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Transparency in hip fracture recovery over institutional boundaries: The transmural monitoring pathway

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Abstract

Objectives: To develop a transmural pathway for healthcare professionals across institutions to monitor the recovery of hip fracture patients. The secondary objectives were to evaluate the pathway's feasibility and initial outcomes.

Design: Prospective cohort study.

Method: Stakeholders of the hospital and geriatric rehabilitation institutions implemented a transmural monitoring pathway in which different geriatric health domains were monitored during three phases: The in-hospital, inpatient rehabilitation, and outpatient follow-up phase. The outcomes for the first 291 patients and the feasibility of the pathway were evaluated. If the outcomes of the clinimetrics significantly improved over time, progress in functional recovery was assumed. Feasibility was assessed according to the rate of adherence to the clinimetric tests.

Results: During the in-hospital phase, patients showed a decline in functional level (the Katz index of independence in Activities of Daily Living (Katz-ADL) pre-fracture vs. discharge: 0 (0–2) vs. 4 (4–5), $P < 0.001$). Patients, in which 78.6% (n = 140) had cognitive impairment and 41.2% had malnutrition, showed the most

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progress (Katz-ADL 2 (1–3)) during the inpatient rehabilitation phase. In the outpatient follow-up phase, recovery remained ongoing, but most patients had not returned to their pre-fracture functional levels (Katz-ADL 1 (1–3)). The pathway feasibility during the first phase was excellent (>85%), whereas room for improvement existed during other phases (<85%).

Conclusion: The transmural monitoring pathway provides insight into the entire recovery process for all involved healthcare professionals. Patients showed the most progress during the rehabilitation phase. The pathway feasibility was excellent during the in-hospital phase, but improvements could be made during other phases.

Keywords

Hip fracture, rehabilitation, elderly, surgery, orthogeriatric

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Introduction

Rehabilitation of older patients after hip fracture surgery is challenging, and functional recovery may not be optimal in a substantial proportion of patients. Almost one-third of patients do not regain their pre-fracture functional levels by 1 year after hip fracture surgery.[1] To improve quality of care, the Centre for Geriatric Traumatology was implemented in 2008 at Ziekenhuisgroep Twente, where patients ≥ 70 years of age are treated according to a multidisciplinary orthogeriatric care pathway. This pathway involves intensive co-management by a geriatrician, who is involved in performing a comprehensive geriatric assessment and evaluating patient treatment on a daily basis. Studies have shown that the implementation of the intramural pathway of the Centre for Geriatric Traumatology decreases the number of complications, length of stay, and mortality.[2] After orthogeriatric treatment at the Centre for Geriatric Traumatology, 47.8% of patients are discharged to a nearby geriatric rehabilitation institution, where the second phase of recovery begins. Patients who are not discharged to a geriatric rehabilitation institution can return home or are unable to undergo rehabilitation (e.g. because of severe dementia). Currently, insights into recovery in those geriatric rehabilitation institutions are limited. After discharge from our hospital, our healthcare professionals are no longer able to follow recovery progress. They obtain only limited information regarding recovery after patients visit the outpatient clinic 3 months after surgery; however, the greatest changes and opportunities to optimize rehabilitation exist within this time period.[3] Conversely, healthcare professionals at geriatric rehabilitation institutions receive only limited data from the in-hospital and the outpatient follow-up phases. The recovery process is not transparent to all involved healthcare professionals, thus potentially resulting in suboptimal rehabilitation. A possible solution is a transmural pathway for monitoring patients' health status over time across institutions, in a manner that is accessible to all involved healthcare professionals. Monitoring could be performed through clinimetrics starting at the hospital and continuing in the geriatric rehabilitation institutions and outpatient clinics. Here, accessibility refers to the ability of professionals from different institutions to view the same data, monitor patient progress, and mutually discuss individual patients and provide interventions when needed. In this way, the quality of care for patients with hip fracture can be optimized during the entire rehabilitation process. Although multiple studies have investigated clinical care pathways for patients with hip fracture and rehabilitation, few have monitored recovery over time.[4,5]

The primary aim of this study was to develop and implement a transmural monitoring pathway for the recovery process of older patients with hip fracture, providing transparency for all involved healthcare professionals across institutions. The secondary aims were to evaluate the feasibility of this pathway in daily practice and to describe the

first results of the recovery trajectories of the included patients. Implementing this pathway may lead to more personalized rehabilitation programs tailored to individual patients' needs. Furthermore, describing the development of the transmural monitoring pathway may be useful for other healthcare facilities developing their own transmural monitoring pathways for patients with hip fracture.

Methods

Development and Implementation of the Transmural Pathway

In April 2017, the transmural *Up&Go after hip fracture* project started, in which healthcare professionals of the Centre for Geriatric Traumatology and geriatric rehabilitation institutions developed a transmural monitoring pathway for patients ≥ 70 years of age with hip fracture. In the Netherlands, inpatient geriatric rehabilitation is provided solely by nursing homes. The *Up&Go after hip fracture* project involved three nursing home institutions in the vicinity of Ziekenhuisgroep Twente, including five geriatric rehabilitation departments (the so-called geriatric rehabilitation institutions). At the beginning of the project, a multidisciplinary working group comprising stakeholders of the hospital and the geriatric rehabilitation institutions was formed. The healthcare professionals involved included trauma surgeons, nursing home physicians, nurse practitioners, occupational therapists, physiotherapists, psychologists, and researchers. Workshops were organized every 6 weeks to develop and implement a transmural monitoring pathway. During the first workshops a Peoples, Activities, Context, Technologies analysis was performed.[6] Every healthcare institution presented its existing care pathway for patients with hip fracture. Goals, ideas, and recommendations were summarized. In the subsequent four workshops, a consensus was reached regarding the relevant clinimetrics that should be performed at predefined times in the transmural monitoring pathway to obtain insights into the recovery progress an individual patients. A detailed content of workshops and decision making is presented in Supplementary Appendix 1.

