Population Health Metrics

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Civilian death and injury from airstrikes: evidence from the war in Tigray, Ethiopia

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Abstract

Background Civilians bear a significant burden of morbidity and mortality in modern armed conflicts, particularly when explosive weapons are used in densely populated areas. Many civilian facilities were attacked in the war in Tigray since the beginning of hostilities in November 2020. This study assessed the impact of airstrikes on civilians from June 2021 until the signing of the Agreement for Lasting Peace through a Permanent Cessation of Hostilities between the Ethiopian Government and the Tigray People's Liberation Front in November 2022.

Methods A retrospective review was conducted of all injury data reported between June 2021-October 2022 from each district health facility in six zones of Tigray, Ethiopia. Descriptive analysis was conducted for variables of interest (e.g., age, sex, location, injury outcomes).

Results A total of 1,143 casualties from airstrikes were reported from six zones and 24 districts of Tigray, Ethiopia. From the total of 80 instances of drone and aerial bombardments incidents, one third of the airstrikes resulted in death (33.7%, $n=385$). The mean age of the victims was 28.9 years (SD = 17.9) with a range of less than 1 year to 87 years. Almost a third of the victims (28.3%, $n=323$) were children aged < 18 years. Approximately 5% of casualties were age > 60 years (5.3%, $n=61$). Almost half (45.1%, $n=516$) of the causalities were female including pregnant and lactating women. The Southern and Northwest zones suffered the most casualties, followed by the Southeast zones and Mekelle. The airstrikes took place predominantly in civilian areas, including marketplaces, internally displaced persons (IDP) camps, residential areas, public transportation, villages, children's playgrounds, churches, mills and hospitals, resulting in numerous casualties that disproportionately affected civilians, especially children, the elderly and women.

Conclusions Civilians suffered significant death and injury from airstrikes during hostilities in the war in Tigray, including a high proportion of women and children. The most common targets were civilian facilities including IDP camps, which the United Nations has determined to be a crime against humanity. Enhanced collaboration between

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health and protection stakeholders can improve support to victims from immediate post-injury care as well as rehabilitation so that they can live as healthy, dignified, and productive citizens.

Keywords Ethiopia, Conflict, Civilian casualties, Tigray, War-related injuries, Drone and air strikes

Introduction

Civilians bear a significant toll of conflict-related morbidity and mortality in modern warfare, particularly in conflicts characterized by the use of explosive weapons in densely populated areas [1] where civilians constitute up to 90% of war-related casualties [2]. In 2022, the war in Ethiopia's Tigray region accounted more deaths than the war in Ukraine [3] with approximately 600,000 deaths [4]. The Tigray war erupted in November 2020 [5], where the Ethiopian National Defence Force (ENDF), the Amhara Special Forces (ASF), and the Eritrean Defence Forces (EDF) altogether have committed a genocide [6] captured many part of Tigray including its capital city of Mekelle until June 2021. The Ethiopian government began to use airstrikes as an offensive tactic which continued until the cessation of hostilities was signed in November 2022 [7]. Profound secondary effects have been documented on maternal and child health as well as sequelae such as infectious disease [8, 9]. However, limited published data exists on the consequences of conflict-related injury in Tigray.

Parties to the conflict have used explosive weapons and air-delivered munitions including drone strikes in areas densely inhabited by civilians during the war in Tigray [10]. Civilian spaces including children's playgrounds, internally displaced people (IDP) camps, and marketplaces have been targets of indiscriminate bombing [11, 12]. The civilian casualties of these bombings have included women and children [13–17]. These airstrikes, in addition to continuous artillery shelling, have caused significant physical trauma to the population [18]. The use of bombing with military unmanned aerial vehicles (UAV) in contemporary wars or armed conflicts has been an issue of significant controversy [19]. The moral facets of the use of armed drones in recent armed conflicts such as Palestine, Syria, Somalia, and Yemen have been highlighted due to the severe consequences on civilians [20–22].

The first use of drones in the war in Tigray was reported in November 2021 after China, Iran and Turkey reportedly supplied Ethiopia with this technology [23, 24]. The use of airstrikes in the war in Tigray has since resulted in hundreds of civilian causalities documented by the United Nations High Commissioner for Human Rights [16]. A community-based assessment conducted during the first eight months of the war from November 2020 to June 2021 found a 6.9% rate of war-related injury among civilians in the sampled region of Tigray [18]. However, despite numerous media and human rights observatory reports [16], there is a lack of published evidence and health facility data on the impact of airstrike on civilian populations after Tigray forces overtook the capital city of Mekelle in June 2021.

