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# **Independence in activities after injury in humanitarian settings: assessment, change over time and associated factors**

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Cover illustration: ©MSF / In Port-au-Prince "We're surviving, not living" – Illustration from a picture taken by Valerie Baeriswy on 2021 November 4, Haiti.

# Independence in activities after injury in humanitarian settings: assessment, change over time and associated factors

Thesis for Doctoral Degree (Ph.D.)

By

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To Yves, Olivia, Maël and Oriane



## Popular science summary of the thesis

One might take it for granted that after an injury, even during a crisis such as a conflict or earthquake, people should be given crutches and instructions on how to get up and walk. However, in such contexts, the priority is all too often to save lives and limbs, rather than to ensure independence in daily life activities. Physiotherapy, when available, is often not prioritized, and therefore mostly provided later in the recovery process. Little is known about how people recover after an injury in such contexts, and for which reasons some recover better than others. Moreover, existing tools to measure recovery are often not adapted to such contexts, because they take too much time to administer, are not relevant to local daily activities, or are not appropriate to the cultural habits. For these reasons, a measure called Activity Independence Measure-Trauma (AIM-T) was developed. It consisted of twenty daily activities to be performed by the patient and to have his/her independence evaluated by a healthcare professional.

In this thesis, the two first studies focused on the adaptation and evaluation of the AIM-T within different crisis contexts, while the third study assessed how patients recovered over time, using the AIM-T among other tools. In the first study, using data collected routinely by physiotherapists in six hospitals, nine duplicates were identified among the 20 activities composing the AIM-T, and these were removed from the AIM-T. Patients and healthcare professionals were then asked about the relevance and appropriateness of the AIM-T, as well as whether it required further revision. Based on their feedback, the AIM-T was further adapted to consist of twelve activities, grouped into three parts, the lower limb, upper limb, and core activities. In the second study, tests conducted with patients confirmed that this shorter and adapted version measured independence as intended and yielded consistent results across the raters. In the third study, the adapted AIM-T was then used with other measures to assess patients' progress over time, across four hospitals situated within a crisis context. Over 500 patients were followed up from hospital admission to their discharge, with subsequent follow-ups conducted at three- and six months after injury. Six months after injury, half still required assistance from another person and/or relied on equipment such as crutches. Less than half had returned to work. Patients recovering better included children, those who had sustained injuries to the arms, trunk, or abdominal organs, or had received early physiotherapy, i.e., within 48 hours of hospital admission.

In conclusion, this research resulted in a short and adapted tool to measure progress of patients over time. This also provided information on how patients recover during the first six months after their injury in different contexts. In addition, the results suggest that early physiotherapy may be beneficial to recovery, potentially enabling patients to recover earlier. Overall, the results from this thesis may support patients to move earlier toward recovery.

# Résumé vulgarisé de la thèse en français

On pourrait penser qu'une personne blessée, même lors d'une crise, comme un conflit ou un tremblement de terre, recevrait des béquilles et des instructions pour se lever et marcher. Cependant, dans les situations de crise, la priorité est trop souvent de sauver des vies et des membres, et non d'assurer l'indépendance dans la vie quotidienne. On sait peu de choses sur la façon dont les personnes se rétablissent après une blessure dans un tel contexte, et pour quelles raisons certaines se rétablissent mieux que d'autres. En outre, les outils existant pour mesurer cette récupération ne sont souvent pas adaptés à ces contextes, parce qu'ils sont trop longs, non pertinents ou non appropriés. Une mesure, appelée AIM-T, a donc été créée, et consistait en vingt activités quotidiennes à réaliser par le patient pour que les professionnels de la santé puissent évaluer son indépendance.

Dans cette thèse, les deux premières études se sont d'abord concentrées sur l'adaptation et l'évaluation de l'AIM-T dans différents contextes de crise, pour pouvoir ensuite l'utiliser dans la troisième étude. Dans la première étude, en utilisant des données collectées régulièrement par des kinésithérapeutes dans six hôpitaux, neuf doublons ont été identifiés parmi les 20 activités composant l'AIM-T, et ceux-ci ont été supprimés de l'AIM-T. Des patients et personnels soignants ont ensuite donné leur avis quant à la pertinence et l'adéquation de l'AIM-T. Sur la base de leurs commentaires, l'AIM-T a été révisé, pour être constitué de douze activités, regroupées en trois parties. Dans la deuxième étude, des tests effectués auprès des patients ont montré que cette version adaptée et plus courte mesurait effectivement l'indépendance comme souhaité et que les résultats étaient constants entre les différents évaluateurs. Dans la troisième étude, l'AIM-T a été utilisé, avec d'autres outils, pour mesurer le rétablissement des patients après une blessure dans quatre hôpitaux. Plus de 500 patients ont été suivis depuis leur admission à l'hôpital, à leur sortie, puis trois et six mois après leur blessure. Après six mois, la moitié d'entre eux avaient encore besoin de l'aide d'une autre personne et/ou d'équipements tels que des béquilles, et moins de la moitié avaient repris le travail. La meilleure récupération de certains patients était liée au fait d'être un enfant, d'avoir une blessure aux bras, au tronc ou aux organes abdominaux, d'avoir eu besoin de moins d'aide pour les activités lors du suivi précédent, ou d'avoir reçu de la kinésithérapie dans les 48 heures suivant l'admission à l'hôpital.

En conclusion, cette recherche a fourni une mesure courte et adaptée ainsi que des valeurs indicatives de la récupération attendue lors des crises. En outre, ces résultats suggèrent qu'une prise en charge précoce en kinésithérapie peut être bénéfique à la récupération, ce qui pourrait permettre aux patients de se rétablir plus tôt. Dans l'ensemble, les résultats produits par cette thèse devraient donc contribuer à ce que les futurs patients se mettent en marche plus tôt vers leur récupération.



# Abstract

**Background:** Injury represents a significant burden in humanitarian settings, overwhelming the limited trauma care resources. Trauma care in these settings mainly focuses on saving lives and limbs, and not on recovery in daily activities. Rehabilitation, including physiotherapy, is often delayed and not systematic. Moreover, the lack of adequate measures of recovery of independence in activities limits the understanding of patients' needs beyond survival. This thesis aimed at assessing recovery over the first six months after an acute orthopedic, visceral, and/or skin injury in different humanitarian settings, first revising and evaluating a measure of independence in activities, the Activity Independence Measure–Trauma (AIM–T).

**Methods:** The three studies were conducted in eight health facilities supported or run by Médecins Sans Frontières in humanitarian settings, located in Burundi, Central African Republic, Cameroon, Iraq, Haiti, and Yemen. Study I used routine clinical data to run an inter-item correlation matrix and assess floor and ceiling effects of the initial AIM–T (AIM–T<sub>1</sub>), aiming for a shortened version (AIM–T<sub>2</sub>). Then, the adequacy of the AIM–T<sub>2</sub> was evaluated through semi-structured interviews with patients and healthcare professionals (HCPs), informing additional revisions for AIM–T<sub>3</sub>. Study II evaluated the construct validity and reliability of the AIM–T<sub>3</sub>. Study III assessed recovery at four time points (hospital admission, discharge, three and six months after injury), with different measures of recovery, including the AIM–T<sub>3</sub>. Factors associated with independence in activities (AIM–T<sub>3</sub>) were identified using multivariable logistic regressions for each of three time points (i.e., discharge, three and six months).

**Results:** In Study I (n=635), the identified redundant AIM–T<sub>1</sub> items were removed, leading to AIM–T<sub>2</sub>. All remaining items were considered adequate by the 60 patients and 23 HCPs interviewed. Some items were revised to improve the adequacy of the content, and one item added to provide AIM–T<sub>3</sub>. In Study II (n=195), the AIM–T<sub>3</sub> construct validity was supported, and inter-rater reliability was found to be good to excellent within a subset of 77 patients. In Study III (n=554), patients improved in all aspects of recovery across the four time points. Factors significantly associated with increased independence at one or several time points were age, type and location of injury, baseline independence and trauma care interventions, including early inpatient physiotherapy.

**Conclusions:** The AIM–T was considered adequate to assess independence in activities after acute injury in humanitarian settings, and its validity and reliability were supported. The AIM–T has thus potential for use as an indicator of recovery in humanitarian settings. Regarding recovery, most patients still experience difficulties at six months. The association of early physiotherapy with better recovery of independence suggests that physiotherapy may be beneficial and may potentially be a modifiable factor to enhance recovery in humanitarian settings.

# List of scientific papers

- I. **Gohy Bérangère**, Opava H. Christina, von Schreeb Johan, Van den Bergh Rafael, Brus Aude, Qaradaya Abed El Hamid, Mafuko Jean-Marie, Al-Abbasi Omar, Cherestal Sophia, Fernandes Livia, Da Silva Frois André, Weerts Eric, The AIM-T study group, Brodin Nina. Monitoring independence in daily life activities after trauma in humanitarian settings: Item reduction and assessment of content validity of the Activity Independence Measure-Trauma (AIM-T). *PLOS Global Public Health*. 2(12): e0001334.
- II. **Gohy Bérangère**, Opava H. Christina, von Schreeb Johan, Van den Bergh Rafael, Brus Aude, Fouda Mbarga Nicole, Ouamba Jean Patrick, Mafuko Jean-Marie, Mulombwe Musambi Irene, Rougeon Delphine, Coté Grenier Evelyne, Gaspar Fernandes Livia, Van Hulse Julie, Weerts Eric, The AIM-T study group, Brodin Nina. Assessing independence in mobility activities in trauma care: Validity and reliability of the Activity Independence Measure-Trauma (AIM-T) in humanitarian settings. *PLOS Global Public Health*. 3(9): e0001723.
- III. **Gohy Bérangère**, Van den Bergh Rafael, von Schreeb Johan, Opava H. Christina, Oundagnon Brigitte, Kitembo Augustin, Beme Appolinaire, Mafuko Jean-Marie, Ndiramiey Eric, Mulombwe Musambi Irene, Wehrung Rachel, Navarro Jacob, The AIM-T study group, White Richard Aubrey, Brodin Nina. Moving early towards recovery – Factors associated with independence in activities at hospital discharge, three and six months after injury in humanitarian settings. [*Manuscript*]

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## List of abbreviations

AIM-T	Activity Independence Measure-Trauma
aOR	Fully adjusted odds ratio
BI	Barthel Index
CAR	Central African Republic
CFA	Confirmatory factor analysis
COSMIN	Consensus-based Standards for the selection of health Measurement Instruments
FPS-R	Face pain scale-revised
GSW	Gunshot wound
HCP	Healthcare professional
HI	Handicap International / Humanity & Inclusion
HIC	High-income country
ICF	International Classification of Functioning, Disability and Health
ICC	Intraclass correlation coefficient
I-CVI	Item-content validity index
IPD	Inpatient department
IQR	Interquartile range
ISS	Injury severity score
LL	Lower limb
LMIC	Low and middle-income country
LOS	Length of stay
LoA	Limits of agreement
MSF	Médecins Sans Frontières
NISS	New Injury Severity Score
NGO	Non-governmental organization
NRS	Numeric Rating Scale
OPD	Outpatient department
OR	Odds ratio

PCC	Pearson correlation coefficient
PROMs	Patient reported outcome measures
PSFS	Patient Specific Functional Scale
R2HC	Research for Health in Humanitarian Crisis
RMSEA	Root mean square error of approximation
RTA	Road traffic accident
SD	Systemic disease
SDC	Smallest detectable change
SEM	Standard error of measurement
SRMR	Standardized root mean square residual
UL	Upper limb
VAS	Visual analogue scale
WG-SS	Washington Group Short Set on Functioning
WHO	World Health Organization

# Definitions

**Activity:** “execution of a task or action by an individual” [1]

**Humanitarian setting:** “any situation in which there is a widespread threat to life, physical safety, health or basic subsistence that is beyond the coping capacity of individuals and the communities in which they reside” [2].

**Independence:** the absence of need for any environmental factors (i.e., human or material) [3].

**Injury:** physical damage that occurs “when energy exceeds the tolerance of human tissue”[4]

**Low-and-middle income countries:** countries with a gross national income per capita, calculated using the World Bank Atlas method, of less than \$13,846 [5]

**Measurement property:** “quality aspect of a measure, i.e. reliability, validity and responsiveness” [6]

**Non-governmental organization:** “a not-for profit, voluntary citizen's group that is organized on a local, national or international level to address issues in support of the public good” [7]

**Rehabilitation:** “a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction, with their environment”, and is offered by a range of healthcare professionals [8].

**Trauma care system:** “A trauma care system is an organized and coordinated effort in a defined geographic area to deliver the full spectrum of care to an injured patient, from the time of the injury through transport to an acute care facility and to rehabilitative care” [9]



drawnALISM

*Sebastian Spencer, Médecins Sans Frontières (MSF) Operational Center Brussels's former medical director, closing remarks of the MSF Operational Research day 2019*



## Preamble

*It was one of my first days as a physiotherapist at the Médecins Sans Frontières (MSF) Kunduz Trauma Center (Afghanistan) in 2011. I was shadowing a surgeon at the outpatient surgical consultation. A man entered, carrying his son in his arms. The boy had sustained a femoral artery gunshot wound a few weeks before and was just coming for routine follow-up. The wound was clean, all was going as expected, so after a few minutes, the surgeon discharged the patient. The father took his son back in his arms and left the room.*

If all was going well, then why was this boy not walking?

No one had informed the father that the child could move his leg, stand, and walk. As a result, he was discharged from the hospital lying down, remained lying down at home, and came back lying down. In humanitarian settings, such as Kunduz, the patient load is high, resources are limited, and the focus is placed on saving lives and limbs. The boy's life was saved, but there was no opportunity to consider the life he needed to live. However, other patients like him shared their concerns about going back to their daily life activities. Additionally, pressure to resume their professional or domestic occupations seemed much higher than I expected, due to the absence of social security to compensate for the lack of income, the fact that one person was often the sole breadwinner for a large family, as well as the burden hospital admission constitutes for caretakers. These patients needed to be independent as soon as possible, and yet this did not seem to be the priority.

Discharge from hospital and from the outpatient department was often based on criteria related to bone and wound healing, rather than on level of independence in daily activities. Moreover, physiotherapy was an intervention that most patients associated with chronic conditions, such as low back pain, rather than an intervention provided within the first days after injury. Some patients feared moving, others were not instructed to do so, such as this little boy.

More data were needed to document the recovery of these patients and investigate the potential effects of early physiotherapy. Without systematic data collection and rigorous methods, such data would not be as informative and would be unlikely to drive any meaningful change. Given the numerous challenges in conducting research in humanitarian settings, documenting the real-life conditions through observational studies seemed the most appropriate approach. This thesis is born from the operational need identified in Kunduz, as well as in other humanitarian settings, to describe the recovery of patients after injury and identify ways to improve it.

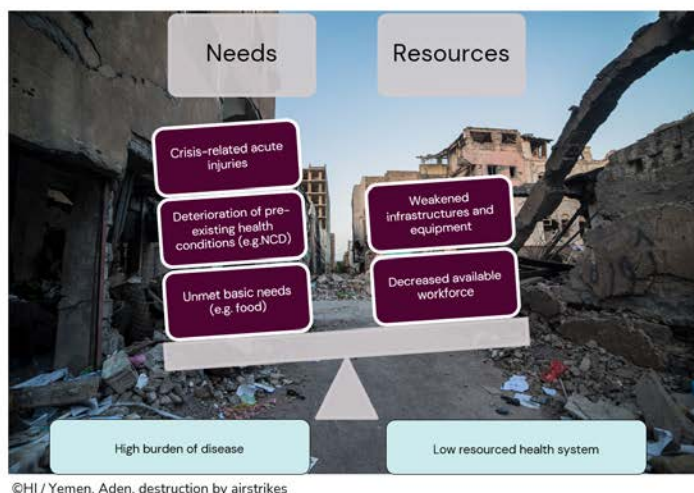
After all, a healed wound (or bone) might not be enough...



# Introduction

Humanitarian crises are caused by natural or technological disasters, epidemics, famine, or armed conflicts, and can be either short-lasting or protracted [10]. In 2023, more than three hundred million people worldwide were in need due to a crisis, exposed to forced displacements, excess mortality, and morbidity [10,11]. The direct and indirect health consequences of a crisis span across different health domains, including nutrition, mental health, non-communicable diseases, and injuries, adding up to the pre-existing burden of disease and injury [12,13].

These health consequences tend to be more severe in settings with low-resourced healthcare systems, which in turn are further weakened and overburdened by the crisis (Figure 1) [14–17]. The imbalance between needs and available resources characterizes ‘humanitarian settings’, which is an umbrella term here defined as “any situation in which there is a widespread threat to life, physical safety, health or basic subsistence that is beyond the coping capacity of individuals and the communities in which they reside” [2]. This imbalance often requires additional assistance, which can be found locally, regionally, or internationally [18]. Such assistance is referred to as humanitarian assistance and includes the involvement of international non-governmental organizations (NGOs) like Médecins Sans Frontières (MSF) and Humanity & Inclusion (HI).



