Conflict and Health

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Under-five mortality during the war in Tigray: A community-based study

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Abstract

Background Child mortality is one of the key indicators of the Sustainable development goals. The Ethiopian healthcare system in general and Tigray's healthcare system in particular has shown a remarkable progress in terms of reducing maternal, neonatal, and under-five mortality in the last couple of decades. However, the war erupted in November 2020 caused the healthcare system to collapse and little is known about the status of child mortality in Tigray. Thus, this study aimed to examine the magnitude and causes of under-five child mortality in the embattled Tigray region was conducted from October 2020 – May 2022.

Methods A cross-sectional community-based survey was employed. The study included all zones except the western zone and some areas of eastern and north western Tigray bordering Eritrea. These areas were skipped for security reasons. Based on multistage cluster sampling, 121 tabiyas in districts were selected. Census was conducted to survey 189,087 households in the 121 Tabiyas. A locally developed household screening tool and the latest world health organization verbal autopsy instrument were used. The Verbal Autopsy data was processed using the Inter-VA–5.1 (probabilistic modeling) to assign the cause of death. Under-five mortality rate (U5MR) was calculated per 1000 live births with a 95% confidence interval (CI).

Results In the present study, out of 29,761 live births, 1761 under-five children died giving an under-five mortality rate of 59(95% CI, 57–62) per 1000 live births. Deaths in the neonatal period and post-neonatal period accounted for 60% and 19.9% of the deaths respectively. Overall, the top 3 causes of under-five child mortality in the present study were: Perinatal asphyxia ($n=277$,18%,) prematurity ($n=235$,16%) and diarrheal diseases ($n=162$, 12.5%). In those who died after first month of life, diarrheal diseases, lower respiratory tract infection, sever acute malnutrition and HIV were the main causes of death. Concerning the place of death, 61.6% of the children died at home.

Conclusion The present study revealed the doubling of under-five mortality in Tigray from where the figure stood in the pre-war period. The leading causes of death in under-five mortality are potentially preventable in situation where the healthcare system is functioning. Restoring the healthcare system and its apparatus, improving access to

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skilled institutional delivery, smooth perinatal transition, improving nutrition status of children, access to full course of vaccines could ameliorate the staggering under-five mortality rate in the war in Tigray.

Keywords Magnitude, Cause, Under-five mortality, Tigray war

Introduction

Under-five mortality rate (U5MR) is the 'probability of dying between birth and fifth birthday', expressed per 1000 live births [1, 2]. It is one of the basic indicators of overall development of a nation and country's socioeconomic status, quality of life and child health [2, 3]. U5MR is one of the key indicator for the Sustainable Development Goals (SDG-3) which aims to reduce U5MR to as low as 25 per 1000 live births by 2030 [4, 5].

Globally, U5MR fell to 37 deaths per 1,000 live births in 2020 from 93 in 1990, a 60% decline. The decrement in U5MR in sub-Saharan Africa is sluggish. In 2020, according to the UN Inter-agency group for child mortality estimation (UN IGME), the average mortality rate for sub-Saharan region was 74 deaths per 1000 live births. The region accounts to more than half (54%) of the global under-five deaths despite having only 27% of the global under-five population [6, 7].

Over the past decade, Ethiopia has made remarkable improvements in many health indicators due to well-coordinated and extensive effort made by the government, community and partners through the health extension program (HEP) and expansion of primary health care. As a result, Ethiopia had achieved the millennium development goal (MDG)-4 of reducing under-five mortality by two-third in 2015 [8]. Despite of the achievement of MDG-4, Ethiopia along with India, Nigeria, Pakistan and the Democratic Republic of the Congo, accounted to half of the under-five deaths in 2019 [9, 10]. Moreover, the 2019 mini Ethiopian DHS report indicate that almost all childhood mortality rates in Ethiopia steadily decreased and the U5MR for 5 years preceding the survey was 59 from a rate of 123 in 2005 [2]. According to the 2021 UN IGME report, the U5MR for Ethiopia was 49 per 1000 live births [7].

Infectious diseases are the main causes of under-five mortality in developing countries. Pneumonia (15%), diarrhoea (8%) and malaria (5%) remain among the leading causes of under-five deaths especially in developing counties whereas preterm birth, intrapartum-related complications (birth asphyxia or lack of breathing at birth), infections and birth defects are the leading causes of neonatal deaths in 2018 [6]. However, there are well demonstrated variation in rate and causes of child mortality in national as well as sub-national level [11, 12] especially in area where there is war and crisis. The rate and causes of deaths could vary during crisis and armed conflict.

In the current study area (Tigray), armed conflict broke out on November 2020. Since then, hundreds of thousands of people remain without access to health care [13]. Accordning to an assesment of the impact of the war in Tigray's health system, war related destruction of the health facilities, displacment of health proffessionals and lack of medical supplies were the reasons for lack of access to medical care [14]. Children are considered to be highly affected with variable degree of increment in mortality due to the destructions to the health facilities and lack of access to health care during crisis [7, 15].

Mortality related data is vital for informed decision making, disease monitoring and outbreak prevention. In developing countries, obtaining data on mortality is hindered by lack of functional vital registration system and poor access to health facility [16]. To overcome the limitation, world health organization developed an interview based data collection and interpretation method, the verbal autopsy tool, to certify cause of death for medically uncertified deaths [17]. The verbal autopsy method is a well established method to fill the gap in knowledge of causes of death and impacts policy making [18, 19].