The implementation of the designed transmural pathway started 6 months after the start of the *Up&Go after hip fracture* project. The items of the transmural pathway were first filled out on paper forms. Researchers instructed the involved healthcare professionals at the geriatric rehabilitation institutions, collected the data, and provided feedback regarding whether the pathway was followed as agreed upon. In the workshops, the outcomes of the clinimetrics and the rates of adherence to the pathway were presented. Stakeholders were requested to provide feedback regarding feasibility in practice. The transmural monitoring pathway was adapted if the frequency or type of clinimetrics was found to be infeasible in practice. Adjustments were made only after all stakeholders had agreed.

In a later stage, a digital solution was investigated to give each professional access to the data. Starting from the Peoples, Activities, Context, and Technologies analysis, the functional requirements of such a platform were defined. Nonfunctional requirements, such as easy use, low cost, and the ability to adapt to include necessary changes were added. Several existing digital platforms were compared, and OZOverbindzorg was selected for this purpose.

Study population, feasibility, total recovery trajectory, and statistical analysis

From 1 October 2017 to 1 October 2020, all patients ≥ 70 years of age who underwent surgical treatment at the Centre for Geriatric Traumatology and rehabilitation in a participating geriatric rehabilitation institution, were prospectively included, to evaluate the outcomes and feasibility of the transmural monitoring pathway. Patients with an indication for total hip replacement who were referred to the orthopedic service and those with pathological or periprosthetic fractures were excluded. This study was designated as not being subject to the Dutch Medical Research Involving Human Subjects Act.

Patient characteristics, clinimetrics, complication rates, 30-day mortality, and 3-month mortality were collected. The patient characteristics included were age, gender, dementia (diagnosed by geriatrician or neurologist), American Society of Anesthesiologists

score,[7] pre-fracture living situation, fracture type, surgical treatment, and weight-bearing ability. Clinimetrics included the Charlson Comorbidity Index (CCI),[8] Short Nutritional Assessment Questionnaire (SNAQ),[9] Short Nutritional Assessment Questionnaire for Residential Care (SNAQRC),[10] Mini–Mental State Examination (MMSE),[11] Montreal Cognitive Assessment (MoCA),[12] Katz index of independence in Activities of Daily Living (Katz-ADL),[13] Barthel Index,[14] Fracture Mobility Score (FMS), Functional Ambulation Categories (FAC),[15] Timed Up and Go Test (TUG), and 10-Meter Walk Test (10 MWT) [16,17] (Supplementary Appendix 2). The TUG and 10 MWT were indicated only if the FAC was ≥ 3.

In the beginning, cognition was tested by the MMSE. After suboptimal registration rates were observed and several healthcare professionals were not convinced of the usefulness of the assessment, this test was replaced by the MoCA. This instrument was already used in more geriatric rehabilitation institutions.

The Barthel Index was assessed with the Dutch version reported by de Haan et al. and ranged from 0 to 20, with lower scores indicating greater disability (presented in Supplementary Appendix 2).[14]

Categorical variables were described as numbers with corresponding percentages. Continuous variables were described as means with SD, or as median with interquartile range (IQR) for skewed data.

To determine whether the transmural monitoring pathway was feasible, we assessed the rate of adherence to the predefined clinimetric tests. Feasibility was assumed if clinimetric measurements were registered in $> 85\%$ of patients. For the TUG and 10M WT, feasibility was measured in patients with a FAC ≥ 3. For exploration of the recovery trajectories, the clinimetric tests were measured frequently. If the outcomes of the clinimetrics significantly improved over time, progress in functional recovery was assumed. Mixed model analysis with a post hoc Sidak test was performed for repeated measurements of normally distributed continuous variables. Friedman test with a post hoc Wilcoxon signed-rank test and Holm–Bonferroni correction were performed for repeated measurements of continuous variables that did not follow a normal distribution. Generalized estimating equations were used for repeated measurement in ordinal variables. $P < 0.05$ was considered statistically significant. Analyses were performed in Statistical Package for the Social Sciences, version 23 (SPSS Inc., Chicago, IL, CA, USA).

Results

During 2018–2020, 910 patients with hip fracture were admitted to the hospital, and 461 (50.7%) were eligible for inpatient rehabilitation in a geriatric rehabilitation institution after the hospital stay. Of the other 449 patients (49.3%), 239 (26.3%) were able to return home, and 210 (23.1%) were discharged to other healthcare facilities, such as assisted living facilities or somatic or psychogeriatric nursing homes.

Of the 461 patients eligible for rehabilitation in a geriatric rehabilitation institution, 116 (25.2%) were excluded because they were admitted outside the study period or were not treated according to the transmural monitoring pathway (e.g. they were rehabilitated at a geriatric rehabilitation institution that was not part of the *Up&Go after hip fracture* project). Because of the COVID-19 pandemic, another 54 patients (11.7%) were excluded from April to August 2020, because measurements could not be collected according to the transmural monitoring pathway. The remaining 291 patients were monitored in accordance with the transmural monitoring pathway and included in this study. Table 1 presents the baseline characteristics of the study population.

