

**MÅNS MUHRBECK**

DEVELOPMENT DISSERTATION BRIEF

**2022:04**

# **SURGERY IN ARMED CONFLICTS: PREDICTING SURGICAL TREATMENT NEEDS AND IMPROVING RESOURCE USE IN RESOURCE-CONSTRAINED SETTINGS**



# Surgery in Armed Conflicts: Predicting Surgical Treatment Needs and Improving Resource Use in Resource- Constrained Settings

Måns Muhrbeck

Development Dissertation Brief, 2022:04  
to  
The Expert Group for Aid Studies (EBA)

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This brief is based on Måns' PhD thesis *Surgery in Armed Conflicts* (No 1791) and intends to emphasize findings of relevance to Swedish development assistance. The thesis was defended at Linköping University on the 3<sup>rd</sup> of December 2021. Principal supervisor was associate professor Peter Andersson MD, PhD.

The thesis is available here:

<https://www.diva-portal.org/smash/get/diva2:1607406/FULLTEXT01.pdf>

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## Sammanfattning

Väpnade konflikter leder till kollaps av existerande sjukvårdssystem, vilket snabbt begränsar möjligheten till kirurgisk behandling för patienter med potentiellt livshotande skador. Det är därför av stor vikt att förstå hur kirurgiska resurser används och kan förbättras i resursknappa konfliktmiljöer. För detta syfte inhämtades journaluppgifter från patienter med vapen-orsakade skador som behandlats vid tre Internationella Rödakorskommittén-sjukhus. Skillnader i skademekanismer, behandling mellan kön och över tid analyserades samt möjligheten att förutsäga det kirurgiska resursbehovet. De flesta patienterna var män i tjugoårsåldern med skador på armar eller ben. Behandling av mjukdelsskador var den vanligaste typen av kirurgi. Mindre än 20 % av patienterna genomgick större operationer och dödligheten under sjukhusvistelsen var mindre än 5 %. Användandet av frakturstabiliserande åtgärder och hudtransplantationer har minskat under de senaste årtiondena, medan risken för amputation var oförändrad. Kvinnor skadades i större omfattning av urskillningslösa vapen, hade allvarligare skador, fick oftare blodtransfusioner och behandlades med mer omfattande kirurgi än männen. Röda Korsets skadepoängssystem (RCWS) var bättre på att förutsäga kirurgisk resursförbrukning än poängsystem som används i civil traumasjukvård.

**Relevans för svensk biståndsverksamhet:** Kirurgisk behandlingen av skador i väpnade konflikter är beroende av fungerande sjukvårdssystem. Svensk biståndsverksamhet bör därför engagera sig i projekt som:

- Syftar till att skapa robusta sjukvårdssystem, särskilt vad beträffar kirurgisk och anesthesiologisk kapacitet, i länder där det finns risk att väpnad konflikt uppstår.
- Syftar till att etablera ett universellt kvalitetsregister för behandling av skadade i väpnade konflikter.

## Abstract

In armed conflicts, civilian healthcare struggles to cope with limited or no surgical resources. Understanding the relationship between demographics, injury mechanism, and injury patterns to predict what resources are needed is therefore vital. To explore this, medical records were obtained from patients with weapon-related wounds, treated at three International Committee of the Red Cross (ICRC) hospitals. Differences in injury mechanisms, injury patterns, and treatments between the sexes and over time were analysed, as well as the possibility of predicting surgical resource consumption. At these hospitals, most patients were men in their twenties with injuries to their arms or legs. Treatment of soft tissue injuries was the most common surgery type. Less than 20% of patients underwent major surgery and mortality during hospital stay was less than 5%. The use of fracture stabilization measures and skin grafts has decreased in recent decades, while the risk of amputation has remained unchanged. Women were injured to a greater extent by indiscriminate weapons, had more serious injuries, received blood transfusions more often, and were treated with more extensive surgery than men. The descriptive Red Cross Wound Score (RCWS) was better at predicting surgical resource consumption than scoring systems used in civilian trauma care.

**Implications for Swedish development assistance:** Surgical treatment of injuries in armed conflicts is dependent on resilient healthcare systems. Swedish development assistance should therefore focus on projects that:

- Aim to improve the resilience of healthcare systems, particularly regarding surgical and anesthesia capacity, in countries that are at risk of being engaged in armed conflicts.
- Aim to establish a universal quality and outcome register for treatment of conflict-related injuries.



## List of Papers

This brief is based on the author's thesis, which included the following original articles, referred to in the brief by their Roman numerals. Article IV is not included in the brief as it was considered to be beyond the scope for the topic of the brief.