This study was conducted to assess the magnitude and causes of under-five death in Tigray from Nov 2020 – May 2022 and aimed to generate data on the impact of the war on child death, establish the probable cause of death to ensure general and cause specific interventions, enable government and partners to set priority for planning and resource mobilization.

Methods

Study area and period

The study was conducted in six zones of Tigray. West Tigray zone, and some Districts of northwest and eastern Tigray bordering Eritrea were excluded for security reasons. Tabia Census was made to survey 189,087 households of 121 Tabias in 31 districts. The study period encompasses the time from Nov 2020 – May 2022. The data collection period was from May 2022 – June 2022.

Study design and population

Community based survey was conducted to document live births and deaths of under-five. All live births and deaths of under-five in the selected households and districts were included. This study didn't aim to determine cause of death for stillbirths; therefore, still births were excluded from the cause of death categories.

Sample size and sampling technique

The study was conducted in six zones from total seven zones in Tigray except the Western zone which was excluded due to security reason. A multistage stratified cluster sampling technique was used to select districts for the study. In first stage, districts were selected randomly. In second stage, 1–7 Tabias were randomly selected from each district then all households in selected Tabias were screened for live birth and under-five deaths during the war period. Tabia (small administrative unit) was considered as cluster in this study. In each selected zones, districts were stratified by urban and rural settings. A total of 22 rural and 9 urban districts (total=31 districts) from the total of 84 districts were randomly selected after proportionally allocated based on the number of districts in each zones. The proportion of selection was based on the urbanization proportion of Tigray, which was 30% at the pre-war era. The number of Tabias in each selected district ranges from 1 to 21. Thus, randomly selected Tabias were included from each selected district. If the total number of Tabias were 1–7, we took randomly 03 maximum Tabias; if 8–16, we took 05 Tabias and if above 16 we took 07 randomly selected Tabias from each district. The randomly selected Tabias from each district represent from 30 to 100% of the Tabias in each districts. Most urban district had less number of Tabias than rural setting. Thus, the probability of including all Tabias from urban setting was higher than rural setting (Supplementary file 1). Detail sampling procedure is attached in figure as Supplementary file 2. Some Tabias bordering with Eritrea were excluded due to security reason. For example, two districts in North West zone were replaced due to war that erupted after conducting first phase survey. However, the two districts were randomly replaced from the zone during data collection periods. Two data collectors' data in Mekelle districts (Hadinet) excluded during analysis due to quality issue in data. As limitation due to this, mortality can be under reported. Overall, a total of 189,087 households in 121 Tabias were included, using census method (Fig. 1). Census was made in all household (HH) to screen live births and death of under-five child in the Tabia between November 2020 to May 2022. November 2020 was the time when the war in Tigray was erupted and May 2022 was the time of data collection period which was both during war period.

In the first round of survey referred to as the census, we visited more than 189,087 households with 2,375,248 estimated residents in the selected districts. Interviewee had reported 29,761 births, 837,379 household members (family size) and 105,814 children<5 years of age. Non houses refused to speak to us and some houses (not recorded) were never at home. When not home, we revisited the houses an average of two times, typically over a one week period while data collectors stay in the specific Tabia. For the second round of visits which calls the verbal autopsy sample, we visited households that had 1,857 reported deaths. About 42 of the families could not be found again but re-visited repeatedly until we get household members and interviewed. None of the deceased's family refused to be interviewed. These households had