In November 2022, the Political Declaration on Strengthening the Protection of Civilians from the Humanitarian Consequences Arising from the Use of Explosive Weapons in Populated Areas (EWIPA) was signed by over 80 member states in Dublin [25] Ethiopia is not a signatory. The impact of EWIPA has received significant attention in conflicts such as Syria and Ukraine but has been less-studied in Sub-Saharan Africa [26–29]. Despite the lack of published evidence in the literature, EWIPA inflicts a severe toll on civilian populations in conflicts in Africa such as Sudan and Tigray [30]. In addition to the direct impact on civilian death and injury, the reverberating effects of EWIPA on civilian infrastructure in settings where access to essential services is already highly constrained is a key driver of displacement and barrier to humanitarian access in such settings [31].

This study aimed to assess the prevalence of airstrike injury and outcomes among civilian casualties from June 2021 to October 2022, before the signing of the African Union-mediated Pretoria agreement or "*Agreement for Lasting Peace through a Permanent Cessation of Hostilities*" between the Government of the Federal Democratic Republic of Ethiopia and the Tigray People's Liberation Front [7]. The findings of this study may provide increased understanding of the impact of explosive violence on civilian populations in Sub-Saharan Africa and inform targeted interventions to improve trauma and blast injury-focused care as well as human rights protections in the future.

Methods

Study setting

The study was conducted in the Tigray region of Ethiopia. The population of Tigray is approximately six million based on projections for the 2016 Ethiopian fiscal year [32], close to 80% of which reside in rural areas. Of the seven zones in Tigray region, six of them were accessible and included in this study. However, data from the seventh zone i.e. Western Tigray was not included in the study as it has been occupied by non-Tigray forces and is inaccessible. This area was occupied by Ethiopian, Eritrean, and Amhara regional forces. The types of health facilities encompassed in data analysis ranged from health posts to tertiary hospitals providing preventive, curative, and rehabilitative services.

Study design

A retrospective review of all injury data reported from June 2021 to October 2022 from each health facility of the six accessible zones to the Tigray Regional Health Bureau (TRHB) was conducted.

Data collection

Data were collected by TRHB from June 2021 to October 2022. The beginning of the study time point coincided with the time at which Tigray forces overtook the capital city of Mekelle in June 2021. In response, the Ethiopian government began to use airstrikes as an offensive tactic which continued until the cessation of hostilities signed in November 2022 [7]. At the beginning of the war, it was determined that the existing routine emergency outpatient department registration form was not detailed enough to capture relevant injury characteristics related to the attacks in general. Therefore, during the first eight months of the conflict, a reporting form for airstrike and other conflict-related injuries was prepared and distributed to all hospitals by the emergency medical services of TRHB. This new form included variables such as place, outcome (e.g., injured, dead), and was distributed to facilities in-person by couriers due to the communications blackout (Supplementary Table 1). Health professionals at each health facility compiled, cleaned, and verified data before submitting these forms to the respective district officials. All records were ultimately submitting to the TRHB where these data were evaluated for its completeness by the research team.

Airstrike-related death in our context defines the death directly linked due to explosives which are dropped from aircraft on to a ground target and confirmed by the district health authority as part of the report. We used the category "multiple" to designate a site of attack where there were multiple different sites targeted at the same time that could not be disaggregated. Data were primarily collected in healthcare facilities where care was provided. However, in certain circumstances, eyewitness accounts were utilized by health workers to complete case reports when deceased individuals could not be transported to hospitals. These casualties were captured in the registration of district health offices, from which the regional health bureau regularly collected public health surveillance data to generate a weekly report. In response to this trend, the weekly report was modified to include the number of patients with death or injury as a consequence of airstrikes.

Data analysis

Geo-mapping techniques were used to map precisely recorded coordinates onto the area where the airstrike occurred. Data were entered into Microsoft Excel and then transferred into SPSS, version 25 software for analysis. Descriptive analysis was applied for variables of interest (e.g., patient age, demographics, place of injury, injury outcomes). Additionally, the numbers of attack episodes were plotted over time. Analysed data were presented using frequencies, percentages, and tables and synthesized in narrative statements.

Results

Demographics

During the 17-month study period, Tigray experienced 80 instances of drone and aerial bombardments with number of casualties per airstrike varying from 0 to 244 (death: 0–70; injury: 0-180) per occurrence. A total of 1,143 airstrike casualties were reported from June 2021 to October 2022 from six zones and 24 districts of Tigray region, Ethiopia (Table 1). The mean age of the victims was 28.9 years (SD = 17.9) with a range of less than one year to 87 years old. Close to one third of the victims (28.3%, $n = 323$) were children age < 18 years comprise 55% of the population as per the 2007 census of Ethiopia [33]. Approximately 5% of casualties were age > 60 years (5.3%, $n = 61$). Sex distribution of casualties demonstrated

Table 1 Zonal level socio-demographic characteristics and injury status of airstrike casualties in Tigray, Ethiopia from June 2021 to October 2022

