



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

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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 centers: 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 injury subgroup. Satisfaction and primary healthcare utilization were analyzed descriptively.

**Results** A total of 2033 (OLVG = 1686; SA = 347) and 1616 (OLVG = 1396; 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.

**Conclusion** 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.

**Level of evidence** II.

**Keywords** Direct discharge · Fracture · Emergency Department · Healthcare utilization · Virtual fracture clinic

## 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

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(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-center 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 this 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 center with two locations in Amsterdam, the Netherlands, and (2) the Sint Antonius hospital (SA): a level-2 trauma center 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.

**Table 1** Simple and stable injuries, criteria and immobilization

Injury	Pediatric/adult	Criteria	Immobilization after DD
Pediatric clavicle Fx	Pediatric	Age $\leq 14$ 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	Pediatric	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 $< 2$ mm 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 $\leq 4$ 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	Pediatric	No Fx based on radiograph Superficial wound	Pressure bandage

DD Direct Discharge, Fx fracture, mm millimeter

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.

## 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

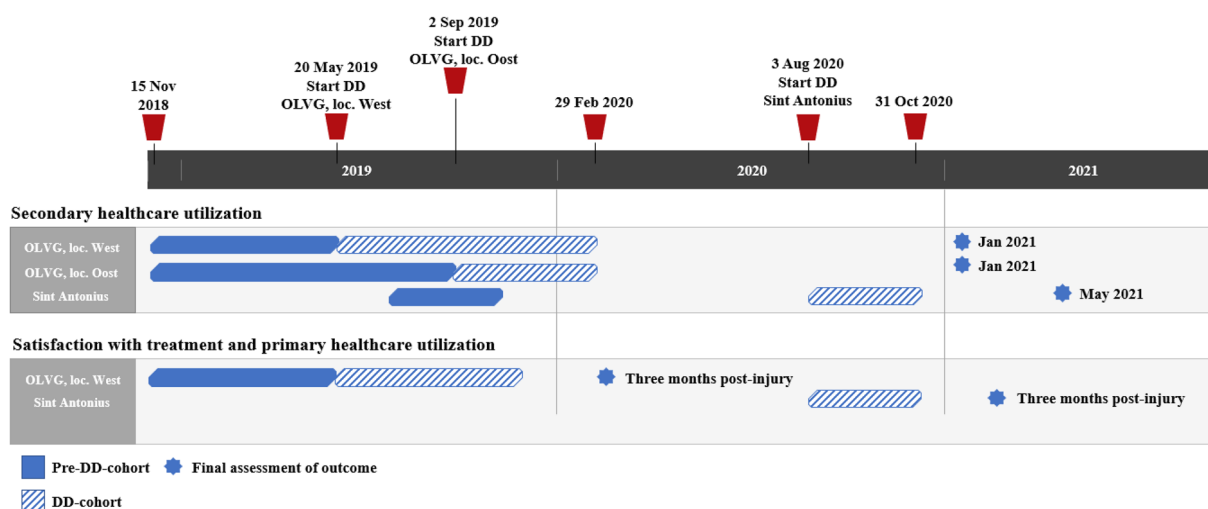
each day by an (orthopedic) trauma surgeon and radiologist, during a routine daily review of all cases and X-rays of patients that presented to the ED on the previous day. Subsequently, patients who were discharged directly incorrectly (e.g., the injury was not a simple, stable injury) were contacted 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 Nov 2018 to 29 Feb 2021. DD was implemented on 20 May 2019 in OLVG, location West, and on 2 Sep 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 (Fig. 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).



**Fig. 1** Inclusion periods of both cohorts in the different centers, to assess healthcare utilization and satisfaction. *DD* Direct discharge, *loc* location

## 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.

## Recruitment and consent

For this 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 were part of a clinical audit that was conducted after implementing DD, i.e., for these outcomes, there were 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 patient’s propensity score to account for 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 [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 5000 replications to estimate uncertainty. A *p* value of < 0.05 was considered statistically significant. Satisfaction with treatment and primary healthcare utilization were analyzed descriptively.