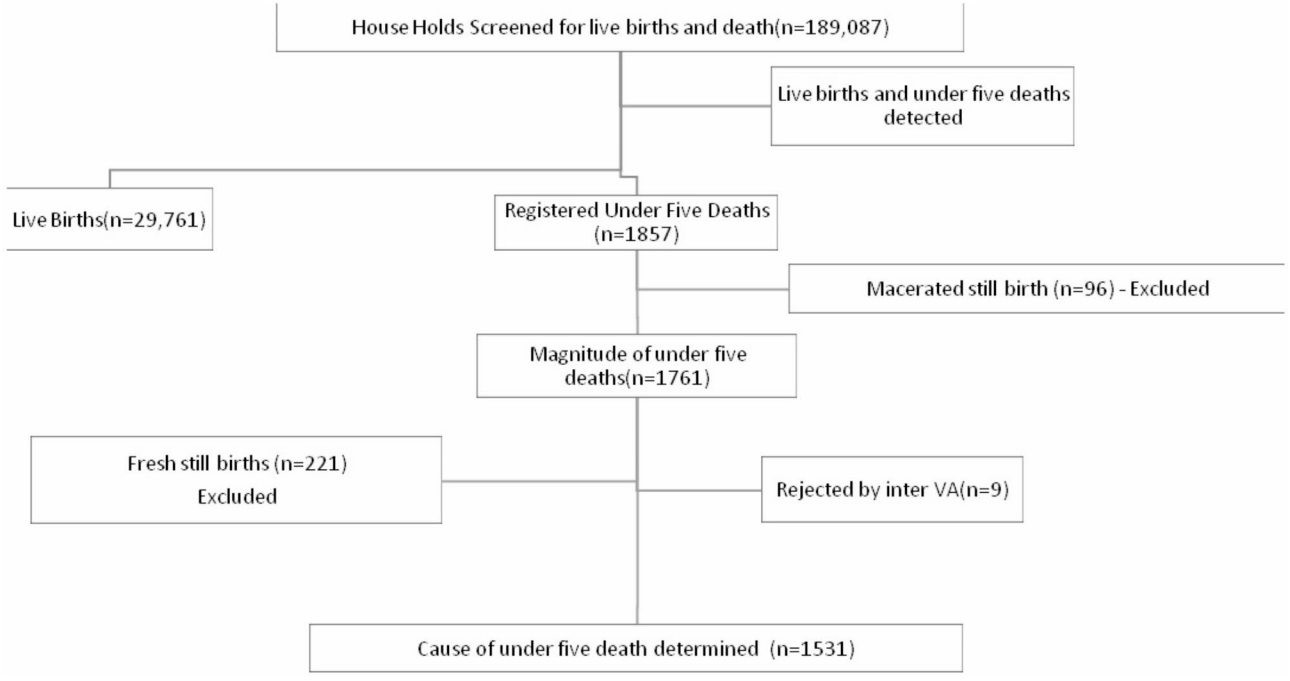

Fig. 1 Flow chart of data collection and analysis of the under five mortality study, Tigray, Ethiopia, 2021/22

837,379 residents with 12.6% (105,814/837,379) still living children less than 5 years of age. Detail population in the selected district is found in Supplementary Table 1. To reduce unavailability at home, the team was using local and traditional gathering to inform people on the expected date of visit.

Data collection tool and procedure

Data were collected in two phases, first phase, census of HH for live birth, under-five and death was done and in second phase, deaths from each Tabias were listed and VA was done to confirm causes of deaths. The data collection tool for the first phase of the study was a screening tool (live births and deaths) during war period (November 2020 to May 2022) which was developed by the research team and the second phase was using the 2022 world health organization (WHO) verbal autopsy tool and guideline to ascertain death and causes of under-five deaths. The tool was translated and administered using the local language (Tigrigna). Questionnaire and information sheet is attached as supplementary file 3. The data were collected using interviewer-administrated verbal autopsy (VA). Tablet based Open Data Kit (ODK collect) was used for data collection for both first phase and second phase survey. Prior to the verbal autopsy, house to house screening for live birth and deaths was done. Components of the screening tool were number and name of live births during November 2020 to May 2022, number and name of children age below five year and date of death, GPS location. For deaths of under-five identified during the screening, verbal autopsy was done using the 2022 WHO verbal autopsy tool. The VA questionnaire had components such as socio-demography of deceased, medical history associated with final illness, history of injury and health history and questions related to health service utilization, other detail variables based on the WHO VA guideline, and GPS location. For the first phase survey, interview was made with HH members mainly with mother for live births, date of birth, age, sex of child, under-five death from November 2020 to May 2023. If there was under-five deaths, further screening of time of death (November 2020 to May 2022), GPS location and additional note for re-visit scheduling of VA was made after identifying respondent to VA. All VA interview were made after completing HHs screening in the selected districts, and further eligibility of time period. Most interviewee tried to tell the interviewer about death of their under-five but, it is known that due to culture and hiding negative feeling, some interviewee may hide death especially of older child. This may affect the true mortality in the population and can be considered as limitation. Even some data collectors found information about death of under-five from neighbor but was not told by the HH members. Then, additional counseling was given and ascertains the death from the family members by revisiting the HH again before VA. For the deaths, we have used from the report of HH members (screening), we did not get any list of death from nearby health facility because more than 70% of health facility were non-functional or destroyed during the war period. Due to this, there could be under reporting of deaths in the study area and can be considered as limitations.

The data collection process was well supervised by senior investigators from school of medicine and school of public health of Mekelle University. For each identified deaths in the selected district and Tabias (list of deaths with location and address was first identified from the first phase of survey), then a trained health professional visited the household of the deceased of age 0 to 59 months to carry out a VA interview with mothers/family members of the deceased. Respondents were mainly mother of the deceased child, if not available a father, or adult relatives who were care givers at the time of death were included as respondents.

The data collectors were recruited from the health facilities in the selected districts and had experience of recording routine data using computer system. The supervisors were MSc and above holders in health profession and were recruited from the regional health bureau, Mekelle University and Tigray health research institute and had experience in research, supervision and data collection. The data collectors and supervisors were trained for seven consecutive days regarding the objective of the study, WHO VA guidelines, informed consent, selection of VA respondent, how to approach participants and ethical procedures. One supervisor was assigned per district to check for the daily activity, consistency, and completeness of the questionnaires, to give appropriate support during the data collection process. IT experts were assigned for each districts to follow data collection process, ODK related errors. Data collector/s visits each HH for screening and then conducts VA if the HH has under-five death. Team of supervisor and data collectors; move to a specific village or area together to ensure better communication, logistic utilization and follow-up of daily activity. The supervisor and team ensure every household is screened before they move to the next station and the final day of stay is defined by completeness of the screening interview. Additional follow up visit was arranged by the team of investigators to evaluate the quality of data collection in sampled Tabias and timely feedback was given to the supervisors and data collectors. As challenge, charging the Tablets at remote rural setting was very challenging due to lack of access to electricity as result of the war. The research team tried to provide power bank for those who were assigned at remote area.

In the absence of the HH members during the data collection period, on average two repeat visited was

conducted. Every screened HHs were coded and marked red marker in front of the HH gate, additional notes were taken for those who were not available, to re-schedule for second visit. If still not available were considered as non-response. Due to movement restriction during war and no transportation service, most HH members were found at their home and neighbour, and data collectors wait until she/he comes. The actual number of HHs included in the non-response were not exactly counted (recorded) especial those who missed during the re-visit for the screening. But, data collectors did several visits for the VA in case of unavailability since VA were few in the specific Tabias, must be interviewed. So, we did not miss any death for VA due to unavailability of HH members. In some HHs, VA respondents were replaced by family members if the one who responded death during screening survey was not available during the VA interview according to the eligibly for VA.

