Averted health burden over 4 years at Médecins Sans Frontières (MSF) Trauma Centre in Kunduz, Afghanistan, prior to its closure in 2015

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Background. *On October 3, 2015, a United States airstrike hit Médecins Sans Frontières (Doctors Without Borders) Trauma Centre in Kunduz, Afghanistan. Our aim was to describe the care provided and estimate the health burden averted by surgical care at the hospital. We also report the benefit rendered by the Trauma Centre to the health of the local population prior to its destruction.*
Methods. *All operations performed in an operating theater at the Trauma Centre from its opening on August 30, 2011, to August 31, 2015, were described. Disability-adjusted life years averted by operative care over the same period were estimated.*
Results. *The Trauma Centre performed 13,970 operations, which included 17,928 procedures for 6,685 patients. The median age of patients who required operative intervention was 21 years (interquartile range 12–34 years). More than 85% of patients were men (12,034 patients; 86%). Of the 6,685 patients who required operative care, 4,387 suffered unintentional, non–violence-related injuries (66%), while 2,276 suffered violence-related injuries (34%). The perioperative death rate at the facility decreased from 7.2 deaths per 1,000 operations in 2011 to 1.3 deaths in 2015 (P = .03). More than 154,250 disability-adjusted life years were averted by operative care (95% confidence interval 153,042–155,465).*
Conclusion. *The health burden averted by the surgical care provided at the Trauma Centre was large; it is critically felt by those still living in the region. Access to essential trauma care for all victims of armed conflict is a human right; as directed by International Humanitarian Law, we must guarantee special protection for the wounded, sick, and medical personnel and facilities during war. (Surgery 2016;■:■-■.)*

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ON OCTOBER 3, 2015, a United States airstrike hit Médecins Sans Frontières (MSF; Doctors Without Borders) Kunduz Trauma Centre in Afghanistan; 30 lives, including those of 14 MSF hospital staff, were lost.[1] The 92-bed hospital was the only facility with comprehensive trauma care capabilities for hundreds of thousands of people living in northern Afghanistan.

MSF is an international, medical, nongovernmental organization that delivers emergency aid to people affected by armed conflict, epidemics, natural disasters, and exclusion from health care irrespective of race, religion, sex, or political affiliation.[2] For >40 years, MSF has provided medical and surgical care to vulnerable populations around the world.[3] MSF's ability to provide humanitarian assistance amid conflict hinges on the special protection of hospitals, medical units, and medical personnel afforded by the Geneva Conventions.[4,5]

Our aim was to report the benefit rendered by the MSF Kunduz Trauma Centre on the health of the local population. Specifically, we reviewed the surgical care provided and estimated the health burden averted by surgical care before the hospital was destroyed.

METHODS

Setting. Kunduz is the fifth largest city in the country with an estimated population of 323,960; the population of Kunduz Province is estimated to be 1,029,473.[6] Increased conflict in the region and a lack of trauma care compelled MSF to establish the Trauma Centre in August 2011.[7] The Trauma Centre was the only facility capable of comprehensive trauma care in northern Afghanistan (eg, resuscitation and critical care, general trauma surgery, orthopedic care, basic neurosurgical care, rehabilitation). It was staffed by 460 Afghan nationals (321 medical and paramedical staff; 139 nonmedical staff), which included 13 surgeons, 2 physician anesthetists, and 6 nurse anesthetists. It was equipped with an emergency department; 3 operating rooms; an 8-bed intensive care unit; x-ray; image intensification; and laboratory, physiotherapy, and mental health services. The Trauma Centre served a planned catchment area that included villages as near as 20 minutes by vehicle (eg, Kunduz City, Gultipa) and as far as 2 hours (eg, Imam Sabib, Dasht-e-Archi).

Given a lack of other facilities with similar capacity in the neighboring provinces and the need to traverse the Hindu Kush Mountains to reach trauma care services in Kabul, the Trauma Centre received patients from a large area in the north of Afghanistan. In addition to the substantial structural barriers to care in Kunduz (eg, poor roads, long distances, lack of vehicular transport options, few capable health care facilities), there were many other barriers to care that precluded timely access to comprehensive trauma care service, including both direct and indirect financial barriers, barriers related to the sex of the individual, and safety-related barriers.[8-11] The Trauma Centre was able to alleviate some of these barriers by rending care completely free of charge, caring for all injured patients indiscriminately, and being proximate to the population living amid conflict.