## Patient and public involvement

Patients were not involved in the design, intervention, research question, or outcome measures of this 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 are shown in Fig. 2. In OLVG, 1686 patients presented to the ED with a simple stable musculoskeletal injury before the implementation of DD (pre-DD-cohort), versus 1492 patients thereafter. Of these 1492 patients, 1369 (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).

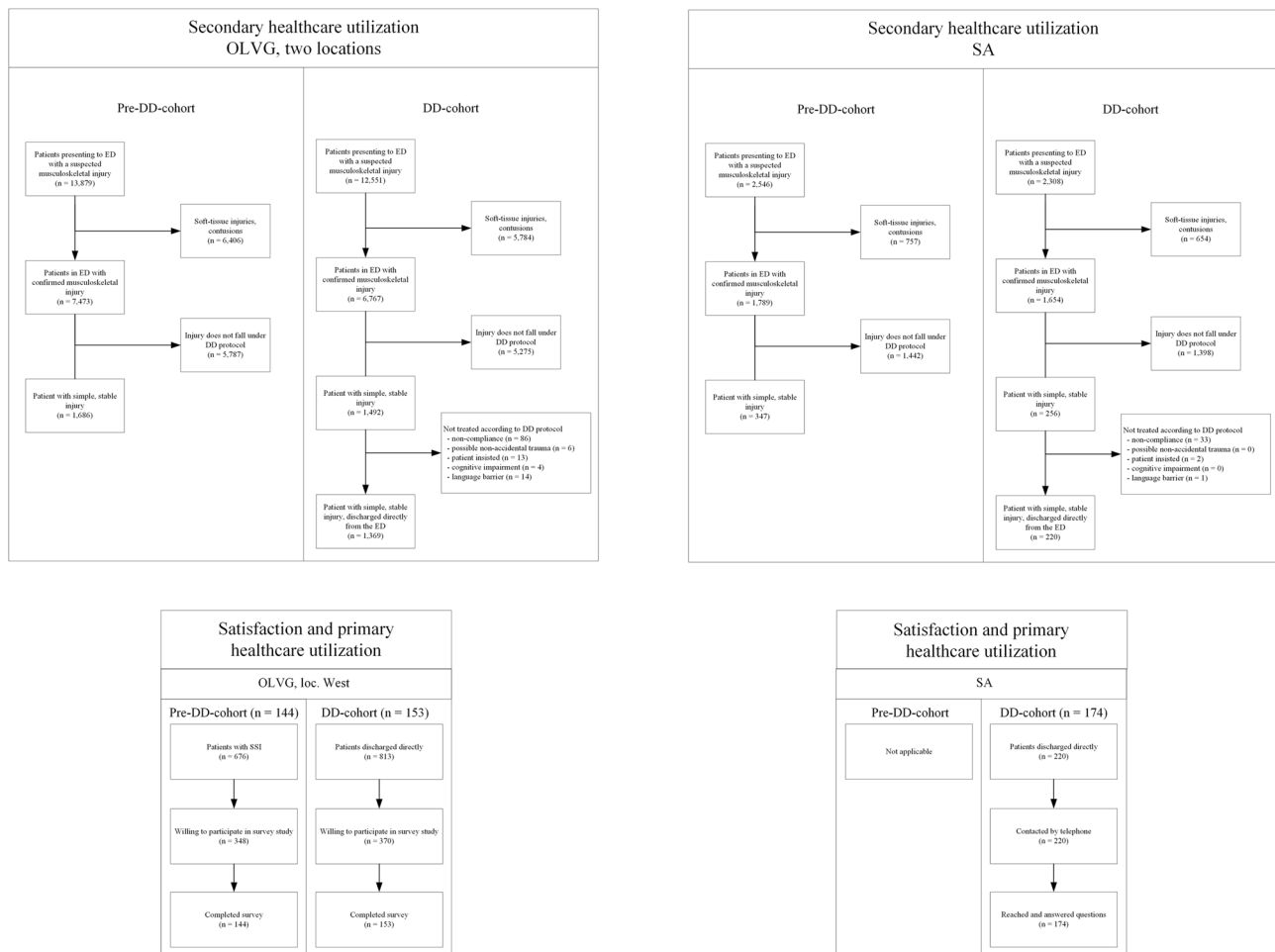


Fig. 2 Depiction of number and flow of the patients included per hospital and outcome type. DD Direct discharge, loc location

