Life after war-related extremity amputations

A retrospective, descriptive clinical follow-up study from Gaza, occupied Palestine

Gaza City, January 2016. Photo: Hanne Heszlein-Lossius

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- Palestinian people are in love with life

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I am a member of the Norwegian Palestine Committee.

ABBREVIATIONS

ALPC (The Artificial Limb and Polio Center)

BMC (BioMed Central)

BMJ (British Medical Journal)

NGO (Non-Governmental Organization)

OR (Operating Room)

OR (Odds ratio)

oPt (occupied Palestinian territory)

DIME (Dense Inert Metal Explosives)

HMTA (Heavy Metal Tungsten Alloy)

IDF (Israeli Defense Forces)

LMICs (Low and middle-income countries)

UN (United Nations)

RMS (Rhabdomyosarcoma)

WHO (World Health Organization)

PTG (Post-Traumatic Growth)

WNiCo (Wolfram-Nickel-Cobalt)

AK (Above-Knee)

BK (Below-Knee)

RTAs (Road Traffic Accidents)

CK (Creatinine Kinase)

LDH (Lactate dehydrogenase)

ESR (Erythrocyte Sedimentation Rate)

MRI (Magnetic Resonance Imaging)

CT (Computed Tomography)

US (Ultrasound)

NAFLD (Non-Alcoholic Fatty Liver Disease)

HCC (Hepatocellular Carcinoma)

LIST OF PAPERS

Paper I: Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik, N, Giil, LM, & Gilbert MF. **Life after conflict-related amputation trauma: A clinical study from the Gaza Strip.** BMC International Health and Human Rights. 2018;18(1):34. doi:10.1186/s12914-018-0173-3

Paper II: Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik N, Giil, LM, & Gilbert MF. **Traumatic amputations caused by drone attacks in the local population in Gaza: a retrospective cross-sectional study.** The Lancet Planetary Health. 2019;3(1):e40-e47. doi:10.1016/S2542-5196(18)30265-1

Paper III: Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik N, Giil LM, & Gilbert MF. (2019). Does pain, psychological distress and deteriorated family economy follow traumatic amputation among war casualties? A retrospective, cross-sectional study from Gaza. BMJ Open. 2019;9:e029892. doi:10.1136/bmjopen-2019-029892

SUMMARY

This thesis is based on a clinical follow-up study of Palestinian patients who have sustained and survived war-related extremity amputations in Gaza, starting in June 2014, two weeks before "Operation Protective Edge", the 51-day Israeli military onslaught on Gaza. Little was known about the amputees' health and living conditions after the traumatic amputation. During the attacks on Gaza in 2006 and 2008/09, local and international surgeons reported new types of injuries. They observed extensive burns and severe amputations, but without the fragment or shrapnel wounds typical of other war-related amputations resulting from explosive weapons. Significantly, these injuries were associated with an increased fatality rate.[1,2] As far back as in 2009 it was suggested that there was a need to perform a systematic study of survivors due to the observed change in injury patterns and fatality.[3] There was also a concomitant change in weapon use during the period from which the patients were recruited to this study. These patients sustained their injuries during 2006-2014 at the same time as the use of drones to deliver weapons steadily increased. There was speculation that some of the unusual injuries observed by experienced trauma surgeons might result from new weapons referred to as "dense inert metal explosives" or "DIME" bombs. DIME bombs are highly accurate, drone-delivered, small lightweight 'precision weapons' known to cause massive traumatic amputation to the lower extremities.[3] The concern about use of DIME bombs was raised again by medical doctors treating civilian amputees during the military onslaught on Gaza in 2014.[4]

A review of the literature on the medical consequences of war-related amputation injuries in Gaza using MEDLINE, PubMed and Google Scholar revealed surprisingly few results. Primary data and peer-reviewed, scientific papers on the impact of drone warfare on civilians in Gaza were non-existent. The hospital files in Gaza are non-electronic. Autopsies are seldom performed, and there are no death registers or national health registries in Gaza. The process of collecting data was initially difficult and chaotic as we struggled to establish a clear understanding of what had happened to the survivors with war-related amputations. We realized it would be hard to accurately establish the number of war-related amputees, and the records could not help us explain what had happened to them. This thesis represents novel work on a vulnerable population where few scientific observations exist. We have faced challenges and obstacles far beyond the common limitations in a scientific study. To do

research in a population under strict siege, long –lasting occupation and repetitious military attacks is not easy.

Traumatic amputations following attacks with explosive weapons

A young Palestinian man with right arm and right leg traumatic amputations.

Shifa Hospital OR, Gaza City, June 2006. *Photo: M. Gilbert*

A young Palestinian boy with right leg above knee traumatic amputation.

Shifa Hospital OR, Gaza City, January 2009. *Photo: Mads Gilbert*

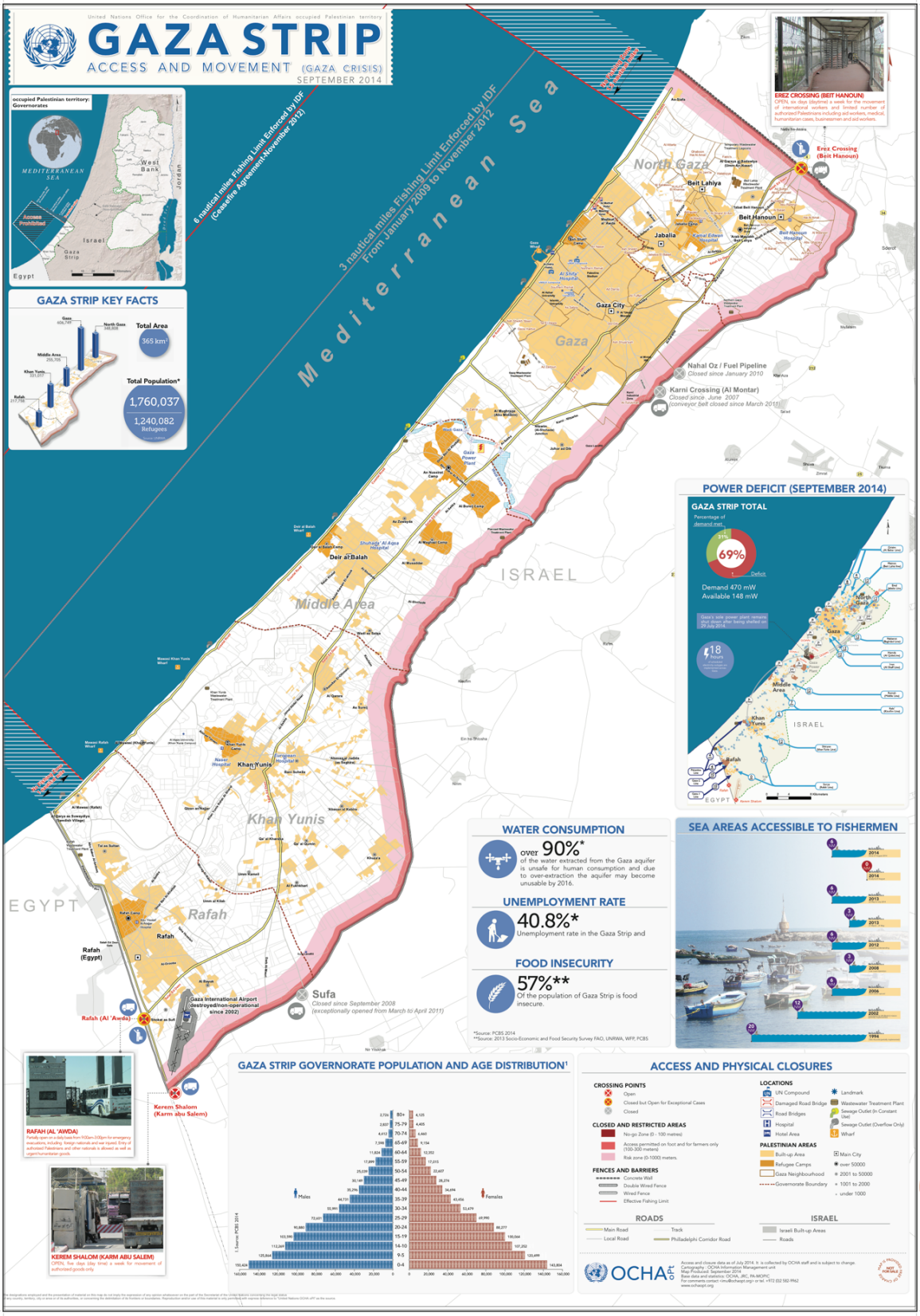

Figure 1. Map of Gaza.

Illustration from the United Nations

ABSTRACT

Background

Thousands of Palestinians were injured during Israeli military incursions in the Gaza Strip during the years 2006 to 2014. An internationally condemned blockade has been enforced the last 12 years. Living conditions in the area are deteriorating, including rising unemployment. An unknown number of civilians suffered traumatic extremity amputations caused by various types of weapons during this period of time. An increasing proportion of war-related injuries are caused by unmanned combat aerial vehicles (drones)in conflict zones like Gaza.

In this thesis we describe the injuries and their complications as well as living conditions and psychosocial health of a selection of traumatic amputees living in the Gaza Strip. We compare prevalence and severity of extremity amputations inflicted by drone strikes to extremity amputations inflicted by other explosive weapons in a cohort of amputees treated at the main physical rehabilitation and prosthesis centre in Gaza. We also studied risk factors for more severe extremity amputations and assessed determinants of psychosocial outcome in amputees.

Methods

We included 254 civilian Palestinians who had survived, but lost one or more limb(s) during, military incursions in Gaza over the period 2006-2016. Every patient underwent standardized clinical examination. We recorded each patient's medical history, the anatomical location of the amputation(s) and self-reported data on the time and mechanism of injury. The severity of the amputations was classified on an ordinal scale: 1 = fingers, toes, hands and feet; 2 = below knee or elbow; 3= above knee or elbow; and 4= bilateral amputation, amputation in both lower and upper extremities or unilateral amputation at hip/shoulder level. We applied the General Health Questionnaire (GHQ-12) to describe the psychosocial health of the amputees. GHQ-12 scores were analysed together with socioeconomic status, mechanism of injury, severity of injury, medical complications and loss of family-members and/or housing.

Results

The amputees were young (median age 23 years at the time of trauma), well educated (37 % above graduate level), predominantly male (92%), and included 43 children (17% ≤ 18 years). Most had suffered major amputations (85% above wrist or ankle). Their limb losses were

unilateral (35% above-knee, 29,5% below-knee), and bilateral (17%) lower extremity amputations. Pain was the most frequent long-term complaint (in joints: 34%; back: 33%: phantom pain: 40.6%). Physical pain increased in amputees with low family income, also after adjusting for the severity of the injury (OR 2.12, p = 0.034). Self-reported mental health was found to be worse among amputees who were unemployed following the injury, (OR 3.22, p = 0.001). There was no association between GHQ scores indicating psychological distress and the extent of the initial trauma. More than half of the traumatic amputations (54%) were caused by drone strikes, and the explosive weapons delivered by drone strikes caused significantly more severe injuries than other types of explosives (OR 2.49, p = 0.001). Compared to all other types of weapons, patients amputated in drone strikes also needed significantly more surgical operations (OR 1.76, p = 0.01).

Conclusion

Traumatic extremity amputations sustained during military actions have wide-ranging, serious consequences for the amputees and their families. The typical traumatic amputee in Gaza is a young, well-educated civilian Palestinian breadwinner. Nearly one in five is a child. Most of the amputees have major amputations in the lower extremities. There was a significant correlation between self-reported pain and mental wellbeing after the loss of one or more limbs and deterioration in the amputees' occupational and financial situation following amputation. Poverty and unemployment secondary to the amputations and the disability appeared to be a more important trauma than the mere physical amputation itself. Drone strikes were the most common cause of amputation injury in the patients. Drone strikes were associated with more severe injuries both regarding anatomy of amputations and the need for surgical treatment of the amputations.

Arabic Abstract

الخلاصة

خلفية

تعرض الالاف من الفلسطينيين للإصابة خلال عمليات عسكرية إسرائيلية مختلفة على قطاع غزة منذ عام 2006 وحتى عام 2014. فُرض حصار مُدان دوليًا منذ 12 عامًا وما زال الحصار قائمًا. الظروف المعيشية في المنطقة في تدهور مستور، ومن جملتها ارتفاع معدلات البطالة. عدد غير معروف من المدنيين عانوا من بتر للأطراف نتيجة استخدام أسلحة متنوعة خلال هذه الفترة الزمنية. في مناطق النزاع مثل غزة، تتسبب الطائرات المسلحة المُسيرة بدون طيار بنصيب متزايد من إصابات الحروب.

في هذه الأطروحة نقوم بوصف الإصابات والمضاعفات والظروف المعيشية والصحة النفسية والاجتماعية بين مجموعة من مبتوري الأطراف نتيجة الإصابة في قطاع غزة. تمت مقارنة مدى انتشار وشدة بتر الأطراف الناجم عن ضربات الطائرات بدون طيار مقارنة ببتر الأطراف التي تسببها أسلحة متفجرة أخرى بين المبتورين الذين يتناوبون على مركز بالإضافة إلى ذلك تمت دراسة عوامل الخطر المرتبطة بإصابات البتر الشديدة .الأطراف الصناعية وإعادة التأهيل في غزة وتم تقييم محددات الناتج النفسي الاجتماعي لدى مبتوري الأطراف.

الطرق

شملت الدراسة 254 مدنيًا فلسطينيًا نجوا من العمليات العسكرية في الفترة 2006-2016، لكنهم فقدوا أحد الأطراف أو أكثر خلال هذه العمليات. تم إخضاع كل مريض لفحص سريري قياسي. تم تسجيل التاريخ الطبي لكل مريض، والموقع التشريحي للبتر، والبيانات المتعلقة بالوقت المحدد وآلية الإصابة والتي تم التبليغ عنها ذاتيًا. تم تصنيف شدة البتر على نطاق ترتيبي حيث 1 = أصابع الأيدي والأقدام واليدين والقدمين؛ 2 = ما بعد الركبة أو الكوع. 3 = ما قبل الركبة أو الكوع. 4 = البتر ثنائي الجانب، بتر في طرف سفلي وعلوي أو بتر الأحادي على مستوى الورك/مستوى الكتف. تم استخدام استبيان لفحص الصحة النفسية والاجتماعية لدى مبتوري الأطراف. تم تحليل النتائج بالإضافة إلى (GHQ-12) الصحة العامة الحالة الاجتماعية والاقتصادية وآلية الإصابة وشدة الإصابة والمضاعفات الطبية وفقدان أفراد الأسرة و/أو السكن.

النتائج

كان المبتورون شبابًا (متوسط العمر 23 عامًا وقت الحادثة)، متعلمين بشكل جيد (37٪ أعلى من مستوى التعليم الجامعي)، بالدرجة الأولى ذكور (92٪)، وكذلك كان من بينهم 43 طفلًا (17٪ ≥ 18 عامًا). الجزء الأكبر عانى من عمليات بتر كبرى (85٪ ما قبل الرسغ أو الكاحل). خسائر الأطراف تركزت في الأطراف السفلية حيث كانت في جانب واحد (35 ٪ ما قبل الركبة، 29.5٪ ما بعد الركبة) وثنائية الجانب (17%). كان الألم هو الشكوى الأكثر شيوعًا على المدى الطويل (في المفاصل: 34٪، الظهر: 33٪ أو الألم الوهمي: 40.6٪)، وزاد الألم الجسدي وفقا لذلك بين مبتوري الأطراف ذوي الدخل = 2.12). وُجد أن الصحة OR = 0.034، نسبة الأرجحية P الأسري المنخفض، كذلك عند تعديلها لشدة إصابة (ع = Pالعقلية المبلغ عنها ذاتيًا أكثر سوءً بين مبتوري الأطراف الذين وجدوا أنفسهم عاطلين عن العمل بعد الإصابة (ع تدلل على وجود GHQ = 3.22). لم تكن هناك علاقة بين نتائج استبانة الصحة العامة OR 0.001، نسبة الأرجحية معاناة نفسية وعلى مدى الصدمة الأولية. أكثر من نصف عمليات البتر (54٪) نجمت عن أسلحة متفجرة بواسطة غارات بطائرات بدون طيار. قنابل أسلحة الطائرات بدون طيار تسببت بإصابات أكثر خطورة من المتفجرات من الطائرات النفاثة = 0.001). احتاج P= 2.49، ع OR العسكرية، طائرات الهليكوبتر، قصف الدبابات والمدفعية البحرية (نسبة الأرجحية المرضى الذين أصيبوا بضربات الطائرات بدون طيار إلى عمليات جراحية أكثر بكثير مقارنةً بجميع أنواع الأسلحة = 0.01).P= 1.76، ع OR الأخرى لعلاج إصاباتهم (نسبة الأرجحية

استنتاج

ينتج عن الإصابات المسببة لبتر الأطراف، والتي نتجت خلال العمليات العسكرية، أثار متعددة وشديدة على مستوى الأشخاص مبتوري الأطراف وعائلاتهم. المصابون بالبتر في غزة عادةً ما يكونون صغار السن، مدنيين، ذوي تعليم جيد، والمعيلين لعوائلهم. كما أن حوالي واحد من كل خمسة مصابين يكون طفلًا. أغلب المصابين يعانون من إصابات بتر كبرى في الأطراف السفلية. الألم المبلغ عنه ذاتيا والصحة العقلية بعد فقدان واحد أو أكثر من الأطراف يرتبطون بتدهور الوضع الوظيفي والوضع المالي بعد البتر. قد يكون الفقر والبطالة الناجمة عن البتر والإعاقة صدمة أشد أثرًا وأهمية من البتر البدني نفسه. كانت ضربات الطائرات بدون طيار هي السبب الأكثر شيوعًا المسببة للبتر بين المرضى. وكانت ضربات الطائرات بدون طيار أيضًا أكثر حدة من خلال تقييمها من الناحية التشريحية للبتر والحاجة إلى العلاج الجراحي.

1. INTRODUCTION

1.1. The epidemiology of war-related traumatic injuries

War-related injuries claim the lives of more than 5 million people every year. The injuries caused by armed conflicts and wars pose a major public health problem. War-related traumatic injuries do not affect countries indiscriminately, but are more common in low and middle income countries (LMICs), such as Palestine.[5,6] Road traffic accidents (RTAs), war-injuries, self-inflicted injuries, and domestic violence are the most common causes of trauma-related deaths worldwide.[7] About 90% of the world's trauma-related deaths occur in LMICs.[8] More than 80% of the global RTA-related deaths also occur in LMICs.[9,10] The risk of dying from a war-related injury is determined by the severity of the injury and the victim's physiological capacity.[11] People who are poor and food insecure may have a lower physiological capacity to handle trauma. More than half of Gaza's preschool children are anaemic due to food insecurity and a low intake of proteins and iron. The anaemia and stunting among children in Gaza are indirect results of the strict siege, and may negatively impact the children's capacity and response to trauma.[12,13] An unknown number of civilians have suffered from limb loss in the many military attacks on Gaza during the last decade.

1.2. The loss of limb(s) is life changing

The sudden and unexpected loss of one or several limbs is a dramatic and life-changing event. The trauma following war-related extremity amputation does not only affect the person losing part(s) of him- or herself, but also their family. The loss of one family member's workforce may also mean the loss of its sole breadwinner. The end result may be poverty for the whole family.[14] Long-lasting poverty for patients and their families is known to be a severe secondary trauma that contributes to pain, insomnia and depression.[15] The same deterioration in the family finances is also seen with other trauma victims, like survivors from RTAs, where most survivors are young bread-winning males.[16] In a study from Gaza, Giacaman and colleagues showed Palestinian females in Gaza to feel less secure than men, explained by the potential loss of the male breadwinner in the family.[17] In addition to the severe bodily harm, years of rehabilitation await the amputee, as well as multiple surgical operations, complications and chronic pain.[14] In short, extremity amputations traumatizes whole families.

1.3. More war-wounded survive, but with amputations

Amputation injuries are common in war. They were often associated with death rather than survival, because the injuries that caused the amputations were from heavy bombardment with large blasts. This not only caused extremity amputations, but also severe blast injuries to the lung and other serious injuries eventually killing the patient.[18] New military technology and smaller explosive weapons may not cause severe lung injuries, but still amputate victims' extremities. Compared to injuries during earlier wars, injuries caused by modern weapons increase the chance of survival, but with amputation(s).[19] The changes over time in weapon technology has been accompanied by important advances in emergency resuscitation, haemorrhage control and surgical and intensive care, significantly contributing to increased survival in war-wounded patients with amputation injuries.[19,20]

1.4. Siege and blockade in Gaza

In 2007, Gaza was placed under an Israeli and U.S.-led economic and political siege and blockade from land, air and sea. This followed the election in 2006 where the political party "Change and Reform" (Hamas) won 74 of the 132 seats in the Palestinian parliament. The forced isolation of Gaza has been condemned by the UN Secretary-General as collective punishment and thus illegal under international law.[21]

The "Gaza Strip" is just 360 km^2 and home to approximately two million Palestinians. The average age is 18.6 years and 60% of the inhabitants are below the age of 16.[22] More than half of Gaza's preschool children are anaemic due to food insecurity and a low intake of proteins and iron. Close to half of the same preschool children are found to have stunted growth and even wasted.[12,13] There is minimal freedom of movement for the people of Gaza, who find themselves incarcerated behind walls, with all borders to land, sea, and air under strict military blockage by the Israeli armed forces.[21] Permits to exit Gaza are almost impossible to obtain, even for critically ill patients needing medical treatment abroad.[23] Amputees in Gaza are at risk of further health deterioration.

1.5. Four major military incursions

During the last decade, the inhabitants of Gaza have experienced four major military incursions by the Israeli Defence Forces (IDF) with massive air, sea and ground forces attacking. This have left thousands of Palestinians injured, disabled and displaced. During that same period, Gaza's healthcare facilities have eroded for lack of funding, material, maintenance and new equipment secondary to siege and occupation.[24] The UN warned in 2009 about the increase in civilians with severe war-related injuries in Gaza during the Israeli military operation " Cast Lead".[25] This warning did not prevent further civilian losses and increasing number of war-wounded during the attack "Pillar of Defence" in 2012 and the 51-day long military operation "Protective Edge" in the summer of 2014.[26,27]

1.6. Combatants, not civilians researched

Most of the existing peer-reviewed literature on traumatic war-related extremity amputations focuses on military personnel and not on civilians. Little is known about the impact of war-related traumatic amputation among civilians in Gaza, as well as in other war-torn regions. Healthcare professionals in the region have stressed the need for more in-depth studies on the civilians in Gaza with war-related amputations.[28] Studies conducted on military personnel have shed some light on the long-term medical complications from extremity amputations suffered by soldiers during combat. Amputations among US military personnel sustained during incursions in Afghanistan and Iraq during the last ten years have often involved the lower extremities, and the number of military patients with multiple amputations is increasing.[18,29]

1.7. Gaza – a different situation

The basic living conditions for Palestinian civilians in Gaza, as well as their access to healthcare and food security, differs significantly from Western military combatants. We cannot assume that the conclusions drawn from research performed on military personnel (regular soldiers) apply to civilians who are living under harsh socio-economic conditions, occupation and siege. Access to emergency medical treatment, follow-up and long-term rehabilitation will vary between Israeli soldiers in Israel or US soldiers in Iraq, and local Palestinian civilians in Gaza. The strain imposed on the local healthcare system is severe both from the patient load following repetitious military attacks and the 12 years of siege and blockade.[30] The amputees who need more advanced medical care outside Gaza will need

special exit permits from Gaza issued by the Israeli authorities. Approvals of permits for such medical referrals are almost impossible to obtain and is decreasing.[31]

1.8. Drones and modern warfare

A drone is an unmanned aerial vehicle (UAV) operated by a drone pilot in a remote control center.[32] They are often equipped with high-altitude long endurance (HALE) technology, high-resolution video cameras and missiles.[33,34] The use of armed drones is increasing globally and in Gaza, drones are part of everyday life.[35] The drones can carry a variety of weapons, including the high-order explosive 'dense inert metal explosive' (DIME) bomb, which was reported used for the first time in Gaza in 2006. [1-4] DIME bombs contain milled and powdered heavy metal tungsten alloy (HMTA). When the DIME-bomb explodes, explosive power is quickly lost due to air resistance, and within a four meter range of the impact zone, everything is burnt and destroyed.[36] If bystanders survive, they often suffer limb loss.[37] The heavy metal powder consists mostly of tungsten with small amounts of nickel, cobalt or iron.[37] DIME-weapons were already in 2009 mentioned by law professors Nasu and Faunce to be "a manifestation of a new generation of nano-scale technological impacts upon modern warfare that at present appears to be poorly regulated under international law".[36] There is an increasing evidence that parts of the weapons used in modern warfare have long-term adverse consequences on survivors health. The use of DIME-weapons and Depleted Uranium (DU) has caused concerns in Gaza because of its association with carcinogenesis.[38-42] Shrapnels embedded in body tissue or solid body organs from high energy blasts injuries is another worrying effect of modern war weapons. Retained weapon fragments can affect a person's health by causing local or systemic toxicities, foreign body reactions or could even lead to malignancies due to chronic inflammation or genotoxic contents.[43] There have to date been no formal confirmation or denial that the IDF have used DIME-explosives in Gaza.