The mean patient age was 83.5 (SD 6.5) years, and 69.4% (n = 202) were women. Dementia, diagnosed by a geriatrician or a neurologist, was seen in 9 (3.1%) patients. Severe comorbidity (American Society of Anesthesiologists score ≥ 3) was seen in 68.4% (n = 199) of patients. Pre-fracture, 93.5% (n = 272) of the patients lived at home, with or without home care services.

The transmural monitoring pathway exists in three phases: in-hospital stay, geriatric rehabilitation, and outpatient follow-up. The pathway includes patient

Table 1. Baseline patient characteristics.

	Total (n = 291)
Age; mean (SD)	83.5 (6.5)
Female gender; n (%)	202 (69.4)
Dementia; n (%)	9 (3.1)
ASA score; n (%)	
1	8 (2.7)
2	82 (28.2)
3	176 (60.5)
4	23 (7.9)
Missing	2 (0.7)
Pre-fracture living situation; n (%)	
Independent, without home care services	158 (54.3)
Independent, with home care services	114 (39.2)
Residential home/assisted living	19 (6.5)
Pre-fracture living with relatives; n (%)	92 (31.6)
Ability to rely on nonprofessional help in the home; n (%)	253 (86.9)
Fracture type; n (%)	
Femoral neck	153 (52.6)
Trochanteric	128 (44.0)
Subtrochanteric	10 (3.4)
Surgical treatment; n (%)	
Proximal femoral nail antirotation	140 (48.1)
Hemiarthroplasty	115 (39.5)
Dynamic hip screw	32 (11.0)
Cannulated screws	4 (1.4)
Weight bearing; n (%)	
Full weight bearing	270 (92.8)
Partial weight bearing	14 (4.8)
Non-weight bearing	6 (2.1)
Missing data	1 (0.3)

ASA: American Society of Anesthesiologists physical status classification

characteristics, diagnosis, treatment, clinimetrics, complications, length of stay, and mortality. Figure 1 presents the clinimetrics for monitoring the geriatric health domains cognition, malnutrition, activities of daily living, and mobility, which were used in the transmural monitoring pathway.

The content and outcomes of the transmural monitoring pathway for each phase are described below. The feasibility, patient course during rehabilitation, and patient discharge status are indicated for each phase, and the total recovery trajectory across the different phases is subsequently described.

Phase 1: In-hospital stay

At the hospital, each patient is treated according to the integrated orthogeriatric treatment model of the Centre for Geriatric Traumatology, which is characterized by early geriatric co-management starting after admission to the emergency department.[18] In the emergency department, most hip fractures are diagnosed with radiographs. Blood tests, chest radiography, and an electrocardiography are taken for preoperative assessment. Patients' health state, social context, and pre-fracture functional level are measured. If total hip replacement is indicated, the patient is referred to the orthopedic service. Otherwise, the patient is admitted to the Centre for Geriatric Traumatology as quickly as possible. The geriatrician is called by the physician at the emergency department and visits the patient at the emergency department or Centre for Geriatric Traumatology. Comprehensive geriatric assessment is performed to identify geriatric conditions and to develop a personalized treatment plan. Hip fracture surgery is performed as quickly as safely possible. The patient is visited daily by a nurse practitioner specialized in trauma surgery. The treatment is evaluated in a daily meeting between the nurse practitioner and the geriatrician. During admission, a medication review, osteoporosis status, and falls risk factors were identified.

In accordance with the transmural monitoring pathway, the following clinimetrics are used during hospital stay: The CCI,[8] the SNAQ,[9] the Katz-ADL (at admission (pre-fracture status) and discharge),[13] the FMS (at admission (pre-fracture status) and discharge), and the FAC (at discharge) [15] (Supplementary Appendix 2). Figure 1 presents the clinimetrics incorporated in the transmural monitoring pathway during this phase.

The feasibility of the transmural monitoring pathway during the in-hospital phase was excellent, with a registration rate for all clinimetrics of > 95%.

Table 2 presents the outcomes of the clinimetrics in the study population.

At the hospital, the median of the CCI was 1 (IQR: 0–2). Risk of malnutrition was observed in 14.4% of patients (SNAQ score > 1, n = 42). The median Katz-ADL at discharge was 4 (IQR: 4–5).

