Primary health care delivery in a Sidama community undergoing demographic transition

Hiwot Abera Areru

Thesis for the degree of Philosophiae Doctor (PhD)
Hawassa University, Ethiopia and
University of Bergen, Norway
2022

HAWASSA UNIVERSITY

UNIVERSITY OF BERGEN

Primary health care delivery in a Sidama community undergoing demographic transition

Hiwot Abera Areru

Thesis for the degree of Philosophiae Doctor (PhD)
Hawassa University and University of Bergen

Date of defense: 14.12.2022

Year: 2022

Title: Primary health care delivery in a Sidama community undergoing demographic transition

Name: Hiwot Abera Areru

Print: Skipnes Kommunikasjon / University of Bergen

Dedication

To

Tadiwos and Iason

Acknowledgments

I would like to express my heartfelt gratitude and appreciation to my main supervisor, Professor Bernt Lindtjørn, for his unreserved support, understanding, patience and timely responses. During the entire period of the PhD work, he has been a great inspiration and guidance from the inception to the completion of the research process. He made sure that I understood the wider picture. His comments, questions and suggestions helped me in exploring new statistical and epidemiological concepts, broaden my level of understanding and be critical of my writings. What always amazes me about his personality is his punctuality and never tiredness when it comes to helping his students. He always guides you to find a way out of the problems at hand and be independent. I have learnt the importance of giving prompt responses to every concern of the students, be it technical or social. With his effort, he tries to see students succeed. It has been an honour to work under his supervision. I couldn't ask for a more holistic and enthusiastic supervisor than him. Thank you so much, Professor Bernt.

I would like to extend my special thanks to Dr Mesay Hailu, my co-supervisor, for his invaluable academic support and advice. His patience, kindness, and insights through the ups and downs gave me the strength to complete this PhD work. His excellent understanding and help on Geographic Information System made the spatial analysis study a reality; it would have been impossible if it wasn't for him. Thank you, Dr Mesay.

I am heartily thankful to the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED) for funding my PhD study. It gives me great pleasure to thank the Centre for International Health, the University of Bergen for the academic and logistic support. I am also indebted to Hawassa University, College of Medicine and Health Sciences for providing me with such a golden opportunity. My special thanks go to the Dale-Wonsho Health and Demographic Surveillance site and its team members, especially Mr Alemu Tamiso, Dr Andargachew Kassa, and Mr Betsegaw Lukas for their cooperation in providing data for the demographic study. I would like to acknowledge the support of my staff members at Hawassa University, Ethiopia, and the University of Bergen, Norway, who have contributed to the success of this PhD work in every possible way.

I also would like to thank the Sidama Region Health Bureau, Dale and Wonsho district health offices, health centre and health post managers for facilitating the research work. All the data collectors, supervisors and data clerks involved in the research work also deserve credit. My special gratitude goes to Mr Lamalo Sonbala, Mr Abera Shunkaro, Mr Misale Jilo and Mr Eyasu Kakamo for their outstanding collaboration and involvement during the research work.

I also like to extend my appreciation for friends in Bergen; Dr Yaliso and Mrs Tigist, Dr Jerin George Kiserud and her family, and Sister Tsion for their friendship and hospitality.

I owe my sincere gratitude to my friends in the NORHED programme; especially Tsigereda Behailu and Bethelihem Mezgebe with their families; Abdella Amano, Debritu Nane and Hiwot Hailu; your support and encouragement were invaluable. My friends, Fasika Shiferaw, Abebe Chaka, Zelalem Tezera, Bereket Hailemariam, Mignote Gebremichael, Hailemariam Melese and Ezra Fikru, thank you for your friendship and encouragement.

It gives me great pleasure to thank Dr Vanum Govindu, Mr Befikadu Tariku and Mr Alazar Bahiru for their technical support in data management and analysis. I also extend my appreciation to Dr Eskindir Loha; he was more than willing to help me with logistic related issues and statistical analysis; his support and encouragement were immensely profound.

I owe my sincere gratitude to my father, Abera Areru, and my mother, Etifwork Mehalu, for their unconditional love, encouragement and prayers. My sisters and brothers, especially Zelalem, Lealem, Berhan, Eskedar and Yeabsira, I have no words to express your love, support, encouragement and prayers. I am deeply indebted to my mother-in-law, Genet Kibret, to Helen Tesfaye, Senait Kibret, Tsige T/Aregay and the whole family for their unreserved support, love and prayer. Dr Belayhun Kibret, not only as a family member and academic staff, you have played an essential role in the research process too. God bless you all.

My beloved husband, Dr Tadiwos Hailu, I owe you my deepest gratitude for your support throughout the PhD journey, technically and emotionally. I can never thank you enough for your love, encouragement, understanding and patience. You are the driving force for the successful completion of this PhD work. I love you and stay blessed.

Above all, I thank the Almighty God, who has stood by my side throughout my life's journey. I couldn't have done any of it without your grace. I bless you for hearing my prayers and all the blessings.

Summary

Background

Ethiopia has been working towards achieving universal health coverage (UHC) through the expansion of primary health care units to the rural community. The primary health care delivery system is one of the three levels of the Ethiopian health care delivery system at the community level. Improving access to and utilisation of primary health care units helps the realisation of the 'health for all' agenda of the sustainable development goals (SDGs). Health service utilisation is considered both an influencer and consequence of population change. Yet, there are variations in health service utilisation across regions in Ethiopia. The population characteristics, such as births, deaths, age, and sex distribution, of the Sidama community have not been investigated since the 2007 census. Understanding the transitions in demographic variables and their impact in health service use can give insight to health planners at the local level. As the health-seeking behaviour of the community improves, morbidity, mortality and birth rates reduce, and life expectancy increases. However, measuring health care utilisation demands good quality population and utilisation data. Ethiopia has low coverage of registration of vital events, such as births and deaths. The quality of self-reported data also lacks accuracy. In addition, the health facility-based recoding system, Health Management Information System (HMIS), also lacks completeness and quality. Therefore, understanding health service utilisation from health facility data at a local level could give insight into how to improve the data quality and the health outcomes of the community they serve. Moreover, identification of measurement and reporting errors in health demographic sites could identify knowledge gaps that could be improved.

Objectives

The overall aim of this thesis was to measure health service utilisation from health facilities and demographic data in Dale and Wonsho districts of the Sidama region in southern Ethiopia. The specific objectives were to assess the health service utilisation and disease distributions (Paper I); to assess the health service utilisation and identify factors that account for the variation in health service utilisation at *kebele* level (Paper II); and to identify the demographic structure and identify some limitations to how the population dynamics are studied in rural districts in the Sidama region in southern Ethiopia (Paper III).

Methods

We conducted an institution-based cross-sectional design study from 1 July 2017 to 30 June 2018 for all patients visiting health facilities in 65 primary health care units in Dale and Wonsho districts of the Sidama region. We trained and employed fifteen local data collectors and two supervisors to collect secondary data from standard registers supplied by the Federal Ministry of Health. The number of patients who visited the health facilities was 81,129. The utilisation rate was calculated as visits per person per year for new cases. We calculated the odds ratio for health service use and proportions of diseases' diagnoses. We also presented the findings to the health managers and incorporated their suggestions for health improvement in the study (Paper I). For Paper II, we conducted an exploratory ecological study design. Fifty-four *kebeles* under the catchment of the 65 health facilities were included. We used ArcGIS and SaTScan software to identify and explore the spatial distribution of health service utilisation. Linear regression was used in the analysis. For Paper III, a mixed-method cross-sectional study was conducted using baseline data of the newly established Dale-Wonsho Health and Demographic Surveillance System site in 2018. A total of 5,179 randomly selected households, having 25,144 individuals,

were analysed. Death-related information was also collected from the traditional burial associations called *iddir*. Focus group discussions and in-depth interviews were used for qualitative data collection. Logistic regression, life tables, and age reliability indices were used in the analysis.

Results

There was a low annual health service utilisation in the study area. The outpatient health service utilisation was 0.18 visits per person per year (95% CI: 0.18–0.19), with a mean of 0.17 (range: 0.01–1.19) visits per person per year. There was an uneven distribution of the low health service utilisation among the 54 rural *kebeles* in the two districts (Papers I–II). The rate of utilisation varied between different demographic attributes. The rural population had lower odds of health service utilisation per year by 91%, compared to the urban population (OR = 0.09; 95% CI: 0.08–0.09). The health service utilisation by children in the age group of 5–14 years was lower than by children under five years of age by 78% (OR = 0.22; 95% CI: 0.21–0.23). Females used health services four times as often as males (OR = 4.17; 95% CI: 4.09–4.25). Health professionals' opinions on improving the health service utilisation were categorised as budget allocations and alternative financial sources, sustainable drug and material supply, health workers capacity-building, quality of services, access to health facilities, public and stakeholders' involvement and collaboration, and supervision and record-keeping (Paper I). *Kebeles* with health centres had a higher service usage. More than half of the *kebeles* were within a 10 km distance from health centres. Thus, as the distance from the health centre increased, the utilisation rate decreased (Paper II). Around three out of seventeen (17.9%; 14,847 of 83,148) diagnoses in all age groups were for febrile illnesses. Close to half the febrile cases were among children under five years of age (46.5%; 3,827 of 8,233). The most common registered diagnosis

among children was pneumonia (36.7%; 2,635 of 7,184 new visitors). Non-communicable diseases were diagnosed rarely. Family planning services constituted the most frequently utilised service (Paper I). The population in which these studies were conducted showed a lower fertility rate. There was a total fertility rate of 2.9 children/woman and a crude birth rate was 22.8/1,000 population. We recorded a crude death rate of 5.2/1,000 population. Factors affecting the fertility level were age, residence and educational status. We identified measurement and reporting errors on age, birth, and death information. The life expectancy declined to an average of 53 years (range 48–58 years), after substituting national and regional mortality estimates (Paper III).

Conclusion

This thesis shows a low and unequal use of health services among population groups and lower-level geographic areas (*kebeles*). The number of non-communicable disease diagnoses at the primary level of care was very low. The fertility in Sidama is lower than in previous studies and is affected by age, education and residence. Moreover, there were measurement and reporting errors in the community and health facility data. The mortality rates are higher and the life expectancy is reduced, after adjusting for reporting errors. The low service usage, coupled with poor diagnostic capacity, might have affected the mortality measures, while relatively higher family planning services usage might have reduced the fertility rates. The health professionals suggested working towards making the health services of good quality, accessible, and affordable to the community to enhance the service use and improve the health outcomes of the local community.

List of original papers

This thesis is based on the following papers, which are referred to in the text by their respective Roman numerals.

Paper I

Areru HA, Dangisso MH, Lindtjørn B. Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: A facility-based cross-sectional study. BMC Health Service Research 2021;21(1):1–14.

Paper II

Areru HA, Dangisso MH, Lindtjørn B. Large local variations in the use of health services in rural southern Ethiopia: An ecological study. PLOS Glob Public Heal. 2022;2(5):e0000087.

Paper III

Areru HA, Dangisso MH, Lindtjørn B. Births and deaths in Sidama in southern Ethiopia: Findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS). Global Health Action. 2020;13(1):1833511.

Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
AOR	Adjusted Odds Ratio
ASFR	Age Specific Fertility Rate
CBR	Crude Birth Rate
CDC	Centers for Disease Control
CDR	Crude Death Rate
CHD	Community Health Day
CI	Confidence Interval
CMR	Child Mortality Rate
CSA	Central Statistical Agency
DALYs	Disability-Adjusted Life Years
DHS	Demographic and Health Survey
D-W HDSS	Dale-Wonsho Health and Demographic Surveillance System
EDHS	Ethiopian Demographic and Health Survey
EPHI	Ethiopian Public Health Institute
EPI	Expanded Programme on Immunisation
ESHP	Essential Health Services Package
FP	Family Planning
FGD	Focus Group Discussions
GAP	Global Action Plan for Healthy Lives and Well-being for All
GBD	Global Burden of Diseases
GFR	General Fertility Rate
GIS	Geographic Information System
GPS	Geographic Positioning System
GPW13	Thirteenth General Programme of Work
GRIPP2	Guidance for Reporting Involvement of Patients and the Public 2

GRR	Gross Reproductive Rate
GTP	Growth and Transformation Plan
HDSSs	Health and Demographic Surveillance Systems
HEW	Health Extension Workers
HEP	Health Extension Programme
HIV	Human Immuno-Deficiency Virus
HMIS	Health Management Information System
HSDP	Health Sector Development Programme
HSTP	Health Sector Transformation Plan
iCCM	Integrated Community Case Management
ICD	International Classification of Disease
IDI	In-depth Interview
IMCI	Integrated Management of Childhood Illnesses
IMR	Infant Mortality Rate
INDEPTH	International Network for the Demographic Evaluation of Populations and Their Health
IRB	Institutional Review Board
IUCD	Intra-Uterine Contraceptive Device
LMICs	Low- and Middle-Income Countries
LLR	Log-Likelihood Ratio
MICS	Multiple Indicator Cluster Survey
NMR	Neonatal Mortality Rate
NRR	Net Reproduction Rate
NORHED	Norwegian Programme for Capacity Development in Higher Education and Research for Development
OR	Odds Ratio
OPD	Outpatient Department
PCA	Principal Component Analysis

PHCUs	Primary Health Care Units
PI	Principal Investigator
REK Vest	Regional Committees for Medical and Health Research Ethics of western Norway
RR	Relative Risk
SDGs	Sustainable Development Goals
SENUPH	South Ethiopia Network of Universities in Public Health
TFR	Total Fertility Rate
UHC	Universal Health Coverage
UNAI	United Nations Age-Sex Accuracy Index
UNICEF	United Nations International Children's Emergency Fund
UNJS	United Nations Joint Score
UTM	Universal Transverse Mercator
VIF	Variance Inflation Factor
WGS	World Geodetic System
WHO	World Health Organization

Table of contents

List of tables

What is this thesis about?