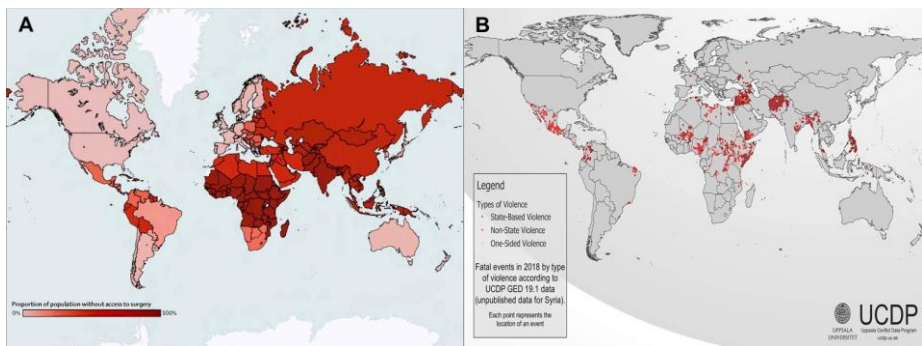
- I. Peter Andersson, Måns Muhrbeck, Harald Veen, Zaher Osman and Johan von Schreeb. **Hospital Workload for Weapon-Wounded Females Treated by the International Committee of the Red Cross: More Work Needed than for Males.**  
*World Journal of Surgery* (2018) **42**(1): 93–98.
- II. Måns Muhrbeck, Kaspar Holmgren, Zaher Osman, Johan von Schreeb, Andreas Wladis and Peter Andersson. **Trends in Demographics and Surgical Treatment of Weapon-Related Limb Injuries Over Two Decades in a Resource-Scarce Setting.**  
*World Journal of Surgery* (2019) **43**(11): 2681–2688.
- III. Måns Muhrbeck, Zaher Osman, Johan von Schreeb, Andreas Wladis and Peter Andersson. **Predicting surgical resource consumption and in-hospital mortality in resource-scarce conflict settings: a retrospective study.**  
*BMC Emergency Medicine* (2021) **21**: 94.
- IV. Måns Muhrbeck, Maria Lampi, Andreas Wladis, Peter Andersson and Johan Junker. **Efficacy of Topical Honey Compared to Systemic Gentamicin for Treatment of Infected War Wounds: A Non-inferiority Pilot Study.**  
*Injury* (2022) **53**(2):381–392.

## Background

### Access to Surgical Care in Armed Conflicts

The onset of an armed conflict can rapidly diminish the capabilities of vital societal structures, such as access to medical care, infrastructure, the justice system, the monetary system, and trade (Leaning and Guha-Sapir, 2013). Furthermore, many of the current conflicts are located in areas and countries where these structures were fragile even before the onset of the armed conflict (Geiß, 2009). It is therefore not surprising to find that many of the countries where access to surgery is poor also are involved in an ongoing armed conflict (Figure 1) (UCDP, 2019; Murray et al., 2012; Alkire et al., 2015).

Figure 1: A: Global distribution of access to surgery for civilians, B: Ongoing armed conflicts in 2018



Sources: **A:** Alkire et al., 2015. Reproduced with permission from Paul Farmer and under the terms of CC BY 4.0. **B:** UCDP, 2019. Reproduced with permission from the Uppsala Conflict Data Program (date of retrieval: 15 October 2019).

Surgical care providers in these low-resource settings not only have to handle the inflow of patients generated by the conflict, but also conditions that are not conflict-related that require surgical treatment, such as incarcerated hernias, obstructed labor, traumas, and burns (Backstrom et al., 2020). Furthermore, elective cases will build up over time as demonstrated by Johan von Schreeb et al. in a conceptual model of the need for hospital resources following sudden-onset disasters (von Schreeb et al., 2008). For healthcare providers planning on delivering healthcare in an armed conflict, these issues need to be taken into consideration.

## **Epidemiology of Civilians Injured in Armed Conflicts**

Several reports have been published describing when and how civilians are injured in armed conflicts (Jeffrey, 1996; Rautio and Paavolainen, 1988; Hinsley et al., 2005). However, most of these reports have limitations in their methodologies, as they are based on data from a single treatment facility, retrospectively collected data, inconsistently defined variables, or treatment needs in relation to gender are not explored. These limitations are effectively inhibiting the possibility to conduct objective comparisons. Moreover, given the insufficient infrastructure and access to healthcare in conflicts, it is reasonable to assume that these reports rarely provide the complete epidemiological picture. Nonetheless, similar findings have been reported from different conflicts. This may be best summarized in a review article by Wild et al. in 2020, where 58,578 patients from 49 contemporary and recent armed conflicts in 18 countries were analysed (Wild et al., 2020). The patients consisted of civilians and local combatants. A majority of these patients were male (79%, range 73–87%) with a median age of 26 years (IQR 22.8–27.6 years). A substantial portion were under 18 years (35%, range 17–38%). The mechanism of injury varied depending on whether the conflict took place in an urban area or not. In urban conflicts,

gunshot wounds (GSW) constituted 42%, and blasts from missiles, bombs, and explosives constituted 19% of the mechanism of injury. Conversely, in conflicts primarily located in rural areas, the reversed relationship was seen, GSW 9% and blast 70%. Injuries to the extremities were the most frequent (34%, range 20–40%). The frequency of thoracic and abdominopelvic injuries was low (10%, range 4–17% and 8%, range 2–12%, respectively), even though blasts and other indiscriminate weapons caused a substantial portion of all injuries treated. This, together with the low in-hospital mortality observed (6%, range 2–16%), could indicate a survivorship bias, where those with life-threatening injuries, such as thoracic injuries, die before reaching the hospital (Wild et al., 2020). However, it is difficult to confirm this assumption given the lack of available data on how many lose their lives at the injury site.

