund door gebruik van afneembare ortheses (bijv. brace) of verband, ontslagfolders, en een speciaal telefoonnummer voor vragen of problemen. In de jaren daarna volgden veel Engelse ziekenhuizen hun voorbeeld door ook DO te implementeren voor een aantal (soms andere) SSLs.

Dit proefschrift focust zich vooral op DO van de SEH voor patiënten met SSLs. Het is belangrijk om hierbij te vermelden dat DO slechts een eerste stap is van een uitgebreider model, dat zich niet beperkt tot patiënten met SSLs. Het meer uitgebreide model wordt meestal het Virtual Fracture Clinic (VFC) model genoemd, en heeft als doel de poliklinische zorg voor patiënten met letsels van het steun- en bewegingsapparaat te stroomlijnen en te optimaliseren (Figuur 1).

Het VFC-model bestaat uit twee onderdelen, waarvan het eerste deel DO van de SEH voor patiënten met SSLs betreft. Het tweede deel heeft betrekking op alle andere patiënten met letsels van het steun- en bewegingsapparaat. Dat wil zeggen patiënten die **niet** direct ontslagen worden van de SEH. Voordat het VFC-model bestond werden alle patiënten routinematig face-to-face gecontroleerd op de polikliniek, met soms onnodige controles tot gevolg of controles die niet op het juiste moment plaatsvonden. Na implementatie van het VFC-model worden deze patiënten dagelijks besproken tijdens de “VFC-bespreking”, voordat er controle afspraken worden gemaakt. Mogelijke uitkomsten van de VFC-bespreking zijn: 1) virtueel ontslag, 2) verwijzing naar een verpleegkundig-specialist, of 3) verwijzing naar een arts/specialist. “Virtueel” ontslag houdt in dat patiënten met vrij eenvoudige letsels, die niet onder de DO protocollen vallen, toch worden ontslagen uit verdere controle, omdat het VFC-team van mening is dat het letsel hiervoor geschikt is. Na de VFC-bespreking wordt met alle patiënten telefonisch contact opgenomen om hun behandelplan te bespreken en eventuele controle afspraken in te plannen.

In 2018 was er in ons ziekenhuis (OLVG, Amsterdam) een snelle toename (ongeveer 30% t.o.v. het voorgaande jaar) van het aantal patiënten op de SEH met letsels van het steun- en bewegingsapparaat, en dat terwijl de incidentie van het aantal patiënten met letsels al jaren steeg. Een belangrijke oorzaak van deze plotselinge toename was



Figuur 1 – Virtual Fracture Clinic model
SEH, Spoedeisende Hulp; SSL, Simpel, stabiel letsel; VFC, Virtual Fracture Clinic

het faillissement van een ziekenhuis in de buurt (MC Slotervaart), waardoor de zorg van een groot deel van de patiënten van dit ziekenhuis verschoof naar OLVG. In een reactie hierop hebben we de optie onderzocht om DO te implementeren in ons ziekenhuis. Als onderdeel hiervan hebben we het Glasgow Royal Infirmary en de Royal Infirmary of Edinburgh bezocht om respectievelijk Lech Rymaszewski en Tim White te ontmoeten. Zij zijn beiden orthopedisch chirurg en waren verantwoordelijk voor de implementatie van het VFC-model in hun ziekenhuis. Op basis van de informatie die zij met ons deelden, de verschillende beschikbare studies op dat moment, consensus meetings in ons eigen ziekenhuis en ook deels *expert opinion,* besloot het traumateam in ons ziekenhuis om vanaf mei 2019 DO te implementeren voor elf verschillende typen SSLs (Tabel 1).

Voordat de studies die in dit proefschrift beschreven staan waren uitgevoerd, was het concept DO nog niet buiten het Verenigd Koninkrijk (VK) onderzocht. Echter, men mag er niet zonder meer van uitgaan dat resultaten met betrekking tot effectiviteit, verwachtingen van de patiënt, patiëntervaringen, patiënttevredenheid en mogelijk ook behandeluitkomst vergelijkbaar zijn in een andere zorgomgeving en/of patiëntpopulatie.

Hoewel we verwachtten dat DO het zorgverbruik in ons ziekenhuis drastisch zou verlagen (dat was één van de redenen om de implementatie ervan überhaupt te overwegen), wilden we er wel zeker van zijn dat DO ook een effectief en acceptabel alternatief van onze eerdere zorg was. Daarom stelden we van tevoren de voorwaarde dat om van DO standaardzorg te maken, de patiënttevredenheid en behandeluitkomst gelijk moesten blijven aan onze pre-DO zorg, met daarbij lage aantallen gemiste letsels of complicaties. Bovendien mocht DO niet zorgen voor een verschuiving van de zorg voor deze patiënten naar de eerste lijn, bijvoorbeeld door een stijging in het aantal huisartsbezoeken.

Om deze redenen richt dit proefschrift zich op de (kosten-)effectiviteit, veiligheid, de patiëntuitkomst en patiëntervaring, van DO van de SEH voor patiënten met SSLs vergeleken met de meer "traditionele" behandeling met routinematige poliklinische controle in Nederland. Het doel hiervan was om de overdraagbaarheid van het concept van DO in een ander land dan het VK te onderzoeken, en bovendien een *evidence base* op te bouwen voor een eventuele implementatie van DO in de rest van Nederland. Dit proefschrift is verdeeld in drie onderdelen.

In **Deel I** wordt een samenvatting gegeven van de wetenschappelijke data met betrekking tot DO die beschikbaar was voorafgaand aan de studies die onderdeel zijn van dit proefschrift. In dit deel werd ook gekeken naar eventuele hiaten in de op dat moment beschikbare kennis, die als basis kon dienen voor het opzetten van onze toekomstige studies. Verder bevat dit deel een evaluatie van de mate waarin DO voor SSLs reeds wordt toegepast vanuit internationaal perspectief, waarbij ook onderzocht of en in welke mate er variatie is in de (na)behandeling van deze relatief veel voorkomende letsels. **Deel II** bevat drie studies gebaseerd op eigen data, prospectief verzameld voor en na de implementatie van DO in ons ziekenhuis. Deze studies kijken o.a. naar het zorgverbruik in de eerste en tweede lijn, patiëntervaringen, patiëntuitkomsten, complicaties en kosteneffectiviteit. In **Deel III** wordt geëvalueerd of de resultaten van onze initiële studies reproduceerbaar zijn in een ander Nederlands ziekenhuis. In het laatste hoofdstuk worden onze ervaringen met- en de potentiële toegevoegde waarde van het tweede onderdeel van het VFC-model in Nederland beschreven. Dit deel werd eerder geïmplementeerd dan initieel gepland, met als belangrijke reden de coronavirus 2019 (COVID-19) pandemie.

Tabel 1 – Simpele en stabiele letsels, criteria en immobilisatie

Letsel	Kind/ volwassene	Criteria	Immobilisatie na DO
Clavicula fractuur kind	Kind	Leeftijd ≤14 Geen indicatie voor chirurgische behandeling	Sling
Radiuskop/-hals fractuur	Volwassene	Kop: Mason type 1, hals: niet verplaatst, or Positief fatpad sign	Drukverband, sling
Greenstick of torus fractuur van de distale radius	Kind	Acceptabele angulatie o.b.v. restgroei Torus: geïsoleerde ulna fractuur, geïsoleerde radius fractuur, of beide Greenstick: geïsoleerde ulna fractuur of geïsoleerde radius fractuur	Afneembare pols brace
Subcapitale metacarpale V fractuur	Volwassene	Volaire angulatie <70 graden Geen rotatie afwijking	Buddy tape en drukverband
Mallet vinger	Volwassene	Ossaal of tendinogeen Conservatieve behandeling	Mallet spalk
Weber A enkel fractuur	Volwassene	Dislocatie <2mm Geen tekenen van stadium 2 supinatie-adductie letsel	Tubigrip en enkel brace
Avulsie fractuur enkel	Volwassene	Laterale of mediale malleolus of tarsalia	Tubigrip en enkel brace
Basis metatarsale V fractuur	Volwassene	Fractuur in zone 1 of zone 2 Dislocatie ≤4 mm	Walker
Hallux fractuur	Beide	Proximale of distale phalanx fractuur Niet verplaatst	Spica drukverband en verbandschoen
Fractuur falanx voet	Both	Elke geïsoleerde fractuur Geen indicatie voor chirurgische behandeling	Buddy tape
Spaakverwonding	Kind	Geen fractuur op röntgenbeeldvorming Oppervlakkige wond	Drukverband

DO, Direct Ontslag; mm, millimeter.