Data quality control

The data collection tool was translated in to local language (Tigrigna) and refined with detailed discussions and pretest. The data collectors and supervisors were trained on the aim and method of the study, data collection procedure, use of the electronic data collection tool (ODK), mechanisms of follow-up and data handling. The supervisors were checking the data quality, giving feedback to collectors on daily bases and took corrective measures before leaving site. The research team conducted site visits and provided feedback to the supervisors and data collectors. Time taken for each questions during VA interview, GPS locations were used to assess quality of data. Every day, supervisors check-up filled data for completeness, error and discuss with data collectors. Special training was given to supervisors on how to see screen and VA data in screen sheet excel (all at once) data from each data collectors to detect errors and incompleteness for every day collected data. Further, investigators check the quality of data, solve challenge at field and communicate with district health office for supports like transportation in case of emergency, local guider, allow solar power to charge Tablets and accommodations for data collectors at health centers and health post (on site).

Data analysis

Data were collected using the ODK collect version 1.27.3 and exported into STATA Version 15 for analysis. Descriptive data analysis was conducted using frequencies and percentage for the categorical data; mean and standard deviation and median and inter-quartile range for normally and not-normally-distributed quantitative variables respectively. The VA data were processed using the Inter-VA–5.1 (probabilistic modeling) to assign the cause of death instead of using physicians to determine cause of death. All births and deaths identified through the household census and VA interview for the eligible cases were used for the analysis of under-five mortality. Under-five mortality rate (U5MR) was calculated per 1000 live births with a 95% confidence interval (CI) for the period of November 2020 to May 2022, which was war period in Tigray, Ethiopia.

Ethical consideration

Ethical clearance was obtained from Mekelle University College of Health Sciences Research and Community Service Ethical review board with ethical clearance number of MU-IRB 1962/2022. At the district level, permission to conduct the study was obtained from the district Health Office before conducting the study. The verbal consent of each individual participant was obtained prior to the interview for each phase of survey. The research team was adequately oriented to respect the culture of the respondents during the data collection process and to keep the confidentiality of the respondent. Study participants were informed about the right to withdraw anytime during interview and to skip some of the questions which create discomfort. The information obtained during data collection was used for the purposes of the study. Only the research team would access collected data and the filled questionnaire was kept secured and locked.

Result

The Under-five mortality rate was 59 per 1000 live births with total of 29,761 live births and 1,761 reported deaths of under-five. Majority (60%) of the deaths were during neonatal period. Perinatal asphyxia, prematurity, diarrheal illness, lower respiratory tract infections and severe malnutrition were the leading causes of death. For deaths beyond the neonatal period, diarrheal diseases, respiratory tract infections and severe acute malnutrition top the list of etiologies.

In this study, most of the screening was done in central zone of Tigray (30%) followed by east Tigray (28.2%). Most (43.2%) of the screened households had 4–6 family size, on average of 4.4 family size per households. Within the war period, most HHs (83.9%) did not have live births, only 29,695 (15.64%) HHs had live births and 758 (0.4) HHs had two live births. Totally, there were 515 twin birth and 06 triple births. Moreover, 64,533 (33.99%) HHs had one under-five child (Table 1).

Socio-demographic characteristics

The mean age at death of under fives was 6 days and 1,062 (60.3%) died in the neonatal period while 348 (19.8%) died after celebrating their first birth day. Majority ($n=1096$) of under five deaths were males. About 85% of under-five deaths were from the rural setting (see Table 2).

Table 1 Characteristics of study participants in the screening of under-five, Tigray, Ethiopia, 2022 ($n=189,087$)

Characteristics of participants	Frequency	Percentage
Zone		
East	53,612	28.2
South east	14,962	7.9
South	26,703	14.1
Central	57,001	30.0
Mekelle	8,110	4.3
North west	29,492	15.5
Family size		
1–3	73,289	38.6
4–6	82,077	43.2
>=7	34,514	18.2
Average family size	4.4 (± 2.2)	
Live births		
None	159,408	83.95
One	29,511	15.64
Two	688	0.40
Three	19	0.01
Multiple birth		
Twin	445	
Triple	06	
Under-five child		
None	105,228	55.42
One	64,533	33.99
Two	19,076	10.05
Three	1,043	0.55

Table 2 Socio-demographic characteristics of deceased under five, Tigray, Ethiopia, 2022 ($n=1761$)

	Variable	Response	Frequency	%
1	Age category	Neonate	1062	60.3
		Post-neonatal	351	19.9
		Child	348	19.8
2	Sex/Gender	Male	1,096	62.2
		Female	665	37.8
3	Place of Residence	Urban	263	14.9
		Rural	1498	85.1

Magnitude of under-five mortality

The under-five mortality rate was 59(95% CI,59–62) per 1000 live births with district level variation of 19 to 158 deaths per 1000 live births. Detail raw data attached as supplementary file 4. For every 17 live births during the war time in Tigray, there was one death. The districts with highest level of mortality were Neksege, Hawzen and Seharti with U5MR of 158,142 and 114 deaths per 1000 live births respectively. These were places of frequent active war and higher level of destruction to the health institutions. Districts such as Quiha district in Mekelle and Maychew town had the lowest U5MR of 19/1000 live births as can be seen in Figure below (Fig. 2).