Variable		Total ($N = 1,143$]	Zone (n, %[1])					
			Southern ($n = 328$)	Southeast ($n = 296$)	Mekelle ($n = 121$)	Eastern ($n = 3$)	Central ($n = 67$)	Northwest ($n = 328$)
Sex	Male	627 (54.9)	169 (51.5)	167 (56.4)	66 (54.5)	1	41 (61.2)	183 (55.8)
	Female	516 (45.1)	159 (48.5)	129 (43.6)	55 (45.5)	2	26 (38.8)	145 (44.2)
Injury status	Injured	758 (66.3)	216 (65.9)	196 (65.9)	103 (85.1)	3	8 (11.9)	233 (71)
	Dead	385 (33.7)	112 (34.1)	101 (34.1)	18 (14.9)	0	59 (88.1)	95 (29)
Age group (years)	0–17	323 (28.3)	94 (28.7)	95 (32.1)	34 (28.1)	1	18 (26.9)	81 (24.7)
	18–60	759 (66.4)	214 (65.2)	187 (63.2)	84 (69.4)	2	44 (65.7)	228 (69.5)
	> 60	61 (5.3)	20 (6.1)	14 (4.7)	3 (2.5)	0	5 (7.5)	19 (5.8)
Age (Mean ± SD)		28.93 ± 17.98	29.47 ± 18.23	29.47 ± 18.23	27.10 ± 15.81	17.00 ± 13.00	30.85 ± 19.14	29.80 ± 17.92

Abbreviations: SD - Standard Deviation

1. For small frequencies (i.e., $n < 5$), percentage is not calculated

that nearly half (45.1%, $n=516$) were females including pregnant and lactating women.

Geographic distribution

The Southern and Northwest zones showed the highest frequency of victims followed by Southeast and Mekelle zones (Table 1; Fig. 1). The map depicting the airstrikes is limited to 17 months within the study areas due to the nature of the war. Alamata, Korem Town, Raya Chercher, Maychew and Raya Azebo districts are found in Southern zone. Enderta and Hintalo districts are found in Southeast zone. Hawelti, Hadnet, Kedamay Woyane, Semien and Quiha sub cities are found in Mekelle zone. Adiet, Naeder, Adwa town and Tanqua Milash districts are found in Central zone. Asgede, Maytsebri, Shire town, Tselemti, Endabaguna, Tahtay Koraro and Maekhel Adyabo district found in Northwest zone while Atsebi Endaselaie founds in Eastern zone. Sub-analyses of zonal data at the district level identified Enderta as the most airstrike-affected district followed by Asgede and Alamata districts (Supplementary Table 2).

Temporal trends

The highest numbers of airstrike casualties were recorded in January 2022 (38.1%, $n=436$) and December 2021 (29.1%, $n=333$) followed by October 2022 (22.1%, $n=253$) and June 2021 (21.3%, $n=244$) (Fig. 2). During January 2022 attacks occurred most frequently in internally displaced persons (IDP) camps, residential areas, and milling sites found in Asgede and Maytsebri districts in the Northwest zone of Tigray. Attacks in December 2021 occurred most frequently in multiple sites (e.g. marketplace, residential areas, hospitals and churches) found in Alamata district in the Southern zone of Tigray. In October 2022 the highest number of casualties occurred in IDP camps in Adidaero district, Northwest zone of Tigray, and in June 2021 the highest number of casualties was occurred in a marketplace in Enderta district, Southeast zone of Tigray.

Site of attack

Airstrikes occurred predominantly in civilian spaces including marketplaces (26.2%, $n=300$), internally displaced persons (IDP) camps (22.1%, $n=253$), residential areas (10.7%, $n=122$), public transport (5.9%, $n=68$),