DEEL I – OVERZICHT VAN HET WETENSCHAPPELIJK BEWIJS EN DE TOEPASSING VAN DIRECT ONSLAG VOOR SIMPELE, STABIELE LETSELS

Direct ontslag van patiënten met simpele, stabiele letsels als alternatief voor routinematige controle: een systematisch overzicht van de huidige literatuur

Het doel van **Hoofdstuk 1** was een overzicht geven van alle wetenschappelijk data over DO van SSLs die beschikbaar was voorafgaand aan de studies in dit proefschrift. Hiervoor werd een *systematic review* uitgevoerd. Voor deze review zochten we naar data over logistieke uitkomsten (bijv. het aantal poliklinische controles), financiële voordelen,

functionele uitkomst, patiënttevredenheid en ongewenste uitkomsten/complicaties.

Zesentwintig studies werden geïncludeerd in het overzicht, waarvan 92% waren uitgevoerd in het VK. Tien studies (38,5%) vergeleken uitkomsten in twee groepen: een DO-cohort en een pre-DO controle cohort (d.w.z. patiënten met een vergelijkbaar letsel die behandeld werden voor de invoering van DO). Zestien studies (61,5%) waren niet vergelijkend en keken alleen naar uitkomsten in een DO-cohort. Met andere woorden, in deze studies werd geen vergelijking gemaakt met een pre-DO situatie. In tien studies (38,5%) werd een duidelijke omschrijving gegeven van de criteria waaraan een letsel moest voldoen om in aanmerking te komen voor DO, en in zestien studies (61,5%) was deze omschrijving niet duidelijk of afwezig. In zeven studies (26,9%) werd de functionele uitkomst gemeten, in negen studies (34,6%) de patiënttevredenheid met de behandeling en in tien studies (38,5%) ongewenste uitkomsten/complicaties. Slechts één studie (3,8%) rapporteerde alle uitkomstmaten waarin wij geïnteresseerd waren.

In de studies met een controle cohort, varieerde het gemiddeld aantal poliklinische controles van 1.00 tot 2.08 per patiënt in het pre-DO cohort, afhankelijk van het type letsel/de typen letsels die werden geïncludeerd. Het gemiddeld aantal poliklinische controles in het DO cohort varieerde van 0.00 tot 0.33 per patiënt. Kostenbesparingen varieerden van 69€ tot 210€ per patiënt. In alle studies die keken naar de functionele uitkomst of patiënttevredenheid werd gerapporteerd dat deze uitkomsten vergelijkbaar waren (in de studies mét een pre-DO cohort) of “naar tevredenheid” (in de studies zonder controle cohort waarbij geen vergelijking kon worden gemaakt). Het voorkomen van ongewenste uitkomsten was laag en/of vergelijkbaar (d.w.z. vergeleken met pre-DO aantallen) in de tien studies die dit rapporteerden.

Deze *systematic review* ondersteunt het idee dat DO een veilig en effectief alternatief van zorg is, zonder dat dit ten koste gaat van behandeluitkomst of patiënttevredenheid, met als kanttekening dat dit vooral is onderzocht in het VK. Op basis van onze bevindingen raadden we dan ook aan dat er in de toekomst studies uitgevoerd moeten worden buiten het VK, en dat alle toekomstige studies, ongeacht het land waarin deze uitgevoerd worden, een duidelijke beschrijving moeten geven van de criteria waaraan aan letsel moet voldoen om in aanmerking te komen voor DO. Daarnaast zouden alle toekomstige studies gestandaardiseerde uitkomstmaten moeten rapporteren. Op deze manier verwachtten wij dat het eenvoudiger wordt om toekomstige studies met elkaar te vergelijken, en daardoor kan ook beter de overdraagbaarheid van het concept in een andere omgeving worden beoordeeld.

Toepassing van direct ontslag voor simpele en stabiele letsels onder traumachirurgen

Met onze *systematic review* vonden we een redelijk aantal studies die DO van SSLs evalueerden, maar de meeste studies waren uitgevoerd in het VK. Het doel van **Hoofdstuk 2** was het evalueren van de mate waarin DO voor SSLs op dat moment internationaal werd toegepast door traumachirurgen, en de mate van variatie in de behandeling van deze veelvoorkomende letsels.

Om dit te bepalen hebben we een online vragenlijst ontwikkeld, met daarin elf verschillende casus van patiënten met een relatief eenvoudig letsel, met bijbehorende röntgenfoto's etc. Voor elk van deze letsels was er tenminste één studie beschikbaar waarin werd onderzocht of DO een geschikte behandeling is. Elke casus beschreef de fictieve presentatie van een patiënt op de SEH van het ziekenhuis waar de persoon die de vragenlijst invulde op dat moment werkzaam was. We nodigden traumachirurgen uit via een internationaal platform om deel te nemen aan deze studie. Zij beantwoordden vervolgens vragen over het behandelplan, waaronder het aantal poliklinische controles, röntgenfoto's en fysiotherapie. Tevens werd gevraagd wanneer zij de fictieve patiënt zouden laten oefenen zonder enige beperking. Per letsel bepaalden we de mate waarin DO reeds wordt toegepast, door te kijken naar het aandeel van de deelnemers die aangaven dat zij geen poliklinische controles zouden afspreken. Vooraf bepaalden we dat er sprake was van overeenstemming als >80% van de deelnemers hetzelfde antwoord zou geven.

In totaal vulden 138 van de 667 (20.7%) genodigden de vragenlijst volledig in. Het merendeel van de deelnemers werkte in Europa of Noord-Amerika. Van alle elf casus werd bij de falanx fractuur van de teen het vaakst aangegeven dat men de patiënt direct zou ontslaan zonder verdere poliklinische controle (45% van de deelnemers), terwijl direct ontslag het minst vaak werd geselecteerd bij de volwassen patiënt met een distale radius fractuur (4%).

Overeenstemming met betrekking tot het totaal aantal poliklinische controles en het moment waarop patiënten mogen starten met oefenen zonder enige beperking werd voor geen van de letsels bereikt. Er was overeenstemming over het aantal röntgenfoto's tijdens de nabehandeling van één letsel (mallet vinger), en er was overeenstemming over het wel of niet routinematig verwijzen van patiënten naar een fysiotherapeut voor vier letsels.

Op basis van deze bevindingen concludeerden wij dat DO van SSLs internationaal nog niet veel wordt toegepast, ondanks dat er al wel verschillende studies zijn die aantonen dat het een effectief en veilig alternatief is. Daarnaast is er nog steeds een grote variatie in de behandeling van deze relatief veelvoorkomende kleine letsels, met waarschijnlijk inefficiëntie tot gevolg.

DEEL II – (KOSTEN)EFFECTIVITEIT VAN DIRECT ONTSLAG VAN PATIËNTEN MET SIMPELE EN STABIELE LETSELS IN NEDERLAND

Direct Ontslag van de Spoedeisende Hulp voor patiënten met simpele en stabiele letsels: een Nederlandse pilotstudie

In **Hoofdstuk 3** bepaalden we met een tussentijdse analyse de potentiële logistieke en financiële impact van DO van voor patiënten met SSLs op een Nederlandse SEH. Daarvoor werden alle data geanalyseerd van patiënten die met één van de elf vooraf gedefinieerde SSLs (Tabel 1) onze SEH bezochten, drie maanden voor en drie maanden na de implementatie van DO in ons ziekenhuis. Middels een vragenlijst bepaalden we patiënttevredenheid en een potentiële verschuiving van zorg naar de eerste lijn (bezoek aan huisarts of fysiotherapeut). Alle data werden bepaald drie maanden nadat de patiënt het letsel had opgelopen.