Even though the Ethiopian health care delivery system has a three-tier system at primary, secondary and tertiary levels, the primary health care system is the government's focus for addressing the health service issues for the majority of the population. The primary health care system at a district level is composed of a primary hospital, health centre, and health posts. These parts are often labelled as the primary health care units that provide preventive, promotive and curative services to the local community. The curative services, however, focus on diagnosis and treatment of common illnesses, and do not include advanced procedures and skilled professionals, as is the case in developed countries. Secondary and tertiary health care systems provide specialist health services. At the heart of the Ethiopian primary health care delivery system are the community health workers, known as the 'health extension workers' (HEWs), working at the health post level. There are also selected members of the community organised in a network of 'one-to-five', known as the 'health development army' (HDA), who work closely with the health extension workers. The coverage and utilisation of primary health care units varies across regions in Ethiopia. National studies have shown that there is a variation in utilisation between health posts and health centres. Patients tend to prefer health centres over health posts mostly due to lack of clinical skills of the health extension workers, deficiency of diagnostic tests, and absence of services on most days of the week. Since the latest Ethiopian census was conducted in 2007, there is also a lack of understanding of the recent changes on population characteristics, such as births, deaths, age, and sex distributions at local level. Hence, there are very few attempts to link the utilisation of the health care delivery with the changing population characteristics of the local community. There is also limited information available on

the occurrence of observed diseases in local communities. Therefore, this thesis aimed to answer the following research questions:

1. What is the current level of primary health care service utilisation and disease pattern in the Dale and Wonsho districts? (Objectives 1 and 2; Papers I and II)
2. How is the health service use distributed across the *kebele* level and what are the geographic factors affecting the distribution? (Objectives 1 and 2; Papers I and II)
3. What are the population characteristics of the local communities and how are these associated with the primary health care delivery system? (Objectives 1 and 3; Papers I and III)

To address the first question, we employed a cross-sectional health facility survey on all primary health care units (50 health posts and 15 health centres) in Dale and Wonsho districts. In this survey, we assessed the health service utilisation, the health managers' opinions and recommendations for the improvement of the health care services, and identified the common diseases and health services. We found low health service utilisation, poor diagnostic capacity, and low non-communicable disease prevalence. Moreover, the use of health services varied among different age groups, sex, residential area (urban-rural), and health facility (health centres versus health posts). We also found a higher family planning and immunisation service use, compared to other services (Paper I). We did a spatial analysis on 67,678 patients living in 54 *kebeles* to determine the local-area level variability in health service utilisation. We found that urban residents and *kebeles* having a health centre nearby had better utilisation than the rural *kebeles* and *kebeles* without health centre nearby. We also showed geographic areas that are far away from primary health care delivery units. Distance from health centre to the *kebele* centre

was associated with the low service usage in the study area (Paper II). We also estimated the birth and death rates. There were also more unreported mortalities in the study area. There was a reduction in fertility rates in the local community (Paper III). The lower utilisation level, in combination with the poor diagnostic and treatment capacity of the health facilities, might have led to the higher mortality and lower life expectancy estimates. However, the improved family planning usage could have contributed to the lower fertility rates. The variation in utilisation rate among different segments of the population gives direction for the health managers' and policy-makers' actions towards making the primary health care delivery system accessible to all.

Research environment

I joined the joint the PhD programme of the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED) through the South Ethiopia Network of Universities in Public Health (SENUPH): Improving Women's Participation in Postgraduate Education project in 2016. This joint programme is a partnership between the School of Public Health, College of Medicine and Health Sciences, Hawassa University, Hawassa, Ethiopia and the Centre for International Health (CIH), Faculty of Medicine, University of Bergen, Bergen, Norway. Intending to generate and improve community-based longitudinal and demographic data, Hawassa University launched its own Health and Demographic Surveillance System site (HDSS) in Sidama in Dale and Wonsho districts in 2017. I obtained data from the sample of the baseline survey of HDSS for one of the papers (Paper III). Thus, this research was carried out based on the HDSS and health facility surveys. This research has been funded by the NORHED-SENUPH project, ETH-13/0025.

Introduction

The primary health care delivery system plays a crucial role in increasing health service coverage and access at a community level (1). The coverage of essential health services varies between regions in Ethiopia, with low overall national coverage (2). The tendency to seek care from a modern health care delivery system has been limited in rural communities. The rural community has only been seeking modern health services after exhausting other alternatives, such as traditional medicine (3). Despite the government's effort to improve health service access, studies at the national level have shown that the health service utilisation rate, expressed as outpatient visits per person per year, was below the target of two visits per person per year by the year 2020 (4). However, there has not been any study that assessed the level of health service utilisation at a local level.

Health improvement has been linked with the reduction of mortality and increased life expectancy, and could also reduce the population growth rate as a result of improved access to fertility and population control measures (5). Furthermore, there has not been any census done in Ethiopia since 2007. Therefore, the actual population measures used in the country in recent years were estimated based on projections. Hence, we conducted a census in the Dale and Wonsho districts of the Sidama region in southern Ethiopia. We showed the relationship between demographic measures, such as births, deaths, age, and sex distribution, with the uptake of the primary health care delivery in a local setting.

Health service utilisation

Health care utilisation describes the use of preventive, curative, and promotive health services, or getting information on the health status of a person. Utilisation can be reported as the number of services used divided by a population over a given time; the percentage of people who use a service over a period of time divided by eligible individuals for that service; or a summarised number without any denominator (6). In the absence of a regular vital registration system, the World Health Organization recommends estimating the denominator for this calculation from census projections (7). Utilisation can be considered as revealed accessibility, and not merely the presence of a facility (8). Health care utilisation can be affected by geography, socio-economic factors, demography and the needs of the population (6,8). One of the conceptual frameworks for health service use demonstrates the determinants of health use as predisposing, enabling and need-related factors (9).

Health service utilisation data can be obtained from the administrative records of those delivering health services or insurance, provider surveys, and self-reported data from population surveys. Common types of surveys include the Demographic and Health Survey (DHS), the Expanded Programme on Immunization (EPI) 30-cluster survey, and the UNICEF Multiple Indicator Cluster Survey (MICS) (6,10). However, both primary and secondary sources of data have limitations. Administrative data are prone to overestimation due to repeated counting in the numerator and uncertain denominator estimates. Even though household surveys are more reliable, they are prone to sampling and reporting errors. Using multiple sources of data could increase the accuracy of the estimates (10).

Health service utilisation models

Health service utilisation is the use of the health care system for preventing and curing health problems, for maintaining health status, or getting information on one's prognosis (11). Models give insight into a range of variables to consider when analysing the health service utilisation in a health care delivery system (8). Conceptual frameworks for health care use or access have been designed by many studies so far. The most widely used behavioural model was developed by Ronald M. Andersen, initially in the 1960s (11,12). The model depicts the predictors for health service use, namely predisposing, enabling and need factors. Predisposing factors include socio-demographic factors, health beliefs, values and attitudes. The enabling factors include resources that assist or block health services (8,12). This model emphasises that the need factors are the most influential predictors of utilisation (8). Another model that extended the variables from Andersen's model was developed by Gross in 1972. In this model, accessibility variables such as distance, travel time, waiting time, delay in appointment, and availability of needed services were incorporated into the model with the predisposing, enabling and need factors (8).

Other models of health service utilisation also exist, focusing on the individual or systems perspectives. The oldest model from the 1950s was the Rosenstock model. The model states that the emotional beliefs of a person are what drive them to use health services. However, the process of seeking health care should be less troublesome than the illness itself. There could also be other barriers such as distance, money, and time that could hinder the utilisation (8).

According to Suchman's model, social groupings influence an individual's utilisation behaviour. The social network indicated in this model includes family, friends and influential persons in the community. Therefore, communities having low socio-economic status, minorities, and isolated cultural or traditional groups tend to be influenced by the 'lay person's' advice, rather than modern medical treatment (8).

Another framework, developed by Aday and Andersen in 1974, considered assessment of the health system with utilisation. It considers the wider national health policy to assess utilisation of health services and level of satisfaction as an outcome. The model can be used to research any health care system. It also considers accessibility from the perspective of the space, time and distance needed to get the health care service (8).

Access to health care is a recent framework designed by Levesque et al. in 2013. According to this model, access deals with the identification of health care needs, seeking, reaching and using the needed health care services (13). It perceives health care access from acceptability, approachability, affordability, appropriateness and availability dimensions. It also considers the socio-economic factors as determinants of the individual's and population's ability to "perceive, seek, reach, pay, and engage" in health services (14).

Health service utilisation globally

Universal health coverage (UHC) states that all people should have access to the essential health services that they need, including promotion, prevention, curative, rehabilitative and supportive services, while protecting them from financial hardship (15,16). Universal health coverage is

Sustainable Development Goal (SDG) target 3.8. It is an important way of achieving other health-related SDG targets (16). Primary health care is identified as a major means of realising universal health coverage. Although the universal health service coverage index has increased in all nations and income groups, the fastest progress has been observed in the low-income countries (1). Primary health care helps in delivering cost-effective interventions to the vast portion of the population (8). Interventions targeting mainly infectious diseases, reproductive, maternal, newborn and child services are the main contributors to this increment in service coverage. Improving the non-communicable disease services should also be emphasised to achieve the targeted indicators (1). The major accomplishment of the health care delivery system ensures the utilisation of services as frequently as needed and at the correct time (8). The strength of the health system in low-income settings contributes to the progress of UHC.

However, if we continue with the current global trend of populations covered by essential health services, which are 33%–49% of the population, the 2030 SDG goal of achieving UHC for all will be unrealistic (1). As primary health care is a programmatic route for achieving UHC, it does so by empowering the community, emphasising social accountability, and linking the health sector with nutrition, education, water, and sanitation programmes. It also integrates communicable diseases, women's and children's health, and non-communicable services which are delivered separately. Primary health care is the most cost-effective engine to comprehensively achieve delivery of essential health services near to the people's residence and the community setting (1,8). Despite these efforts, almost fifty percent of the global population is deprived of essential health services (2).

Health service utilisation in Ethiopia

In Ethiopia, primary health care coverage is used as a proxy indicator for service access. Physical accessibility is defined in Ethiopia as areas within two hours walking distance or located less than 10 km from the primary health care unit (17). The coverage of essential health services and health service utilisation remains low in Ethiopia. Furthermore, there is a high disparity in service coverage geographically or among residential areas (urban-rural) (2). A recent study on universal health coverage showed a national coverage of 34%, with great regional variability (2). The national household health service utilisation survey showed that, among people who reported being ill, only 53% visited health facilities.

The common reasons for not seeking care were cost, proximity, self-medication and the thought of the disease as not serious (18). A study conducted 30 years ago in 26 health facilities in central, southern and western Ethiopia showed that substantial variations in health service utilisation rates occurred across regions, districts, and local communities (19). National studies on outpatient visits per person and hospital admission registries also revealed low health service utilisation (4). Outpatient service utilisation, one of the recommended core indicators of health service delivery, is calculated by the number of outpatient department (OPD) visits per person per year (20). Ethiopia aims to reach an OPD utilisation of two visits per person per year by 2020; however, the average OPD visits rate in Ethiopia was 0.48 visits per person per year in 2015 (4). Lower rates of outpatient visits show the lower quality of services or limited accessibility (21). The country's Health Sector Transformation Plan (HSTP), together with the second Growth and Transformation Plan (GTPII), aims to improve the coverage, utilisation and

quality of the basic health services with equity, and to improve the capacity of the health sectors from primary to tertiary level.

Ethiopia showed progress in improving access to primary health care units by employing a large number of low- and mid-level health workers, as well as the construction of health centres and health posts. The health extension programme (HEP) links the community with the health facilities, predominantly health centres. The programme is sustained by the involvement of a functional health development army (HDA) (4). The HDA is a community-based organisation comprising women from a team of 30 households. The team is networked into six groups called one-to-five networks. The leaders of each team receive training and become representatives who will work with the health extension workers (HEWs) (22). This functional relationship is thought to improve the accessibility and utilisation of essential health services.

To increase accessibility and utilisation of services, Ethiopia has organised health service delivery at various levels, such as household/family, community and health facilities. To attain the desired goals, strengthening primary health care units (PHCUs) with a well-functioning health extension programme having a firm community base is mandatory (4). Like other developing countries, Ethiopia is challenged with a triple-burden of diseases, including communicable, non-communicable and injuries. To tackle these challenges and improve the health service utilisation, key components are outlined in the Essential Health Services Package (ESHP); this ESHP identifies priority health services (23). The package includes important strategies to improve the health status of the population through accelerated economic growth of the country as a consequence of a reduction in birth and death rates (24). This EHSP also serves

as a primary framework to progressively achieve universal health coverage (UHC) in the country through quality primary health care services. The package included nine priority areas based on the disease burden of the country. These include major communicable diseases (HIV/AIDS, tuberculosis and malaria), non-communicable diseases, reproductive, maternal, neonatal, child and adolescent health, surgical and injury care, emergency and critical care, neglected tropical diseases, health education and behaviour change communication services, hygiene and environmental health services, and multi-sectoral nutrition interventions (23).