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 (Fig. 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 (Table 3)**

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) 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

**Table 2** Baseline characteristics of included patients

Characteristic	OLVG Hospital ( <i>n</i> = 3055)		Sint Antonius Hospital ( <i>n</i> = 567)	
	Pre-DD ( <i>n</i> = 1686)	DD ( <i>n</i> = 1369)	Pre-DD ( <i>n</i> = 347)	DD ( <i>n</i> = 220)
Age; median (IQR)	30 (13–50)	28 (12–48)	27 (11–52)	22 (9–50)
Age < 18; <i>n</i> (%)	501 (29.7)	437 (31.9)	136 (39.2)	95 (43.2)
Gender male; <i>n</i> (%)	878 (52.1)	718 (52.4)	170 (49.0)	105 (47.7)
Type of injury; <i>n</i> (%)				
Pediatric 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)
Pediatric 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

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 was 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 (Table 4).

In OLVG, the mean satisfaction with treatment was 8.1 (SD 1.5) in the pre-DD-cohort, versus 7.95 (SD 1.7) 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.

## 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  $\geq 7.75$ ). 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]. This 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 1686 and



**Table 3** Secondary healthcare utilization

Outcome	Descriptive outcome; mean (SD)				Difference (regression DD vs. pre-DD); mean (95% CI)			
	OLVG hospital		Sint Antonius hospital		OLVG hospital		Sint Antonius hospital	
	Pre-DD (n=1686)	DD (n=1369)	Pre-DD (n=347)	DD (n=220)	Difference	Sig	Difference	Sig
<b>Whole cohort</b>								
Follow-up appointments	1.29 (1.18)	0.22 (0.68)	1.19 (1.04)	0.13 (0.52)	- 1.06 (- 1.13 to - 0.99)	<b>&lt;0.001</b>	- 1.07 (- 1.02 to - 0.93)	<b>&lt;0.001</b>
<b>Follow-up imaging</b>								
X-ray	0.22 (0.60)	0.05 (0.31)	0.19 (0.49)	0.01 (0.10)	- 0.17 (- 0.20 to - 0.13)	<b>&lt;0.001</b>	- 0.18 (- 0.23 to - 0.12)	<b>&lt;0.001</b>
CT scan	0.02 (0.14)	0.01 (0.13)	0.00	0.00	- 0.004 (- 0.013 to 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 to - 0.001)	<b>0.021</b>	NP	-
<b>SSI subgroup</b>								
<b>Follow-up appointments</b>								
Pediatric clavicle Fx	1.45 (0.75)	0.20 (0.54)	1.10 (0.53)	0.06 (0.25)	- 1.29 (- 1.49 to - 1.09)	<b>&lt;0.001</b>	- 1.03 (- 1.24 to - 0.80)	<b>&lt;0.001</b>
Radial head/neck Fx	1.29 (1.01)	0.10 (0.42)	1.50 (0.98)	0.13 (0.61)	- 1.17 (- 1.29 to - 1.05)	<b>&lt;0.001</b>	- 1.42 (- 1.80 to - 1.04)	<b>&lt;0.001</b>
Pediatric forearm Fx	1.44 (0.64)	0.10 (0.38)	1.17 (0.49)	0.04 (0.27)	- 1.34 (- 1.44 to - 1.24)	<b>&lt;0.001</b>	- 1.13 (- 1.26 to - 0.98)	<b>&lt;0.001</b>
MC5 neck Fx	1.94 (0.21)	0.21 (0.54)	2.00 (1.37)	0.00	- 1.73 (- 1.98 to - 1.46)	<b>&lt;0.001</b>	- 1.95 (- 2.68 to -1.38)	<b>&lt;0.001</b>
Mallet finger	2.50 (1.64)	1.89 (1.44)	1.00 (0.62)	0.57 (1.09)	- 0.60 (- 1.10 to - 0.10)	<b>0.019</b>	- 0.43 (- 0.96 to - 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 to - 0.81)	<b>&lt;0.001</b>	- 1.45 (- 2.09 to - 0.83)	<b>&lt;0.001</b>
Avulsion Fx ankle	0.94 (1.22)	0.26 (0.61)	1.45 (0.93)	0.06 (0.25)	- 0.68 (- 0.86 to - 0.51)	<b>&lt;0.001</b>	- 1.37 (- 1.92 to - 0.79)	<b>0.005</b>
Fx of MT5 base	2.20 (1.26)	0.22 (0.61)	2.55 (1.43)	0.35 (0.83)	- 1.98 (- 2.20 to - 1.75)	<b>&lt;0.001</b>	- 2.29 (- 2.86 to - 1.72)	<b>&lt;0.001</b>
Fx of greater toe	0.78 (1.01)	0.11 (0.58)	0.63 (0.83)	0.00	- 0.68 (- 0.85 to - 0.51)	<b>&lt;0.001</b>	- 0.62 (- 0.95 to - 0.35)	<b>0.005</b>
Fx of lesser toe	0.26 (0.77)	0.03 (0.18)	0.12 (0.33)	0.05 (0.22)	- 0.22 (- 0.38 to - 0.08)	<b>0.016</b>	- 0.08 (- 0.21 to 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 to - 0.69)	<b>&lt;0.001</b>	- 1.09 (- 1.40 to - 0.81)	<b>0.002</b>