In de drie maanden voordat DO werd geïmplementeerd presenteerden 275 patiënten zich met een SSL op onze SEH, versus 318 patiënten in de drie maanden na implementatie van DO. Gedurende deze eerste drie maanden na implementatie van DO werden 304 van de 318 patiënten direct ontslagen (protocol compliantie 95.6%). Een patiënt met een veronderstelde Weber type A enkelfractuur werd direct ontslagen door het SEH-personeel. Tijdens de dagelijkse screening van alle SEH röntgenfoto's werd echter gezien dat deze patiënt een Weber type B enkelfractuur had en de patiënt werd daarom teruggeroepen en behandeld volgens protocol.

Na invoering van DO zagen wij een significante daling in het aantal poliklinische controles (-91%), poliklinische radiologische beeldvorming (-72%), en kosten. De patiënttevredenheid met de behandeling was vergelijkbaar voor en na de implementatie van DO. Er was geen verschuiving van zorg naar de eerste lijn. Op basis van deze tussentijdse analyse concludeerden wij dat DO van de SEH voor SSLs ook in Nederland een effectief en veilig alternatief lijkt te zijn voor de meer "traditionele" behandeling met routinematige poliklinische controle.

Direct ontslag vanaf de Spoedeisende Hulp voor simpele en stabiele letsels: een voor propensity-score gecorrigeerde non-inferioriteitsstudie

In **Hoofdstuk 4** werd geëvalueerd of DO van de SEH voor patiënten met SSLs non-inferieur is aan de "traditionele" zorg met routinematige poliklinische controle, voor de uitkomstmaten patiënttevredenheid met de behandeling en functionele uitkomst. Daarnaast werden andere patiënt-gerapporteerde uitkomsten vergeleken zoals kwaliteit van leven (EQ-5D-5L voor volwassenen en EQ-5D-Youth voor kinderen), aantal dagen tot teruggaan naar werk, school en sport, werk- of schoolverzuim, zorgverbruik in de tweede lijn (poliklinische controles en beeldvorming), zorgverbruik in de eerste lijn (bezoeken aan huisarts en fysiotherapeut), ongewenste uitkomsten (vertraagde genezing of geen

genezing van het bot), en het aantal gemiste letsels ten tijde van het SEH bezoek, in aanvulling op het SSL. Er werden vooraf gedefinieerde afkapwaarden gebruikt om non-inferioriteit te bepalen voor patiënttevredenheid (op een visueel analoge schaal van 1-10), en functionele uitkomst (bepaald middels een van vier gevalideerde vragenlijsten, afhankelijk van de locatie van het letsel en de leeftijd).

In deze studie werden alle patiënten met een SSL geïncludeerd die *informed consent* hadden gegeven tijdens hun initiële SEH-bezoek, zes maanden voor (pre-DO-cohort) en zes maanden na de implementatie van DO in ons ziekenhuis (DO-cohort). Patiënt-gerapporteerde uitkomsten en ervaringen werden verzameld middels een vragenlijst welke drie maanden na het SEH bezoek aan patiënten werd verstuurd. Alle andere data werden verzameld door raadplegen van het elektronisch patiëntendossier, minstens 14 maanden na het SEH bezoek.

In totaal namen 348 (pre-DO-cohort) en 371 (DO-cohort) patiënten deel aan de studie, waarvan respectievelijk 144 (41.4%) en 153 (41.2%) patiënten de vragenlijst na drie maanden invulden. De patiënttevredenheid met de behandeling en de functionele uitkomst in het DO-cohort was non-inferieur aan het pre-DO-cohort. Als voorbeeld: de gemiddelde patiënttevredenheid was 8.13 (pre-DO-cohort) en 7.95 (DO-cohort, gemiddeld verschil: -0.16, p=0.408). Pijn, kwaliteit van leven, het aantal bezoeken aan de huisarts/fysiotherapeut en het aantal dagen tot teruggaan naar werk/school/sport waren vergelijkbaar voor en na de implementatie van DO. Het werkverzuim was hoger in het pre-DO-cohort (OR:0.110, p<0.001), net als schoolverzuim (OR:0.084, p<0.001). Na implementatie van DO daalde het aantal ziekenhuis bezoeken per patiënt: -1.68 (p<0.001), net als het aantal poliklinische röntgenfoto's per patiënt: -0.26 (p<0.001). Er was bij één patiënt sprake van een gemist letsel in het pre-DO-cohort en bij twee patiënten in het DO-cohort (d.w.z. een additioneel letsel, naast het SSL). Er waren geen ongewenste uitkomsten in beide cohorten.

De resultaten van dit hoofdstuk bevestigden dat patiënten met verschillende SSLs behandeld kunnen worden middels DO, zonder dat dit ten koste gaat van de behandeluitkomst of de patiënttevredenheid. Op basis van onze schatting dat 85.000 patiënten ieder jaar een Nederlandse SEH bezoeken met een SSL, zou de implementatie van DO in potentie kunnen leiden tot een vermindering van het aantal poliklinische controles van 142.800 per jaar in heel Nederland. Echter, omdat de subgroepen per letsel in deze studie relatief klein zijn, moet in toekomstige studies worden gekeken of deze non-inferioriteit ook geldt voor elk afzonderlijk letsel.

Kosteneffectiviteit van Direct Ontslag vanaf de Spoedeisende Hulp voor patiënten met simpele en stabiele letsels in Nederland

In **Hoofdstuk 5** werd een economische analyse uitgevoerd op basis van de data van de vragenlijsten uit het vorige hoofdstuk, waarbij de "traditionele" routinematige poliklinische controle werd vergeleken met DO. Deze economische analyse werd verricht vanuit het maatschappelijk perspectief. Tevens werd een sensitiviteitsanalyse uitgevoerd om de kosteneffectiviteit van DO te bepalen.

Tot de maatschappelijke kosten werden gerekend alle zorgkosten, kosten ten gevolge van werkverzuim en reiskosten, op basis van Nederlandse referentiewaarden. Effectiviteit werd bepaald met de generieke gezondheid-gerelateerde kwaliteit van leven (HR-QoL, EQ-5D-5L of EQ-5D-Youth); ziekte-specifieke kwaliteit van leven (functionele uitkomst, verschillende gevalideerde vragenlijsten, omgerekend naar één uniforme schaal van 0-100); tevredenheid met de behandeling (visueel analoge schaal (VAS), 1-10); en pijn (VAS, 1-10).

Er was geen statistisch significant verschil tussen het pre-DO-cohort en het DO-cohort voor de uitkomsten generieke HR-QoL (0.03; 95%CI [-0.01]–[0.08]), ziekte-specifieke HR-QoL (4.4; 95%BI [-1.1]–[9.9]), pijn (0.08; 95%BI [-0.37]–[0.52]), en tevredenheid met de behandeling (-0.16; 95%BI [-0.53]–[0.21]). De totale maatschappelijke kosten waren lager in het DO-cohort vergeleken met pre-DO-cohort (-€822; 95%BI -€1719 tot -€67), en dit was ook het geval voor de subcategorieën "zorgkosten" (-€168; 95%BI [-€205]–[-€131]) en "kosten ten gevolge van werkverzuim" (-€645; 95% BI [-€1535]–[€100]). De waarschijnlijkheid dat DO kosteneffectief is, was 0.98 bij een betalingsbereidheid van €0 voor alle effectiviteitsmaten. Dit veranderde niet bij een hogere betalingsbereidheid voor de generieke HR-QoL, ziekte-specifieke QoL en pijn. Voor de patiënttevredenheid daalde dit enigszins voor hogere waarden van betalingsbereidheid. In het vorige hoofdstuk was echter al duidelijk geworden dat de verschillen in deze groepen ruim binnen de marges vielen van een klinisch relevant verschil.