Determinants of health service utilisation

People use health services for the purpose of diagnosis, cure, rehabilitation from disease or injury, maintenance of function, or getting information about their health status. Ideally, health care utilisation should be determined by need and health status. Yet practically, other factors, such as accessibility, availability, timeliness, convenience, and affordability, are correlated with health service utilisation. Other factors also affect the differential use of health services among population groups. These include geography (urban-rural), social and demographic characteristics, economic status, environmental exposure, and disability status (8,25). Geographic determinants of health service utilisation include physical accessibility, such as the distance of the households from the health facilities, distribution of health facilities, population density, altitude and urbanisation (19,26,27). Variations in health service utilisation can exist at the small geographic area level (28). Access to health services can be affected by low health service coverage and geographical inaccessibility of health facilities (29). However, some studies show the under-utilisation of primary health services, even if they are available (30).

Other studies done in Ethiopia showed that people living close to health centres or hospitals have a better health service utilisation (27,31). Similarly, people tend to prefer health centres over health posts because of the absence of qualified professionals and lack of trust in curative services at the health posts (32).

Conversely, demographic factors can also affect the rate and the type of health service utilisation. The health service utilisation pattern observed in the developed world is partly attributed to the change in demographic characteristics of the population (33). The same is true in other sub-Saharan countries (27,34). Poor people and those living in rural areas have lower service coverage and usage, even for basic health services (1). Similarly, other studies showed better health service utilisation in urban areas (19,31,35,36). This might be due to the difference in accessibility and distance of the health facilities (8).

Other factors in and beyond the health systems affect health service utilisation patterns. Poor infrastructure, lack of human resources, reduced quality of service, and lack of trust in health professionals exert undue influence on health service usage, ultimately influencing health outcomes (1). Priorities set in the health care delivery system can also affect health service usage. An unfavourable attitude of patients towards the health care providers can reduce the utilisation rate. Generally, it is important to consider both the supply and consumer sides of the utilisation process to properly understand the level of health service usage (8).

Morbidity

The burden of disease and injury should be assessed accurately in order to develop and evaluate health improvement policies (37). Globally, the leading causes of morbidity and mortality are non-communicable diseases (38). Even though the non-communicable disease burden is on the rise, countries are not performing as well on non-communicable disease performance indicators as they are achieving on communicable disease, and maternal and child health indicators (39). Global burden of disease (GBD) 2019 showed non-communicable diseases contributed to 42 million (95% uncertainty interval [UI]: 40.1 to 43.9) deaths and 1,620 million (95% UI: 1,430 to 1,820) disability-adjusted life years (DALYs). The WHO forecasted the disease burden from non-communicable diseases to account for more than 60% of disease burden in developing countries by 2020 (37,40). However, in 2019, communicable diseases, in combination with maternal, neonatal and nutritional problems, led to 10.2 million (95% UI: 9.19–11.4) deaths and 669 million (95% UI: 593–758) DALYs worldwide (40).

There is a limitation in diagnosing non-communicable diseases in developing countries. The reason could be the gaps in skill, infrastructure and quality of data (32). Moreover, the distribution of disease-causing agents or diseases has been studied infrequently (8). There is a lack not only of reliable recording of mortality data, but also in acquiring quality morbidity data in developing countries. Thus, to make the health service more equitable and improve the quality of life of the population, information on non-communicable diseases should be obtained, analysed and used for better decision-making (37).

Disease diagnoses

Disease diagnosis is a major component of the activities performed at the primary health care level (41). Errors in making an accurate diagnosis are associated with reduced patient safety; committing errors in diagnosis may harm the patients in terms of incorrect testing and treatment. Making accurate diagnoses depends on the clinical competency of the primary health care providers and the diagnostic resources available. The extent of diagnostic errors in primary health care is higher in low- and middle-income countries (LMICs), compared to the developed countries; this is due to lack of diagnostic materials and qualified health professionals or specialists, as well as poor record-keeping systems (41).

The majority of harmful diagnostic errors in primary care are observed on cancers, infections and cardiovascular diseases, such as hypertension, diabetes, and high cholesterol levels. The diagnostic reliability could be improved by equipping the primary health care providers with appropriate training on clinical skills and critical reasoning. Increasing access to care, supplying better quality diagnostic tests, and advancing health information technology in primary care could also improve diagnostic accuracy. High-quality diagnostic tests in low-income countries could substantially increase the quality of care in communicable and non-communicable diseases (41,42). However, few health facilities in LMICs provide even fundamental diagnostic services (43). Morbidity and mortality from preventable causes, and unwanted use of specialist and hospital resources, could be reduced by making primary care safe and effective. Safe and reachable primary health care is mandatory, in order to achieve universal health coverage and SDG goals of healthy lives for all (41).

Treatment of diseases

Patients benefit from treatments if they get an accurate diagnosis from high-quality diagnostic tests (42,43). The most common services available at health facilities above the health post level are emergency services, treatment of sick children, and diagnosis and management of malaria and sexually transmitted diseases. Intensive care unit services are provided in 1% of the health facilities in Ethiopia (44). Health posts mainly provide care for sick children, family planning and antenatal care services. No laboratory tests are performed at the health post level. Basic client services in Ethiopia include maternal and child health services, family planning services, and services for adult sexually transmitted diseases. Around 80% of health centres and 10% of health posts give all the basic services (44).

Existing strategies to improve health service utilisation

The implementation of Sustainable Development Goal 3 (SDG3), 'to ensure healthy lives and well-being for all', is not progressing with adequate speed to achieve the goal by 2030. Therefore, the World Health Organization and other global allies designed an action plan, called the Global Action Plan for Healthy Lives and Well-being for All (SDG3 GAP). The aim is to create better coordination between the signing members by aligning all efforts, speeding up progress, describing their results and assessing the outcomes (45).

Future plan to improve health service use

To address the existing inequalities in health service use, countries with low service coverage and enduring financial hardship should implement full reform of both health service delivery and

health care financing (1). Consequently, in 2020, the Ethiopian Ministry of Health commenced a 15-year (2020-2035) roadmap for primary health care units to increase service coverage, quality and access. The reform aims to upgrade the health centres and health posts. This scale-up could resolve the challenges of the health extension programme in delivering quality service, addressing population health needs and expectations, and ultimately realising universal health coverage. As a result, the advanced health facilities will have better clinical services, infrastructure, information systems and health professional compositions (15,46).

The other strategy to improve health service use is implementing partnerships with the community and other stakeholders. Involving stakeholders, including health service providers, health authorities, service users, patients or the public, has been a recent phenomenon in Africa, unlike other developed nations (47,48). The quality and impact of health research can be improved by integrating the efforts of these stakeholders and researchers. The collaboration can help in the identification of significant problems and give direction for appropriate implementation strategies (48–50). Health authorities make decisions which have policy implications after reviewing the benefit of the findings to improve the health services (51). Therefore, engagement in evidence-based and collaborative health research can help in building trust and understanding between involved stakeholders from local to national levels. This can ensure the execution of research findings and policy changes impacting health care (52,53).

Flexible and multi-sectoral health planning at the local level can improve the utilisation of health services by providing local solutions. The local scale is where the day-to-day planning and implementation of health services takes place. Besides, the health services are practically

delivered at a local level. Therefore, planning health strategies locally can optimise the health service usage for the intended community (8).

Ethiopian health care system

A nation's health care delivery system plays an important role in ensuring health service access and usage (8). The structure of the Ethiopian health system is a three-tier system. The system consists of primary, secondary, and tertiary levels of care. The difference lies in the type of services, the number of people they serve and the staff composition. A unit at the primary level of care is composed of a primary hospital, a health centre and five satellite health posts (4). Primary health care is the base upon which the hierarchy of the health care system is organised (8). A health post serves a 3,000-5,000 people. Each health post is staffed with at least two health extension workers. Health posts constitute a larger portion of the primary health care system. Through the health extension programme, health posts deliver 18 packages of preventive, promotive, and curative services. However, evidence shows a low availability of these services in reality (54). A health centre is composed of an average of 20 staff, with a capacity for five inpatient beds. It provides both preventive and curative services. The health extension workers get practical training in the health centres, which also serve as a referral centre for the health posts.

A primary hospital provides inpatient and outpatient services to an average population of 100,000 people. In addition to all the services provided at a health centre, a primary hospital renders emergency surgical services, such as caesarean sections. Blood transfusion service is also given at the primary hospital level. A primary hospital serves as a referral site for health centres;

it also serves as a practical training hub for nurses and other paramedical health professionals. A primary hospital has an average of 53 staff and a 25-50 inpatient bed capacity (4). The primary hospital provides well-planned and coordinated catchment area mentorship and coaching services for health centres and health posts (15).

A general hospital at the secondary care level provides inpatient and outpatient services to an average of one million people. It has an average of 234 professionals. A general hospital serves as a referral centre for primary hospitals and gives training for emergency surgeons, nurses and health officers. A specialised hospital, a tertiary level of care, gives service to an average of five million people. It serves as a referral centre for general hospitals and has an average of 440 staff (4).

The strength of referral practice in the health care delivery system of a country shows the level of accessibility of health services. A service is said to be effectively accessible if it is always open, available for everyone without social and financial discrimination, and the time and distance required to access care are acceptable to the users (8). The referral linkage between the primary health care units in Ethiopia considers the health posts as an entry point for patients, who may proceed to the health centres and primary hospitals. However, the implementation of the referral network system has been weak (4). To alleviate this problem, the government has planned to implement a strong bi-directional (upward and downward) referral system to avoid disruption in the continuity of care (54). Unlike other developed countries (55), the primary care delivery units (health centres and health posts) are not equipped with medical doctors, with only nurses and health officers giving curative services (56). Several studies have shown that a strong primary

health care system has an impact on enhancing the population's health by improving health outcomes (57). Optimising primary health care interventions could lead to saving lives and an increase in life expectancy in LMICs (58).

In the last decades, Ethiopia has recorded major achievements in the health sector. One of the programmes responsible for this gain is the HEP (15). The HEP is an innovative community-based programme launched by the Federal Ministry of Health of Ethiopia in 2003 with the aim of delivering basic promotive, preventive, and curative health services by the HEWs at the community level, with the active participation of both households and the community (4,59). The HEWs are community health workers located at primary health care delivery units. The HEP is hailed for improving information access, providing promotive and preventive services to the community. The programme was aligned with the Health Sector Transformation Plan II (HSTP-II) and the Sustainable Development Goals (SDGs) (54).

However, the programme has been facing challenges in terms of keeping up with the changing epidemiologic, demographic and socio-economic transitions of the country. Consequently, it could not address the changing demands and needs of the population by modifying its momentum and implementation strategies. To mitigate these drawbacks, the Ministry of Health developed a strategy called the 'HEP Optimisation Roadmap (2020-2035)' based on previous national appraisals of the programme. This optimisation will accelerate the achievement of universal health coverage. The optimisation goes in line with the existing health care delivery system. At every level of the health care delivery system, there will be a responsible body to coordinate the HEP implementation. After revising the HEP structure, a 'comprehensive health

post' will be established for areas beyond a one-hour walking distance from the nearby health centre, having a population of more than 5,000 and being geographically inaccessible (15).

Population health

According to the Centers for Disease Control and Prevention (CDC), population health depends on a collaborative approach between various communities such as health departments, academic institutions, and governmental bodies in order to realise desirable health outcomes (60). This collaboration creates a conducive environment to link the practice to policy so that change can happen at the local level. Population health gives attention to priority health problems and ways of allocating resources to tackle the problems. This gives an opportunity to create an interdisciplinary relationship between the stakeholders to achieve a positive health outcome for the population (60). Moreover, population health indicates the health status and the multi-dimensional determinants affecting the health of the population. It also determines the variation in the patterns of conditions affecting the health of the population. The findings obtained from such measurements are used to develop policies and implement actions for securing the well-being of the community. Population health also deals with groups of individuals or geographic areas which have practical importance for policymaking. Population health should focus on the partnership between practice and academia, and the transfer of knowledge to improve the health of the population they serve (61).

Demography

Demography refers to population studies in a wider scope. Population study deals with the relationships between population trends and other determinant variables, such as social, economic, biological, geographic, genetic, and political factors. Demography is a science dealing with the size, structure, distribution, and changes of the population. Size refers to the number or quantity of persons. Distribution is the organisation of people geographically or among various settings at a given time. Structure refers to the allocation of people among sex and age groupings. Change is the increment or decline of the total population or structural units. Fertility, mortality and migrations bring change to the total population (62). The application of demographic concepts to the study of health and health care is known as health demography. Health demography deals with how demographic characteristics affect health status and health behaviour, and how health-related attributes influence demographic phenomena (33). Understanding the size and characteristics of the population is vital in measuring health and health care needs. Knowledge of the interaction between births, deaths, and migration gives insight into forecasting future population characteristics. Understanding these population dynamics can help to strengthen health care planning (63).

Population structure and change

Demographic transition theory demonstrates the sequential stages a population undergoes as a result of the birth and death rates. A shift from high to low mortality and fertility states takes place during these stages. Usually, a decline in mortality occurs prior to fertility reduction. The number of births, deaths, and migrations are also affected by the age and sex structure of the population. Changes in one of the basic population determinants, such as births, deaths, or

migration, will alter the population size or structure (64). Mathematically, demographic change is the addition of natural increase and net migration. This demographic formula is known as the 'balancing equation'. The natural increase is denoted by the number of deaths subtracted from the number of births. Similarly, the difference between in-migration and out-migration gives the net migration. The numbers obtained from the balancing equation, however, might not be closely similar to the actual census count. This variation is known as an 'error of closure', and this occurs because the measurements of fertility, mortality, migration, and population size are not free from errors. A high magnitude of error of closure shows poor consistency and poor quality of demographic data and the data collection process. Errors might originate from misreporting, omissions or differences in the definition of people being counted. Globally, the most commonly misreported variable is age. In addition to misreporting, age distribution can be altered due to changes in mortality, fertility and migration levels (64).