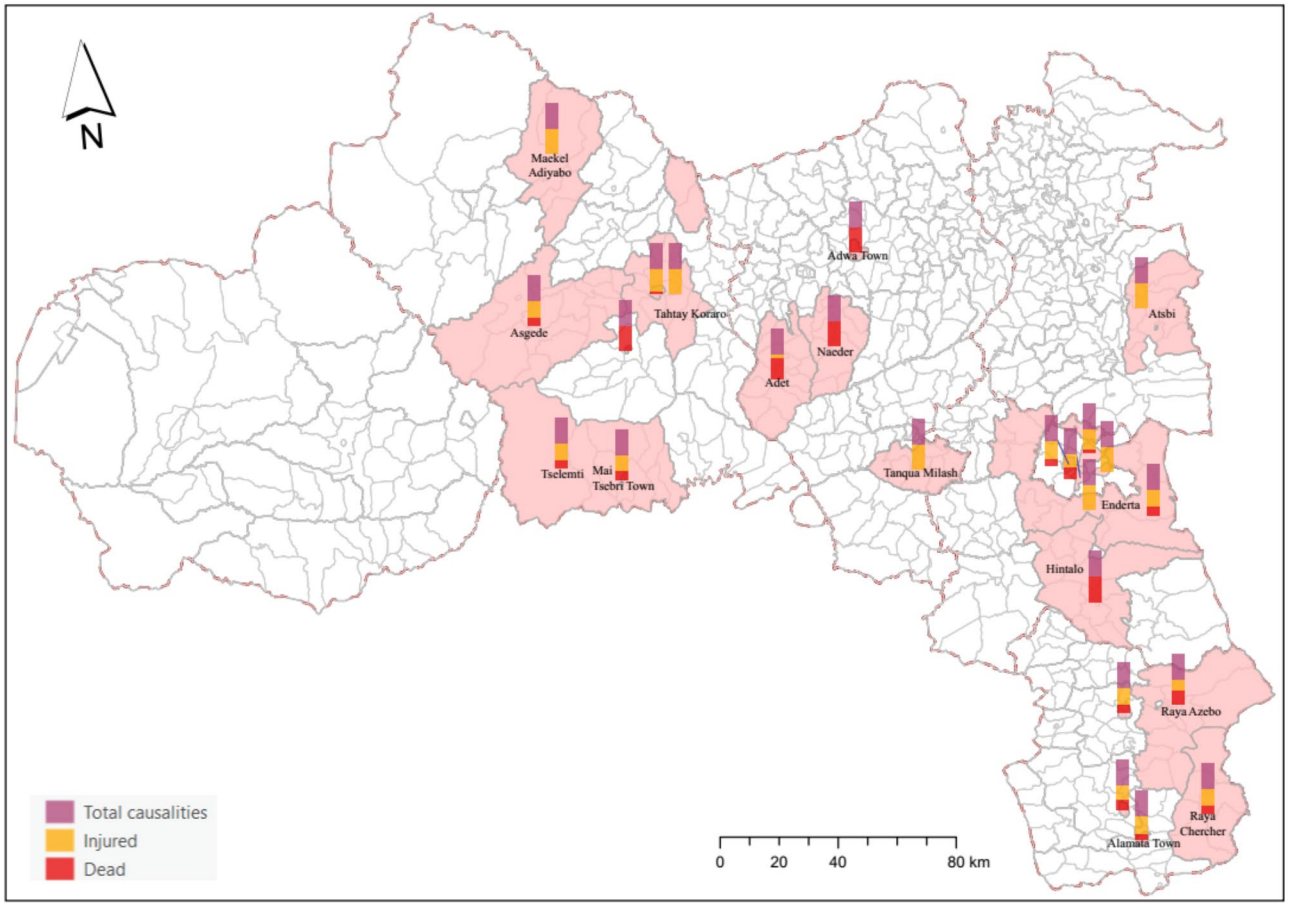

Fig. 1 Geographic distribution of total airstrike affected districts in Tigray, Ethiopia from June 2021 to October 2022