**Figure 1.** An imbalance between health needs and resources, which characterizes a humanitarian setting; often taking place in a low-resource setting, with structurally high burden of disease and injury and a low-resourced health system.  
*NCD: noncommunicable diseases*

Despite the burden of disease and injury in humanitarian settings, robust research on health interventions in these settings remains scarce [19,20]. Findings from research conducted in other – often well-resourced – settings are rarely transferable, given the different needs and available resources [21]. However, assessing health consequences in humanitarian settings is needed to address those needs appropriately.

This thesis therefore aimed at assessing the recovery of patients after injury across different humanitarian settings, to gain a broader understanding of the related health needs in humanitarian settings and thereby inform effective trauma care interventions, including physiotherapy.

While acknowledging that low-resource settings are highly heterogeneous and can be located in any country, this thesis will primarily focus on humanitarian crises in low and-middle-income countries (LMICs) [22].

# 1 Background

## 1.1 High health needs related to injury

### 1.1.1 Global burden of injury

Injury is defined as a physical damage that occurs “when energy exceeds the tolerance of human tissue” [4]. Globally, injury accounts for 9.8% of the burden of disease, expressed as disability-adjusted life years (DALYs), and is responsible for 4.3 million deaths [23]. Overall, males and the working-age population are most affected by injury, and 45% of the societal costs are estimated to be related to disability-related productivity loss [23,24]. Falls have the highest age-standardized injury incidence rate [25].

The LMICs bear a disproportionate burden of injury, with a higher age-standardized mortality rate, largely due to road traffic accidents (RTA) [25]. In LMICs, a greater proportion of patients admitted to hospitals are males, below 30 years, and have extremity injuries, including open fractures [26–32]. On the other hand, fewer patients are admitted with low-energy falls or traumatic brain injuries than in HICs [26–32].

#### 1.1.1.1 *Burden of injury in humanitarian settings*

The burden of injury due to humanitarian crises is estimated based on limited data, due to the sudden-onset nature of these crises and disruption of health information systems, among other barriers [25]. However, data collected by healthcare providers involved in the humanitarian assistance gives some indication. Among almost 20,000 patients surgically treated at MSF health facilities across different humanitarian settings, including natural disasters, armed conflicts, and protracted crises, 32% of patients were younger than 18 years, and 76% were males [33]. Across all procedures, a third was related to RTA injuries, emphasizing that the scope of injuries is much wider than those caused directly by the crisis [33–35]. In contrast, a systematic review of studies conducted in acute armed conflict settings reported that the majority of the injuries were associated with blasts, bombs, or landmines (69%), with a higher proportion of gunshot wounds in urban settings [36]. In the same review, the overall severity of the injuries was moderate, as measured by the injury severity score (ISS) (median 9), with a wide variety of injuries, mainly to the extremities (33%), abdomen and thorax (18%), and head and neck (18%) [36]. This thesis will focus solely on orthopedic, visceral, and/or skin injuries, composing the majority of injuries receiving trauma care in humanitarian settings. Patients with injuries

to the central neurological system (i.e. spinal cord injury and traumatic brain injury) will be excluded, due to the different expected recovery patterns.

### **1.1.2 Recovery after injury**

Globally, for every person who dies from injury, 99 persons survive [23]. Recovery after injury therefore extends beyond mere survival. Recovery will be defined here as a return to pre-injury health state, such as the restoration of physiological functions, performance of daily life activities, and participation in society [37–39]. Each of these aspects of recovery potentially follows a different pattern of change over time.

The expected time to restore physiological functions and/or integrity of anatomical structures to their pre-injury state depends strongly on the type of injury, as well as on patient- and care-related characteristics. For instance, bone healing time differs between bones and can be influenced by factors such as age, smoking, or nutrition [40,41]. Acute pain is reported by 50% of patients at hospital discharge and is expected to decrease over the first three to six months [30,42,43]. Muscle atrophy, soft tissue contractions around joints, and/or physical deconditioning start as soon as a few days after an injury and are related to a decreased level of physical activity as well as medical interventions, including immobilization methods [44–47]. Deviations from expected recovery in these physiological functions and body structures are termed secondary complications and include non or malunion of fractures, infections, and pain [48]. Up to 27% of deep infection rates have been reported after fractures [41,49]. Pain persisting beyond six months, considered chronic, has been reported in 30–50% of patients and is more likely in patients having reported moderate to severe pain at hospital discharge [42,50,51].

Resuming daily life activities is also vital for patients and their well-being. This includes activities such as walking or getting dressed, as well as participating in more complex life situations, such as work and social life [52–54]. Limitations in activities are frequently observed in the first six months after injury, with 60% and 23–50% of patients reporting problems in mobility activities three- and six months post-injury, respectively, before reaching a plateau [30,50,55–58]. However, some limitations may last for years, especially after moderate to severe injury [30,50,55–57]. Common predictors of activity limitation are older age, lower level of education, pre-injury difficulties in functioning, lower extremity injury, presence of co-morbidities or mental illness, high levels of pain, longer lengths of hospital stay, and intensive care unit stay [30,50,59–67]. Sex and injury severity

have also been suggested to play a role, though no consensus exists for these characteristics [50,60–62].

In addition, participation across a range of life situations often remains restricted for months to years after trauma, with 46–82% of patients having returned to work six months after their injury [50,55,59,63,68–73]. Psychosocial difficulties, such as anxiety, feelings of helplessness and anger are commonly reported in the first weeks after injury. However, these difficulties can also occur at a later stage, especially when patients realize their potential inability to resume previous activities and dependence on caretakers [50,62,72,74]. Moreover, post-traumatic stress disorder (PTSD), which impacts the patient's participation and quality of life, has also been commonly reported [50,75]. While acknowledging the impact of psychological difficulties on recovery, this thesis primarily focuses on recovery in physical aspects of health, as well as return to occupation.

#### *1.1.2.1 Recovery in LMICs*

Overall, the lack of trauma research in LMICs, including in humanitarian settings, is disproportionate in relation to the burden of injury [36,76–79]. Existing studies mostly employ a cross-sectional design or involve a small sample size [80–82]. Recently, some larger longitudinal studies have been conducted in LMICs, including recent publications from Malawi, Ethiopia, and Uganda as described below [83–88]. However, such longitudinal studies remain sparse in humanitarian settings, especially for the description of recovery in the first weeks and months after injury, and most focus has been put on the epidemiology of injury and/or surgical interventions rather than longer-term recovery [19,89].

Global patterns of recovery in LMICs tend to resemble those from HICs, even though comparisons are hindered by differences in study populations, settings, and measurement methods. Various infection rates have been reported, with an average of 18% across studies included in a systematic review on open fractures in LMICs, with rates up to 85% in specific cohorts [90]. Regarding return to daily life activities, some studies indicated that as few as 1–30% of individuals encounter mobility-related limitations at three months following an injury, while others reported more persistent challenges up to a year after the injury [31,83,84,86,88]. Additionally, a lower rate of return to work has been documented in LMICs [77,84,90–92]. In LMICs, the socio-economic consequences of a poor and delayed return to work may be particularly pronounced, due to environmental

factors, such as the limited social security systems and high out-of-pocket health expenditure [91,93,94]. This is especially true when the person injured is the main breadwinner of the family [77,91]. In LMICs, such as in humanitarian settings, the recovery beyond survival is therefore crucial and needs to be addressed comprehensively.

## **1.2 Limited resources to cope with injury**

### **1.2.1 Focus on saving life and limbs**

A trauma care systems is “an organized and coordinated effort in a defined geographic area to deliver the full spectrum of care to an injured patient, from the time of the injury through transport to an acute care facility and to rehabilitative care” [9]. These systems were initially developed in HICs to decrease the mortality rate, which has led to an increased proportion of persons surviving with complex short- and long-term disabilities [95,96]. Rehabilitation, while being a core health strategy to reduce disability and optimize functioning, was historically perceived as a luxury and as a fallback strategy [97]. Over the last two decades, more comprehensive trauma care systems have been promoted. This addresses the multifaceted consequences of injuries, where integration of rehabilitation is recognized [98–100]. However, such a comprehensive system is not available in most LMICs, where quality and timely provision of trauma care is limited and the rehabilitation needs after injury are often unmet throughout the continuum [16,81,101,102].

In humanitarian settings, damage to health facilities, limited availability of qualified human resources, challenging procurement of equipment, increased incidence of injuries, and deterioration of chronic conditions further increase these unmet trauma care needs [16,21,103,104]. Moreover, there is often a ‘patchwork’ of healthcare providers to support coping with these needs, resulting in fragmented or absent trauma care systems [36,105]. Within trauma care provision, the priority often remains on life and limb-saving, leading to discharge as soon as the patient is medically stable, which in turn results in a delayed and often broken chain of rehabilitation [103,106].

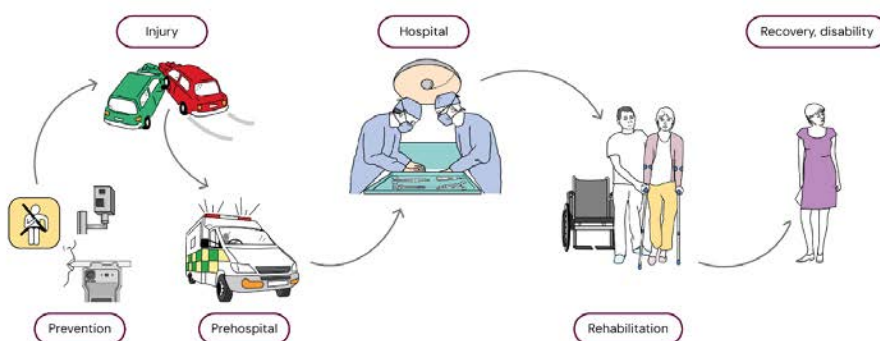
### **1.2.2 The rehabilitation hole**

Early rehabilitation is heterogeneously described and can be defined as rehabilitation provided during acute inpatient care, within 48 to 72h of admission, by a range of healthcare professionals (HCPs) such as occupational therapists, physiotherapists,



psychologists, and rehabilitation physicians, aiming to optimize recovery of functioning and prevent complications [46,107,108].

Within comprehensive trauma care systems, rehabilitation is often still represented as the last step of the patient's pathway, to be provided once the patient is medically stable (Figure 2) [109]. This representation has led to the so-called 'rehabilitation hole', with a lack of systematic implementation of early rehabilitation [96,110]. On the other hand, several rehabilitation services are often made available after acute inpatient care, leading to different potential discharge destinations (e.g., home, nursing home, specialized inpatient rehabilitation) and a variety of follow-up care pathways, differing in availability and coordination [96,111].



**Figure 2.** Patient's journey after injury [112] (*reproduced with permission of Oxford University Press on behalf of the BJS Society Ltd*)

Some integrated interventions have been implemented to close the aforementioned 'rehabilitation hole' in acute inpatient care, acknowledging that early rehabilitation requires a coordinated approach [110,113–115]. Across these integrated interventions as well as in studies evaluating more distinct interventions, the main reported benefits of early rehabilitation include reduced secondary complications, shorter length of stay, decreased pain, and increased independence in daily activities or return to work [116–122]. These benefits are typically achieved with no or few adverse effects, even though some findings show mixed results [116–122].

### 1.2.3 Unmet rehabilitation needs throughout the continuum

In LMICs, in addition to various barriers related to cost and workforce availability, rehabilitation is often misconceived as an intervention for persons with chronic

disabilities, rather than for persons with acute and post-acute needs [119,123,124]. Moreover, (bed)rest can be perceived as the prescribed approach after an acute injury or illness, and patients might be afraid of moving the affected body parts, even months after injury [125–128]. These perceptions are deeply related to health beliefs on the causality of a disease or an injury, as well as methods of health maintenance and restoration, specific to each setting [129–131]. Similarly, low awareness among rehabilitation professionals and other HCPs about the role of rehabilitation in acute stages leads to inconsistent referral within acute care, and to delayed mobilization [128,132–135]. There is a limited number of studies reporting specifically on the provision of physiotherapy after a range of injuries in LMICs. These reports show that inpatient physiotherapy was provided to less than 20% and outpatient physiotherapy to 12–52% of the patients [85,125,133,136].

In the majority of the LMICS, within the limited set of skilled rehabilitation professionals available for acute care, physiotherapists are often the most widely represented [137,138]. Physiotherapists tend to provide a combination of different rehabilitation components, including interventions often performed by occupational therapists [138]. Given its relatively wide availability in the settings of interest, this thesis will focus on the provision of rehabilitation by physiotherapists, considered as one rehabilitation intervention, though composed of more than one component [139].

#### *2.2.2.1 Provision of physiotherapy in humanitarian settings*

The field of physiotherapy has evolved considerably during the last century, to which armed conflicts (e.g. World War I and II) have contributed [140]. Specialized physiotherapy services were set up to provide rehabilitation to young veterans with limb amputations or spinal cord injuries [106,141]. International organizations, such as the International Committee of the Red Cross (ICRC) from 1979 and Handicap International / Humanity & Inclusion (HI) from 1982 have also contributed to introducing rehabilitation services in many humanitarian settings [140,142]. The physiotherapists' role in humanitarian settings has expanded, and now includes coordination efforts to strengthen the continuum of care across healthcare providers and to ensure emergency preparedness of physiotherapy activities [142,143]. The massive rehabilitation needs resulting from earthquakes in China in 2008, Haiti in 2010, and Nepal in 2015 have underlined the crucial role of rehabilitation in such settings, with multiple documented lessons learned and calls for action [103,144–146].

Following these major humanitarian crises, early rehabilitation, including physiotherapy, has gained recognition and is included in several standard documents such as the minimum standards for Rehabilitation in Emergency Medical Teams (EMTs), the Sphere standards for humanitarian response, and the World Health Organization (WHO) policy brief on rehabilitation in health emergencies, among others, as well as in clinical guidelines [106,140,143,147–149]. The adoption of the first resolution on rehabilitation by the World Health Assembly (WHA) in May 2023 represents the latest achievement of civil society in urging states to recognize the importance of investing in rehabilitation services to meet the growing population needs, including in humanitarian settings [150].

However, early integration of physiotherapy in humanitarian settings remains unsystematic and is poorly documented [19,151–156]. From the few studies reporting its provision, the timing of early physiotherapy is heterogenous across cohorts, from days to months, illustrating the lack of standard definition and implementation [92,157–161]. The limited scope of research on early physiotherapy in humanitarian settings may hinder its more systematic and effective integration within trauma care provision, potentially affecting patient outcomes after injury.

### **1.3 Assessing health outcomes after injury**

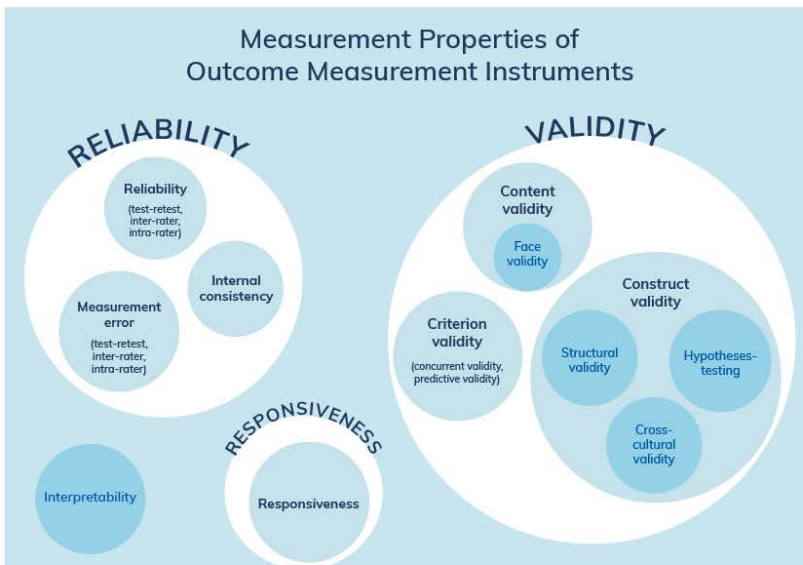
The short-term programming characterizing most humanitarian interventions has led to a focus on short-term objectives and on output rather than outcomes [89]. Furthermore, data collection in humanitarian settings is often seen as a burden, partly due to the lack of understanding from the staff on its added value [162,163].

However, in the past decade, increased emphasis has been placed on measuring outcomes of interventions in order to ensure quality and effective responses, reinforce the accountability of humanitarian actors, and prioritize resources to where they are most needed [8,148,164–166]. Moreover, with the increasing number and diversity of stakeholders involved in humanitarian settings and the global reach of some international NGOs, standardized data collection systems have been called for [105,154,166,167].

Therefore, a pragmatic choice of indicators is required in humanitarian settings, aligning with the main objectives of the health intervention, the feasibility of data collection, international comparability, as well as quality of the information produced [166,168,169].