Fertility

Fertility deals with the actual childbearing ability of a woman or population (63). It shows the number of live births (64). There are different ways of measuring the level of fertility. If we are dealing with births occurring at a specific time, it is period fertility. Period fertility analysis is done cross-sectionally. Cohort fertility analysis deals with all births occurring within a specific group of women over a period of time. Cohort fertility is a longitudinal analysis (64). Annual period fertility indicators, which are frequently used by health administrators and planners, include the child-woman ratio, crude birth rate (CBR), age-specific fertility rates (ASFR), general fertility rate (GFR), total fertility rate (TFR), gross reproduction rate (GRR), and net reproduction rate (NRR) (64,65).

Mortality

Mortality deals with the number of deaths occurring in a particular population over a given time. (66). The history of mortality analysis dates back to fertility analysis. The main component of mortality analysis is life table construction. The basic measures used in mortality analysis include crude death rate (CDR), neonatal mortality rate (NMR), infant mortality rate (IMR), child mortality rate (CMR), and cause-, age- and sex-specific death rates (64). Mortality can also be expressed based on age and other pertinent population characteristics. Life expectancy or survival period can also be obtained from mortality data (66). Mortality related data can be affected by under-reporting of deaths, especially neonatal and infant deaths (65).

Migration

Migration refers to the movement of people from one area to another, temporarily or permanently (66). In developed countries, where there is the lowest mortality and fertility, net migration plays a substantial role in population change. A person who moves from one country to another, intending to stay there, is called an immigrant; this is an international move. In-migration and out-migration refer to internal movements within a country. A person is an in-migrant if they cross boundaries from one administrative area to another (64). A person is referred to as an in-migrant at the destination area and out-migrant (emigrant) for the original place he or she left (64,66).

Sources of data for health demography

A census, surveys and vital event registration are common sources of demographic data. Population structure, composition and trend-related data are generated from these data sources. Likewise, mortality, birth, and marriage-related estimates are computed (62). Health data can be obtained from the community or institution level. Community-related data could be gathered from a nation, a state, or any type of geographical boundary level. Institutional data can be acquired from specific organisations, like hospitals (33). Improved quality, quantity, and specificity of data are needed for planning purposes in the current health care system (33). Most developed nations have routine and well-established sources of demographic and health information registration systems. However, reliable information systems are scarce in developing countries, including Ethiopia. Thus, these countries depend on the national census, intermittent national surveys, demographic and health surveys, and reports from health facilities (67–69). These countries also lag in the implementation of national civil and vital events registration systems.

Although Ethiopia initiated the vital registration system in 2016, the coverage is at just 3% in southern Ethiopia (70,71). To fill this gap of absent or weak routine vital registration systems, Ethiopia has been establishing Health and Demographic Surveillance Systems (HDSSs). HDSSs serve as a means of obtaining more consistent and timely data at the lower level of government structure (67,68). Synthetic data can also be generated from the existing demographic data by considering assumptions about population growth to make future forecasts and estimates (33). There is a newly established Dale-Wonsho HDSS (D-W HDSS) site, set up by Hawassa University.

The implications of demography for health service delivery

Major demographic profile changes are happening in most developed nations. The changes are observed in terms of age, ethnic composition, family size and income, as a result of the immigration pattern. Such changes affect the health system. Access to health services, resource allocation and expenditure, demand and supply are all affected by the changes in population structure and composition (72). The birth, death and morbidity patterns of the population influence the population composition. In the last decades, Ethiopia has been one of the fastest-growing economies and experienced a demographic transition. The reduction in mortality led to population growth, while the fertility reduction resulted in slower population growth. Following the current trend, the population growth rate is anticipated to reduce further, while an increase in life expectancy is expected (5,73). Ethiopia's reduction in mortality and fertility rates was faster than other sub-Saharan African countries (74). This created a higher proportion of the working-age group population which is crucial for rapid economic growth (24).

Of the policy and programme achievements that the Ethiopian government is hailed for internationally, the health extension programme (HEP) is majorly responsible for changes observed in reducing mortality and fertility rates (24). However, the programme has been unable to keep up with the accelerated demographic and epidemiological changes in the country. Therefore, the Ministry of Health of Ethiopia has initiated a roadmap to improve the programme. With the optimisation of the HEP, the issues of poor quality and limited health service coverage are expected to be resolved. During this 15-year plan (2020-2035), the health posts will be

improved, with better health professional composition, governance and leadership, clinical services, infrastructure, and information systems (15,54).

Demographic trends and public health

The bond between demography and public health dates back 300 years. A weekly mortality household survey was performed by John Graunt in London. Another significant factor for registering births and deaths was the need for health planning. The need to understand the interplay between demographic factors and population growth on public health led to the origin of 'public health demography' (75).

Effect of demographic trends on health policy

The health care system should follow the population and epidemiologic transitions. For instance, the growing number of old-age populations and the rise in chronic disease in a segment of the population should be given due attention (63). In addition, projections of the population structure help in the planning of the health care needs. Yet, there exists a gap between the continued population growth and the limited resources to improve the population's health and quality of life (63). The increase in the number of the young population is also considered as an opportunity for advancing the economic growth of a country. To reap the fruit of this population segment, the country should address the needs of the young generation through policies directed towards education, health and work opportunities (24).

Strategies to improve population health

One of the ways of improving population health can be through the implementation of standardised measurement, reporting methods, and establishing the accuracy of disease diagnoses by using different data sources (75). Due to the rapid increment in non-communicable disease burden among the young age groups in developing countries, the health system should be prepared for this demographic and epidemiological shift. Furthermore, the reduction of modifiable behavioural risk factors should be emphasised by health policies (76). Many governments in low-income countries spend only a few dollars per person on health. The rest of the health expenditure is covered out-of-pocket by the individuals (76). The implementation of mandatory health insurance could alleviate the financial stress for the government and the population (77).

Patient-public involvement or engagement in research is one way of assuring the World Health Organization's 1978 Alma-Ata declaration of the "right and duty to participate individually and collectively in the planning and implementation of their health care". The new initiative, including the Sustainable Development Goals on the integration of the public into the health services, is critical in achieving the universal health coverage goal (47,78). Involving the stakeholders in all or parts of the research process – from planning to dissemination – leads to improved quality of the findings. Moreover, the issue to be studied will have more relevance to the community, help in building trust, and empower them. The findings can also be translated from the participants' perspectives and be disseminated to the relevant population (47). Active

participation of communities in health services leads to reduced health inequalities and improved health status (79).

Context of the study

We conducted our study in Sidama region. Sidama is one of the most densely populated areas, with 533 persons/km^2, located in the southern part of Ethiopia (80,81). The region contains 4% of the national population (82). Sidama is known for having three traditional agro-ecologic or climatic zones (83). The wet or moist highland areas or *dega* have altitudes above 2,600 metres; the semi-arid midland areas, or *woina dega*, are situated with altitudes ranging from 1,700 metres to 2,600 metres, and dry lowland areas, or *kola*, have an altitude of 560 metres to 1,700 meters (84,85). Ninety-five per cent of the population speaks the local language called *Sidaamu Afoo* and lives in rural areas. Females compose 49.5% of the population. Children under five years of age constitute 15.8% of the population. More than 84% of the population is Protestant in their religion, and almost 3% of the total population practice traditional religion (83,86).

This study was done in the context of the newly established Dale and Wonsho Health and Demographic Surveillance System site (D-W HDSS), found in the Dale and Wonsho districts of the Sidama region. The estimated population of the Dale district (*woreda*) in 2017 was 268,839 people, living in 53,768 households. The area coverage of the district was 30,212 km^2. There were 36 rural and two urban *kebeles* (the lowest governmental administrative structure) in the Dale district. Wonsho district encompasses an area of 14,528 km^2, with 129,730 people in 21,857 households, living in 17 rural and one urban *kebele*.

The way of farming is traditional, despite agriculture being the backbone of the districts' and region's economy. The staple foods in the area are enset (*E. ventricosum*) and maize. Cash crop products include coffee and fruits. These crops comprise more than half of the gardening areas. Khat (*Catha edulis*), a form of chewable stimulant, is another cash crop widely produced. Coffee and crop production are dominant in both districts. Vegetables, pulses, roots, tubers and spices take a smaller share of production in the region. Enset has played a central role in Sidama culture and identity; however, the community has been changing to maize farming in recent years (83,87–89). In addition, the backyards of the Sidama people include trees and livestock species. Therefore, the society is known for an integrated farming system, due to the presence of livestock, such as cattle, goats, sheep, donkeys, horses, mules, and chickens, as well as the home gardening practices (87). There is a traditional indigenous method of conflict resolution in the Sidama community. However, the people also use formal government structures, such as courts, to resolve disagreements (90).

The use of traditional medicine gradually decreased in the region after the introduction of modern health care services during the late 1930s in Yirga Alem (91). During the study period, the region – the then Sidama zone – did not include Hawassa city administration. Hence, the region had three hospitals, 132 health centres and 523 health posts: 658 functioning public health facilities in total. In 2015, there were also seven clinics in the region, owned by non-governmental organisations (83,89). There were two private clinics in rural Dale and one in Wonsho district during the study period; however, we believe most rural communities prefer to access government institutions for their health services (59).

As described in the three-tier Ethiopian health care system, health centres and health posts are the principal components of primary health care units giving service to the community. The health post refers to the health centre; the health centre refers to the primary hospital. The referral linkage then proceeds to the secondary and tertiary levels of health care (4). Therefore, all governmental primary health care facilities (fifteen health centres and 50 health posts) were included in the studies assessing health service utilisation in Dale and Wonsho districts. Furthermore, to assess the change in population estimates, such as births, deaths, age and sex structure, we mainly used the baseline census conducted in Dale and Wonsho districts by the D-W HDSS.

Rationale for this thesis

Universal health coverage (UHC) pledges that all people should get quality health services without an undue financial burden on them. UHC is prioritised by the Sustainable Development Goals (SDGs) and WHO's Thirteenth General Programme of Work (GPW13) as a policy to ensure positive health outcomes for all people. A strong primary health care delivery system is an engine for achieving SDG-3, "ensuring healthy lives and promoting well-being for all at all ages" and other health-related SDG targets (39,92). However, globally, at least 50% of the population is still deprived of access to basic health services. Sub-Saharan African countries have recently shown faster progress on the effective coverage index (39); nevertheless, Ethiopia's UHC service coverage index in 2015 was only 39%, with regional variability (92).

In the last two decades, access to economic and social services have shown faster growth in Ethiopia. Health indicators and life expectancy in the country have shown improvement (54). The health extension programme (HEP), a community-based primary health care delivery platform, played a major role in making health services accessible to all Ethiopian populations, with a special focus on women, children, hygiene and sanitation. Since access to primary health care is one of the proxy indicators of UHC, the health extension programme played a vital role in improving the service coverage (4,54). To keep up with demographic, socio-economic, epidemiologic, global and national priority changes, the programme has been revised, and the current fifteen-year roadmap for upgrading the HEP was launched in 2020 (54). Implementing sustainable UHC reforms, however, requires political commitment from higher officials. Inequalities arising from making health services accessible to only selected groups of the population should also be resolved (93).

A gap in health service utilisation studies lies in the number and types of services investigated, and the involvement of stakeholders as part of the study. Different studies in Ethiopia assessed health service utilisation for specific services, mainly maternal and child health services (94–97). Others also assessed overall health-seeking behaviour at a household level (31,98). The geographic variations of specific diseases and health services have also been studied previously (26,35,99–101). However, there was limited information regarding the local variation in health service utilisation at the lower administrative structure (*kebele*) levels. There was also a lack of literature on the population characteristics, including fertility and mortality rates of the population in which the health service utilisation study was conducted. Therefore, this study was

done to fill these gaps by assessing the level and distribution of health service utilisation in the context of population characteristics of the local community.

Moreover, this thesis will help policymakers to identify the existing gaps in the measurement of health service utilisation among all segments of the population. The findings inform on the level, inequalities and geographical differences of health service use at the local level (Objectives 1 & 2). The policymakers could make use of this information to prioritise and allocate health resources. The understanding of the demographic characteristics of the population and the levels of mortality and fertility also serves as a base for designing appropriate interventions, considering the current population transition (Objective 3). Moreover, identification of the under- or misreporting of variables in demographic sites and health facilities helps the local health authorities to devise strategies of quality control. In the end, these efforts will yield increasing service use and positive health outcomes for the local community. The findings from the thesis could also serve as an evidence base for the scientific community.

Objectives

General objective

To measure the health service utilisation from health facilities and demographic data in Dale and Wonsho districts of the Sidama region in southern Ethiopia.

Specific objectives

Objective 1 To assess the health service utilisation and disease patterns, with local health authorities' suggestions to improve the health services, in Dale and Wonsho districts (Paper I).

Objective 2 To explore geographical factors contributing to the variation in health service utilisation at *kebele* level in Dale and Wonsho districts (Paper II).

Objective 3 To identify the demographic structure and identify some limitations on how the population dynamics are studied in rural districts in Sidama region in southern Ethiopia (Paper III).

Methods

Study area and period

We conducted our study in Sidama Region from 1 July 2017 to 30 June 2018. Dale and Wonsho districts (*woredas*) of the Sidama region were included in the study. In 2017, the estimated population of the Dale district (*woreda*) was 268,839 people. There were 36 rural and two urban *kebeles* (the lowest governmental administrative structure) in the Dale district. Correspondingly, Wonsho district had 129,730 people living in 17 rural and one urban *kebeles*. There were 65 functional primary health care units in both districts. There were 15 health centres, 50 health posts, and no primary hospitals during the study period (83,89).