### **Surgical Resource Consumption**

“War surgery is the management of an epidemic of trauma.”  
(Nikolai Ivanovich Pirogov, 1810–1881, Russian anatomist and surgeon)

Surgical workload, i.e. surgical resource consumption, in armed conflicts is often discussed in terms of the number and type of surgical procedures, amputations, use of blood products, and mortality (Gertsch, 1987; Coupland and Korver, 1991; Ramalingam, 2004; Hinsley et al., 2005; Giannou et al., 2019). The International Committee of the Red Cross (ICRC) War Surgery textbook defines surgical workload as the number of operations and blood transfusions per patient and the length of hospital stay (Giannou et al., 2019). Whether these variables best reflect surgical resource consumption is of course debatable. However, to my knowledge, there is currently no universally accepted definition of what surgical resource consumption should entail. This is not surprising as the definition could vary depending on the context and available resources (Figure 2).

Figure 2: Total amount of surgical equipment, medications, and operation theatre available at a first-level hospital in Pool-region, the Democratic Republic of the Congo during 2005–2006



Photos by author.

Nonetheless, much would be gained if context-specific surgical resource consumption could be assessed, especially in resource-constrained settings. This would facilitate planning and monitoring of surgical care and enable comparisons of treatment outcomes between hospitals. Trauma scores (e.g., Revised Trauma Score (RTS), Kampala Trauma Score (KTS) and Injury Severity Score (ISS)) used in non-conflict settings could potentially be used for this purpose. Studies on trauma patients, mostly from high-resource settings, have demonstrated that trauma scores intended to be used for mortality predictions also can be used to predict resource-related outcomes, such as the need for admission and surgical intervention, massive haemorrhage, and prolonged intensive care (ICU) stay (Emerman et al., 1991; Raux et al., 2011; Azad et al., 2020). However, the predictive abilities for these trauma scores could be diminished in armed conflicts due to the survivorship bias previously discussed. Furthermore, injury patterns in armed conflicts are different from those seen in civilian traumas. Penetrating injuries are more prevalent in conflicts, whereas blunt injuries are more frequent in civilian traumas (Søreide, 2009; Wild et al., 2020). It is therefore reasonable to question the predictive abilities of trauma scores when applied in the context of armed conflicts.

## **Red Cross Wound Score**

In the early 1990s, Mr. Robin Coupland, at the time Chief surgeon for ICRC, devised a system for classifying penetrating wounds, the Red Cross Wound Score (RCWS). RCWS was intended as a descriptive tool to facilitate triage and the surgical management of wounds in armed conflicts (Coupland, 1992; Giannou et al., 2019). To classify a wound according to RCWS, the extent of the wound (RCWS grade) and type of tissue involved (RCWS type) is assessed through visual inspection and, if needed, x-ray and assigned to one of twelve different categories. The grade component corresponds to the energy transfer to the tissue at the time of injury (Giannou et al., 2019; Coupland, 1992).

The use of RCWS as a predictive tool for resource-related outcomes and mortality is poorly examined. However, there are compelling reasons to study if such a relationship does exist. The RCWS is a robust classification system that does not rely on advanced diagnostic equipment or calculation, making it suitable for use in trauma care and especially in resource-constrained settings. Similar to the Injury Severity Score (ISS), RCWS also provides data on injury severity, which enables measurements of injury- and treatment-specific outcomes. Unlike many commonly used trauma scores, RCWS does not rely upon vital parameters, which may reduce the influence of survivorship bias.

## **Quality Assessment of Surgical Care in Armed Conflicts**

Surgical care in low-resource armed conflicts is predominantly experience-driven. The scientific body of evidence that supports treatment practices and subsequent outcomes is limited (Wild et al., 2020). Several stakeholders in the humanitarian surgical field have therefore advocated for the implementation of a universal data set that would enable systematic evaluations of the care provided (Chu et al., 2011; WHO, 2021; Meara et al., 2015; Wild et al., 2020). Parallels have been drawn to the importance that trauma registers in

high-resource settings have had to the improvement of trauma care (Wren et al., 2019; Haider et al., 2012). In an article from 2020, the Stanford humanitarian surgical response in conflict working group, a consensus framework for humanitarian surgical response to armed conflict is outlined (Wren et al., 2019). This framework also includes a suggested universal minimum data set that would enable systematic data collection that could be used for quality assessment (Table 1).

Table 1: Suggested minimum data set for humanitarian trauma system by Stanford humanitarian surgical response in conflict working group

Required
Age
Gender
Mechanism and anatomic location of injury
Estimated time of injury
Time of arrival at each point of care
Mode of transport
Vital parameters
Triage category (WHO, 2017) and Kampala Trauma Score (Weeks et al., 2016)
Procedures performed
Status at discharge (dead/alive)
Time of discharge
Intended destination at discharge
Desirable
Geographic place of injury (if not risking patient safety)
Clinical complications
Functional status at discharge
Any available data about long-term patient outcomes

Source: Wren et al., 2019). Reproduced with permission from Sherry Wren and under the terms of CC BY 4.0.