### 1.3.1 Quality aspects of a measure

To ensure quality information, measurement properties of a measure (i.e. its validity, reliability and responsiveness) need to be evaluated [170]. Several frameworks exist to guide the assessment of measurement properties of already existing measures, as well as the development of new measures, should there be no adequate measures identified [170–173]. The Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) framework was identified as the most comprehensive and most widely used for health measures [174]. Figure 3 presents the main domains (i.e., reliability, validity, and responsiveness) and corresponding measurement properties of the COSMIN taxonomy.



**Figure 3.** Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) taxonomy of measurement properties [6]

When no suitable measure is identified, a comprehensive and iterative development process is recommended, as summarized in Figure 4. During that process, the initial version of the measure will go through one or several rounds of pilot and field testing where the properties of the measures are evaluated, informing required revisions, before its use for clinical or research purposes [175,176]. The definition of the construct to be measured is at the core of the process and should be defined for a specific context of

use, including the target population and the main measurement purpose (e.g., evaluate changes in health outcomes over time) [175].

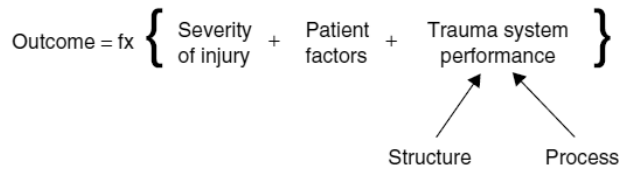


**Figure 4.** Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) Stepwise process of development and evaluation of a measure [175] (reproduced with permission of The Licensor through PLSclear)

### 1.3.2 Indicators of quality of trauma care, beyond mortality

Health outcomes can be seen as a result of non-modifiable (e.g., the severity of health condition or age) and modifiable factors (e.g., healthcare structure and process). The

evaluation of such interaction has been used to assess the quality of care, such as described by the Donabedian model, here applied to trauma care (Figure 5) [112,177,178].



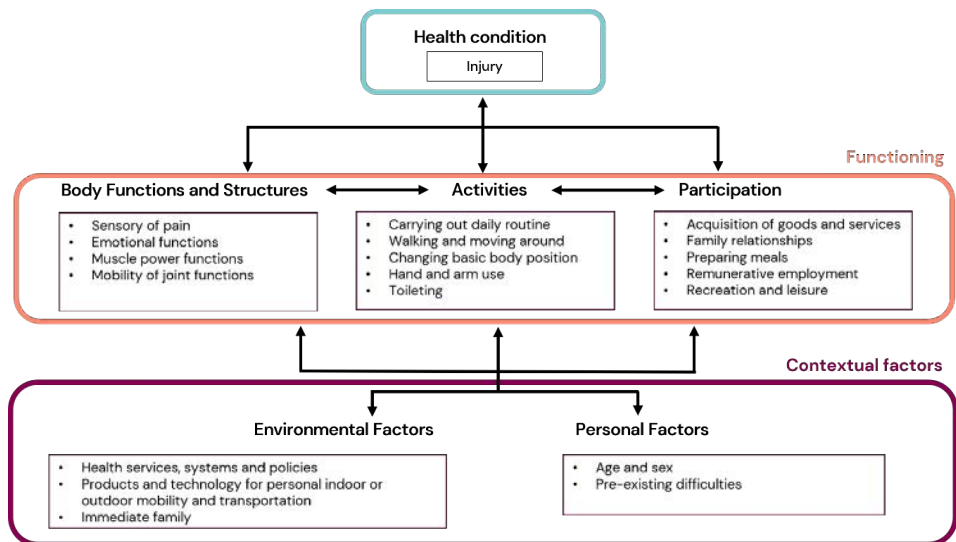
**Figure 5.** Donabedian model applied to quality of trauma care [112] (*reproduced with permission of Oxford University Press on behalf of the BJS Society Ltd*)

Historically, mortality rate has been used as the main outcome of trauma care, along with other acute care process indicators, such as length of stay [112]. However, in HICs, further major reductions in mortality rates through improved quality of care are not considered likely [179]. At the same time, the in-hospital mortality rate in LMICs does not always reflect the hospital's performance, as most deaths may occur before reaching the hospital [33].

Recovery of functioning has therefore been increasingly recommended as indicator of quality of trauma care to reflect performance of the whole trauma care system [112,180]. This recommendation also aligns with the Sphere standard on injury and trauma care in humanitarian settings, highlighting that avoidable suffering and disability should be prevented, as well as mortality and morbidity [148].

The WHO introduced functioning as part of the International Classification of Functioning, Disability and Health (ICF), confirming the need for a biopsychosocial approach to health [1]. Full functioning and complete disability lay on the extreme ends of a continuum, being its positive and negative extremes respectively [181]. Functioning captures the lived experience of a health condition by a person, defining it as a non-linear and dynamic interaction with the environment [1].

The ICF is organized into two main parts interacting with each other, i.e., functioning and contextual factors, as illustrated in Figure 6 with examples of subdomains applicable to injury. The 'functioning' part is composed of 'body functions and structures', and 'activity and participation', the latter comprising nine overlapping domains, including mobility activities and self-care activities [1].

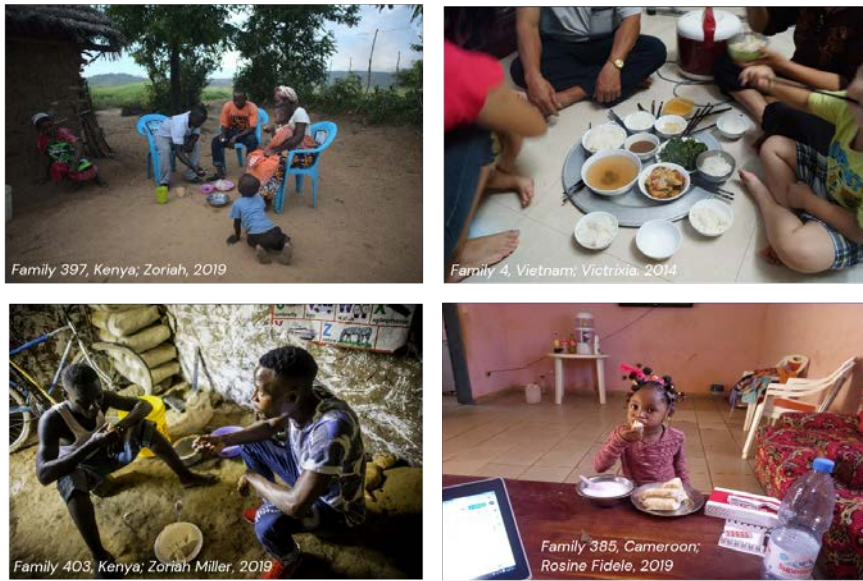


**Figure 6.** The International Classification of Functioning, Disability and Health (ICF) model illustrated with selected subdomains of functioning and contextual factors, identified as relevant for patients after injury [1,182].

### 1.3.3 Assessing independence in activities

Within functioning, recovery in mobility and self-care activities are among the main objectives of early physiotherapy after injury, and therefore represent critical indicators of its effectiveness [46].

The ICF mobility domain comprises a variety of activities involving the core, lower and upper body (e.g. changing body position, walking and moving around, fine hand use), beyond the more common understanding of 'mobility', often restricted to lower limb mobility. Additionally, self-care activities, such as getting dressed, eating or toileting, are quite universal tasks [183]. However, the way self-care activities are performed may vary considerably across patients and settings [184]. Figure 7 illustrates the diversity in performing the activity 'eating', which involves different body positions, fine hand use, and mobility in knee joints, depending on the person and his/her environment. When assessing patients, these normal variations may challenge the comparability of results between and within countries, due to different levels of difficulties and assistance required for a given activity [185].



**Figure 7.** Eating as performed by different persons across different settings. Pictures from Dollar street : [www.gapminder.org/dollar-street](http://www.gapminder.org/dollar-street), (reproduced under CC BY 4.0)

Moreover, the assistance one may require performing such activities (e.g. using crutches or assistance from another person) is highly volatile in humanitarian settings. This makes individuals who are dependent on any assistance more vulnerable, potentially creating additional challenges for them to fulfil their basic needs [186,187]. The ICF uses this 'dependency' perspective to describe the extent of limitations in activities according to the type and level of assistance (i.e., any environmental factors) required [3]. In this thesis, 'independence in activities' will therefore be defined as the absence of need for any environmental factors (i.e., human or material) in the performance of mobility and self-care activities.

### 1.3.3.1 Existing measures of functioning

In the literature, independence in mobility and self-care activities are sometimes referred to as physical or motor functioning, functional status, or activities of daily life [61,188–190]. These terms do not always reflect exactly the same construct, which complicates comparisons between studies. To address this issue, an ICF trauma core set has been drafted, though its finalized version has not been published yet, preventing its uptake [182].



Most of the existing measures used in trauma research and trauma registries so far were not developed for patients after trauma [189,191]. In a systematic review, the most common measures used to assess functioning across types of injuries and across the continuum of care are found to be generic measures such as the European Quality of Life Questionnaire (EQ-5D) or the Functional Independence Measure (FIM) [189,192]. Trauma-specific measures, such as the Trauma Outcome Profile (TOP), are less widely used [189]. Some measures have also been developed for a specific setting or stage of recovery, such as the Activity Measure for Post Acute Care (AM-PAC) for the post-acute stage, acknowledging that the patient's level of independence is expected to improve over time after acute injury, in contrast with other health conditions [193]. Other measures have been developed for specific body regions, such as the Upper Extremity Functional Index (UEFI) and the Lower Extremity Functional Scale (LEFS), illustrating the different dimensions of independence [194,195].

#### *1.3.3.2 Main shortcomings of measures of functioning in humanitarian settings*

The above-mentioned measures have not been commonly used in trauma research or within trauma registries in LMICs [90,189,196,197]. Instead, a variety of measures for which the validity has not been tested or described, has been used, compromising the quality of evidence produced and hindering comparison across studies [35,155,163,198–201]. Over the last five years, standardized measures have increasingly been used in studies in LMICs, such as the EQ-5D, but their use remains scarce in humanitarian settings [83,84,86,202]. The Barthel index (BI) is one of the few measures of independence used in trauma registries in LMICs [197]. The BI has also been used to report functioning in humanitarian settings, mainly in studies conducted after natural disasters in China, though its validity and reliability in such settings have not been tested [155].

Most existing measures were developed and evaluated in HICs and have shortcomings in humanitarian settings [104,142]. Being developed in HICs, the included items might not always be relevant, capture what is needed in daily life, and/or appropriate to assess [31,83,184,203,204]. Additionally, the majority of these measures are self-reported, and might therefore be burdensome in settings where literacy is low, limiting their feasibility [205,206]. Different cultures might also have different thresholds before reporting a difficulty, hindering comparability [207]. Some of the measures are lengthy and/or require accredited training, which is problematic in settings where resources are scarce and where the focus should remain on the provision of health interventions rather than

documentation [104,142,163]. One additional barrier could be the affordability and accessibility of existing measures that are often patented and not translated into local languages [208,209]. However, until now, no core data set has been identified for rehabilitation professionals in humanitarian settings [105,142,143].

#### *1.3.3.3 The AIM-T*

Based on these shortcomings, a measure was developed in 2011 in the MSF Kunduz Trauma Centre (KTC) in Afghanistan for patients after injury and this measure was later called the Activity Independence Measure-Trauma (AIM-T)) [160]. Based on the ICF framework, the AIM-T aimed at measuring changes over time in the performance of independence in mobility and self-care activities after acute injury, through observation by physiotherapists. The initial version of the AIM-T (AIM-T<sub>1</sub>) included 20 items, divided into 2 sub-scales: the lower limb and upper limb sub-scales (Supplement 1 – Study I). The total score ranges from 20 to 100 and is based on the assistance required and difficulties experienced, a higher score corresponds to a higher level of functioning and less disability [160]. As with many other measures, the AIM-T<sub>1</sub> was self-made for a specific setting (i.e., Kunduz), without following a rigorous development process. Nevertheless, the AIM-T<sub>1</sub> was used routinely between 2011 and 2018, by physiotherapists in other settings (i.e., MSF health facilities providing acute trauma care in Haiti, Burundi, Central African Republic, Yemen, and Iraq, and health facilities providing reconstructive surgery in Iraq and Gaza), without prior evaluation of its measurement properties.

## 2 Research aim and research questions

The overarching aim of this thesis was to assess the recovery of functioning among patients over the first six months following acute orthopedic, visceral, and/or skin injury in different humanitarian settings, with a focus on independence in activities.

To accomplish this overarching aim, the first step involved the revision and evaluation of the measurement properties of the Activity Independence Measure–Trauma (AIM-T<sub>1</sub>), a measure of independence in activities, to ensure its quality before using it along other well-established measures to assess functioning.

**The specific research questions of this thesis were:**

- Is there any inter-item redundancy in the AIM-T<sub>1</sub>, and to what extent does the shortened AIM-T (AIM-T<sub>2</sub>) assess the independence in activities adequately and require revisions? (Study I)
- To what extent are the revised AIM-T (AIM-T<sub>3</sub>) construct validity and reliability supported? (Study II)
- To what extent do patients recover in different aspects of functioning over the six first months in four different humanitarian settings, and what are the health condition, functioning, environmental, and personal factors associated with recovery of independence in activities, as measured by the revised AIM-T (AIM-T<sub>3</sub>), at hospital discharge, three months and six months after their injury? (Study III)

**Table 1.** Overview of the three studies in the thesis

Study	Research question	Study focus	Study design	Year(s) of data collection	Data sources	Data collection point(s)	Study participants	Age	Settings	Data analyses
I	<p>-Is there any inter-item redundancy in the AIM-T?</p> <p>-To what extent does the shortened AIM-T (AIM-T<sub>2</sub>) assess the independence in activities adequately and require revisions?</p>	Item reduction	Cross-sectional, retrospective	2018	Routine data	Any of the time point(s): IPD admission, IPD discharge, OPD admission, OPD discharge	Patients (n=635)	≥5	Yemen, Burundi, Haiti, Iraq	- Inter-item correlation - Spearman correlation coefficient
		Content validity	Cross-sectional	2019	Semi-structured interviews and routine data	One time point: No defined time since injury	HCPs (n=23), patients (n=60)	>5	Burundi, Haiti, Iraq	- Proportions - I-CVI
II	<p>-To what extent are the revised AIM-T (AIM-T<sub>3</sub>) construct validity and reliability supported?</p>	Construct validity	Cross-sectional	2019	Routine and questionnaires	One time point: <6M of injury	Patients (n=195)	>5	Burundi, Iraq, CAR, Cameroon	- CFA - Independent t-test - Pearson correlation coefficient
		Reliability					Patients (n=77)	>5		- ICC <sub>agreement</sub> - Cronbach alpha
III	<p>-To what extent do patients recover in different aspects of functioning over the six first months after their injury in four humanitarian settings?</p> <p>-What are the health condition-, functioning-, environmental- and personal factors associated with recovery of independence in activities, as measured by the revised AIM-T<sub>3</sub> at discharge, three months and six months after injury?</p>	Longitudinal change	Longitudinal observational	2020-2022	Routine and questionnaires	Four time points: IPD admission, IPD discharge, 3M, 6M	Patients (n=554)	>5	Burundi, Haiti, CAR, Cameroon	- Wilcoxon signed rank test - Mc Nemar test
		Associated factors				IPD discharge, 3M 6M				Logistic multivariable regression

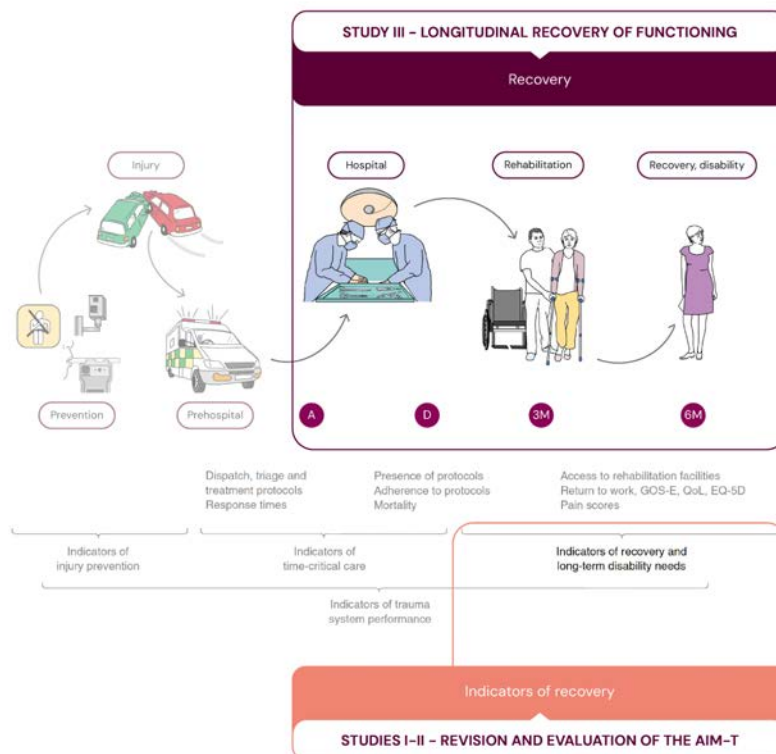
AIM-T<sub>1,2,3</sub> : Activity Independence Measure-Trauma version 1, 2, 3; CAR: Central African Republic; CFA: Confirmatory factor analysis; HCPs: health care professionals; ICC: Intraclass correlation coefficient; I-CVI: item-content validity index; IPD: inpatient department; M: months; OPD: outpatient department

### 3 Materials and methods

This thesis is based on three studies presented in Table 1. The main materials and methods are summarized in this section. A more detailed description is available in each of the three constituent papers.