Study design and data

This thesis is based on studies conducted using cross-sectional and ecological study designs. The paper titles, study designs, participants and the data collection method are summarised in Table 1. Paper I employed a facility-based cross-sectional study on 81,129 cases from 65 health facilities (15 health centres and 50 health posts). All functional health centres and health posts in the study areas were included. In addition, the health professionals' opinions on improving health service utilisation were assessed. Each health manager or professional was interviewed, after presenting the results of our research to them.

The data were collected from the standard registries developed by the Federal Ministry of Health of Ethiopia for the health centres and health posts. Registries in each unit or department had registration, identification, and service-related information. The diagnoses on these registries

were made by health professionals, predominantly clinical, using the Integrated Management of Childhood Illness (IMCI) (102), Integrated Community Case Management (iCCM) guidelines (103), or manuals, and sometimes based on laboratory findings. We used the Guidance for Reporting Involvement of Patients and the Public 2-short form (GRIPP-2) to collect, analyse, and present the data from the health professionals (104).

For Paper II, we used an exploratory ecological study design (105) on the 67,678 cases from 54 *kebeles*. Secondary data were collected from the standard registries of the health facilities (15 health centres and 50 health posts). Geographical information was collected from different sources such as the Central Statistical Agency of Ethiopia, Sidama Region Plan Commission and a previous study (26). The facility-based data were collected by fifteen local data collectors with a diploma in nursing, who received training for the data collection.

For Paper III, we collected the data primarily from the Dale-Wonsho Health and Demographic Surveillance System (D-W HDSS) database established in Hawassa University. The D-W HDSS performed a de facto census in 2017 on the selected 12 HDSS kebeles over a six-month period. We used 41% of the households from the total census. The missing mortality data from HDSS was, however, collected from the *iddirs*, traditional voluntary organisations established with the primary purpose of offering mutual aid in burial issues (106) of the same community. Then, the family of the deceased was interviewed to ascertain the age of the deceased and probable cause of death.

Table 1: Summary of the papers' titles, study designs, participants and data collection methods

Papers	Study design	Participants	Data
Paper I: Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: A facility-based cross-sectional study	Cross-sectional	Health facilities; health professionals	Standard registries supplied by the Federal Ministry of Health; interview with health staff at local and regional level
Paper II: Large local variations in the use of health services in rural southern Ethiopia: An ecological study	Ecological	Kebeles; health facilities	Standard registries supplied by the Federal Ministry of Health
Paper III: Births and deaths in Sidama in southern Ethiopia: Findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS)	Mixed-method design (both quantitative and qualitative data); cross-sectional	Households; community members; government officials	Dale-Wonsho Health and Demographic Surveillance System (D-W HDSS) database as a secondary source of quantitative data; interviews and focus group discussion with community members, *kebele* and district officers; record review of *iddirs* for mortality data; interview with the deceased family (primary data)

Sample size

The sample size calculation was done using OpenEpi (107) statistical software. We estimated the sample size for Paper I, based on the following assumptions: 48% prevalence of the national utilisation rate per year of OPD visit, a power of 80, 95% confidence interval, a margin of error of 1.4% and the ratio of sample size in unexposed/exposed of 1. The resultant required sample size was 4,869 patients. However, we enrolled all 81,129 patients who visited the health facility in our study. Similarly, for Paper II, we assumed a prevalence of 0.48 health service utilisation per person per year, 80% power, 95% confidence interval, a precision of 1% and a design effect of 1.5. The required sample size was 14,246 patients. However, excluding cases outside the study area, we enrolled all 67,678 new cases for the analysis. For Paper III, we assumed the national crude death rate of 6.7 per 1,000 population, 95% confidence interval, power of 80%, and unexposed/exposed ratio of 1. Using these assumptions, the sample size needed was 14,600; for this sample size, the margin of error was 0.13%. However, we included the allowed 41% of the individuals in the D-W HDSS, which was 25,144 persons.

Assessment of exposure and outcome variables

The exposure and outcome variables used in this thesis are summarised in Tables 2 and 3. The outcome variables were visits to primary health care units per person per year, proportions of diagnoses, health service utilisation rate per *kebele*, and births and deaths. We used socio-demographic variables such as age, gender, ethnicity, religion, educational status, wealth index, and place of residence (in Papers I and III) as exposure variables. Districts, type of health facility, disease types and visit types were also exposure variables (in Paper I). Area-level variables, such as altitude, population density, family size, and distance from the health centre to the *kebele* centre, were exposure variables used in Paper II.

Table 2: Definition of exposure variables used in this thesis

Variable	Level	Definition or measurement	Paper
Gender	Individual	Proportion of male and female	I & III
Age	Individual	Proportion of different age groups	I & III
Ethnicity	Individual	The origin of ethnic group the participants are from.	III
Religion	Individual	The faith or religious status of the respondents.	III
Educational status	Individual	The highest education level attained by the respondents.	III
Wealth index	Individual	Information related to ownership, material of house construction, source of light and drinking water, toilet facilities and cooking material was analysed. Then, population was ranked into three categories ('lower', 'middle', and 'upper').	III
Residence	Individual	Proportion of urban and rural population or cases.	I , II & III
District	Individual	Proportion of population or cases living in Dale and Wonsho districts.	I & III
Type of health facility	Individual	Proportion of cases visiting health posts and health centres.	I
Disease types	Individual	Proportion of cases with specific types of disease diagnosis.	I
Visit types	Individual	Proportion of cases registered as new or repeat visitors to the health facilities.	I
Altitude	*Kebele*	Elevation above sea level obtained from the database of the Central Statistical Agency of Ethiopia.	II
Population density	*Kebele*	The number of people living within a square kilometre in each *kebele.*	II
Family size	*Kebele*	The average number of people living together in a household, sharing food, shelter, and other essential things in each *kebele*.	II
Distance	*Kebele*	Distance measured from the health centre to the centre of the *kebele*.	II

Table 3: Definition of outcome variables used in this thesis

Variable	Level	Definition or measurement	Paper
Health service utilisation rate	Individual	The number of new outpatient visits to health facilities per year, relative to the total population of the same geographical area.	I & II
Proportions of diagnoses	Individual	The number of disease events, divided by the eligible population of the same geographic area.	I
Births	Community	Birth-related information in the last year among reproductive-age-group women. The calculated information included: *Crude birth rate*: Births in a year, divided by mid-year population; expressed per 1,000 people. *Total fertility rate*: The number of children a woman would have if she survived to age 50, and throughout her reproductive life she experienced exactly the age-specific fertility rates for the year in question. *General fertility rate*: Births during a year, divided by mid-year female population aged 15-49; expressed per 1,000 women. *Gross reproductive rate*: The average number of daughters a woman would have if she survived to at least age 50, and experienced the given female age-specific fertility rate. *Net reproduction rate*: The average number of daughters a woman would have during her reproductive years, given the fertility and mortality rate.	III
Deaths	Community	Death-related information in the last year among the whole population. The calculated mortality estimates include: *Crude death rate*: The number of deaths in a year, divided by the total mid-year population; expressed per 1,000 people. *Infant mortality rate*: Number of deaths of children under one year of age in a year, divided by live births in the same year; expressed per 1,000 live births. *Child mortality rate*: The number of deaths of children between one and five years old, divided by the number of live births in a year; expressed per 1,000 live births. *Under-five mortality rate*: The number of deaths of children less than five years old, divided by the number of live births in a year; expressed per 1,000 live births.	III

Data management and statistical analysis

We carried out double data entry and validation in EpiData (108) version 3.1 software (Papers I, II and III). The data cleaning and analysis were done by STATA software version 13 (Papers I, II and III) (109).

We performed descriptive statistics for all cases and variables in Paper I. We did a stratified analysis, based on the background characteristics of the clients, on health service utilisation and disease diagnosis. The number of new visitors was used to calculate the odds ratio and 95% confidence interval. We also compared the rate of health service utilisation for each explanatory variable. The denominator for the utilisation rate calculation was estimated from the projection of the Ethiopian 2007 census (110). The outpatient utilisation rate was computed based on the WHO core health indicators manual (20). Microsoft Excel and MedCalc software version 19.2.6 (MedCalc Software Ltd., Ostend, Belgium) were used to calculate the utilisation rates. We analysed the health staff's feedback manually into emerging themes.

For Paper II, we used ArcGIS 10.3 for data visualisation and presentation (111). The World Geodetic System (WGS) 1984, Universal Transverse Mercator (UTM) zone 37°N, was used to define the coordinates' projection. The spatial variation of the health service utilisation was analysed by using the SaTScan version 9.6.1 software (112). For the purely spatial analysis, we used the number of people in each *kebele*, number of visits to the health facilities, area coverage of each *kebele*, health service utilisation rates, population density, altitude, distance from health centres, and the coordinates of each *kebele* and health centre as inputs. We used the discrete Poisson model, which assumes the number of cases at each location was Poisson distributed with

the known population at risk. We used a circular window to identify significant clusters by Kulldorf's spatial scan. The maximum reported cluster size was set at a radius of less than 50% of the total population at risk. The relative risk was calculated from likelihood ratios. The most likely and secondary clusters were reported when a p-value was less than 0.05. For each scanning window, a likelihood ratio test was conducted to test whether there was a low rate of health service utilisation compared with the distribution outside the window, at a p-value <0.05 (28).

In Paper III, we carried out a descriptive analysis and constructed the population pyramid. We calculated age reliability indices using Whipple's index, Myer's blended index, and United Nations Age-Sex Accuracy Index (UNAI) or Joint Score (UNJS) for both sexes (64,113,114). We performed a principal component analysis (PCA) to establish a wealth index. Sensitivity analysis for children's mortality and crude birth rates was done by substituting estimates from regional and national studies, to cross-check the consistency of the results. We compared our total fertility rate data with the national estimates and predicted the projected total fertility using the software Spectrum version 5.761, a policy development and planning tool for improved health (Spectrum, Avenir Health, Glastonbury, USA) (115). Factors associated with fertility were analysed by using bivariate and multivariable logistic regression models. The qualitative data were coded and analysed by using ATLAS.ti 6.2 qualitative data analysis software (ATLAS.ti, GmbH, Berlin, Germany).

Ethical considerations

The ethical clearance for all three papers was obtained from the Institutional Review Board at the College of Medicine and Health Sciences of Hawassa University (Reference number IRB/ 022/10), and from the Regional Ethics Committee for Medical and Health Research in Norway (2018/67/ REK Vest). Permission was obtained from Hawassa University Research and Community Service Directorate to access the data from the D-W HDSS database (Paper III). Permission letters were obtained from the Sidama Zone Health Department, Dale and Wonsho *woreda* (district) health offices to access the secondary data from all primary health care facilities and for the qualitative data collections (Papers I, II and III). The above-mentioned ethical committees ruled that no formal consent was required for secondary data use.

For the qualitative study participants, written informed consent was obtained after giving information about the objectives of the study, the role of the participant, risk or discomfort, benefit, confidentiality, and voluntary participation. They were also given the option to withdraw from the interview at any time. All the methods used in these studies were in accordance with relevant ethical guidelines and regulations. No children under the age of eighteen were interviewed or directly involved in our study. There was no personal identifier in the data sets. The data collection tool was kept in a secure place to maintain the confidentiality of information obtained.

Results

The results from the three papers in this thesis showed a low and variable health service utilisation rate in the local community in Sidama. The variation in health service utilisation was observed on population characteristics, such as age groups, area of residence and gender. There was also a difference in health service usage based on the health facility characteristics such as the type of health facility and distance from the health centre to the *kebele* centre. There were common diseases identified in different population segments in our study, yet very few non-communicable disease diagnoses were made. Family planning services were the major health services given to the community; hence, we observed a lower fertility rate than observed in previous studies in our study area. There was higher mortality and reduced life expectancy estimates demonstrated by our study, which could be linked with the low health service usage, coupled with poor diagnostic and treatment capacity in the primary health care facilities, as confirmed by the local health professionals' opinions. The summaries of the attached research papers are presented below.

Paper I: Low and unequal use of outpatient health services

We aimed to assess health service utilisation and disease patterns in southern Ethiopia, by including the health authorities' suggestions to improve the services. An institution-based cross-sectional design study was done in 65 primary health care units in Dale and Wonsho districts, in Sidama region, for all patients visiting health facilities from 1 July 2017 to 30 June 2018. We estimated the utilisation rate as visits per person per year, the odds ratio for health use, and

proportions of diseases' diagnoses. The results of our study were presented to local health authorities, and their suggestions for improvements were incorporated into the analysis.
A total of 81,129 patients visited the health facilities. The annual outpatient health service utilisation was 0.18 (95% CI: 0.18–0.19) new visits per person per year. The health service utilisation rate per year for the rural population was lower than the urban utilisation by 91% (OR = 0.09; 95% CI: 0.08–0.09). Children in the age group of 5–14 years had lower odds of health service utilisation by 78% (OR = 0.22; 95% CI: 0.21–0.23), compared to children under five years of age. Females were four times (OR = 4.17; 95% CI: 4.09–4.25) more likely to utilise health services than males. Febrile illness constituted 17.9% (14,847 of 83,148) of the diagnoses in all age groups. Almost half of the febrile cases, 46.5% (3,827 of 8,233), were among children under five years of age. There were very few cases of non-communicable diseases diagnosed in the health facilities. The health authorities suggested improving diagnostic capacities at health centres, enhancing health professionals' skills and attitudes, and improving affordability and physical accessibility of the services.