The nearby government-run, provincial hospital was capable of general surgical, obstetric, and basic orthopedic care; however, the facility was not equipped with the human or physical resources necessary to provide comprehensive trauma care. Given the capacity of the provincial hospital to care for general surgical and obstetric emergencies, attempts were made to stabilize and transfer patients with these conditions to the provincial hospital when possible.

Data collection. MSF collects data routinely to monitor the volume and types of procedures performed at each of the facilities they support.[12] For this report, patients were defined as individuals who underwent an operation in an operating theater; procedures were the specific operative tasks performed (eg, amputation, laparotomy).

All operations performed from August 30, 2011, to August 31, 2015, were recorded using a standardized Patient Surgical Record (PSR). The PSR was developed by MSF for operational research needs.[12] Therefore, patient identifiers for longitudinal evaluation were not recorded. The PSR variables are: age, sex, indication for operation, American Society of Anesthesia (ASA) physical status score, operation order and urgency, type of anesthesia given, procedure(s) performed, and perioperative death (ie, death from initiation of anesthesia care to discharge from the postanesthesia care unit).

PSR data are entered into a database and transmitted regularly to MSF headquarters in Brussels, Belgium. At headquarters, the Surgical, Anaesthesia, Gynaecology and Emergency Medicine (SAGE) Unit reviewed all data for completeness and accuracy. Discrepancies or missing data were reconciled immediately with program personnel.

Indications and procedures. Indication for operation was grouped into trauma and nontrauma indications. Trauma indications included injuries

associated with violence (eg, injuries from land mines, bombs, gunshots, assault, rape, torture, etc) and unintentional, non–violence-related injuries (eg, injuries from road traffic crashes, falls, agricultural injuries, etc).

Procedures were grouped into five mutually exclusive categories of surgery: minor, wound, visceral, orthopedic, and specialized. Examples of minor surgery included simple wound management and chest tube placement. Wound surgery included extensive debridement, burn care, and removal of shrapnel. Visceral surgery included procedures such as exploratory laparotomy and repair of solid or hollow viscus injury. Orthopedic surgery included treatment of fractures, amputations, and repair of tendon or nerve injury. For this analysis, specialized operations included procedures typically performed under the auspices of a specialist provider if resources allowed (eg, obstetrics, neurosurgery).

Data analysis. Patients, indications for operation, and procedures performed were described; median and interquartile range [IQR] were used to describe patients' ages, which were slightly positively skewed (skewness = 0.81). Children were defined as individuals aged <15 years to be consistent with international humanitarian law.[5] Potential differences in the distribution of perioperative deaths over time were examined with the χ^2 test for trend. Perioperative death rate was defined as death from initiation of anesthesia care to discharge from the postanesthesia care unit; this metric does not capture deaths that occurred in the hospital during convalescence or within 30 days of discharge.

Next, disability-adjusted life years (DALYs) averted by surgical care were estimated. First, counterfactual DALYs incurred were calculated (ie, those that would have been incurred without surgical care). Then, the actual DALYs incurred were calculated. The actual DALYs incurred were then subtracted from counterfactual DALYs:

$$DALYs\ averted = Counterfactual\ DALYs - Actual\ DALYs$$

To allow apposite comparison with other hospitals in a low-income country, methods reported previously were used to score condition severity and treatment efficacy.[13,14] DALYs were calculated using standard age-discounted life expectancies, a severity weight for each condition, a treatment efficacy weight for each procedure, and both a treated and an untreated disability weight for each condition.

The severity of each condition was assigned a weight of 1.0 if the condition was considered fatal ≥95% of the time without surgical care. Accordingly, a weight of 0.7 was assigned for conditions that were considered to be fatal <95% of the time but ≥50% of the time, 0.3 for <50% of the time but ≥5% of the time, and 0.0 for <5% of the time. The setting in which the injuries and conditions occurred was considered in making these decisions (ie, the lack of other options for medical or surgical care).

Similarly, the treatment efficacy for a procedure was assigned a weight of 1.0 if the procedure had a ≥95% chance of rendering a cure of the condition, 0.7 if the chance of cure was <95% but ≥50%, 0.3 if the chance of cure was <50% but ≥5%, and 0.3 if the chance of cure was <5%.