#### 3.1 Thesis framework

The graphic representation of the indicators of the trauma system performance, developed by Gruen et al, was used to frame the three studies composing this thesis (Figure 8). **Studies I and II** revised and evaluated an indicator of recovery that could be suitable for humanitarian settings. **Study III** assessed the changes over time in patients' outcomes, using several indicators of recovery, from the point of admission to the hospital until six months after injury, and identified factors associated with the revised and evaluated indicator of recovery.



**Figure 8.** The three studies in the thesis illustrated using the patient's journey after injury as described by Gruen et al (adapted with permission of Oxford University Press on behalf of the BJS Society Ltd) [112]

## **3.2 Settings**

### **3.2.1 Humanitarian settings**

Data was collected in seven settings (Burundi, Cameroon, Central African Republic (CAR), Haiti, Iraq (Baghdad and Mosul), and Yemen), all facing humanitarian crises of high to very high severity at the time of data collection [210]. These settings were confronted with armed conflict and/or urban violence, most often protracted, and additionally experienced acute crises to different extents, such as the earthquake in August 2021 along with the political crisis in Haiti, the elections and political tension in CAR in early 2021, and Boko Haram attacks in the far north of Cameroon.

### **3.2.2 Study sites**

Across the three studies, eight health facilities were included. All health facilities were supported or run by the international NGO Médecins Sans Frontières (MSF) and were purposively selected based on their admission criteria, average caseload, feasibility of data collection, as well as their location, seeking for diversity (Study II).

Trauma care was provided in adherence with the MSF quality of trauma care standards. Nevertheless, these facilities differ in their set up (i.e., trauma center, rehabilitation center, regional hospital). Physiotherapy was provided in all sites to patients after injury in inpatient and outpatient departments. Tailored treatment was provided based on individual needs assessment.

An overview of the eight health facilities located in seven settings is provided in Figure 9 (pages 20–21).

### 3.3 Study population

Four different datasets were used throughout this thesis, all including patients after injury admitted within an MSF health facility. Study I also included HCPs working in those facilities. In total, 1444 patients (Table 2) and 23 HCPs were included.

**Table 2.** Inclusion and exclusion criteria, and patients' characteristics in Studies I-III.

	Study I		Study II	Study III
	Item reduction	Content validity	Construct validity and reliability	Longitudinal recovery
Total (n)	635	60	195	554
Inclusion criteria	MSF trauma care Physiotherapy ≥ 1 AIM-T score All ages Any acuteness	MSF trauma care  ≥5year Any acuteness	MSF trauma care  ≥5year <6months injury	MSF trauma care  >5year <72h injury
Exclusion criteria	Isolated central neurologic injury	Isolated central neurologic injury	Isolated central neurologic injury	Isolated central neurologic injury
Age, years (med IQR)	25.0 (16-35)	28.5 (18.75-40.25)	31.0 (22-44)	30.0 (23-39.25)
Age (%)				
<18years	26.1	21.7	16.4	9.0
18-49years	59.9	66.7	67.2	78.9
>49years	9.4	8.3	16.4	12.1
Missing	4.6	3.3	0.0	0.0
Male (%)	82.6	68.3	66.2	83.2
Female %	17.2	31.7	33.8	16.8
Missing	0.2	0	0	0
<b>Cause of injury (%)</b>				
Accidental, RTA	31.3	N/A	N/A	57.9
Accidental, others	25.6			9.1
Violent, GSW	27.7			22.2
Violent, others	13.4			10.8
Missing	2.0			0.0
<b>Type of injury (%)<sup>1</sup></b>				
≥1 LL injury	58.7	73.3	75.4	66.1
≥1 UL injury	36.4	35.0	30.3	30.5
≥1 trunk injury	13.1	15.0	9.7	26.9
<b>Severity of injury (SATS) (%)</b>				
Green	N/A	3.3	6.7	1.4
Yellow		25.0	45.1	43.4
Orange		23.4	22.1	48.1
Red		15.0	0.5	7.1
Missing		33.3	25.6	0

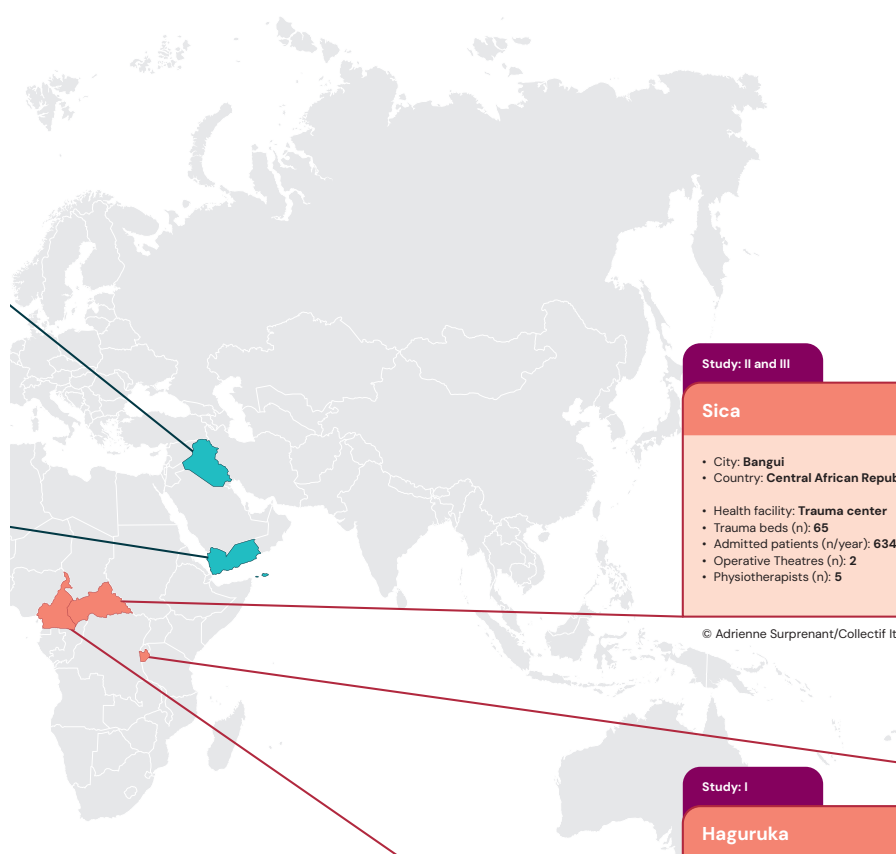
<sup>1</sup>Patients could have more than one injury type. AIM-T: Activity Independence Measure-Trauma; GSW: gunshot wound; h: hour; IQR: Interquartile range ; LL: lower limb; MSF: Médecins Sans Frontières; N/A: not applicable; RTA: road traffic accident; SATS: South African Triage Scale [211]; UL: upper limb.



**Figure 9.** Overview of the study sites.  
Data from each of the eight health facilities routine reports. BMRC: Baghdad Medical Rehabilitation Centre.

(1) This number includes all patients presenting at the emergency department for urgent health conditions.





#### Study: II and III

##### Sica

- City: **Bangui**
- Country: **Central African Republic**
- Health facility: **Trauma center**
- Trauma beds (n): **65**
- Admitted patients (n/year): **634**
- Operative Theatres (n): **2**
- Physiotherapists (n): **5**

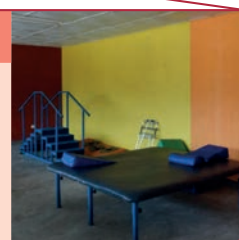


© Adrienne Surprenant/Collectif Item for MSF – “The MSF SICA hospital in Bangui.”

#### Study: I

##### Haguruka

- City: **Bujumbura**
- Country: **Burundi**
- Health facility: **Rehabilitation center**
- Trauma beds (n): **8**
- Admitted patients (n/year): **16**
- Operative Theatres (n): **0**
- Physiotherapists (n): **4**



© HI – “Physiotherapy room at the HI Rehabilitation center Haguruka in Bujumbura.”

#### Study: II and III

##### Maroua

- City: **Maroua**
- Country: **Cameroon**
- Health facility: **Regional hospital**
- Trauma beds (n): **70**
- Admitted patients (n/year): **1748<sup>(1)</sup>**
- Operative Theatres (n): **2**
- Physiotherapists (n): **1.5**



© MSF / Pierre-Yves Bernard – “Maroua Regional Hospital – Far North Region of Cameroon.”

#### Study: I, II and III

##### Arche

- City: **Bujumbura**
- Country: **Burundi**
- Health facility: **Trauma center**
- Trauma beds (n): **60**
- Admitted patients (n/year): **1397**
- Operative Theatres (n): **2**
- Physiotherapists (n): **6 (June 2020) to 1 (April 2021)**

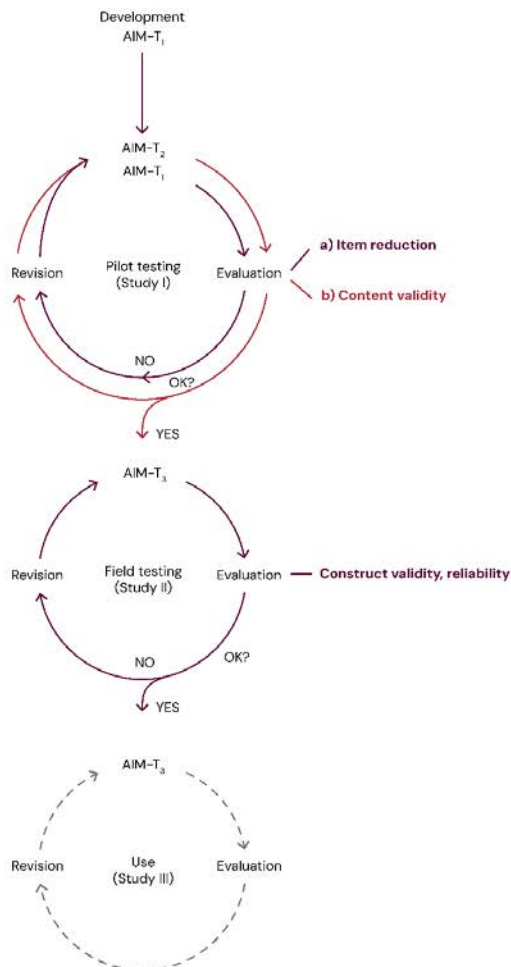


© Evrard Ngendakumana – “The MSF “L’Arche de Kigobe” trauma center in Bujumbura.”

### 3.4 Study design and methods

#### 3.4.1 Revision and evaluation of the AIM-T (Studies I–II)

Studies I and II were designed in accordance with the COSMIN development process, including stepwise pilot testing (Study I), and field testing (Study II), in order to revise and evaluate the AIM-T as a measure of independence in activities (Figure 10) [175]. The successive versions of the AIM-T were denoted by a number in subscript (i.e., AIM-T<sub>1</sub>, AIM-T<sub>2</sub>, and AIM-T<sub>3</sub>). The AIM-T<sub>1</sub> was developed and used routinely in MSF health facilities before this thesis.



**Figure 10.** Sequential steps were undertaken in Studies I–II, starting with two rounds of pilot testing for the AIM-T<sub>1</sub> and AIM-T<sub>2</sub> (Study I), followed by one round of field testing for the AIM-T<sub>3</sub> (Study II), before its use in Study III [175] (*adapted with permission of The Licensor through PLSclear*). AIM-T<sub>1,2,3</sub>: Activity Independence Measure–Trauma version 1, 2, 3

#### 3.4.1.1 *Revisions of the AIM-T (Study I)*

##### **Item reduction**

The first part of Study I was a retrospective cross-sectional study using data routinely collected in five health facilities (Tabarre (Haiti), Arche (Burundi), Haguruka (Burundi), BMRC (Iraq) and Aden (Yemen)), between July 2017 and August 2018.

The AIM-T<sub>1</sub> scores available from one or several of the four routine physiotherapy data collection timepoints (i.e., hospital admission, hospital discharge, OPD admission, OPD discharge) were pooled. An inter-item correlation matrix was generated for the ten lower limb items for patients with at least one lower limb injury, and for the ten upper limb items for patients with at least one upper limb injury, using the Spearman Correlation coefficient ( $r$ ). Pairs of items with an  $r \geq 0.9$  were considered redundant. The AIM-T<sub>1</sub> was revised in this fashion, leading to AIM-T<sub>2</sub>.

##### **Content validity**

The second part of Study I was a cross-sectional study, consisting of semi-structured individual interviews conducted among a purposive sample of patients and HCPs in four health facilities (Tabarre (Haiti), Arche (Burundi), Al-Wahda (Iraq), and BMRC (Iraq)) between March and June 2019.

Content validity is “the degree to which the measurement is an adequate reflection of the construct to be measured” [173]. It was evaluated through the assessment of five aspects of adequacy: ‘relevance’, ‘comprehensiveness’, ‘feasibility’, ‘clarity’ and ‘appropriateness’. Item-content validity indexes (I-CVI) were calculated for each AIM-T<sub>2</sub> item, capturing the proportion of participants considering the item as highly relevant, comprehensive, feasible, clear, and appropriate in measuring independence in activities, respectively, ranging from 0 to 1. The I-CVI values informed revisions as follows: if  $< 0.50$ , the item needed to be deleted, if  $\geq 0.5$  and  $< 0.85$ , it needed revisions. If an activity was mentioned by  $> 15\%$  of study participants, it was considered for addition. These assessments guided the AIM-T<sub>2</sub> refinement, leading to the AIM-T<sub>3</sub>.

**Table 3.** Hypotheses tested, analyses and criteria applied for each of the measurement properties evaluated for the AIM-T<sub>3</sub>

Domain	Measurement property	Measurement property aspect	Hypothesis	Analysis	Criteria
Validity		Structural validity	The three-factor structure has an adequate fit and better summarizes the construct of independence than the single factor structure.	CFA	RMSEA < 0.06 or CFI > 0.95 or SRMR < 0.08
			Patients with acute injury (<30days) have a significantly lower level of independence than patients with post-acute injury (>30days).	Independent t-test Cohen's d	p < 0.05 and d ≥ 0.5
			Patients with at least one lower limb injury have a significantly lower level of independence in lower limb activities than patients without lower limb injury.	Independent t-test Cohen's d	p < 0.05 and d ≥ 0.5
		Hypothesis testing: Known-group validity	Patients with at least one upper limb injury have a significantly lower level of independence in upper limb activities than patients without upper limb injury.	Independent t-test Cohen's d	p < 0.05 and d ≥ 0.5
	Construct validity		Patients with multiple injury have a significantly lower level of independence than patients with a single injury.	Independent t-test Cohen's d	p < 0.05 and d ≥ 0.5
Reliability			The AIM-T scores correlate strongly with the BI scores.	PCC	PCC ≥ 0.7
		Hypothesis testing: Concurrent validity	The AIM-T scores correlates moderately with the pain scores.	PCC	PCC < -0.7
			The AIM-T scores correlate more strongly with the pain reported during activities than at rest.	PCC	PCC < -0.7 and PCC activity>PCC rest
	Internal consistency	N/A	The items within each of the three AIM-T subscales are interrelated.	Cronbach alpha	α ≥ 0.7
	Reliability	Inter-rater reliability	There is a good agreement in scoring the AIM-T (sub)scales between two independent raters.	ICC	ICC ≥ 0.7

AIM-T: Activity/Independence Measure-Trauma; α: Cronbach alpha; CFA: Confirmatory factor analysis; CFI: Comparative fit index; d: standardized effect size Cohen's d; PCC: Pearson correlation coefficient; ICC: intraclass correlation coefficient; N/A: not applicable; RMSEA: Root mean square error of approximation, SRMR: Standardized root mean square residuals

#### 3.4.1.2 *Evaluation of the AIM-T construct validity and reliability (Study II)*

Study II was a cross-sectional study, using routine and study-specific data from patients in four health facilities (BMRC (Iraq), Arche (Burundi), Sica (CAR), and Maroua (Cameroon)) between July and November 2019. The main evaluation criteria for construct validity and reliability, established according to the COSMIN framework, are summarized in Table 3 [212].

