Original Article

The Epidemiologic Transition for three decades in the Butajira community, South-Central Ethiopia: using Butajira HDSS database

Hailelule Aleme Yizengaw[1*], Wubegzier Mekonnen Ayele[1], Alemayehu Worku Yalew[1]

Abstract

Background: Health and Demographic Surveillance System sites are the primary source of community-based death and cause of death data, providing essential policy inputs. Currently, many African countries, including Ethiopia, have undergone different stages of epidemiological transition.

Objective: To assess the epidemiologic transition in the Butajira community in south-central Ethiopia.

Methods: All deaths registered in the Butajira Health and Demographic Surveillance System databases were included. The trend in the overall mortality rate and the change in the proportion of major causes of death were evaluated, and significant trends were checked using the Mann-Kendall statistical test with significance set at $P< 0.05$.

Results: The overall mortality rate per 1000 population declined from 9.8 in 1987 to 2.8 in 2016. The decline was significant (*tau*, the measure of the strength and direction of association,= -0.76, p-value <0.05). During this study period, 2610 deaths were registered in the Health and Demographic Surveillance System database, of which 1,625 were adults. The proportion of yearly deaths attributed to communicable diseases, maternal and perinatal conditions, and nutritional deficiencies showed a significant decline (*tau* = -0.727, $p < 0.05$), while there was a significant increase in non-communicable diseases (*tau* = 0.469, $p < 0.05$), and a rise in external causes (*tau* = 0.0953, $p > 0.05$). Furthermore, there were notable changes in the death proportion in the top five leading causes of death, showing a transition in the epidemiology of major causes of death, especially in the age group 15+.

Conclusion: The decline in mortality and burden shift implies the existence of an epidemiological transition. This transition necessitates policymakers to design a responsive health system that cater to the population undergoing this epidemiological transition. [*Ethiop. J. Health Dev.* 2023; 37(3) 000-000]

Keywords: Cause of death; Epidemiological transition; Mortality, Trend

Introduction

Mortality statistics and cause of death (CoD) are among the main components of health planning (1). However, accurate death registration systems are lacking in most low and middle-income countries (LMICs), mainly in areas where mortality rates are highest (2, 3). In Ethiopia, the death registration system and its coverage are poorly functional and under-recorded (4). Local health and demographic surveillance system sites can be an indispensable source of death and cause of death data at the community level through household surveys, providing essential inputs for policy (5). In this context, national and sub-national CoD analyses, as well as time-trends of such patterns, are, of vital importance for public health interventions (6). Alongside declining fertility, improvements in survival are an indicator of a population's progress through the demographic and epidemiological transition (7).

The general shift from acute infectious/communicable diseases(CDs) and deficiency diseases to non-communicable diseases (NCDs) is usually referred to as the epidemiological transition (8). The Epidemiological transition is a newly described insidiously growing global phenomenon (9) and a theory presented by Omran almost 50 years ago. He typified three phases of transition: the "age of pestilence and famine," the "age of receding pandemics," and "the age of degenerative and man-made diseases" (10). Though several updates and variants of models since its origin in 1971, this theory explains the shift in the pattern of diseases (principally, from CDs to NCDs) (11, 12).

The classic epidemiological transitions theory could not be generalized for every country and remains contentious (13). In the Low and Middle-Income Countries (LMICs), a significant transition occurred due to the decline in mortality from major infectious diseases and the growing burden of chronic diseases like cancer (14-16).This transition is characterized by ill-health systems (17, 18). The Epidemiological transition is gradually creeping into Africa [9]. Despite variations in the stages and rates, the epidemiological transition occurs in most African countries [19]. However, due to the scarcity of epidemiological data (20, 21), understanding mortality and associated epidemiological transitions remains challenging (22). Therefore, this study aimed to evaluate the progression of the epidemiologic transition in the Butajira community using a 30-year demographic surveillance and 12-year CoD surveillance systems.

Materials and Methods

Study setting

Butajira HDSS is located in south-central Ethiopia within the Guraghe and Siltie Zones of central Ethiopia regional state, approximately 130 kilometers south of Addis Ababa, the capital city of Ethiopia (23); the HDSS site consists of both rural- and town-based households (24,25) (Figure 1).

[1] School of Public Health, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia
*Corresponding author email- hailelule.aleme@aau.edu.et

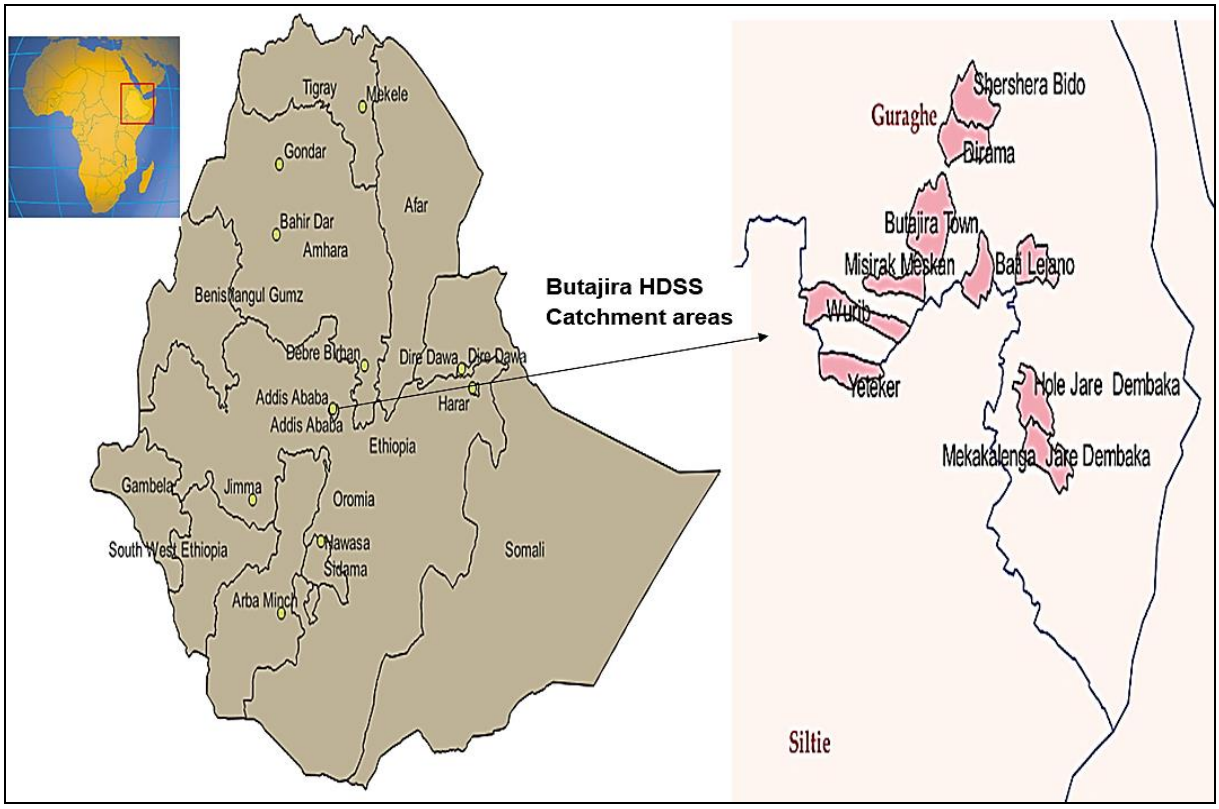

Figure 1. Map of the study area

The Butajira Rural Health Program was initiated in 1987 following a population census of randomly selected nine peasant associations (rural communities) and one urban dweller's association (urban village) from eighty-two rural and four urban kebeles, using the probability proportionate to size technique, which is nationally representative samples (26). Of these selected kebeles, four are located in the lowland, and the rest six kebeles (each three) are located in the highland and midland areas. The initial census was used to obtain the baseline population and to establish a system of demographic surveillance with continuous registration of vital and migratory events (birth, death, marriage, new household, out-migration, in-migration, and internal move) at the household level. Initially, data were collected every month. This was changed to be every three months since 1999. In addition, censuses were conducted every 3-5 years to update the baseline characteristics of households and individuals. Undertaking population census has been changed to annual housing, individual, and family reconciliation since 2003 (Figure 2).