Paper II: Large local variations in the use of health services

We assessed the health service utilisation and identified factors that account for the variation in health service utilisation at *kebele* (the smallest administrative unit) level in the Dale and Wonsho districts of the Sidama region. An exploratory ecological study design was employed on the secondary patient data collected from 1 July 2017 to 30 June 2018 from 65 primary health care units of the fifty-four *kebeles* in Dale and Wonsho districts in the Sidama region. ArcGIS software was used to visualise the distribution of health service utilisation. SaTScan analysis was performed to explore the unadjusted and covariate-adjusted spatial distribution of health service

utilisation. Linear regression was applied to adjust the explanatory variables and control for confounding.

A total of 67,678 patients in 54 *kebeles* were considered for spatial analysis. The distribution of the health service utilisation varied across the *kebeles*, with a mean of 0.17 visits per person per year (range: 0.01–1.19). Five *kebeles* with health centres had a higher utilisation rate than other rural *kebeles* without health centres. More than half (57.4%) of the *kebeles* were within a 10 km distance from health centres. The study found that longer distance to the health centre was associated with low health care utilisation.

Paper III: Births and deaths in Sidama

We aimed to investigate the population characteristics in Sidama, with an emphasis on fertility estimates, age, and death reporting. This was a mixed-method cross-sectional study, conducted in Sidama in southern Ethiopia, using baseline data of the newly established Dale-Wonsho Health and Demographic Surveillance System site in 2018. We used the quantitative data of 5,179 randomly selected households having 25,144 individuals. We collected information on deaths in the same study period and population from the traditional burial associations (*iddirs*). Qualitative data were collected using focus group discussions and in-depth interviews. Life tables, age reliability indices and logistic regression were used to analyse the quantitative data.

The total fertility rate was 2.9 children/woman, the crude birth rate was 22.8/1,000 population, and the crude death rate was 5.2/1,000 population. The dependency ratio was 66/100 working-age population. Urban residents had higher birth rates (OR = 1.4; 95% CI: 1.05–1.78), and

women with basic education had lower birth rates (OR = 0.6; 95% CI: 0.46–0.78), compared to those with no education. The age accuracy indices showed unreliable age reporting. The number of deaths increased from 29 to 132 when death reports from the *iddirs* were included. There was under-reporting of neonatal and young child deaths. Substituting national and regional mortality estimates, the life expectancy declined to an average of 53 years (range 48–58 years).

Result of post hoc power analysis

We did a post hoc power analysis to identify the probability of overlooking an effect should the effect truly exist. The sample size and the effect size were used to analyse the statistical power for each objective using one-sample and two-independent-samples proportion power tests. The power for insignificant findings was calculated for each paper. There was no non-significant explanatory variable in Paper I. For variables included in the linear regression in Paper II, we performed an estimated power for a one-sample correlation test. The power was 6% for population density and distance from the health centre to the centre of the *kebele*, and 11% for explanatory variable, altitude. In Paper III, we did a post hoc power analysis for variables used in logistic regression with non-significant findings, using G*Power version 3.1.9.6 (Franz Faul, Universität Kiel, Germany) (116). We considered fertility as an outcome variable and the explanatory variables were characteristics of reproductive-age women such as age group, ethnicity, religion, educational status, and wealth index. The power was 100% for age group, 88.8% for ethnicity, 7% for religion, 35%-100% for educational status categories, and 99.5%-100% for wealth index.

Discussion

Methodological discussion

An epidemiologic estimate is the result of the study objectives and design, the implementation of the study, and the data analysis. This entire stage (study design, conduct, and analysis) leading to an estimate is called the estimation process. The overall goal of an epidemiologic study can be accuracy in the estimation process. Explicitly, the objective of an epidemiologic study is to get a valid and precise estimate of the effect of an exposure on the occurrence of a disease or the frequency of a disease in the source population (105).

Study design

In this thesis, we employed cross-sectional (in Papers I and Paper III) and ecological study designs using spatial epidemiological methods (Paper II). Cross-sectional studies can be used by clinicians to make diagnoses and estimate the predictive value of investigations (117). They are also conducted as prevalence studies useful for planning purposes in public health (118). Cross-sectional studies are also helpful in identifying associations that can be further examined using stronger studies such as cohort studies and randomised controlled trials (117). However, a cross-sectional study design has some limitations in identifying causation and the sequence of exposure and outcome (117,119). Nevertheless, there are conditions that make a cross-sectional study appropriate for making causal inferences. These criteria include a stationary population, non-selective survivorship, similarity in duration of exposure between exposure groups, and no reverse causality (120). Thus, the associations observed between place of residence, gender, age, and type of health facility, and the low health service utilisation, can suggest causal relationships.

Similarly, because we used a stable population with similar duration of exposure and due to the absence of reverse causality and selective survivorship, the effect of age, residence and education on the total fertility rate may indicate a causal relationship. In terms of population trends, the demographic characteristics shown in the study are 'snapshots' taken during the study period; therefore, it is difficult to understand the trend of the population changes (Paper III). However, the prevalence and associations observed in our studies could give insight for public health planners to devise specific strategies based on the identified population characteristics. Similarly, the random selection of participants in Paper III ensures the representativeness of the samples.

In Paper II, we employed an ecological study. In an ecological study, the unit of analysis is a group or population, not an individual (105). Area-level studies are useful in monitoring population health in order to devise public health strategies. Ecological studies are employed when population-level risk factors have a stronger effect on a disease or event than individual-level determinants (121). Such studies are used to explore the effect of intervention at the population level or for surveillance purposes (122). Ecological studies can also be useful to provide insight for further investigation, based on the associations observed between exposure distributions and diseases (105,123).

However, like other cross-sectional studies, an ecological study design is less powerful in determining causation (121). Besides, the study is prone to ecological fallacy if we try to infer the result from aggregate data to the individual level (122). However, we minimised this bias by analysing the data at the lower-area level (*kebele*), which is closer to individual-level data (124). Moreover, the area-level exposure variables analysed in this study, namely, altitude, population

density, and distance from the health centre to the centre of the *kebele*, were less likely to differ at *kebele* and individual levels. We also did not make any inference at the individual level based on individual or biological factors, albeit they could contribute to the aggregation of health service use. Therefore, the findings presented in our study can be attributed to the geographic variables only.

Sample size

Sample size refers to the number of participants or other units that should be incorporated in a study which is sufficient to address the research question (125). Insufficient sample size leads to a wide confidence interval (105,126). We can reduce the random error, the distortion of an observed estimate from the true population value, by increasing the sample size. Thus, the role of chance will be minimised (127). We need an optimum sample size to estimate the population prevalence with fair precision in cross-sectional studies (125). In Papers I and II, we used a larger sample size than needed.

In Paper III, we were allowed to study 40% of the population from the D-W HDSS census data. Therefore, notwithstanding the entire calculated sample sizes, we included all health facility visitors (Paper I), all *kebeles* in the study area (Paper II), and the allowed number of samples from the census done by D-W HDSS (Paper III), resulting in a power of over 80%. Hence, the chance of missing an effect when it really exists is low in our study, predominantly because of the larger sample sizes used. Therefore, in our analysis, the confidence intervals for determinants of health service utilisation rates (Papers I and II), and fertility (Paper III) were very narrow, depicting the precision of the estimates (119). All the variables which had significant results also had a power of over 80% in Paper III. We found a power ranging from 7%–100% for non-

significant variables and categories for Paper III. The low power demonstrated on multivariable analysis might be due to the small number of cases in some of the categories (in Paper III) or the small sample size (54 *kebeles*) (in Paper II). Moreover, including all *kebeles* and health facilities available in the study area (Papers I and II) could ensure the adequacy and representativeness of the sample size. Too high a power might lead the researcher to find statistically significant results with little clinical importance (128). However, all the variables in our studies had clinical or public health importance. We also presented all the significant and non-significant findings in each paper, in order to minimise the reporting bias which can arise due to reporting positive results only.

Validity of the study

The ultimate goal of an epidemiologic study is estimation accuracy. Obtaining a valid and precise estimate of the source population is the primary aim of an epidemiologic study. Another aim is to obtain an estimate that can be generalised to the relevant target population (105). Validity refers to the extent to which a test is measuring what it sets out to measure. For a study to be valid, there should be no systematic error or bias and minimum random error, if possible. Increasing the sample size can minimise random error. Validity can be categorised as internal and external (127). If the validity is concerned with the study subjects, we call it internal validity; however, if the inferences are made to the general population, it is labelled as external validity. In order to assess possible causality, maintaining the internal validity ensures the external validity or generalisability (105).

Internal validity

Internal validity refers to the extent to which the estimates of observation are accurate for the study population (127). Threats to internal validity include selection bias, information bias, confounding, and effect modification (105).

Selection bias

Selection bias occurs when people selected to participate in a study are different from those who should have been theoretically suitable for the study or those who do not participate (105,127,129). It is an error observed when the study population is not a representative sample of the target population. In this case, the effect measures do not represent the target population to whom the inferences are made (130). We can reduce selection bias by setting clear criteria for including participants in the study, having an explicit understanding of the diseases and their management, and securing a high response rate (127).

For Papers I and II, we included all registered cases from all health centres and health posts in the study area. Selection bias resulting from non-response is minimised when studying the entire population (105). We also included all *kebeles* in the study area. In addition, we excluded those who came from other districts from the analysis (Paper II). Thus, any overestimation of the outcome was minimised. Moreover, in an ecological study, the probability of selection bias is not a concern since we did not use individual data, or infer to, the individual level (127).

However, since our study extracted data from primary health care facilities, we might have missed cases from the community or those referred to secondary and tertiary levels of care. This might introduce health care access bias, by which patients or cases at institutions differ from

cases in the community (130). Therefore, this might lead to an underestimation of the health service utilisation rate. However, the proportion of the population living in proximity to private and higher-level health facilities was around 6%, which is small compared to the total study population (Papers I and II). For Paper III, to ensure representativity, we used a simple random sampling technique to select the sample of the D-W HDSS census.

Information bias

Information bias refers to inaccurate measurement or classification of disease, exposure or both (127,129). This type of bias occurs during the data collection process. Misclassification bias might occur when there is missing data, error in data collection or entry, or digit preference. Under-reporting bias occurs when collecting socially detrimental events (130). A concern of data quality arises when using secondary data, as we used in Papers I–III. Diagnoses made could be uncertain and prone to misclassification. Yet, the misclassification of exposure and the disease is usually non-differential (105). This is due to the fact that we have not collected samples of diagnoses; instead, we used all recorded diagnoses from all health facilities that were using similar diagnostic and registration methods.

Due to the absence of a recent census in the country, we used the 2007 census projection estimate for the current population size in the study area, which might have resulted in an inaccurate denominator estimate for our calculations (Papers I–III). Although the diagnoses in registries were not standardised, we used national and international standard disease classification guides to minimise the misclassification error (Paper I) (131,132). We also had under-reporting for obstetrics and eye services, due to loss of data. We had missing information

on one of the variables labeled as 'visit information'. However, because of the large study population, this missing information is probably small and would not change the results of the study. Moreover, under-reporting of vaccine coverage was observed, due to the registration of children from the previous year as repeat visitors. Therefore, the vaccine coverage could have been higher than our findings suggest, if we had not used new vaccine users for our analysis.

Moreover, the qualitative interview with the health staff for Paper I might introduce a social desirability bias, since the interviewed health staff knew the results of the study before giving their opinions. They gave feedback on general, administrative, and structural solutions without being critical on findings that required local or institutional recognition. Therefore, we believe there could be additional practical solutions to improve the health service usage. However, the issues raised could expose some factors which were new from the health professionals' point of view.

For Paper III, the D-W HDSS used a standardised and validated tool from INDEPTH Network to collect the data (133), which makes information bias less likely. Hence, we used the same format to extract variables needed for our analysis. However, we encountered measurement bias due to age reporting because of the unreliable data collection method which depended on the memory of the respondents. Under-reporting bias also occurred due to the omission of information on deaths of infants, children and stillbirths, mainly as a result of cultural issues and the quality of the data collection procedure. However, we tried to adjust for this error by collecting death information from alternative sources, namely from the burial associations of the community called *iddir*. Our sensitivity analysis showed that the rates of mortality and fertility could have

been higher than reported in this study. Therefore, while using the findings of Paper III, caution should be exercised by considering the measurement errors. Furthermore, future data collection phases and other Health and Demographic Surveillance System sites should try to avoid measurement errors due to faulty data collection procedures on age and death-related information.

The use of secondary data in this thesis eliminates the chance of observer bias (117). However, it makes the data prone to incompleteness or lacks the power to test the current hypotheses. However, we triangulated the findings with primary data qualitatively, which is known for generating quality information (117). In addition, the sample sizes we used for our studies showed adequate power (over 80%); therefore, our studies were not underpowered.

Confounding

Confounding is a blurring of effect created due to the association of a third variable with the exposure and the outcome, without the third variable being present in the chain of causation and unaffected by the exposure or the disease (129,130). Every epidemiological study is prone to confounding (130). Confounding is less severe in ecological studies than other observational studies done at an individual level. However, it is more difficult to control for confounding in ecological analyses than analyses done at the individual level (105). Confounding can be minimised by using randomisation, restriction, or matching during the design phase (127). During analysis, confounding can be controlled by stratification and multivariable statistical modelling (127,130). On the other hand, residual confounding is a type of confounding observed after controlling for all known confounders in the design and analysis of a study which might

lead to biased results (105,134).The most common confounders in epidemiological studies are age and social class (127). For Paper I, we stratified age into groups and calculated rates and odds ratios. For Paper II, we performed covariate-adjusted spatial clustering analysis. For Paper III, we employed a multivariable logistic regression model to control for confounding in associations between fertility rate and exposure variables such as age, educational status, ethnicity, religion, wealth index, and place of residence. One of the possible confounders in our study, age, was stratified into multiple categories; hence, the likelihood of residual confounding as a result of dichotomising a continuous variable was minimised. Therefore, we believe the effects of confounders were sufficiently controlled, and the susceptibility bias was neutralised in our studies.