##### **Construct validity**

To evaluate construct validity, patients were assessed by one rater per health facility using, in sequential order, the AIM-T, the Barthel Index (BI), and self-reported pain at rest and during activity, using either the visual analog scale (VAS) or the face pain scale-revised (FPS-R) [213–215]. Patients were given the possibility to self-report their difficulties in performing the BI activities when not comfortable being observed, as per the BI guideline. The AIM-T and BI assessments were timed.

Construct validity is “the degree to which the scores of the measurement are consistent with hypotheses based on the assumption that the measurement validly measures the construct to be measured” and includes structural validity and hypothesis testing. The structural validity, and two types of hypothesis testing (i.e., known group validity and concurrent validity) were evaluated based on hypotheses regarding the AIM-T structure, as well as discriminative ability and relationships with comparator measures, respectively (Table 3). Overall, 75% of the pre-formulated hypotheses had to be met for the construct validity to be supported.

##### **Reliability**

The reliability was evaluated through testing of internal consistency, inter-rater reliability, and measurement error. Internal consistency is the “degree of the interrelatedness among items” and was evaluated through Cronbach alpha ( $\alpha$ ) [173]. A subset of patients ( $n=77$ ) was re-assessed independently by a second rater to test inter-rater reliability. Inter-rater reliability is defined as “the extent to which scores for patients who have not changed are the same for repeated measurement by different persons on the same occasion” and was investigated using the intraclass correlation coefficient (ICC) for absolute agreement [173]. Standard error of measurement (SEM), the smallest detectable change (SDC) and

the limits of agreement (LoA) were calculated for the total score and subscales measurement error, defined as “systematic and random error of a patient’s score that is not attributed to true changes in the construct to be measured” [173].

### **3.4.2 Recovery of functioning (Study III)**

Study III was a multicentric longitudinal cohort study. It included patients after acute orthopedic, visceral and/or skin injury admitted to four health facilities (Arche (Burundi), Maroua (Cameroon), Sica (CAR), and Tabarre (Haiti)), and was conducted between June 2020 and January 2022.

The included patients were assessed by a dedicated research officer who collected study-specific data via questionnaires and retrieved information from medical and physiotherapy files. There were four data collection time points (i.e. hospital admission, hospital discharge, three months after injury, and six months after injury) across a range of variables reflecting health condition, functioning, and contextual factors, as summarized in Table 4.

In addition to the AIM-T, one of the other measures of functioning was the Patient Specific Functional Scale (PSFS), which assesses the perceived ability to perform three chosen activities, in comparison with their pre-injury state. Each activity was scored by the patient from 0 to 10, where 0 is ‘unable to perform’ and 10 is ‘able to perform at prior level’ (i.e., before the injury), and an average score was then calculated for the scored activities [216].

Patients were grouped into seven injury categories, expected to recover similarly [217]. These categories were based on the type of injury (i.e., fracture, soft tissue, visceral, or skin) and its location (i.e., lower limb, upper limb, or trunk), using the International statistical Classification of Diseases and related health problems 10<sup>th</sup> version (ICD-10) [218].

**Table 4. Measurement, definition, data source, and data collection time points of the variables collected in Study III, organized according to the International Classification of Functioning, Disability and Health (ICF).**

ICF part	ICF component	Construct measured	Measurement used	Definition	Data source	Routine / Study specific	Time points of data collection			
							Adm.	Dis.	3M	6M
Health condition	Health condition									
		Injury cause	MSF classification	RTA, Accident other, GSW, violent other	Medical file	Routine		X		
		Injury type and location	ICD-10	Injury categories	Medical file	Routine		X		
		Injury severity	NISS (1-75)	Minor (NISS≤15)/Major (NISS>15)	Medical file	Routine		X		
Functioning		Open fracture severity	Gustilo-Anderson	I, II, IIIa, IIIb, IIIc	Medical file	Routine				
	Body functions and structure	Sensation of pain	NRS (0-10)	Moderate-severe (NRS≥5)	Self-report	Study-specific	X	X	X	X
		Secondary complications	Clavien-Dindo	No or grade 1 / Grade 2 or 3	Observation	Study-specific		X	X	X
	Activities	Mobility activities	AIM-T (0-60)	Independent/Not independent	Observation	Study-specific	X	X	X	X
Contextual factors		Activities	PSFS (0-10)	Mean of available scores	Self-report	Study-specific		X	X	X
	Participation	Major life areas	Return to occupation	Yes / No	Self-report	Study-specific			X	X
	Environmental factors	Hospital length of stay	Adm. date, Dis. Date	1-7, 8-14, ≥15 days	Medical file	Routine		X		
		Quantity of surgery	Surgical interventions	None, 1-2, ≥3	Medical file	Routine		X		
		Readmission	Readmission date	Yes / No	Medical file	Routine			X	X
		Timeliness of IPD physio.	Time first IPD physio.	None, <48h, ≥48h	Medical file	Routine		X		X
		Timeliness of OPD physio.	Time first OPD physio.	None, <2w, 2w-3M, >3M	Medical file	Routine		X		
		Settings	N/A	1, 2, 3, 4	N/A	N/A		X		
	Personal factors	Age	Years	6-17, 18-49, ≥50	Self-report	Routine		X		
		Sex	N/A	Male/female	Self-report	Routine		X		
		Pre-injury occupation	Occupation name	Manual/Non-manual/No	Self-report	Study-specific		X		
		Pre-injury difficulties	Washington Group SS	No difficulties/At least some difficulties	Self-report	Study-specific		X		
		Pre-operative status	ASA score	Healthy/Mild-severe systemic disease	Medical file	Routine		X		

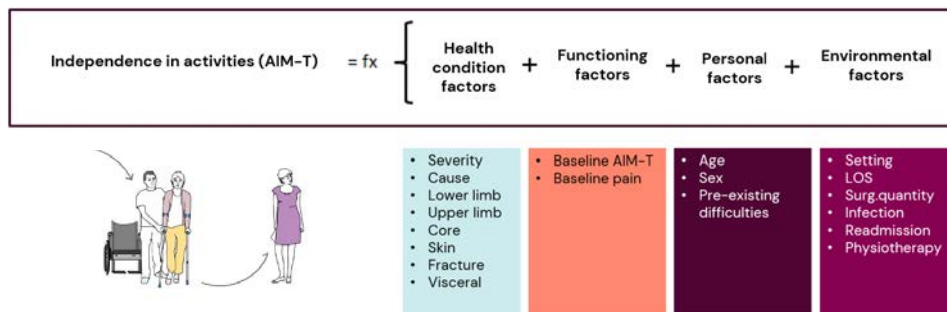
Adm: admission; AIM-T: Activity/Independence Measure-Trauma; ASA: American Society of Anesthesiologists physical status classification system; Dis: discharge; GSW: gunshot wound; h:hours; ICD-10: 10th revision of the International Statistical Classification of Diseases and Related Health Problems; IPD: inpatient; NISS: New Injury Severity Score; NRS: New Injury Severity Score; N/A: not applicable; Numeric Rating Scale; OPD: outpatient; physio: physiotherapy; PSFS: Patient Specific Functional Scale; RTA: road traffic accident; w:week(s); SS: Short set

### 3.4.2.1 Pattern of recovery of functioning over time

The change over time between two time points was assessed with the Wilcoxon signed rank test for non-binary variables and the McNemar test for binary variables. The patterns of recovery were also visually inspected through radar charts of the median of the three AIM-T subscale scores, as done previously by others [219]. Moreover, the activities chosen by the patients for the Patient Specific Functional Scale (PSFS) were coded using the ICF as a framework and categorized into the corresponding ICF activity and participation domain(s).

### 3.4.2.2 Factors associated with independence in activities

The factors associated with independence in activities were identified by performing multivariable logistic regression for each of the three time points: discharge, three months, and six months after injury, using the AIM-T as the primary outcome. A clinically relevant definition of independence in activities was used for the AIM-T dichotomization, based on criteria for expected recovery of independence at the three time points (i.e., independence from human assistance at discharge, and independence from all assistance at three and six months). The models were adjusted for health condition, functioning, personal, and environmental covariates, as summarized in Figure 11. Crude, semi-adjusted, and fully adjusted models were performed, providing the respective odds ratios.



**Figure 11.** Overview of the health condition, functioning, and contextual (i.e., personal and environmental) factors included in the multivariable logistic regression for independence in activities, as measured by the Activity Independence Measure-Trauma (AIM-T) [112] (adapted by permission of Oxford University Press on behalf of the BJS Society Ltd). LOS: Length of stay; Surg.quantity: Quantity of surgical interventions.



### **3.5 Role of funding**

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscripts.

### **3.6 Ethical considerations**

The three studies were conducted in different humanitarian settings, which resulted in several ethical challenges.

Foremost, in humanitarian settings, the priority should remain to address the needs of the population: the burden of research should be minimized, both for patients and their caretakers, as well as for the HCPs. To address this, routine data was used as much as possible, and some data collections were merged (i.e., evaluation of hypothesis testing and reliability, initially planned in sequence). As Study III involved two follow-ups, these were synchronized with routine appointments when possible, and transportation costs were covered by the research project. When security constraints or other logistic constraints were identified as barriers, the follow-ups were conducted by phone or through home visits, as appropriate. Moreover, for Studies I and II, daily workers were hired during data collection to take over the routine work, to avoid a gap in the provision of care, while for Study III, one dedicated research officer was appointed for each site, covering the planning, data collection and closure phases.

As research was conducted within health facilities providing free trauma care and as part of routine care, humanitarian misconception may have occurred, with over-acceptance to participate, due to the power imbalance and/or sense of gratefulness towards the organization. The right to decline was emphasized in the consent form and reiterated by the persons administering the consent, and the distinction between clinical care and research was explained. However, especially in Study III which assessed the recovery longitudinally, study participants who did not recover by the last follow-up expressed expectations for additional support (e.g., financial support). Such financial support was not foreseen in the MSF activities, and orientations towards other services were done.

In addition to their living environment, the studied population was also particularly vulnerable given their acute health condition. For Study III, the time between injury and data collection was especially short and constraining (i.e., within 48h of admission), leaving little time for patients to reflect before providing consent, when their physical, cognitive, and mental status were also potentially impacted. The research officers were sensitized

on the right attitude and approached the patient only after a first introduction made by the routine clinical team.

As all data collections, except Study I, involved the performance of activities, study participants included across studies incurred risks for increased fatigue, pain, or further injuries. To minimize those risks, a careful and continuous assessment of the participants' health status, potential contraindications, and precautions was conducted, in close collaboration with the routine clinical team. Additionally, fatigue and pain levels were regularly evaluated, and measures were taken to ensure that participants received adequate rest.

Furthermore, the interviews in Studies I and III asked about difficulties in daily life, which could have been distressing for a person who had just suffered an injury and might therefore already have been experiencing psychological distress and/or might have suffered an injury with life-changing impairments and limitations. The research officers were trained by the local psychologists to be able to identify signs of distress, apply the psychological first aid principles, and refer to the psychosocial team when appropriate. Research officers were also briefed on self-care and were given the space to discuss and reflect on the impact of the research on themselves, to mitigate potential vicarious trauma.

Besides, while injury is often not a stigmatizing condition per se, the cause of injury (in particular violent injury, such as gunshot wounds in an armed conflict or due to urban violence) may entail a danger to participants if disclosed, as it might relate them to combatant activities. To ensure the confidentiality of sensitive and personal health-related information, strict data management and protection procedures were put in place, including pseudonymization, data minimization as well as secured data storage, and strict access rules.

### **3.6.1 Ethical approvals**

The following ethical approvals were obtained to conduct the studies: the MSF Ethics Review Board, Geneva, Switzerland (ID 1893 and ID 1934), as well as by the respective ethics review committees competent for each participating health facility: University of Aden (REC-53-2019), Ethics Committees of the Baghdad Directorate of Health and the Ninewa Directorate of Health (p. 1/5/10), Burundi National Ethics Committee for the

Protection of Human Rights of Participants in Biomedical (15/04/2019 and CNE/05/2020), Behavioral Research and Haiti National Committee of Bioethics (Ref.1819–23 and Ref.2021–15), Scientific Committee for the Validation of Study Protocols and Research Results on Health in Central African Republic (28/UB/FACSS/CSCVPER/19 and 21/02/2021), the National Ethics Committee for Research in Human Health in Cameroon (2019/08/1184/CE/CNERSH/SP and 2020/01/1202/CE/CNERSH/SP). The Swedish Ethical Review Authority, (Dnr 2022–02806–01) has approved data management of the project at Karolinska Institutet.

### **3.7 Reflection on project management**

This work consisted of research activities conducted across multiple settings and in partnership with different actors. The research project was funded by the Research for Health in Humanitarian Crisis (R2HC) grant, bringing together an academic institution, i.e., Karolinska Institutet, and two operational organizations, i.e., Humanity & Inclusion (HI) and Médecins Sans Frontières (MSF).

Implementing research within an academic–operational partnership represents important opportunities but is also challenging [220]. The main opportunity presented here was to couple the knowledge of operational needs that are relevant to the end beneficiaries and knowledge of the setting from the operational organizations, with a rigorous methodology brought by the academic partner. This was strengthened by the fact that the research project took place as part of a doctoral education. Indeed, the doctoral student was also the principal investigator (PI). However, timeframes and priorities do not always align between operational and academic organizations. Moreover, conducting research in humanitarian settings requires constant adaptations, and implies methodological compromises that might not be always understood by academic actors.

In addition, by the way MSF and HI are structured, all project activities had to be coordinated on different levels, with a high turn-over of staff. Nevertheless, throughout this research project, local focal points were appointed, and the physiotherapists working in the different health facilities under study have consistently remained the core group. A real sense of community was present, bringing communicative energy, essential insights from the reality in each setting, as well as technical expertise, and overall safeguarding that this research was meaningful to the targeted communities.

In addition to the research activities (i.e., Studies I–III), one major focus of the R2HC grant is the uptake of the research findings, to avoid research sitting nicely on a shelf, very far from the end users and even farther from the individuals living in humanitarian settings. An uptake plan was developed as part of the initial proposal and evolved over time based on operational constraints, the evolution of humanitarian crisis severity, and the Covid-19 pandemic, among others. The main uptake activities included the development of training materials for the AIM-T, written guidance, and posters, as well as an e-learning module. These materials were developed throughout the three studies, informed by the results but also by the process of training the research officers in AIM-T data collection and ensuring data quality.

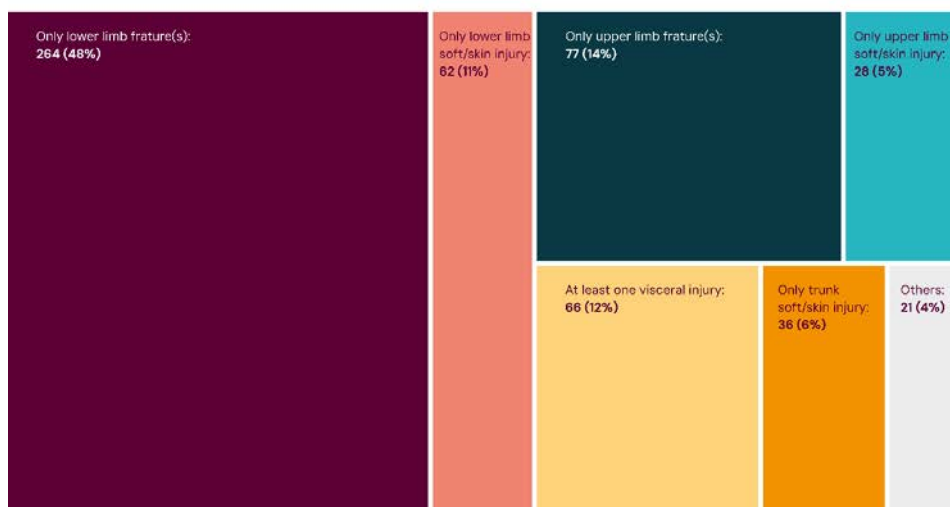
## 4 Results

### 4.1 Study population

Patients were mostly males (66–83%) and of working age (median age 25–30 years) (Studies I–III). RTA was the leading cause of injury (31–58%), followed by GSW (22–28%) (Studies I–III). Injuries to the lower limb were the most common (59–75%), twice as many upper limb injuries (30–36%) (Studies I–III).

From the more detailed information collected in Study III, severe trauma represented a minority (13%), based on the NISS. The frequencies and proportions of injury categories is summarized in Figure 12. Patients with only upper limb or lower limb fractures accounted for 62%. Among patients with at least one fracture, 87% had an open fracture and 39% had at least one Gustilo III grade fracture. Half of the patients with fractures were immobilized with external fixation, which was removed after a median period of 106 days (71–146).