Scores were assigned independently by 2 coauthors (BTS, ALK); disagreements were settled by a third coauthor (MT; Supplementary Material, online version only). Standard, age-discounted life expectancies and disability weights were obtained from the Global Burden of Disease Study 2010 (Supplementary Material).[15,16] Short-term disability was not included.

Using these terms, the DALYs averted from surgical care were estimated with the equation:

$$DALYs\ averted = \sum_{i=0}^{i=l} L_i[S_l + (1 - S_l) \times C_l] - L_i[T_i \times A_l + (1 - T_l) \times C_l]$$

where i is the observation; l is the last observation; L is the age-discounted life expectancy; S is the severity weight; C is the disability weight without surgical care; T is the treatment efficacy weight; and A is the disability weight despite surgical care.

For patients with >1 condition, only the condition with the greatest severity score was considered (eg, only the gunshot wound to the abdomen would be considered in a patient with a gunshot wound to the abdomen and a superficial laceration on the leg). To avoid doubly counting DALYs averted for patients who required >1 operation, only the operation associated with the condition that corresponded to the greatest severity score was used in the calculations (eg, in the example patient above, only the laparotomy to repair injuries incurred by the abdominal gunshot wound would be used in the calculations; the closure of the superficial laceration on the leg would not be used in the calculations). No DALYs were averted for patients who died.

Sensitivity analysis. To examine the stability of our model, we performed bootstrap resampling,

Table I. Age and sex of patients cared for at the Médecins Sans Frontières Kunduz Trauma Centre from August 2011 to August 2015

	Total patients	Violence-related injuries	Unintentional, non–violence-related injuries	Other conditions
	n (%)	n (%)	n (%)	n (%)
Total	6,685 (100)	2,276 (34.1)	4,387 (65.6)	22 (0.3)
Age (yr)				
<5	304 (4.5)	41 (1.8)	262 (6.0)	1 (4.5)
5–14	1,802 (27.0)	305 (13.4)	1,487 (33.9)	10 (45.5)
≥15	4,579 (68.5)	1,930 (84.8)	2,638 (60.1)	11 (50.0)
Sex				
Female	974 (14.6)	258 (11.3)	712 (16.2)	4 (18.2)
Male	5,711 (85.4)	2,018 (88.7)	3,675 (83.8)	18 (81.8)

Violence-related trauma mechanisms include land mines or bomb blasts, gunshots, stabbings, assaults, rape, and torture. Unintentional trauma mechanisms include road traffic crash, falls, unintentional burns, and other injuries. Other causes include general surgical care and obstetric emergencies.

where 1,000 replicates of the data set were made with replacement.[17] Then, we recalculated the DALYs averted and used the corresponding standard errors to calculate 95% confidence intervals (CIs).

Ethics. MSF Ethical Review Board, Johns Hopkins Bloomberg School of Public Health, and the Institutional Review Board of Afghanistan approved description of deidentified, routinely collected data.

RESULTS

Patients and indications. From its opening in August 2011 to August 2015, MSF Kunduz Trauma Centre performed 13,970 operations, which included 17,928 procedures for 6,685 patients who came from 6 of the country's 34 provinces. The median age of patients who required operative intervention was 21 years (IQR 12–33 years; range 1 month to 95 years); 85% of patients were male (5,711 patients; Table I).

Although most patients were ≥15 years (4,579 patients; 69% of all patients), 31% of patients were children <15 years (Table I). Of the 6,685 patients who required operative intervention, 4,387 suffered unintentional, non–violence-related injuries (66%), and 2,276 suffered violence-related injuries (34%). There were 346 children ≤15 years injured by violence (15% of patients injured from violence), including 41 children who were <5 years of age (2%).

Of the patients who underwent operative intervention, 56,484 had life- and/or limb-threatening emergencies (50.3%). Nearly 40,000 patients had urgent conditions (ie, conditions that would lead to death or limb loss if not operated on within 72 hours [39,442 patients; 35.2% of patients]). Only 16,298 patients had elective operations (14.5%).