## Aims of thesis

### Overall

The aims of the thesis were to generate knowledge regarding the relationship between demographics, injury mechanism, injury patterns, and surgical resource consumption with the intention to identify predictive factors and treatment practices that can improve how surgical resources are used in armed conflicts. Aim IV was considered to be irrelevant for the topic of the present brief.

### Specific

- I. To investigate injury mechanism, injuries, and surgical treatment needs in resource-constrained conflict settings. (Understanding)
- II. To investigate trends in demographics and surgical practices of weapon-related limb injuries in a resource-constrained setting between 1992–1995 and 2009–2012 focusing on amputation rates. (Understanding)
- III. To determine if RCWS and commonly used trauma scores have predictive ability to assess surgical resource consumption and in-hospital mortality in resource-constrained conflict settings. (Predicting)
- IV. To assess the efficacy of topical honey as treatment for *S. aureus* infected war wounds compared to systemic antibiotics. (Improving)



## Methods and Study Designs

The empirical material, methods, and statistical analyses used in each paper (*Papers I–III*) are summarized in Table 2. The material used consists of routinely collected clinical data (*Papers I–III*). The data were obtained from three different ICRC hospitals in two different armed conflicts. The data were prospectively collected by healthcare staff that was specifically trained for the task. However, at the time of data collection, the intended use was not specified, more than vaguely to be used for quality control purposes. In *Paper III* we also utilized data extracted from patient charts located in the ICRC archives in Satigny, Switzerland. The data collected was applied in observational cohort studies (*Papers I–III*) with the intention to test the hypothesized cause-effect relationships.

Table 2: Overview of original papers for this brief

	<b><i>Paper I</i></b>	<b><i>Paper II</i></b>	<b><i>Paper III</i></b>
Study periods	2009–2012	1992–1995 and 2009–2012	2009–2012 and 2012–2014
Aims	Understanding	Understanding	Predicting
Designs	Retrospective cohort study	Retrospective cohort study	Retrospective cohort study
Participants	Patients with conflict-related injuries	Patients with conflict-related extremity injuries	Patients with conflict-related injuries
Hospital locations	Peshawar	Peshawar, Quetta	Peshawar, Goma

	<b><i>Paper I</i></b>	<b><i>Paper II</i></b>	<b><i>Paper III</i></b>
Study periods	2009–2012	1992–1995 and 2009–2012	2009–2012 and 2012–2014
Number of study subjects	3,028 patients	998 patients	834 patients
Data sources	Routinely collected clinical data	Routinely collected clinical data	Routinely collected clinical data
Main statistical analysis	Descriptive, Chi-square, and Mann-Whitney <i>U</i>	Logistic regression models	Logistic regression models and ROC curves
Main outcome measures	Differences in surgical treatment needs for females compared to men	Differences in surgical practices in 1992–1995 compared to 2009–2012	Trauma score's predictive ability for surgical resource consumption and mortality

ROC: receiver operating characteristics.

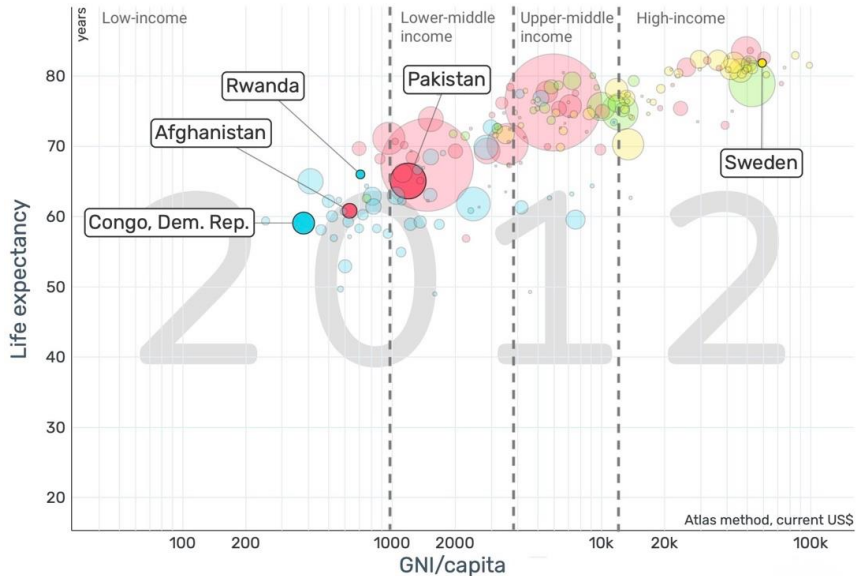
For all papers (*Papers I–III*), a statistician was consulted regarding appropriate statistical methods. Statistical analysis was done using IBM SPSS Statistics software version 23–25 (IBM Corporation, Armonk, NY, USA). Non-overlapping confidence intervals (CI) and p-values (two-tailed) less than 0.05 were considered significant in all analyses.