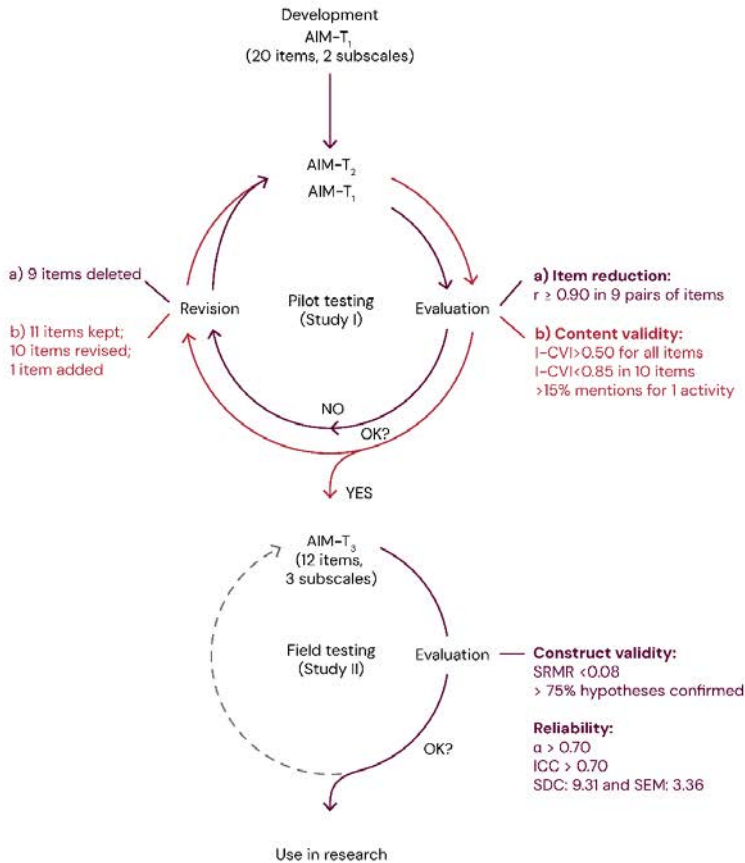
Overall, 84% of patients were considered healthy before the injury, based on their ASA score, 15% reported any pre-injury difficulties in functioning, and 4% had pre-injury difficulties specifically in walking or climbing stairs. Most patients had manual occupations prior to the injury (76.7%), such as taxi drivers, construction workers, and farmers, and the majority were urban dwellers (76%).



**Figure 12.** Frequencies and proportions of injury types among Study III patients (n=554).

## 4.2 AIM-T revision and evaluation

The results of the stepwise AIM-T revision and evaluation are summarized in Figure 13.



**Figure 13.** Summary of results from Studies I-II, according to the Consensus-based Standards for the selection of health Measurement Instruments (COSMIN) process of development and evaluation

#### **4.2.1 The shortened AIM-T is an adequate reflection of independence in activities after injury**

From the AIM-T<sub>1</sub> composed of twenty items, nine items were removed based on redundancies identified by pairwise correlations and on the item score distributions, leading to the AIM-T<sub>2</sub> (Study I). The 11 remaining AIM-T<sub>2</sub> items were thereafter judged highly adequate by most study participants, even though some specific concerns were raised regarding appropriateness and relevance (Study I), as illustrated by selected quotes from study participants (Table 5).








The main adequacy concern was the lack of appropriateness of observing the AIM-T<sub>2</sub> self-care activities (i.e. 'squat' and 'put on pants') (Study I). High rates of self-reports were also observed for the Barthel Index (BI) self-care activities (Study II).

Another adequacy concern was the varying relevance of some AIM-T<sub>2</sub> activities between study participants, highlighting how the same mobility activity is used in different life situations, to different extents, and the relative relevance of given activities depending on the acuteness of injury (Study I). The inclusion of basic as well as more advanced activities was also considered important (Study I). 'Walk long distances' was mentioned by more than 15% of study participants, describing its role in many life situations, such as employment, education, or domestic activities (Study I). In addition, the clinical relevance of the AIM-T<sub>2</sub> activities was mentioned by HCPs and patients, either from an activity-oriented perspective (e.g. to improve arm and hand use in daily activities) or rather from a body function perspective (e.g. to improve cardiovascular functions) (Study I).

Moreover, all items were judged highly feasible, but some feasibility concerns were raised by HCPs in specific settings, depending on the available equipment and space (Study I). The unclarity of some items and the difficulty of understanding by some patients were also mentioned.

These adequacy concerns informed the revised AIM-T<sub>3</sub>, composed of 12 items, including a new item as a proxy for 'walking long distances' and grouped into three subscales (i.e. core, lower limb, and upper limb activities) (Study I).

**Table 5.** Selected quotes of Study I participants on the adequacy of the shortened Activity Independence Measure-Trauma (AIM-T<sub>2</sub>) items

Adequacy component	Topic	Selected quotes	Applications of AIM-T items to daily life situations
Appropriateness	Appropriateness of self-care activities	<b>Put on pants:</b> 'This activity will cause many problems, especially if there are women or even for some men who might not accept' (Nurse, male, Mosul).	
Relevance	Diversity in use and performance	<b>Open jar:</b> 'This activity is relevant only for a category of people, for example people living in the countryside, which jar are we talking about, the one where we put the syrup for the children? we do this occasionally when we have a child who's sick, but for people living in the city, the oil they use for the face is in a jar, the butter, the jams; do we have that?' (Patient, female, upper limb fracture, Burundi)	
Relevance	Diversity along the continuum	<b>Climb up and down 5 steps:</b> 'This is an advanced level to measure the lower limbs activities we need to use simple activity first such as walking and then this one' (Physiotherapist, male, Baghdad)	
Relevance	Clinical relevance (activity-oriented)	<b>Grab small object:</b> 'It's really essential to be able to see the functionality of the hand or arm.' (Physiotherapists, female, Burundi)	
Relevance	Clinical relevance (related to body functions)	<b>Walk 50 meters:</b> 'from a medical point of view, the patient needs to move in order to make his circulation move too. And movement will help the digestive system so that the patient would not get constipation. It will also help in wound healing' (IPD nurse, female, Mosul).	
Relevance	Walking long distances	<b>Walk 50 meters:</b> 'This activity is of little importance in my private life because in a day I can walk more than ten times that distance; around you in the morning when you see people walking, the majority do at least five kilometers, the children who go to school two kilometers, those who go to the market two kilometers' (Patient, male, Lower limb fracture, Burundi).	
Clarity	Clarity for patients	"For me it's always clear but often we have to repeat it so that the patient can understand, at which point I project the action I want the patient to do. It would be better to add images. Because some people understand better with pictures" (Physiotherapist, female, Haiti)	
Feasibility	Feasibility	<b>Walk 50 meters:</b> "This is not always easy to observe, especially for inpatients, who are usually assessed on the ward" (Physiotherapist, female, Haiti)	



#### **4.2.2 The revised AIM-T construct validity and reliability are supported**

The AIM-T<sub>3</sub> had its construct validity and reliability supported in the studied population (Study II).

All pre-formulated hypotheses were confirmed. In particular, the AIM-T<sub>3</sub>, as structured in three subscales, reflected the hypothesized multidimensionality of independence in activities, with a better fit than the total AIM-T<sub>3</sub> as one scale. Moreover, as hypothesized, the AIM-T<sub>3</sub> was moderately correlated with pain scores ( $PCC < 0.70$ ), with an increased correlation when activity-related pain was reported. The subgroup of patients assessed within 30 days of injury had a significantly lower independence than those assessed after 30 days ( $d = 0.5$ ). On average, it took 10 minutes to administer the AIM-T<sub>3</sub> (Study II).

Regarding reliability, the evaluation showed an adequate internal consistency of the three AIM-T<sub>3</sub> subscales and a good to excellent inter-rater reliability (Study II).

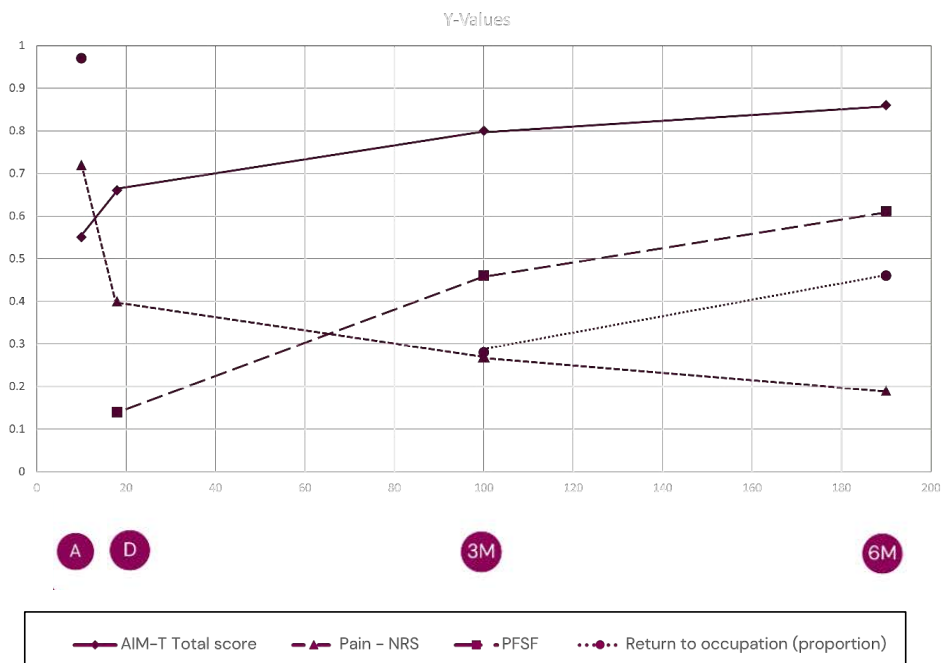
The AIM-T<sub>3</sub> and its accompanying guidance have also been adapted to include feedback from study participants. The feedback included the need for alternative equipment to be used, clarifications of some activities, and the inclusion of drawings of the 12 activities and their application in daily life situations (Studies I – II) (Supplement 4, Study II).

From here on, the AIM-T<sub>3</sub> will be named the AIM-T.

### 4.3 Patterns of recovery and associated factors

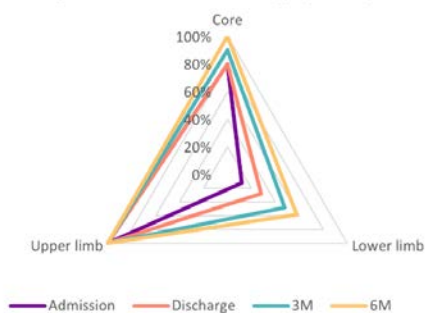
#### 4.3.1 Patients gradually recovered functioning over the first six months after injury

Out of the 554 patients included in Study III, 545 patients were assessed at hospital discharge, 477 patients at the three-month and 486 at the six-month. Three patients died during the follow-up period (0.5%), and 104 patients (19%) had an infection. The followed-up patients recovered gradually and significantly between each of the time points, being more independent (AIM-T) and reporting better ability in activities (PSFS), reporting less pain (NRS), and more patients returning to occupation ( $p<0.001$ ), as presented in Figure 14 (Study III). Regarding independence in activities, patterns of recovery for each injury category are displayed with radar charts in Figure 15.

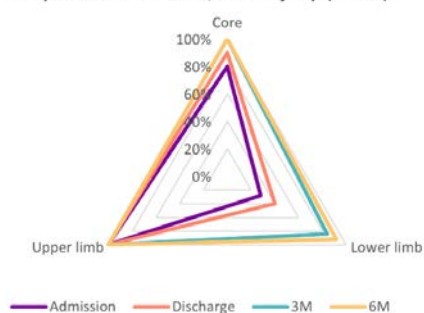


**Figure 14.** Normalized median scores of the different aspects of functioning between hospital admission and six months after injury. For return to occupation, proportions are presented. A: hospital admission; AIM-T: Activity Independence Measure-Trauma (AIM-T); D: hospital discharge; NRS: Numerical rating scale; PSFS: Patient Specific Functional Scale; 3M: three months after injury; 6M: six months after injury.

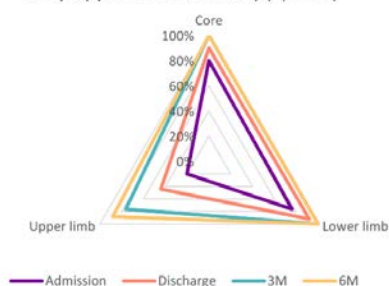
Only lower limb fracture(s) (n=194)



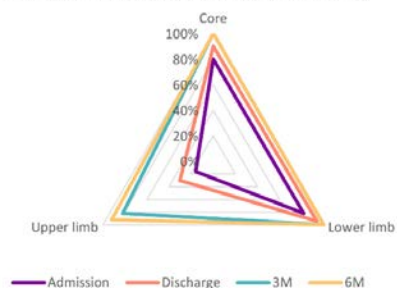
Only lower limb soft/skin injury (n=49)



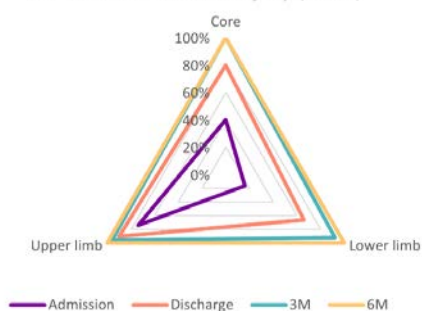
Only upper limb fracture(s) (n=53)



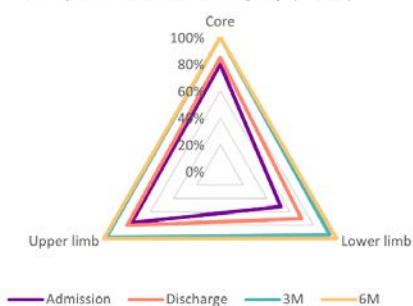
Only upper limb soft/skin injury (n=24)



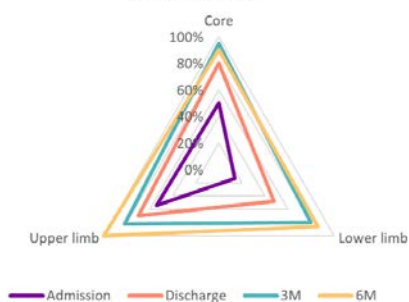
At least one visceral injury (n=44)

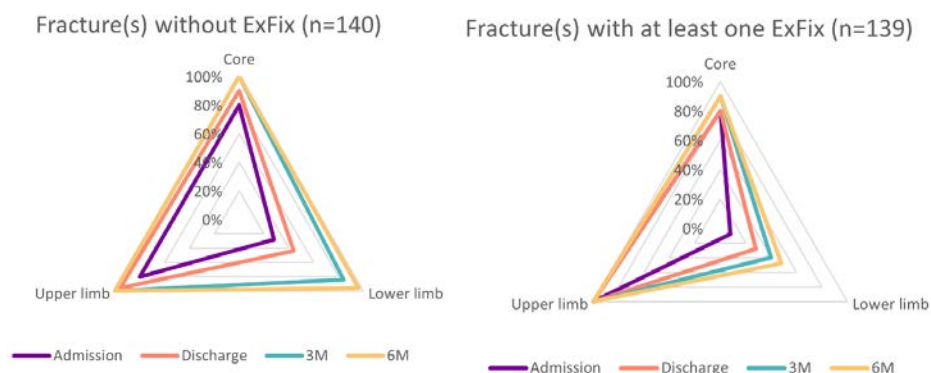


Only trunk soft/skin injury (n=24)



Others (n=12)





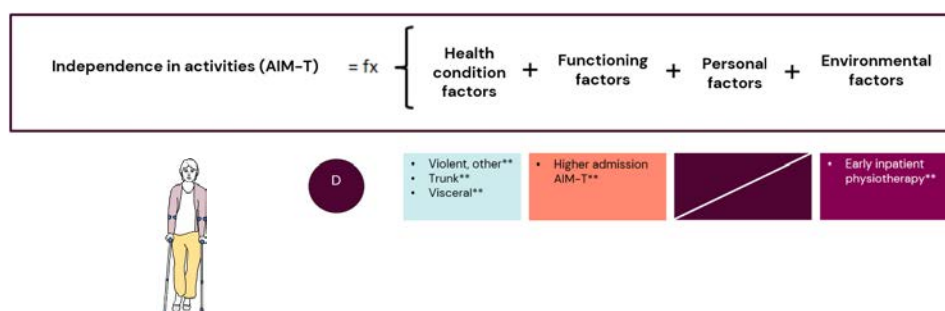
**Figure 15.** Radar charts of the AIM-T normalized median scores for different types of injury, as well as for patients with fracture(s) with or without external fixation. Each corner of the radar chart triangle represents one of the three AIM-T subscales (i.e., core, lower limb, and upper limb), where a full triangle means full independence in all three subscales. Within each triangle, data from the four time points are distinguished by color. *ExFix*: external fixation; *3M*: three months after injury; *6M*: six months after injury.