Op basis van deze bevindingen concludeerden we dat DO vanuit maatschappelijk perspectief ook kosteneffectief lijkt ten opzichte van routinematige controle. Op basis van onze schatting dat 85.000 patiënten elk jaar een Nederlandse SEH bezoeken met een SSL, zou implementatie van DO in Nederland in potentie kunnen leiden tot een jaarlijkse besparing van 14 miljoen euro in directe zorgkosten en een besparing van 54.8 miljoen euro in kosten door verlies aan productiviteit.

DEEL III – DE OPSCHALING VAN VIRTUAL FRACTURE CARE EN TOEKOMSTIGE STAPPEN IN HET OPTIMALISEREN VAN DE TRAUMAZORG

Zorgverbruik en tevredenheid met de behandeling voor en na de implementatie van Direct Ontslag vanaf de Spoedeisende Hulp voor patiënten met simpele en stabiele letsels in Nederland

Hoofdstuk 6 was het laatste hoofdstuk in dit proefschrift dat betrekking heeft op DO van SSLs, en het doel van dit hoofdstuk was het bevestigen van onze bevindingen op twee manieren: 1) door te kijken of de resultaten van onze initiële studie in hoofdstuk 4 vergelijkbaar bleven in ons eigen ziekenhuis over een langere periode gezien, en dus onder grotere aantallen patiënten, en 2) of deze resultaten vergelijkbaar waren met de resultaten in een tweede ziekenhuis in Nederland, het Sint Antonius ziekenhuis (SA). De uitkomstmaten waren zorgverbruik in de tweede lijn, tevredenheid met de behandeling en zorgverbruik in de eerste lijn.

In totaal werden respectievelijk 2033 (OLVG=1686; SA=347) en 1616 (OLVG=1396; SA=220) patiënten geïncludeerd in het pre-DO-cohort en het DO-cohort. Na implementatie van DO, was de gemiddelde daling van het aantal poliklinische controles 1.06 (1.13-0.99; $p<0.001$) in OLVG en 1.07 (1.02-0.98; $p<0.001$) in SA. Als aanvulling op onze eerdere studies, waarbij de uitkomstmaten voor alle SSLs samen werden geanalyseerd, konden we bij deze studie ook de daling in het aantal poliklinische controles per letsel bepalen. Het gemiddelde aantal poliklinische controles daalde na DO significant voor elk van de SSL-subgroepen. De gemiddelde daling van het aantal poliklinische röntgenfoto's per patiënt was 0.17 in OLVG ($p<0.001$) en 0.18 in SA ($p<0.001$). In OLVG was de gemiddelde tevredenheid met de behandeling 8.1 (pre-DO-cohort) versus 7.95 (DO-cohort), versus 7.75 in SA (alleen DO-cohort). In het pre-DO-cohort in OLVG bezocht 23.6% van de patiënten hun huisarts voor de controle van hun letsel, versus 26.1% in het DO cohort, versus 13.3% in SA (alleen DO-cohort). Het aantal bezoeken aan de fysiotherapeut was voor en na de implementatie van DO vergelijkbaar onder patiënten met een SSL.

Op basis van dit hoofdstuk concludeerden we dat - ook wanneer gemeten over een langere periode en in een grotere groep patiënten dan eerder - de resultaten met betrekking tot DO vergelijkbaar bleven. Daarnaast bleek dat deze resultaten ook vergelijkbaar waren in een ander Nederlands ziekenhuis. Dit laat zien dat het concept van DO dat is geïmplementeerd in ons ziekenhuis overdraagbaar is naar andere ziekenhuizen. Dit kan van toegevoegde waarde zijn voor andere Nederlandse ziekenhuizen wanneer zij overwegen DO te implementeren in de nabije toekomst.

Optimaliseren van de traumazorg tijdens de COVID-19 pandemie

In **Hoofdstuk 7** evalueerden we de implementatie en de potentiële toegevoegde waarde van een dagelijkse VFC-bespreking in een Nederlandse setting. Zoals eerder beschreven bestaat het VFC-model uit twee onderdelen, 1) DO voor patiënten met SSLs, en 2) een dagelijkse bespreking voor alle andere patiënten met letsels van het steun- en bewegingsapparaat (Figuur 1). Initieel was het de bedoeling dat dit proefschrift zich alleen zou richten op DO, maar de implementatie van de dagelijkse VFC-bespreking werd in ons ziekenhuis versneld in een reactie op de COVID-19 pandemie. De richtlijn voor de poliklinische behandeling van patiënten tijdens de COVID-19 pandemie schreef voor dat *face-to-face* contact tot een minimum moesten worden beperkt, en dat meer gebruik gemaakt moest worden van zorg op afstand. Wij verwachtten dat de VFC-bespreking ons zou ondersteunen bij het volgen van deze richtlijn. Als namelijk een deel van de patiënten die aangemeld worden voor de VFC bespreking "virtueel" kunnen worden ontslaan uit controle, en als compleet behandelplan gedocumenteerd wordt voor alle andere patiënten, zou dit mogelijk het aantal onnodige (face-to-face) controles kunnen verminderen.

In de originele VK-versie van het VFC-model, kunnen patiënten "virtueel" worden ontslagen, worden verwezen naar een verpleegkundig specialist of worden verwezen naar een arts/specialist voor verdere behandeling. Tijdens elke poliklinische controle wordt vervolgens bepaald of daarna nog een poliklinische controle moet plaatsvinden. Met andere woorden, na de VFC-bespreking in het VK is er niet een duidelijk behandelplan voor elke patiënt. Wij waren van mening dat zo'n systeem kan leiden tot behandelvariatie en mogelijk ook tot onnodige ziekenhuisbezoeken, en daarom hebben wij onze VFC-bespreking zodanig aangepast, zodat er voor elke besproken casus een volledig behandelplan werd gedocumenteerd, inclusief alle afspraken, beeldvorming, etc.

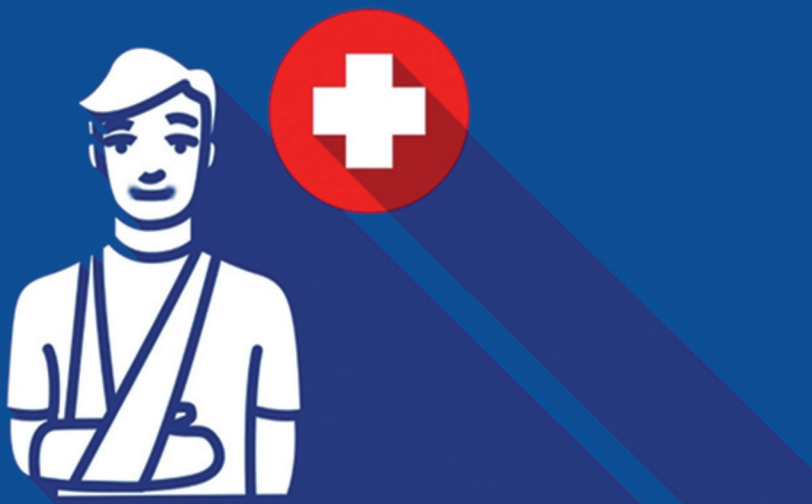
Daarnaast hebben we ook geprobeerd de traumazorg op de SEH te stroomlijnen door een trauma "*fast-track*" zorgpad te implementeren, om zodoende de werkdruk op de SEH te verminderen tijdens de pandemie en de wachttijden te beperken tot een minimum voor trauma patiënten op de SEH, door de presentatie van grote aantallen patiënten met een verdenking op COVID-19.

De implementatie van deze veranderingen werd geëvalueerd middels een "*closed-loop audit*", uitgevoerd gedurende twee periodes van vier weken, met de volgende vier vooraf gedefinieerde standaarden: 1) alle geschikte patiënten met letsels van het steun- en bewegingsapparaat krijgen vanaf de SEH een verwijzing voor de VFC-bespreking; 2) zij kunnen daarna allemaal worden bereikt om hun behandelplan te bespreken; poliklinische controle vindt zoveel als mogelijk 3) op initiatief van de patiënt plaats en 4) vindt zoveel als mogelijk op afstand plaats. De totale wachttijd op de SEH, tijd-tot-beoordeling; tijd-voor-beoordeling; en tijd-na-beoordeling werden tijdens beide audit periodes gemeten en vergeleken met reeds eerder verrichte metingen.