## Conflicts

In the thesis, data from patients injured in two different armed conflicts are utilized. Both these conflicts are still ongoing. For *Papers I–II*, we analysed data from patients injured in the border conflict between Afghanistan and Pakistan (the Durand Line conflict). For *Paper III*, we also analysed data obtained from patients injured in the Kivu conflict in the eastern part of the Democratic Republic of the Congo (DRC). This conflict also involves neighboring countries, in particular Rwanda.

Afghanistan, DRC, and Rwanda are low-income countries, and Pakistan a lower middle-income country (Bank, 2012). Life expectancy and income per capita at the time of data collection are demonstrated in Figure 3. Total health expenditure per capita for these countries was in the lower quarter of the world's countries (WHO, 2012; Bank, 2012). Moreover, the proportion of the population that has access to safe, affordable surgery and anesthesia is estimated to be less than 10% (Alkire et al., 2015).

Figure 3: Life expectancy, gross national income (GNI) per capita and income thresholds for 2012, arranged by country



Source: [www.gapminder.org](http://www.gapminder.org) (date of retrieval: 5 May 2021). Income thresholds according to the World Bank (Bank, 2012).

### The Durand Line and Afghanistan Conflict (*Papers I–III*)

The borderline between Afghanistan and Pakistan, the Durand Line, was a result of an agreement between the British diplomat Sir Henry Mortimer Durand and the Amir of Afghanistan, Abdur Rahman, in 1893 (Figure 4) (Christina Wagner, 2013; Kaura, 2017). The Durand Line has been a constant source of tension between Afghanistan and Pakistan ever since its creation. There are several reasons for this. It divided the ethnic group Pashtun's land and forced Afghanistan to give up the province of Baluchistan. Furthermore, it effectively prevented Afghanistan from accessing the Arabian sea (Kaura, 2017).

Therefore, no government of Afghanistan has recognized the legitimacy of the Durand Line (Qassem and Durand, 2008; Kaura, 2017). The Pakistani government, on the other hand, views the Durand line as a necessity for Pakistan's existence (Kaura, 2017). Consequently, the Durand line has been the reason for recurring clashes between Afghan and Pakistani security forces, resulting in injured and killed civilians (Kaura, 2017). The Durand Line conflict can best be described as an asymmetric war, with civilians being injured by the use of explosives, grenades, attacks by gunmen, and remote-controlled aerial bombings on both sides of the Durand Line (Arreguin-Toft, 2005; Coupland and Korver, 1991).

The Durand line conflict is closely interlinked with the complex internal conflict in Afghanistan. The Soviet invasion of Afghanistan in 1979 provided an opportunity for Pakistan to intervene in Afghanistan's internal affairs (Kaura, 2017). Supported by the Central Intelligence Agency (CIA), the Pakistan Inter-Services Intelligence Agency (ISI) aided mujahideen groups to oppose the Soviet invasion, which subsequently led to the fall of the Afghan government in 1992 (Kaura, 2017). The Taliban rule that followed was supported by Pakistan. Despite this, the Taliban refused to recognize the Durand Line as the legitimate border (Kaura, 2017). Pakistan's attempt to stop Pashtuns from crossing the Durand Line spurred the Taliban to carry out attacks inside Pakistan (Kaura, 2017). The nature of the internal conflict in Afghanistan changed again with the U. S. invasion in Afghanistan in 2001 and the establishment of a democratic government, which forced Taliban members to escape to remote mountain areas of Afghanistan and to Pakistan. However, this change of government had little impact on the Durand line conflict as clashes continued with varying intensity (Khan and Wagner, 2013). On August 30, 2021, the U. S. withdrew its military forces from Afghanistan and the Taliban once again seized power over Afghanistan. At the time of

writing this brief, it is unclear what position the new Taliban government will take concerning the Durand line and in their relations with Pakistan. Most likely, the Durand Line conflict will continue as the underlying reasons for the conflict remain unsolved.

### The Kivu Conflict (*Paper III*)

The conflict in the Kivu province of DRC has its roots in the First Congo War 1993–1997 and the Rwandan Civil War 1990–1994 (Lyall, 2017). In 2004, following increased tensions, an armed conflict broke out between the Forces armées de la République démocratique du Congo (FARDC), a Hutu militia group, and the Democratic Forces for the Liberation of Rwanda (FDLR) in the southern Kivu province of eastern DRC (Stauss, 2005). At later stages, Tutsi rebel forces (National Congress for the Defence of the People, CNDP) and several local armed groups, the largest group being the Mouvement du 23 Mars (M23), got involved (Lyall, 2017). The conflict is driven mainly by rights to mineral resources in the region (Autesserre, 2010; Lyall, 2017). The use of children as soldiers and systematic rapes have been frequently reported (Rakisits, 2009; Peterman et al., 2011). Compared to the conflict along the Durand Line, fewer injuries from indiscriminate weapons such as grenades, bombs, and anti-personnel mines have been observed (Chu et al., 2010; Andersson et al., 2018; Haverkamp et al., 2019).