### 4.3.2 IPD recovery: dependence and pain at hospital discharge

During the IPD stay (med. 8 days (4–15)), pain decreased by a median of 3, and AIM–T total score by 5. At hospital discharge, the median NRS pain score was 4 (IQR 2–6), and 42% of patients reported moderate to severe pain. The median AIM–T total score was 41 (IQR 35–46), with 65.5% of patients not independent from human assistance in one or more of the three AIM–T subscales. Among patients who were not independent, 44% required human assistance or could not perform at all the AIM–T activity ‘climb up and down 10 steps’, and more than 15% of patients needed human assistance for core activities (i.e., ‘roll over’ and ‘sit up’), ‘stand up’ and/or ‘walk/move around 14 meters’. Overall, maximum subscale scores were reached at discharge by 29% for the core subscale, 9% for the lower limb subscale, and 53% for the upper limb subscale.

On the radar charts (Figure 15), a rapid increase in independence was visually identified for patients with visceral injury across the three AIM–T subscales. Patients with trunk injury seemed already highly independent from admission. Milder improvements in activities related to the affected body part were observed for patients with only upper or lower limb injury.

Factors significantly associated with independence from human assistance at discharge when adjusted for other covariates are summarized in Figure 16 and include higher independence at admission (AIM–T) and having received early IPD physiotherapy. Early IPD physiotherapy was provided to 62% of patients.



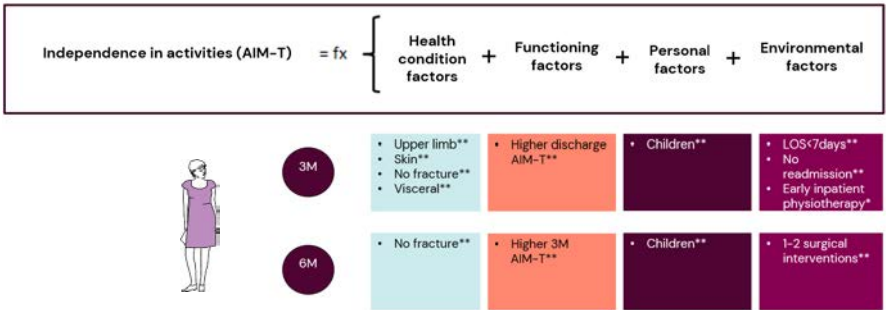
**Figure 16.** Factors significantly positively associated with independence from human assistance in activities at discharge, when adjusted for other covariates, \*\*p<0.05. [112] (adapted by permission of Oxford University Press on behalf of the BJS Society Ltd). Activity Independence Measure–Trauma (AIM–T)

4.3.3 OPD recovery: difficulties across aspects of functioning at six months

The recovery continued gradually across aspects of functioning over the OPD period. The median gain in independence in activities was numerically larger between discharge and three months, compared to between three and six months, as measured by the AIM-T total score (med. 6 vs. 3, unstandardized\_values). Regarding pain, the numerical decrease was identical during the two OPD periods (med. -1). At six months, most patients still experienced difficulties in one or several aspects of functioning. Among the 55% of patients who were considered independent at six months (AIM-T), 48 % still reported some pain, 80% reported some difficulties in performing the chosen PSFS activities and 33.5% had not returned to work. Among patients with external fixation, 23% of patients were independent at six months, 16% had returned to occupation and 29% had moderate to severe pain. At six months, 65%, 38%, and 75% reached the core, lower limb, and upper limb subscale scores, respectively.

From the radar charts (Figure 15), most patients with soft tissue and/or skin injury3had recovered independence by three months, unlike patients with fractures. Patients immobilized with an external fixation had a slower improvement over time than patients without.

After adjustment for other covariates, baseline independence (i.e., at discharge and three months) was significantly associated with independence from all assistance at three and six months, respectively, and early inpatient physiotherapy was associated with the three months independence, along with other factors summarized in Figure 17. The majority of patients received inpatient and/or outpatient physiotherapy over the six-month period (86%).

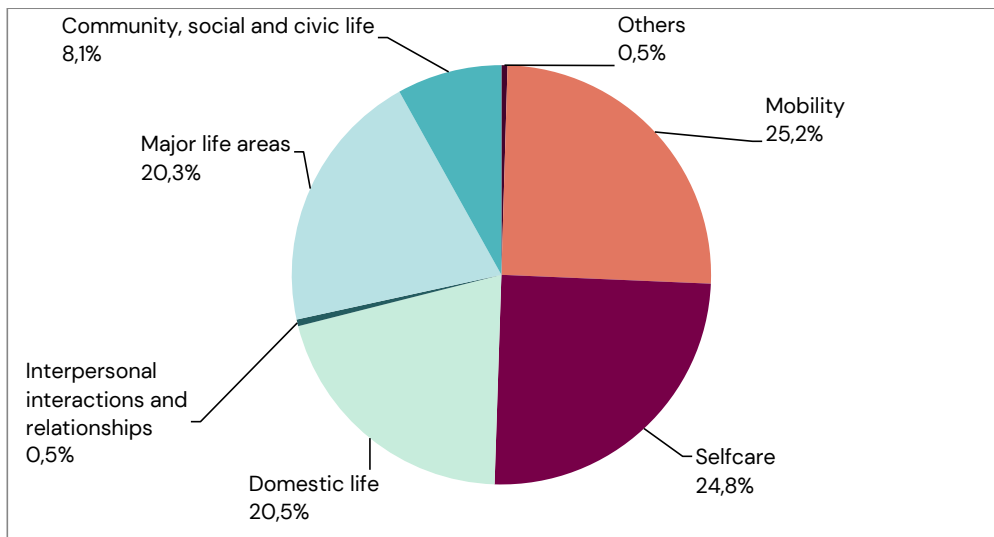


**Figure 17.** Factors significantly positively associated with independence from all assistance at three and six months after injury, \*\*p<0.05 \*p<0.1. [112] (adapted by permission of Oxford University Press on behalf of the BJS Society Ltd ). Activity Independence Measure-Trauma: AIM-T; LOS: Length of stay; 3M: three months

#### 4.3.4 Importance of participation in life situations – beyond independence in mobility activities

Using the PSFS, the self-reported performance in three activities chosen by each patient was among the aspects of functioning measured over time. The median PSFS score changed from 1 (0–2.33) at discharge to 6.33 (4–8.67) at six months. From the 1,525 activities chosen for the Patient Specific Functional Scale (PSFS), 1,928 units of information were identified and coded using the ICF.

The proportions of chosen activities are presented in Figure 18 according to the different ICF domains of functioning. ‘Remunerative employment’ was chosen the most often (n=359). Other frequently chosen activities included ‘caring for household objects and assisting others’ (n=145, e.g., construction work or agriculture), ‘recreation and leisure’ (n=145, e.g., sports), ‘driving’ (n=142; e.g., taxi driving), ‘acquisition of goods and services’ (n=137; e.g., fetching water) and ‘doing housework’ (n=66; e.g., washing and drying clothes) (Study III). The ‘body functions’ chosen by patients were related to ‘voice functions’ and ‘sensation of pain’, while ‘interpersonal interactions and relationships’ (n=10) mainly concerned ‘intimate relationships’.



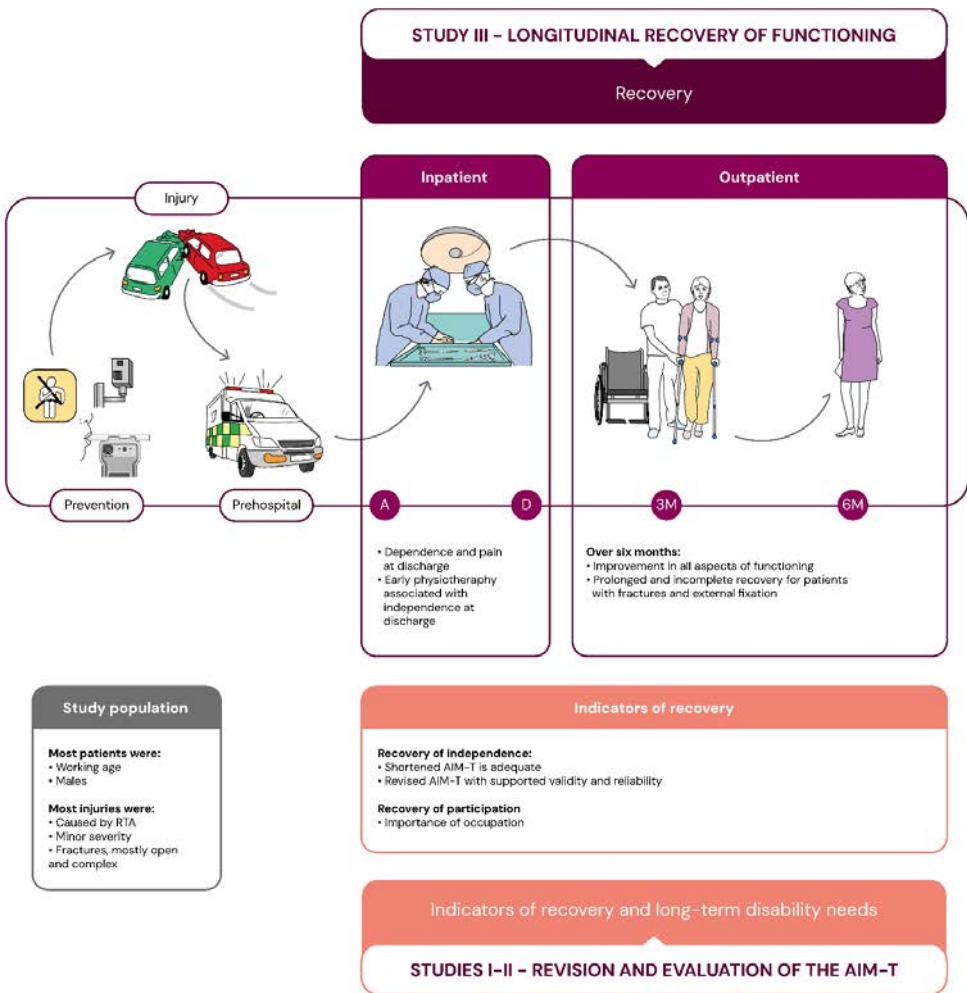
**Figure 18.** Mapping of the chosen Patient Specific Functional Scale (PSFS) activities categorized by ICF domains. ‘Others’ contains the ‘voice functions’ and ‘sensation of pain’ domains.





# 5 Discussion

## 5.1 Main findings



**Figure 19.** Overview of the main findings within the thesis framework. [112] (adapted by permission of Oxford University Press on behalf of the BJS Society Ltd).

## 5.2 Study population

*“While it is important to know why people die, it is also important to understand how they live (with their health condition)” [181]*

The patients included across the three studies mainly had injuries that threatened functioning, rather than threatening life or limbs. This contrasts with the strong focus on life and limb savings interventions in humanitarian settings. Indeed, the mortality rate over the Study III period was 0.5%, and most patients had minor injuries, as measured by NISS.

The typical patient across the three studies was a male, around 30 –years old, and with a lower limb injury. More particularly, in Study III, most injuries were extremity fractures, often open and of high –energy. Notably, among patients with fractures, the incidence of open fractures (87%) was much higher than global figures from LMICs [26]. However, high incidences were reported in studies including specific types of patients, such as military patients, patients with earthquake-related injuries, or those admitted to tertiary hospitals [92,125,221].

Road traffic accidents were the leading cause of injury across all three studies, consistent with the growing incidence of RTA injury in LMICs, including in protracted crises [25,34,35]. Falls represented a minority (5.4%), contrasting with global estimates and most other cohorts from LMICs [23,25–27].

The differences in study population observed here, compared to most studies conducted in LMICs, might be explained by multiple and interconnected factors, including the protracted and violent nature of the crises, as well as the MSF health facilities inclusion criteria and free trauma care provision. However, the recent longitudinal studies conducted in LMICs and especially those focusing only on patients with open lower limb fractures resemble Study III population the most in terms of age, sex, and injury causes, and are therefore useful comparisons in terms of expected recovery [83,87,88].

### 5.3 Indicators of recovery

*“What is not defined, cannot be measured; what is not measured cannot be improved”  
(William Thomson Kelvin)*

#### 5.3.1 The AIM-T, as measure of recovery of independence in activities

In this thesis, the AIM-T was shown to be an adequate, valid, and reliable reflection of independence in activities for patients after orthopedic, visceral, and/or skin injury in the studied humanitarian settings. It thus has the potential to serve as an indicator of recovery and inform trauma care interventions. However, beyond scientific acceptability (i.e., validity and reliability), interpretability, feasibility, and relevance are key criteria for the uptake of such indicators [162,169,222].

Interpretability is ‘the degree to which one can assign qualitative meaning (that is, clinical or commonly understood connotations) to a measure’s quantitative scores or change in scores’ [173]. The dichotomization of the AIM-T used in Study III yields a clinically meaningful indicator of recovery, where a certain level of independence from assistance had to be reached in all three AIM-T subscales for the patient to be considered independent. This dichotomization was informed by the confirmed AIM-T structure in three subscales in Study II and differs from others where thresholds are defined statistically or clinically considering functioning as a unidimensional construct or using single tasks as proxies (e.g., independence in walking) [223–226]. Studies II and III also provide, for the first time, reference values for relevant subgroups, which is useful for future comparisons and benchmarking. However, half of the overall Study III cohort reached maximum scores in the upper limb subscale at hospital discharge: this may have limited the capacity to capture further improvements, similar to reports from other generic measurements, such as Patient-Reported Outcomes Measurement Information system physical function (PROMIS-PF) and FIM [113,227,228]. Nevertheless, floor and ceiling effects are not problematic when in line with the expected level of independence of the studied population at a given time point [175]. Indeed, the score distribution of a measure reflects the study population, as well as the expected patterns of recovery [65,229,230]. In Study III, the study population was composed mostly of patients with lower limb injuries, expected to be independent in upper limb activities at discharge, while patients with upper limb injuries have usually a faster recovery [55].

The AIM-T feasibility and relevance have been evaluated and supported as part of the revision process in Study I. The feasibility of the AIM-T for research purposes was also

supported by its relatively short administration time in Study II and is further enhanced by its open access and available e-learning materials produced during Study III. Most trauma registers in HICs favor patient-reported outcome measures (PROMs), and some authors questioned the feasibility of the routine inclusion of observed measures, such as the AIM-T [50,56,226]. However, an observed measure may be more feasible and valid in settings with low literacy rates, where the use of PROMs has known shortcomings that potentially compromise cross-cultural validity [104,163,205].

Moreover, having a measure that is part of the clinical practice, and is thus not seen as an additional task, is central to minimizing the burden of data collection and thus enhancing its uptake in humanitarian settings [162,163,231]. The added value of using such observed and clinically relevant measures of independence has been underlined previously in HICs [231–233]. The clinical relevance of the AIM-T items was expressed by some participants in Study I. However, the relevance for clinical practice was not specifically evaluated within this thesis and would require specific investigation.

### **5.3.2 Measuring recovery beyond independence**

When given the opportunity to choose important activities (PSFS), patients selected activities covering different domains of functioning. Half of the activities were mobility and self-care activities, and the other half were a variety of life situations, dominated by occupation-related activities, as well as activities related to fulfilment of basic needs (e.g. fetching water). These results illustrate that patients valued both the recovery of independence, as well as of full participation [52,93]. Moreover, the selected activities match the majority of the ‘activity and participation’ items identified in the preliminary ICF trauma core set [182]. In contrast, the social aspects of recovery were seldomly selected, unlike in other reports on patients’ priorities and concerns [94,234,235]. The way the PSFS is phrased, prompting to choose ‘activities’ may not have evoked social roles and relationships for the participants.

## 5.4 Recovery along the first six months after injury

### 5.4.1 Safely discharged home?

*'Coming home does not mean that the injury has gone'* [235]

Across the four studied health facilities in Study III, most patients were discharged while still needing assistance from another person for one or several mobility activities, including basic activities (i.e., bed transfers, stairs, walking short distances). In other studies, independence in these activities has been identified as key for safe discharge home and as a factor associated with discharge destination [38,236]. However, in LMICs, and more specifically in humanitarian settings, the hospital structure is often strained, and hospital discharge might therefore happen earlier than desired, and mostly to home [106,134,237]. While the length of stay might not be easily modifiable in such settings, the patient's level of functioning at discharge does inform on the burden of care for the patient's relatives, as well as the potential risk of complications, and could thus inform follow-up care [103,106,238]. Moreover, consistent with the association between discharge and three-month independence in Study III, independence in mobility activities at discharge is reported to predict longer-term outcomes in some studies and has been reported to be amenable to interventions [110,239,240].