Tijdens beide audit periodes werd het merendeel van de geschikte SEH patiënten ook daadwerkelijk verwezen naar de VFC-bespreking (1e periode: n=162[88.0%]; 2e periode: n=302[98.4%]), en de meeste patiënten konden daarna worden bereikt (1e periode: 98.1%; 2e periode: 99.0%). Van alle verwezen patiënten tijdens de eerste en tweede audit periode werden respectievelijk 17.9% en 13.6% patiënten "virtueel" ontslagen, terwijl binnen alle behandelplannen respectievelijk 45.0% en 41.1% van alle controle afspraken gepland was als zorg op afstand. De mediane totale wachttijd op de SEH nam af (1e periode: -36 minuten, ($p<0.001$); 2e periode: -33 minuten, ($p<0.001$)). Tijdens de tweede audit periode nam de tijd-tot-beoordeling af: -13 minuten ($p<0.001$), net als de tijd-voor-beoordeling: -10 minuten ($p=0.019$).

Dit resultaten in dit hoofdstuk laten zien dat er een potentiële toegevoegde waarde is van een VFC-bespreking als alternatief voor de routinematige verwijzing van alle patiënten vanaf de SEH naar de polikliniek. Zo kon er, naast de patiënten met SSLs die reeds vanaf de SEH direct ontslagen waren, een relatief groot aanvullend aantal patiënten "virtueel" worden ontslagen tijdens de VFC-bespreking. Tijdens onze VFC-bespreking wordt een volledig behandelplan gedocumenteerd voor elke patiënt. Hoewel dit geen onderdeel was van deze studie, verwachten wij dat deze werkwijze onze behandelvariatie zal verminderen met mogelijk ook minder onnodige poliklinische controles en daarmee kosten tot gevolg. Toekomstige studies moeten zich o.a. richten op de effecten van een VFC-bespreking op behandelvariatie, het daadwerkelijke aantal poliklinische controles en poliklinische beeldvorming, patiënt-gerapporteerde uitkomsten en patiëntervaringen.

Virtual Fracture Care is (ook) in Nederland een waardevol behandelconcept in de zorg voor patiënten met letsels van het steun- en bewegingsapparaat. Enerzijds biedt DO van patiënten met SSLs een doelmatig en efficiënt alternatief voor de meer traditionele behandelwijze met routinematige poliklinische controle. Anderzijds biedt de dagelijkse VFC bespreking voor alle andere patiënten de mogelijkheid om voor alle andere patiënten een volledig behandelplan te maken, wat zou moeten zorgen voor minder behandelvariatie en onnodige poliklinische controles en beeldvorming. In de toekomst kan het VFC concept uitgebreid worden, met meer aandacht voor een behandeling op maat voor elke individuele patiënt, bijvoorbeeld door het tijdens de nabehandeling op vaste momenten verzamelen van patiënt-gerapporteerde uitkomsten zoals functionele uitkomst.



PORTFOLIO
LIST OF PUBLICATIONS
WOORD VAN DANK
ABOUT THE AUTHOR

&

PORTFOLIO

PhD student: Thijs H. Geerdink
PhD period: September 2018 – September 2021
Promotor: Prof. dr. J. Carel Goslings
Copromotores: Dr. Ruben N. van Veen, Dr. J.M. (Hanneke) van Dongen

1. PhD Training	Year	Workload (ECTS)
Courses		
ICH-GCP, EMWO, Amersfoort, the Netherlands	2018	1.0
Scientific Writing in English for Publication, OLVG, Amsterdam, the Netherlands	2019	1.5
Practical Biostatistics, OLVG, Amsterdam, the Netherlands	2019	1.1
Specific courses		
Advanced Trauma Life Support, Washington, USA	2017	2.0
Review activities		
Abstract reviewer Symposium Experimenteel Onderzoek Heelkundige Specialismen	2019	0.5
Conferences		
Surgical annual "*Najaarsdag*", Ede, the Netherlands	2016	0.5
Traumadagen NVT, RAI, Amsterdam, the Netherlands	2019	0.5
Santeon Congress, Amersfoort, the Netherlands	2019	0.5
Surgical annual "Najaarsdag", Noordwijk, the Netherlands	2020	0.5
5th World Trauma Congress AAST, virtual, USA	2021	0.5
Oral presentations		
Evaluation of the effects of the new guideline for acute appendicitis in children. *Annual Surgical "Najaarsdag", Ede, the Netherlands*	2016	0.5
Virtual Fracture Clinic and Direct Discharge from the Emergency Department. *Annual meeting Dutch Trauma Association, RAI, Amsterdam, the Netherlands*	2019	0.5
Virtual Fracture Clinic and Direct Discharge from the Emergency Department. *Santeon congress, Amersfoort, the Netherlands*	2019	0.5
Direct Discharge from the Emergency Department: a new concept in the Netherlands. Annual Surgical "Najaarsdag", Noordwijk, the Netherlands	2020	0.5
Webinar Direct Discharge and Virtual Fracture Care for 24 interested Dutch hospitals. *Virtual webinar*	2021	0.5

Direct Discharge from the Emergency Department of Patients with Simple Stable Injuries. 5th World Trauma Congress of the American Association for the Surgery of Trauma, virtual	2021	0.5

Poster presentations

Virtual Fracture Clinic: a new concept in the Netherlands Annual Science Day, OLVG, Amsterdam, the Netherlands	2018	0.5

2. Teaching

Supervising

M. van Delft; Master thesis	2018	1.0
O.V.A. Bouwmeester; Master thesis	2018 – 2019	1.0
J.J. Groen; Master thesis	2019	1.0
M.J. van der Ven; Master thesis	2019	1.0
B.A. Uijterwijk; Master thesis	2019 - 2020	1.0
K.A. de Vries; Master thesis	2020	1.0
N.J. Geerdink; Bachelor thesis	2020	1.0
N. van der Velde; Bachelor thesis	2021	1.0

3. Parameters of esteem

Grants

Research Grant OLVG – Added value of Mini-C-Arm device	2019	-
Innovation Grant OLVG – Pilot Virtual Fracture Clinic & Direct Discharge	2019	-
Research Grant Zilveren Kruis, Achmea – Direct Discharge of Simple Stable Injuries	2019	-
Research Grant other health insurance companies: CZ, VGZ, Menzis, ASR, DSW, Caresq	2019 – 2020	-
Innovation Grant St. Antonius Ziekenhuis – Improving VFC smartphone app	2021	-

Awards

Audience award best Poster presentation OLVG annual Science Day	2018	-
Innovation award Santeon Congress	2019	-
Best Abstract annual meeting Dutch Surgical Association (NVvH)	2020	-

4. Other

Organization

Chair of Board Symposium Experimenteel Onderzoek Heelkundige Specialismen (SEOHS)	2019	1.0

LIST OF PUBLICATIONS

Publications in this thesis

Geerdink TH, Verbist J, van Dongen JM, Haverlag R, van Veen RN, Goslings JC. Direct discharge of patients with simple stable musculoskeletal injuries as an alternative to routine follow-up: a systematic review of the current literature. Eur J Trauma Emerg Surg. 2021.

Geerdink TH, Uijterwijk BA, Meijer DT, Sierevelt IN, Mallee WH, van Veen RN, Goslings JC, Haverlag R. Adoption of direct discharge of simple stable injuries amongst (orthopaedic) trauma surgeons. Injury. 2021;52(4):774-9.

Geerdink TH, Haverlag R, van Veen RN, Bouwmeester OVA, Goslings JC. [Direct discharge from the ED for patients with simple stable injuries: a Dutch pilot study]. Nederlands tijdschrift voor geneeskunde. 2020;164.