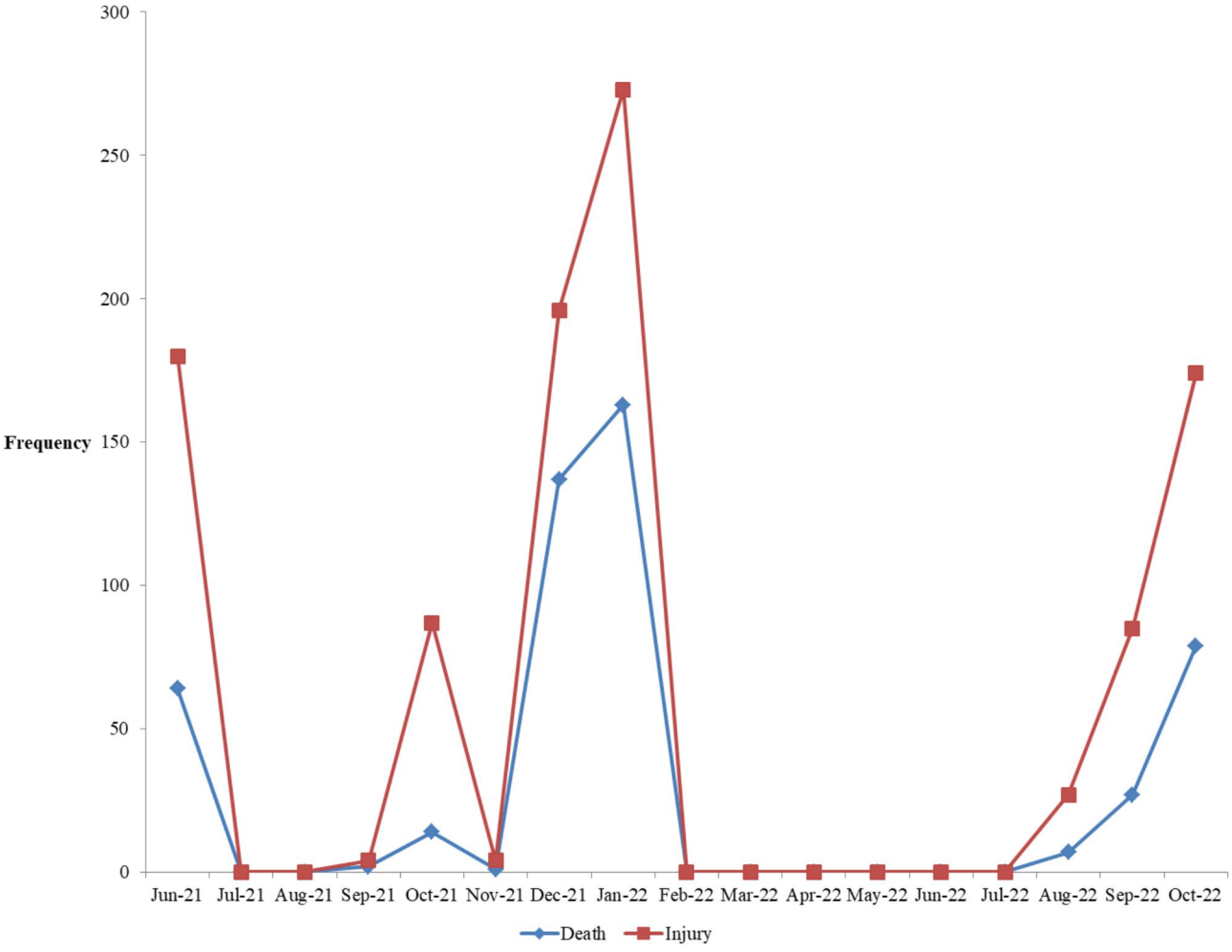

Fig. 2 Trend of death and injuries due to airstrikes in Tigray, Ethiopia from June 2021 to October 2022

Table 2 Airstrike sites by age, sex, and injury status during the war in Tigray, Ethiopia from June 2021 to October 2022

Variables		Air strike sites						
		Market (*n* = 300)	Multiple[1] (*n* = 297)	IDP camp (*n* = 253)	Residential area (*n* = 122)	Public transport (*n* = 68)	Village (*n* = 58)	Children playground (*n* = 14)
Age category (years)	0–17	90 (30.0)	84 (28.3)	63 (24.9)	39 (32.0)	24 (35.3)	11 (19.0)	4 (28.6)
	18–60	192 (64.0)	201 (67.7)	171 (67.6)	79 (64.8)	40 (58.8)	43 (74.1)	10 (71.4)
	> 60	18 (6.0)	12 (4.0)	19 (7.5)	4 (3.3)	4 (5.9)	4 (6.9)	-
Sex	Male	161 (53.7)	155 (52.2)	143 (56.5)	69 (56.6)	43 (63.2)	32 (55.2)	6 (42.9)
	Female	139 (46.3)	142 (47.8)	110 (43.5)	53 (43.4)	25 (36.8)	26 (44.8)	8 (57.1)
Injury status	Injured	222 (74.0)	196 (66.0)	187 (73.9)	95 (77.9)	8 (11.8)	21 (36.2)	10 (71.4)
	Dead	78 (26.0)	101 (34.0)	66 (26.1)	27 (22.1)	60 (88.2)	37 (63.8)	4 (28.6)

Abbreviations: IDP - Internally Displaced Persons

1. Multiple = Residential area + market, Residential + church + market, Residential + milling, Hospital + market

villages (5.1%, *n* = 58), and children's playgrounds (1.2%, *n* = 14) (Table 2). A high frequency of airstrikes occurred in multiple sites simultaneously (e.g., combination of residential area, church, marketplace, milling sites, hospitals) resulting in many casualties (26.0%, *n* = 297; Fig. 3).

Patient outcomes

Painfully, one third of airstrike casualties died (33.7%, *n* = 385). There was a statistically significant difference in mortality by age category. Children (age < 18 years) and the elderly (age > 60 years) had a higher mortality rate of 41.2% and 41.0% respectively while a mortality rate of 29.9% was observed among casualties between the ages