Bold values are p-value < 0.05

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)

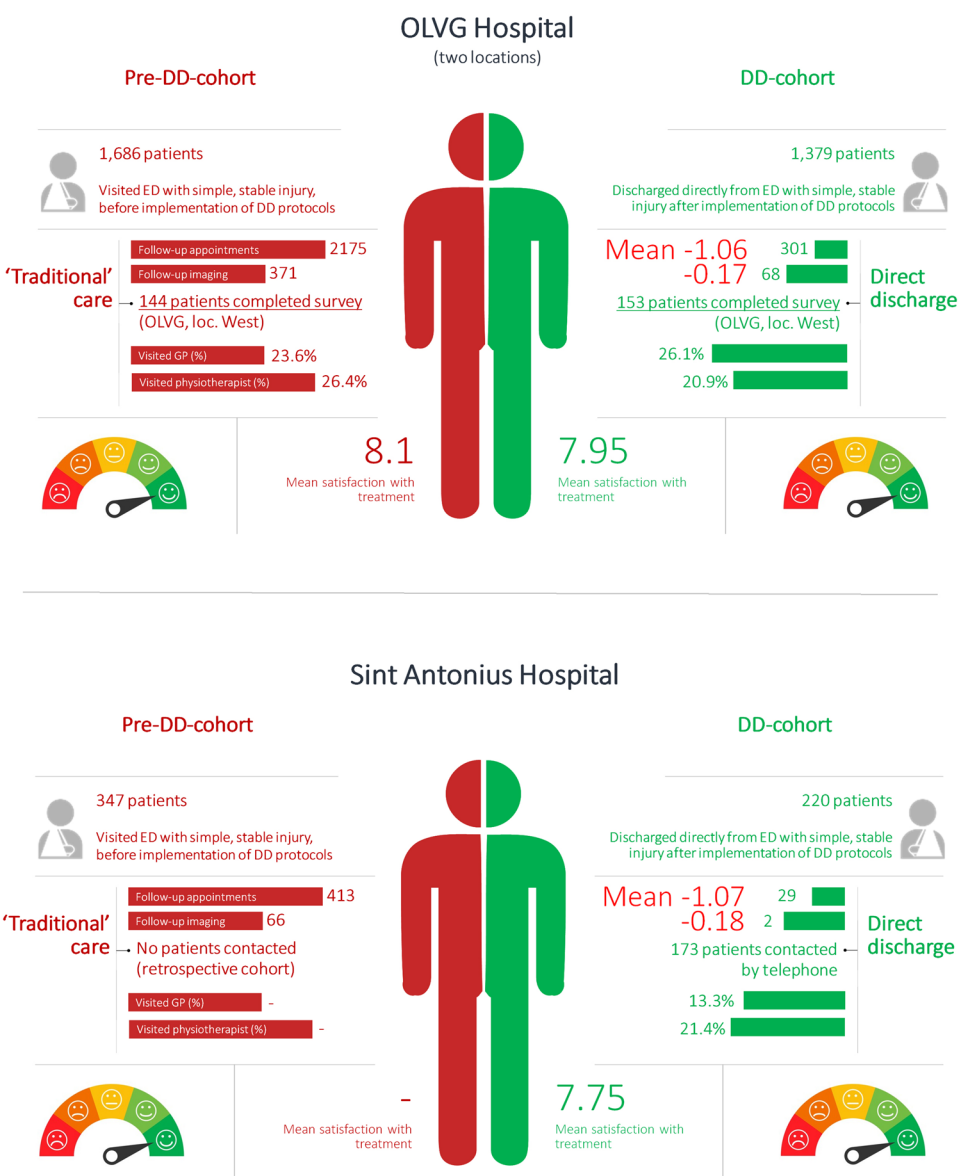
**Table 4** Satisfaction with treatment and primary healthcare use