1.9. Aims of the thesis

The aim of this thesis was to investigate the consequences of war-related traumatic extremity amputations among Palestinians in Gaza; the health effects, the psychosocial effects and to examine the weapons used versus the types of injuries. The patients were recruited from the attending the central Palestinian rehabilitation institution in Gaza.

This was accomplished through three studies with specific study questions:

- *Paper 1*: Who is the typical survivor with a war-related traumatic extremity amputations in Gaza?
- *Paper 2*: Which weapons cause traumatic amputation in the war-wounded in Gaza? Are there differences in the severity of the amputations and the weapons used?
- *Paper 3*: What are the psychosocial consequences of surviving with war-related traumatic extremity amputation in Gaza? What are the determinants of psychosocial distress and pain among patients with war-related traumatic amputations in Gaza?
- *Ongoing research:* In depth medical follow-up at secondary care level of war-related amputees with suspicious clinical findings. Is there an increased risk of serious pathology among amputation survivors with weapon residuals in their body?

2. MATERIALS AND METHODS

2.1. Study population

Our studies are based on the same patient cohort. This cohort includes 254 Palestinian patients with traumatic extremity amputations residing in Gaza. All amputees were patients at the central prosthesis and rehabilitation institution, the Artificial Limb and Prosthesis Workshop (ALPC) in Gaza, where they received rehabilitation treatment and were fitted with artificial limbs.

The patients had lost their extremities during various military attacks. The dates of initial injuries were matched with publicly available data of the dates of military incursions declared by the Israeli military forces (IDF). These incursions are given different names by the IDF, called 'operations'. The matching of the dates revealed the following: a total of 24 patients were amputated during '*Operation Summer Rain'* in 2006,[44,45] 57 patients were amputated during '*Operation Cast Lead'* in 2008/09,[46] four patients were amputated during '*Operation Pillar of Defence'* in 2012 [47] and 73 patients were amputated during the latest military incursion, '*Operation Protective Edge'* in 2014.[48,49]

Ninety-five patients were amputated between these 'operations', in times of declared ceasefire. One patient only provided the year, but not the exact date, of the injury leading to amputation.

2.2. The Artificial Limb and Polio Center (ALPC)

In meetings with the local health authorities in Gaza, it was decided that the local Artificial Limb and Polio Center (ALPC) in Gaza City was the best place to conduct our study. We started with a pilot study to assess the feasibility of the study (June-November 2014). To randomize the selection of the pilot cohort, we included the first 90 patients in the register at ALPC who met our inclusion criteria. The inclusion criteria was one or several amputations caused by a military weapon between 2006-2016 and having a registered record at ALPC. All non-war related amputation injuries were excluded. The health secretary at ALPC made one phone call to each of the 90 to invite them to participate. We had a response rate of 99 % in the pilot group. In November 2014, we proceeded to invite all registered patients who met the inclusion criteria to ensure we had a representative sample of amputees attending rehabilitation.

The ALPC is the only producer and provider of artificial limbs in Gaza. The center offers good facilities for examining and interviewing patients, running water and a stable power supply thanks to working generators that supply electricity during the frequent power outages. It also provided security for patients and our research team to use the ALPC as our study center. Researchers did not have to make home visits to study patients during times of attacks or incursions. All ALPC services are free of charge. Access to treatment is not depending on the patient's financial position. The center is well known among the orthopedic surgeons and hospitals in Gaza, who refer patients for follow-up at ALPC.

2.3. Language and translation

We describe the demographics, injuries and complications after war-related amputation injury. To explore the survivors' experiences, we used printed questionnaires in Arabic designed for yes/no answers or using the Likert scale (**Paper I**).[50] The questions focused on socioeconomic status, amputation-related complications, comorbidity, use of artificial limbs, and ongoing therapy. All written material in Arabic was quality assured by translation-retranslation between English and Arabic by researchers with Arabic as their native language. Retranslating translated texts back into the original language is an important technique in cross-cultural settings.[51]

2.4. Level of extremity amputation and comorbidity

The Palestinian co-authors, Dr. Al-Borno, Dr. Nashwa Skaik, and Dr. Samar Shaqqoura determined the severity level of the amputations and diagnosed comorbidities based on a clinical examination of the patient and on each ALPC patient records. The examination included vital signs (heart rate, temperature, and arterial blood pressure), weight, and height, examination of the abdomen, lungs, heart, skin, amputation stump, and palpation of lymph node stations (**Paper I**). The level of extremity amputation was drawn on an anatomical sketch. Each amputee and each amputation was photographed. The photos were labelled with patient's file number and stored in a locked closet at ALPC.

2.5. Socioeconomic status

Socioeconomic status was assessed by asking the participants about their level of education, family situation, number of persons in the household, the number of siblings, employment, perceived reasons for unemployment (no available job, student/housewife, unemployed due to injury), family income, and the number of dependents.

We recorded family income from each patient's self-reported questionnaires which included the following alternatives: a total family income per month 0 = less than 700 New Israeli Shekels* (NIS) 1 = 800-1600 NIS 2 = 1700-2500 NIS 3= 2600-3400 NIS, and 4 = more than 3500 NIS.

* (100 NIS= 32 USD)

2.6. Lost family members and lost homes

We started the data collection in June 2014, just weeks before the military incursion "Operation Protective Edge" started on July 8th.[52] Twelve patients had been interviewed and examined clinically before the bombing forced our research group to pause its work until September the same year. An open-ended question was posed to patients included after July 8th in order to explore their specific experiences during the more than 50 days incursion. Patients spoke freely with the examining medical doctor about their personal losses and if relevant, losses of a spouse, children, other family members and friends. During data analysis, we realised that we should have included questions about lost family members also for the 12

patients included in June. We concluded it was wrong to interview them again on these sensitive personal questions (**Paper I**).

We also asked all patients about the destructions of their homes and if their destroyed homes had been rebuilt (**Paper I**).

2.7. Mechanisms of injury

We examined the mechanisms of injury and the weapons leading to the traumatic extremity amputation (**Paper II)**.

Each amputee gave a detailed description of the initial trauma that had caused the amputation(s). Each patient described his or her whereabouts at the time of attack, if other witnesses were present, the sounds, sights and destruction of nearby cars and buildings. Palestinians in Gaza have a long experience with military incursions. They can accurately differentiate between the various weapon carriers, weapon types and explosives. At the time of data collection, the researchers were unaware of the drone's role as the dominating weapon-delivery system responsible for the most common and most severe injuries (**Paper II)**.

2.8. Severity of injury: one outcome measure

In the treatment and care of trauma patients, injury severity scores are used to catalogue the severity of trauma. The anatomical Injury Severity Score (ISS) is derived from the Abbreviated Injury Scale (AIS) and internationally accepted to use in most injury types.[53,54] Physiological scoring of trauma patients can be done with various scoring systems based on patient's vital signs such as systolic blood pressure, capillary refill time, respiration rate, heart rate and Glasgow Coma Scale (GCS, level of consciousness).[55-58] In order to score patients with any of these scales, knowledge of the trauma to all body organs and knowledge of the patient's vital signs at the time of trauma is mandatory. We did not have such complete medical records, and our study was retrospective. (**Paper II)**. We could not use the ISS or other physical trauma scoring systems retrospectively since we lacked of the needed anatomical and physiological data. This is weakness similar to other retrospective studies conducted under similar circumstances. In order to use severity of injury as an outcome measure, we classified the amputations by increasing severity based on proximity to the

patent's torso and the total number of affected limbs. The severity of injury was classified on an ordinal scale: 1 = finger/toes/hands/feet; 2 = below knee or below elbow; 3 = above knee or above elbow; and 4 = bilateral amputation or amputation in both lower and upper extremities or unilateral amputation at hip level/shoulder level. This was presented to two orthopaedic surgeons in, one in Haraldsplass Deaconess Hospital and one at Haukeland University Hospital in Norway to assess the face validity, and they were in agreement that this represented a scale of increasing injury-severity. This severity of injury variable was used as the outcome variable in ordinal logistic regression (**Paper II)**.

2.9. Local Expertise

To explore determinants of psychosocial distress and pain in patients who have survived extremity amputation in Gaza (**Paper III**), we used two well validated forms: the 12-question General Health Quality survey (GHQ-12) and Short Form Health survey (SF-36).[59-62]

As relatively foreign to Palestinian culture and value systems, we decided to use local expertise to assess mental health factors. Palestinian psychologists at the Gaza Community Mental Health Program (GCMHP) advised us to use the validated questionnaire GHQ-12 to assess the mental health among the patients.[63] The questionnaire is a 12-question screening tool in Arabic commonly used to assess mental distress in the general population in a community. The advantages is that it self-administrated, easy to complete, and not very time consuming The Arabic version has been validated for use in Arab-speaking patients. Several studies have been conducted in Gaza using the Arabic version of the questionnaire.[62,64-65] We used a bimodal scoring system for the GHQ-12 (0-0-1-1),[65] and a cut-off of 3 when calculating the GHQ scores, in accordance with a previous study conducted in Gaza by the World Health Organization (WHO).[65] The use of a cut-off value is only relevant if the investigators are screening for "caseness", which was our intention in this study.[66] Cronbach's alpha was 0.72 for the GHQ items 1 through 12, which is considered good.[67] (**Paper III**).

2.10. Assessment of pain

The patients provided details on the frequency of their pain during an average week on the following ordinal scale: 0= never pain, 1= pain one day a week or less, 2= pain two-three days a week, 3= pain four-six days a week, and 4= pain every day.

We used income, amputation severity based on proximity to torso, current employment status, loss of family members and loss of home as independent variables (**Paper III**).

In our use of the Short Form Health survey (SF-36), an error occurred, and the inter-consistency and quality was therefore too poor to be included in any of the analysis (**Paper III**).

2.11. Clinical and radiological work-up of a symptomatic subgroup

We discovered that 105 out of the 254 traumatically war-amputated patients who presented signs and symptoms of possible serious illness (symptoms described in Results) based on the clinical examinations (unpublished material). In agreement with the local health authorities, we referred 94 of these patients for further diagnostic investigations at Gaza's main hospital, The Al-Shifa Hospital. There, computed tomography (CT) scans of the abdomen and chest; ultrasound (US) investigations of the abdomen, magnetic resonance imaging (MRI) of the amputation stumps, and lab tests were performed for the 94 patients.

Clinical chemistry tests included erythrocyte sedimentation rate (ESR), complete blood count, kidney and liver function, serum concentrations of glucose, creatinine kinase (CK), Lactate dehydrogenase (LDH), Hepatitis B and C. Eleven of the 105 patients with clinical symptoms of potential illness did not want such referral.

2.12. Power analysis: attained power

We did not conduct a power analysis for a predetermined sample size due to the potentially volatile study conditions. However, we did conduct a power analysis of achieved power once we had included all available participants (a convenience sample). The main analytic tool we used was logistic regression. We set the conditions for logistic regression as follows: a binary outcome with a varying probability of having the outcome, an alpha value of 0.05, an R^2 of 0.2 with 1 covariate, and a sample size of 254. We then performed several power analyses at different probabilities (or frequencies) of the outcome with either a normal (Gaussian) distributed predictor or a binary predictor with odds ratios (ORs) varying from 1.5 till 2.0 or 2.5 (Figure 2). The study was well powered for any Gaussian predictor with an OR above 2.0 and was close to 80% power with an outcome frequency of 50% and an OR of 1.5. For binary predictors, the study was only well powered to assess moderate effect sizes (OR 2.5).

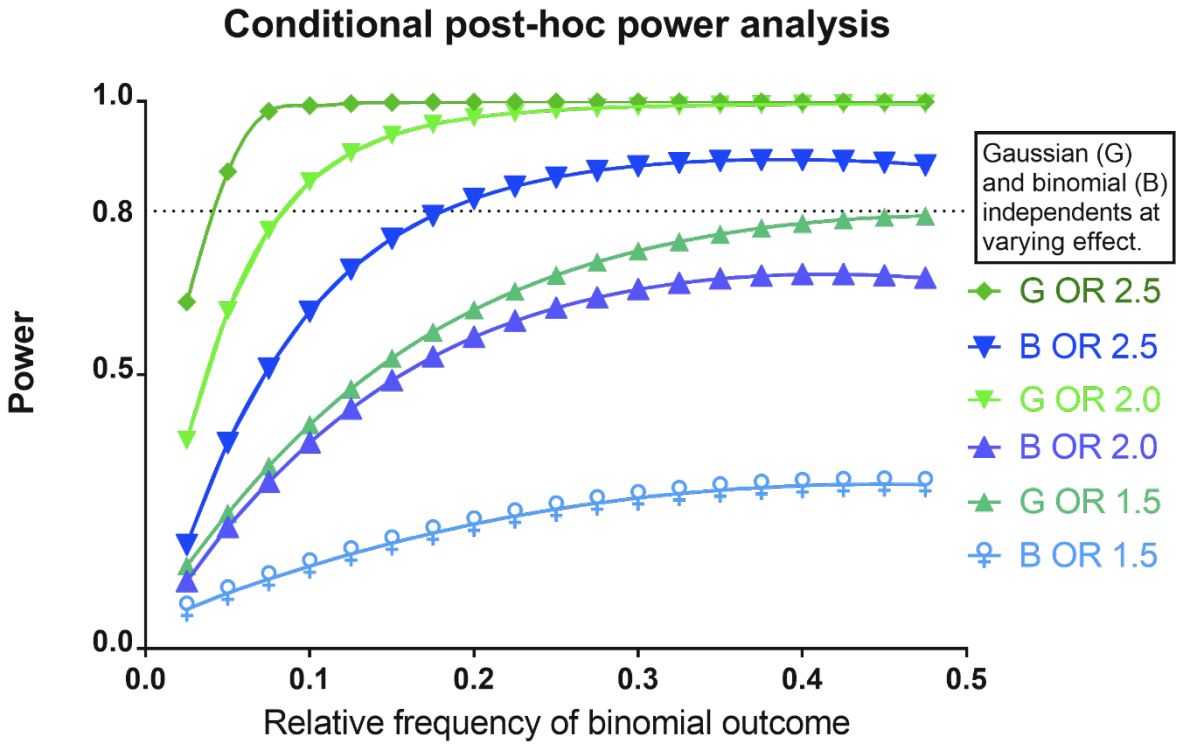

Figure 2. Achieved power

The graph shows that with a normally distributed predictor, the study has excellent power for finding novel risk factors where the effect size is low-to-moderate (OR 2.0-2.5), even when the outcome is only present in 10% of the cohort. However, with binary predictors, the study is only powered for finding moderate risk factors (OR ~ 2.5) with decreasing power for rarer outcomes.

2.13. Statistics

An alpha value of 0.05 was considered statistically significant. We used linear, ordinal, and logistic regression to accommodate the range of distributions of dependent variables in the studies. Continuous and skewed predictor variables were transformed as appropriate by logarithmic or square root transformations, as assessed by normal quantile-quantile plots post-transformation. Descriptive statistics are reported as mean and standard deviation (SD) for parametric data and as median and interquartile range (IQR) for non-parametric data. The determination of approximate normality was made by inspecting histograms and quantile-quantile plots.

We assessed the relationships between medical complications by multiple correspondence analysis (MCA) with principal normalization (**Paper I**). MCA uses the contingency tables as the matrix of relation and tells us which of the multiple complications that are related to each other.

Ordinal logistic regressions were used to investigate the relationships between mechanism of injury, amputation severity and number of surgical revisions adjusted for age and gender (**Paper II**). Both outcomes were classified into categories reflecting increasing severity. To obtain more interpretable estimates of the effect sizes, Monte-Carlo simulations (N=1000) were performed. Briefly, the quantity of interest (difference in probability) was obtained by first simulating the main and ancillary parameters obtained by ordinal regression, and then calculating the expected values if, and if not, a drone strike had been reported as the mechanism of injury (**Paper II**). Finally, the differences between these probabilities were calculated. Gunshot wounds were excluded from the mechanisms of injuries, which then included only explosive or shelling injuries (**Paper II**).

Logistic regression was used to assess association with a binary categorization of the GHQ-12 score (**Paper III**). Ordinal regression was used for multivariate analysis of pain, using a scale of increasing pain frequency from 0 to 4 as the outcome. Both models were first assessed with age, gender and the independent variable of interest, before adjusting for additional variables (**Paper III**). When ordinal regression was used, the proportional odds- and adequate cell count assumptions were both assessed. Alluvial flow diagrams were used to visualize complex relations between categorical variables (**Paper I** and **Paper II**).[68] Data analysis was conducted in SPSS Statistics version 22.0 (SPSS Inc., Chicago, IL, USA) and STATA 15 (StataCorp. 2015. *Stata Statistical Software: Release 15*. College Station, TX: StataCorp LP).

2.14. Ethical considerations

The studies were approved in Norway by the Regional Ethical Committee (approval number: 2016/1265/REK nord) and in Gaza by the local health authorities, the board of Al-Shifa Hospital, and the Director of the ALPC. The Palestinian Ministry of Health approved the study through The Helsinki Ethics Approval Committee in Gaza. All included patients gave written informed consent following detailed explanation in Arabic of the study objectives and procedures. The patients were not given any financial compensation except to cover actual

costs for their travel between home and the clinic. We performed the clinical examinations and interviews at the ALPC in Gaza City. All patients were informed that they could withdraw their consent and leave the study at any time. One participant withdrew. The patients from the three case studies in this thesis gave their written consent for the publication of their individual stories and pictures.

3. RESULTS

3.1. Paper I

3.1.1. Demographics

The typical patient in this study is an educated young male with financial responsibilities for an extended family. The amputees had suffered the loss of homes and family members in addition to the loss of extremities. Nearly half of the amputees (46%, *n*=116) had lost their home in one of the attacks, and very few of them had seen their homes been rebuilt (11.6%, *n*=29). Thirteen percent of the amputees who had lost one or more family members, and nine amputees (4%) had lost one or more children. (Table 1).

Table 1. Characteristics of study participants [a] (N = 254)

	Variables	n (patients)	% or median, [IQR]*
Demographics [b]	Palestinian	254	100
	Male	234	92
	Children	43	17
	Female	20	8
	Refugee status	154	57
	Age –Inclusion, years		28 [10]*
	Age-Injury, years		23 [9]*
Education [c]	Illiterate	9	4
	Elementary school	45	18
	Secondary school*	75	30
	High school	26	10
	Graduate*	22	9
	Postgraduate*	70	28
	PhD	1	0.4
Destruction of home [d]	Loss of home	116	46
Treatment [e]	Uses artificial limb	142	56
	Waiting for artificial limb	38	15
	Not using	72	28
	Receives physiotherapy	215	85
Financial situation [f]	Household (Hamula)	103	41
	> 8 Persons per household	135	54
	> 6 Siblings	185	74
	Family income, NIS[e]:		
	< 700***	76	30
	800-1600	105	42
	>1700	50	28

Abbreviations: IQR = interquartile range.
[a] Number of participants: 254, from 0-2 % of the participants had missing data on any variable.
[b] Refugee = patient is from a family who have a refugee status as of 1948
[c] Secondary school = 12 years of education, Graduate = has completed the first academic degree in university, post-graduate = completed Master degree
[d] Number of patients who lost their home in one of the incursions.
[e] Treatment 38 patients were at the time of inclusion waiting for an artificial limb to be fitted due to recent trauma. 72 patients did not use their fitted artificial limbs due to different reasons.
[f] Financial situation: Hamula: The Palestinian term for extended family. Here compared with the nuclear family
NIS= New Israeli Shekel. 1 NIS equals 0,26 US Dollar. Note: This table was adapted from **paper I**.

3.1.2. Major amputations

Most of the amputees had major amputations (*n*= 216, 85%). Unilateral above-knee amputations were the most frequent amputations among the patients (*n*= 89, 35%). Lower limb amputations were the most common major amputations. Most minor amputations were in the upper extremities. Bilateral amputations were most often found above the knees (*n*= 27, 11%), while bilateral amputations below the knees occurred in 7% (n=17). Among patients with upper limb amputations, the most common amputation was distally in the arm and hand. Twenty-one patients (8%) had both upper and lower limb amputations.

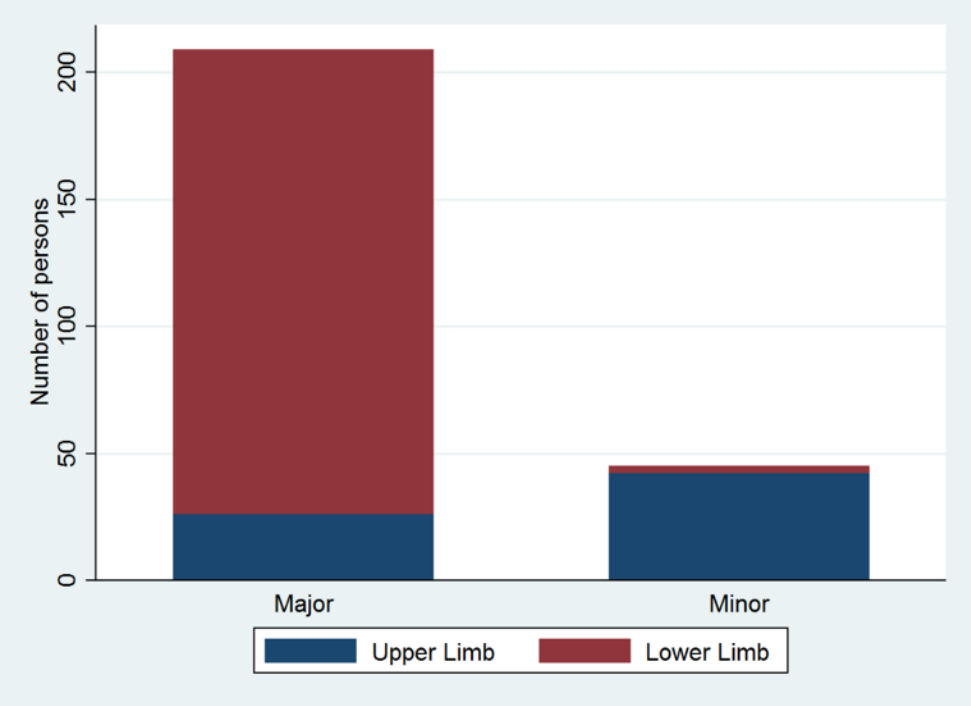

Figure 3. Minor and major amputations by limbs (N = 254).

Nearly nine out of ten amputations were major amputations: 216 (85%) suffered amputations proximal to the wrist or ankle. Major = proximal to wrist or ankle. Minor = distal to wrist or ankle. Note: This figure was adapted from **paper I**.

3.1.3. Rehabilitation and use of artificial limbs

More than half of the amputees were using an individually fitted artificial limb (prosthesis) (142/254, 56%). Thirty-eight patients (15%) were waiting for their prosthesis to be made. Seventy-two patients (28%) were not using their prosthesis; five (2%) because it was painful,

39 (15%) claimed they had better function without the prosthesis and eight (3%) who had an injury judged unsuitable for prosthesis. Twenty-one patients (8%) avoided using their artificial limb because they "disliked it". Amputees with below-knee amputations were more likely to be using their prosthesis than those with above-knee amputations. Among above-knee amputees, 59% (*n*= 52) were using a prosthesis compared to 72% (*n*= 54) of those with below-knee amputations.

Rehabilitation physiotherapy was given to 215 (85%) of the patients on a regular basis, while 33 (13%) had not started the training at the time of the study.

3.1.4. Medical comorbidity

The amputees reported physical and psychological problems in relation to the limb loss. Pain was most common, typically phantom pain (103/245, 40.6%), back pain (84/254, 33.1%) and joint pain (87/254, 34.3%). The dominant psychological problems were insomnia (69/254, 27.2%), anxiety (79/254, 31.1%) and feeling depressed (46/254, 18.1%). By using multiple correspondence analysis (MCA), we found that some complications occurred more frequently in conjunction with one another. Joint, back and phantom pain occurred frequently together, as did depression, anxiety and sleep disturbances (Figure 4).

3.1.5. Increased workload on the exhausted healthcare system

This patient group increased both the acute and long-term workload of the already exhausted healthcare system in Gaza. The 254 patients included in this study increased the caseload of the rehabilitation center by 28%.