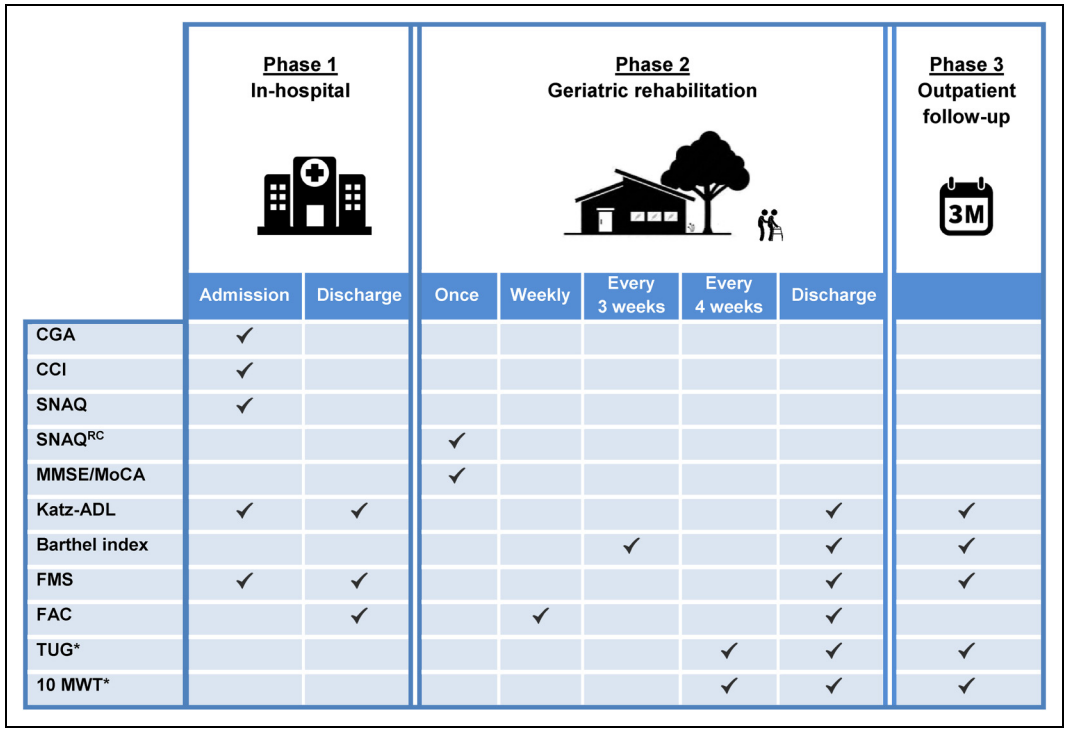

Figure 1. Clinimetrics in the transmural monitoring pathway.
*When the Functional Ambulation Categories was ≥ 3.
CGA: comprehensive geriatric assessment; CCI: Charlson Comorbidity Index; FAC: Functional Ambulation Categories; FMS: (Pre-) Fracture Mobility Score; Katz-ADL: the Katz index of independence in Activities of Daily Living; MMSE: Mini–Mental State Examination; MoCA: Montreal Cognitive Assessment; SNAQ: Short Nutritional Assessment Questionnaire; SNAQRC: Short Nutritional Assessment Questionnaire for Residential Care; TUG: Timed Up and Go test; 10 MWT: 10-Meter Walk Test.

At that time, all patients were dependent on one or more activities of daily living, as measured with the Katz-ADL (Figure 2). The FMS indicated that most patients could not go outside without thr help of another person after discharge from the hospital (73.2%, n = 213) (Figure 3.).

The median length of hospital stay was 9.0 (IQR 7.0–11.0) days. The most common complications during the in-hospital phase were anemia leading to blood transfusion (22.0% n = 64), delirium (18.9%, n = 55), and pneumonia (11.0%, n = 32) (Table 3).

Phase 2: Geriatric rehabilitation

After discharge from the hospital, the patient is transferred to a geriatric rehabilitation institution, where the second phase of recovery starts. In geriatric rehabilitation institutions, the same rehabilitation structure is used, comprising a so-called "rehabilitation climate," in which all daily activities are used as therapeutic opportunities. Caregivers and family members are also involved in the rehabilitation process. Multidisciplinary treatment is directed toward each individual's rehabilitation goal. The multidisciplinary team consists of a nursing home physician, physical therapist, occupational therapist, dietician, psychologist, and nursing staff. After the patient is allowed to bear weight on the operated leg, physical therapy is performed for 30 minutes on all weekdays. When a non- or partial postoperative weight-bearing protocol is prescribed, and the individual is able to exercise independently, 30 minutes physical

Table 2. Outcomes of clinimetrics during the transmural monitoring pathway.

	Phase 1 In-hospital		Phase 2 Geriatric rehabilitation			Phase 3 Outpatient follow-up
	Pre-fracture	Discharge	Admission	During[b]	Discharge	
CCI; median (IQR)	1 (0–2) *(n = 291)*					
SNAQ > 1; n (%)	42 (14.4) *(n = 291)*					
SNAQRC orange or red; n (%)				120 (41.2) *(n = 274)*		
MMSE; median (IQR)				26 (22–28) *(n = 27)*		
MoCA; median (IQR)				19 (16–23) *(n = 151)*		
Katz-ADL; median (IQR)	0 (0–2) *(n = 290)*	4 (4–5) *(n = 289)*			2 (1–3) *(n = 271)*	2 (1–3) *(n = 255)*
Barthel Index; median (IQR)			10.0 (7.0–12.0) *(n = 278)*	12.0 (9.0–15.0) *(n = 194)*	16.0 (14.0–17.0) *(n = 272)*	MF
TUG (sec)[a]; mean (SD)			36.7 (19.8) *(n = 97)*	40.5 (22.9) *(n = 151)*	27.4 (13.5) *(n = 196)*	MF
10 MWT (m/s)[a]; mean (SD)			0.50 (0.22) *(n = 95)*	0.44 (0.20) *(n = 152)*	0.61 (0.22) *(n = 200)*	MF

[a]Performed when Functional Ambulation Categories ≥ 3.
[b]First scoring after measurement at admission, median (IQR): TUG: 20 days after admission (12.0–28.3), 10 MWT: 20 days after admission (12.0–28.0), and Barthel Index: 21 days after admission (15.0–23.0).
Significant differences in repeated measurements and post hoc analyses are presented in the text.
CCI: Charlson Comorbidity Index; IQR: interquartile range; Katz-ADL, the Katz index of independence in Activities of Daily Living; MF: measurement failed; MMSE: Mini–Mental State Examination; MoCA: Montreal Cognitive Assessment; SNAQ: Short Nutritional Assessment Questionnaire; SNAQRC: Short Nutritional Assessment Questionnaire for Residential Care; TUG: Timed Up and Go test; 10 MWT: 10-Meter Walk Test.

therapy is usually performed two to three times per week in this period.