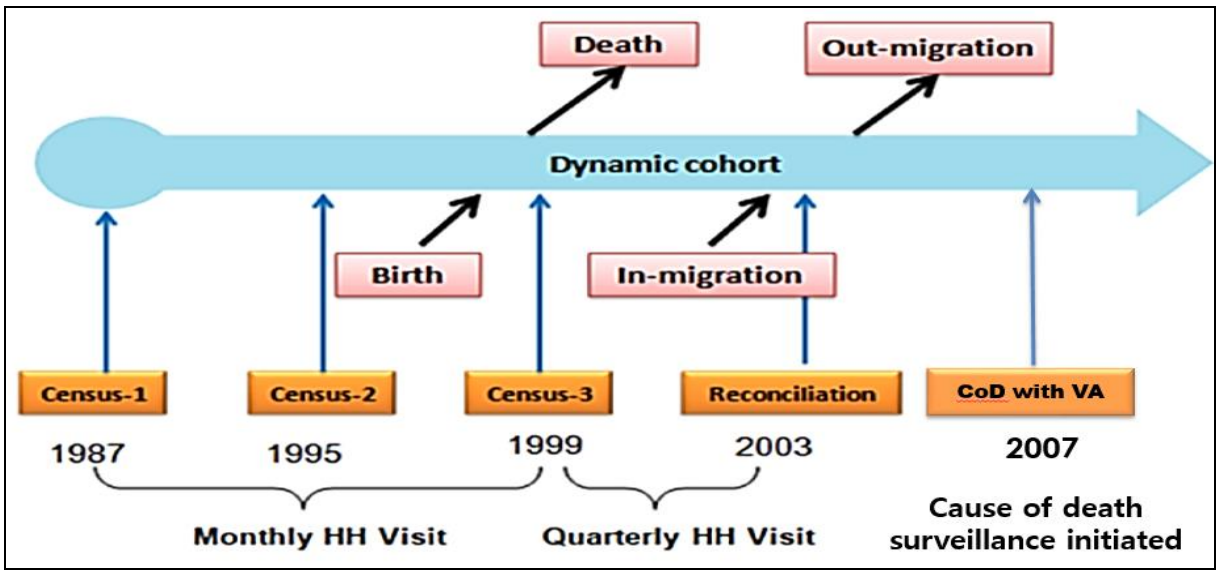

Figure 2. Event tracking in Butajira Demographic Surveillance System

Study design and study period
This study used the Butajira Demographic and CoD Surveillance System databases. All deaths that occurred in the Butajira HDSS sites from 1987 to 2016 were used, and in addition, from 2008 to 2020, the deaths with the underlying CoD were considered for this study.

Population
The study population for this research consists of the typical inhabitants living in eighty-two rural and four urban kebeles located in the central Ethiopia regional state. These kebeles are from four districts: Meskan, Mareko, Silti, and Butajira. Additionally, the study includes residents from nine rural surveillance kebeles and one urban kebele, which is the smallest administrative unit in Ethiopia, specifically from the Bujita HDSS residents [27]. As a result, all the populations being monitored in these ten kebeles were taken into consideration for this study.

Data sources, collection tools, and CoD determination procedure
The demographic and CoD surveillance system of the Butajira HDSS database was used as a data source. The WHO/INDEPTH-Network event registration forms have been used for this study. The data collection was done by village-based data collectors using the paper-based format and standard data collection procedure.

The demographic and the CoD data collection research team members were used to collect the data. Generally, each Kebele is divided into eight equal parts, and events happening in one-eighth of a kebele are recorded in a week running from Monday to Thursday; Friday is used to transfer completed forms to the project office.

Deaths captured by the demographic data collection team were shared with the CoD data collection team to conduct a Verbal Autopsy (VA) after the cultural mourning period. The VA involves a structured interview with the next of kin or a caregiver about signs, symptoms, and events the deceased experienced before death [28]. Forty days is regarded as the usual mourning period in the study area. The 60-day maximum was applied to minimize recall bias concerning details of symptoms and circumstances of death.

The VA data were collected using VA forms that contained questions that exploring relevant and detailed information from relatives of the deceased individual. The VA forms and surveillance questionnaire were translated into Amharic language to be used in the field. Hence, the underlying cause of death for each deceased resident member of the HDSS is extracted from the VA, conducted through cyclical visits to the household on systematically identified and registered deaths in the surveillance system, following a suitable bereavement interval.

In the data collected through VA, underlying CoD was assigned using the physician-certified VA method (29) of data collected from January 2008 to April 2017. For data collected from May 2017 to April 2020, the InterVA/computer-coded VA method was used (30, 31). The specific CoD is then grouped into broad categories, such as communicable diseases (CD), which are caused by micro-organisms such as bacteria, viruses, parasites, and fungi that can be spread, directly or indirectly, that are either transmitted from person to person or animal-to-humans. One the other hand, non-communicable diseases (NCD) are not transmissible from one person to another and tend to occur over a long period of time in an individual. External causes(EC)/ injuries have been defined as physical damage to a person from various external sources (further details explained elsewhere) (32).

Data management and analysis
Initially, the data were checked and cleaned. Descriptive analysis was employed, and age at death was categorized as < 5 years, 5-15 years, and ≥ 15 years. The overall mortality rate per 1000 population was computed for 30 years, including the four-year moving averages to depict the progression of epidemiological transition in the Butajira community.

Death rate trends were stratified based on age, sex, residence, and ecology. Furthermore, the 12-year trend and pattern of specific causes of death were evaluated. We categorized the broad CoD into three groups: 1. communicable diseases, maternal and perinatal conditions, and nutritional deficiencies; 2. Non-communicable causes, and 3. external causes (injuries (19).

The top five causes of death for each age group were taken to evaluate transition in the epidemiology of major causes of death. The Mann-Kendall statistical test was used to detect a trend in the data. A positive value of *tau* (Kendall's tau statistic) indicates an increasing trend, whereas its negative value indicates a decreasing trend (33). A significant trend was assumed where $P<0.05$ using the Z statistic (34, 35).

Data cleaning and the computing of descriptive summaries were managed in Microsoft Excel worksheets. Further analyses were carried out using the R-Statistical software package version 3.6.3.

Data quality assurance
The quality assurance mechanism of the longitudinal data was presented in other works conducted using the HDSS data (36, 37).

Results
Socio-demographic characteristics of the deceased
For the 30-year follow-up period, 12,615 deaths were registered in the demographic surveillance database. A total of 6,558 (51.9%) male and 6057 (48.1%) female deaths occurred. The mean age at death was 23.4 years. A large proportion of deaths, 5,988 (47.5%), were

children under five years of age, followed by 1,335 deaths among those aged 5-15 years and 5,292 among 15+ years. Moreover, 11,028 (87.4%) deaths were recorded in rural areas, and 1,587 (12.6%) deaths occurred in urban areas. The highest number of deaths, 5,573 (44.2%), were registered in the lowland area, and 4,676 (37.1%) and 2,366 (18.8%) death were documented from the highland and midland areas, respectively (Table 1).