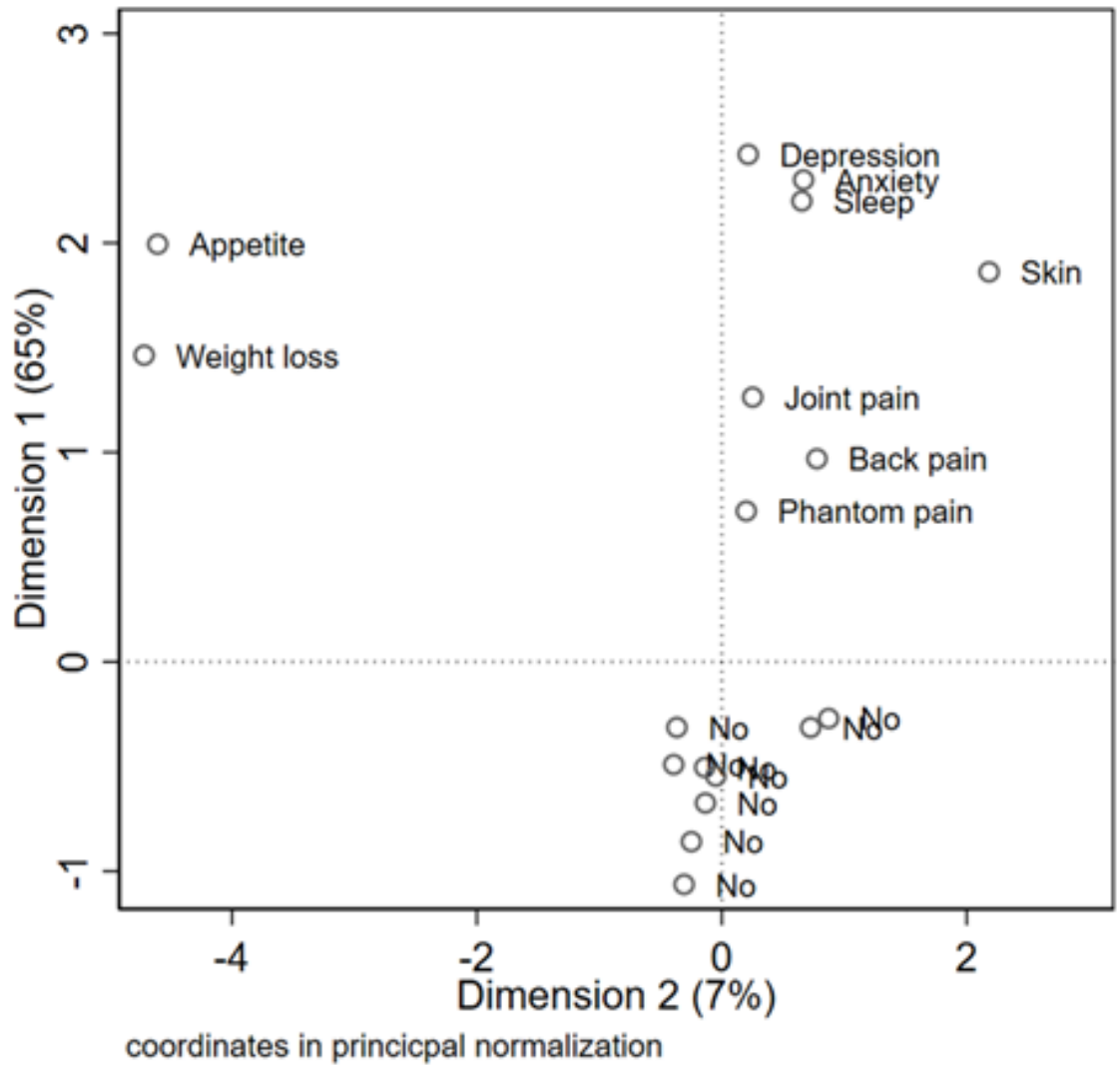

Figure 4. Relationships between long-term complications and frequencies (N = 254).

Dimension 1 and 2 from multivariate correspondence analysis (MCA), using the Burt matrix and principal normalization. "No" is an indicator for all the asymptomatic patients having, for example, "no depression", but as this asymptomatic group tends to have few of any of the symptoms, markers have been removed for visual reasons. MCA uses a contingency table to identify related categorical variables, and the method of principal normalization used both rows and columns. The symptoms close together tend to co-occur more frequently.

Note: This figure was adapted from **paper I**.

3.2. Paper II

3.2.1. Mechanisms of injuries

More than half of all patients reported that drone strikes had caused their amputation(s) (136/254, 53.5%). Weapons delivered from drones, typically explosives, had caused the amputation in eight out of the 19 (40%) female amputees and in 14 of the 136 children (10%) (Table 2 and figure 5). Weapons delivered from tanks had caused the amputation(s) in 28 of 254 patients (11%). Unexploded ordnance (UXO, weapons exploding long after being deployed) had caused amputations in 23 of 254 patients (9%). In two patients (0.8%), the amputation injury was caused by Palestinian rockets fired from Gaza aimed at Israel.

Table 2. Weapon delivery method causing amputation injury (N = 254)

Weapon delivery	Number of patients	Percentage
Drone strike[a]	136	54
Helicopter (Apache)	6	2
Aircraft (manned)	9	4
Artillery shell	7	3
Cannon shell	9	4
Naval shell	3	1
Other shelling injury[b]	7	3
Tank shell	28	11
UXO[c]	23	9
Landmine	2	0.8
Gunshot wound[d]	12	5
“Friendly fire”	2	0.8
Unknown/missing	10	4

Note: Table adapted from **paper II**. Abbreviations: N, number of participants; UXO, unexploded ordnance.

[a] Drone strike: weapons delivered from an unmanned combat aerial vehicle.
[b] Other shelling: the patient only reported shelling, but did not specify.
[c] Leftovers that explode in the aftermath of war, often when clearing up attacked premises.
[d] Not included in multivariate analyses.
[e] ‘Friendly fire’: Palestinian rockets fired from Gaza intended to reach Israel.

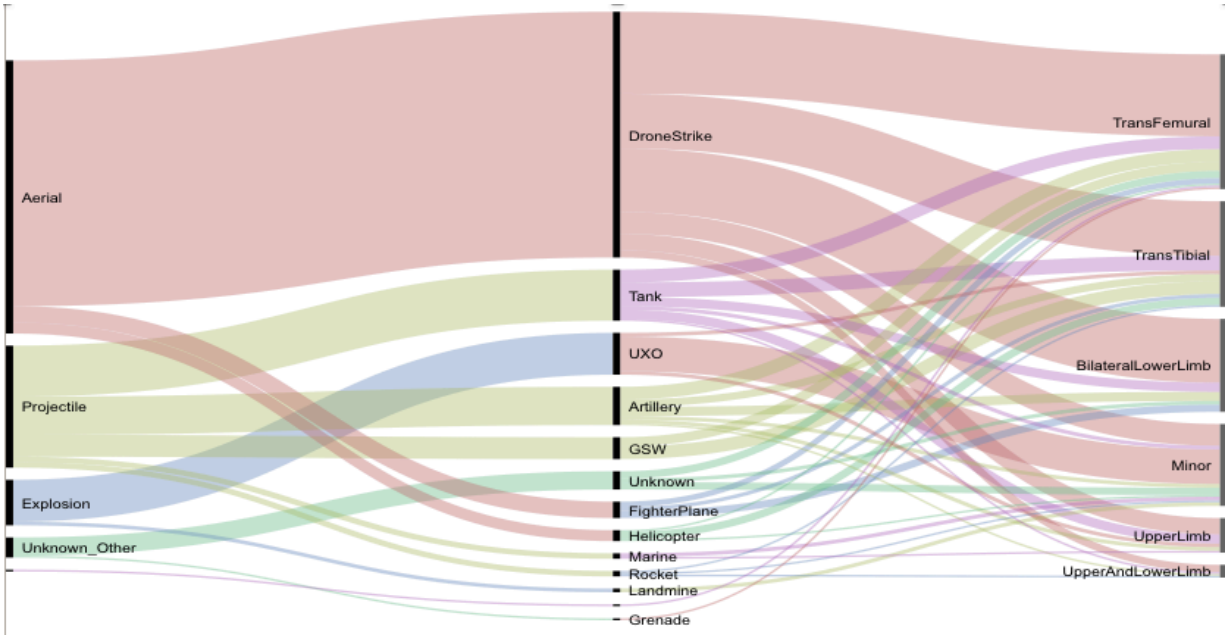

Figure 5. Weapon delivery methods vs. types of extremity amputations.

Data based on 254 Palestinian patients with traumatic extremity amputations following use of Israeli explosive weapons in Gaza. Drone strike: weapons delivered from an unmanned combat aerial vehicle. UXO: unexploded ordnance, also known as "war rubbish", that explodes in the aftermath of war, often during clean-up. Fighter plane: military F-16 jet airplanes. Helicopter: military Apache attack helicopter. Marine: shelling from naval vessels. Unknown: patient is not aware of the type of weapon. GSW: Gunshot wound. Note: This figure was adapted from paper II.

3.2.2. Amputating injuries following drone strikes

Explosive weapons delivered by drone strikes caused the most severe amputation injuries. Drone strikes caused the worst traumatic amputations when compared to other explosive and shelling injuries, adjusted for age and gender (OR 2.49, p = 0.001) (Table 3). An odds ratio of 2.5 is equivalent to an eight percent increase in the relative probability of having a higher severity category when a traumatic amputation is caused by a drone strike (Figure 6).

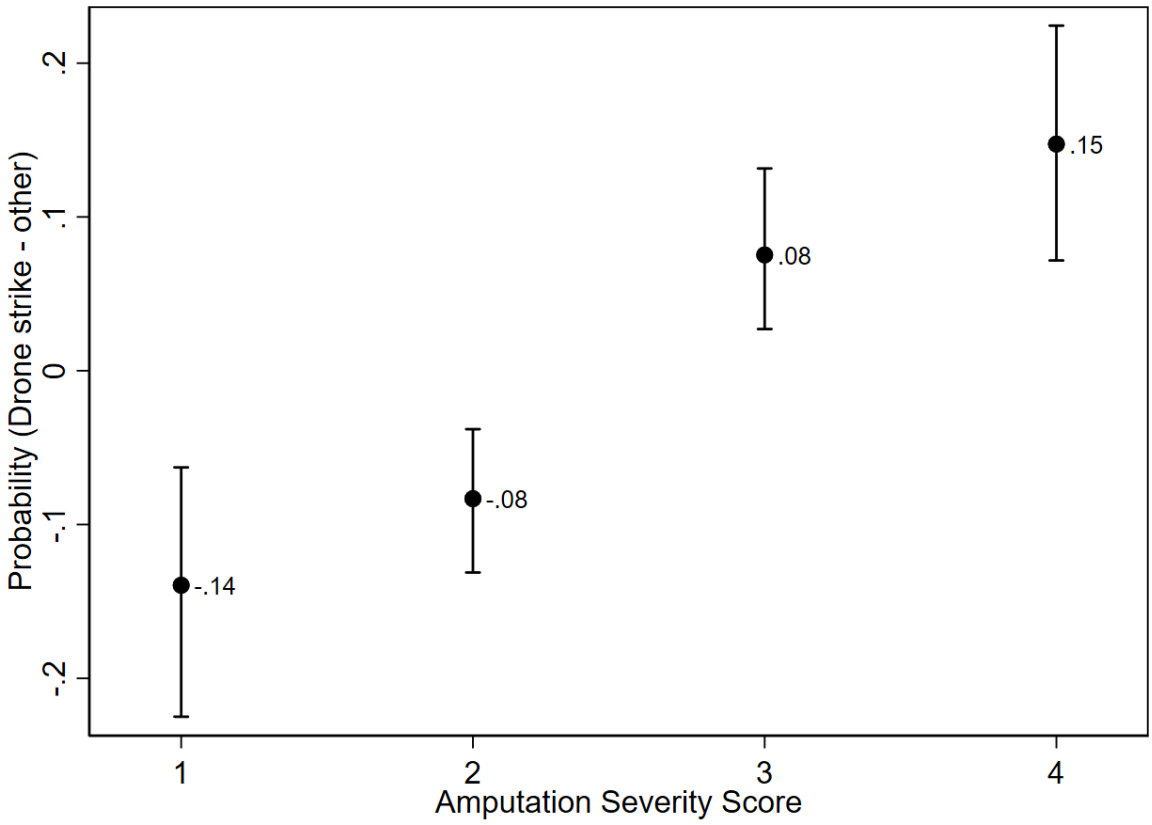

Figure 6. Difference in probability of drone strike vs other weapons for each severity level of extremity amputation.

Results from 232 participants. Twelve out of 254 Gaza Palestinians amputated following gunshots are excluded as are ten non-responders. The severities of amputations were classified on an ordinal scale (1 = fingers, toes, hands and feet, 2 = below knee or elbow, 3 = above knee or elbow, 4 = bilateral amputation, amputation in both lower and upper extremities or unilateral amputation at hip/shoulder level). The figure displays the difference in probability between a drone strike and other weapon causing an amputation(s) at each severity level. Abbreviations: N, number of participants. Note: This figure was adapted from **paper II**.

3.2.3. Drone strikes and needs for surgical treatment

Patients with amputations following drone strikes needed significantly more surgical interventions following the initial trauma than patients amputated by other weapons. Fifty-three patients needed more than ten surgical operations following their initial injury. Of these, 37 (70%) patients had been amputated by explosive weapons fired from drones (Table 4).

Table 3. Drone strikes predict severity of extremity amputation injury in Gaza[a] (N = 232)

Variable	OR	95%CI	p-value
Age[b]	1.04	0.52-2.07	0.918
Male	1.69	0.70-4.10	0.243
Drone Strikes	2.50	1.52-4.11	<0.001*

Note: Twelve patients with gunshot wounds were excluded. There were 10 non-responders. This table was adapted from **paper II**.

Abbreviations: OR = Odds Ratio, 95% CI = 95 per cent confidence interval.

[a] Ordinal regression with injury severity as the outcome. Scale: 1 = finger, toes, hands, feet; 2 = below elbow or knee; 3 = above elbow or knee; 4 = bilateral amputation, upper and lower extremity amputation or at shoulder/hip level.

[b] log-transformed

* $p < 0.05$

Table 4. Drone strike injuries in Gaza require multiple surgical operations[a] (N = 229)

Variable	OR	95% CI	p-value
Age[b]	0.39	0.19-0.78	0.008*
Male	0.94	0.40-2.19	0.882
Drone strike	1.93	1.19-3.14	0.008*

Note: The table was adapted from **paper II**.

Twelve patients with gunshot wounds were excluded. Ten non-responders, operations unknown for three patients.

Abbreviations: OR = Odds Ratio, 95% CI = 95 per cent confidence interval.

[a] Ordinal regression with the number of operations as the outcome. Scale: see Table 1.

[b] log-transformed

* $p < 0.05$.

3.2.4. Periods of military incursions versus periods of ceasefire

Drone strikes caused amputation injury both during periods of ceasefire and during declared military incursions. One-hundred of the 136 cases (73.5%) of traumatic amputation caused by drone strikes happened during military incursions and 36 of 136 (26.5%) cases during declared ceasefires (Figure 7).

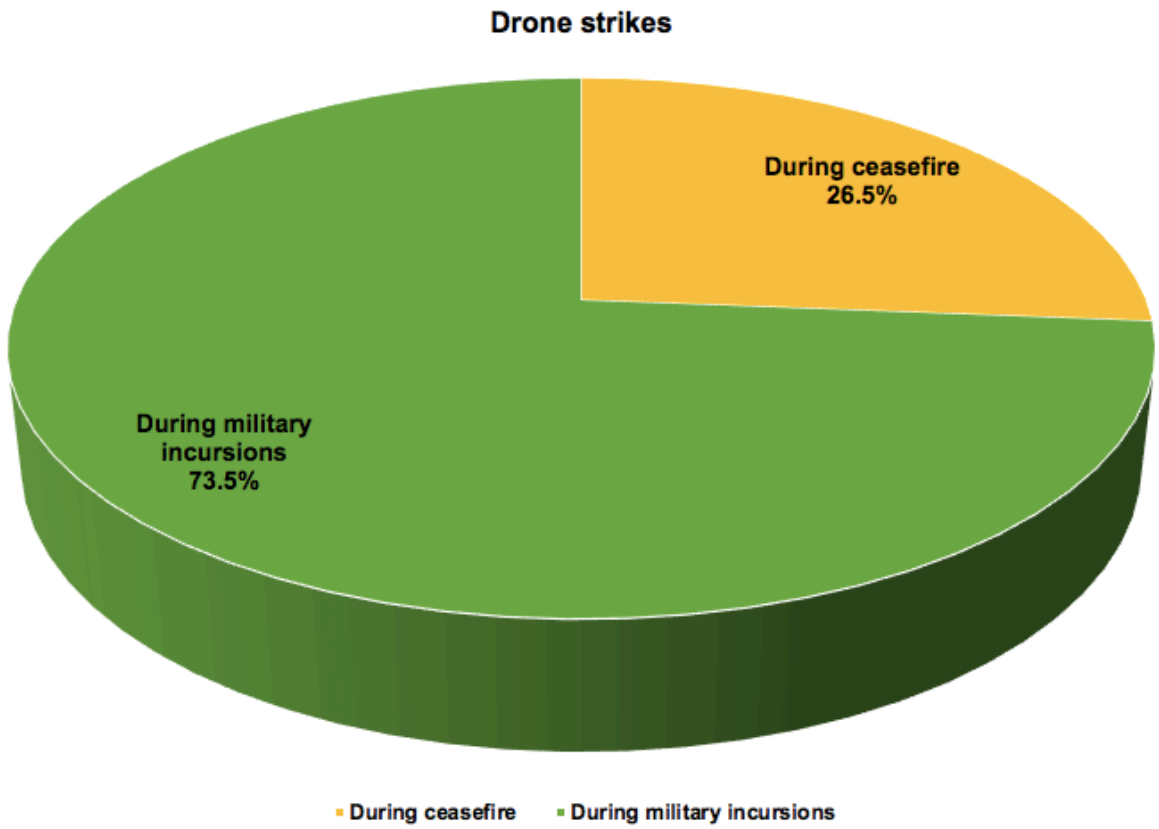

Figure 7. Drones strikes during periods of military incursion and during ceasefires in Gaza.
The figure is based on 136 amputees with injuries caused by explosive delivered by drone strikes. This figure was adapted from **Paper II**.

3.3. Paper III

3.3.1. Psychological distress and unemployment

Among the 191 (75%) unemployed patients, 112 (44%) reported that their unemployment was a direct result of the extremity amputation. More than half of the amputees (55%, n=135) had GHQ scores above the cut-off of 3 points indicative of psychological distress.

We found psychological distress to be higher among amputees who considered themselves unemployed due to the injury (OR 1.36, p = 0.011). In contrast, we did not find any association between the level of extremity amputation and level of psychological distress when assessed by GHQ scores (Table 5).

Table 5. Psychological distress among traumatic amputees in Gaza

	Crude model [a]			Adjusted model [b]		
	OR	95% CI	p	OR	95% CI	p
Unemployment due to trauma	1.36	1.07–1.72	0.011*	1.39	1.10–1.76	0.006*
Pain	1.35	1.12–1.65	0.002*	1.38	1.13–1.67	0.001*
Severity of injury				0.97	0.88–1.06	0.324
Family income				0.96	0.81–1.14	0.653
Loss of family members				1.06	0.80–1.37	0.687

Note: This table was adapted from **Paper III**. Psychological distress indicated by a binary cut-off at a GHQ-score ≥ 3.

Abbreviations: CI = confidence interval; GHQ = General Health Questionnaire; OR = odds ratio.

[a] Logistic regression adjusted for age and gender, with GHQ > 3 points as the dependent variable.

[b] Severity of injury, pain frequency and severity of injury added to the model described in [a].

* p-value < 0.05

3.3.2. Pain and poverty

One third of the amputees (n = 80, 32%) in our cohort suffered from daily pain.

The frequency of physical pain correlated with low family income, even after adjusting for the severity of the injury (OR 0.54, p=0.002, see Table 6).

Table 6. Pain severity among traumatic amputees in Gaza

	Crude model a			Adjusted model b		
	OR	95% CI	p	OR	95% CI	p
Family income	0.54	0.36 - 0.80	0.002*	0.55	0.35-0.88	0.012*
Psychological distress	2.40	1.48 - 3.39	<0.001**	2.39	1.42-4.02	0.001*
Severity of injury				0.24	0.26-1.41	0.134
Unemployment due to trauma				0.91	0.44-1.89	0.808
Loss of family members				1.49	0.73-3.06	0.277

Note: This table was adapted from **Paper III**.

Ordinal weekly pain scale from 0 to 4: never, 1 day a week or less, 2-3 days, 4-6 days and daily.

Abbreviations: CI = confidence interval; OR = odds ratio.

[a] Crude model: Ordinal logistic regression adjusted for age and gender, with "Pain" as the dependent variable.

[b] Adjusted model: severity of injury, psychological distress and severity of injury added to the model described in [a].

* p-value < 0.05, ** < 0.001

3.3.3. Psychological distress and pain

The frequency of pain was significantly associated with the level of psychological distress (higher GHQ) among the patients. GHQ-12 scores were increased among patients with frequent pain (OR 1.35, p=0.002). In addition, self-reported pain was more frequent in patients with higher levels of psychological distress (OR 2.40, p<0.001).

3.4. Medical findings (unpublished material)

3.4.1. Study participants referred for further medical investigations

We found clinical symptoms of serious illness in 105 of the 254 patients with traumatic amputations. These patients were referred to Al-Shifa Hospital. The majority of the referred patients where young (median age 31.5 years) and male (88/94, 92.6%). More than half (48/94) of the total referred patients had been amputated in drone attacks. The patients presented a variety of symptoms and findings: 24 had symptoms from the abdomen, 27 patients had problems with natural functions (urinary tract and bowel system dysfunction), while ten had symptoms from the lungs. Sixty-one patients presented general reduced condition with symptoms including night sweats, malaise, self-reported long-term fever, self-reported weight loss and reduced appetite.

In twenty patients, we found ulceration, palpable lumps or pain in the amputation stump. We found palpable and enlarged lymph nodes in 39 of the patients (Figure 8).

3.4.2. Radiology results

Ultrasound imaging showed 19 of 90 patients (20%) to have fatty liver. CT-scans revealed that three patients had chest nodules. Twelve patients had shrapnel in the chest, five had shrapnel in the abdomen and one had shrapnel in the scrotum. We found shrapnel in the stump of 26 patients' amputated limbs, while eight patients had shrapnel in a non-amputated limb. Three patients had liver lesions. Among the patients with liver changes, 14 of 19 (73.7%) had been amputated in drone attacks. Enlarged lymph nodes were found in six patients on chest CT (six axillary and one brachial, Figure 9).

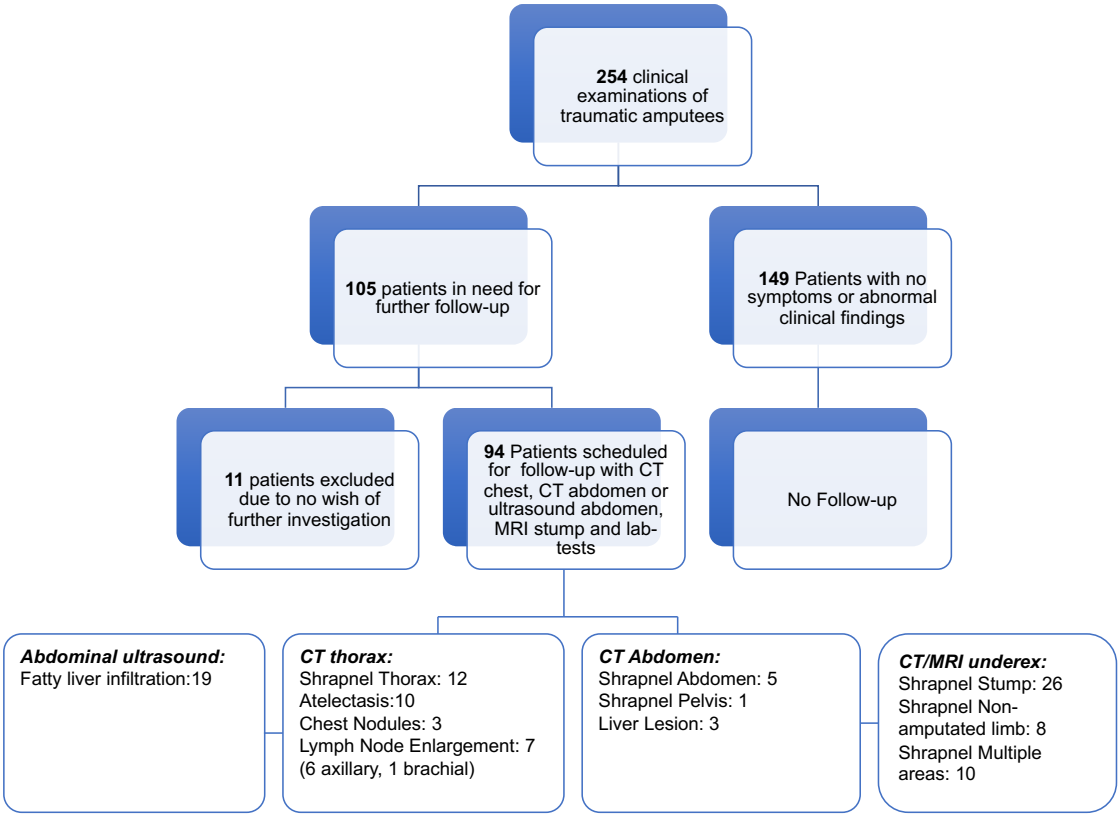

Figure 8. Patient distribution

Number of patients referred to secondary care and the results of the medical follow-up.