### 5.4.2 Moving early towards recovery

*'No rest for the wounded'* [122]

In Study III, patients receiving early inpatient physiotherapy (i.e., within 48h of admission) were more likely to be independent at discharge and three months, after adjusting for potential confounders. Study III was observational, and no causality can be implied. Nevertheless, results are consistent with those from other studies, including randomized control trials, where early physiotherapy accelerated recovery, by improving short-term outcomes (e.g., at hospital discharge or up to three months), though often no differences were identified when outcomes were measured later [113,114,120,239]. Even though these studies compared different types of interventions (e.g., strengthening, weight-bearing, ambulation), one common thread associated with the effectiveness of early physiotherapy is early mobilization, emphasizing the importance of progressive active exercises and getting out of bed, and this, beyond the timing of physiotherapy alone. Some authors highlighted that the difficulty of clearly differentiating the intervention from "usual care" may have prevented the identification of significant effects of early

physiotherapy [113,114]. However, in the studied settings, delayed or no physiotherapy may correspond to bedrest during the first days, in contrast to other studies, where the control arm would be much more active [126,134]. This implies that our study might have had a larger contrast in exposed versus unexposed, as opposed to the other studies.

Two out of three patients received early inpatient physiotherapy in Study III, similar to or greater than other reports from HICs, adhering to current recommendations [46,241–244]. This high coverage however contrasts with the very low proportion of patients receiving inpatient physiotherapy, as reported in health facilities located in other LMICs [133,136,245]. In addition to patient characteristics, this discrepancy might be explained by organizational barriers reported in other LMICs. These barriers include the limited available rehabilitation workforce and the lack of awareness of the HCPs towards early physiotherapy and prescribed restriction, such as delayed ambulation and weight-bearing, though these barriers were not explored here [126–128,132–134,246].

#### **5.4.3 Being independent is not enough**

*'Life is at a standstill'* [94]

Across all patients, 55% were independent from all assistance in performing mobility activities at six months. Even though the recovery of mobility is viewed as central in the recovery process, the fulfilment of social roles is also a major concern [93]. In Study III, even when independent from all assistance, one-third of the patients had still not resumed occupation at six months. This low return to occupation is similar to or higher than other studies in LMICs and is known to be largely influenced by environmental factors as well as personal factors, such as type of occupation [247,248]. Three-quarters of the Study III patients were engaged in manual activity prior to injury, including physically demanding activities such as farming and construction, which is often predictive of a more difficult return to occupation [59,249]. Moreover, our cohort was composed of 83% males, who are often the main breadwinners in similar settings, which has potential long-term socio-economic consequences for the patient and his family [91,93,94,247]. In a study conducted in Haiti among patients with complex limb injuries caused by the 2010 earthquake, 46% of patients reported not having enough food, and 23% still living in temporary shelters, two years after their injury [92]. While these unmet needs may not be solely attributable to the injury, they do reflect some of the challenges faced by patients,

also experiencing physical barriers in their environment, such as hilly terrain or distances to fetch water [94].

More specifically, as opposed to the rapid inpatient recovery of most patients with visceral and trunk injury, patients with limb fractures, and particularly those immobilized with an external fixation, experienced a prolonged and incomplete recovery. This is consistent with the delayed recovery reported across different studies on patients with complex and/or open lower limb fractures, with continued and slow improvements up to three years after injury [83,249–252]. Most of the Study III patients were healthy and reported no difficulties in functioning before the injury, suggesting that this subgroup of patients has mostly not recovered their baseline functioning and may need to adapt to a new baseline [37]. This is in contrast with the low availability of rehabilitation services along the continuum in these settings, and the short-term view of most trauma care interventions in humanitarian settings [106].

Overall, acute and prolonged difficulties have been observed up to six months after injury in highly challenging settings. These difficulties illustrate the need for early as well as prolonged multidisciplinary rehabilitation as part of trauma care, including occupational rehabilitation and pain management, to support the patients living, not just surviving.

## **5.5 Methodological considerations**

### **5.5.1 Studied health facilities**

This thesis only includes data from patients admitted to MSF-managed or -supported health facilities, strengthening the internal validity of the results by guaranteeing a similar level of quality of trauma care and a structured routine data collection system.

However, this may also have introduced a selection bias, as the included patients might not be representative of patients admitted at other public or private health facilities, nor the overall trauma population in a given setting. MSF health facilities have specific inclusion criteria and refer some patients to other facilities, such as patients after central neurologic system injury; the MSF health facility is therefore one facility among others [83,88]. Besides, trauma care was free at the MSF health facilities, influencing the access to care [91].

### **5.5.2 Observational study design**

All three studies had an observational design. This ensured real-life data, documenting routine practice, without intervening with choices made by patients or HCPs. However, these uncontrolled conditions may somehow bias data, and cannot be adjusted for. Besides, at health facility level, several changes may have influenced the provision of trauma care during the data collection, such as the closing of the Arche project in April 2021, preceded by months of phasing out; the withdrawal of MSF from Maroua regional hospital in January 2021, leading to the end of the free of charge care; or the merging between the burn and trauma projects in Tabarre, mutualizing resources from February 2021.

### **5.5.3 Heterogenous settings and population**

The inclusion of health facilities located in humanitarian settings across different world regions contributed to the generalizability of results and allowed access to otherwise 'hard to reach' populations [220]. Though acknowledging the diversity within and between these settings, data were pooled across settings for sample size concerns and assuming thereby a certain homogeneity. In Study III, the variable 'setting' was added to the model to adjust for setting specific variables not accounted for. However, this is a lump variable, from which no conclusion can be drawn. To identify and understand further differences between settings, more investigations are needed.

The patient inclusion criteria were kept relatively wide to reflect as much as possible the heterogeneity of the trauma population, increasing the generalizability of the findings [253]. The composition of the studied population influences the measure's validity and reliability in any evaluation of measurement properties. Validity and reliability evaluated here are therefore specific to the studied population. The heterogeneity of patients may also have influenced the association of trauma care factors, as the categories might not apply adequately to all (e.g., the definition of early vs. late outpatient physiotherapy). Moreover, children above five years of age were included, as these patients typically represent one-third of the trauma population in similar settings, and more research including children after injury has been called for [33,36,254]. However, the cohort in Study III was only composed of 10% children, preventing any sub-analysis. The regression model was adjusted for age, in the semi-adjusted and fully adjusted models, considering age as a factor potentially strongly associated with independence, which was confirmed at three and six months.



Across the three studies, data has been collected in several languages, and translated to English for data analysis, sometimes with an intermediary translation in French. This has created risks for translation and interpretation bias [255]. None of the studies were qualitative, reducing the room for interpretation. However, even when using quantitative data collection, the translation of each individual question could carry variations across the different languages, especially for latent constructs such as ‘independence’ used in the introductory question in Study I, or ‘activities’, used in the PSFS in Study III. As mitigation, the questionnaires were translated into local languages, and back-translated for proofreading. However, the four languages are rather oral languages, with a different scope in the vocabulary used. The research officers most often had to explain and clarify the concepts, which potentially introduced measurement bias. Beyond the language itself, rating items using a scale is not always well understood in settings with low literacy rates and less exposure to numerical scales [205]. Some authors have suggested the use of verbal scales, describing each scoring level and/or dividing the scale into meaningful parts, which is what the research officers did spontaneously, especially for the pain NRS. With observed measures, such as the AIM-T, such measurement and translation bias may be reduced as the scoring is based on specific criteria to be observed by the HCPs, while the patient is performing defined tasks that are illustrated with drawings.

#### **5.5.4 AIM-T development, revision, and evaluation**

Evaluating a measure that was developed under the PI’s supervision was not straightforward and carried risks of confirmation bias. The main risks were in the analysis, especially in Study I, where AIM-T revisions needed to be decided on using the study results. However, having set pre-formulated objective criteria, as advised by COSMIN, helped to mitigate these biases throughout Studies I and II, as well as co-authors and supervisors safeguarding. Moreover, data was collected by other people with whom there was no hierarchical link. Nevertheless, the PI was responsible for the training of persons who knew of the PI’s involvement in the AIM-T development, which may have influenced how the data was collected, especially when evaluating the AIM-T adequacy.

As mentioned above, the use of the COSMIN framework supported a rigorous methodology throughout the Studies I-II. However, some development steps were adapted to fit with available time and resources. For Study II, no gold standards for the performance of independence in mobility activities after injury were identified, thereby

preventing the evaluation of criterion validity. Instead, the construct validity was assessed, as advised by COSMIN for other measures of functioning [175].

For Study III, the AIM-T was used as the primary outcome for the logistic regression once its validity and reliability were supported by Study II, without having tested its responsiveness. Given the longitudinal design necessary to evaluate responsiveness and therefore time and resources required, it was decided to evaluate responsiveness while conducting Study III. Some indications were however inferred from Study II, where the AIM-T's ability to discriminate patients with acute versus post-acute injury was supported, even though it was not an assessment of change over time. Moreover, the AIM-T had been revised and evaluated with similar patients, in similar settings and within the same timeframe (i.e., within six months of injury) in Studies I-II. The ceiling effects identified and discussed above could however indicate that the AIM-T might lack responsiveness for some subgroups of patients, requiring further investigation.

#### **5.5.5 Recovery timeline and rehabilitation**

In Study III, the timeline of six months was chosen primarily based on the research question focusing on independence in activities, expected to be mostly recovered in six months. Moreover, given the volatile settings in which the data was collected, a timeframe beyond six months was not considered realistic, based on the challenges experienced by the HCPs for routine follow-ups. For the same reasons, a limited number of follow-up time points were chosen (i.e., three and six months), while intermediary time points would have allowed a more nuanced understanding of the patterns of recovery, especially between discharge and three months.

### **5.6 Helicopter research in humanitarian settings?**

This thesis includes research conducted in several humanitarian settings. Data collected by NGOs in humanitarian settings most often include data on hard-to-reach populations, whose information on recovery might not have been documented otherwise – thereby addressing a gap [21,220]. However, conducting such research as a principal investigator not coming from nor living in these settings, and involving three organizations based in Europe, comes with limitations and risks. Research dumping, also termed 'helicopter research', has been increasingly denounced, calling for more equity in research conducted in LMICs [256].

Throughout this research project, continuous and purposeful efforts have been made to avoid this practice. Healthcare professionals, including academics, based in each of the settings have been involved in the different steps of the research project. In particular, the research questions were based on needs identified at a local level, driven by local priorities. Indeed, the lack of systematic and timely integration of rehabilitation within trauma care is present in most humanitarian settings and has been expressed by the local healthcare professionals across the different studied settings. The same persons were then involved in the study design, including in the identification of variables most relevant to include, supervision of the data collection as well as in the interpretation of results and manuscript revision. Results have also been shared with local actors not directly involved in the research project, such as representatives of national physiotherapist associations and Ministries of Health, which allowed a broader perspective and related to ongoing national initiatives. Moreover, through the consistent involvement of local healthcare professionals throughout the research project, the research skills of those persons have been enhanced.

Providing healthcare in another setting requires cultural competencies, and so does research implementation [257]. Indeed, there are cultural risks related to cultural differences, such as differences in health beliefs and practices. These risks have been mitigated to an extent by the implication of local healthcare professionals, even though this is a continuous learning exercise.

## **5.7 Implications, and future studies**

Most patients studied throughout this thesis had prolonged difficulties across different aspects of functioning. This increased understanding of patient needs during the first six months after injury in several humanitarian settings provides information that can be used to adapt trauma care interventions accordingly. However, the following implications highly depend on the specific setting, including available resources (e.g. rehabilitation workforce, existing national strategy, health beliefs, and education of trauma care professionals), which will drive priorities [246,258].

### **5.7.1 Policy and practice**

The AIM-T, by providing quality information on the independence in activities, could be considered as an indicator of recovery for quality of trauma care monitoring in low-resourced and humanitarian settings. Study III also illustrated the complementarity of

standardized and patient-specific measures of activities and participation in providing information on recovery of functioning. This highlights the importance of assessing patients beyond independence in activities, and incorporating tailored treatment goals that are oriented towards participation in meaningful life situations [96]. Moreover, the knowledge on factors associated with independence eases the interpretation of the AIM-T scores at an individual but also at a group level, such as for benchmarking of different health facilities [112].

In humanitarian settings, the discharge destination after acute trauma care is mostly home, where daily life activities are often highly physically demanding [106,134]. Independence in activities at discharge is therefore valuable to consider when planning discharge, along with physical and social environmental factors [259,260]. The importance of education on self-management, and of clear communication on follow-up during discharge planning is further emphasized by the prolonged needs of some patients and potential barriers to outpatient rehabilitation [106,132,238,261].

Additionally, a fast recovery is a real stake in low-resourced settings where injuries can have dramatic socio-economic consequences [77,91]. In Study III, the significant association of early inpatient physiotherapy with an earlier recovery was consistent with the landmark WHA resolution 76.6 on 'Strengthening rehabilitation in health systems' urging member states to integrate rehabilitation timely in humanitarian settings, i.e., from the onset of the patient's pathway, the onset of a trauma care intervention, the onset of a crisis, but also in preparedness plans [143,150,262]. However, such timely integration of rehabilitation requires allocation of dedicated rehabilitation resources in acute care, a common understanding of the role of early rehabilitation by all healthcare professionals to foster a multidisciplinary approach, and information on patients and communities based on knowledge generated locally. Moreover, the implementation of targeted and multidisciplinary models of trauma care that promote early rehabilitation and coordination may be of value to evaluate in the future, using pre/post study design and cost-effectiveness as done by others [110].

Road traffic accidents were the leading cause of injury across the three studies, consistent with other studies in LMICs, including in humanitarian settings [34,263]. Even though the proportion of violent injuries is most often higher in humanitarian settings, it does not represent the totality of the study population. While not the focus of this thesis,

prevention is part of the trauma care interventions and law enforcement has shown effective in other settings [264].

### **5.7.2 Future research**

Validity and reliability are not fixed properties of a measure and depend on the studied sample [265]. Further evaluation of these properties in other settings and/or with other types of patients could provide additional information on the AIM-T to researchers and practitioners. Besides, the evaluation of cross-cultural validity and responsiveness is particularly needed.

Additionally, the effects of using the AIM-T in practice have not been studied yet and could inform on its relevance in enhancing the rehabilitation care delivery. For instance, its contribution to early mobilization, multidisciplinary coordination, and/or identification of treatment goals could be assessed.

The activities chosen by patients as part of the PSFS were diverse and the PSFS scores used in analysis were averages. Further analyses of patterns of recovery of specific ICF domains could inform on the use of the PSFS in future research, but also provide complementary information on the recovery itself.

The population studied here was heterogeneous, which was essential to have a representative overview of the patients' needs. However, further studies in more specific subgroups, such as patients with lower limb fractures, could allow a more tailored study design and identification of more specific beneficial interventions.

This thesis only included quantitative studies, limiting the wider understanding of recovery. More specifically, quality of life, social roles, and mental health are aspects of functioning particularly difficult to capture through standardized measures. Qualitative studies would not only provide information on the recovery itself but also on how these constructs are understood by the patients in humanitarian settings and how to best measure them.

Only the timing of physiotherapy was described and included as a potential associated factor of independence in Study III. However, other aspects of physiotherapy provision might influence the outcomes, such as the intensity, the type of interventions, the

patient's adherence, and the multidisciplinary environment in which it is provided [110,113,242,266]. Moreover, a description of the provision of other rehabilitation interventions with known benefits after acute injuries, such as occupational therapy and psychosocial support, would complement the present findings.

In addition, gaining more information on which patients tend to receive inpatient and/or outpatient physiotherapy after injury in humanitarian settings could inform referral processes. The adequacy between needs and provision, as well as the barriers and facilitators, would be worth investigating to improve the integration of physiotherapy within trauma care.

Similar longitudinal studies in more diverse health facilities are needed to support the findings of this thesis, given that all studies were conducted within health facilities run or supported by an international NGO.

## 6 Conclusions

This thesis included data collected across different humanitarian settings, including a longitudinal study. It highlights the feasibility of conducting quality research in such complex settings, thus providing information generated from these settings.

More specifically, the conclusions are:

- The AIM-T was considered by patients and HCPs an adequate measure for the assessment of independence in activities after acute injury (Study I), and its validity and reliability were supported in the studied settings (Study II). Some specific properties require further investigation, including responsiveness, cross-cultural validity, and interpretability.
- Patients improved in all studied aspects of functioning, including independence in activities, over the six first months after injury (Study III). Most patients were discharged from hospital while still dependent on human assistance and with moderate to severe pain. In particular, patients with fractures managed by external fixation had prolonged difficulties in functioning (Study III).
- Independence in activities was significantly associated with factors related to health conditions (i.e., location and type of injury), activity and participation (i.e., baseline independence in activities), personal (i.e. age), and environmental (i.e. processes of health care services) factors. Early inpatient physiotherapy was associated with independence at hospital discharge and three months post-injury when adjusted for other covariates (Study III). However, no causality can be inferred given the observational study design.

This thesis offers insight into the recovery of functioning following injury in patients from usually underreported populations. However, the generalizability of these findings remains challenging as all patients were admitted to healthcare facilities supported or run by an international NGO, subject to specific inclusion criteria, and provided with free trauma care, as well as well-resourced physiotherapy.





## 7 Acknowledgements

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