Chance

Chance is defined as a random variation or random error (105). The p-value measures chance. P-value shows the probability of a false positive conclusion (Type I error) (129). It shows the incompatibility between observed data and the null hypothesis (135). Interpretation of statistical tests should not rely only on a precise p-value. Rather, statistical tests should consider effect size, confidence limit, and contextual factors, such as the study design, measurement quality, external confirmation for the event under study, and the validity of the hypothesis (135,136). Even though it does not show any evidence about the effect size, the arbitrary cut-off point of 0.05 for the p-value is used as the threshold of statistical significance (136). In this thesis, we presented a 95% confidence interval, p-value, effect size, validity checks, and context of the events studied. Increasing the sample size of a study is one way of increasing precision or decreasing the random error (105). Due to the large sample size enrolled in our studies (Papers I–III), the p-value was

precise. Consequently, we encourage readers and health planners to accept the accuracy of our findings and make use of the results based on the contextual factors, the confidence limits, and the effect size. The sole use of low p-value for decision-making by investigators and policymakers should be avoided (136,137).

Causality

An event is said to be a cause if it leads to an effect alone or together with other causes. A cause is called sufficient if it certainly results in the effect (138). All statistical associations do not guarantee causation (129). Causal inference, the process of identifying the association as causal, should be checked after excluding the possibility of bias, confounding, and chance (127).
The nine criteria suggested by Sir Austin Bradford Hill (139) help in deciding whether the association is real or causal (140). The Hill's criteria are the following:

- *strength*: the stronger the association, the higher the likelihood of the association being causal; weak association could be due to hidden biases;
- *consistency*: shows the presence of association when the study is conducted in different populations and situations;
- *temporality*: implies the cause must precede the effect;
- *specificity*: an exposure should lead to a single outcome;
- *biologic gradient*: it is a dose-response relationship; as an exposure increases, there will be more of the outcome;
- *plausibility*: the association should be supported by scientific or biological knowledge and should make sense to the scientific community;

- *coherence*: the association is in agreement with the existing evidence on the natural history and biology of the disease;
- *experimental evidence*: conducting an experimental or quasi-experimental study to prove the association observed; and
- *analogy*: the association is observed in other settings.

However, some scholars do not agree with all of Hill's criteria, except for temporality (129,139,140). For practical reasons, such as cost reduction, ethical issues, time constraints and lack of incidence data, cross-sectional studies have been used to assess causal associations. We can use cross-sectional design to assess causation if: 1) the population is stationary; 2) the mean duration is similar for exposed and unexposed; 3) there is no selective survival in the exposure groups; 4) reverse causality does not happen; and 5) temporality is assured. If these conditions cannot be achieved, crude measures or subgroup prevalence can be used (120). Reverse causality is excluded if the outcome does not cause the exposure (141). If we do not infer to individuals from the aggregate data, ecological studies could be good in establishing causation in some exposures only found at area level (127).

In this thesis, we employed cross-sectional (Papers I and III) and ecological (Paper II) study designs. However, the associations depicted as factors for low health service utilisation fulfill the criteria stated above; therefore, we believe causal relationship can be established. In addition, the crude estimates and the subgroup prevalence can give direction for further exploration using more robust designs. Moreover, for Paper III, after dealing with potential biases and chance, we performed multivariable logistic regression to control for confounding and establish the

association between demographic variables (age, religion, ethnicity, wealth index, educational status, and area of residence) and fertility. Thus, we believe that the population studied was stable, the mean duration was the same, there was no survivorship bias, and the causal pathway was not reversed. Therefore, some of the possible causes of low fertility in the study area were identified. Other analyses for all three studies were crude measures (odds ratio and rates), proportions or frequency measures. Yet, these findings can be used for identification of poor service areas and population groups, and hence they can be a basis for public health planning purposes at a local area level.

Neutrality and interest

Neutrality, also known as confirmability, refers to the extent to which the findings of the study reflect the participants' experience and not the researcher's personal interest, philosophy and experience (142,143). It should be taken into account that there is an inherent link between the extended exposures with the participants, the methods used, and the findings, with the researcher's point of view. The difference between the experiences of the researchers and the participants should be clear (142). One's interests and ideologies should be identified so that the implementation and interpretation of the research process will be as free of them as possible (144). Neutrality can be achieved through auditing, which is a clear and detailed description of the investigation process and documentation of issues and challenges from the initial stages to the end of the research process.

Another method of ensuring neutrality is by involving other investigators with qualitative research experience to discuss the findings and themes (142). In this thesis, we applied

qualitative data collection and analysis in Papers I and III. In Paper I, we utilised the short form of a standard tool called the Guidance for Reporting Involvement of Patients and the Public 2 (GRIPP2-SF) to collect, analyse and present the information obtained from the health professionals. The health staff were selected purposively, which might be linked with the inherent need of obtaining the expected response by the researchers. The results were presented to the participants before the interview. Their suggestions on areas of improvement are based on the results collected via interviews conducted with each health staff separately by local data collectors. The analysis was done manually by the principal investigator. This approach might lead to confirmation bias from the health professionals' side. However, we explained the purpose of the interview, gave them enough time to analyse the findings and give us honest feedback. The lead investigator was also not present in the interview setting to minimise unnecessary coercion effects. Moreover, the transcripts and emerging themes were discussed between research team members.

The trustworthiness of a study was ensured by implementing a detailed guide from data collection to interpretation, through record-keeping, presenting the details verbatim supporting the findings, and involving other researchers in the process (142). For Paper III, the investigator had prior assumptions when dealing with age reporting and causes of mortality under-reporting. However, we implemented different strategies to ensure neutrality, starting from the initial interview guide preparation to generating findings. The data collection tool was prepared by reviewing existing literature with feedback from other research team members. The data were collected by a trained interviewer and his assistant in the local language (*Sidamuu Afoo*). Field notes were taken by the assistant data collector. The transcription was done by individuals who

are fluent speakers of *Sidamuu Afoo*, Amharic and English. The audio recordings of the interviews and the transcripts were given to a member of the research team for the discussion of the emerging themes. In addition, the data collection period was short; this minimises the influence the researcher had on the participants. Furthermore, the qualitative findings were supported by the quantitative results and vice versa.

External validity

Generalisability and transferability

Generalisability is one way of addressing the external validity of a study. It refers to the extent to which inferences can be made to people not included in the study, based on the observed population (127,145). An evidence-based practice relies on the generalisability of a study. Applicability of a study's findings to other persons, measures, times and situations is an important aspect of the decision-making process (145,146). Increasing the sample size and random selection of participants might improve the generalisability of the study and statistical power as well. Sampling from more than one site could also enhance the representativeness of the study.

Likewise, transferability is also known as case-to-case translation or reader generalisability (145). Transferability is a form of theoretical or conceptual generalisation which is not expressed quantitatively (144). Transferability deals with the application of study findings to different settings or groups of people, mainly by the reader or consumer of the study. To ensure the transferability of a study, the researcher should present a detailed description of the setting,

context, participants and methodology. Thus, the reader is responsible for only extrapolating the results to similar contexts (145).

The external validity of the study is augmented by employing a robust study design, with clearly defined study participants and hypotheses, and the existence of similar findings in other studies (127). Hence, we ensured the representativeness of the study population by including all health facility visits from every primary health care unit and all *kebeles* in the study area (Papers I and II). For Paper III, we used a simple random sampling technique to select samples from the census database. Our study setting is primarily rural area with mixed agricultural and climatic conditions. Therefore, our findings could be representative of rural areas in the Ethiopian highlands because other studies from the country also showed inadequate health service usage (19,27,36). Similarly, different studies show that the country has been experiencing a fall in fertility and mortality rates in recent decades (71,147,148).

Discussion of the main findings

The main aim of this thesis was to measure health service utilisation from health facilities, as well as population demographic data, in rural Dale and Wonsho districts in the Sidama community. We observed a low health service utilisation rate. Family planning cases constituted the highest proportion, and a lower fertility rate was observed among different population categories of women. The low health service utilisation and the inability to make an accurate diagnosis could have contributed to reduced life expectancy and higher mortality estimates. Meanwhile, the improved usage of family planning services might be linked with the lower fertility level in the study area, compared to previously reported fertility rates.

Outpatient service utilisation is one of the global indicators of health service delivery suggested by the World Health Organization (WHO) (20). The number of outpatient department (OPD) visits recommended by the WHO is three to four visits per person per year (149). Low rates of outpatient visits indicate reduced accessibility or poor quality of services (21). A global study done in 130 countries showed an outpatient age-standardised utilisation rate of 5.4 visits per individual per year (150). However, the Ethiopian average OPD visit rate in 2015 was 0.48 visits per person per year, although the target was two visits per person per year by 2020 (4,151). Other community-based studies in Ethiopia showed utilisation rates of 0.46 (27) and 0.39 (36). In comparison, we demonstrated a lower health service utilisation rate. However, in a study done 30 years ago, the rate of first-visit outpatient service utilisation per year was 0.04 to 0.37 visits per person for health centres, and from 0.05 to 0.33 visits per person for health stations, which is far lower than our finding (19). This discrepancy may be due to the difference in outcome definitions, study period, and study design. The closure of health posts for some periods during working hours and the inability to provide some services by the health centres for the entire week could be other contributors to the low service utilisation (152). Other studies also show that patients prefer traditional medicine or self-treatment, private clinics, or they go to higher-level health facilities outside their catchment area (18,36). The reasons behind seeking these alternatives might include unsatisfactory quality of health services in government health facilities, absence of essential drugs and diagnostic tests, lack of skilled manpower, long waiting time, and unfriendly health staff (18,152,153). These could also be the challenges underlying the low health service utilisation observed in our study.

The health service utilisation rate can also be affected by demographic factors such as age, sex, marital status, education, area of residence and income (27,33,34). Consistent with our findings (Papers I and II), various studies have shown lower health services usage among the rural population than the urban residents (36,154). However, one study done in Kenya showed a higher health service utilisation among rural residents than urban dwellers (155). The possible explanation for this inverse relation was the higher self-medication tendency in urban Kenyan residents. The difference in health service utilisation rate between the areas of residence might be due to the lower education coverage, limited access to health facilities, and the pronounced poverty level exhibited in the rural population (31). This shows the challenges of addressing the health services needs of the rural community. Other determinants outside the health sector, such as education, economy, housing, social system, and governance, also influence the health of the population (156,157). Therefore, inputs from and partnerships between multiple sectors can help in resolving the challenges in health services and outcomes (157).

Age is one of the major demographic determinants of health service utilisation (33). A study showed that adults aged 20–59 years used health services more than children and older people above 60 years age (36). The reason for the difference in utilisation rates between these age groups might be due to their dependency on other adults to take them to health facilities. Besides, older people tend to rely more on traditional medicine than modern medicine (158). The number of children accessing services might decrease, since some child health services are not given throughout the week (152). This is consistent with our findings.

Another demographic factor affecting health service use is gender. In our study, there was a higher health service utilisation by women than men, which was consistent with other studies (27,98). This could be explained by the additional reproductive health needs, such as family planning, and antenatal and postnatal care services among women than men. Besides, women might get services of treatment for themselves while also taking their children to health facilities (27). Men also tend to self-medicate more than women (34). Overall, the differences in demographic attributes indicate the inequality in health service delivery across the population composition.

Over the past decades, Ethiopia has been working on the expansion and accessibility of health care services (159). Over a six-year period (2009-2014), the number of available health centres increased by 67% and health posts by 16% (160). However, there is a variation in the use and preference for health centres and health posts. Consistent with our findings (Papers I and II), other studies showed people's preference for health centres over health posts, hospitals and private health facilities (34,161). Studies elsewhere also showed better health service use among people living closer to health centres or hospitals (27,31). The possible explanation could be improved accessibility of health centre locations, in addition to the lack of skilled professionals and limited service availability at the health posts (18). The communities' perception of health extension workers as providers of only preventive services could also contribute to the preference for health centres over health posts (162). This implies the need for upgrading health posts and strengthening the capacity of the health extension workers. The Ethiopian government is currently scaling-up the health posts to a level at which they can give better health service, with more adequately trained professionals and equipment (15). Hence, we believe that changing the health system could improve health service utilisation by resolving the accessibility issue and

improving staff capacity. This would entail a change from a basic to a comprehensive health post level, where additional curative, maternal and child health, and non-communicable disease services are given by the health extension workers, midwives, nurses and health officers. These initiatives could also help in the realisation of the health-related SDGs, specifically achieving universal health coverage through improving primary health care services (1).

The triple burden of disease from communicable diseases, non-communicable diseases and injuries are one of the challenges Ethiopia has been facing in recent years, similarly to other developing nations (159). The revised Ethiopian essential health service package prioritised health services based on the disease burden of the country (23). Our findings on the common causes of morbidity are in line with the national health and health-related indicators study (160), yet different from a similar study done three decades ago (19). Pneumonia was a common cause of morbidity among children below five years of age in our study. There were, however, some discrepancies on other causes of morbidity between our study and others (19,160). We believe there might be inaccuracies, such as incorrect diagnoses, or over-diagnosis, in the recorded causes of morbidity, due to lack of knowledge or skill of the health staff (163). Therefore, we suggest improving the knowledge and skill of health professionals and ensuring the availability and functionality of diagnostic modalities.