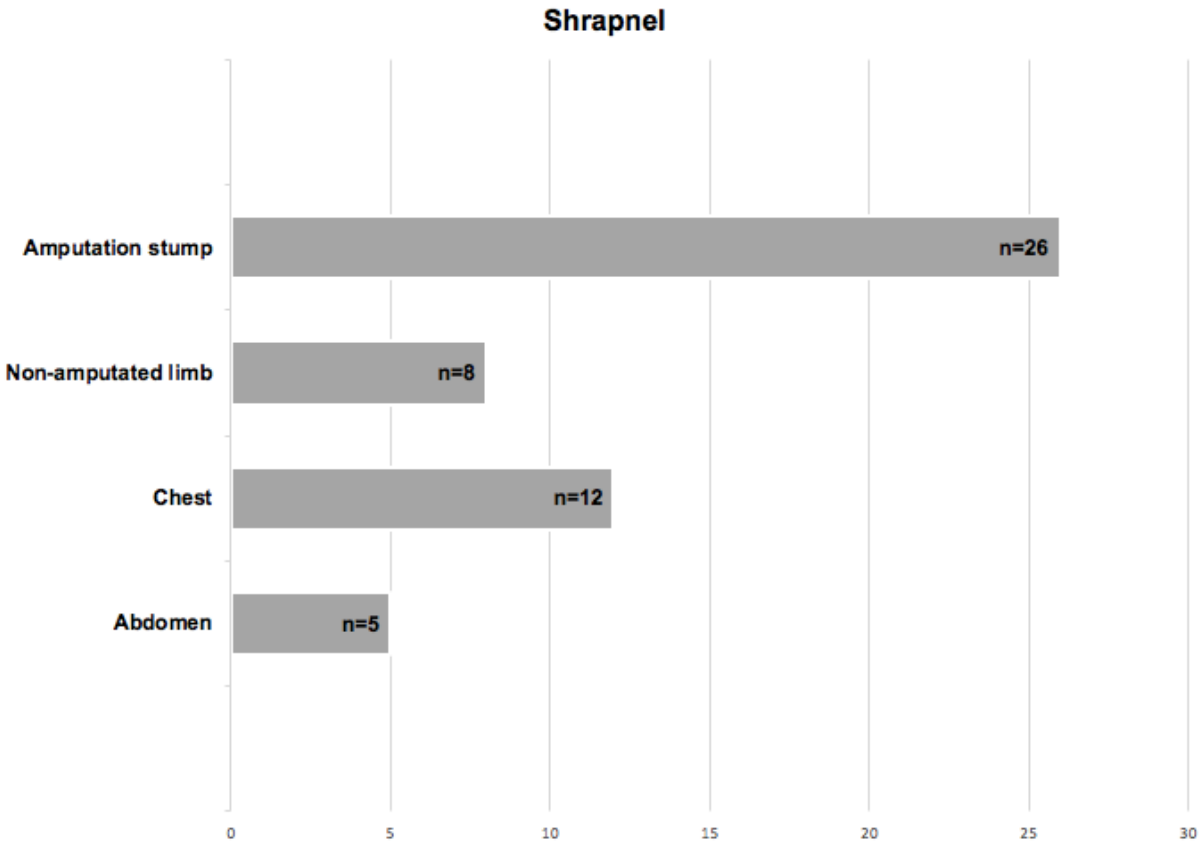

Figure 9. Shrapnel.

Distribution of the total amount of embedded shrapnel in body tissue among 94 traumatic amputees referred to Al-Shifa Hospital for follow-up.

4. GENERAL DISCUSSION

4.1. Principal findings

These studies show the impact of military attacks on a young civilian population living under siege, blockade and military occupation. The survivors have severe and extensive physical as well as psychological and psychosocial trauma. The trauma become collective trauma for themselves, their families and their communities.

We found that explosive weapons delivered during military drone strikes were the most prevalent cause of traumatic extremity amputations. Drone attacks also caused the most severe amputations. The need for surgical operations following drone strikes was significantly higher than for the amputees injured by other explosive weapons. Mental distress and pain was associated with unemployment following loss of limb(s) and the ensuing deterioration in the family income. In addition to the loss of limb(s), the amputees suffered the loss of homes, jobs, family members and friends.

4.2. The extremity-amputated survivor of military incursions

4.2.1. Young, well-educated males with large financial responsibilities

The majority of the studied patients were young males who had suffered amputations affecting their lower extremities. The injuries were severe. One in five suffered bilateral lower leg amputations. In addition to the mere loss of their limb(s), the amputees frequently reported loss of family, loved ones, income and housing. Thirteen percent of the patients had lost one or more family member and 4% of the patients had lost one or more children. Close to half of the amputees in our cohort had in addition lost his/her home in one of the military attacks. At the time of the study only 11.6% of their destroyed homes were rebuilt (**Paper I).**

The strain on the local Palestinian health care system has been heavy, with one in five amputees needing more than ten surgical interventions after the initial trauma.

Our findings also illustrates the complexity of the extremity amputation injuries. Above knee (AK) amputations were found in one third of the patients. These patients had more troubles having a suitable artificial limb fitted. Fifty-nine percent of AK amputees were using artificial limbs, compared to 72% of those amputated below knee (BK). Artificial limbs are known to be more difficult to fit for AK amputees.[69,70] (**Paper I).**

The preventable, man-made traumatic amputations continue to affect Gaza's young civilian population. Since March 30th 2018 the weekly mass protests in Gaza - '*The Great March of Return'* demanding the right of return for Palestinian refugees to their homes - has been met with heavy military measures from IDF. Two-hundred and seventy-seven Palestinians have been killed and 31,214 injured in these protests by mid-May 2019. More than 100 Palestinians have been amputated following IDF-soldiers use of live ammunition. The United Nations Human Rights Council (UNHRC) reported in February 2019 that the IDF's military response to the protestors may be regarded as crimes against humanity.[71,72] The large number of wounded people from the weekly demonstrations who need reconstructive surgery, external fixation and treatment for post-amputation infections is almost insurmountable for Gaza's already severely strained healthcare system.[73]

Also Gaza's latest extremity amputees are likely to suffer from the same medical and psychosocial burdens as the survivors described in our studies. Phantom, joint and back pain and a deterioration in the family finances will also be their burdens after traumatic amputation.[14,15,74] (**Paper I**).

4.3. Drones

4.3.1. "Zanana"

Use of explosive weapons fired from military drones were found to be the most common cause of extremity amputation injury in our study participants (Paper II). Drones were also responsible for the most severe amputation injuries and for the injuries requiring most surgical treatment. The Palestinians in Gaza call the drones "Zanana", the Arabic word for wasp, due to the buzzing sound they make as they almost constantly fly over the Gazan skies. Israeli authorities claimed that the IDF used "precision-guided aerial strikes" to "minimize civilian casualties" during the 2014 military incursion in Gaza.[75] Quite the opposite seems true as seen from Gaza, where these military drones cause the most serious of the traumatic amputation injuries among the civilians we studied. Our results must be seen in the context of the increased use of military drones. Our findings challenge the widely-held view that drone-delivered explosives are more precise, lead to fewer civilian casualties, and are claimed to cause less "collateral damage".[76] (Paper II).

4.3.2. The IDF and drones

The IDF has used military drones for almost half a century. It started during the Yum Kippur war in 1973, followed by the war with Syria in the Bekaa Valley in 1982, during which Israeli drones were used for intelligence, surveillance and reconnaissance.[77]

In 1995, the US-based company General Atomics Aeronautical invented the Predator drone, which six year later, on 16 February 2001, fired a Hellfire missile (AGM-114 C) at a target. This gave military drones the capacity to carry out military attacks.[78] Israel has been the largest recipient of U.S military aid and weapons since the 1970s and U.S.-supplied weapons are regularly used in Israeli military incursions in Gaza.[79] There are large variations in the reported numbers of Gazan casualties from Israeli drone attacks. Estimates of the number of people killed by drone attacks in Gaza during the military incursion 'Operation Cast Lead' (2008-09) vary from less than 100 to more than 500.[80-82] The variations in the reported numbers of drone attacks and drone casualties may reflect both methodological problems and the secrecy of military drone programs.[83] (**Paper II**).

Still, their use is increasing, and the Israeli drones have become a painful part of everyday Palestinian life in Gaza.[35]

In his recent book, *"War against the people: Israel, the Palestinians and the global pacification",* the Israeli author Jeff Halper explains how the integration of military systems, such as databases tracking civilian activity, automated targeting systems, and unmanned military drones, becomes a seamless part of everyday life. And the occupied Palestinian territories (oPt), he argues, is a veritable laboratory for that approach.[84]

4.3.3. Increasing the workload of the local healthcare system

The repeated, often massive military attacks on Gaza result in mass casualties which are saturating and partly overwhelming the emergency capacity of the local Palestinian healthcare system. The ensuing trauma patients in need of advanced medical treatment and surgery are rushed to already over-stretched hospitals and clinics, where staff already were struggling to find medical supplies, spare parts, electricity and funding.[24]

More than 1,300 surgical interventions were performed on the 254 trauma patients we studied.[85] The need for surgical revisions was significantly higher in the patients amputated following drone strikes.[86] (**Paper II**). In sum, traumatic extremity amputations caused by

military drone strikes added significantly to the large workload on the already over-stretched local healthcare system in Gaza.[87]

Our findings are in accordance with previous studies from Pakistan and Afghanistan where military drones pose serious threats to lives of civilians.[88,89] (**Paper II**).

The 254 patients included in this study also increased the caseload of the ALPC by 28%. This demonstrates the significant impact war-related extremity amputations have on Gaza's physical and psychosocial rehabilitation systems in addition to the strain placed on the emergency medical systems (**Paper I**).

4.4. Psychosocial health and wellbeing among traumatic amputees in Gaza

We know that more than more than half of the amputees had GHQ scores indicating psychological distress, and that the psychological distress was higher among unemployed amputees (**Paper III**). This finding is in line with Giacaman's study conducted in Gaza, where poor family finances after periods of military offensive had a significant negative impact on mental health.[90] Chronic diseases were also significantly associated with poverty among civilians in Gaza.[90]

A poor financial situation can affect a person's of function in society.[90,91] In another study from oPt, Harsha et.al. found a high prevalence of elderly Palestinians in Gaza living with disabilities.[92] This group's socioeconomic situation should be taken into special consideration when trying to improve their health and wellbeing.[92] To only diagnose and treat mental distress in a society burdened with widespread and chronic human insecurity, can be seen as unethical. The underlying causes of mental distress must be changed in order to truly ease the everyday life of the Palestinians. It is imperative to recognize the social suffering as a result of limited human security and constant violations of human rights.[93]

Mental distress and suffering experienced in wartime can be seen as a normal reaction to an abnormal situation, rather than psychopathology, with *justice* being the best treatment.[94,95]

4.4.1. Pain

Daily pain was experienced by one third of the amputees. The frequency of physical pain correlated with low family income, also when adjusting for the severity of the injury (**Paper**

III). The same correlation between pain and ruined family income has been found in traumatic amputees from other LMIC, such as Cambodia and Kurdistan.[14] Studies on surviving landmine victims with traumatic extremity amputations demonstrated how psychological adjustment after amputation, recovery, level of pain, and acceptance of limb loss was correlated to the amputees' financial situation.[96] Living below or near the poverty line was also a significant risk factor for developing depression among US civilians after limb loss.[97]

We did not, however, find any association between the extent of the initial trauma, extent of extremity amputation and the level of psychological distress or frequency of pain. Is the poverty that follows the extremity amputation a more important long-term trauma than the amputation itself?

4.5. Medical findings need future studies

4.5.1. Embedded weapon shrapnel(s)

Among the 254 clinical examinations we performed, disturbing medical findings were discovered in 105 of the patients. Ninety-four of these 105 amputees were referred to Al-Shifa Hospital for further investigations in agreement with local health authorities (hitherto unpublished material). More than half (48/94) of the total referred patients had been amputated in drone attacks, and almost half of them had metal fragments from weapons embedded somewhere in their bodies. Retained embedded weapon metal fragments in war injuries has traditionally been thought of as harmless, and are seldom removed surgically.[43] However, research on cell-lines, lab animals and humans are providing increasing evidence of the opposite.[38-43] The American Armed Forces Institute of Pathology started in 2013 to collect longitudinal data of veterans with retained shrapnel in body tissue. This was due to the concern of hazardous health effects of embedded shrapnel, and the lack of clinical guidelines in the follow-up of the veterans.[43]

'Modern warfare' involves novel weapons that leave a range of heavy metals in body tissues of the targeted humans and the physical environment in general (water, soil, air).[1-5] A study from Gaza found traces of carcinogenic heavy metals in the wounds of survivors sustaining their traumatic amputations in 2006 and 2009.[98] A recent study found significantly higher heavy metal loads in hair samples from Gazan women exposed to military attacks than in

those from non-exposed women. The heavy metal load in new-borns' hair correlated with the load found in their mothers.[99]

Ultrasound of the abdomen revealed 20 percent of them to have liver changes with fatty infiltration. Due to religious reasons and the prohibition of alcohol in Gaza, we have ruled out alcohol as a likely cause of these liver changes. Non-alcoholic fatty liver disease (NAFLD) is an umbrella term for liver disease characterized by hepatic steatosis in patients with low or no alcohol consumption. The changes in the liver may progress to cirrhosis and eventually hepatocellular carcinoma (HCC).[100]

Our finding of such high prevalence of fatty liver disease was unexpected. Further investigations are needed in order to conclude.

4.6. Research difficulties in occupied territory

It is difficult to conduct research in an occupied territory under siege, exposed to repeated, heavy military incursions. Access to Gaza is strictly controlled and severely limited. Visitors as well as locals must enter it either at Erez on the Israeli border in the north or at Rafah on the Egyptian border in the south.[101,102] The Rafah crossing has unpredictable shutdowns and is difficult to cross.[103] Israeli military rule enforce that nobody can enter and exit at two different borders. If you cross into Gaza via Rafah, this is where you have to exit. This may take months, as the border is shut without warning.[104] To cross the Erez border, a special, personal Israeli military permit is required.[105] This permit can only be obtained through an application from an international NGO allowed to operate in Gaza. The application process is long and unpredictable. Entry permits are denied without further explanation.[105]

People who enter and exit Gaza face a number of restrictions. Individuals are not allowed to bring medical equipment which is not for personal use. Video cameras, hairdryers, and electric shavers are all on the same restriction list.[106] Every personal belonging is checked by Israeli border military police before you are allowed to enter or exit Gaza. It was impossible for us to bring biological samples and other research material out of Gaza. We could not expose researchers, patients or the material to the potential risks.

Between the Norwegian authors physical travels to Gaza, our Palestinian-Norwegian research group conducted a series of online Skype research meetings. The power supply to Gaza is

severely limited from the siege. The daily power outages can last up to 20 hours, which often affected our group calls by interrupting the Internet connection.[107] Lack of electricity is also a major problem for the healthcare sector. It took us more than a year to get the 94 patients through all of the clinical and laboratory tests at the hospital.[108]

Since 2012, we have participated in seven international scientific conferences where we presented our research and findings, orally and in poster sessions.[109] Our fellow Palestinian researchers from Gaza were denied permits to exit Gaza for six of these conferences.

4.7. Limitations

The three papers in this thesis describe the survivors from a macroscopic view. The microscopic details are still missing.

The lack of longitudinal data in our studies has limitations. Longitudinal studies provide continuous or repeated measures over long periods of time.[110] Some of the included patients had more recent traumatic extremity amputations, while others had lived with their amputation injury for years. Time from amputation would probably affect their ability to work **(Paper III).**

ALPC is the sole provider and manufacture of artificial limbs in Gaza. However, an increasing number of NGOs are now offering rehabilitation to amputees in Gaza. We can therefore not be sure we have a complete and fully representative sample of all traumatic amputees in Gaza **(Papers I-III).**

Minor traumas may never have been referred to the ALPC, and we have not elucidated the patients who were killed immediately or during the immediate post-trauma period. Our data therefore have a potential risk of selection bias.[111] The use of self-reported data in the studies is a general weakness we need to be aware of.[112,113]

The majority of the studied patients were male. This might indicate a non-civilian status for some of them. However, the gender pattern we found is not unusual in conflicts and the same gender patterns is also seen among children in Palestine.

United Nations documentation of fatalities among Palestinians and Israelis since the start of the second Intifada (September 2000 - July 2007) found a male predominance among Israelis and Palestinians; Israelis (69%) and Palestinians (94%).[114] Similar male predominance among children, with 87% of the Palestinian children killed being boys and 13% girls.[114]

During our discussions with local health care workers, it has been pointed out that Gaza is a paternalistic society where the roles of males and females are defined by certain social rules. Women tend to stay at home with the children, and are often indoors during ongoing attacks, while men must leave the home to seek food, water and other necessities, and thus be more exposed and vulnerable.

A research group where only half of the researchers speak and understand the native tongue of the patients in the study has certain obvious limitations. Important information may get lost in translation and there may be misunderstandings. All our studies were conducted in Arabic. We made sure that all written material was translated from English to Arabic and retranslated back to English to ensure accuracy. The translations were done by bilingual medical personnel fluent in Arabic and English.

We do not know the chemical composition of the shrapnel(s) embedded in the survivor's body tissue and the potential adverse health effects such weapon residuals pose.

5. THE FACES BEHIND THE NUMBERS

This thesis is based on the work published in three scientific articles. In these articles, the stories of survivors living with severe traumatic amputation under siege and occupation are told with the scientific language, with confidence intervals and p-values. The survivors are more than numbers.

Mohammad

"27. April 2018 was named the Friday of Youth. Hundreds of protesters gathered at the eastern and northern border of Gaza on this day. The protest this Friday was meant to honour the protestors who had been shot and killed in the weeks before. The electricity was gone for 16 hours daily in this period. I was a law student and 28 years old. I went to the eastern border area, Malaka, with my friends. It was a peaceful march. We went there to remember those who had been killed and to demand the right of return to Palestine, our homeland.

An expanding bullet hit my right leg below the knee. I was rushed to Al-Shifa hospital.

Because the bullet was an expanding bullet, my artery was torn. The doctors did an attempt to make an artery graft of my saphenic vein. This failed and my right leg was amputated below my knee. I had a massive bleeding and I felt weak as my haemoglobin dropped to 7.0. I received eight units of blood and stayed in the intensive care unit for six days. I suffered from an infection and became septic. I am grateful to Allah who chose to let me live. Now I try to give something back to my society. I travel to Al-Shifa every day to visit others who lost their limbs in the march. I am trying to be a psychological support for them.

What about yourself? How are you coping?

I love to swim. Now I cannot swim. I try to work out as much as I can, I want to stay healthy, but I fear no one will ever marry me".

According to Palestinian Health Authorities three people were killed, 611 wounded and 138 hit by live fire on 28.th April 2018.[115]

Mohammad 28 years old June 2018

Photo: Mohammed Dwema, ALPC

Abdallah

Abdallah is 13 years old. I meet him in his home with his two brothers, mother and father. His little brother cannot stand the sound of the Israeli warplanes. He starts to cry and becomes restless when they roar above their house. Abdallah lives close to Gaza's East side. He and his friends went to the fence area and the demonstrations one Friday in May 2018. His parents were not aware that their young son had left to join the group of young boys this Friday. Abdallah and one of his friends decide to cross into the Israeli side of the fence. They wanted to take down one of the many Israeli surveillance cameras on the fence. They made it all the way up close to the camera, climbing a small wall to reach the camera. "We were about to take it down when the soldier came. He was two meters away from us. He looked us in the eyes as he shot my friend in the chest. I was shot in my left leg. The soldier carried me back to Gaza. He left me to bleed in front of my friends. I remember how one of my friends kept saying he was sorry. He said "Please forgive me. I cannot reach you. I am so sorry. I can´t. I am sorry". I think the soldier understood I would die. He lifted me up over his shoulder and brought me back to the Israeli side. An Israeli helicopter took me to a hospital in Israel". Abdallah spent 16 days in the Israeli hospital. It took two days before his parents were notified. Abdallah says the nurses and doctors treated him with respect and were nice. They tried to save his leg, but it was in vain. He is now amputated at the level of his hip and it is impossible to have an artificial limb fitted. When I meet him he is in a wheelchair. A US-based NGO has offered him treatment in USA, but his parents cannot pay for their journey.

Abdallah, 13 years old, June 2018

Photo: Mohammed Dwema, ALPC

Abu Shaera

“I am not Hamas. I am not Fatah. I am Abu Shaera.“

He is 58 years old. Retired and has three sons. “I heard about President Trump’s move of the American Embassy to Al-Quds. I am usually not interested in politics, but Al-Quds is my capital and I had to stand up for my capital. Who would not?“

On May 14th 2018 he joined the Great March of Return at Gaza’s Eastern fence.

“I was standing in the back of a group of people. I heard and smelled something I did not understand what was. I raised my arms towards the sky and received my left leg. I held it in my arms without realizing this was my own leg. I don’t remember much after this. But I have been told I almost died. My haemoglobin level was three and I was given 28 units of blood. I was in a shock because of the blood loss and lucky to survive.”

He is suffering from daily, severe pain. His doctors in Gaza has applied for a transfer to Makassad Hospital in East Jerusalem. They consider that he needs more advanced surgery outside of Gaza.

“Now I am waiting. I am waiting for Allah’s and Israel’s approval to be able to leave Gaza to go to hospital“.

Abu Shaera 58 years old June 2018

Photo: Mohammed Dwema, ALPC

6. CONCLUSION

Survivors of war-related traumatic extremity amputations in Gaza are typically young, well-educated Palestinian males with large financial and family responsibilities. Most of the survivors suffer major amputations, and their injuries seriously incapacitate them. In addition to the traumatic amputation, many survivors also see the destruction of their homes, loss of family members and friends, and a significant deterioration in their total financial situation.

Weapons delivered during military drone strikes caused the majority of traumatic extremity amputations in surviving Palestinian victims from 2006-2016, both during various Israeli military incursions and during the periods of 'ceasefire' in Gaza. Our findings support the impression that drone strikes increasingly affect civilians living in war-zones and areas of armed conflicts. Our findings support arguments for restrictive formal rules on the use of armed drones and a clear humanitarian legal framework to limit the use of these weapons against civilians.

Following 11 years – and ongoing - siege and recurrent military incursions, living conditions in Gaza are severely deteriorated. Losing the ability to support and feed one's family and living in the poverty that follows war-related extremity amputations may be a more significant trauma than the physical amputation itself.

To ameliorate the needs of the population of traumatic war-related extremity amputees, we must address the underlying reasons for their suffering. Lack of human security and protection from military attacks, and the increased poverty, may be some of their most significant trauma.

The unexpected radiological and clinical findings among the amputees in this study require further investigation. It is important to further study the chemical composition of the metal shrapnel(s) embedded in the amputee's body tissue in order to better understand potential health risks of these weapon residuals. We can neither confirm nor reject possible systemic effects of heavy metal contamination from the remains of explosive weapons in the body tissues of Palestinian patients who survived traumatic extremity amputations during military incursions on Gaza. Hence, we conclude this thesis with a number of important, but still unanswered questions.

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8. APPENDIX

1. Paper I-III
2. Examples of informed consent forms in Arabic (from three patients telling their stories in this Thesis)
3. Norwegian REK consent form
4. Questionnaire for the study patients (English)

List of enclosed papers

Paper I: Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik, N, Giil, LM, & Gilbert MF. **Life after conflict-related amputation trauma: A clinical study from the Gaza Strip.** BMC International Health and Human Rights. 2018;18(1):34. doi:10.1186/s12914-018-0173-3

Paper II: Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik N, Giil, LM, & Gilbert MF. **Traumatic amputations caused by drone attacks in the local population in Gaza: a retrospective cross-sectional study.** The Lancet Planetary Health. 2019;3(1):e40-e47. doi:10.1016/S2542-5196(18)30265-1

Paper III: Heszlein-Lossius HE, Al-Borno Y, Shaqqoura S, Skaik N, Giil LM, & Gilbert MF. **Does pain, psychological distress and deteriorated family economy follow traumatic amputation among war casualties? A retrospective, cross-sectional study from Gaza.** BMJ Open. 2019;**9**:e029892. doi:10.1136/bmjopen-2019-029892

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Life after conflict-related amputation trauma: a clinical study from the Gaza Strip

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Abstract

Background: More than 17.000 Palestinians were injured during different Israeli military incursions on the Gaza Strip from 2006 to 2014. Many suffered traumatic extremity amputations. We describe the injuries, complications, living conditions and health among a selection of traumatic amputees in the Gaza Strip.

Methods: We included 254 civilian Palestinians who had survived, but lost one or more limb(s) during military incursions from 2006 to 2016. All patients were receiving follow-up treatment at a physical rehabilitation center in Gaza at the time of inclusion. We measured and photographed anatomical location and length of extremity amputations and interviewed the amputees using standard questionnaires on self-reported health, socioeconomic status, mechanism of injury, physical status and medical history.

Results: The amputees were young (median age 25,6 years at the time of trauma), well educated (37% above graduate level), males (92%), but also 43 children (17% ≤ 18 years). The greater part suffered major amputations (85% above wrist or ankle). Limb losses were unilateral (35% above-, 29·5% below knee), and bilateral (17%) lower extremity amputations. Pain was the most frequent long-term complaint (in joints; 34%, back; 33% or phantom pain; 40·6%). Sixty-three percent of amputees were their family's sole breadwinner, 75·2% were unemployed and 46% had lost their home. Only one in ten (11·6%) of the destroyed homes had been rebuilt.

Conclusions: The most frequently observed amputees in our study were young, well-educated male breadwinners and almost one in five were children. Conflict-related traumatic amputations have wide-ranging, serious consequences for the amputees and their families.