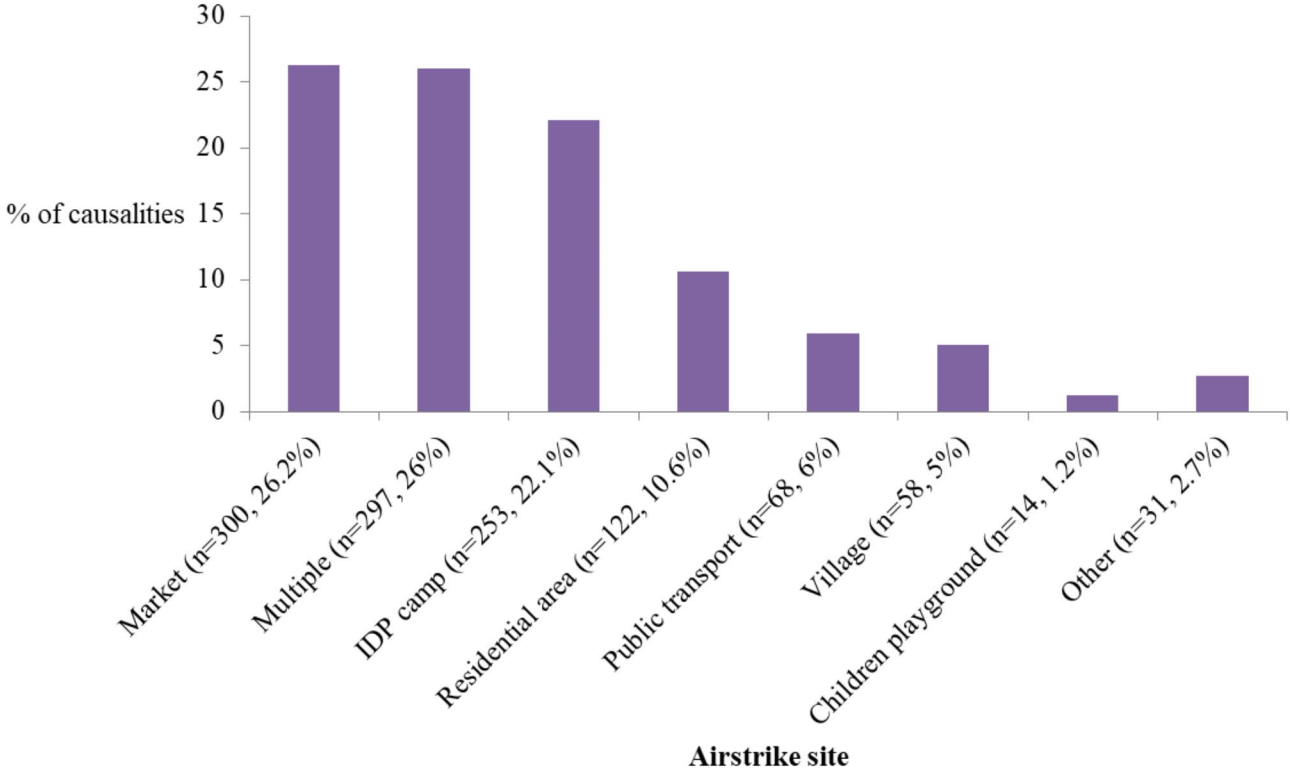

Fig. 3 Airstrike sites during the war in Tigray, Ethiopia from June 2021 to October 2022. Abbreviations: IDP– Internally displaced persons

Table 3 Chi-square test of association between age, sex, and outcome among airstrike casualties in Tigray, Ethiopia

Variable		Status		*p-value*
		Injured	Dead	
Age (years)	0–17	190 (58.8%)	133 (41.2%)	0.001
	18–60	532 (70.1%)	227 (29.9%)	
	>60	36 (59%)	25 (41.0%)	
Sex	Male	423 (67.5%)	204 (32.5%)	0.366
	Female	335 (64.9%)	181 (35.1%)	

of 18–60 years old ($p = 0.001$). No statistically significant difference was observed in mortality rate between male and female casualties (Table 3). Data on functional outcomes of surviving casualties were not available.

Discussion

We conducted a retrospective analysis of airstrike casualties that occurred between June 2021 to October 2022 following the first eight months of the war in Tigray (November 2020 to June 2021). During this period, a total of 1,143 airstrike casualties were reported across six zones and 24 districts in the Tigray region. Key findings include: (1) a significant proportion of casualties occurred among females and children less than 18 years of age; (2) the majority of airstrikes occurred in civilian spaces such as marketplaces, hospitals, playgrounds, and residential areas including IDP camps, corroborating the findings of the United Nations (UN) International Commission of Human Rights Experts on Ethiopia (ICHREE) [34] consistent with war crimes and crimes against humanity; and (3) a statistically significant increase in mortality rate was observed among children (age < 18 years) and the elderly (age > 60 years). The nature of available data limited the granularity of conclusions that could be drawn regarding anatomic region of injury or clinical cause of death among casualties as well as functional outcomes among surviving casualties. Though numerous media and human rights observatories have reported on airstrike-related civilian casualties in Tigray, our analysis provides the largest health facility-based dataset of airstrike casualties during the war in Tigray to date [10, 35]. This study adds to the very limited literature documenting the impact of explosive violence on civilian populations in Sub-Saharan Africa [31, 36].

Of the total of 1,143 casualties from airstrikes reported, sadly, one third of the airstrikes resulted in death. In addition to the direct effects of aerial and drone attacks, further loss of life occurred due to lack of access to treatment after the airstrike due to attacks on healthcare facilities in the region and lack of medical supplies caused by a de facto blockade, which have left over 85% of hospitals and health centers in the region incapacitated [37–40]. Socio-demographic analysis of casualties in our dataset demonstrated that nearly half (45%) of airstrike victims were female and 28% were children. In addition to the

airstrike, Tigrayan females, were also severely affected by gender-based violence during the war [41–43]. This highlights the multifaceted impact of the war on Tigrayan women, as they not only endure the immediate physical threats of aerial and drone strikes but also suffer from the pervasive and traumatic consequences of gender-based violence [44].