The clinimetrics incorporated at this phase of the transmural monitoring pathway are the SNAQRC,[10] MMSE or MoCA, Katz-ADL (at discharge), Barthel Index (at admission, every 3 weeks and at discharge),[14,19] FMS (at discharge), and FAC (at admission, every 3 weeks and at discharge). If the FAC is ≥ 3, the TUG and the 10 MWT are also assessed every 4 weeks.[16,17] Figure 1 presents the clinimetrics incorporated in the transmural monitoring pathway during this phase.

During the geriatric rehabilitation phase, some clinimetrics showed moderate feasibility. A registration rate < 85% was achieved in the FAC (n = 234, 80.4%). In patients with a FAC score ≥ 3, the TUG and the 10 MWT were performed. These two tests also showed suboptimal registration rates of < 85%: For the TUG, 69.5% (n = 97) at admission and 76.0% (n = 196) at discharge and for the 10 MWT: 67.9% (n = 95) at admission and 77.5% (n = 200) at discharge. The MMSE was performed in less than 20% at the beginning of the implementation. The MoCA was subsequently performed in 64.1% (n = 151) of patients. The other clinimetrics during the geriatric rehabilitation phase (SNAQRC, Katz-ADL, and FMS) were feasible (registration rate > 85%).

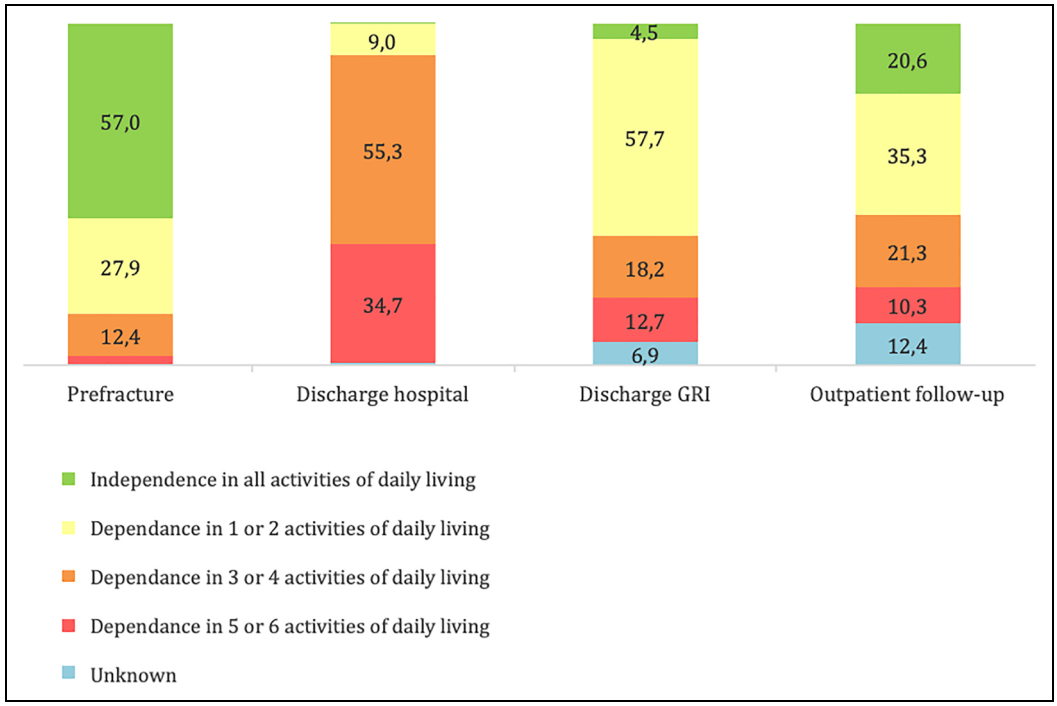

Figure 2. Outcomes of the Katz-ADL during the pathway.
Percentage distribution of patients per category.
*Presented percentages are above 2%.
GRI: geriatric rehabilitation institution; Katz-ADL: the Katz index of independence in Activities of Daily Living.

The outcomes indicated that 41.2% of the patients (SNAQRC orange or red, n = 120) were at risk of malnutrition, on the basis of the SNAQRC. The median MMSE and MoCA scores were 26 (IQR: 22–28) and 19 (IQR: 16–23), respectively. Cognitive impairment was observed in 78.6% of patients (MMSE < 24 or MoCA < 26, n = 140).

The median Katz-ADL was 2 (IQR: 1–3) at discharge at the geriatric rehabilitation institutions, and only 4.5% of patients (n = 13) were fully independent in activities of daily living. Progress in independence in activities in daily living during geriatric rehabilitation was assessed with the Barthel Index (Table 2.). At discharge, 178 patients (61.2%) were mobile outdoors with or without aids, 75 (25.8%) could not go outside without support, 16 (5.8%) had no functional mobility in using the lower limbs, and 21 (7.2%) had unknown mobility status. Figure 4 shows the outcomes of the FAC measured during the geriatric rehabilitation phase. Repeated FAC, TUG, and 10 MWT measurements indicated significant improvement during geriatric rehabilitation ($p < 0.001$).