Rural districts had twice higher mortality rate of the urban setting. In urban districts there were 263 under-five deaths and 7,738 live births and the U5MR was 34 per 1000 live births. For rural districts, the mortality rate was 68/1000 live births (1,498 deaths and 22,023 live births).

The commonest place of death for under five was home. One thousand eighty five deaths (61.6%) happened at home and 30.8% ($n=543$) died at health facility (Fig. 3).

The mortality rate was variable through the months of the study period with the peak of mortality near to the end of the study period (April 2022 to May 2022) (Fig. 4).

Cause of death

Cause of death was assigned for 1752 of the under five deaths. Overall, the leading cause of under five death based on the cause specific mortality fraction and probabilistic method were birth asphyxia ($n=277$,18%), prematurity ($n=235$,16%),Diarrheal disease (162,12.5%),acute respiratory infection including pneumonia ($n=67$, 10%) and Severe malnutrition ($n=52$,3.%). The cause for 11.6% of the deaths was undetermined (Fig. 5). Six hundred ninety nine under fives died after the neonatal period. For deaths beyond the neonatal period, the commonest causes were Diarrheal disease ($n=162$, 23%), Acute respiratory infection including pneumonia ($n=137$, 19.7%) and sever acute malnutrition ($n=52$, 7.5%). The other causes of death were HIV related death, malaria, meningitis and encephalitis, other infectious disease and transport related and pertussis.

Discussion

During the study period, there were 29,761 live births and 1,761 under-five deaths. The under-five mortality rate was 59 with neonatal deaths accounting near two third (61%) of the magnitude. The most common causes of death for children of age below 59 month were perinatal asphyxia (18.1%), prematurity (15.3%), diarrheal diseases (10.6%) and lower respiratory tract infections (9.1%). For children age 1–59 month, the most common causes of mortality were diarrheal disease (23.2%), Lower respiratory tract diseases (19.7%) and severe malnutrition (7.5%). 65% of children died at home or en route to health facility.

In this study, the magnitude of under-five death was 59/1000 live births. According to the 2019 ethiopian demographic health survey, the rate of under-five mortality rate in Ethiopia was 59 deaths per 1000 live births and the UNIGME estimated Ethiopian under five mortality rate for the year 2020 was 49 per 1000 live births [2, 7]. The U5MR during the study period is higher as compared to studies in Ethiopia [20] and showed a sharp increment as compared to pre-war data from the study area [21, 22]. In an under five mortality study covering trend over the period 2009 to 2017 in tigray, the under five mortality rate was 35 per 1000 live births and as per

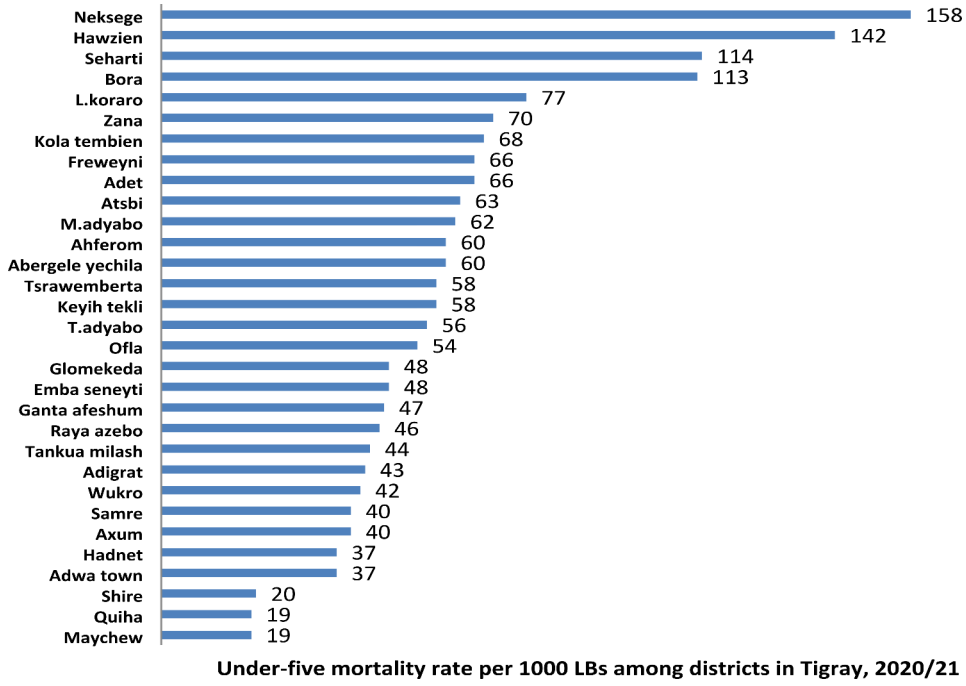

Fig. 2 Under five mortality rate among districts in Tigray, Tigray, Ethiopia, 2021/22