Operations and procedures performed. The number of operations performed increased generally after the hospital opened, particularly in the few months prior to the airstrike (Fig 1). Of the 13,970 operations performed, 8,841 were for unintentional, non–violence-related injuries (63%), and 5,089 were for violence (37% of procedures). Only 40 operations were performed for non-trauma indications (<1%). While the number of unintentional injuries that required an operation was generally greater than the number of violence-related injuries, the hospital cared for relatively more violence-related trauma between April and June 2015, which corresponded to the increase in conflict in the region over the same period.[18]

Procedures for complex wounds (eg, extensive debridement, removal of shrapnel, burn care) were the most common procedures performed (43% of all procedures performed), followed by orthopedic procedures (eg, skeletal traction, external or internal fixation, major amputation; 32%) and minor procedures (eg, minor debridement, chest tube placement, drain placement; 19%; Fig 2). Visceral (eg, management of solid or hollow viscus injury) and specialized procedures (eg, burr holes, repair of genitourinary system) were performed far less often (4% and 2% of all procedures performed, respectively).

Perioperative death rate. The perioperative death rate (ie, death from initiation of anesthesia care to discharge from the postanesthesia care unit) decreased from 7.2 deaths per 1,000 operations in 2011 to 1.3 in 2015 (χ^2 test for trend; $P = .03$). In 2015, the Trauma Centre began recording systematically perioperative mortality rate (ie, death from initiation of anesthesia to
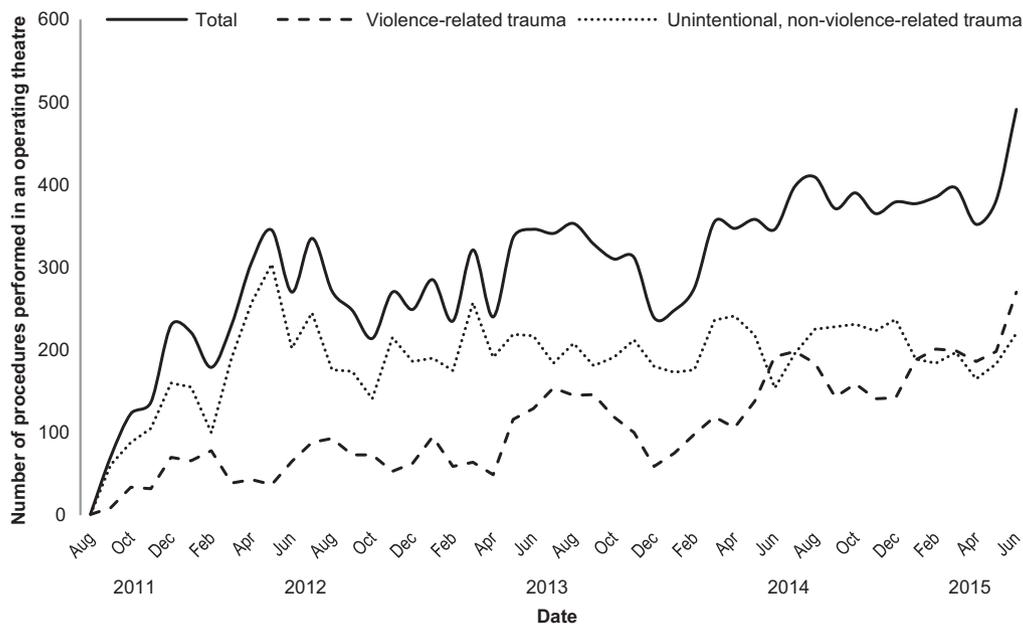
Fig 1. Operative volume at the Médecins Sans Frontières Kunduz Trauma Centre from August 2011 to August 2015 (N = 13,970 operations). Violence-related trauma mechanisms include land mine or bomb blast, gunshot, stabbing, assault, rape, and torture. Unintentional trauma mechanisms include road traffic crash, falls, unintentional burns, and other injuries. There were only 40 procedures performed for nontrauma indications; thus, they are not included separately in the figure.
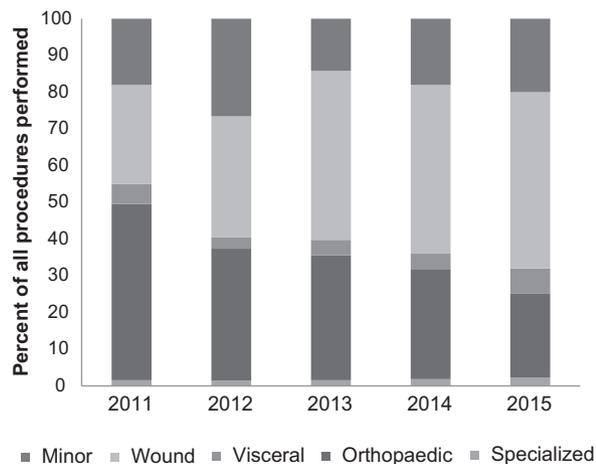