The median length of stay at the geriatric rehabilitation institution was 38.0 (IQR: 25.0–49.8) days. The most common complications were urinary tract infections (7.2%, n = 21), fall accidents (5.5%, n = 16), and pneumonia (4.8%, n = 14). Nine patients (3.1%) died during inpatient geriatric rehabilitation.

Phase 3: Outpatient follow-up after 3 months

Three months after surgery, patients have appointments with a physiotherapist and a trauma surgeon at the outpatient clinic. During this visit, the last clinimetrics are collected according to the transmural monitoring pathway: The Katz-ADL, Barthel Index,

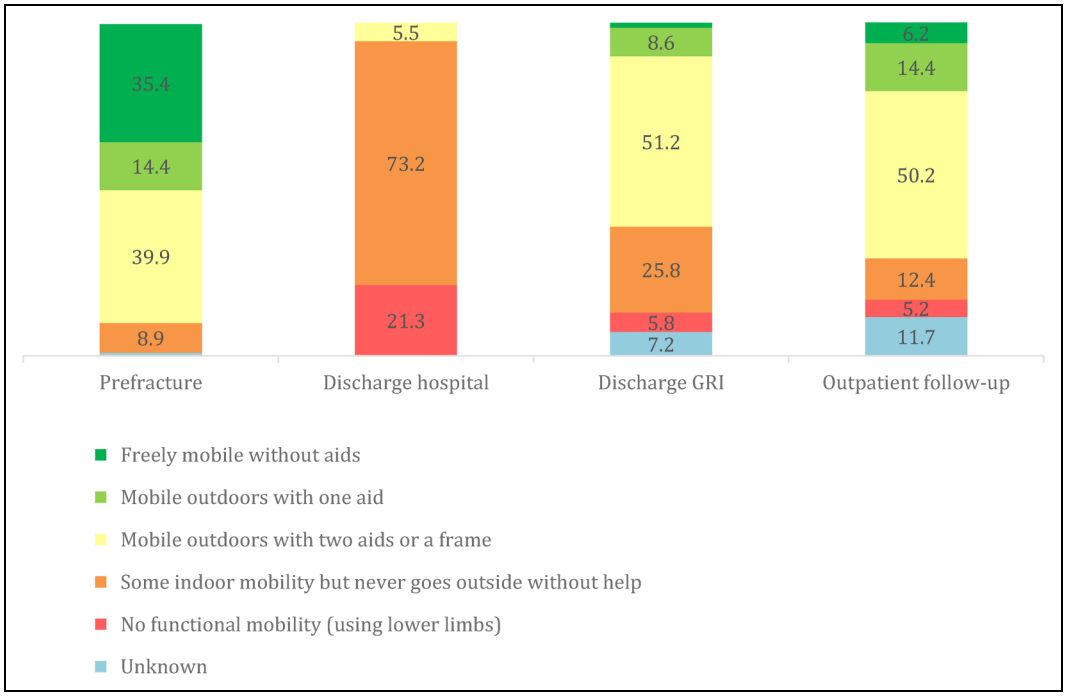

Figure 3. Outcomes of the fracture mobility score (FMS) during the pathway.
Percentage distribution of patients per category.
*Presented percentages are above 2%.
GRI: geriatric rehabilitation institution.

FMS, TUG, and 10 MWT. When the patient remains in rehabilitation, these measurements are performed at the geriatric rehabilitation institution to minimize the patient burden. If a patient is not able to visit the outpatient clinic and is not staying at the geriatric rehabilitation institution, the patient/caregiver is interviewed by an administrator by telephone or receives a questionnaire at home that can be filled out and returned by mail. The administrator subsequently registers the outcomes. Figure 1 presents the clinimetrics incorporated in the transmural monitoring pathway during this phase.

The feasibility of the FMS and Katz-ADL during the outpatient follow-up phase was very good (>85%). However, the assessment of the Barthel Index, TUG, and 10 MWT failed (n = 0, 0.0%).

At the outpatient clinic, the median Katz-ADL was 2 (IQR: 1–3). The FMS indicated that 6.2% of the patients (n = 18) were freely mobile without aids, 77.0% of the patients (n = 224) needed the help of aids or a person, and 5.2% of the patients (n = 15) did not have any functional mobility after 3 months after hip fracture surgery.

Total recovery trajectory across phases

Independence in activities of daily living significantly changed during each phase of the pathway ($p < 0.001$). Before the fracture, 57.0% (n = 166) of patients were fully independent in activities of daily living, as measured with the katz-ADL, whereas at discharge, only 0.3% (n = 1) and 4.5% (n = 13) were fully independent at the hospital and geriatric rehabilitation institutions, respectively. During the first phase, the median in-hospital Katz-ADL significantly worsened from 0 (IQR: 0–2) to 4 (IQR: 4–5) ($p < 0.001$). Whereas 43.0% of the patients needed help with activities of daily living before the fracture, 99.0% needed help with activities of daily living after the hospital

Table 3. Complications, length of stay, and mortality during the transmural monitoring pathway.