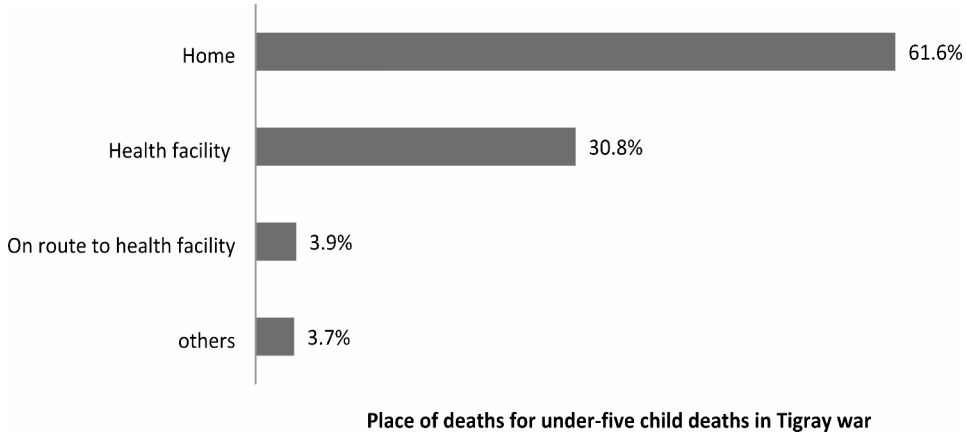

Fig. 3 Place of death for deceased under five in Tigray, Tigray, Ethiopia, 2021/22

the report by the Tigray statistics agency (TSA), the 2020 U5MR for the study area was 30 per 1000 Live births [21, 22]. The current finding is nearly twice of the prewar rate [21]. In a 9 year regression analysis of data on under-five mortality during conflict and war, the U5MR doubled in 3–5 years after onset of the war [15]. According to the 2021 UNIGME estimate of under-five mortality, the overall U5MR for conflict affected areas and fragile situation was three times higher as compared to the non fragile state rate of under-five death. For the estimate, conflict and fragile situation was defined as, a setting with conflict lasting few years and conflict related death of more than 10% of the non conflict related death [7]. The current study despite being early in the course of the conflict and of shorter duration, the war time mortality doubled, indicating circumstance of the war and the effect on the health system as key factor to determine extent of the impact [23].

Majority (61%) of the deaths were in the neonatal period. This is higher as compared to other studies in Ethiopia and sub-Saharan Africa [20, 22, 24, 25]. Generally, among under-five deaths, share of newborn deaths are higher in setting of lower under-five mortality, and vice versa [6]. In 20 years preceding the 2019 Ethiopian DHS, for example, the proportion of neonatal mortality was increasing with decreasing under-five mortality rate(U5MR) [2]. In this study, however, proportion of neonatal mortality is high despite a higher under-five

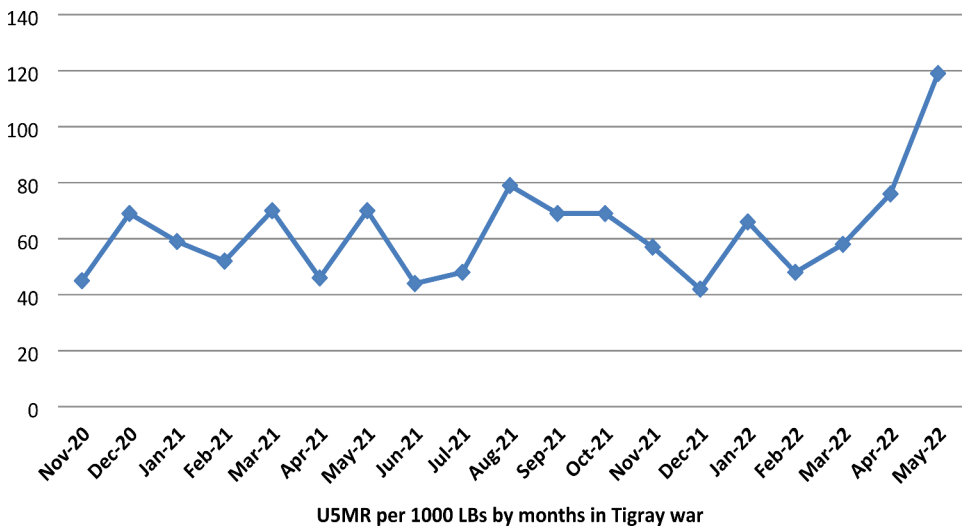

Fig. 4 Under five mortality rate per months during war time in Tigray, Ethiopia, 2021/22

mortality rate [6, 26]. War is associated with increased infant and child mortality and its context determines the extent of the direct and indirect harm to child health. Within months of onset of the war, multiple reports indicated that, almost all health posts and health centers were non functional with most facilities destroyed and some facilities occupied by armed forces [13, 27, 28]. The health extension program, started in Tigray in 2003 and thought to be one of the effective programs in reducing under-five death in Ethiopia, was completely non functional with most of the Health extension workers either displaced, killed or living in stressful and insecure condition [14]. Delivery by trained health professional and full vaccination of children dropped from 81% and 73% in the prewar era, to 21% and 27% at the end of 2021, respectively [21]. The early and sharp increment in under-five mortality rate in this study, therefore, can be explained by total collapse of the health system and lack of access to health care services [14, 15, 23].

The rural to urban difference in mortality was wide with 68 and 38 /1000 live births respectively. This is consistent with most studies in sub-Saharan Africa and Ethiopia [29, 30]. In this study, the district level difference in mortality was wide with areas such as Neksge (158), Hawzen (142), Bora (114) and Seharti (113) having high U5MR and districts such as Quiha district of Mekelle [19], Maychew (19 and shire [20] recorded lower U5MR. The prior are rural districts and had intense and long fighting between the warring parties. Intensity of armed conflict and residence in proximity to area of armed conflict (within 50 km) are important factors to infant and child mortality [23].