Table 1. Socio-demographic characteristics of the deceased, Butajira HDSS, 1987-2016, Ethiopia

Year	Age(years)						Sex				Residence				Ecology						
of	<5 years		5-15 years		≥15 years		Female		Male		Rural		Urban		Highland		Midland		Lowland		**Total**
death	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
1987	152	54.7	38	13.7	88	31.7	131	47.1	147	52.9	267	96.0	11	4.0	133	47.8	53	19.1	92	33.1	278
1988	324	48.2	108	16.1	240	35.7	324	48.2	348	51.8	634	94.3	38	5.7	208	31.0	77	11.5	387	57.6	672
1989	226	43.7	126	24.4	165	31.9	226	43.7	291	56.3	472	91.3	45	8.7	164	31.7	78	15.1	275	53.2	517
1990	257	54.0	56	11.8	163	34.2	230	48.3	246	51.7	397	83.4	79	16.6	182	38.2	106	22.3	188	39.5	476
1991	350	49.9	111	15.8	241	34.3	330	47.0	372	53.0	616	87.7	86	12.3	287	40.9	179	25.5	236	33.6	702
1992	181	44.9	48	11.9	174	43.2	179	44.4	224	55.6	377	93.5	26	6.5	121	30.0	35	8.7	247	61.3	403
1993	252	46.6	61	11.3	228	42.1	267	49.4	274	50.6	485	89.6	56	10.4	208	38.4	97	17.9	236	43.6	541
1994	254	41.8	101	16.6	253	41.6	285	46.9	323	53.1	570	93.8	38	6.3	243	40.0	76	12.5	289	47.5	608
1995	160	36.8	65	14.9	210	48.3	235	54.0	200	46.0	395	90.8	40	9.2	190	43.7	72	16.6	173	39.8	435
1996	196	47.8	36	8.8	178	43.4	210	51.2	200	48.8	366	89.3	44	10.7	169	41.2	57	13.9	184	44.9	410
1997	265	49.0	58	10.7	218	40.3	259	47.9	282	52.1	477	88.2	64	11.8	230	42.5	96	17.7	215	39.7	541
1998	398	52.0	86	11.2	282	36.8	385	50.3	381	49.7	699	91.3	67	8.7	279	36.4	95	12.4	392	51.2	766
1999	588	46.9	167	13.3	500	39.8	647	51.6	608	48.4	1175	93.6	80	6.4	518	41.3	148	11.8	589	46.9	1255
2000	249	49.5	42	8.3	212	42.1	244	48.5	259	51.5	421	83.7	82	16.3	179	35.6	121	24.1	203	40.4	503
2001	194	53.2	25	6.8	146	40.0	176	48.2	189	51.8	298	81.6	67	18.4	120	32.9	92	25.2	153	41.9	365
2002	230	55.7	34	8.2	149	36.1	196	47.5	217	52.5	344	83.3	69	16.7	138	33.4	99	24.0	176	42.6	413
2003	228	50.7	39	8.7	183	40.7	229	50.9	221	49.1	377	83.8	73	16.2	189	42.0	97	21.6	164	36.4	450
2004	199	59.9	7	2.1	126	38.0	147	44.3	185	55.7	282	84.9	50	15.1	123	37.0	70	21.1	139	41.9	332
2005	168	57.9	12	4.1	110	37.9	125	43.1	165	56.9	240	82.8	50	17.2	105	36.2	65	22.4	120	41.4	290
2006	155	52.0	12	4.0	131	44.0	139	46.6	159	53.4	237	79.5	61	20.5	112	37.6	70	23.5	116	38.9	298
2007	109	46.2	9	3.8	118	50.0	108	45.8	128	54.2	197	83.5	39	16.5	97	41.1	54	22.9	85	36.0	236
2008	153	48.3	15	4.7	149	47.0	148	46.7	169	53.3	273	86.1	44	13.9	119	37.5	51	16.1	147	46.4	317
2009	159	53.0	9	3.0	132	44.0	129	43.0	171	57.0	258	86.0	42	14.0	79	26.3	56	18.7	165	55.0	300
2010	116	48.5	6	2.5	117	49.0	108	45.2	131	54.8	192	80.3	47	19.7	73	30.5	54	22.6	112	46.9	239
2011	111	43.2	15	5.8	131	51.0	124	48.2	133	51.8	202	78.6	55	21.4	81	31.5	74	28.8	102	39.7	257
2012	75	35.7	10	4.8	125	59.5	115	54.8	95	45.2	169	80.5	41	19.5	82	39.0	51	24.3	77	36.7	210
2013	55	29.9	6	3.3	123	66.8	71	38.6	113	61.4	139	75.5	45	24.5	56	30.4	57	31.0	71	38.6	184
2014	80	36.7	14	6.4	124	56.9	100	45.9	118	54.1	169	77.5	49	22.5	64	29.4	59	27.1	95	43.6	218
2015	45	24.7	9	4.9	128	70.3	80	44.0	102	56.0	133	73.1	49	26.9	50	27.5	57	31.3	75	41.2	182
2016	59	27.2	10	4.6	148	68.2	110	50.7	107	49.3	167	77.0	50	23.0	77	35.5	70	32.3	70	32.3	217
Total	5988	47.5	1335	10.6	5292	42.0	6057	48.0	6558	52.0	11028	87.4	1587	12.6	4676	37.1	2366	18.8	5573	44.2	12615

The 30-year mortality rate transition in the Butajira HDSS catchment areas

The burden and trend in the monthly and yearly distribution of deaths for 30 years indicated that the highest death peak was recorded in year 1999 (1255) and July(224) of the same year(Figure 3).