Keywords: Amputees, Gaza, Israel, Military incursion, Modern warfare, Palestine, Trauma

Background

During four major Israeli military incursions (Operation Summer Rain 2006, Operation Cast Lead 2008–09, Operation Pillar of Defense 2012, Operation Protective Edge 2014), around 4000 Palestinians were killed and over 17.000 injured (2006: 412 killed/ 1264 injured, 2009: 1383 killed/> 5300 injured/, 2012: 130 killed/1399 injured, 2014: 2251 killed/11231 injured) [1–3]. Many survivors lost one or more limb(s). Mechanisms and severity of amputation injuries as well as the living conditions and health of the amputees in Gaza has to our knowledge not been systematically studied. The literature on conflict related trauma is mainly focused on military personnel, not on civilians, making comparison with previous studies difficult. More in depth studies on the civilians in Gaza with conflict related amputations has been called upon by health professionals [4]. Non-peer reviewed articles and human right groups reports on the civilian consequences of conflict related amputations are available, many of them from war-torn areas in Afghanistan and Pakistan. In Afghanistan the country's growing number of amputees face harsh living conditions with financial and social deterioration [5].

Studies conducted on military personnel has provided knowledge on the long-term medical complications from conflict related amputations occurring in combat.

In a cross-sectional study on traumatic amputee veterans from the Vietnam war and Operation Iraqi

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Freedom, the most frequently reported long-term complications were chronic back pain (36.2% and 42·1%), phantom pain (72·2% and 76%), and residual-limb pain (48·3% and 62·9%) [6]. In a retrospective study on traumatic amputations, the amputees were found to have a near doubled risk of infections, septicemia, anemia, and thromboembolic disease compared to those with extremity injuries without amputation [7]. Poor mental health is prevalent among amputees with low education [8]. Chronic pain syndromes are common among civilian victims of traumatic extremity amputations caused by landmines [9]. The strain placed on the Gazan healthcare system from repetitious military attacks has in previous studies been highlighted as severe [10]. Gazans require referral permits to access more advanced medical care outside of Gaza, and reports from human rights observers are indicating that the approval of such referrals are hard to obtain and in general decreasing [11]. Complicated access to adequate treatment may hamper possibilities for healing and recovery with further burdens for the amputees. We hypothesize that the personal losses of amputees are reaching beyond the sheer loss of limb(s).

The aim of our study was to describe extent and consequences of traumatic amputations among Palestinians in the Gaza Strip attending rehabilitation. We recorded mechanisms of injury, severity of amputations, post-amputation complications, living conditions, and psychosocial trauma in a population of civilian amputees followed up in the main rehabilitation center in Gaza, The Artificial Limb and Polio Centre in Gaza City (ALPC).

Methods

Study participants

We included Palestinians in Gaza who had one or more traumatic amputation(s) caused by a weapon in the time frame 2006–2016. This period was chosen because it includes four major military incursions. The cross-sectional study was conducted from June 2014 to December 2016. Among 1170 patient records screened at ALPC, 254 patients met our inclusion criteria, while 915 were excluded because amputations were not war related or happened prior to 2006 (Fig. 2).

This study followed a pilot study of 90 patients (June--Nov. 2014) from the ALPCs patient register who were the first 90 found to meet the inclusion criteria. The 90 patients were invited to participate by one phone call made by a health secretary at the ALPC. The response rate in the pilot group was 99%. Following the pilot study, we proceeded to invite all patients from the ALPC register who met the inclusion criteria. ALPC is the only producer and provider of artificial limbs in Gaza. The center offers good physical facilities patients could be examined and interviewed, running water and stable power supply thanks to well-functioning generators supplying electricity during the daily power outages caused by the on-going siege of Gaza. The ability and permission to have the ALPC as the study center had significant security advantages. Here, researchers could meet the patients in a set and relatively safe place. Also, this avoided travels for researcher's home visits in situations when there was ongoing attacks or incursions. All services offered by ALPC to the amputees in Gaza is free of charge and access to treatment was independent of the patient's financial status.

An experienced physician examined each patient and recorded his or her physical status and medical information. The patients were given printed questionnaires in Arabic, designed for yes/no answers or for Likert-scale graded answers. The questionnaires assessed the mechanism of injuries, socioeconomic status, amputation-related complications, co-morbidity, use of artificial limbs, and ongoing therapy. The questions were quality assured by translation-retranslation between English and Arabic. Two well validated forms were used: the 12-question General Health Quality survey (GHQ-12) and Short Form Health survey (SF-36) [12, 13]. The questionnaire assessing amputation-related complications was inspired by the questionnaire made by Reiber, McFarland, Hubbard, et al. in their study *Servicemembers and veterans with major traumatic limb loss from Vietnam war and OIF/OEF conflicts: survey methods, participants, and summary findings*.[1]

The patients completed the questionnaires prior to meeting with the study physicians. One of the investigators read the questions out loud when examining illiterate patients. The procedures for study inclusion are summarized in Fig. 1.

Ethics, consent and permission

The ALPC location was chosen as the local study base in accordance with the local health authorities, the board of Gaza's main hospital, Al-Shifa Hospital (Gaza's trauma center), and the ALPC director. All patient completed written consent prior to participating. The study was approved by the Regional Ethical Committee (approval number: 2016/1265/REK Nord) in Norway and the Committee for Helsinki ethics approvals in Gaza. All participants' roundtrip travel expenses to ALPC were reimbursed.

Clinical examination

A standardized clinical examination was performed with measurement of heart rate, blood pressure, height and weight as well as auscultation of heart, lungs and examination of the abdomen. The amputation stump(s) were examined for ulcerations, pain, and tumors. Each stump was photographed and photos labelled with a unique patient number.

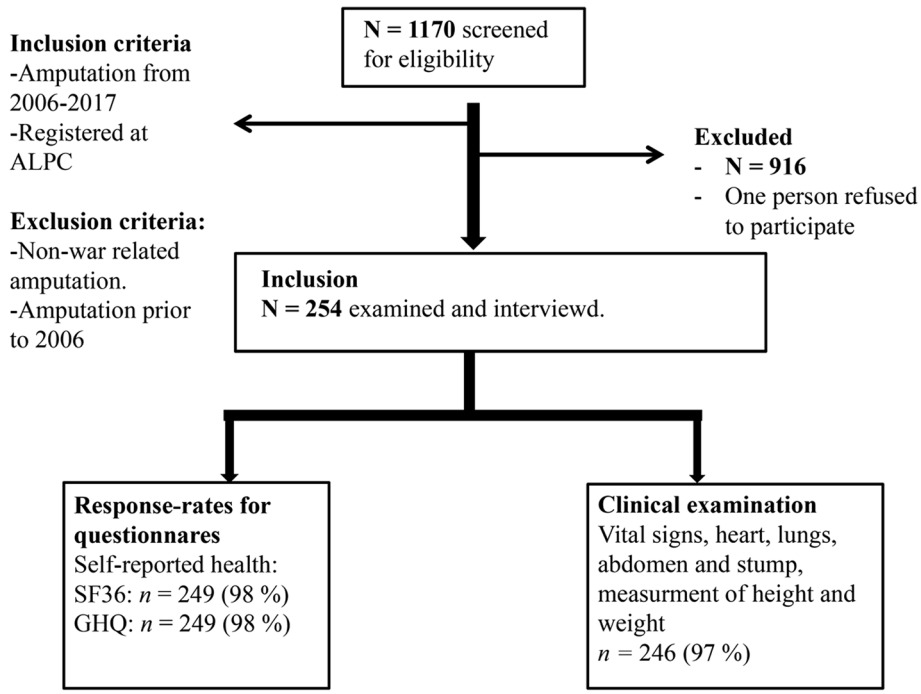

Fig. 1 Inclusion of study participants. *N = 1170. ALPC: Artificial Limb and Polio Center, Gaza's main rehabilitation clinic where patients were selected for participation

The questionnaires

The 12-item general health questionnaire (GHQ-12)

The GHQ-12 is a 12-questions screening tool commonly used to detect mental illness in the general population in a community. It is self-administrated and easy to complete. The Arabic version has been validated for use in Arab-speaking patients and used to map occupational stress among hospital nurses in Gaza [13, 14].

The thirty-six item short form survey (SF-36)

The SF-36 is a multi-purpose, short-form self-administered questionnaire with 36 questions. Items are organized to give an eight-scale profile-score of health and well-being [12]. The results are presented with one summary of physical components and one with mental health components.

Socioeconomic status

Socioeconomic status was assessed by asking the participants about their level of education, family situation, number of persons in the household, the number of siblings, employment, perceived reasons for unemployment, income, family income, and the number of dependents. In addition, the destruction and reconstruction of the patients' homes were recorded.

Personal loss

Twelve patients had been interviewed and examined prior to the start of the military incursion "Operation Protective Edge" July–August 2014. Patients included after this were asked about their specific experiences during this period. Patients spoke freely with the examining medical doctor about their personal losses and loss of spouse, children, other family members and/or friends.

Mechanisms of injuries

Each patient was asked to report on types and modes of weapon or explosive they knew or believed to have caused the injury leading to the amputation. The patients told the interviewer about witnesses, hospital reports and their own knowledge of various weapons used. The Palestinian residents of Gaza have experienced multiple, recurrent military attacks, and are used to differentiate between different weapons and weapon carriers. The various weapon delivering systems (attack helicopters, fighter jets, naval artillery, tank artillery, drones etc.) and their potential for trauma will be subjects in later publications.

Level of amputation

The level of each extremity amputations were examined and classified as above or below the concomitant extremity joint.

Major amputations were defined as limb amputations above wrist or ankle. Minor amputations were defined as amputations below wrist or ankle. The examining

physician recorded amputation levels by drawing on an anatomical sketch for each patient.

Statistics

Descriptive statistics are reported as mean and standard deviation (SD) for parametric data, median and interquartile range (IQR) for non-parametric data. We consider a p-value < 0·05 statistically significant. Frequencies are reported as percentage of the total study population for groups and subgroups. Alluvial flow diagrams are used to visualize complex relations between categorical variables. We assessed medical complications by multiple correspondence analysis (MCA) with principal normalization. In MCA, one seeks to identify the relationships between the measured matrices and potential latent variables. MCA uses the contingency tables as the matrix of relation and answers which of the multiple complications that are related to each other. Data analysis is conducted in SPSS Statistics version 22.0 (SPSS Inc., Chicago, IL, USA) and STATA 15 (StataCorp. 2015. *Stata Statistical Software: Release 15*. College Station, TX: StataCorp LP), with graphical displays from RAW Graphs (https://rawgraphs.io/about/).

Results

Patient demographics and war-related loss

The study-population included 254 Palestinian patients with traumatic extremity amputations residing in Gaza. All had rehabilitation treatment with fitting of artificial limb(s), physiotherapy and training at the ALPC. Patient characteristics are described in Table 1.

Twenty-four patients were amputated during the military incursion, *Operation Summer Rain*, in 2006, 57 patients were amputated during *Operation Cast Lead* in 2008/90, 4 patients were amputated during *Operation Pillar of Defense,* in 2012 and 73 patients were amputated during the latest military incursion, *Operation Protective Edge,* in 2014. Ninety-five patients were amputated between these periods of declared military operations and one person only provided the year, but no exact date of the injury leading to amputation.

Most amputees were males in their early 20s when injured and in their late 20s at inclusion. Seventeen percent were amputated when they were children (aged 18 years or younger, $n = 43$) (Table 1). The majority were well educated. Illiteracy rate was low. The overall unemployment rate was 75% ($n = 191$) and 44% ($n = 112$) had lost their jobs as a result of the traumatic amputation(s). Almost half of the amputees lived in extended families with large households. Nearly half of the amputees (46%, $n = 116$) had lost their home in one of the attacks. Few destroyed homes had been rebuilt (11·6%, $n = 29$). In the subgroup of amputees asked about loss of family and friends during the incursion in 2014 ($n = 242$), 13% reported loss of at least one family member, while nine amputees (4%) had lost one or more children (Table 2).

Thirty per cent of the amputees (76/254) were surviving on less than 700 New Israeli Shekel (100 NIS = 32

Table 1 Characteristics of study participants[a] ($N = 254$)

Variables	n (patients)	Percentage or median, [IQR]
Demographics[b]		
Palestinian	254	100
Male	234	92
Children	43	17
Female	20	8
Refugee status	154	57
Age –Inclusion, years		28 [10]
Age-Injury, years		23 [9]
Education[c]		
Illiterate	9	4
Elementary school	45	18
Secondary school	75	30
High school	26	10
Graduate	22	9
Postgraduate	70	28
PhD	1	0·4
Destruction of home[d]		
Loss of home	116	46
Treatment[e]		
Uses artificial limb	142	56
Waiting for artificial limb	38	15
Not using	72	28
Receives physiotherapy	215	85
Financial situation[f]		
Household, Hamula	103	41
> 8 Persons per household	135	54
> 6 Siblings	185	74
Family income, NIS		
< 700	76	30
800–1600	105	42
> 1700	50	28

Abbreviations: IQR interquartile range
[a]Number of participants: 254, from 0 to 2% of the participants had missing data on any variable
[b]Refugee = patient is from a family who have a refugee status as of 1948
[c]Secondary school = 12 years of education, Graduate = has completed the first academic degree in university, post-graduate = completed Master degree
[d]Number of patients who lost their home in one of the incursions
[e]Treatment 38 patients were at the time of inclusion waiting for an artificial limb to be fitted due to recent trauma. 72 patients did not use their fitted artificial limbs due to different reasons
[f]Financial situation: Hamula: The Palestinian term for extended family. Here compared with the nuclear family
NIS New Israeli Shekel. 1 NIS equals 0,26 US Dollar

Table 2 Personal losses during the 2014 incursions

Loss of:	n patients	Percentage
≥ 1 children	9	4
Spouse	3	1
Friend	22	9
Parent	8	3
≥ 1 Sibling	12	5
Total	54	22

Abbreviations: N = number (of participants), N = 242 participants
Children: Four patients lost one child, two patients lost two children, two patients lost three children and one patient lost four children
Siblings: Seven patients lost one sibling, three patients lost two siblings, one patient lost three siblings and one patient lost four siblings

USD) monthly and 63% (160/254) were the sole breadwinner for more than three persons in their household. (Table 3).

Classification and anatomical localization of amputations

Nearly nine out of ten of patients had major amputations (n = 216, 85%). Lower limb amputations were the most common major and most minor amputations were in the upper extremities (Fig. 2). As illustrated in the Alluvial flow diagram (Fig. 3), unilateral above knee amputations were the most frequent amputation among the patients (n = 89, 35%). Bilateral amputations were most often found above the knees (n = 27, 11%), while bilateral amputations below the knees occurred in 7% (n = 17). Among patients with upper limb amputations, the most common amputation was distally in the arm and hand. Twenty-one patients (8%) had both upper and lower limb amputations.

Rehabilitation and use of artificial limbs

The 254 patients included in this study increased the caseload on the rehabilitation center by 28%. More than half of the amputees were using an individually fitted artificial limb (142/254, 56%), while 38 (15%) of the patients were waiting for their prosthesis. Seventy-two patients (28%) were not using their prosthesis; five (2%) because it was painful, 39 (15%) claimed their functions were better without prosthesis and eight patients (3%) had an injury judged unsuitable for prosthesis. Twenty-one (8%) patients avoided using their artificial limb because they 'disliked it'. Amputees with below knee amputations were more often using their prosthesis compared to those with above knee amputations. Among above-knee amputees, 59% (n = 52) were using prosthesis compared to 72% (n = 54) of those with below-knee amputations.

Rehabilitation physiotherapy was given to 215 (85%) of the patients at a regular basis, while 33 (13%) had not started the training at the time of the study.

Table 3 Employment status

Variables	n Patients	Percentage
Employment[a]		
Unemployed	191	75
Unemployed due to amputation	112	44
≥ 3 unemployed family members	152	61
≥ 3 persons economically dependent on amputee	160	64

Number of participants: 254, from 0 to 2% of the participants had missing data on any variable
[a]Employment: ≥ 3 persons economically dependent on amputee- the amputee is the solve breadwinner for more than three persons in his/her household

Surgeries after the injury

Most amputees underwent several surgical interventions after the initial amputation trauma, and 53/254 (21%) of the amputees had more than 10 surgical operations, while 91/254 (36%) had at least 4 surgeries after their initial trauma (Table 4). Around 1300 surgical operations were needed to treat the surgical complications and adjust the amputation stumps among the 254 amputees.

Medical problems

The amputees reported physical and psychological problems in relation to the limb loss. Pain was most common, typically phantom pain (103/245, 40·6%), back pain (84/254, 33·1%) and joint pain (87/254, 34·3%). The dominating psychological problem were insomnia (69/254, 27·2%), anxiety (79/254, 31·1%) and feeling depressed (46/254, 18·1%) (Table 5.) By using multiple correspondence analysis (MCA), we found that some complications occurred more frequently in conjunction. Joint-, back and phantom pain occurred frequently together, as did depression, anxiety and sleep disturbances (Fig. 4).

Discussion

In this study of 254 Gaza Palestinians who had sustained war-related traumatic extremity amputations and were currently attending physical rehabilitation, nine out of ten had major amputations (85%) with unilateral lower extremity amputations as the most common type (64·5%). Nearly one in five amputees was a child. The majority of the amputees were young men, mostly family breadwinners. Close to half of the patients reported being unemployed because of their physical disabilities adding to the already exceptionally high unemployment rate in Gaza. Loss of a steady income may cause new burdens to the patients and their families in addition to the loss of limb(s).

The majority of the studied patients had suffered severe amputations affecting the lower extremities. Nearly one in five had bilateral lower leg amputations. In addition, one in five needed more than ten surgical operations after the

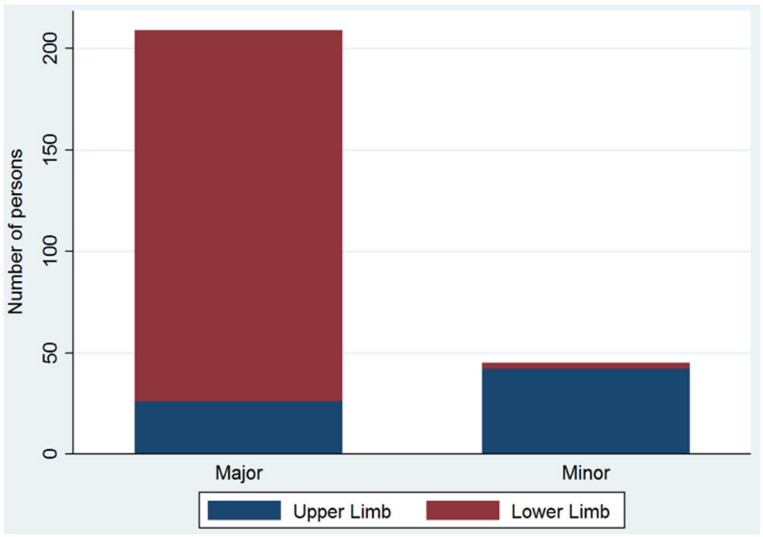

Fig. 2 Minor and major amputations by limbs ($N = 254$). * $N = 254$. Nearly nine out of ten amputations were major amputations: 216 (85%) suffered amputations proximal to wrist or ankle. Major = proximal to wrist or ankle. Minor = distal to wrist or ankle

initial trauma, illustrating the complexity of the injuries and challenges to the local medical system. In total, this patient population underwent around 1300 surgical operations following the trauma, adding burden to an already exhausted health care system [10]. In addition, the 254 included patients in this study represented a 28% increase in the total caseload of the ALPC proving the serious impact war-related amputations have on both health care (emergency and later surgeries) as well as the physical and psychosocial rehabilitation systems in Gaza.

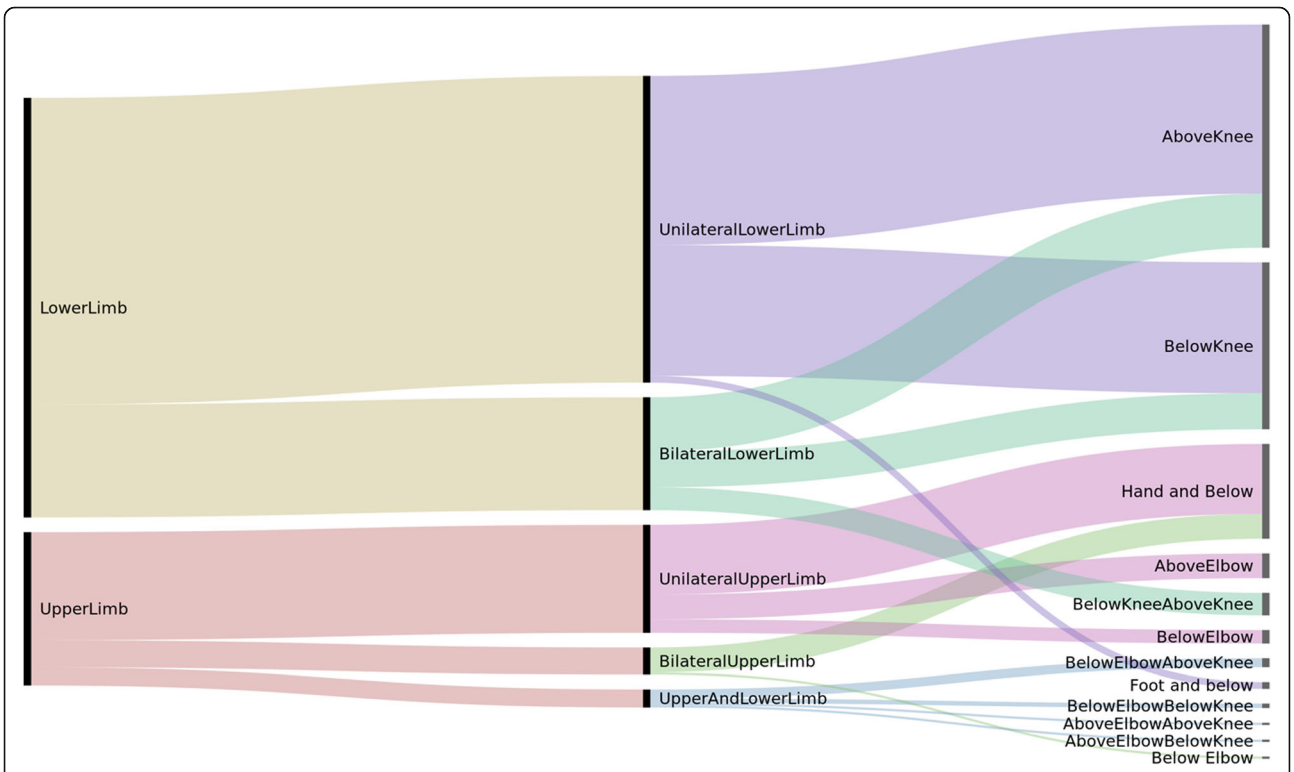

Fig. 3 Frequency of amputations by classification and anatomical location ($N = 254$). *$N = 254$. The alluvial flow diagram shows how the general category (lower limb and upper limb left side) contains parts of finer classification, moving towards the right. The bold vertical lines indicate relative frequency. The colour code shows how each category moves into sub-categories, but change colour in the next step

Table 4 Post-injury surgery

Operations	n patients	Percentage
0-1	44	17
2-3	63	25
4-5	47	19
6-7	21	8
8-9	23	9
>10	53	21

Post-injury surgery: Number of operations performed after trauma
Number of participants: 254, from 0 to 2% of the participants had missing data on any variable

One in three amputations (35%) were above the knee and 59% of these patients were using artificial limbs, compared to 72% of those amputated below the knee. Artificial limbs are more difficult to fit for above knee amputees [15].

Traumatic losses of limbs following military attacks can lead to long-lasting physical incapacitation as well as medical problems and complications [16]. The main medical and mental burdens among the Palestinians we studied were pain, depression, anxiety and insomnia. The dominating types of pain were phantom pain, joint- and back-pain. The amputees also reported weight loss and loss of appetite. This is in accordance with studies showing a high prevalence of anxiety and depression in traumatic amputees [17]. Phantom pain and skin problems are also common complications in trauma related amputees [18].

Our finding of a clear male predominance among traumatic amputees is concomitant with other studies on war-related amputations [19]. This pattern of a male predominance is also found in the United Nations' documentation of major trends in fatalities among Palestinians and Israelis since the beginning of the second Intifada (Sept. 2000 - July 2007) [20]. Men constituted the majority of the killed among both Israelis (69%) and Palestinians (94%). Similar numbers were found among children with 87% boys among Palestinian children killed, 13% girls [20]. Among intensive care patients in Gaza's main trauma hospital during "Operation Protective Edge" in 2014, 77·9% were male, and 74% of patients admitted to this hospital during "Operation Pillar of Defense" in 2012 were also males [21, 22]. Possible reasons for the male predominance among amputees were discussed with local health care personnel. More systematic research will be necessary to reach firm conclusions. Health care professionals in Gaza point out that gender role in Gaza will typically assign different obligations to males and females. The women tend to stay at home to look after children and elderly in times of food scarcity and limited security. The male members of the family are more obliged to leave the relative safety of the home to find food in the market. Further, males also take higher risks in terms of volunteering to arrange evacuation of wounded to the hospital, in helping relatives, neighbors and friends during ongoing attacks and during the recovery phase when a building has collapsed following bombardment. Females typically stay in the home during such hostilities and are expected to take less personal risk.