	Phase 1 In-hospital	Phase 2 Geriatric rehabilitation	Total
Complications[a]; n (%)			
Anemia	64 (22.0)	10 (3.4)	68 (23.4)
Heart failure	15 (5.2)	4 (1.4)	18 (6.2)
Decubitus ulcer	13 (4.5)	7 (2.4)	17 (5.8)
Delirium	55 (18.9)	10 (3.4)	59 (20.3)
Fall accident	4 (1.4)	16 (5.5)	20 (6.9)
Pneumonia	32 (11.0)	14 (4.8)	45 (15.5)
Renal failure	2 (0.7)	0 (0.0)	2 (0.7)
Urinary tract infection	24 (8.2)	21 (7.2)	41 (14.1)
Wound infection	3 (1.0)	2 (0.7)	5 (1.7)
Reoperation within 60 days	1 (0.3)	1 (0.3)	2 (1.7)
Readmission within 30 days		4 (1.4)	1 (0.8)
Uncomplicated; n (%)	128 (44.0)	175 (60.1)	76 (26.1)
Length of stay in days; median (IQR)	9.0 (7.0–11.0)	38.0 (25.0–49.8)	46.0 (34.0–62.0)
Mortality[b]			
≤ 30 days; n (%)			6 (2.1)
≤ 3 months; n (%)			17 (5.8)

[a]Some complications are double recorded (in both the in-hospital and geriatric rehabilitation phases for one patient). For instance, double recording occurred if the treatment started in-hospital for pneumonia (antibiotics) continued in the geriatric rehabilitation institution.
[b]The mortality during geriatric rehabilitation was 3.1% (n = 9).
IQR: interquartile range.

stay. After geriatric rehabilitation, at 3 months after surgery, the Katz-ADL improved to 2 (IQR: 1–3) ($p < 0.001$). A total of 88.6% of patients needed help with activities of daily living. Almost half the patients who were independent in activities of daily living before the fracture had returned to full independence in activities of daily living after 3 months (20.6%, n = 60). At that time, 66.9% of the patients still needed help with activities of daily living.

Similar results were observed for independence in mobility, as measured with the FMS and FAC. Both clinimetrics improved during the geriatric rehabilitation and outpatient follow-up (in-hospital vs. geriatric rehabilitation institution: $P < 0.001$, geriatric rehabilitation institution vs. outpatient follow-up after 3 months: $P < 0.001$). On average, during the in-hospital phase, the FMS worsened with respect to the pre-fracture status. The FMS at the outpatient clinic follow-up was still poor in comparison with the pre-fracture Fracture Mobility Score ($p < 0.001$). Whereas 35.4% of the patients (n = 103) were freely mobile without aids before the fracture, only 1.4% (n = 4) and 6.2% of patients (n = 18) returned to this status after geriatric rehabilitation and after 3 months after surgery, respectively (Figure 3). At the end of the pathway, most patients were mobile outdoors with two aids or a walker (50.2%, n = 146).

Discussion

This study describes the development and implementation of a transmural monitoring pathway across institutional boundaries for older patients with hip fracture. The iterative multi-stakeholder approach led to a consensus regarding the content of the pathway, which appeared to be implementable in daily practice. Using the online communication platform OZOverbindzorg, healthcare professionals can follow the progress in recovery of their patients across institutional boundaries.

Our study revealed the course of functional recovery during the three phases of recovery. In the first phase, the functional level declined with respect to the pre-fracture status, as expected as a

Figure 4. Outcomes of functional ambulation categories (FAC) during the rehabilitation phase.
Percentage distribution of patients per category.
*Presented percentages are above 2%.
**After median 12 days after admission (n = 233, interquartile range 7–20 days).
GRI: geriatric rehabilitation institution.

result of the fracture and surgery. In the second phase, the most progress was made regaining independence in activities of daily living and mobility. During the last phase of recovery, progression of recovery remained ongoing. Clinimetrics indicated that patients remained more dependent on activities of daily living and less mobile than before the fracture. However, progress in functional recovery after this phase remains possible. Earlier studies have demonstrated that recuperation times in patients with hip fracture are almost a year for lower extremity function,[20,21] thus underscoring the importance of prolonged rehabilitation after the transmural monitoring pathway, as recommended in the Dutch Guidelines for Proximal Femur Fracture.[22] The guidelines recommend continuing physiotherapy until 1 year after a hip fracture. An expansion of the transmural monitoring pathway to primary healthcare with a follow-up period of 12 months might be advisable.

A notable finding was the high percentage (41.2%) of patients at risk of malnutrition, according to the SNAQRC. This finding is remarkable, because during the first phase, only 14.4% of patients were detected to be at risk of malnutrition, according to the SNAQ. A possible explanation for this finding might have been the differences between scores. In contrast to the SNAQ, the SNAQRC includes BMI and a question regarding whether the patient is receiving help with eating.[10] Furthermore, the SNAQ is taken at admission to the hospital and primarily concerns the pre-

fracture status. The SNAQ is performed after the hospital stay. The fracture, surgery, and hospital stay influence factors contributing to malnutrition, such as loss of appetite, depression, inability to eat, and diminished physical performance.[23] A systematic review and meta-analysis by Wojzischke et al. has indicated that nutritional status is associated with a decrease in physical function in geriatric rehabilitation patients, thereby emphasizing the need for screening and, if necessary, targeted interventions, as implemented in this pathway.[24] Currently, we have not implemented the SNAQ in phase 3, despite the high percentage of patients at risk of malnutrition during geriatric rehabilitation. In the future, implementing this tool in phase 3 may be valuable to evaluate the last nutritional status and, if needed, to deploy a dietician in the home.