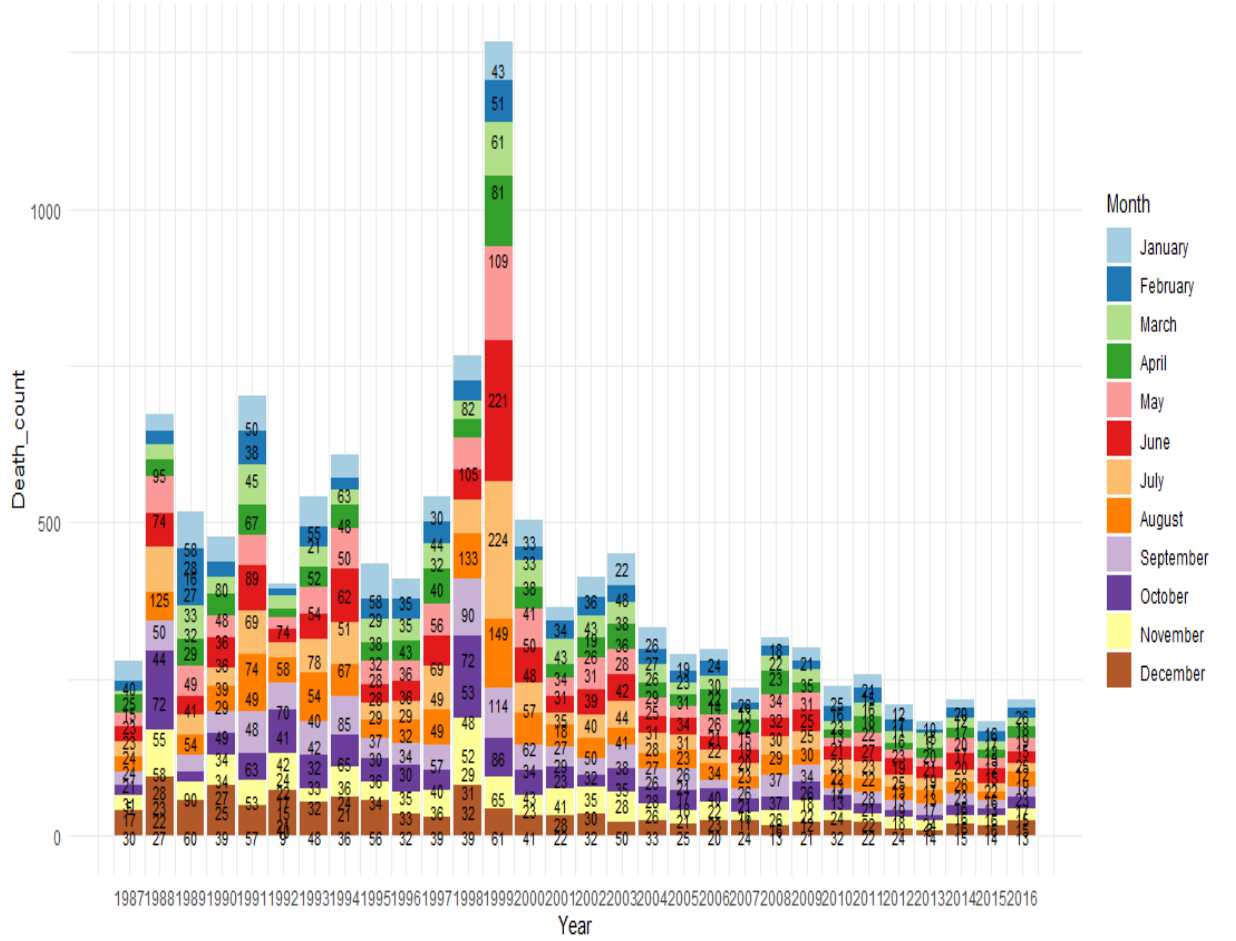

Figure 3.Monthly and yearly distribution of deaths in Butajira HDSS, 1987-2016, Ethiopia

Furthermore, a trend in the rate of changes per 1000 population in the distribution of deaths in the 30 years showed a tremendous reduction in the overall mortality rate (9.8 in 1987 to 2.8 in 2016). A Similar reduction was observed in mortality differentials (age, sex, and residential and ecological factors). The highest mortality rates were observed in the year 1999 and around. However, the peaks in the mortality rate at this point were not pronounced in urban settings and midland environments (pink and light blue flat curve under the year 1999) (Figure 4).

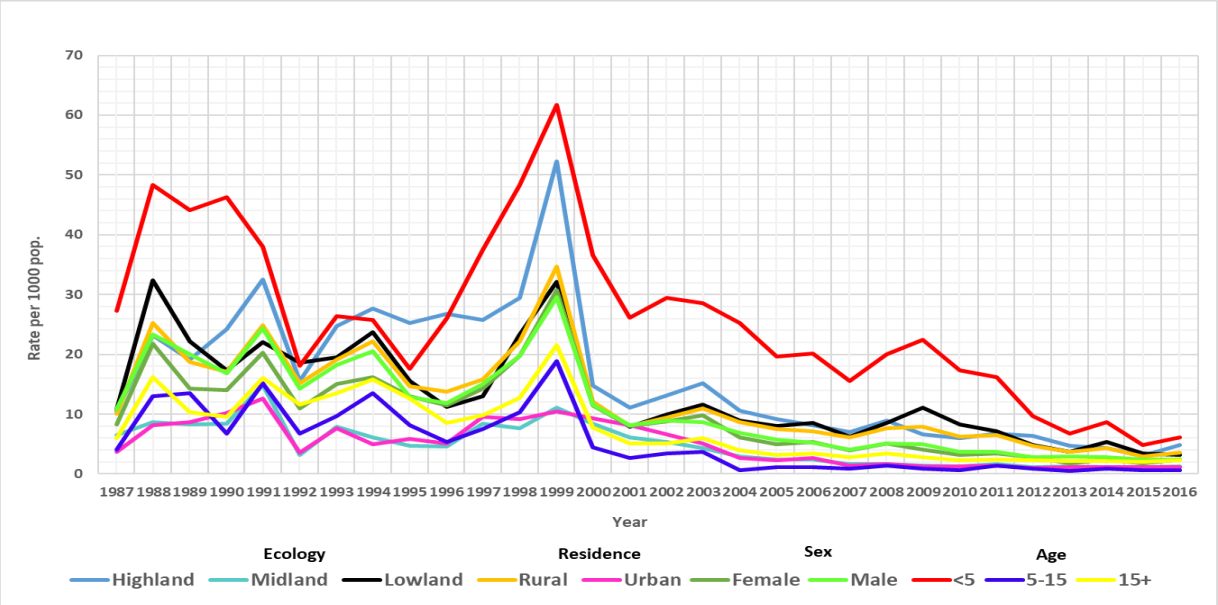

Figure 4. Trends in the death rates from 1987 to 2016, Butajira HDSS, Ethiopia

As indicated in Figure 5 below, the red dotted smoothed line clearly indicated the downward trend in mortality rates (1987-2016). Furthermore, using the Mann-Kendall trend test analysis, the overall death rate across the 30-year showed a significant downward trend in the overall mortality trend(*tau* = -0.76, p-value <0.05)(Figure 5).

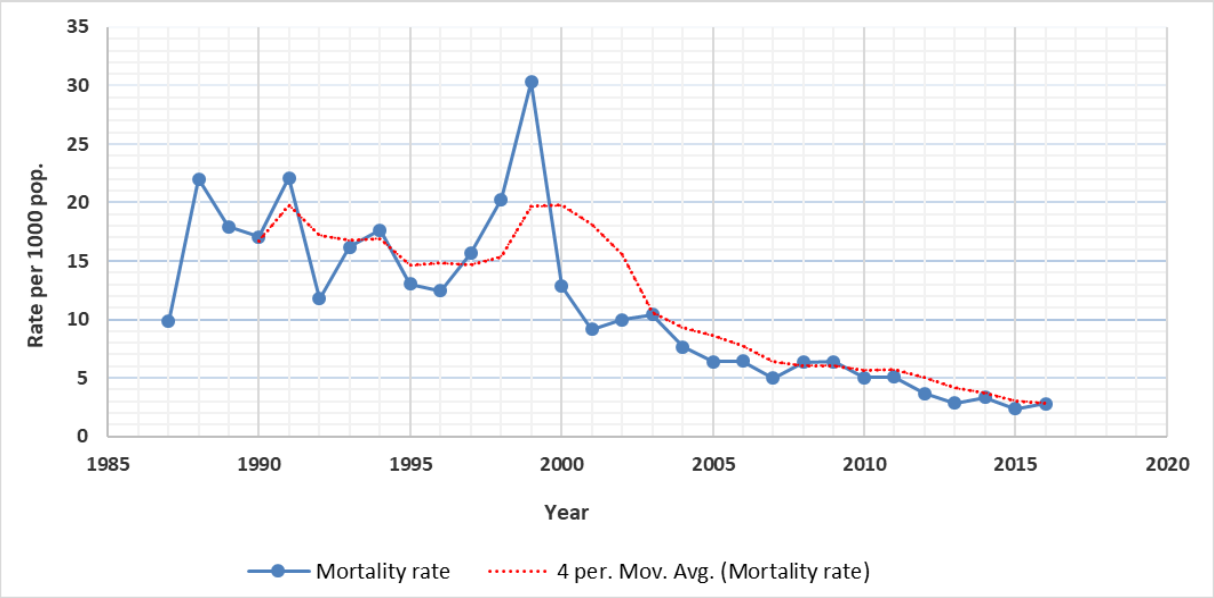

Figure 5. The overall and the 4-year moving average of trend in mortality rate, Butajira, Ethiopia

The 12-years cause-specific mortality transition in Butajira HDSSs

From January 2008 to April 2020, a total of 2610 deaths were recorded in the CoD surveillance database. The cause of death for each case was determined using VA methodology. Out of these deaths, 1364 (52.3%) were male and 1246 (47.7%) were female. Furthermore, 868 (33.3%) deaths occurred in the age group <5 years, 117 (4.5%) in the 5-15 year range, and 1625 (62.3%) in individuals aged 15 or above. Among the registered deaths, 2095 (80.3%) occurred in rural areas while 515 (19.7%) were reported in urban areas. Additionally, in terms of ecological regions, 687 (26.3%) deaths were recorded in highland areas, 793 (30.4%) in midland areas, and 1130 (43.3%) in lowland areas (Table 2).