The most common causes of death for children of age between 0 and 59 months were perinatal asphyxia (18.1%), prematurity (15.3%), diarrheal diseases (10.6), lower respiratory tract infections (9.1%) and neonatal pneumonia. The top five causes are similar compared to study from Tanzania, Rwanda, India and prewar Tigray [11, 22, 31]). Both periantal asphyxia and prematurity are complications of maternal malnutrition, impaired socioeconomic and heath status, and failure to provide quality antenatal and intrapartum care [3, 20, 24, 31]. Survival of neonates with asphyxia and prematurity depends on immediate postpartum care with essential new born care and beyond [24]. The significant decline in ANC, delivery by skill birth attendant and access to health service coupled with frequent interruption of electricity, lack of oxygen and medical supplies during the study period might be the reason for the change in U5M pattern towards increased proportion of asphyxia and prematurity related deaths [14, 21].

For children age 1–59 month, the most common causes of mortality were diarrheal disease (23.2%), lower respiratory tract diseases (19.7%) and severe acute malnutrition (7.5%). Globally applicable interventions like provision of vaccine, increased sanitation, access to clean water and therapeutic interventions such as provision of Oral Rehydration therapy, zinc and antibiotics are significantly impaired at times of conflict and war [32]. In Tigray, rate of pentavalent 1 and 3 vaccinations decreased from prewar 95.4% and 84.4 to 32% and 30% at the end of 2021. Lack of support and follow-up from health extension workers, failure to maintain interventions such as the integrated community case management (ICCM), and difficulty to reach a nearby health facility for lack of money, transportation and frequent blockage of roads might contribute to the increased mortality from diarrheal disease and lower respiratory tract infections [16, 20, 21, 26, 29, 32, 33].

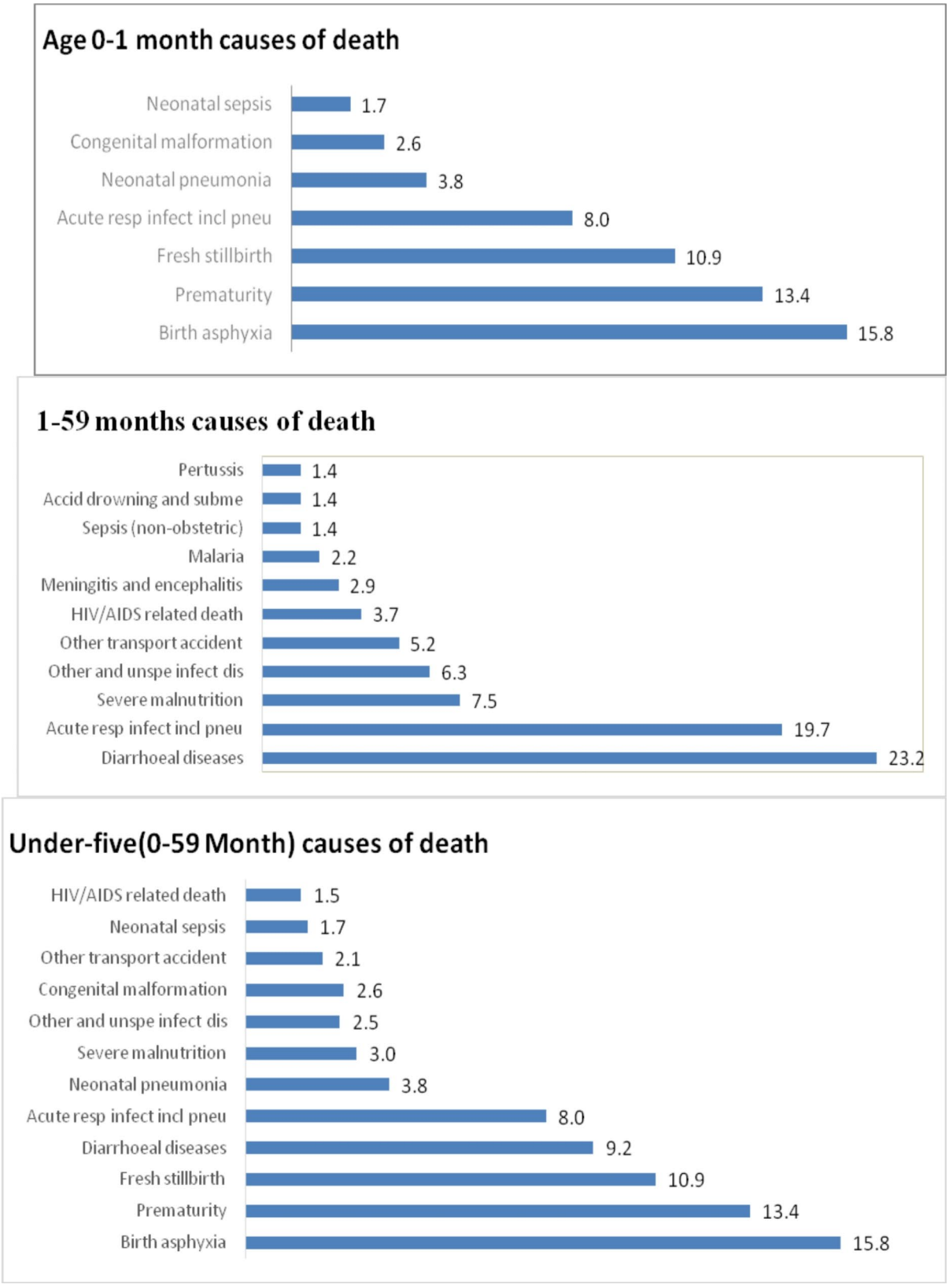

Fig. 5 Cause specific mortality fraction for under-five deaths during war time in Tigray, Ethioipia,2020/2021