Geerdink TH, Augustinus S, Groen JJ, van Dongen JM, Haverlag R, van Veen RN, Goslings JC. Direct discharge from the emergency department of simple stable injuries: a propensity score-adjusted non-inferiority trial. Trauma Surg Acute Care Open. 2021;6(1):e000709.

Geerdink TH, Geerdink NJ, van Dongen JM, Haverlag R, Goslings JC, van Veen RN, Virtual Fracture Care Study Collaborative. Cost-effectiveness of direct discharge from the emergency department of patients with simple stable injuries in the Netherlands. Trauma Surg Acute Care Open. 2021;6(1):e000763.

Geerdink TH, Spierings JF, Schuijt HJ, Eversdijk HAJ, van Dongen JM, Kokke MC, Twigt BA, Goslings JC, van Veen RN. Healthcare utilization and satisfaction with treatment before and after direct discharge from the Emergency Department of simple stable musculoskeletal injuries in the Netherlands. Eur J Trauma Emerg Surg. 2022;48(3):2135-44.

Geerdink TH, Salentijn DA, de Vries KA, Noordman PCW, van Dongen JM, Haverlag R, et al. Optimizing orthopedic trauma care delivery during the COVID-19 pandemic. A closed-loop audit of implementing a virtual fracture clinic and fast-track pathway in a Dutch level 2 trauma center. Trauma Surg Acute Care Open. 2021;6(1):e000691.

Other publications

de Castro SMM, **Geerdink TH**, Macco S, van Veen RN, Jensch S, Vrouenraets BC. Mandatory imaging in the work-up of children suspected of having appendicitis reduces the rate of unnecessary surgeries. J Pediatr Surg. 2018;53(10):2028-31.

Geerdink TH, Augustinus S, Atema JJ, Jensch S, Vrouenraets BC, de Castro SMM. Validation of a Scoring System to Distinguish Uncomplicated From Complicated Appendicitis. J Surg Res. 2021;258:231-8.

Nijland LMG, van Veen RN, Ruys AT, van Veldhuisen CL, **Geerdink TH**, de Castro SMM. Feasibility of Postoperative Home Monitoring Using Video Consultation and Vital Sign Monitoring of Bariatric Patients. Obes Surg. 2020;30(6):2369-74.

CONTRIBUTORSHIP STATEMENT

- **Geerdink TH**, Verbist J, van Dongen JM, Haverlag R, van Veen RN, Goslings JC. Direct discharge of patients with simple stable musculoskeletal injuries as an alternative to routine follow-up: a systematic review of the current literature. Eur J Trauma Emerg Surg. 2021.

  JCG was the guarantor, THG, JV, JMvD, RvV, RH and JCG drafted the manuscript. All authors contributed to the development of the selection criteria and data extraction criteria. THG, JV and JCG are responsible for the systematic search and the riskof-bias assessment strategy. THG developed the search strategy. All authors read, provided feedback and approved the final manuscript.

- **Geerdink TH**, Uijterwijk BA, Meijer DT, Sierevelt IN, Mallee WH, van Veen RN, Goslings JC, Haverlag R. Adoption of direct discharge of simple stable injuries amongst (orthopaedic) trauma surgeons. Injury. 2021;52(4):774-9.

  THG was responsible for the conduct of this study, methodology, development of the survey, draft of the article, collection of data, and analysis of all data. DTM was responsible for the development of the survey, collection of data and draft of the article. INS was responsible for the analysis of the data. WHM was responsible for the development of the survey, the interpretation of the data and the draft of the article. RNvV, JCG and RH all contributed to the methodology of this study, the development of the survey, as well as writing of the article.

- **Geerdink TH**, Haverlag R, van Veen RN, Bouwmeester OVA, Goslings JC. [Direct discharge from the ED for patients with simple stable injuries: a Dutch pilot study]. Nederlands tijdschrift voor geneeskunde. 2020;164.

  THG was responsible for the conduct of this study, methodology, draft of the article, collection of data, and analysis of all data. OVAB supported the implementation of direct discharge as well as collecting parts of the data. RH, RNvV and JCG all contributed to the methodology of this study, implementation of direct discharge as well as writing of the article. JCG was the guarantor.

- **Geerdink TH**, Augustinus S, Groen JJ, van Dongen JM, Haverlag R, van Veen RN, Goslings JC. Direct discharge from the emergency department of simple stable injuries: a propensity score-adjusted non-inferiority trial. Trauma Surg Acute Care Open. 2021;6(1):e000709.

  THG was responsible for the conduct of this study, methodology, draft of the article, collection of data, and analysis of all data. SA supported the implementation of direct discharge and contributed to the writing of the article as well as collecting parts of the data. JJG supported the implementation of direct discharge as well as collecting parts of the data. JMvD contributed to the writing of the article and analysis of all data. RH, RNvV and JCG all contributed to the methodology of this study, implementation of direct discharge as well as writing of the article. JCG was the guarantor.

- **Geerdink TH**, Geerdink NJ, van Dongen JM, Haverlag R, Goslings JC, van Veen RN, Virtual Fracture Care Study Collaborative. Cost-effectiveness of direct discharge from the emergency department of patients with simple stable injuries in the Netherlands. Trauma Surg Acute Care Open. 2021;6(1):e000763.

  THG was responsible for the conduct of this study, the methodology, draft of the article, collection of data, and analysis of all data. NJG was responsible for the draft of the article and analysis of all data. JMvD contributed to the methodology, writing of the article, and analysis of all data. RH, RNvV and JCG all contributed to the methodology of this study, implementation of direct discharge, as well as the writing of the article. JCG was the guarantor.

- **Geerdink TH**, Spierings JF, Schuijt HJ, Eversdijk HAJ, van Dongen JM, Kokke MC, Twigt BA, Goslings JC, van Veen RN. Healthcare utilization and satisfaction with treatment before and after direct discharge from the Emergency Department of simple stable musculoskeletal injuries in the Netherlands. Eur J Trauma Emerg Surg. 2022;48(3):2135-44.

  THG was responsible for the conduction of this study, the methodology, draft of the manuscript, collection of the data in OLVG, partial collection of data in SA, and analysis of all data. JFS was responsible for collection of the logistic data in SA, methodology, and the draft of the manuscript. HAJE was responsible for the collection of the logistic data and patient-reported outcomes/experiences in SA. HJS was responsible for the implementation of DD in SA as well as the data collection and draft of the manuscript. JMvD was responsible for the statistical analyses, the methodology and the draft of the manuscript. MCK was responsible for the implementation of DD in

SA and has contributed to the draft of the manuscript. BAT, RNvV and JCG all have contributed to the implementation of DD in OLVG, the methodology of this study, as well as the writing of the manuscript. JCG was the guarantor.

- **Geerdink TH**, Salentijn DA, de Vries KA, Noordman PCW, van Dongen JM, Haverlag R, et al. Optimizing orthopedic trauma care delivery during the COVID-19 pandemic. A closed-loop audit of implementing a virtual fracture clinic and fast-track pathway in a Dutch level 2 trauma center. Trauma Surg Acute Care Open. 2021;6(1):e000691.

  THG was responsible for the methodology, statistical analysis of the data, and the writing of the article. DAS was responsible for the methodology and writing of the article. KAdV was responsible for time measurements, methodology, statistical analysis of the data and draft of the article. PCWN was responsible for the development of the VFC review and implementation in the EPR, and the writing of this article. JMvD was responsible for the methodology, statistical analysis and writing of the article. RH, JCG and RNvV were responsible for the development of the VFC review, the methodology of this study and the writing of this article. RNvV was the guarantor of the study.