Table 5 Medical and psychological complications

Pain	n	%	Mechanical	n	%	Systemic	n	%
Joint	87	34	Knee arthritis[b]	10	4	Weight loss	39	15
Back	84	33	Hip arthritis	2	0·9	Anorexia	34	13
Heel	21	8	Ankle arthritis	2	0·9	Insomnia	69	27
Phantom[a]	103	41	Knee stiffness	24	9	Depression[c]	46	18
			Hip stiffness	1	0·5	Anxiety[d]	79	31
			Ankle stiffness	9	4			
			Plantar fascitis	5	2			

Number of participants: 254, from 0 to 2% of the participants had missing data on any variable
[a]Phantom pain, defined as pain occurring in the amputated limb
[b]Stiffness refers to self-reported stiffness in joints, arthritis is self-reported as previous known diagnosis
[c]Depression refers to "feeling depressed"
[d]Anxiety refers to "feeling anxious"

However, the societal impact of a male predominance should not be underestimated. More than half of the male participants in our study were the sole breadwinners of their families and 63% of the male amputees were economical responsible for more than three persons in their household. Gaza reached a 43·6% unemployment rate in 2017, with a youth unemployment at 58% [23]. Young graduates reached an unemployment of 53% during the first quarter of 2017 [24].

Long lasting poverty for patients and families are known to be severe secondary trauma contributing to pain, insomnia and depression [25]. We have documented an unemployment rate at 75% among the amputees, extending the harm of war trauma, both for the amputees and their families [9]. Previous studies from Gaza found females in the region to feel less secure, and related this to the potential loss of the male breadwinner in the family [26].

Lacking a safe family housing may inflict severe strain on war injured patients, adding to unemployment. Almost half of the study population lost their home in one of the military incursions. Few homes had been rebuilt at the time of the study (11·6%, $n = 26$). Around 4000 families including 23.500 individuals were still displaced at the end of November 2017 following the military incursion, Operation Protective Edge, in 2014 [27]. To witness the destruction of your own home by enemy soldiers, as many of the amputees had done, is a significant psychological trauma [28].

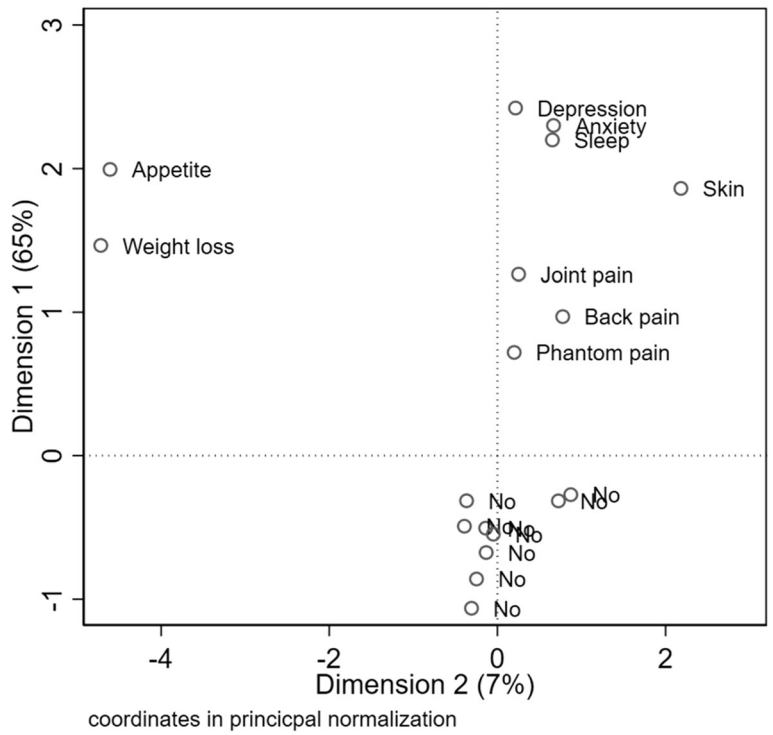

Fig. 4 Relationships between long-term complications and frequencies ($N = 254$). *$N = 254$. The alluvial flow diagram shows how the general category (lower limb and upper limb left side) contains parts of finer classification, moving towards the right. The bold vertical lines indicate relative frequency. The colour code shows how each category moves into sub-categories, but change colour in the next step

The patients interviewed and examined after operation Protective Edge in 2014, shared in-depth stories about family members they had lost. Nine of the amputees in the study had lost one or several children in the conflict. This further illustrate the extent of profound, personal losses traumatic amputees in Gaza have suffered beyond the mere loss of limb(s).

Children injured or killed composed a considerable part of the civilian casualties in 2014 (556 killed, approx. 3.500 injured) [29].

Limitations and strengths

The use of self-reported reasons for unemployment is a potential weakness of our study, though self-reported data are generally accurate [30]. The most recent cases were in an early stage of treatment and rehabilitation and would probably be more unlikely to be able to work, this may be a weakness in the self-reported data in the study. There is a potential for selection bias is present in our study. Some amputees sustain fatal injuries while others with minor injuries may not be referred for rehabilitation. Thus, although treatment at ALPC is free of charge, the patients attending ALPC are not representative of the whole population of amputees, as our study population does not include those who died before rehabilitation, or who did not need rehabilitation. However, due to the ongoing conflict, the lack of infrastructure and sometimes incomplete medical records, it would be close to impossible to obtain a completely representative set of data from the whole population of amputees.

Young men constituted the majority of patients in the study, and could indicate that they might have had a non-civilian status in the conflict. Ethical and security concerns limited the validation of social status beyond the information given by each amputee. Such information in the registry could pose a risk to them. We relied on the oral information obtained from each patient and local medical staff in our research group. Based on this, we are confident that more than 90% of the study participants were civilians.

Strengths of this study include a representative sample of the patients attending rehabilitation at ALPC (response rate 99%).

Conclusions

In summary, amputation trauma following Israeli military incursions on the Gaza Strip is a major health problem for the otherwise healthy young civilians in our study, in particular for young adult men and for children. In addition to their amputation trauma, they suffer destruction of their homes, loss of family members and friends as well as significant financial deterioration.

These preventable, man-made traumatic amputations add significant physical, medical and psychological burdens to a civilian population who has also endured more than ten years of siege and blockade.

Endnote

[1]The first author was contacted by email and permission to use their questionnaire was given in writing.

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Availability of data and materials

The datasets used during the current study are not publically available as the authors did not apply any ethical committees for the permission to share the data. In this particular context, sharing of data could raise safety concerns for the participants in the study and thus considered unethical.

Authors' contributions

HEH-L contributed study design, data collection, data entry, data analysis, interpretation of the results, the primary draft of the manuscript writing, editing the manuscript, literature search and final approval of the manuscript. YA-B contributed to study design, patient inclusion, data collection, data transfer, revising the manuscript and final approval of the manuscript. SS contributed to study design, patient inclusion, data collection, data transfer, revising the manuscript and final approval of the manuscript. NS contributed to study design, patient inclusion, data collection, data transfer, revising the manuscript and final approval of the manuscript. LMG contributed to the statistical analysis, interpretation of the results, visualization of the data in figures, editing and revising and manuscript, and final approval of the manuscript. MG contributed the original research idea, the study design, interpretation of the results, revising and editing the manuscript, and final approval of the manuscript.

Ethics approval and consent to participate

All patient completed written consent prior to participating. The study was approved by the Regional Ethical Committee (approval number: 2016/1265/REK Nord) in Norway and the Committee for Helsinki ethics approvals in Gaza.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

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Traumatic amputations caused by drone attacks in the local population in Gaza: a retrospective cross-sectional study

Hanne Heszlein-Lossius, Yahya Al-Borno, Samar Shaqqoura, Nashwa Skaik, Lasse Melvaer Giil, Mads F Gilbert

Summary

Background Little data exist to describe the use and medical consequences of drone strikes on civilian populations in war and conflict zones. Gaza is a landstrip within the Palestinian territories and the home of 2 million people. The median age in Gaza is 17·2 years and almost half of the population is below the age of 14 years. We studied the prevalence and severity of extremity amputation injuries caused by drone strikes compared with those caused by other explosive weapons among patients with amputations attending the main physical prosthesis and rehabilitation centre in Gaza.

Methods In this retrospective cross-sectional study, we recruited patients from the Artificial Limb and Polio Centre (ALPC) in Gaza city in the Gaza strip with conflict-related traumatic extremity amputations. Patients were eligible if they had one or more amputations sustained during a military incursion in Gaza during 2006–16 and had an available patient record. Each patient completed a self-reporting questionnaire of the time and mechanism of injury, subsequent surgeries, comorbidities, and their socioeconomic status, and we collected each patient's medical history, recorded the anatomical location of their amputation or amputations, and interviewed each patient to obtain a detailed description of the incursion or incursions that led to their amputation injury. We classified the severity of amputations and number of subsequent surgeries on ordinal scales and then we determined the associations between these outcomes and the mechanism of explosive weapon delivery (drone strike *vs* other) using ordinal logistical regression.

Findings We collected data on 254 patients from APLC who had sustained an amputation injury. Of these patients, 234 (92%) were male and 43 (17%) were aged 18 years or younger at the time of injury. The age of participants was representative of the Gaza population, with a median age at inclusion was 28 years (IQR 23–33), and the median age at the time of injury was 23 years (IQR 20–29). 136 (54%) amputation injuries were caused by explosive weapons delivered by drone strikes, with explosives delivered by tanks being the next most common source of amputation injury (28 [11%]). Adjusted for age and sex, drone-delivered weapons caused significantly more severe injuries than explosives delivered by other mechanisms (eg, military jet airplanes, helicopters, tank shelling, and naval artillery; odds ratio [OR] 2·50, 95% CI 1·52–4·11; p=0·0003). Compared with all other types of weapons, the patients whose injuries were caused by drone strikes needed significantly more subsequent surgical operations to treat their amputation injuries than those injured by other weapons (OR 1·93, 1·19–3·14; p=0·008).

Interpretation Drone strikes were the most commonly reported cause of amputation injury in our study population and were associated with more severe injuries and more additional surgeries than injuries caused by other explosive weapons. Limitations of our study include the self-reported nature of the mechanism of injury and number of subsequent surgeries and selection bias from not incorporating amputation injuries from individuals who died immediately or due to complications. The increasing use of drones needs to be addressed, rather than passively accepted, by the international community. This study fills a gap in our knowledge of the civilian consequences of modern warfare and we believe it is also relevant to the growing populations that are being exposed to drone warfare and for health-care personnel treating these people.

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Introduction

Serious explosive injuries from a variety of weapons can cause traumatic extremity amputations, often needing immediate lifesaving surgery.[1] The use of remote-controlled, unmanned aerial vehicles (UAE or drones) is increasing in present-day armed conflicts, both for surveillance and as weapon carriers.[2] Few studies have assessed the medical consequences of drone-delivered explosive weapons (drone strikes) during armed conflicts and war.

The Palestinian population in the Gaza Strip has experienced four major Israeli military incursions over the past decade (2006, 2008–09, 2012, and 2014). Various military weapons have killed around 4000 Palestinians and injured more than 17 000 during 2006–14, mostly civilians.[2] During the military incursion Operation Cast Lead (2008–09), 42 drone strikes killed 87 civilians.[3] Amnesty International documented 48 civilian deaths from drone strikes during the same period but suggested the actual numbers to be much higher than those

For **the Israeli Information Center for Human Rights in the Occupied Territories Statistics webpage** see http://www.btselem.org/statistics

Research in context

Evidence before this study

Civilians who have traumatic extremity amputation injuries during modern warfare seem to be increasingly caused by explosive weapons delivered by unmanned aerial vehicles, also known as drones. The magnitude and consequences of such injuries in affected populations are poorly described and understood. We searched PubMed, MEDLINE, Embase, and Google Scholar from database inception to May, 2014, for publications in English and Norwegian using the search terms "drone*", "drones*", "drone strikes*", "modern warfare*", "Traumatic amputation(s)*", "Gaza*", "Israel*", "Palestine*", "military incursions", "war-related amputations*", "amputees*", and "amputations*". We found a paucity of peer-reviewed literature on these topics and could not find any peer-reviewed studies of tramatic amputations among civilians casued by drone strikes. We studied the prevalence and consequences of traumatic extremity amputations, including amputation severity and additional surgeries needed, among Palestinians in the Gaza Strip after drone strikes and compared these with amputations caused by other weapons.

Added value of this study

We found that drone strikes are the most prevalent weapon-delivery mechanism that causes traumatic amputations in Palestinian patients with amputation injuries who attended a central rehabilitation clinic in Gaza. This finding challenges the idea that drone-delivered explosives are more precise and lead to less civilian causalities and so-called collateral damage than other weapons used in modern warfare. The participants who reported having been injured by drone strikes had more severe, proximal amputations and needed more surgical revisions after the initial amputation than those who had been injured by conventional explosive weapons.

Implications of all the available evidence

Our findings support that drone strikes substantially affect civilians living in areas of armed conflicts, and that restrictive formal rules for the use of armed drones and a clear humanitarian legal framework should be generated to restrict the use of these weapons on civilians.

reported.[4] The human rights organisation Al Mezan reported that 513 people were killed by drone strikes during the same period.[5] The variation between the number of reported drone strikes and the number of casualties attributed to drone strikes could indicate either methodological problems or the secrecy of military drone programmes, or both.[6] Israeli authorities state that the Israeli Defence Forces used precision-guided aerial strikes to "minimise potential civilian casualties" during the 2014 military incursion on Gaza.[7] The secrecy surrounding military drone programmes and variable estimates of civilian casualties is not limited to Gaza. The reported number of civilian casualties after US military drone strikes in Pakistan in 2015 varies from 158 to 2600.[8] Therefore, further studies are needed to clarify civilian consequences of drone strikes.

The paucity of information regarding civilian consequences of military drone strikes restricts understanding of the impact of these weapons, and narrows the discourse on military attack drones that is pertinent to international law and human rights. We studied drone strikes as the cause of traumatic extremity amputations in a local population in Gaza. We aimed to compare the severity of amputation injuries caused by drone strikes with those caused by other weapons in a population with traumatic amputations attending physical rehabilitation in Gaza.

Methods

Study participants

On the basis of a previous feasibility study (Heszlein-Lossius H, masters thesis, unpublished) in the Gaza strip, of 91 patients from Gaza's main physical rehabilitation centre and prosthesis workshop, the Artificial Limb and Polio Centre (ALPC),[9] we completed a retrospective cross-sectional study, for which we invited all patients attending ALPC during the study period and all participants from the previous feasibility study to participate. Inclusion criteria were one or more amputations sustained in Gaza during a military incursion or incursions during 2006–16 and an available patient record. Exclusion criteria were if the amuptation injury was not caused by a military incursion and if the amputation injury was from before 2006.

The study was approved in Norway by the Regional Ethical Committee (2016/1265/REK nord); in Gaza by the local health authorities, the board of Al-Shifa Hospital, and the Director of the ALPC. The Palestinian Ministry of Health approved the study through the Helsinki ethics approval committee in Gaza. All included patients gave written informed consent following detailed explanation in Arabic of the study objectives and procedures. No economical compensation was offered to the patients except for covering their costs of transportation from home to the clinic. We did the clinical examinations and interviews at the ALPC in Gaza City. All patients were informed that they could withdraw their consent and leave the study at any time.

Data collection

The participants completed a self-reporting questionnaire without any investigator instruction before a physical examination. Participants reported the date of injury, age at time of injury, age at time of questionnaire, diseases or injuries, comorbidities, use of rehabilitation and artificial limbs, physiotherapy, their socioeconomic status (ie,

living and working status, number of people in household, number of people economically dependent on patient, level of education), and number of surgeries since injury. We made no documatation of any military activities. All the written material we used was in Arabic and the questions were read aloud by one of the Palestinian investigators (YA-B, SS, or NS) for participants who were illiterate.

An experienced physician (YA-B, SS, or NS) then collected their medical history; did a clinical examination, including measuring their heart rate, blood pressure, height, and weight, and registered the results of heart and lung auscultation, examination of the abdomen, and any heart palpations; and examined and photographed their amputation stump or stumps. Each patient was then interviewed and the mechanisms of injury was explored.

In the interview, each patient gave detailed descriptions of the incursion or incursions that caused their traumatic amputation or amputations. The interviews were done one to one with a local clinician who had been coached in how to conduct the interview beforehand. By use of a pre-prepared list of questions, the interviewers asked the participants to describe in detail where they were at the time of the incursion, other witnesses, sounds, sights, and concomitant destruction of cars and buildings. We recorded the reported mechanism of weapon delivery (eg, tank, helicopter, jet fighter, naval gunship, drone). The patients and local clinicians were not told that injuries from drone strikes were specifically of interest.

The physician who did the examination used a simple anatomical sketch to draw the level of the amputation or amputations. Immediately after each interview, each photo of an amputation stump was given a unique identification number and a photocopy was kept at the ALPC with the patient's files. We classified the amputations using common terms for extremity amputations—ie, above or below the extremity joints.[10] We categorised types and combinations of extremity amputations by generating an ordinal scale that classified the amputations in increasing order of severity on the basis of proximity to the torso and number of affected limbs. The ordinal scale was as follows: 1 indicated a finger, toe, hand, or foot; 2 indicated below the knee or below the elbow; 3 indicated above the knee or above the elbow; and 4 indicated a bilateral amputation or an amputation in both lower and upper extremities, or a unilateral amputation at hip or shoulder level.

To analyse how different types of weapons affected the need for additional surgical treatment, we classified the total number of self-reported surgical operations after the trauma on an ordinal scale. We had to collapse the categories to fulfil the ordinal regression assumption of adequate cell count, and so the scale used in our calculations was as follows: 1 was one surgery; 2 was two to three surgeries; 3 was four to five surgeries; and 4 was six to nine surgeries; and 5 was ten or more surgeries.

Four different major military incursions took place in Gaza from December, 2006, to August, 2014. We classified conflict time on the basis of the official recorded dates of each military operation. We defined times of cease-fire on the basis of the periods between each of the four major military incursions. The dates of injury for each patient were matched with periods of conflict or cease-fire.

Around the four major documented incursions several minor incursions have occurred, and so we included six periods in our definition of conflict time, based on dates used by Israeli authorities:[11–14] from June 27, 2006, to Nov 11, 2006 (two operations overlapped, with one not officially declared over and another starting on Nov 1, 2006); from Feb 28, 2008, to March 3, 2008; from Dec 27, 2008, to Jan 17, 2009; from Nov 14, 2012, to Nov 21, 2012; and from July 7, 2014, to Aug 26, 2014.

Outcomes

Our primary objectives were to determine the prevalence and severity of extremity amputations caused by drone strikes compared with those caused by other explosive weapons among amputees attending the main physical prosthesis and rehabilitation centre in Gaza. We determined the severity of amputation injuries using two outcomes: proximity of the amputation to the torso, and the number of subsequent surgeries to date.

Statistical analysis

We report descriptive statistics as mean and SD for normal distributions. Skewed variables were log-transformed before multivariate analysis. For non-normal data, we report the median and IQR. Frequencies are reported as percentages. A p value of less than 0·05 was considered statistically significant.

We created an alluvial diagram to visualise complex associations between categorical variables. We used multivariate ordinal logistical regression to investigate the association between mechanism of injury, amputation severity, and number of subsequent surgeries adjusted for age and sex. We used Monte Carlo simulations (n=1000) of the estimates we obtained from the multivariate ordinal regression analysis to obtain easily interpretable probability estimates. Briefly, the probability of being injured via drone strike versus other explosive weapon was simulated across the ordinal severity score for amputations. The difference in probability was then calculated from the simulations, with a 95% CI for drones strikes versus other explosive weapons for each ordinal category. The number of additional surgeries and the severity of the amputation are related outcomes. Post hoc, we generated a probability based Venn diagram of the outcomes and drone strikes using cutoffs that were the closest to dividing the study population in equal binary categories (≥6 surgeries *vs* ≤5 surgeries, amputation at knee or elbow and higher *vs* more distal). We excluded gunshot injuries from our comparative analyses with drone strikes because guns have less potential to cause amputation injuries than

	Patients (n=254)
Sex	
Male	234 (92%)
Female	20 (8%)
Age at inclusion, years	28 (23–33)
Age at injury, years	23 (20–29)
Aged ≤18 years at injury	43 (17%)
Refugee status*	154 (57%)
Immediate amputation	215 (86%)
Surgical attempt at salvage	24 (10%)
Surgeries after amputation	
0–1	44 (17%)
2–3	63 (25%)
4–5	47 (19%)
6–9	44 (17%)
≥10	53 (21%)
Missing data	3 (1%)†

Data are n (%) and median (IQR). *Patrilineal descendants of refugees from the establishment of the Israeli state in 1948. †Three patients did not answer this question on the questionnaire.

Table 1: **Patient demographic and clinical characteristics**

	During declared military incursions (n=159)	Between declared military incursions (n=95)	Overall (n=254)
Drone strike*	100 (63%)	36 (38%)	136 (54%)
Helicopter (Apache)	6 (4%)	0	6 (2%)
Aircraft (manned)	8 (5%)	1 (1%)	9 (4%)
Artillery shell	6 (4%)	1 (1%)	7 (3%)
Cannon shell	7 (4%)	2 (2%)	9 (4%)
Naval shell	1 (<1%)	2 (2%)	3 (1%)
Other shelling injury†	3 (2%)	4 (4%)	7 (3%)
Tank shell	19 (12%)	9 (9%)	28 (11%)
Unexploded ordnance‡	1 (<1%)	22 (23%)	23 (9%)
Landmine	0	2 (2%)	2 (1%)
Gunshot wound‡	0	12 (13%)	12 (5%)
Friendly fire§	1 (<1%)	1 (1%)	2 (1%)
Unknown	7 (4%)	3 (3%)	10 (4%)

Data are n (%). *Weapons delivered from an unmanned armed airplane. †Other shelling; the patient only reported shelling but did not specify. ‡Not included in multivariate analyses. §Palestinian rockets fired from Gaza into Israel.

Table 2: **Mechanism and time of traumatic amputation injuries**

drone strikes do, hence our comparative analyses include only explosive or shelling injuries.

We analysed data using STATA 15 (version 15), with graphical displays from RAW Graphs, and post-hoc simulations by the STATA package moreClarify.

Results

Between June 25, 2014, and Dec 30, 2016, we recruited 254 patients from the ALPC in Gaza city, of whom 90 took part in the previous feasibility study (one of 91 participants took part in the previous study declined to participate). Most of the participants were male, with a median age of 28 years (IQR 23–33) at the time of inclusion, and a median age of 23 years (20–29) at the time of the amputation trauma (table 1). 43 (17%) participants were children (ie, 18 years or younger).

136 (54%) participants reported that drone strikes had caused their amputations, of whom eight (6%) were female, and 14 (10%) were children, equivalent to 40% of 19 female patients and 33% of 43 children who participated (table 2; figure 1). 28 (11%) patients were injured by weapons delivered by tanks. 23 (9%) patients had amputation injuries caused by unexploded ordnances (weapons that explode long after being deployed). For two (1%) patients, their amputation injuries were caused by Palestinian rockets fired from Gaza aimed at Israel (ie, friendly fire).

By ordinal logistic regression, drone strikes caused more proximal amputation injuries that needed more surgeries than other explosive weapons did, adjusted for age and sex (OR 2·50, 95% CI 1·52 to 4·11; p<0·0003; table 3). After estimation of the results by ordinal logistic regression, Monte Carlo simulation showed that when an amputation injury was caused by a drone strike the amputation trauma is 8% more likely to fall into a higher severity category than if it was caused by another explosive weapon (OR 2·50, 95% CI 1·52–4·11; figure 2).

By ordinal logistic regression, patients with amputations caused by drone strikes needed significantly more surgeries after the initial trauma compared with those who had amputation injuries caused by other weapons (OR adjusted for age and sex 1·93, 95% CI 1·19–3·14; p=0·008; table 4). 53 (21%) patients needed ten or more surgical operations after their initial injury. Of these patients, 37 (70%) had an amputation injury caused by explosive weapons during drone strikes. Notably, the number of surgeries after amputation injury and the severity of the amputations are related outcomes (figure 3).

Drone strikes caused amputation injuries both during periods of cease-fire and during declared military incursions. Of 136 amputation injuries caused by drone strikes reported, 100 (74%) were during military incursions and 36 (26%) were during periods of cease-fire (table 2). Amputation injuries caused by unexploded ordinances (23 [9%] of 254 injuries) mainly occurred between declared military incursions, and amputation injuries caused by explosive weapons delivered by helicopters (six [2%] of 254) only occured during declared military incursions. For the other shelling injuries, they caused amputation injuries both during and between declared incursions.