Our findings reflect a trend in age and gender distribution of war-related civilian casualties in conflicts characterized by the use of EWIPA [45]. An analysis of conflict-related death among civilians during the war in Syria due predominantly to aerial bombardments and shelling found that between 2011 and 2016 approximately one quarter to greater than one third of casualties from barrel bombs were children, while the rate of women casualties quadrupled over the study period [46]. Similar to our findings derived from health facility data in Tigray, six-month projections of traumatic injury-related mortality in Gaza predict that 43% of civilian casualties will be women and 42% under age 19 [47]. Furthermore, a UN Security Council report also indicated that in 2023 the proportion of women and children killed double and tripled respectively compared with 2022 [29]. In Africa, previous studies indicate that women are at an increased risk of death due to nearby high-intensity armed conflicts [48]. Compositely, these findings highlight the indiscriminate nature of EWIPA and the severe toll inflicted on non-combatants, raising concerns around proportionality under international humanitarian law (IHL) [49]. However, empiric data on the impact of EWIPA on conflict-affected civilian populations on the African continent is extremely limited and is drawn almost exclusively from datasets derived from media reports (e.g., Action on Armed Violence [AOAV], Armed Conflict Location & Event Database [ACLED]) or human rights inquiries. In light of the proliferation of drones and other technology facilitating the use of air-dropped munitions against civilians, health personnel providing emergency care to victims of explosive violence in Africa should be provided with the necessary research support to publish casualty data. Such documentation is critical both to inform planning and preparedness of the emergency health response to such events, as well as to provide evidence of civilian harm that can support policy efforts for strengthened protection of civilians.

Our analysis demonstrated that the majority of airstrikes occurred in civilian spaces. Specifically, the most common sites of airstrike included marketplaces, residential areas, and IDP camps followed by places of public transport, villages and playgrounds. Certain location categories designated as "multiple" were not adequately specified in raw data to support disaggregation but likewise encompassed civilian spaces such as hospitals and mill sites. While attacks against non-combatants have been reported by numerous international media outlets and human rights observatories during the war in Tigray, we present the first facility-based data corroborating patterns of civilian harm from the use of air-delivered munitions and drone strikes against non-military targets [10, 50]. In its 2022 report to the Human Rights Council, the ICHREE documented civilian harm resulting from over fifty airstrikes since June 2021, including the January 7, 2022 drone strike on Dedebit IDP camp. During this incident, three MAM-L laser-guided bombs were dropped on an IDP camp in Dedebit established within a school compound. During this attack, the first bomb struck a building densely occupied by IDPs and a second delayed bomb dropped on a crowd of civilians attempting to flee the compound gates after the first bomb hit, including children [34]. These accounts were corroborated by the UN Satellite Center, with no evidence of military targets present in Dedebit on the date of attack. The precision enabled by laser-guided munitions in addition to the lack of valid military target was found to constitute a violation of IHL, with clear targeting of non-combatants. A recent report from New Lines Institute "concludes that, on the evidence currently available, there is a reasonable basis to believe that members of the Ethiopian National Defence Forces (ENDF), Amhara Special Forces (ASF), and the Eritrean Defence Forces (EDF) have committed genocide against Tigrayans", including corroborating evidence that "the Ethiopian government was later aided by drones, from the United Arab Emirates, China, Turkey, and Iran" [6]. In tandem with high-level efforts to strengthen protections for civilians such as the Political Declaration on Strengthening the Protection of Civilians from the Use of Explosive Weapons in Populated Areas [1], clear mechanisms should be established for health personnel caring for civilian victims of air-delivered explosive weapons to engage in casualty reporting to strengthen the evidence base for the direct and indirect effects of EWIPA.

Among civilian airstrike casualties of the war in Tigray included in our analysis, a statistically significant increase in mortality was observed in children less than eighteen years of age and individuals greater than 60 years of age. Previous reports have presented conflicting data on mortality rates among paediatric conflict casualties compared to overall cohorts [51]. However, certain subsets of paediatric conflict casualties have significantly higher rates of mortality– specifically, the youngest age group (children less than five years of age) as well as children with traumatic brain injury (TBI) and war-related burns [52]. Since this constellation of clinical injuries is frequently observed among patients with multidimensional blast injuries, the high rate of child mortality observed in our analysis may be attributable to these injury patterns. There is a lack of peer-reviewed literature focusing on war-related injury characteristics and outcomes among

elderly patients from which further comparison or conclusion may be drawn [53].