DANKWOORD

Prof. dr. J.C. Goslings

Beste Carel, in juni 2017 startte ik mijn eerste ANIOS-baan in OLVG. Een maand later kwam jij er als professor Traumachirurgie terug, met 16 jaar ervaring als staflid in AMC. Je wilde terug naar de kern van het vak: patiëntenzorg en opereren, en – zo klonk het in de wandelgangen – het wetenschappelijk onderzoek wellicht op een iets lager pitje zetten? Je kunt je voorstellen dat ik wat moed bij elkaar moest schrapen toen ik je in de maanden daarna vroeg om hulp bij het opzetten van een eigen promotietraject in OLVG. Gelukkig voor mij kon jij het onderzoek toch ook niet helemaal los laten en voor je het wist had je er juist weer een promovendus bij. Dat was voor mij de aftrap van een enorm leerzaam traject waarin je me met veel vrijheid en vertrouwen aan de slag liet gaan. Ik kon altijd bij je terecht om even te sparren. Door jouw altijd snelle maar toch punctuele revisies ben ik zowaar nog perfectionistischer geworden.
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Dr. R.N. van Veen

Beste Ruben, what a ride! Jij had in dit project allerlei rollen, die van traumachirurg, wetenschapper, bij tijd en wijle ook die van zakenman, maar je was vooral de persoon die durfde dingen te veranderen en door te drukken. Daar wil ik je in het bijzonder voor wil bedanken: de manier waarop jij je zo in volle overtuiging hebt ingezet voor het VFC project. Vol met ideeën, recht op het doel af, laaiend enthousiast. Jij gaf gas wanneer dat moest, en zette precies de juiste mensen bij elkaar om een bepaald doel te bereiken. Waar de meeste mensen de COVID maatregelen zagen als een beperking, zag jij juist de kans om het tweede deel van het VFC project versneld in te voeren. Bedankt voor al je inzet bij het ontwikkelen, invoeren en promoten van dit project. Ik geloof dat jouw eigenschappen perfect mijn drang tot in-de-puntjes willen uitwerken, perfectionisme en – zoals jij het noemt – “flowchart-denken” aan hebben gevuld en daarmee het VFC project succesvol hebben gemaakt. Ik blijf daarom heel graag betrokken bij de verdere ontwikkeling van het VFC project (waarover een kleine tip van de sluier wordt gelicht in de discussie van dit proefschrift), en ik heb er dan ook alle vertrouwen in dat dit een succes gaat worden.

Dr. J.M. van Dongen

Beste Hanneke, nadat het VFC project enigszins op poten stond nam ik contact met je op omdat ik begeleiding nodig had bij een kosteneffectiviteitsanalyse. Het was eigenlijk bedoeld als een eenmalige begeleiding bij één artikel, tot je vervolgens ook wel even

feedback wilde geven op mijn systematic review en mee wilde denken over de geschikte statistische analyses voor de studie naar patiëntuitkomsten. Ik bleek zoveel baat te hebben bij jouw feedback, kennis en advies, dat ik je heb gevraagd om mijn co-promotor te worden. Je altijd zeer uitgebreide, kritische maar scherpe feedback hebben elk van de stukken uit dit proefschrift naar een hoger niveau getild. Ik merk dat ik daardoor ook echt scherper ben gaan schrijven. Je was altijd laagdrempelig bereikbaar via app of mail voor een vraag. Je hulp bij alle statistiek en de interpretatie van de data was onmisbaar voor de totstandkoming van dit proefschrift.

Overige leden van de promotiecommissie; **prof. dr. J.A.M. Kremer**, **prof. dr. M.A.A.J. van den Bosch**, **prof. dr. H.J. Bonjer**, **dr. J.A. Halm**, **dr. S. van Dieren**, **prof. dr. L. Witkamp** bedankt voor de interesse en de beoordeling van het proefschrift.

Robert Haverlag
Beste Robert, eind 2017 werkte ik net een paar maanden als ANIOS in OLVG West. Op een dinsdagmiddag was er de gebruikelijke ortho-traumabespreking met afsluitend een presentatie van één van de AIOS. Ik weet nog dat je zei: "zorg dat je er bij bent, dit is echt een leuk en interessant onderwerp". De presentatie ging over direct ontslag van verschillende simpele en stabiele letsels. Ik vond het tijdens mijn ANIOS-baan tijd al vrij krom dat patiënten met een radiuskopfractuur na een week terug moesten komen om informatie te krijgen die ik ze ook al bij hun eerste bezoek op de SEH kon geven. Dit was echt het moment waarop ik ervan overtuigd raakte dat het anders kon. Ik was razend enthousiast; de volgende dag had ik in Photoshop een ontslagfolder in het Nederlands ontwikkeld in OLVG stijl. In de maanden daarna werkten we samen aan de uitwerking van de plannen om Direct Ontslag als pilot op te zetten in OLVG. Het was het begin van een prachtig project dat ondertussen veel groter is geworden dan we destijds hadden kunnen verwachten. Hier ben ik je eeuwig dankbaar voor. Je hebt me daarnaast vanaf het begin af aan bij Carel gepromoot, zodat ik onder hem kon promoveren, en ondanks dat je zelf niet deelneemt in de promotiecommissie, ben je altijd zeer nauw betrokken geweest bij het project en stond je altijd klaar om mee te denken.

Bas Twigt
Bas, jij raakte meer en meer betrokken bij het VFC project toen men er in Nederland in geïnteresseerd raakte. Je hebt je ontfermd over de opschaling en uitrol van het project in Nederland en bent nauw betrokken geweest bij de verdere uitrol van de VFC app om dit mogelijk te maken. Mede dankzij jouw inzet en hulp is het project nu in maar liefst 17 Nederlandse ziekenhuizen geïmplementeerd. Hopelijk kunnen we er voor zorgen dat dit binnen enkele jaren de standaard behandeling in Nederland wordt.

Alle andere traumachirurgen van OLVG
Bedankt voor al jullie steun bij het uitrollen van het VFC project. Toen ik met het project startte was ik bang dat het nooit zou lukken om daadwerkelijk alle neuzen dezelfde kant op te krijgen en de behandelprotocollen zo radicaal om te gooien. Door jullie vertrouwen, medewerking, inzet en feedback hebben we een project neergezet dat nu als voorbeeld dient voor heel Nederland.

Philip d'Ailly
Phil, ik ben de tel kwijt van al die keren dat jij tijdens de COVID-lockdown om 08:30 op de stoep stond, waardoor ik wel op moést staan. Eén ding weet ik zeker, als je dat niet had gedaan zou dit proefschrift nog lang niet af zijn. Van jou moest altijd alles korter, maar ik was te perfectionistisch en deed dan ook niet altijd wat met je feedback. Desalniettemin heb je elk van de stukken in dit proefschrift toch minstens twee keer van feedback voorzien. Bedankt voor alle potjes schaak tussendoor, om het brein scherp te houden. Het is niet meer dan logisch dat je mijn paranimf bent. Ik heb er alle vertrouwen in dat ook jij binnenkort staat te verdedigen en aangenomen wordt. Wat zou het mooi zijn als we na al die gezamenlijke onderzoeksdagen ook eens samen staan te opereren.

Guus van Baar
Klasgenoot sinds de eerste klas op de Bataafse Kamp. Daarna naar Amsterdam om Geneeskunde te studeren. Ik zal niet vergeten hoe we voor elke toets met veel te veel koffie op elkaar tot in de nachtelijke uurtjes overhoorden voor een goed cijfer. Ondertussen wonen we alweer 13 jaar in Amsterdam en zijn we beiden in opleiding tot (MKA-)chirurg. Dus die twee ettertjes uit 1F hebben het toch nog best een eind geschopt. Als broer van Peet heb je ondertussen een nog bijzonderder rol gekregen in mijn leven. Tal van redenen om je te vragen als paranimf. Bedankt dat je al deze rollen hebt willen vervullen en op nog heel veel bijzondere momenten samen.