Discussion

In this cross-sectional study of traumatic amputees attending a physical rehabilitation centre in Gaza, we found drone strikes were associated with more proximal amputations that needed more surgical operations after initial life-saving emergency surgery than traumatic

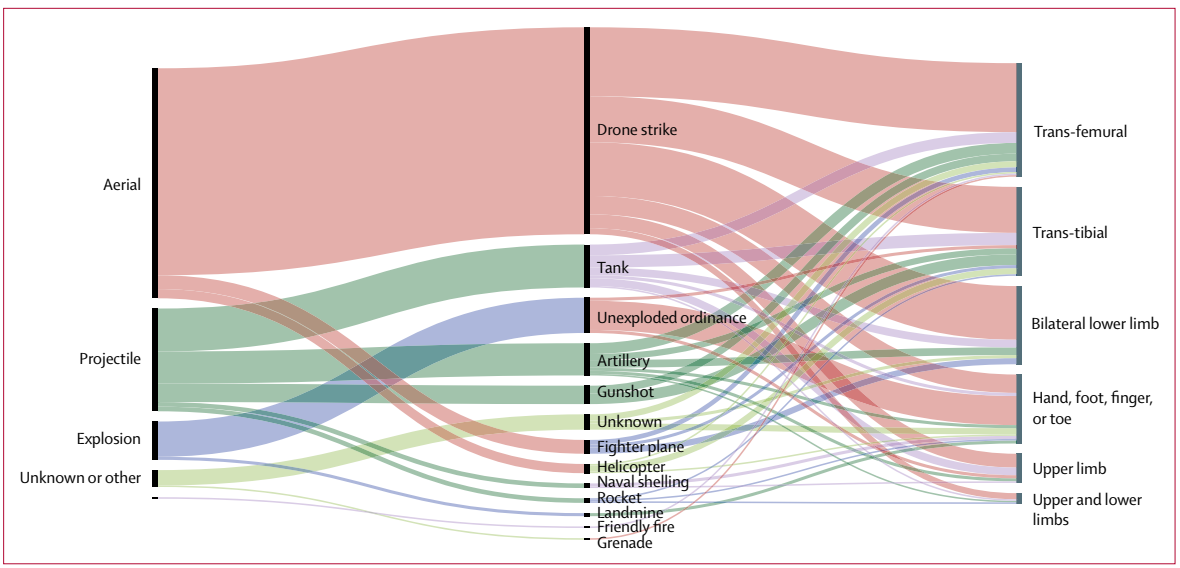

Figure 1: **Alluvial diagram of mechanism of weapon delivery and type of amputation**
Widths of bands correspond to the frequency of the mechanism of injury and the frequency of different types of amputation injuries, and the vertical axis is organised with the most prevalent injuries and mechanisms of delivery at the top. Data are from all 254 Palestinian patients included in the study. Fighter plane indicates military F-16 jet airplanes, helicopter indicates military Apache attack helicopter. Unknown indicates the patient does not know which type of weapon caused their amputation injury or they did not supply the information.

amputations caused by other types of explosive weapons. To our knowledge, this is the first study to show the frequent use of armed drone strikes on the Palestinian population in Gaza and that armed drone strikes are the most frequent cause of traumatic extremity amputations in this population.

Aerial drones were developed throughout the 19th century, but were first used in close combat during the Israeli Bekaa Valley campaign in 1982.[15] Armed drones were widely used during Operation Desert Storm in 1991, with unmanned aircrafts developed by a joint effort of the Israeli and US armies.[15] Drones are mainly used against targets in low-income and middle-income countries and most military drone programmes are clandestine, leading to possible under-reporting of drone-inflicted injuries, in particular when drone attacks affect civilians. The predominance of young male patients with amputations in our study raises the question of whether they were combatants from the resistance forces. However, we did not validate the social status of each patient beyond the information they self-reported because of ethical and security concerns. Collecting personal information on Palestinian resistance fighters could endanger their lives, and so we considered a detailed investigation and registration to be unethical.

The predominance of male patients with amputation injuries in our study could be a result of several factors. The male patients in our study were young, with an overall median age among all participants of 23 years at time of injury. This finding is unsurprising since, as of July, 2017, the median age of Gaza's about 1795 000 inhabitants was 17·2 years, and 803 919 (45%) people were aged 14 years or younger.[16] Boys comprised 87% of children killed in Palestine during the second Intifada (2000–07).[17]

	Risk factors	Odds ratio	p value
Age*	NA	1·04 (0·52–2·07	0·918
Sex	Male sex (n=213) *vs* female sex (n=19; ref)	1·69 (0·70–4·10)	0·243
Mechanism of injury†	Drone strike (n=136) *vs* non-drone explosive weapon (n=96; ref)	2·50 (1·52–4·11)	<0·0003*

Data in parentheses are 95% CIs. Ordinal logistic regression with injury severity as the outcome. 12 patients with gunshot wounds and ten who did not report the mechanism of injury are excluded from analyses (n=232). (ref) indicates the reference group in the analysis. *Log transformed for regression analysis. †Adjusted for age and sex.

Table 3: **Risk factors for increased severity of amputation injury**

The amputation injuries caused by drone strikes were more severe as measured by proximity to the torso and need for subsequent surgical revisions. Traumatic amputations caused by drone strikes were more frequent than those caused by other explosive weapons both during times of declared military incursion and between these incursions. More than 1000 daily raids on Gaza were reported during Operation Protective Edge from July 7, 2014, to Aug 26, 2014, with nearly 90% of attacks taking place in densely populated areas.[18]

Among patients admitted to Al-Shifa Hospital, Gaza during July–August, 2014,[19] extremity amputations were reported to be caused by drone strikes, unexploded ordnances, tank shells, ground and naval artillery shelling, and attacks from Apache helicopters and jet fighters. In the current study, two (1%) of 254 patients reported that their amputation injuries were caused by Palestinian rockets fired from Gaza aimed at Israel (ie, friendly fire).

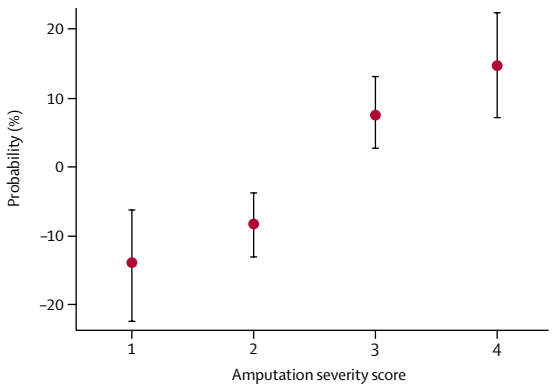

Figure 2: **Difference in probability of drone strike versus other weapons by severity of extremity amputation**
Datapoints are the difference in probability estimates, whiskers are 95% CIs of simulated probabilities. Data are from all participants excluding 12 with gunshot wounds and ten who had an unknown or missing mechanism of injury (n=232). The severity of amputations is classified on an ordinal scale (1 indicates finger, toe, hand, or foot; 2 indicates below the knee or elbow; 3 indicates above the knee or elbow; and 4 indicates a bilateral amputation, amputation in both the lower and upper extremities, or a unilateral amputation at hip or shoulder level).

	Risk factors	Odds ratio	p value
Age*	NA	0·39 (0·19–0·78)	0·008
Sex	Male sex (n=213) *vs* female sex (n=19; ref)	0·94 (0·40–2·19)	0·882
Mechanism of injury†	Drone strike (n=136) *vs* non-drone explosive weapon (n=96; ref)	1·93 (1·19–3·14)	0·008

Data in parentheses are 95% CIs. Ordinal regression with the number of operations as the outcome. 12 participants with gunshot wounds were not included, ten who not report the mechanism of injury, and three who had an unknown number of operations were not included in these analyses (n=229). (ref) indicates the reference group in the analysis. *Log transformed for regression analysis. †Adjusted for age and sex.

Table 4: **Risk factors for multiple operations after initial amputation injury (n=229)**

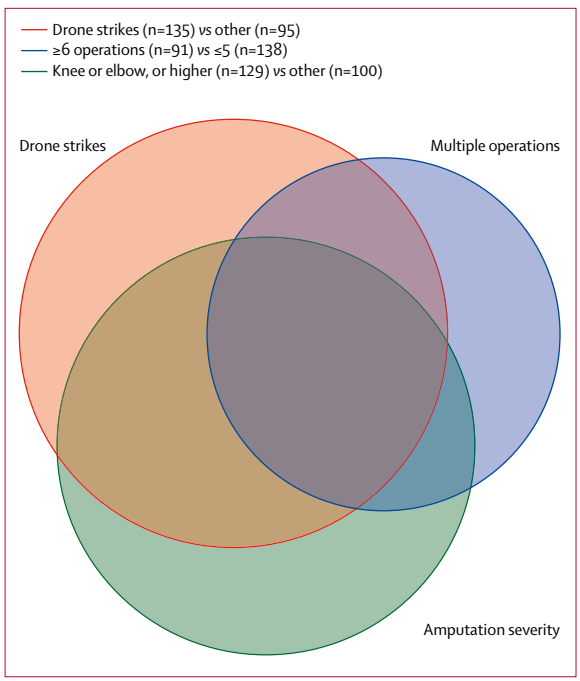

Figure 3: **Proportional association between amputation severity, number of surgeries, and drone strikes as the mechanism of injury**
Proportional associations between amputation injuries that are proximal to the torso, more than six operations after the initial trauma, and drone strike as the mechanism of injury. Figure based on 136 amputees with injuries caused by drone strikes.

More patients with proximal or multiple amputations, or both, are now able to survive such war injuries than ever before because of advances in primary and secondary trauma resuscitation,[20] but to survive they often needs several surgical revisions. As we reported in a separate study using the same cohort,[21] more than 1300 surgeries were done among the 254 patients we studied. Patients who had an amputation injury caused by a drone strike had significantly more surgical revisions than those injured by other explosive weapons. Thus, drone strikes caused amputations that added substantially to the almost insurmountable burdens on the already overstretched local health-care system in Gaza.[22] This burden is aggravated by the military siege and blockade of Gaza that has lasted more than 10 years and that continues to result in insufficient medical and power supplies, a lack of clean water, and unsafe working conditions for health-care personnel, among other consequences.[23,24]

Our findings are in accordance with previous reports from Pakistan and Afghanistan where drone-based weapon systems are a major threat to civilian lives and health.[25,26] A study[27] on the effects of drone strikes on politics found that the use of drones will increase violence on both sides of a conflict. Our finding of a high prevalence of drone-related amputations compared with amputations caused by other explosive weapons challenges the claim that armed drones minimise so-called collateral damage.[28] On the contrary, we found that attacks by armed drones were associated with extensive traumatic injuries among Palestinians in Gaza, and that the injuries were of significantly higher severity, and added substantially to an already overstretched local health-care system than the injuries caused by other explosive weapons.

This study has several limitations. We did not include injury patterns in patients who had died due to their amputation injury, either immediately or due to early complications such as sepsis. Thus, selection bias could have occurred due to immediate and in-hospital mortality for people with the most severe injuries. The ALPC rehabilitation centre is the only institution in Gaza where patients are fitted with artificial limbs and are given subsequent rehabilitation and training, and so all hospitals and primary care centres in the area refer patients with traumatic amputations to the ALPC. It is also free of charge for all patients, avoiding selection bias

due to patients' financial situation. Thus, although we included all patients with conflict-related amputation injuries at the ALPC during the study period, and hence have a representative sample of Gaza amputees, we cannot be sure that all people who had an amputation injury (eg, minor finger amputations) are referred to the centre, and so our study has unavoidable inclusion bias. Although few alternatives exist in countries with few registries, the use of self-reported data in our survey overall has weaknesses. For instance, although Palestinians in Gaza have long-standing experience with military incursions and can usually accurately differentiate between commonly used weapon carriers, weapon types, and explosives, we relied on the judgment and ability of each included patient to classify the type of weapon and weapon-delivery system that caused their amputation injury, and so some human error could have occurred.

Another limitation is that we did not validate the social and military status of each patient beyond the information they self-reported. The high predominance of male participants with amputations in this study raises the question of possible non-civilian status. We believe that a detailed investigation of the personal information of potential Palestinian resistance fighers could endanger their lives, and hence regarded the collection of further personal details beyond the information supplied by participants to the local investigators to be unethical.

Compared with other methods of weapons delivery, drone strikes caused the most traumatic amputations in surviving Palestinian citizens from 2006–16 during Israeli military incursions and periods of cease-fire in Gaza. Explosive weapons delivered by military drones inflicted more severe injuries in survivors than non-drone delivered weapons did. Our study shows the need for a specific legal framework for remote-controlled, human-directed weaponised drones that are used as carriers of attack weapons.

Contributors

HH-L contributed to study design, data collection, entry, and analysis, interpretation of the results, the primary draft of the manuscript, editing of the manuscript, and the literature search. YA-B, SS, and NS contributed to study design, patient recruitment, data collection and transfer, and revision of the manuscript. LMG contributed to the statistical analysis, interpretation of the results, design of the figures, and editing and revision of the manuscript. MFG contributed to the original research idea, the study design, interpretation of the results, and editing and revision of the manuscript. All authors approved the final version of the manuscript.

Declaration of interests

We declare no competing interests.

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Does pain, psychological distress and deteriorated family economy follow traumatic amputation among war casualties? A retrospective, cross-sectional study from Gaza

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ABSTRACT

Objectives The aim of this study was to explore determinants of psychosocial distress and pain in patients who have survived severe extremity amputation in Gaza.

Setting This study was conducted in a secondary care rehabilitation centre in Gaza, Palestine. The clinic is Gaza's sole provider of artificial limbs.

Participants We included 254 civilian Palestinians who had survived but lost one or more limb(s) during military incursions from 2006 to 2016. We included patients with surgically treated amputation injuries who attended physical rehabilitation at a specialist prosthesis centre in Gaza. Amputees with injuries prior to 2006 or non-military related injuries were excluded. We assessed their pain and psychological stress using the General Health Questionnaire (GHQ-12). We used income, amputation severity scored by proximity to torso, current employment status, loss of family members and loss of home as independent variables.

Results The amputees median age was 23 years at the time of trauma, while a median of 4.3 years had passed from trauma to study inclusion. Nine of 10 were male, while 43 were children when they were amputated (17%≤18 years). One hundred and ninety-one (75%) were unemployed and 112 (44%) reported unemployment caused by being amputated. Pain was the most frequent problem, and 80 amputees (32%) reported to suffer from daily pain. Family income was significantly correlated with the physical pain (OR=0.54, CI 0.36 to 0.80, p=0.002). Psychological distress was higher among unemployed amputees (OR=1.36, CI 1.07 to 1.72, p=0.011). We found no association between psychological distress (GHQ-scores) and the extent of the initial amputation.

Conclusion Pain and psychological distress following war-related extremity amputation of one or more limbs correlated stronger with deteriorated family economy and being unemployed than with the anatomical and medical severity of extremity amputations.

Strengths and limitations of this study

- The use of self-reported reasons for unemployment is a potential weakness in this study.
- The lack of longitudinal data also poses limitations. The most recent cases we included were in an early stage of treatment and rehabilitation and would probably be more unlikely to be able to work.
- We also have a potential risk of selection bias as some amputees sustained fatal injuries while others with minor injuries (like finger/toe amputations) may not have been referred for rehabilitation.
- Strengths of this study include a representative sample of the patients attending rehabilitation in Gaza, a response rate of 99%, the close cooperation with the local staff and the conduction of the study in Arabic.

BACKGROUND

During the last decade Gaza has experienced four large scale military incursions, leaving thousands of Palestinians injured, disabled and displaced. The number of civilians surviving with traumatic war-related amputations are increasing. The traumatic injuries from the recurrent military incursions on Gaza are aggravated by a siege enforced by military blockade since 2007, a shattered local economy, and high unemployment rates. According to the Palestinian Central Bureau of Statistics, 10 369 Palestinians have been killed from 2000 to 2016.[1]

Limb loss is associated with a number of secondary conditions, including psychological distress and pain, which may affect the long term outcome for the patients.[2]

The risk factors for such complications among traumatic amputees in Gaza are relatively unknown, and has to our knowledge, not been studied before. To understand and establish knowledge of common complications like pain and psychological distress, and the risk factors for these complications,

is important and may result in better outcomes for the amputees in Gaza.

Poverty is known to follow physical war injuries and further amplifies the burden of trauma for victims and families.[2] The public health problems posed from war and conflict injuries are more common in low and middle-income countries, such as Palestine.[3–5]

Limb loss due to military attacks is a sudden, brutal life-changing event for both amputees and families. As stated by Clasper and colleagues: traumatic amputations remain one of the most emotionally disturbing wounds of conflict.[6] These wounds may be followed not only by pain and loss of function, but also poverty if the ability to carry on with everyday work is lost,[7 8] and poverty predicts poorer outcomes after trauma-related amputations.[7 9 10] The negative impact of traumatic life events, such as war, are more severe among Palestinians in Gaza with a low family income.[11] Life satisfaction following traumatic limb amputation is closely related both to the ability to return to work and to adequate rehabilitation.[12 13]

We wanted to find out whether psychosocial factors (family income, unemployment) were significant predictors of the level of psychological distress and of the presence or absence of pain in Palestinian patients who had suffered traumatic extremity amputations and were attending rehabilitation in Gaza.

MATERIAL AND METHODS

Study participants

This study was conducted in the Gaza Strip which has seen four major military incursions since 2006 (Operation Summer Rain 2006, Operation Cast Lead 2008–09, Operation Pillar of Defense 2012, Operation Protective Edge 2014).[14–16]

We included 254 extremity civilian amputees from Gaza in a cross-sectional study. Inclusion criteria were one or several extremity amputations during 2006–2016 due to a military attack and being a Palestinian resident above the age of 16 years at the time of inclusion. We screened 1170 patient records and excluded 915 amputees whose amputations were not related to war or was sustained before 2006. The study was conducted at The Artificial Limb and Polio Center (ALPC) in Gaza City which is the sole place in the Gaza Strip where limb prostheses are tailored and fitted.[17] There were no major differentiation between the patients.

We conducted a pilot study from June to November in 2014 where the first 90 patients who met the inclusion criteria participated. The pilot study response rate was 99%, and we followed up by including all registered patients from ALPC who met the inclusion criteria. This pilot was followed by an in-depth descriptive study[18] The decision to use ALPC as a study centre had numerous advantages: it is located in central Gaza City, has good facilities with running water and generators supplying electricity during the daily power outages. It is a relatively safe place where the researchers and patients could meet without travelling to other areas of Gaza during ongoing military incursions. The centre provides gratis services for the amputation patients, which was an important asset and prevented recruitment of patients from being biased by patients' financial situation.[18]

Patients' medical history was taken the patient filled in a printed questionnaire in Arabic. Questionnaires were designed for yes/no or Likert-scale graded answers. Illiterate patients had the questions read out loud in Arabic. We used 12-question General Health Quality survey (GHQ-12), a well validated questionnaire to assess mental health.[19 20] The questionnaires were completed before each included patient underwent a detailed clinical medical examination by an experienced physician.

Level of amputation and severity of injury

We classified the amputations with the commonly used orthopaedic terms: above or below the extremity joints (reference). Every amputation was pictured by hand by the examiner on an anatomical sketch in addition to being photographed. The amputations were classified in an ordinal scale by an increasing order of severity based on proximity to the torso and number of affected limbs. The ordinal scale was as follows: 1=finger/toes/hands/feet; 2=below knee or below elbow; 3=above knee or elbow; and 4=bilateral amputation or amputation in both lower and upper extremities or unilateral amputation at hip-level/shoulder-level. Various weapon deliverers had caused the amputations in all cases.[21]

Pain

The patients provided details on the frequency of their pain during an average week. The ordinal scale was as follows: 0=never pain, 1=pain 1 day a week or less, 2=pain 2–3 days a week, 3=pain 4–6 days a week and 4=pain every day.

Mental health

To assess mental well-being, we were advised by local Palestinian psychologists at the Gaza Community Mental Health Center (GCMHC) to use the validated questionnaire GHQ-12. The questionnaire is a 12-questions screening tool in Arabic commonly used to assess mental distress in the general population in a community. It is self-administrated and easy to complete. The Arabic version has been validated for use in Arab-speaking patients, and has been used in previous studies in Gaza.[19 20 22] Scoring methods for GHQ-12 were bi-modal (0-0-1-1). We used a cut-off of 3 when we scored the GHQ-scores in accordance with a previous study conducted in Gaza by the WHO.[22] Cronbach's alpha was 0.72 for the GHQ-items 1 through 12. The use of a cut-off value is only relevant if the investigators are screening for 'caseness', which was our intention in this study.[23]

Family income

We recorded family income from each patient's self-reported questionnaires which included the following alternatives: a total family income per month 0=less than 700

New Israeli Shekels (NIS) 1=800–1600 NIS; 2=1700–2500 NIS; 3= 2600–3400 NIS; and 4=more than 3500 NIS (100 NIS= US$32).

Employment status

The self-reported employment status and patients perceived reason(s) for unemployment (employed, no available job, student/housewife, unemployed due to injury) were documented.

Ethics, consent and permission

We chose the ALPC as our local study base in agreement with the local health authorities, the board of Gaza's main hospital, Al-Shifa Hospital (Gaza's trauma centre), and the Director of the ALPC. All patient completed written consent prior to participating. We reimbursed all participants' roundtrip travel expenses to ALPC.

Statistics

Descriptive statistics are reported as mean and SD for parametric data, median and IQR for non-parametric data. We consider a p value<0.05 statistically significant. Frequencies are reported as percentage of the total study population for groups and subgroups. Logistic regression was used to assess association with a binary categorization of the GHQ-12 score (bimodal 0-0-1-1), as described by WHO.[22] Ordinal regressions was used for multivariate analysis with pain, a scale described above of increasing pain frequency from 0 to 4, as the outcome. Both models were first assessed with age gender and the independent variable of interest, before adjusting for additional variables.

Data analysis is conducted in SPSS Statistics V.22.0 (SPSS) and STATA V.15 (StataCorp.).

RESULTS

Patient demographics

Two-hundred and fifty-four patients participated in the study. Most of them were males in their 20s, all Palestinians from Gaza. All participants were registered as patient at the ALPC and had sustained one or more traumatic extremity amputations. Nearly 9 of 10 patients had major amputations (n=216, with 85% above wrist or ankle). Seventeen per cent17% (n=43) had been hit and sustained amputation(s) during childhood (aged 18 years or younger, 75% (191) of the amputees were unemployed at the time of inclusion in the study.

Thirty per centof the amputees (76/254) were surviving on less than 700 New Israeli Shekel monthly at the time of inclusion.

Table 1 summarises the patient characteristics.

Psychological distress and unemployment

Among the 191 (75%) unemployed patients, 112 (44%) reported that their unemployment was a direct result of the amputation injury. More than half of the amputees (55%, n=135) had GHQ-scores above the cut-off of 3 points indicative of psychological distress.

Table 1 Characteristics of study participants* (n=254)

Demographics	Patients (n)	Statistics (%)
Palestinian	254	100
Male	234	92
Children†	43	17
Female	20	8
Refugee status‡	154	57
Age—inclusion, years		28 (10)§
Age-injury, years		23 (9)§
Family income, NIS/US$¶		
<700/220	76	30
800–1600/252–504	105	42
>1700/535	50	28
Employment		
Unemployed	191	75
Unemployed due to amputation	112	44
≥3 unemployed family members	152	61
≥3 persons economically dependent on amputee	160	64

*Number of participants: 254, from 0% to 2% of the participants had missing data on any variable.
†Children refers to participant that were amputated at the age of 18 years or younger.
‡Refugee= patient is from a family who has formal UN refugee status as of 1948.
§Median and IQR.
¶NIS, New Israeli Shekel. 1 NIS equals US$0.26.

We found psychological distress to be higher among amputees who considered themselves unemployed due to the injury (OR=1.36, CI 1.07 to 1.72, p=0.011). In contrast, we did not find any association between the level of extremity amputation and level of psychological distress as assessed by GHQ-scores (table 2).

Pain and poverty

Every third amputee (n=80, 32%) studied reported that they suffered from daily pain.

The frequency of physical pain correlated with low family income, also when adjusted for the severity of the injury (OR=0.54, CI=0.36 to 0.80, p=0.002, see table 3 and figure 1).

Psychological distress and pain

The frequency of pain was significantly associated with the level of psychological distress (GHQ) among the participants. GHQ 12 scores increased among patients with frequent pain (OR=1.35, CI 1.12 to 1.65, p=0.002). Also, self-reported pain increased among patients with higher levels of psychological distress (OR=2.40, CI 1.48 to 3.39, p<0.001).

Table 2 Psychological distress

	Crude model †			Adjusted model‡		
	OR	95% CI	P value	OR	95% CI	P value
Unemployment due to trauma	1.36	1.07 to 1.72	0.011*	1.39	1.10 to 1.76	0.006*
Pain	1.35	1.12 to 1.65	0.002*	1.38	1.13 to 1.67	0.001*
Severity of injury				0.97	0.88 to 1.06	0.324
Family income				0.96	0.81 to 1.14	0.653
Loss of family members				1.06	0.80 to 1.37	0.687

Psychological distress indicated by a binary cut-off at a GHQ-score ≥3.
*P<0.05.
†Logistic regression adjusted for age and gender, with GHQ >3 points as the dependent variable.
‡Severity of injury, pain frequency and severity of injury added to the model described in †.
GHQ, General Health Questionnaire.

DISCUSSION

More than half of the traumatic amputees in this cross-sectional study from Gaza's main rehabilitation clinic reported psychological distress with GHQ-12 scores above the cut-off. Psychological distress was clearly associated with financial deterioration following their loss of work due to their extremity amputations. The frequency of pain was also higher among the poorest patients, and increased with decreasing family income. On the other hand, the anatomical extent and severity of the initial physical amputation trauma did not affect GHQ-scores or the frequency of pain experienced by the amputees.