Table 2. Background characteristics of the deceased, Butajira HDSS, January 2008-April 2020, Ethiopia

Year of death	Age category						Sex				Residence				Ecology					
	<5 years		5-15 years		≥15 years		Male		Female		Rural		Urban		Highland		Midland		Lowland	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
2008	104	40.6	12	4.7	140	54.7	122	47.7	134	52.3	226	88.3	30	11.7	99	38.7	45	17.6	112	43.8
2009	112	45	14	5.6	123	49.4	135	54.2	114	45.8	210	84.3	39	15.7	61	24.5	58	23.3	130	52.2
2010	85	39	5	2.3	128	58.7	118	54.1	100	45.9	184	84.4	34	15.6	57	26.1	47	21.6	114	52.3
2011	106	47.3	15	6.7	103	46	123	54.9	101	45.1	198	88.4	26	11.6	59	26.3	50	22.3	115	51.3
2012	91	38.7	10	4.3	134	57	119	50.6	116	49.4	184	78.3	51	21.7	64	27.2	70	29.8	101	43
2013	72	33	8	3.7	138	63.3	119	54.6	99	45.4	168	77.1	50	22.9	47	21.6	75	34.4	96	44
2014	63	30	10	5.1	124	62.9	104	52.8	93	47.2	158	80.2	39	19.8	50	25.4	62	31.5	85	43.1
2015	69	33.3	5	2.4	133	64.3	118	57	89	43	159	76.8	48	23.2	48	23.2	73	35.3	86	41.5
2016	62	29.1	9	4.2	142	66.7	117	54.9	96	45.1	163	76.5	50	23.5	50	23.5	86	40.4	77	36.2
2017	50	21.3	13	5.5	172	73.2	113	48.1	122	51.9	172	73.2	63	26.8	57	24.3	95	40.4	83	35.3
2016	33	17.6	4	2.1	150	80.2	94	50.3	93	49.7	145	77.5	42	22.5	44	23.5	77	41.2	66	35.3
2019	16	11	4	2.8	125	86.2	67	46.2	78	53.8	111	76.6	34	23.4	43	29.7	45	31	57	39.3
2020	5	19.2	8	30.8	13	50	15	57.7	11	42.3	17	65.4	9	34.6	8	30.8	10	38.5	8	30.8
Total	868	33.3	117	4.5	1,625	62.3	1,364	52.3	1,246	47.7	2095	80.3	515	19.7	687	26.3	793	30.4	1130	43.3

The proportion of yearly deaths in the broad CoD, those who had ascribed the CoD between January 2008 to December 2019 (n = 2582), 1187 (46.0%) were categorized under NCDs, whereas 1066 (41.3%) were grouped under CDs, maternal &perinatal conditions, and nutritional deficiencies. Moreover, external causes (ECs) contributed to 162 deaths (6.3%) (Table 3).

Table 3. The yearly distribution of broad CoDs, 2008-2019, Butajira HDSS, Ethiopia

	Broad CoD category								
	NCDs		CDs, maternal and perinatal conditions, and nutritional deficiencies		Ecs		Undetermined		
Yearof death	No	%	No	%	No	%	No	%	**Total**
2008	90	28.7	185	58.9	16	5.1	23	7.3	314
2009	94	35.7	130	49.4	13	4.9	26	9.9	263
2010	91	41.7	100	45.9	7	3.2	20	9.2	218
2011	90	40.7	92	41.6	13	5.9	26	11.8	221
2012	95	41.3	95	41.3	14	6.1	26	11.3	230
2013	95	43.2	101	45.9	14	6.4	10	4.5	220
2014	101	50.8	69	34.7	18	9.0	11	5.5	199
2015	90	43.5	89	43.0	11	5.3	17	8.2	207
2016	99	66.0	37	24.7	11	7.3	3	2.0	150
2017	123	55.9	77	35.0	17	7.7	3	1.4	220
2018	127	67.6	48	25.5	11	5.9	2	1.1	188
2019	92	60.5	43	28.3	17	11.2	0	0.0	152
Total	1187	46.0	1066	41.3	162	6.3	167	6.5	2582

The trend analysis in the broad CoD, the proportion of yearly deaths attributed to CDs, maternal and perinatal conditions, and nutritional deficiencies showed a significant decline in mortality (58.9% in 2008 to 28.3% in 2019, *tau* = -0.727, $p < 0.05$). Significant mortality increases attributed to NCDs were observed (28.7% in 2008 to 60.5% in 2019, *tau* = 0.469, $p < 0.05$). Moreover, deaths due to ECs showed a non-significant increasing trend (5.1% in 2008 to 11.2% in 2019, *tau* = 0.0953, $p > 0.05$). This significant shift from CDs, maternal and perinatal conditions, and nutritional deficiencies to NCDs and ECs can indicate an epidemiological transition in the area.

The trend changes of the death proportion in the top five leading causes of death across the three age groups (< 5 years, 5-15 years, and ≥ 15 years) indicated a transition in the epidemiology of major causes of death. Death due to tuberculosis is registered every year throughout the CoD surveillance period and was consistently the common CoD throughout the follow-up period in adults (age 15+) with an average percentage of 12.5%, a change from 20.0% in 2008 and 8.8% in 2019 were observed. Besides, the proportion of yearly deaths of tuberculosis indicated that there was a peak in 2008 (20.0%) ,reduced for some years, and re-emerged again in 2012 (17.9%) and in 2017 (15.7%). Similarly, death due to HIV/AIDS was registered yearly except in 2011 and 2016, with a trend change from 13.6% in 2008 to 8.0% in 2019. In addition, it was the most significant CoD in the earlier follow-up years, 2008 and 2009, with yearly proportions of 13.6% and 17.1%, respectively. Then, it decreased for some years and again increased in later surveillance years in the same group, and still, it caused a considerable CoD.

On the other hand, major NCDs showed a growing trend; Neoplastic diseases like digestive organ neoplasms, increased 3.6% in 2008 to 22.4% in 2019. These diseases became the leading cause of death in 2017, 2016, and 2019, with annual death proportions of 15.1%, 20.0%, and 22.4% respectively for the adult age group 15+.

In this age group, a consistent annual trend in deaths due to hypertensive diseases was observed throughout the study period, with an average yearly death proportion of 7.2%, a change from 2.9% in 2008 to 11.2% in 2019.

Moreover, acute lower respiratory infections like pneumonia showed a reduction but still caused considerable death in individuals aged 15 years and above.

Deaths in the age group between 5 and 15 years were sparsely distributed. Deaths are more concentrated on infectious diseases, nutritional causes, and injuries. Principally, severe malnutrition, accidental drowning and submersion, acute lower respiratory infections, pedestrian injured in traffic accidents, and intestinal infectious diseases are the major causes of death in this age group, with no clear reduction trend in any specific causes of death. Generally, they were increasing one time and decreasing another time intermittently.

In the under-five age group, the result indicated that birth asphyxia and perinatal respiratory disorders were the most significant CoD, and the death trend showed a relatively similar yearly death proportion (an average percentage of 21.5%) in the surveillance period; however, bacterial sepsis of newborn generally showed an increasing trend, especially high burden of the deaths from this specific cause happened between the year 2011 (12.3%) to 2016 (19.4%). Though little reduction was observed (the lowest yearly death proportion, 6.3% in 2014); however, death due to severe malnutrition consistently existed as a CoD in this age group. Moreover, the trend in death due to acute lower respiratory infections was increasing and decreasing intermittently, with the highest death peak (20.0%) in 2017. Intestinal infectious diseases have also significantly reduced since 2016 (Figure 6).