Diederik Meijer
Died, we leerden elkaar kennen als junior-co in het 4e jaar van onze Geneeskunde opleiding. We zaten bij enig toeval twee jaar lang samen in hetzelfde ziekenhuis en hebben ook nog enkele weken een SEH afdeling in een afgelegen gebied in Zuid-Afrika gerund (als ik hier nu aan terugdenk, denk ik eigenlijk niet dat we daar toen echt geschikt voor waren). Jij hebt mij tijdens onze co-assistententijd geënthousiasmeerd voor het onderzoek. Het artikel waar we destijds samen aan begonnen is nog altijd niet af en dat zal er waarschijnlijk ook niet meer van komen, maar who cares. Ondertussen hebben we een gezamenlijke publicatie en je hebt veel bijgedragen aan hoofdstuk twee uit dit proefschrift. Door jouw hulp was dat binnen no time klaar. Dank voor alle koffietjes en etentjes op de momenten dat mijn motivatie voor het onderzoek even een dieptepunt had bereikt.

Dorien en Leontien
Waar voorheen altijd één onderzoeker Bariatrie een computer probeerde te vinden in het assistentenhok in OLVG West, zaten wij eind 2018 ineens met zijn drieën als promovendi in een soort tot research center omgebouwde stafkamer Chirurgie. Het was in OLVG niet altijd makkelijk om onze weg te vinden of hulp te krijgen zoals collega's die werkten in de promotiefabriek van academische centra. Maar met elkaars hulp, advies, steun, hardloopsessies en dakterras borrels zijn we toch een heel eind gekomen. Ik heb er alle vertrouwen in dat ik op korte termijn aanwezig ben bij jullie verdediging!

Roos van Nieuwenhuizen
Roos, tijdens mijn ANIOS jaar in OLVG heb ik de plannen voor het VFC project uitgewerkt en aan menig persoon gepresenteerd. Iedereen was enthousiast, maar er was één probleem: geld. Ik was al bezig om een sollicitatiebrief te schrijven voor een promotietraject in het AMC toen je me vroeg om nog heel even te wachten deze te versturen. Nadat de traumachirurgen hun vertrouwen in het project hadden uitgesproken durfde ook jij de gok te wagen door mij via een of andere constructie voor een jaar aan te nemen om eens te kijken waar het schip zou stranden. Dankjewel dat je dit hebt gedaan, anders had het VFC project nu misschien nog wel helemaal niet bestaan.

Gipsverbandmeesters OLVG
Aan alle gipsverbandmeesters van OLVG Oost en West, dank voor jullie vertrouwen! Ondanks dat er voor jullie best wat zou kunnen gaan veranderen door het invoeren van Direct Ontslag hebben jullie met volle overtuiging meegeholpen met de pilot van Direct Ontslag. Gelukkig bleek het beter te werken dan de meesten van jullie verwacht hadden en worden jullie nu door menig collega gipsverbandmeester uit het land benaderd voor een presentatie of uitleg over jullie rol binnen het VFC project.

Bart Huybrechts en Victor Bon
In jullie rol als Verpleegkundig Specialist van de Spoedeisende Hulp zijn jullie altijd nauw betrokken geweest bij het ontwikkelen en de uitrol van het VFC project. Jullie fungeerden als de brug tussen de SEH en de afdelingen Traumachirurgie en Orthopedie. Daarmee hebben jullie enorm bijgedragen aan een geslaagde uitrol van Direct Ontslag, o.a. door jullie meedenken en communicatie/scholing aan alle andere SEH collega's, zowel collega VS'ers, verpleegkundigen en ook SEH-artsen.

Lieke van Deursen en Elise Hoedemaker
Dan heb je ineens een idee, steun, vertrouwen, geld, je kan een jaar aan de slag. Maar waar moet je in godsnaam beginnen om dit uit te werken, laat staan vervolgens ook nog eens in te voeren? In het eerste en tevens meest belangrijke jaar (want daarin hebben we alles tot in de puntjes uitgedacht en uitgewerkt en dat is mede een verklaring voor het succes van Direct Ontslag) hielpen jullie mij wekelijks en soms zelfs vaker door mee te brainstormen, plannen en doelen op te stellen voor de aankomende week etc. Door die hulp hebben we in een toch relatief korte tijd van 9 maanden het hele project kunnen uitwerken, voorbereiden en invoeren. Dat was anders nooit gelukt.

Geeske Duyzings
Geeske, op een gegeven moment werd het project zo groot met alle interesse uit het land en het invoeren van deel twee (hoofdstuk 7 van dit proefschrift), dat we echt hulp nodig hadden. Binnen no time nam ontpopte jij je tot projectleider, coördinator, en nog veel meer, en nam mij vele taken uit handen, waardoor ik eindelijk de tijd kreeg om mijn artikelen af te schrijven.

Jelle en Gijs
Dank dat jullie het stokje van het VFC project van mij hebben willen overnemen. Ik heb er alle vertrouwen in dat het jullie lukt om het project naar een nog hoger niveau te tillen en de traumazorg in Nederland nog verder te optimaliseren.

Henk Jan
HJ, toen jij door corona plots Amerika moest verlaten werd je door het St. Antonius gevraagd om het Direct Ontslag project daar in te voeren. We hebben veel samengewerkt om dit tot een succes te maken. De ervaringen die we opdeden tijdens deze implementatie hebben we samengevat in een handleiding welke nu door vele andere ziekenhuizen in Nederland wordt gebruikt om het project in enkele maanden in te voeren. Met als resultaat dat er momenteel al 17 ziekenhuizen in Nederland gebruik maken Direct Ontslag en de VFC app.

Effendy en Ruth
Dank voor al jullie hulp bij het verzamelen van de data gedurende mijn project. Zonder jullie database queries was het nooit gelukt om alle data te verzamelen die nodig was om dit proefschrift te schrijven.

Lieve pap en mam
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Niek en Ruud
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Peet
Lieve Peet, we leerden elkaar (opnieuw) kennen toen ik promovendus was en jij bezig met je masterscriptie. Daardoor konden we af en toe (of misschien wat vaker dan dat) zomaar even vrij nemen, weekendtrips maken en ook in Zuid-Afrika en Thailand hadden we de tijd van ons leven. Ondertussen zijn we allebei iets drukker als arts-assistent, beiden bezig met een promotietraject en ook nog een klushuis. Er is dus iets minder vrijheid dan voorheen, maar ik weet zeker dat we desondanks nog heel veel mooie herinneringen zullen maken. Ik weet ook zeker dat jij er in gaat slagen om te promoveren en in opleiding te komen. Bedankt dat jij er de afgelopen jaren voor me was, nu bent, en hopelijk komende jaren nog zult zijn. Zonder jou was het echt nooit gelukt. Ik hou van je.

ABOUT THE AUTHOR

Thijs Hendrik Geerdink was born (3rd of April 1991) and raised in Hengelo with his two younger brothers Niek and Ruud. After obtaining the Gymnasium degree at the Bataafse Kamp in Hengelo he was admitted to the Medical School at the Vrije Universiteit in Amsterdam in 2009.

Nearing the end of his medical studies Thijs attended his senior internship at the Surgery Department of the OLVG West hospital in Amsterdam. This was followed by six months of medical research within the same department, resulting in a thesis and subsequent publication on the differentiation between complicated versus uncomplicated appendicitis. This marked the end of his Medical School and he graduated in early 2017. He was then employed by Surgery Department of the OLVG West hospital as a surgical resident not in training (ANIOS).

During his months as resident Thijs found himself ordering patients to return to outpatient clinics to receive information that could also be provided a week earlier. Following discussions with the Trauma surgeons of OLVG, including Robert Haverlag, Ruben van Veen and Carel Goslings, Thijs decided to document a plan to implement Direct Discharge from the Emergency Department for patients with simple stable injuries. This ultimately resulted in Thijs receiving various grants allowing him to further develop and implement his plans as a full-time PhD student, which served as the basis for this thesis.

Throughout his years as PhD student Thijs performed many presentations regarding the project, both nationally and internationally. He received several awards, including the Innovation award at the Santeon Congress in 2019 and the award for Best Abstract during the annual meeting of the Dutch Surgical Association in 2020.

Following his work in OLVG as resident and PhD student, Thijs started to work as resident not in training in the Amsterdam UMC hospital in October 2021. Several months later he successfully applied for a position as a surgical resident-in-training, which he commenced in July 2022. An important step towards his ultimate goal to become a Trauma surgeon.