Outcome	OLVG hospital		Sint Antonius hospital
	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)

OLVG data were collected as part of a previous study [8]

DD Direct Discharge, SD Standard deviation

**Fig. 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



1369 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 this 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 pediatric fractures was higher in the SA DD-cohort, and we assume that these pediatric 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 this 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 center [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-randomized nature of this study, all effect measures were adjusted for the patient's propensity score using regression models, 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 patient's 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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**Author contributions** 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.

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**Data availability** All data are available upon reasonable request.

**Code availability** Not applicable.

## Declarations

**Conflict of interest** All authors have completed the ICMJE uniform disclosure form at [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf) and declare: apart from the unrestricted grant, the authors have nothing to declare; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

**Ethical approval** 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).

**Consent to participate** For the assessment of secondary healthcare utilization, informed consent was not necessary. For the assessment of satisfaction with treatment and primary healthcare utilization by either a survey (OLVG Hospital) or telephone call (Sint Antonius Hospital), patients provided written informed consent and verbal informed consent, respectively.

**Consent for publication** Not applicable.

## References

- Jenkins PJ, Gilmour A, Murray O, et al. The Glasgow Fracture Pathway: a virtual clinic. *BJJ News*. 2014;2:22–4.
- White TO, Mackenzie SP, Carter TH, et al. The evolution of fracture clinic design: the activity and safety of the Edinburgh Trauma Triage Clinic, with one-year follow-up. *Bone Joint J*. 2017;99(4):503–7.
- Jayaram PR, Bhattacharyya R, Jenkins PJ, et al. A new “virtual” patient pathway for the management of radial head and neck fractures. *J Shoulder Elbow Surg*. 2014;23(3):297–301.
- Ferguson KB, McGlynn J, Jenkins P, et al. Fifth metatarsal fractures - Is routine follow-up necessary? *Injury*. 2015;46(8):1664–8.
- Mackenzie SP, Carter TH, Jefferies JG, et al. Discharged but not dissatisfied: outcomes and satisfaction of patients discharged from the Edinburgh Trauma Triage Clinic. *Bone Joint J*. 2018;100(7):959–65.
- McKirdy A, Imbuldeniya AM. The clinical and cost effectiveness of a virtual fracture clinic service: An interrupted time series analysis and before-and-after comparison. *Bone Joint Res*. 2017;6(5):259–69.
- Geerdink TH, Haverlag R, van Veen RN, et al. Direct discharge from the ED for patients with simple stable injuries: a Dutch pilot study. *Nederlands tijdschrift voor geneeskunde*. 2020;2020:164.
- Geerdink TH, Augustinus S, Groen JJ, et al. 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.
- App maakt direct ontslag vanaf de SEH mogelijk [press release]. 2020
- Virtual Fracture Care [press release]. 2020
- App geeft patiënt regie over eigen herstel [press release]. 2021
- Virtual Fracture Care-Na breuk direct naar huis [press release]. 2021
- App zorgt voor minder controlebezoeken in ons ziekenhuis [press release]. 2021
- IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp
- StataCorp. Stata Statistical Software: release 16. College Station: StataCorp LLC; 2019.
- Becker SO, Ichino A. Estimation of Average Treatment Effects Based on Propensity Scores. *Stand Genomic Sci*. 2002;2(4):358–77.
- Geerdink TH, Uijterwijk BA, Meijer DT, et al. Adoption of direct discharge of simple stable injuries amongst (orthopaedic) trauma surgeons. *Injury*. 2021;52(4):774–9.