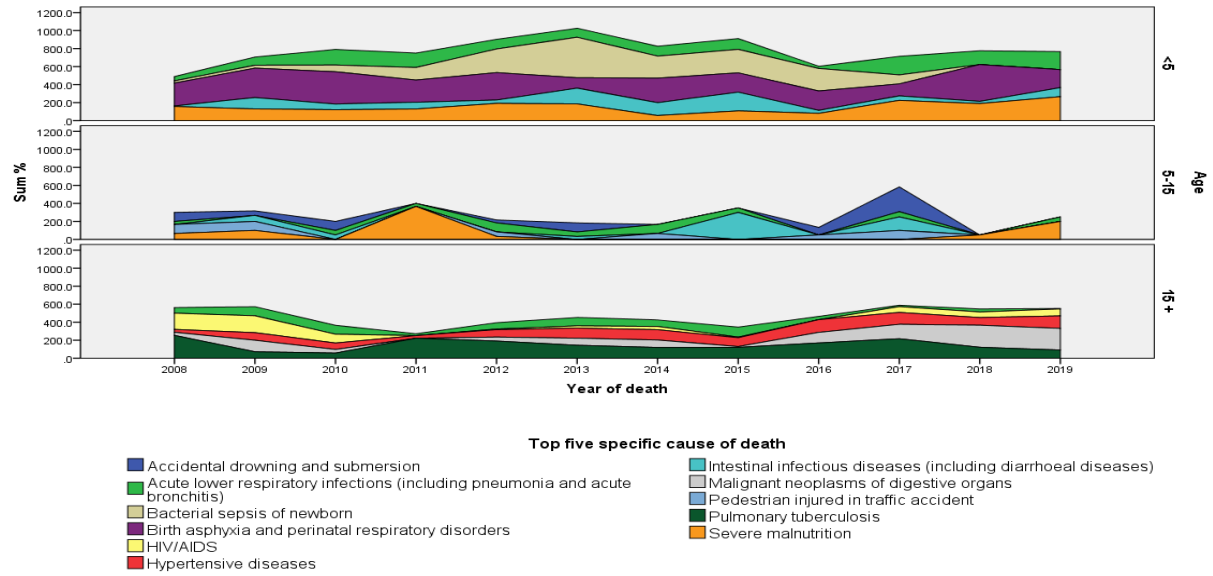

Figure 6. The yearly distribution top five specific causes of death, Butajira HDSS, Ethiopia

Though not on the top list of specific causes of death, the death proportion due to malaria indicated a declining trend (from 3.2 % in 2008 to 0.7% in 2019) across all ages. Furthermore, the monthly distribution of specific CoD was also presented (Supplementary Figure 1).

Discussion

This study found that the overall mortality rate from the demographic surveillance database indicated a significant downward trend (from 9.8/1000 in 1987 (22.0% in 1988) to 2.8/1000 population in 2016), which indicates a decline in mortality. The population undertook a demographic and epidemiological transition with a decline in mortality rate over time and a population increase (37, 38, 39).A decline in fertility has resulted in a shift toward an older population, and the epidemiological profiles of developing countries reflect the diseases and health problems of adults (40).

A reduction trend in mortality differentials was also observed (age, sex, residence, and ecology). A significant reduction in the under-five mortality rate per 1000 population was observed: 27.2 in 1987 (48.3 in 1988) to 6.1in 2016. A study conducted between 1987 and 1988 in the Butajira HDSS indicated that under-five mortality was high (209 per 1000) and 32.3 per 1000 for children aged 1-4 years (39). Ethiopia shows significant progress in under-five mortality (41), which is 72% lower now than 25 years ago (42), contributing to an epidemiological transition in the region. The widespread fertility and child mortality declines contribute to the shifting age structures of developing countries, older age (40).

The 12-year trend analysis in the broad CoD further indicated that the proportion of yearly deaths attributed to CDs, maternal and perinatal conditions, and nutritional deficiencies showed a decline in mortality, whereas an increase in mortality attributed to NCDs and ECs was observed. This significant shift can indicate an epidemiological transition in the area. In developing countries, CDs and nutritional deficiencies to NCDs' burden shift (43), the burden superimposed (44), and the epidemiological transition is evidenced as a"double burden" (45).

Moreover, there were emerging and ongoing burdens of NCDs, like cancer (digestive system neoplasms), hypertensive diseases, and re-emerging and chronic epidemic infections, such as tuberculosis and HIV. This transition in the major causes of death creates a double burden, predominately in adults (15+). However, there was no clear transition in the major causes of death in the age group < 5 and 5-15. Specifically, a major transition occurs not only between disease categories but also within a major CoD (43). The burden of cancer incidence and death is rapidly and dramatically expanding in developing countries (46), and evidence has shown a rise in colorectal cancer in this nation (47)**.** Furthermore, though the burden of pulmonary tuberculosis and HIV/AIDS still exists, a significant decline in deaths of other major communicable diseases like malaria was observed. Pragmatically, the burden of tuberculosis, malaria, and HIV/AIDS is decreasing (48). Even though challenges persist (49, 50), a remarkable decline in major communicable disease mortality has been reported in Ethiopia (51). However, non-communicable diseases are emerging in rural communities (45, 52). Almost three-quarters of all NCD deaths and the majority (82%) of premature deaths occur in low- and middle-income countries (33, 16). Socioeconomic, behavioral, and lifestyle factors have increased the NCD burden (44), with no exception in Ethiopia (51).

Very few studies have been conducted on epidemiological transition in Ethiopia. However, the mortality decline for 30years (1987 to 2016), especially under-five mortality, and the massive shift in mortality from CDs to NCDs for 12 years (2008 to 2019), agreed with an earlier study in the area, birth and mortality rates fell (53). For instance, in the current study, exceptionally, the highest number of yearly deaths was recorded in 1999 (1255). Many deaths happened from

1988 to 1999 due to malaria (54) and HIV/AIDS (55). The 1998 burden of disease study in the Butajira HDSS also indicated that 82.4 % of deaths were due to communicable, maternal,perinatal, and prenatal conditions (56). However, a remarkable decline has been achieved through a reduction in major CDs in Ethiopia with ever-increasing NCDs (51); the major shift from CD to NCD implied that an epidemiologic transition had taken place. As evidenced, various transitions have happened; there might be changes associated with demographic, epidemiologic, and health transitions (57-60), and different stages of an epidemiological transition occur in various African countries (19). Despite variations in the rates, the epidemiological transition occurs in most African countries (19). Sub-Saharan Africa is experiencing a rapid epidemiological transition with the growing burden of NCDs (9, 61 62).

The current study further identified that injuries create an extra burden and contribute to a triple burden of diseases in the defined area. This evidence also highlights the progression of the epidemiological transition and the transition in the epidemiology of major causes of death. Ethiopia is facing a triple burden due to CDs, NCDs, and ECs (49), which is posing increasing challenges to the healthcare system. In developing countries, chronic and degenerative diseases and injuries are becoming more significant causes of adult mortality, signaling an epidemiological transition (40).

Conclusion

Ethiopia's civil registration or vital statistics systems are at their infancy stage. However, mortality surveillance at HDSS sites is presently the only source of death information in rural communities for evaluating mortality trends and patterns and providing critical information on the changing epidemiological profile. The HDSS data in Butajira could be representative of the Ethiopian situation the site encompasses the three climatic zones. The proportion of yearly deaths attributed to CDs, maternal and perinatal conditions, and nutritional deficiencies has shown a decline in mortality, while an increase in mortality attributed to NCDs and ECs has been observed. This significant burden shift from CDs, maternal and perinatal conditions, and nutritional deficiencies to NCDs and ECs supports the evidence in the progression of epidemiological transition in the area.