## Hospitals

### The Durand Line and Afghan Conflict (*Papers I–III*)

In response to the conflict in Afghanistan and at the Durand Line, the ICRC opened its first hospital 60 kilometers from the Afghanistan border in Peshawar, northwestern Pakistan, in 1981. This was followed by the opening of another hospital in Quetta, 80 kilometers from the border and 840 km south of Peshawar, in 1983 (Figure 4). Both hospitals closed in the 1990s, but due to the intensification of the conflicts in the border area, the Peshawar hospital was reopened in 2009 and remained operational until 2012, and finally closed in 2014. The hospital in Peshawar had 116 beds, three operating rooms, a laboratory, X-ray service, blood bank, and basic ICU (Haverkamp et al., 2019). The hospital in Quetta had 150 beds, one operation theatre with three operation tables, a laboratory, X-ray service, and a blood bank (Haverkamp et al., 2019). Both hospitals had access to rehabilitation centers for training and prosthesis fitting (Haverkamp et al., 2019). Patients were not asked whether they were combatants or civilians. Together with some small facilities run by non-governmental organizations (NGOs), the ICRC hospitals were the only hospitals at the time providing surgery for weapon-wounded regardless of origin, completely free of charge. Public hospitals did provide initial surgical care for free but were difficult to access for others than Pakistanis.

Figure 4: The Durand Line, i.e., Afghanistan–Pakistan border, and locations of ICRC hospitals



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### The Kivu Conflict (*Paper III*)

In November 2012, due to the escalation of the armed conflict, the ICRC deployed surgical teams to support the N'Dosho hospital in Goma, Northern Kivu (Figure 5). The hospital at the time had 65 beds, one operating theatre, an X-ray service, and a laboratory (Haverkamp et al., 2019). The hospital had access to a rehabilitation center for training and prosthesis fitting (Haverkamp et al., 2019). Care at the hospital was free of charge. Patients were not asked whether they were combatants or civilians.

Figure 5: The border area of the Democratic Republic of the Congo and Rwanda and the location of the ICRC hospital



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## Main Findings and Discussion

### Descriptive Findings (*Papers I–III*)

Characteristics of the patients included in *Papers I–III* are shown in Table 3. Consistent with reports from other armed conflicts, most patients were male in their mid-twenties and arrived at the hospital more than six hours after the injury (Wild et al., 2020; Haverkamp et al., 2019; Forrester et al., 2019). Injuries caused by indiscriminate weapons were more frequent in patients treated in Peshawar compared to Goma. This finding is consistent with the previously described differences in weapons used in these conflicts. Even though a substantial share of the patients treated in Peshawar between 2009–2012 were injured by indiscriminate weapons, only 5% of the patients had injuries caused by anti-personnel mines (APM). This figure contrasts sharply with figures reported from the beginning of the 1990s, where 48% of all weapon-wounded from the same area in northwestern Pakistan and neighboring Afghanistan were injured due to mines (Jeffrey, 1996). Consistent with this, we also noted a higher number of APM-related injuries in the cohort of the patients treated for extremity injuries in Quetta 1992–1995, analysed in *Paper II* (19% of the patients). The potential decline in APM-related injuries between 1992–1995 and 2009–2012 is most likely a favorable result of the global work against landmines, launched by the ICRC, resulting in the Ottawa treaty in 1997 that prohibiting their use (UN, 1997). Less than 20% of the patients analysed in *Papers I–III* were subjected to any major surgery, and in-hospital mortality was under 5% in all the studied cohorts. The low in-hospital mortality, absence of need of major surgery, coupled with that most patients arrived more than six hours after the injury, indicates potential survivorship bias.

Table 3: Overview of patient characteristics per hospital site

	Hospital site and period				
	Quetta 1992–1995 <i>n</i> = 419 (%)	Peshawar 1992–1995 <i>n</i> = 44 (%)	Peshawar 2009–2012 <i>n</i> = 3,028 (%)	Goma 2012–2014 <i>n</i> = 177 (%)	Total <i>n</i> = 3,668 (%)
Included in <i>Paper</i>	<i>II</i>	<i>II</i>	<i>I–III</i>	<i>III</i>	
Injury location	Extremity	Extremity	Any	Any	
Gender					
Male	405 (97)	44 (100)	2,622 (87)	149 (84)	3,220 (88)
Female	14 (3)	0	376 (12)	28 (16)	418 (11)
Missing	0	0	30 (1)	0	30 (1)
Median age (IQR <sup>a</sup> )	26 (10)	25 (10)	24 (14)	28 (13)	25 (14)
Injury mechanism					
Bullet	254 (61)	26 (59)	1,119 (37)	156 (88)	1,555 (42)
APM <sup>b</sup>	79 (19)	12 (27)	166 (5)	0	257 (7)
Indiscriminate weapon <sup>c</sup>	80 (19)	6 (14)	1,679 (56)	17 (9)	1,782 (49)
Other	6 (1)	0	32 (1)	3 (2)	41 (1)
Missing	0	0	32 (1)	1 (1)	33 (1)