Fig 2. Types of procedures performed in an operating theater at the Médecins Sans Frontières Kunduz Trauma Centre from August 2011 to August 2015. Examples of each procedure type are as follows: minor procedures—minor debridement, chest tube placement, drain placement; major procedures—extensive debridement, removal of shrapnel, burn care; visceral procedures—management of solid or hollow viscus injury; orthopedic procedures—skeletal traction, external or internal fixation, major amputation; specialized procedures include burr holes, repair of genitourinary system.

discharge from the hospital). Of the 1,821 patients who underwent an operation in 2015, the perioperative mortality rate was 29.1 per 1,000 patients.

Health burden averted. The Trauma Centre averted 154,254 DALYs by providing surgical care (95% CI 153,042–155,465; Table II): 98,167 DALYs were averted by operations for unintentional, non–violence-related injuries (64% of DALYs averted; 95% CI 97,188–99,146), and 55,750 DALYs were averted by operations for violence (36% of DALYs averted; 95% CI 55,066–56,434). The remaining DALYs were averted by other procedures (0.2% of DALYs averted).

DISCUSSION

This study was performed to document the surgical care provided at the MSF Kunduz Trauma Centre and to estimate the health burden averted by the operations performed. Although the hospital provided surgical care for predominantly unintentional, non–violence-related traumatic injuries, injuries from violence were also cared for commonly and increased dramatically in the months prior to the airstrike. Children comprised nearly 25% of the operations performed for violence-related trauma (eg, wounds from gunshots, bomb blasts, and land

Table II. Disability-adjusted life years averted by surgical care at the Médecins Sans Frontières Kunduz Trauma Centre from August 2011 to August 2015

	Patients	DALYs averted		
	n (%)	Estimate	Low	High
Unintentional, non–violence-related trauma	4,387 (65.7)	98,167	97,188	99,146
Other unintentional injuries	2,265 (34.0)	50,888	50,179	51,596
Road traffic crashes	2,122 (31.9)	47,279	46,604	47,955
Violence-related trauma	2,276 (34.0)	55,750	55,066	56,434
Gunshots	1,459 (23.9)	35,745	35,237	35,254
Land mines, bomb blasts	569 (10.3)	13,802	13,432	14,173
Assault, rape, torture	248 (2.3)	6,203	5,935	6,471
Other conditions	22 (0.3)	337	236	437
Total	6,685 (100)	154,254	153,042	155,465

Low and high estimates represent 95% confidence intervals derived from the bootstrap resampling standard errors.

mines). In 4 years, the hospital averted more than 154,250 DALYs. Without access to trauma care, many people in the region will die or be disabled from injury in the months and years to come.

More procedures were performed for unintentional, non–violence-related trauma than for violence-related trauma, except in the months immediately prior to the airstrike. While we are unable to infer the epidemiology of injury in the population from these hospital-based data, the findings support other studies from Iraq that suggest unintentional injuries predominate in populations affected by prolonged insecurity.[19-21] A population-based survey of injuries in Baghdad from 2003–2014 reported that falls, road traffic crashes, and mechanical injuries were more common than all violence-related injuries combined.[20] The authors concluded that deterioration of infrastructure, changes in safe behavior, and a lack of injury prevention and control programs contribute to this epidemiology.

Few studies have described the DALYs averted by surgical care at a hospital in a low-income country; none have reported the health burden averted by surgical care in a conflict setting. Two years after the conflict in Sierra Leone, a first-level hospital with surgical capabilities reported the surgical epidemiology and DALYs averted by surgical care over a 3-month period.[14] Both the MSF Kunduz Trauma Centre and the hospital in Sierra Leone had about 90 beds, >1 operating theater (Sierra Leone 2; Kunduz 3), and laboratory and x-ray capabilities. Extrapolating to 1 year, the hospital in Sierra Leone averted 13,140 DALYs from surgical care (6.0 DALYs averted per patient). Using similar methodology, we found that the MSF Kunduz Trauma Centre averted an average of 30,851 DALYs per year (8.7 DALYs averted per patient). The difference could be explained by several factors, including potential differences in age distribution and a greater proportion of life- and limb-threatening emergencies in Kunduz than in Sierra Leone. Both of these estimates were greater than the DALYs averted from nonobstetric surgery in a first-level hospital in Bangladesh (2,784 DALYs averted per year).[13] While the differences in DALYs averted should not be used to assess the differential effectiveness between these hospitals without controlling for externalities (eg, local burden of disease, population age structure), our estimate suggests that the MSF Kunduz Trauma Centre was at least as effective as others that operated in a low-resource setting during peacetime.