The feasibility of the clinimetrics incorporated in the transmural monitoring pathway differed by phase. The feasibility in the in-hospital phase was excellent, as expected, because these clinimetrics were already implemented in the orthogeriatric care pathway of the CvGT. The feasibility of the clinimetrics during the geriatric rehabilitation phase varied. Suboptimal registration rates were observed on the items MMSE or MoCA, FAC, TUG, and 10 MWT. Evans-Lacko et al. have described several facilitators and barriers in the design, implementation, and evaluation of clinical care pathways.[25] One barrier leading to the suboptimal registration rates during the implementation of our pathway was the so-called "inertia of previous practice." Before the start of the *Up&Go after a hip fracture* project, measurements were not performed at the predefined times in the geriatric rehabilitation institutions, and healthcare professionals were not motivated to change their standard practice. Another barrier contributing to the suboptimal registration rates was the lack of outcome expectancy, particularly regarding the MMSE. Several healthcare professionals were not convinced of the usefulness of the assessment. Stakeholders were challenged to contribute ideas for a solution, and the MMSE was eventually replaced by the MoCA, an instrument that is used in more geriatric rehabilitation institutions, and is more sensitive and has a lower ceiling effect.[26] The involvement of stakeholders in this process led to strong accountability and resulted in the cognitive assessment's better performance. Barriers to performing the TUG and 10 MWT in the outpatient follow-up phase included a lack of staff involvement. Physiotherapists at the outpatient clinic were insufficiently involved at the beginning of the project, while they were expected to perform these measurements. These measurements failed because of time constrains and insufficient available facilities, such as a lack of time or places to perform collection of this measurement at the outpatient clinic. Currently, we are involving the physiotherapists and implementing the clinimetrics of the last phase. This task remains challenging because many older patients cancel their appointments at the outpatient clinic. Their overall health status makes hospital visits quite difficult or, in cases of full functional recovery, unnecessary.

Overall, the finding that most patients with hip fracture treated at Ziekenhuisgroep Twente are discharged to one of the three nursing home institutions in the vicinity of Ziekenhuisgroep Twente benefited the development and implementation of a transmural monitoring pathway. The development of a transmural monitoring pathway might potentially be more difficult in other regions in the Netherlands, where general hospitals discharge patients with hip fracture to more different geriatric rehabilitation institutions. Our transmural monitoring pathway includes different clinimetrics measuring similar outcomes, such as the Katz-ADL and the Barthel Index. This is because the fact that different healthcare institutions (the hospital and the geriatric rehabilitation institutions) are obligated to deliver different outcome measurements by different authorities in the Netherlands. This, together with the desire to limit the burden of registration and number of assessments, resulted in different tests at different institutions. A future goal would be to use uniform clinimetrics during the different phases of the pathway.

Extending our transmural monitoring pathway to other healthcare institutions could facilitate the development process of a transmural monitoring pathway. Implementing this process internationally

could be quite difficult, because the inpatient rehabilitation programs and settings substantially differ among countries. Nonetheless, transmural monitoring of the geriatric domains of cognition, malnutrition, activities of daily living, and mobility is relevant for all patients with hip fracture worldwide. How such monitoring can be achieved is strongly dependent on the organization of care. The detailed content of the workshops and decision making regarding the development of the transmural monitoring pathway given in Supplementary Appendix 1 may inspire healthcare institutions in other countries to develop a customized recovery pathway for patients with hip fracture. With the implementation of a transmural monitoring pathway, rehabilitation can be tailored to individuals, thereby improving the quality of care for patients with hip fracture.

Notably, our population represents only older patients with hip fracture with an indication for geriatric rehabilitation. The study population excluded patients who were not discharged to a geriatric rehabilitation institution, because they had such a good level of functioning that they were able to return home or they were unable to undergo rehabilitation at all. Therefore, the outcomes are not comparable to the general population with hip fracture. Another potential limitation is selection bias. The TUG and 10 MWT were performed only if the Functional Ambulation Categories was ≥ 3. Outcomes of these measurements represent a relatively fit subpopulation and should be interpreted carefully. Furthermore, we did not address the clinical utility of the pathway, for example, if the pathway was useful for health professionals using it. This would be an excellent purpose for future studies.

In conclusion, the development and implementation of a transmural monitoring pathway for patients with hip fracture across institutional boundaries are feasible but challenging, because intensive cooperation of all stakeholders is required. The pathway focuses on the geriatric health domains of geriatric health domains cognition, malnutrition, activities of daily living, and mobility, and provides insight into the entire recovery process from hospital admission to follow-up at the outpatient clinic for all involved healthcare professionals from different institutions. Recovery trajectories indicated that, during the in-hospital phase, patient's functional levels declined as a result of the fracture and surgery. During the inpatient rehabilitation phase, patients showed the most progress. In the third phase, most patients had not returned to their pre-fracture functional level, and progression of the recovery remained ongoing.

Clinical Messages

- The transmural monitoring pathway should monitor recovery during the in-hospital, geriatric rehabilitation, and outpatient follow-up phase.
- Geriatric health domains cognition, malnutrition, activities of daily living, and mobility should be observed.
- First, the results showed that functional level declines during hospital stay, progresses most during rehabilitation, and remained ongoing in outpatient follow-up.

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Supplemental Material

Supplemental material for this article is available online.

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