Furthermore, the emerging and ongoing burden of NCDs, including cancer and hypertensive diseases, as well as the re-emerging and chronic epidemic infections, such as tuberculosis and HIV, indicate a shift in the primary causes of death. This leads to a double burden, predominately in adults (15+), which reflects the transition in the epidemiology of major causes of death. Using a longitudinal data set from the oldest HDSS site in Africa, the results from this study implicate that the country is in its epidemiological transition. This transition calls for policymakers to design a responsive health system that can cater to the population under epidemiological transition.

Ethical considerations

This study was conducted after getting written permission from the Research Ethics Committee of the School of Public Health and IRB of the College of Health Sciences, AAU. Hence, ethical clearance was obtained. In addition, the consent of the Butajira Rural Health Program management team was secured.

Acknowledgments

We would like to acknowledge Addis Ababa University, College of Health Sciences, School of Public Health, for granting us permission to conduct this study in the Butajira-HDSS catchment area. We are also grateful to acknowledge the BRHP management committee, program leaders, Butajira Community members, and the data collectors.

Authors' contributions

HAY had taken a principal role in the conception of ideas, writing the full proposal, analyses, write-up, and drafting of this manuscript. WMA contributed to the proposal writing, analyses, write-up, and critical revising of the manuscript. AWY contributed to the proposal writing, analyses, write-up, and editing of the manuscript. All the authors read and approved the final manuscript.

Disclosure statement

All authors declared that they have no competing interests.

Funding information

None

References

1. Yavari PA, A. Mehrabi, Yad Elah. Mortality and Changing Epidemiological Trends in Iran During 1979-2001. Hakim Research Journal. 2003;6(3):7-14.
2. Nichols E, Byass P, Chandramohan D, Clark S, Flaxman A, Jakob R, et al. The WHO 2016 verbal autopsy instrument: An international standard suitable for automated analysis by InterVA, InSilicoVA, and Tariff 2.0. PLoS Medicine. 2018;15(1):1-9.
3. United Nation. Practical Guide on the Improvement of Death Registration and Causes of Death Processes within a Civil Registration and Vital Statistics System. 2017. https://repository.uneca.org/handle/10855/24034. Accessed Oct 10, 2022.
4. Immigration Nationality and Vital Events Agency, Federal Democratic Republic of Ethiopia and Central Statistical Agency. The Ethiopian Civil Registration and Vital Statistics (CRVS) Comprehensive Assessment Report. Addis Ababa, Ethiopia: 2021.
5. Patil R, Roy S, Ingole V, Bhattacharjee T, Chaudhary B, Lele P, et al. Profile: Vadu Health and Demographic Surveillance System Pune, India. Journal of global health. 2019;9(1):010202.
6. Huicho L, Gonzales F, Walter Mendoza and JaimeMiranda. Mortality profiles in a country

facing epidemiological transition: An analysis of registered data. BMC Public Health. 2009; 9(47):1-13.
7. United Nation. Changing Levels and Trends in Mortality: the role of patterns of death by cause. Department of Economic and Social Affairs Population Division. 2012. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/files/documents/2020/Jan/un_2012_levelsandtrends.pdf.Accessed Oct 16 2022.
8. Wahdan MH. The epidemiological transition. . Eastern Mediterranean Health Journal. 1996;2:8-20.
9. Hussein AA. The "Epidemiological Transmission" and "Double-Burden of Disease": A Focus on Africa. Majmaah Journal of Health Science. 2014;12(2):1-9.
10. Omran AR. The epidemiologic transition. A theory of the epidemiology of population change. The Milbank Memorial Fund quarterly. 1971;49(4):509-38.
11. Omran AR. The epidemiologic transition theory revisited thirty years later. World Health Statistics Quarterly. 1998;52(2,3,4):99 - 119.
12. Omran AR. The epidemiologic transition theory. A preliminary update. Journal of tropical pediatrics. 1983;29(6):305-16.
13. Weisz G, Olszynko-Gryn J. The theory of epidemiologic transition: the origins of a citation classic. Journal of the history of medicine and allied sciences. 2010;65(3):287-326.
14. Hebe N Gouda R, Seri Maraga, Abraham D Flaxman, Andrea Stewart J, Patricia Rarau,Regina Wangnapi H, et al. The epidemiological transition in Papua New Guinea: new evidence from verbal autopsy studies. International Journal of Epidemiology, 2019. 2019;48(3):966-77.
15. Chadli S, Taqarort N, El Houate B, Oulkheir S. Epidemiological transition in Morocco (1960-2015). Medecine et sante tropicales. 2018;28(2):201-5.
16. WHO. Global status report on noncommunicable diseases. 2010. https://apps.who.int/iris/handle/10665/44579(2010). Accessed Feb 22 2023.
17. Cle´mentine Rossier ABS, Ge´ raldine Duthe, Sally Findley. Non-Communicable Disease Mortality and Risk Factors in Formal and Informal Neighborhoods, Ouagadougou, Burkina Faso: Evidence from a Health and Demographic Surveillance System. PloS one. 2014;9(12):1-18.
18. Lopez CJLMaAD. Measuring the Global Burden of Disease. n engl j med 2013;369(5):448-57.
19. Lopez A, Mathers, CD, Ezzati,M, Jamison DT, Murray, CJL. Global Burden of Disease and Risk Factors. Alan D. Lopez CDM, Majid Ezzati, Dean T. Jamison, and Christopher J. L. Murray editor. Washington: Oxford University Press and The World Bank:2006.
20. Biruk Tensou T, Daniel S. Telake, Peter Byass, Yemane Berhane, Tolcha Kebebew, Eduard J. Sanders, et al. Evaluating the InterVA model for determining AIDS mortality from verbal autopsies in the adult population of Addis Ababa. Trop Med Int Health 2010;15(5):547-53.
21. Kone S, Furst T, Jaeger FN, Esso EL, Baikoro N, Kouadio KA, et al. Causes of death in the Taabo health and demographic surveillance system, Cote d'Ivoire, from 2009 to 2011. Global health action. 2015;8:27271.
22. Santosa A, Wall S, Fottrell E, Högberg U, Byass P. The development and experience of epidemiological transition theory over four decades: a systematic review. Global health action. 2014;7:23574.
23. Byass P, Berhane Y. Butajira Dss Ethiopia. INDEPTHMonograph: Volume 1 Part C. 2001. http://www.indepth-network.org/dss_site_profiles/butajira.pdf. Accessed Oct 16, 2019.
24. Kassahun Alemu Gelaye, Befikadu Tariku, Semaw Ferede Abera, Alemseged Aregay Gebru, Nega Assefa , Desalew Zelalem, et al. Injury-related gaining momentum as external causes of deaths in Ethiopian health and demographic surveillance sites: evidence from verbal autopsy study. Global Health Action. 2018; 11(1430669).
25. Corrina Moucheraud AW, Mitike Molla, Jocelyn E Finlay, Jennifer Leaning, Alicia Ely Yamin. Consequences of maternal mortality on infant and child survival: a 25-year longitudinal analysis in Butajira Ethiopia (1987-2011). Reproductive Health 2015;12(Suppl 1):1-8.
26. Byass P, Worku A, Emmelin A, Berhane Y. DSS, and DHS: longitudinal and cross-sectional viewpoints on child and adolescent mortality in Ethiopia. Population health metrics. 2007 2007/12/27;5(1):12.
27. Mitike Molla, Yemane Berhane, Bernt Lindtjorn. Mortality Decreases among Young Adults in Southern Central Ethiopia. EthiopJHealth Dev. 2008;22(3):219-25.
28. WHO. Verbal autopsy standards: the 2012 WHO verbal autopsy instrument. Geneva: WHO. 2012.
29. Edward F, Kathleen K, Stephen T, Peter B. Probabilistic Methods for Verbal Autopsy Interpretation: InterVA Robustness in Relation to Variations in A Priori Probabilities. PloS one. 2011;6(11):1-7.
30. Streatfield PK, Khan WA, Bhuiya A, Alam N, Sié A, Soura AB, et al. Cause-specific mortality in Africa and Asia: evidence from INDEPTH health and demographic surveillance system sites. Global health action. 2014;7:25362.
31. Byass P, Chandramohan D, Clark Samuel, D'Ambruoso L, Fottrell E, Graham W, et al. Strengthening standardised interpretation of