Under-nutrition in children can cause death directly and contributes to increased mortality from infectious diseases such as pneumonia, diarrhea and HIV. In Tigray, within months of onset of the war more than 85% of Tigray's population was food insecure and the general acute malnutrition in children tripled from a prewar level of 10–28% [34]. In a representative survey of deaths of all age group in tigray, sever acute malnutrition was the third direct cause of death for the age 1–59 month and might have contributed to the increased mortality from infectious causes [14]. Vaccine preventable diseases, in addition to diarrheal disease and lower respiratory tract infections, were among the top ten lists of causes of under-five death with pertussis and meningitis related rate of 1% and 2.9% respectively. HIV related deaths were direct cause of death for 5% of the under-five deaths. This is higher than a study in Tanzania, where rate of pertusis, meningitis and HIV related death was 0.7%, 4.2% and 3.8% respectively [31]. Increased pertussis and meningitis related mortality might be related to lack of access to vaccination. HIV related death is lower compared to study in east Ethiopia [20]. but, this study was done early and was short in duration to conclude on the impact of the war on HIV related mortality for under-fives [6]. Malnutrition and HIV are known to contribute to near half of under-five deaths [35, 36] but it is not within the scope of this study to assess the extent of the indirect impact of both diseases to the current under-five death.

Majority of children died either at home or on their way to health facility. This is consistent with other studies from Ethiopia [20, 22].

The success of reducing under-five mortality was achieved mostly through cause specific interventions of the top causes of mortality. A more than two-third (63.3%) reduction in global U5MR from 2000 to 2019 was achieved through reduction in deaths from diarrhea, lower reparatory infection, preterm births, intrapartum related complication, malaria and measles [32]. Reduction in intensity of conflict was associated with improvement in mortality with faster rate of reduction in the first five years post conflict [23]. Cost effective and proven interventions such as Integrated management of the new born and childhood illnesses (IMNCI) [37], neonatal resuscitation for intrapartum related complications and acess to emergency obstetric care [32], institutional delivery and improved perinatal care for preterm and low birth weight babies [20, 38], improved access to vaccination [29] and access to low cost interventions such as rehydration therapy and zinc [33], improved access to nutrition and sanitation [6] and revitalization of the health system are important areas of intervention.

Limitations

The verbal autopsy tool used for data collection was the WHO 2022 VA tool but interpretation was using the updated version of the 2016 inter VA 5.1. The interpretation tool for the 2022 WHO-VA was not available to date. This disparity in version, coupled with recall bias for detailed symptoms and events preceding death might have resulted in misclassification of cause of death towards still birth [39] and contributed to the 11% level of undetermined cause of death for this study. During the data collection period, the community was still unstable and some households were missed. For some of the respondents, remembering the circumstances of mortality was unbearable and was not easy to complete the interview in one contact. Especially stillbirth and early neonatal death, some interviewees were not telling interviewers about deaths due to cultural perception, and do not want to remember the death [39]. Community's negative perception towards reporting child death [30] and exclusion of areas of insecurity, might have under estimated the mortality rate finding of our study.

Strength

The research presented here, to the best of our understanding, is the largest study to address the magnitude and causes of U5M in the war time Tigray. The study overcame the war related failure of vital registration and community instability related challenges by implementing a multistage stratified sampling and Tabia (smallest administrative unit) level house hold census. Besides, the study employed electronic data collection and automated analysis as per the WHO approved data collection and interpretation tools. The data collectors were well trained health professional and supervised by scholars with research and data handling experience.

Conclusion

The U5MR in the present study was twice of the prewar rate and the proportion of neonatal deaths is higher than prewar Tigray. Preventable causes of death dominated the list of etiologies with most dying at home and before arrival to health facilities. Neonatal causes, diarrheal illness, lower respiratory tract infections and severe malnutrition were the major causes of under five death in this study. The documented increment in mortality is earlier and sharp indicating the nature and impact of the war on child health. Cause specific and effective interventions that contributed to the global success in reduction of under-five mortality including Integrated management of the new born and childhood illnesses (IMNCI), neonatal resuscitation for intra-partum related complications and access to emergency obstetric care, institutional delivery and improved perinatal care for preterm and low birth weight babies, improved access to vaccination and access

to low cost interventions such as rehydration therapy and zinc, improved access to nutrition and sanitation and revitalization of the health system are important areas of intervention.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Author contributions
Authors 1-8 developed the proposal for the study, framed the objective and data analysis of the study. Authors 9-14 worked the details of data collection and managed the logistics for the data collection. Authors 15-16 and 18 developed the open data kit tool and led the electronic data collection
All authors partiicipated in data analysis and writeup and reviewed the manuscript.

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Data availability
Data and materials are available upon request from the publisher.

Declarations

Ethics approval and consent to participate
Ethical clearance was obtained from Mekelle University College of Health Sciences Research and Community Service Ethical review board with ethical clearance number of MU-IRB 1962/2022.

Consent for publication
I, the main Author, herby confirm that all authors consented to publication of the article on conflict and health.

Competing interests
The authors declare no competing interests.

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