Unemployment due to injury and mental distress

The psychological distress increased significantly among the amputees who were unable to continue work as a result of their limb loss. This finding is supported by WHOs previous findings in Gaza, where GHQ-levels were higher among unemployed.[24]

Three out of four patients in this study were unemployed. Close to half of them reported that they currently were unemployed as a consequence of their physical disabilities caused by the loss of limb(s). Unemployment was a major risk factor for depression and anxiety in Jordanian amputees.[25] The long-term outcomes in 146 traumatic amputees in USA, showed that 75% had sustained change in occupation after amputation with more than half reporting to be less paid in their new positions.[2]

The unemployment among local Palestinian documented in our study is adding up to an already exceptionally high unemployment rate in Gaza, reaching 43.6% in 2018.[26 27]

The increased poverty that followed after severe extremity amputation injury in this cohort of amputees in Gaza, appears to be more important for psychological well-being than the extent of the amputation.

Pain and low family income

We also found that low family income was the main predictor to determine how often the amputees experienced pain. The frequency of pain increased among amputees who lived in families with low income. Surprisingly, neither pain nor psychological distress were affected by the extent of the initial physical trauma. Our findings are supported by the conclusion in the study by Husum and colleagues on chronic pain in land mine accident survivors in Cambodia and Kurdistan, where patient-related loss of income correlated with the rate of chronic pain syndrome.[7] Ferguson and colleagues studied the psychological adjustment after amputation in landmine victims and found that the amputees recovery and acceptance of limb loss were dependent on the patients economic situation.[28] In the context of living with disabilities in a society where

Table 3 Pain severity after amputation

	Crude model†			Adjusted model‡		
	OR	95% CI	P value	OR	95% CI	P value
Family income	0.54	0.36 to 0.80	0.002*	0.55	0.35 to 0.88	0.012*
Psychological distress	2.40	1.48 to 3.39	<0.001**	2.39	1.42 to 4.02	0.001*
Severity of injury				0.24	0.26 to 1.41	0.134
Unemployment due to trauma				0.91	0.44 to 1.89	0.808
Loss of family members				1.49	0.73 to 3.06	0.277

Ordinal weekly pain scale from 0 to 4: never, 1 day a week or less, 2–3 days, 4–6 days and daily.
*P<0.05, **P<0.001
†Crude model: ordinal logistic regression adjusted for age and gender, with pain as the dependent variable.
‡Adjusted model: severity of injury, psychological distress and severity of injury added to the model described in †.

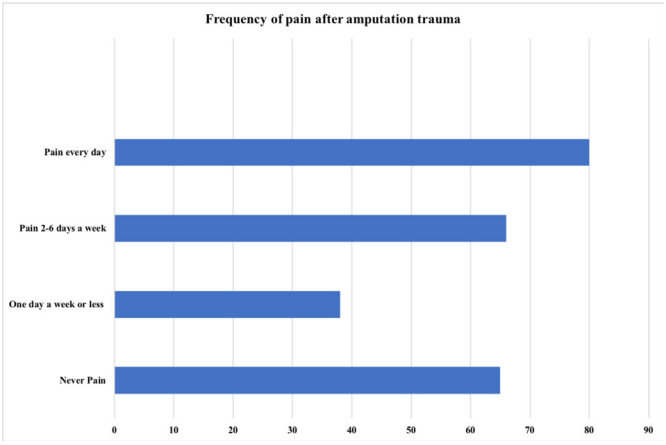

Figure 1 Frequency of pain after amputation trauma
Number of participants: 249. Five (1.96%) participants had missing data.

siege, occupation and recurrent military attacks are part of everyday life, it is also important to acknowledge the effects this may have on fundamental psychosocial determinants of pain and psychological distress.

The most important factor to improve mental health among civilians in Gaza, is end the occupation.[29]

Social suffering such as unemployment and poverty are effects of the long-lasting siege of Gaza which adds burdens to the lives of the amputees and their families. The unemployment rate in Palestine was 31% in 2018. In Gaza 52% of the labour force was unemployed.[30] In order for the Palestinian economy to improve, the World Bank stresses the need for a political solution allowing the Palestinian economy to expand through access to the regional and international markets with export of Palestinian products and services. This requires an immediate end to the siege of Gaza.[30]

To ameliorate the needs of the population of amputees, the context of Palestine and lack of human security must be taken into account. As stated by Giacaman and colleagues: "these issues requires a shift in the emphasis from narrow medical indicators, injury and illness to the lack of human security and human rights violations experienced by ordinary Palestinians".[31]

Limitations and strengths

The use of self-reported reasons for unemployment is a potential weakness in this study.

The lack of longitudinal data also poses limitations. The most recent cases we included were in an early stage of treatment and rehabilitation and would probably be more unlikely to be able to work. We also have a potential risk of selection bias as some amputees sustained fatal injuries while others with minor injuries (like finger/toe amputations) may not have been referred for rehabilitation. However, due to the ongoing conflict, the lack of infrastructure and sometimes incomplete medical records, it would be close to impossible to obtain a completely representative set of data from the whole population of amputees.

Strengths of this study include a representative sample of the patients attending rehabilitation at ALPC with a response rate of 99%, the close cooperation with the local staff and the conduction of the study in Arabic.

INTERPRETATION

More physical pain and decreased mental well-being correlated significantly with the more unemployment and less family income (poverty) following traumatic extremity amputations among Palestinians in Gaza. Poverty and unemployment after traumatic amputations and disability are heavy, extra burdens adding to the trauma of the physical extremity amputation itself.

PATIENTS AND PUBLIC INVOLVEMENT

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

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Contributors HEH-L contributed study design, data collection, data entry, data analysis, interpretation of the results, the primary draft of the manuscript writing, editing the manuscript, literature search and final approval of the manuscript. YA-B contributed to study design, patient inclusion, data collection, data transfer, revising the manuscript and final approval of the manuscript. SS contributed to study design, patient inclusion, data collection, data transfer, revising the manuscript and final approval of the manuscript. NS contributed to study design, patient inclusion, data collection, data transfer, revising the manuscript and final approval of the manuscript. LMG contributed to the statistical analysis, interpretation of the results, visualisation of the data in figures, editing and revising and manuscript and final approval of the manuscript. MG contributed the original research idea, the study design, interpretation of the results, revising and editing the manuscript and final approval of the manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval All patient completed written consent prior to participating. The study was approved by the Regional Ethical Committee (approval number: 2016/1265/REK Nord) in Norway and the Committee for Helsinki ethics approvals in Gaza.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No data are available.

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List of appendices

1. Examples of informed consent forms in Arabic (from three patients telling their stories in this Thesis)
2. Norwegian REK consent form

3. Questionnaire for the study patients (English)

نموذج موافقة Consent Form

اسم المريض: أحمد صادق سعيد الناجي

صلة القرابة بالمريض (إذا لم يكن المريض نفسه هو الموقع على النموذج): _____

أقر أنا، أحمد صادق سعيد الناجي، على الموافقة أن تستخدم د. هانا لوسيوس قصتي وتاريخي المرضي فيما يتعلق بإصابة البتر التي لحقت بي في سنة ٢٠١٨. كما أنني أقر بأنني قمت بتقديم المعلومات المتعلقة بقصتي وتاريخي المرضي للدكتورة هانا لوسيوس خلال شهر يونيو من عام ٢٠١٨. وأدرك أن قصتي وتاريخي المرضي سيتم نشره في بحث علمي يتعلق بإجراء واستكمال متطلبات درجة الدكتوراه والمتعلقة بدراسة إصابات البتر في قطاع غزة خلال الفترة ٢٠٠٦-٢٠١٦.

أؤكد على أن د. هانا لوسيوس لديها موافقتي الخطية لاستخدام ونشر الصور الفوتوغرافية التي التقطتها لي خلال زيارتها وحديثنا في شهر يونيو من عام ٢٠١٨. كما أنني أؤكد أنني رأيت هذ الصور التي تخصني.

التوقيع: _____ الاسم كاملاً: أحمد صادق سعيد الناجي

العنوان: غزة - الشيخ رضوان

في حالة التوقيع نيابة عن المريض الذي يقل عمره عن 18 عامًا.

توقيع ولي الأمر: _____ الاسم كاملاً: _____

نموذج موافقة Consent Form

اسم المريض: عادل احمد ابراهيم ابو شعره

صلة القرابة بالمريض (إذا لم يكن المريض نفسه هو الموقع على النموذج): _____

أقر أنا، عادل احمد ابراهيم ابو شعره، على الموافقة أن تستخدم د. هانا لوسيوس قصتي وتاريخي المرضي فيما يتعلق بإصابة البتر التي لحقت بي في سنة ٢٠١٨. كما أنني أقر بأنني قمت بتقديم المعلومات المتعلقة بقصتي وتاريخي المرضي للدكتورة هانا لوسيوس خلال شهر يونيو من عام ٢٠١٨. وأدرك أن قصتي وتاريخي المرضي سيتم نشره في بحث علمي يتعلق بإجراء واستكمال متطلبات درجة الدكتوراه والمتعلقة بدراسة إصابات البتر في قطاع غزة خلال الفترة ٢٠٠٦-٢٠١٦.

أؤكد على أن د. هانا لوسيوس لديها موافقتي الخطية لاستخدام ونشر الصور الفوتوغرافية التي التقطتها لي خلال زيارتها وحديثنا في شهر يونيو من عام ٢٠١٨. كما أنني أؤكد أنني رأيت هذ الصور التي تخصني.

التوقيع: _____ الاسم كاملاً: عادل ابو شعره

العنوان: غزة - الشجاعية - شارع فلسطين - عمارة المعاجيني

في حالة التوقيع نيابة عن المريض الذي يقل عمره عن 18 عامًا.

توقيع ولي الأمر: _____ الاسم كاملاً: _____

نموذج موافقة Consent Form

اسم المريض: عبد الله عماد كمال الأشقر

صلة القرابة بالمريض (إذا لم يكن المريض نفسه هو الموقع على النموذج): الأم

أقر أنا، رانيا فتحي خضر الأشقر، على الموافقة أن تستخدم د. هانا لوسيوس قصتي وتاريخي المرضي فيما يتعلق بإصابة البتر التي لحقت بي في سنة ٢٠١٨. كما أنني أقر بأنني قمت بتقديم المعلومات المتعلقة بقصتي وتاريخي المرضي للدكتورة هانا لوسيوس خلال شهر يونيو من عام ٢٠١٨. وأدرك أن قصتي وتاريخي المرضي سيتم نشره في بحث علمي يتعلق بإجراء واستكمال متطلبات درجة الدكتوراه والمتعلقة بدراسة إصابات البتر في قطاع غزة خلال الفترة ٢٠٠٦-٢٠١٦.

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التوقيع: _____ الاسم كاملاً: _____

العنوان: الشجاعية أخر شارع المطحونة - غزة - فلسطين

في حالة التوقيع نيابة عن المريض الذي يقل عمره عن 18 عامًا.

توقيع ولي الأمر: رانيا الأشقر الاسم كاملاً: رانيا فتحي خضر الأشقر

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord			30.08.2016	2016/1265/REK nord
			Deres dato:	Deres referanse:
			14.06.2016	

Vår referanse må oppgis ved alle henvendelser

Mads Gilbert
Klinikk for akuttmedisin

2016/1265 Retrospektiv studie av traumatisk amputerte

Forskningsansvarlig: UNN
Prosjektleder: Mads Gilbert

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK nord) i møtet 18.08.2016. Vurderingen er gjort med hjemmel i helseforskningsloven (hfl.) § 10, jf. forskningsetikkloven § 4.

Prosjektleders prosjektomtale
Prosjektet er en oppfølgingstudie av 250 pasienter med krigselaterte amputasjoner fra 2006-2015. Vi ønsker å undersøke hvordan det har gått med denne gruppen som det etter vår kunnskap ikke finnes noen oppfølging på per i dag. Alle pasientene skal fylle ut to validerte spørreskjema, GHQ12 og SF 36 for å kartlegge fysisk restfunksjon samt psyko-sosiale utfordringer. Vi ønsker å beskrive studiepopulasjonen gjennom demografiske deskriptive data. Vi ønsker å kartlegge grad av skade etter ISS score, hvorvidt pasientene har fått fysikalsk behandling og tilpasset protese. Alle pasientene vil få en klinisk undersøkelse av lege. Prosjektet startet som særoppgave for stud. med Hanne Lossius i 2012, og vi ønsker nå å gå videre med studien for internasjonal publisering. (Se vedlegg: særoppgave i medisinstudiet).

Vurdering

Geografisk virkeområde
Helseforskningslovens geografiske virkeområde er regulert i helseforskningsloven § 3. Av bestemmelsens første ledd følger at loven gjelder forskning på norsk territorium eller når forskningen skjer i regi av en forskningsansvarlig som er etablert i Norge. Dette prosjektet gjennomføres i regi av Universitetssykehuset Nord-Norge, og er et doktorgradsprosjekt. Prosjektet faller således inn under lovens geografiske virkeområde.

Forskningsansvarlig institusjon
Universitetssykehuset Nord-Norge er oppgitt som forskningsansvarlig institusjon med klinikkoverlege Mads Gilbert som kontaktperson. Komiteen legger til grunn at Universitetssykehuset Nord-Norge ved øverste ledelse/klinikksjef Eva-Hanne Hansen står som kontaktperson for forskningsansvarlig institusjon.

Av protokollen fremgår det at studien vil bli utført ved lokalt rehabiliteringssenter, ALPC (Artificial Limb and Polio Center). Dr. Nashwa Skaik (gynekolog) og Samar Shaqqoura (turnuslege ved Al-Shifa sykehus) vil stå for datainnsamlingen på Gaza.

Det fremgår av søknaden at prosjektet er godkjent av det palestinske helseministeriet MOH (Ministry Of

Health). Denne godkjenningen er ikke vedlagt søknaden. Prosjektleder skriver: «*Tidligere godkjent informasjonsskriv og dokumentasjon på godkjent samtykkeprosedyre: Dokumentet ligger på ALPC I Gaza. Dette er et dokument på arabisk og i samsvar med samtykkeprosedyren som gjøres på Gaza. Det var ikke mulig for oss å få dette dokumentet tilsendt til Norge tidsnok men det kan selvfølgelig ettersendes*».Det tilligger prosjektleder å ha ansvar for at nødvendige godkjenninger i Palestina foreligger. Det er ikke nødvendig å ettersende dokumentasjonen.

Forespørsel/informasjonsskriv/samtykkeerklæring
Forespørselsskrivet er utformet med en layout som er vanskelig å lese. Innholdet er greit, men prosjektleder må fjerne/rydde det som ikke er relevant, f.eks. samtykke fra foreldrene dersom dette ikke er aktuelt.

Oppbevaring av data
Av søknaden fremgår det at koblingsnøkkel oppbevares på Gaza hos Dr. Nashwa Skaik. Data som overføres til Norge er avidentifisert.

Vedtak
Med hjemmel i helseforskningsloven §§ 2 og 10 godkjennes prosjektet.

Sluttmelding og søknad om prosjektendring
Prosjektleder skal sende sluttmelding til REK nord på eget skjema senest 01.07.2019, jf. hfl. § 12. Prosjektleder skal sende søknad om prosjektendring til REK nord dersom det skal gjøres vesentlige endringer i forhold til de opplysninger som er gitt i søknaden, jf. hfl. § 11.

Klageadgang
Du kan klage på komiteens vedtak, jf. forvaltningsloven § 28 flg. Klagen sendes til REK nord. Klagefristen er tre uker fra du mottar dette brevet. Dersom vedtaket opprettholdes av REK nord, sendes klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag for endelig vurdering.

Med vennlig hilsen

May Britt Rossvoll
sekretariatsleder

Kopi til: rek-svar@unn.no

Questionnaire for patients

For office use only

Questionnaire number:

Date:

Demography

1 Date of birth:

2 Gender:

1 male 2 female

3 Nationality:

Are you or your parents refugees (1948)

1 yes 2 no

4 Where in Gaza do you live?

SES

5 What is your level of education:

Please cirkle the most suitable.

1 illiterate
2 elementary school
3 secondary school
4 high school
5 undergraduate
6 graduate
7 post graduate
8 PhD

6 Emplyment status:

Please cirkle the most suitable.

1 employed
0 unemployed

7 if you answered unemployed, please specify why:

1 disabled
2 student
3 No available job
4 other, please specify_____

8 Avarage monthly income of your family:

Please cirkle the most suitable answer.

1 Less than 700 Shekels
2 800-1600
3 1700-2500
4 2600-3400
5 more than 3500

9 Household

What kind of family do you live in:
Please cirkle the most suitable for you

1 an extended family («El Hamula»)
2 nuclear family

Please specify:

3 Number of siblings
0
1-2
3-4
5-6
more than 6

4 Total number of persons living in your household?
only me
2-3
4-5
6-7
8 or more

10 Avarage monthly income of your extended family(«El Hamula»):

Please cirkle the most suitable answer.

1 Less than 700 Shekels
2 800-1600
3 1700-2500
4 2600-3400
5 more than 3500

11 Total number of persons living in your household that are economically dependent on you?
0
1-2
3-4
5-6
7-8
more than 8

12 Number of persons unemplyed in your household
0
1-2
3-4
5-6
7-8
more than 8

13 Has your house or apatment been destroyed?

1 yes
2 No

14 If your house or appartment has been destroyed, has it been rebuilt?

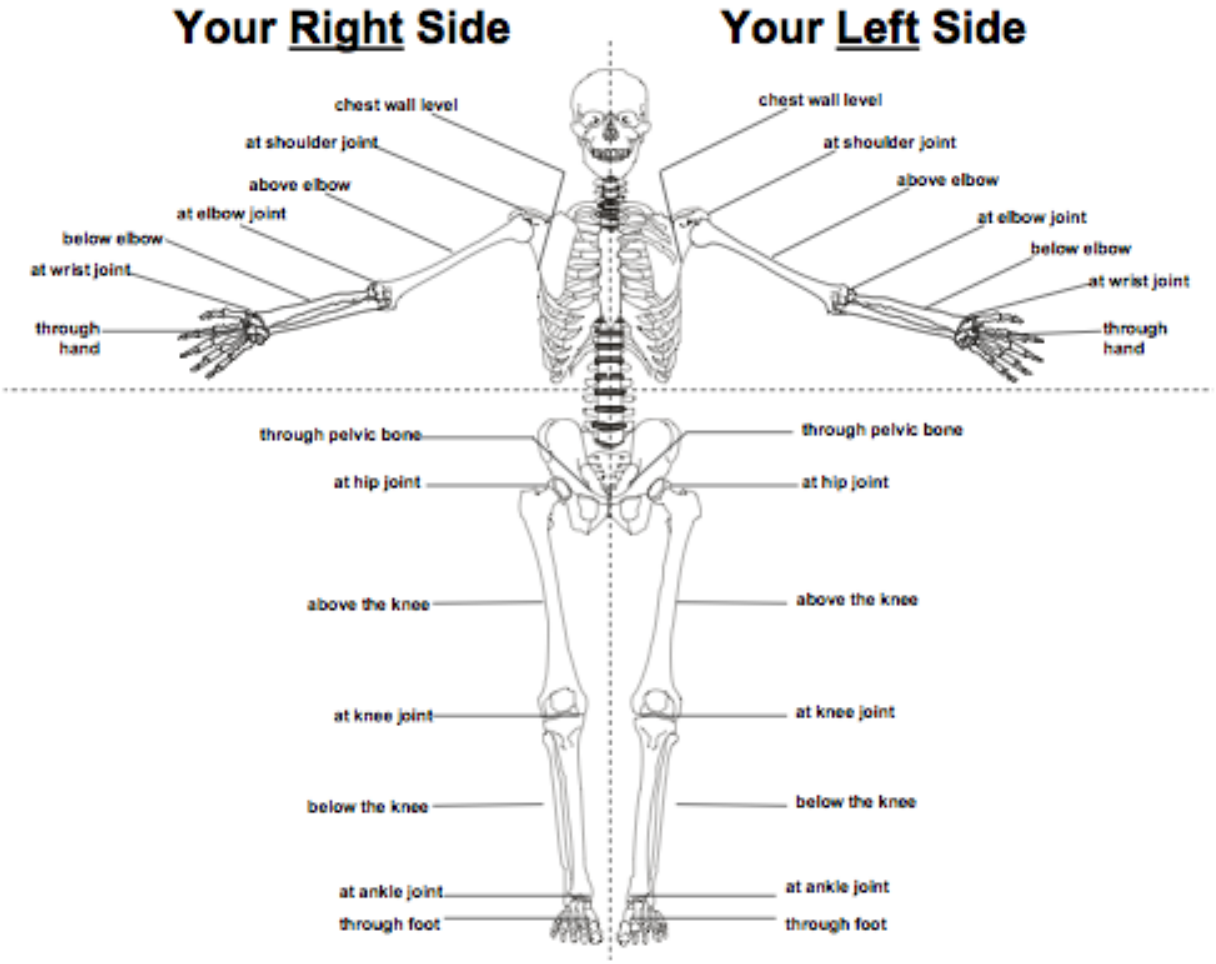
1 Yes
2 No

Amputation

10 Date of the injury?

12 Anatomic place of injury:

Please cirkle the area of your amputee(s) in the drawing below.


Your Right Side
Your Left Side
chest wall level
at shoulder joint
above elbow
at elbow joint
below elbow
at wrist joint
through hand
chest wall level
at shoulder joint
above elbow
at elbow joint
below elbow
at wrist joint
through hand
through pelvic bone
at hip joint
above the knee
at knee joint
below the knee
at ankle joint
through foot
through pelvic bone
at hip joint
above the knee
at knee joint
below the knee
at ankle joint
through foot

12 If you have lower limb amputation- Since your amputation, have you ever been diagnosed with any of the following in your non-amputated lower limb?

(Check any or all that apply.)

□ Ankle arthritis

□ Knee arthritis

□ Hip arthritis

□ Stiff ankle

□ Stiff knee

□ Stiff hip

□ Heel pain

□ Plantar fasciitis

□ Other (describe):

13 If you have upper limb amputation- Since your amputation, have you ever been diagnosed with any of the following in your non-amputated upper limb?

(Check any or all that apply.)

□ Carpal tunnel syndrome (wrist)

□ Cubital tunnel syndrome (elbow)

□ Tendonitis

□ Tennis elbow (lateral epicondylitis)

□ Golfer's elbow (medial epicondylitis)

□ Stenosing Tenosynovitis (trigger finger)

□ Stenosing Tendosynovitis (DeQuervains) (thumb)

□ Ganglion cyst

□ Rotator cuff tendonitis (shoulder)

□ Osteoarthritis/degenerative joint disease

□ Other (describe):

14 Mechanism of the damage:

Are you aware of what kind of weapon that caused your initial damage?
(hvilke alternativer skal vi inkludere? skal det i det hele tatt være med?)

15 About the amputattion:

Please cirkle the answer suitable for you:

1 The amputation was a direct result of the trauma
2 The amputation was a result of an infection after the initial trauma

16 operations:

How many operations have you had:
Before the trauma :
0-1
2-3
4-5
6-7
8-9
over 10

2 After the trauma :
0-1
2-3
4-5
6-7
8-9
over 10

17 prostetic limb

Are you currently using a prostetic limb?

1 Yes
2 No

If yes, for how many hours during each day do you use it?

_____

If yes, how well is the prostetic limb working for you?

(Please cirkle the answer suitable for you)

4 Very good
3 good
2 bad
1 very bad

If no, what is the reason you do not use a prostetic limb?

_____

Rehabilitation after the amputation

18 Have you recieved physiotherapy and/or guided physical training after the amputation?

1 Yes
2 No

If yes, how many times each month did you recieved physiotherapy and/or guided physical training within the first 6 months after the amputation?
1
2
3
4
5 or more

If no, why have you not recieved physiotherapy and/or guided physical training after the amputation?

_____

Comorbidity

19 Do you suffer from any of the following conditions:

Please cirkle the most suitable answer(s)

1 Phantom pains	yes no
2 Phantom sensations	yes no
3 Back pain	yes no
4 Weight loss	yes no
5 Loss of apetite	yes no

6 Joint pain yes no
7 Peripheral arterial disease yes no
8 asthma yes no
9 skin related problems yes no
10 sleeping disturbances yes no
11 cardio vascular disases yes no
12 cancer (malignancies) yes no
13 anxiety yes no
14 depression yes no
15 arthiritis yes no

others, please specify_____

21 Have you within the last 8 years been diagnosed with any of the following conditions:

Heart disease yes no
Diabetes yes no
Cancer yes no
Asthma yes no

If yes on any of the alteranatives above, pleace explain which kind of illness:
_____
_____
_____

22 Pain
How often do you experience physical pain due to your damage?

1 Every day
2 4-6 days each week
3 2-3 days days each week
4 1 day a week or less
5 Never

23 VAS

On an average day within the last 6 weeks, describe the pain you feel on a scale from 0-10, where 0 is absolutely no pain and 10 is the worst possible pain. Please cirkle the most suitable answer.

0
1
2
3
4
5
6
7

8
9
10