verbal autopsy data: the new InterVA-4 tool. Global health action. 2012;5(19281).
32. Yizengaw HA, Ayele WM, Yalew AW. The trend and pattern of adult mortality in South-Central Ethiopia: analysis using the 2008-2019 data from Butajira Health and Demographic Surveillance System. Global health action. 2022 Dec 31;15(1):2118180.
33. United States Army Corps of Engineers. Mann-Kendall Analysis. 2005. https://www.statisticshowto.com/wp-content/uploads/2016/08/Mann-Kendall-Analysis-1.pdf. Accessed Oct 1, 2021.
34. Helsel D, Mueller D, Slack J. Computer program for the Kendall family of trend tests: US Geological Survey Scientific Investigations Report. Virginia. 2006, Pg. 4.
35. Donald W, Jean S, Steven AD, Jon BH. Statistical Analysis for Monotonic Trends, National Nonpoint Source Monitoring Program. 2011. https://polk.wateratlas.usf.edu/upload/documents/Statistical-Analysis-for-Monotonic-Trends-2011-EPA-TetraTech.pdf. Accessed Sep 12 2021.
36. Desta Shamebo, Anita Sandstrom, and Stig Wall. The Butajira Rural Health Project in Ethiopia: Mortality Pattern of the Under Fives. Journal of Tropical Pediatrics 1991;37.
37. Ayele W. The Interrelationship between Population Dynamics and Childhood Mortality in Butajira District, South Central Ethiopia[dissertation]. [Addis Ababa]: Addis Ababa University; 2012. 191 p.
38. Berhane Y, Wall S, Fantahun M, Emmelin A, Mekonnen W, Hogberg U, et al. A rural Ethiopian population undergoing epidemiological transition over a generation: Butajira from 1987 to 2004. Scandinavian Journal of Public Health. 2008;36(436-441).
39. Desta S, Sandström A, Wall S. The Butajira Rural Health Project in Ethiopia: Mortality Pattern of the Under Fives. Journal of tropical pediatrics. 1991;37.
40. Population Commission on Behavioral and Social Sciences and Education National Research Council. The Epidemiological Transition: Policy and Planning Implications for Developing Countries: Workshop Proceedings. Washington (DC): National Academies Press (US). 1993. https://www.ncbi.nlm.nih.gov/books/NBK236450/. Accessed Nov 22 2022.
41. Gebremichael SG, Fenta SM. Under-five Mortality and Associated Risk Factors in Rural Settings of Ethiopia: Evidences from 2016 Ethiopian Demographic and Health Survey. Advances in Public Health. 2020;2020:8430246.
42. Mehretie Adinew Y, Feleke SA, Mengesha ZB, Workie SB. Childhood Mortality: Trends and Determinants in Ethiopia from 1990 to 2015—A Systematic Review. Advances in Public Health. 2017;2017:7479295.
43. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. Circulation. 2001;104(22):2746-53.
44. Awoke Misganaw, Damen Haile Mariam, Tekebash Araya. The Double Mortality Burden Among Adults in Addis Ababa, Ethiopia, 2006-2009. Preventing chronic disease. 2012;9(110142):1-10.
45. Devleesschauwer B. The Burden of Zoonoses in Nepal: University of Gent. 2015. https://biblio.ugent.be/publication/5904404(2015). Accessed Jun 12 2022.
46. Kanavos P. The rising burden of cancer in the developing world. Annals of Oncology: official journal of the European Society for Medical Oncology. 2006 Jun;17 Suppl 8:viii15-viii23.
47. Bishehsari F, Mahdavinia M, Vacca M, Malekzadeh R, Mariani-Costantini R. Epidemiological transition of colorectal cancer in developing countries: environmental factors, molecular pathways, and opportunities for prevention. World journal of gastroenterology. 2014 28;20(20):6055-72.
48. Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, Mock CN, et al. Disease Control Priorities: Improving Health and Reducing Poverty. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development/ The World Bank: 2017.
49. Federal Ministry of Health, Ethiopia. Health Sector Transformation Plan (HSTP), 2015/16-2019/20. 2015. https://www.moh.gov.et/(2020). Accessed Mar 22, 2020.
50. Byass P, Fantahun M, Emmelin A, Molla M, Berhane Y. Spatio-temporal clustering of mortality in Butajira HDSS, Ethiopia, from 1987 to 2008. Global health action. 2010;1.
51. Federal Ministry of Health, Ethiopia. Health Sector Transformation Plan II, 2020/21-2024/25. https://www.moh.gov.et/(2021). Accessed Nov 10, 2021.
52. Yigzaw Kebede, Abebaw Gebeyehu, Tadesse Awoke, Mezgebu Yitayal, Solomon Mekonnen, Mamo Wubshet, te al. Tuberculosis and HIV are the leading causes of adult death in northwest Ethiopia: evidence from verbal autopsy data of Dabat health and demographic surveillance system, 2007–2013. Population Health Metrics 2017;15(27):1-13.
53. Berhane Y, Wall S, Fantahun M, Emmelin A, Mekonnen W, Högberg U, et al. A rural Ethiopian population undergoing epidemiological transition over a generation: Butajira from 1987 to 2004. Scandinavian Journal of Public Health. 2008;36(4):436-41.
54. Federal Ministry of Health, Ethiopia.. National strategic plan for malaria prevention, control and elimination in Ethiopia, 2011–2015. Ministry of Health of Ethiopia Addis Ababa; 2010.

55. Kloos H, editor HIV/AIDS in Ethiopia: The Epidemic and Social, Economic, and Demographic Impacts International Conference on African Development Archives 2001 Department of Epidemiology and Biostatistics, University of California, San Francisco Medical Center, San Francisco, California.
56. Harar A, Derege K. Burden of disease analysis in rural Ethiopia. Ethiopia Medical Journal. 2001;39:271-281.
57. Llambías-Wolff J. The Challenge Of Epidemiological Transitions. York University, Canada.
58. Defo BlmK. Demographic, epidemiological, and health transitions: are they relevant to population health patterns in Africa? Global health action. 2014;7(22443):1-39.
59. Frenk J BJ, Stern C, Frejka T, Lozano R: . Elements for a theory of the health transition. . Health Transit Rev. 1991;1(1):21-38.
60. Wallace R. Bridging epidemiology and demography: theories and themes. Ann N Y Acad Sci. 2001;954:63-75.
61. Juma KJ, P. A. Mohamed, S. F. Owuor, J. Wanyoike, A. Mulabi, D. Odinya, G. Njeru, M. Yonga, G. First Africa non-communicable disease research conference 2017: sharing evidence and identifying research priorities. Journal of global health. 2019;8(2):020301.
62. Shumbusho E. The Trend of Communicable and Non-Communicable Diseases in East African Community (EAC) Countries: Case Study of Burundi, Rwanda, and Uganda - 1990 to 2013. MSc Thesis Wright State University CORE Scholar. 2016, https://corescholar.libraries.wright.edu/mph/208/. Accessed Jul 19, 2021.