	Hospital site and period				
	Quetta	Peshawar	Peshawar	Goma	Total
	1992–1995	1992–1995	2009–2012	2012–2014	
	<i>n</i> = 419 (%)	<i>n</i> = 44 (%)	<i>n</i> = 3,028 (%)	<i>n</i> = 177 (%)	<i>n</i> = 3,668 (%)
Time since injury					
≤6 hours	13 (3)	12 (27)	401 (13)	35 (20)	461 (13)
7–24 hours	205 (49)	25 (57)	830 (27)	78 (44)	1,138 (31)
>24 hours	201 (48)	7 (16)	1797 (60)	64 (36)	2,069 (56)
Major surgery					
Craniotomy	0	0	61 (2)	2 (1)	63 (1.5)
Thoracotomy	0	0	24 (1)	0	24 (0.5)
Laparotomy	0	0	270 (9)	14 (8)	284 (8)
Amputation	40 (10)	6 (14)	239 (8)	8 (5)	293 (8)
None of the above	379 (90)	38 (86)	2,434 (80)	153 (86)	3,004 (82)
Discharge status					
Alive	414 (99)	44 (100)	2,893 (96)	174 (98)	3,525 (96)
Dead	5 (1)	0	135 (4)	3 (2)	143 (4)

<sup>a</sup> Interquartile range (IQR); <sup>b</sup> Anti-personnel mine; <sup>c</sup> Bombs, shells, missiles, and other explosives.

## **Females were more likely to be injured by indiscriminate weapons than men and had more extensive surgical treatment needs (Paper I)**

A total of 3,028 patients (378 females) were treated for weapon-related injuries at ICRC hospital in Peshawar during the period 2009–2012. 12.4% of the treated patients were females. This contrasts sharply with reports from other armed conflicts where females have constituted up to 43% of the treated patients (Trelles et al., 2015; Tounsi et al., 2019). The observed difference may be explained by the fact that ICRC facilities are devoted to only treating patients with weapon-related injuries, whereas other healthcare facilities in conflict areas may also treat patients with conditions that are not weapon-related.

In our material, females were injured by fragments from mortars and bombs significantly more often than males. These weapons are indiscriminate by nature and have in several previous reports been demonstrated to affect civilians to a proportionally greater extent than combatants (Guha-Sapir et al., 2015; Hicks et al., 2011; Coupland and Samnegaard, 1999). Furthermore, females arrived sooner after the injury, had more altered vital parameters, required more surgical procedures per person, and were given more blood transfusions than the males. They were also subjected to more surgical procedures involving the skull, thorax, and abdomen. This is consistent with a report from Coupland from the same area where he suggested that females injured at a greater distance from the ICRC hospital with less severe injuries were never transported to the hospital (Coupland and Korver, 1991). This could possibly indicate that the females represent a different cohort of weapon-wounded than that of males. Most likely, the female cohort comes from areas closer to the hospital than the male cohort. Given the shorter transportation time to the hospital, they were more likely to survive more severe injuries than males.

### **In low-resource conflict settings the risk of amputation was unchanged over time (*Paper II*)**

Consecutive data from 535 patients treated in 2009–2012 and 463 patients treated in 1992–1995 were analysed. After adjusting for confounders, particularly the degree of tissue damage, no difference in amputation-risk could be detected between 1992–1995 and 2009–2012, nor were there any statistically significant differences in the use of debridement/change of dressing, length of hospital stay, or in-hospital mortality. However, the use of external fixation, split skin graft, and blood transfusion had declined in 2009–2012. There are several plausible explanations for the observed differences in surgical procedures between the two periods. Surgeons deployed by the ICRC during both periods were predominantly general surgeons from high-resource countries (personal communication with the ICRC health unit). Their familiarity with basic orthopaedic, plastic, and vascular surgery may have varied. This is especially true for the later period as current trends in surgical training in high-resource countries have favoured subspecialisation with specific rather than general skill sets (Stitzenberg and Sheldon, 2005). In a recent survey among ICRC healthcare staff on self-perceived training needs, 31% requested additional training in fracture surgery, 20% in reconstructive surgery and 19% in vascular surgery (Haverkamp et al., 2018). This, together with our findings, indicates that the pre-deployment preparation and international team composition should be adjusted to address context varying injuries better.

### **RCWS predicted surgical resource consumption better than KTS and RTS (*Paper III*)**

When comparing RCWS with KTS and RTS, commonly used trauma scores in non-conflict settings, RCWS had a better ability to predict surgical resource consumption. This is consistent with previous studies that have demonstrated

an association between RCWS and the need for surgery, in-hospital amputation, and blood transfusions (Coupland, 1993; Hinsley et al., 2005; Muhrbeck et al., 2019). Furthermore, in a study from our group, RCWS correlated with the number of surgeries, blood transfusions, and hospital stay in paediatric patients with weapon-related extremity wounds (van Gennip et al., 2020). The better predictive ability for RCWS, compared to KTS and RTS, might not be surprising since both the former scores were designed to predict mortality following trauma (Champion et al., 1989; Kobusingye and Lett, 2000). However, to our knowledge, no instrument or trauma score has yet been validated to measure surgical resource use in conflict settings.