Several studies have reported methods for estimating the DALYs averted by surgical care using logbook data.[13,14,22,23] Each of these reports has been instrumental to the understanding that essential surgical care in low-resource settings is as cost-effective as other public health interventions (eg, BCG vaccination to prevent tuberculosis, antiretroviral therapy for HIV), and should be a component of universal health coverage.[24] The method we propose builds on these landmark reports by including terms for: (1) counterfactual DALYs (ie, the DALYs that would have been incurred without surgical care) and (2) both treated and untreated disability weights. By doing so, a more robust estimate of the DALYs averted by surgical care can be calculated.

In May of 2015, the World Health Assembly (WHA) passed unanimously resolution 68.15: "Strengthening Emergency and Essential Surgical Care and Anaesthesia as a Component of Universal Health Coverage."[25] The resolution urges member states to "collect and compile data on the number, type, and

indications of surgical procedures performed." The ability to compare DALYs averted between facilities or countries and over time adds a valuable dimension to this charge put forth by the WHA.

This method would be particularly useful if severity and treatment efficacy scores and disability weights were standardized for all essential surgical conditions, as defined by The World Bank.[26] The WHA resolution also calls on member states to collect, assess, and report data on the economic impact of the delivery of essential and emergency surgical care and anesthesia.[25] Given that surgical logbooks are available at almost every operating theater globally, this method might be applicable broadly and facilitate cost-effectiveness analyses to better estimate the cost per DALY averted by providing essential surgical care in any setting.

This report has several limitations. First, the figures presented do not describe fully the scope of care provided at the Trauma Centre and should be considered bare minimum estimates of the health burden averted. The hospital had an outpatient department, an inpatient service, and an intensive care unit; 20,227 patients who did not require operation were treated at the facility in 2014 alone (eg, patients with closed fractures that required reduction and splinting, nonoperative management of solid organ injuries).[3] The care described above does not include the contribution of these important services.

Second, procedures performed outside of the operating theater were not included. These procedures were often life or limb-saving (eg, surgical airway, chest tube placement, closed reduction of fracture, or dislocation). Next, the findings may not be directly comparable to other hospitals of a similar size, because most patients with nontrauma conditions (eg, general surgical and obstetric emergencies) were cared for at a nearby provincial hospital; the effect of trauma specialization on the number of DALYs averted by surgical care at the facility is unknown.

Lastly, we defined the severity and treatment efficacy scores used to estimate the DALYs averted by surgical care at the Trauma Centre given the lack of a different scoring system. Two experienced surgical care providers proposed the scores, and a third provider resolved the conflicts. Conscious of the risk of information bias, we performed a sensitivity analysis by calculating bootstrap standard errors from our input data including the scores. The resultant 95% CI are purposefully conservative. Future use of this method would benefit from a standardized scoring system for essential surgical conditions and procedures.

Despite these limitations, these findings demonstrate the volume of surgical care provided at the Trauma Centre and allow reasonable conclusions to be made about its contribution to limiting the burden of injury in the region.

In conclusion, these findings demonstrate that the MSF Kunduz Trauma Centre provided surgical care for a large number of wounded and injured patients in the region. The surgical epidemiology is consistent with reports from other areas of prolonged insecurity in that unintentional, traumatic, non–war-related injuries generally outnumber those from violence. Nevertheless, we report that the Trauma Centre provided surgical care for many adults and children injured directly by conflict (eg, injuries due to gunshots, land mines, bomb blasts).

The health burden averted by surgical care at the Trauma Centre was large; its absence will be critically felt by those living in northern Afghanistan who no longer have timely access to essential trauma care. Additionally, the attack on the MSF Kunduz Trauma Centre has broader implications for humanitarian action and actors worldwide. Access to essential trauma care for all victims of armed conflict is imperative. Special protection afforded by International Humanitarian Law to the wounded, the sick, and medical services in times of war must be guaranteed in all circumstances.

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