On the basis of these findings, several actions can be taken. First, additional research is needed to provide insight into the unique needs of elderly patients suffering conflict-related injuries in modern warfare. Second, there is an urgent need to promulgate existing resources focused on emergency care for paediatric blast injury victims. The Paediatric Blast Injury Manual [54] developed by the Paediatric Blast Injury Partnership provides comprehensive guidance on the management of paediatric victims of explosive violence. On the basis of this course, a paediatric blast trauma care course (the Paediatric Trauma Resuscitation Course [PTRC]) has been developed and piloted in conflict-affected low-resource settings. This course and manual should be made widely available to health personnel caring for victims of explosive injury and included as a standard paediatric-focused component of other trauma and blast injury trainings (e.g., World Health Organization [WHO] Basic Emergency Care Course, International Committee of the Red Cross Blast Trauma Care Course). Third, coordination between health and protection stakeholders (e.g., humanitarian mine action) can be enhanced to strengthen victim assistance through improved local trauma care capacity [55]. The Explosive Weapons Trauma Care Collective (EXTRACCT) was founded to address the gap faced by civilian victims of explosive ordnance and other explosive weapons, 40% of whom die of their injuries, in reaching adequate trauma care [56]. EXTRACCT works closely with mine action stakeholders such as the United Nations Mine Action Service, Antipersonnel Mine Ban Convention Implementation Support Unit, mine action operators and victims' representatives to leverage the medical capabilities present within mine action teams to strengthen local trauma care capacity in settings affected by explosive violence. Such partnerships have the potential to enhance implementation of WHO Emergency, Critical, and Operative care (ECO) toolkits and other strategies for improving trauma care for civilian victims of explosive injury in conflict settings [55, 57, 58].

This study sheds light on the distribution and effects of drone and armed aerial strikes on civilians in the Tigray war. However, the study had several limitations. First, the nature of available data were limited by the variables (i.e., death and injury) collected in district health facility registers and reported to the regional health bureau following airstrikes. This prevented us from reporting on more granular data such as anatomic region of injury or outcomes other than injury/death. Second, our study only accounted for casualties resulting directly from attacks, and individuals affected by secondary effects may not be captured in our data. Third, the complete communications blackout during the conflict made data collection and quality monitoring difficult. Consequently, there is potential for underreporting of drone attacks. Finally, our study encompassed a limited geographic range and time period due to its focus on airstrike-related casualties as well as constraints on data collection inherent to conflict. For example, the present study was unable to consider Western Tigray due to its occupation by other forces with associated security issues and lack of access. This study therefore represents only a small portion of the total 600,000 deaths reported in Tigray [4]. Nonetheless, this report provides important insight into patterns of airstrike-related injury among vulnerable civilian populations in the Tigray war.

Conclusion

We present an analysis of the first health facility-based dataset documenting civilian harm from the use of air-dropped explosive munitions in Sub-Saharan Africa. Findings from victims of airstrikes during the war in Tigray, Ethiopia demonstrate that women and children represent a significant proportion of affected casualties, with statistically significant increased mortality rates among children and the elderly. Consistent with reports from the UN ICHREE, airstrikes occurred predominantly in civilian spaces including IDP camps, which constitutes a crime against humanity. In tandem with high-level policy efforts to secure enhanced protection of civilians against EWIPA such as those discussed at the recent Oslo Conference on implementation of the Political Declaration on Strengthening the Protection of Civilians Against the Use of EWIPA, humanitarian practitioners and trauma care providers can support focused efforts to improve casualty reporting, paediatric blast injury trainings, and data on functional outcomes among survivors to support the rehabilitation of victims to enable them live as healthy, dignified, independent and productive citizens. Future work evaluating causes of preventable death and functional outcomes among survivors of airstrike-related injury, and individuals affected by secondary effects could provide critical insight into opportunities for focused trauma care quality improvement interventions and the rehabilitative needs of victims.

Abbreviations

EWIPA	Explosive Weapons In Populated Areas
SD	Standard Deviation
IDP	Internally Displaced Persons
ENDF	Ethiopian National Defence Force
ASF	Amhara Special Forces
EDF	Eritrean Defence Forces
UAV	Unmanned Aerial Vehicles
TRHB	Tigray Regional Health Bureau
SPSS	Statistical Package for Social Sciences
UN	United Nations
ICHREE	International Commission of Human Rights Experts on Ethiopia
IHL	International Humanitarian Law
AOAV	Action on Armed Violence
ACLED	Armed Conflict Location & Event Database

MAM	Mini Akıllı Mühimmat
TBI	Traumatic Brain Injury
PTRC	Paediatric Trauma Resuscitation Course
WHO	World Health Organization
EXTRACCT	Explosive Weapons Trauma Care Collective
ECO	Emergency, Critical, and Operative care

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12963-025-00373-1.

Supplementary Material 1

Supplementary Material 2

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Author contributions
MG, AAA, AE and HG designed the study and collected the data. MG, AAA, HEA, HT, AE, TB, GHR, NMG, AAM, HG, DG and HW analysed and interpreted the data, and wrote the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Patient confidentiality was strictly maintained and all data accessed were de-identified. Ethical clearance was obtained from Mekelle University, College of Health Science Institutional Review Board (Ref. No. MU-IRB 1906/2021).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Disclaimer
The views expressed in the study are those of the authors and may not be shared by all institutions with which they are affiliated.

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