Consistent with other studies from armed conflicts, a low in-hospital mortality was observed (Trelles et al., 2016; Haverkamp et al., 2019). In the logistic regression analysis, none of the components of RCWS, KTS, and RTS were found to be significant predictors for in-hospital mortality. However, when performing the logistic regression analysis with imputed data, RCWS had significantly better predictive ability for in-hospital mortality than KTS and RTS. The inferior performance of KTS and RTS in the present study could be explained by survivorship bias. The low in-hospital mortality and that more than 90% of the patients in our material arrived more than six hours after the injury occurred supports this assumption. The conclusion that RCWS has better predictive ability for in-hospital mortality than KTS and RTS in conflicts must therefore be made with caution.

## **Ethical Considerations**

The data utilized in the thesis (*Papers I–III*) emanates from areas with ongoing armed conflict where academic institutions are non- or malfunctioning, making local ethics approvals impossible to obtain. Furthermore, as these studies are secondary analyses of previously collected non-identifiable quality control data from ICRC-operated hospitals, local ethics approvals and consents were not

deemed necessary. However, to ensure that ethical standards were met, ethical approval for exploration and compilation of data for scientific presentation was obtained from the Regional Ethical Review Board in Linköping, Swedish Ethical Review Authority, approval numbers 2014/417–31, 2015/66–33 and 2016/298–32. The ICRC approved the studies and gave all the necessary administrative permissions. The studies were performed in accordance with the ethical standards stipulated by Linköping University and the Declaration of Helsinki (World Medical Association, 2009).

## Conclusions

- I. Females treated at an ICRC hospital in northwestern Pakistan were markedly affected by indiscriminate weapons. Their surgical treatment needs were greater than those of males treated at the same hospital.
- II. In resource-constrained conflict settings, the risk of amputation appears unchanged over time, while the use of external fixation and split skin grafts was less common in 2009–2012 than in 1992–1995.
- III. RCWS appears to predict high surgical resource consumption better than, and in-hospital mortality at least equal to, Kampala Trauma Score (KTS) and Revised Trauma Score (RTS).

## Implications for Swedish Development Assistance

The possibility of providing development assistance in areas of armed conflict are limited, especially when it comes to strengthening surgical care capabilities for civilians. This is due to the inherent unpredictability and risks that come with armed conflicts. It may also be argued that developmental assistance by foreign governmental organizations to stakeholders in an armed conflict may potentially aggravate the conflict by changing the balance of resources (Perrin, 1998; Wood and Sullivan, 2015; Mousseau, 2020). For these reasons, it is better that



immediate and time-limited assistance in armed conflicts is provided by neutral and independent organizations (e.g. ICRC and Médecins Sans Frontières) that have the mandate, experience, and capabilities to work in resource-constrained conflict settings to assist victims on both sides of the conflict. Swedish development assistance should instead facilitate and participate in projects that:

1. **Improve the surgical resilience of healthcare systems in countries that are at risk of being engaged in armed conflicts.** This aligns with the United Nation's Sustainable Development Goals and WHO's A68/15 resolution, which stress the importance of strengthening healthcare systems and that emergency and essential surgical care are intricate components of universal health coverage (UN, 2015; WHO, 2015). Furthermore, assisting in strengthening healthcare systems in resource-constrained settings would give Swedish healthcare personnel invaluable and much-needed experience in providing surgical care with limited resources. These proficiencies are invaluable in mass casualty incidences and other situations where even the abundance of resources of the Swedish healthcare system are insufficient in meeting the needs.
2. **Aim to establish a universal quality and outcome register for treatment of conflict-related injuries.** Fundamental to increasing the resilience of healthcare systems are tools that allow for quality and output assessments. This is of course especially important in settings where the resources are limited, such as in armed conflicts. The WHO is currently exploring the possibilities of establishing a universal database for conflict settings that could be used for these purposes (Wild et al., 2020; WHO, 2021). The findings of my thesis (*Paper III*) indicate that RCWS could be used in this database as a tool to assess weapon-related injuries in a consistent manner. However, there are several ethical, technical, and validity issues that need to be addressed prior to any implementation of a register of this nature. Sweden could here provide several of the skills needed to resolve these issues.

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In armed conflicts, access to medical care as well as surgical resources are often limited. Using records from three different Red Cross hospitals, this Development Dissertation Brief analyses the relationship between types of injuries, demographics, and surgical resource consumption in order to improve how surgical resources are used in armed conflicts.

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Väpnade konflikter begränsar ofta både tillgången till sjukvård och kirurgiska resurser. Denna Development Dissertation Brief använder journaluppgifter från tre olika Röda Korset-sjukhus för att studera sambandet mellan typer av skador, demografi och kirurgisk resursförbrukning, för att göra användningen av dessa knappa resurser mer effektiv i konfliktmiljöer.

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