Maternal and child health services have been given priority by the Ethiopian government (159,164). Even though family planning services constitute the largest (28%) maternal and child health service in our study, it was lower than other studies conducted elsewhere (165,166). The explanation for the discrepancy in the prevalence could be attributed to the inclusion of urban

areas and multiple sites in the other studies. However, we believe that the lower fertility rate demonstrated in our study area (65) could also be linked to the frequent use of family planning services. Above and beyond, in government health facilities, where most rural communities seek health services (18), family planning services are given free of charge.

In this study, the antenatal care, the institutional delivery and postnatal care utilisation were lower than the national and regional estimates (167,168), yet higher than findings from elsewhere (95,169,170). The explanation for the differences in maternal health service use might be linked to the methods of data collection (health facility-based, community-based, or linked studies), the context of the community (pastoral, agrarian, or mixed), and the availability of suitable maternity waiting and delivery rooms in primary health care units. These findings warrant the expansion of maternal health services with skilled professionals at the primary health care delivery units, to improve the low coverage identified.

Unfortunately, we believe that we failed to show the true picture of the non-communicable diseases in the study area. Contrary to our finding, various studies showed a high prevalence of hypertension (171–174), and the prevalence of anaemia was also higher in other studies (71). Likewise, the recorded number of diabetes cases in our study was very few. The discrepancy in the findings is most likely because of a lack of laboratory materials and clinical skills to make an accurate diagnosis at the health facilities. These findings imply the need to strengthen the diagnostic capacity and appropriate record-keeping at the primary health care unit level.

In our study, we involved health service providers by enabling them to present their suggestions for improving the health service, after reviewing the study results. Integration of health service providers, service managers, and other stakeholders in the research process has been implemented in the developed nations for some time, though it is a new practice in Africa (48,49). The collective process of these stakeholders and researchers impacts the quality of health research. It can also create a clear understanding of the problems and a framework for appropriate solutions (48–50). The research process should include an interaction between researchers and local, regional, national, and international policymakers. This relationship helps in establishing evidence, trust, and understanding, in order to realise the implementation of research findings (52,53). However, the health staff involved in our study might not have critically evaluated the results in relation to the day-to-day services at their institution. This may be due to social desirability bias, as a result of the political context that emphasises positive feedback and overlooks findings that require local or institutional recognition (175). Therefore, we suggest further studies to evaluate how the involvement of health workers in the research process could possibly enhance service provision and resource allocation.

According to the Ethiopian HMIS technical standard, a health facility is physically accessible if it is within 10 km or two hours walking distance (17). Consequently, geographically inaccessible health facilities are associated with lower health service coverage and lower health usage (29). Another study also revealed that the availability of health centres within a 5 km distance increases the service delivery substantially (176). As the new national initiative on optimising primary health care units is concerned with the expansion and upgrading of health facilities, these are key to meeting the needs of the population (15). We showed in our study that only

around half of the locations were within a 10 km distance from nearby health centres. Moreover, we observed an inverse relationship between the distance from the health centre to the centre of the *kebele* and the health service utilisation rate, as seen in other studies (19,26,27). These findings showed the geographic areas in which people lack access to better health services. Therefore, policymakers should focus on those areas when constructing health facilities, to improve accessibility and ultimately, enhance health service utilisation.

In Paper III, we demonstrated a decline in fertility rates in the study area. Ethiopia has been transitioning from high to low mortality and fertility, starting from the 1990s (73). The fertility decline was faster in Ethiopia than in other sub-Saharan countries (5). The total fertility rate of Sidama reported by the 2007 national census was 4.1 children per woman (110), which was lower than the 2016 National Demographic and Health Survey estimate of 4.6 children per woman (71). However, our finding showed a total fertility rate of 2.9 children per woman, which is lower than the census and the national survey results (71,177–179). The population pyramid also suggests the decline in fertility in the study area. Even though we believe in the declining trend of fertility in the study area, we also believe that under-reporting in mortality might have affected the magnitude substantially.

Fertility studies conducted in Ethiopia showed low fertility associated with higher income, 45–49 years age group, better education level, and urban dwellers (71,180). Consistent with other studies (71,181,182), a higher fertility rate was observed in our study among women in the 25–29 years age group. Surprisingly, as opposed to other studies, our study did not find higher educational level and urban residence as factors for lower fertility (71,180). Consistent with our

finding was a study done in 74 countries, where Guatemala, a central American country, showed an increase in fertility among urban women (183). In our study, no difference was observed between the fertility levels in highly educated women and uneducated women. Likewise, rural residents were less likely to give birth than their urban counterparts. These discrepancies might be explained by the fact that, in current times, uneducated and rural women have improved access to contraceptive use, whereas educated and urban women have enough financial support to raise more children (184–186). Another explanation for the increased fertility in the urban area could be the increment of rural-to-urban migration in African countries (187). The improved use of birth registration in urban communities, compared to their rural counterparts, might also partly explain the higher fertility level recorded in urban dwellers (188,189). There might also be a methodological reason for such differences. We used the number of births one year before the census, whereas the other studies used data from three years before the survey.

There has been a decrease in death rates in Ethiopia over the past 30 years. The crude death rate (CDR) decreased by 65% between 1985 and 2015. The median life expectancy has also increased from 46 years to 66 years during the same period (147). However, the CDR of 5.2 per 1,000 population in our study was lower than the CDR in other HDSS sites, which ranged from 6.1 to 8.0 per 1,000 population (177–179). The possible explanation for this variation might be the under-reporting of neonatal and child deaths (Paper III). Moreover, we did a sensitivity analysis by considering the possible reduction in number of deaths. Hence, we found a higher death rate and reduced life expectancy than we initially estimated. Therefore, we suggest considering different scenarios where confirmed data loss or under-reporting are observed, in order to reach a more accurate estimation.

A fast decline in fertility results in a change in dependency ratios (24). Following the Ethiopian population projection, it is believed that the dependency ratio will be high. The increasing family planning use could not guarantee a demographic dividend, if not supported by economic growth, and education and health sector achievements (5). However, the dependency ratio in our study was lower than the national (147) and HDSS estimates (179). Since the fertility level in our study was lower than others, it is expected to find a lower dependency ratio, especially the young dependency ratio. Therefore, the variability in the fertility rate might be one of the explanations for the difference observed. Another possible reason for the discrepancy might be related to the misreporting or the distortion in age reporting observed in our study among the lower- and higher-age groups. We have demonstrated the inaccuracies in age reporting by age reliability indices and the qualitative interviews. Therefore, caution should be taken when using self-reported ages in analysing and reporting such research findings.

Conclusion and recommendations

Conclusions

Our general aim was to measure the health service utilisation in the context of health and demographic study sites, and we concluded that the health service utilisation rate was low and unevenly distributed among population groups and geographically. The fertility rate was also low, and the mortality estimates remain high.

I present the conclusions for each of the specific objectives as follows:

Objective 1 aimed to assess the health service utilisation and disease patterns with local health authorities' suggestions for improving the health services (Paper I).

- The health service utilisation rate was low among rural residents, men, children and the elderly, and health post users.
- Pneumonia was the most prevalent disease recorded among children under five years of age.
- Family planning cases constituted the most frequently recorded services.
- Very few non-communicable diagnoses were recorded because of a lack of clinical skill and poor laboratory capacity.

Objective 2 was to explore geographical factors contributing to the variation in health service utilisation at the *kebele* level (Paper II).

- There was variation in health service utilisation between *kebeles*.
- The geographical factor associated with the low health care utilisation was the distance from the health centre to the centre of the *kebele*.

Objective 3 aimed to investigate the demographic structure and identify some limitations on how the population dynamics are studied in rural districts in the Sidama region in southern Ethiopia (Paper III).

- There was a lower fertility rate in Dale and Wonsho districts of the Sidama region than fertility rates reported by previous studies.
- The total fertility rate was affected by age, residence and education of women.

- Important measurement and reporting errors in age, births and deaths were identified. Consequently, the mortality rate was higher, and the life expectancy was lower than our initial findings.

Recommendations

Based on the research findings, the recommendation for the general objective is that the health planners and policymakers should measure and understand the geographical, disease type and population characteristics differences at a local community level. Separate recommendations are made for each specific objective below.

Operational recommendations

Several operational recommendations are made to improve the health service utilisation at primary health care delivery units in the Dale and Wonsho districts of the Sidama region in southern Ethiopia.

For Objective 1 (Paper I), the operational recommendations are the following:

- Ensure the availability of laboratory tests, drugs or medical supplies in primary health care units.
- Strengthen the capacity-building sessions to upgrade the knowledge of primary health care professionals.
- Establish functional diagnostic modalities at the primary health care level.

Regarding Objective 2 (Paper II), the recommendations for programme implementation are as follows:

- Reduce the distance between the health facilities and the community.
- Resources should be allocated based on the assessment of health service usage at the *kebele* level.

Regarding Objective 3 (Paper III), the operational recommendations are as follows**:**

- Strengthen interventions targeting a reduction of mortality rates.
- Ensure the continuation of contraceptive usage in the rural community.

Policy recommendations

The main policy recommendation is to improve the health service utilisation at primary health care delivery units by enhancing the quality of the service delivery and consequently reducing the mortality rates.

- Specifically, for Objective 1 (Paper I), I recommend improving the health service utilisation at the primary health care level by improving the diagnostic capacity and health professionals' skills.
- For Objective 2 (Paper II), I recommend constructing primary health care units close to the community to improve accessibility. The health extension programme optimisation roadmap should be accelerated to achieve the universal health coverage goal.
- For Objective 3 (Paper III), I recommend considering the demographic transition created by the lower fertility rate while planning for health services.

Future research

For Objective 1, I recommend the following research areas:

- Assessment of diagnostic accuracy, treatment options and determinant factors at the primary health care unit level could give new information to the health planners for improving health service usage.
- Ensure the involvement of local service users, service providers, and other stakeholders throughout the research process.

For Objective 2, I recommend determining the service area coverage by including all governmental and non-governmental health facilities; thus, unidentified areas for health facility construction could be discovered, and the physical accessibility of health services could improve.

For Objective 3, the recommendations are as follows:

- Assess trends of population change by including birth, deaths and migration, to identify the real process of the transition.
- Link the HDSS data with the health facility data, to identify individual demographic determinants of health service usage.
- Ensure the data quality of demographic sites by considering possible measurement errors, to decrease limitations observed in reporting of age, births and deaths.

References

1. World Health Organisation (WHO). Primary Health Care on the Road to Universal Health Coverage: 2019 Monitoring Report: Executive Summary. WHO; 2019; Available from: https://www.who.int/docs/default-source/documents/2019-uhc-report.pdf

2. Eregata GT, Hailu A, Memirie ST, Norheim OF. Measuring progress towards universal health coverage: National and subnational analysis in Ethiopia. BMJ Glob Heal. 2019;4:e001843. https://doi.org/10.1136/bmjgh-2019-001843

3. Slikkerveer LJ. Rural health development in Ethiopia:Problems of utilization of traditional healers. Soc Sci Med. 1982;16(21):1859–72. https://doi.org/10.1016/0277-9536(82)90447-6

4. Ethiopian Federal Ministry of Health. Health Sector Transformation Plan (2015/16-2019/20). 2015;1–84. Available from: https://www.issup.net/knowledge-share/publications/2021-05/health-sector-transformation-plan-201516-201920-0

5. Hailemariam A. Demographic Transition and Demographic Dividend in Ethiopia:Opportunities and Challenges; Country Case Study. 2012; Available from: https://www.researchgate.net/publication/271733028

6. Carrasquillo O. Health care utilization. In: Gellman MD, Turner RJ, editors. Encyclopedia of Behavioral Medicine. New York, NY: Springer; 2013. p. 909–10. https://doi.org/10.1007/978-1-4419-1005-9_885

7. World Bank. Global Civil Registration and Vital Statistics: Scaling up Investment Plan 2015–2024. 2014; Available from: https://www.worldbank.org/en/topic/health/publication/global-civil-registration-vital-statistics-scaling-up-investment

8. Joseph AE, Philips DR. Accessibility & Utilization: Geographical Perspectives on Health Care Delivery. London: Harper & Row Publishers; 1984.

9. Andersen RM. Revisiting the Behavioral Model and Access to Medical Care: Does it

Matter? J Health Soc Behav. 1995;36(1):1–10. https://doi.org/10.2307/2137284

10. World Health Organization. World Health Statistics 2014: Health Service Coverage. Geneva, Switzerland: World Health Organization; 2014. https://doi.org/978 92 4 156458 8

11. Lederle M, Tempes J, Bitzer EM. Application of Andersen's behavioural model of health services use: A scoping review with a focus on qualitative health services research. BMJ Open. 2021;11(5):e045018. https://doi.org/10.1136/BMJOPEN-2020-045018

12. Ryvicker M. A Conceptual Framework for Examining Healthcare Access and Navigation: A Behavioral-Ecological Perspective. Soc Theory Health. 2018;16(3):224–40. https://doi.org/10.1057/S41285-017-0053-2

13. Levesque JF, Harris MF, Russell G. Patient-centred access to health care: Conceptualising access at the interface of health systems and populations. Int J Equity Health. 2013;12(1):Article 18. https://doi.org/10.1186/1475-9276-12-18/FIGURES/2

14. Cu A, Meister S, Lefebvre B, Ridde V. Assessing healthcare access using the Levesque's conceptual framework – a scoping review. Int J Equity Health. 2021;20(1). https://doi.org/10.1186/S12939-021-01416-3

15. Ethiopian Federal Ministry of Health. An Implementation Manual for Optimizing Health Extension Program. Addis Ababa, Ethiopia; 2021.

16. Hogan DR, Stevens GA, Hosseinpoor AR, Boerma T. Monitoring universal health coverage within the Sustainable Development Goals: Development and baseline data for an index of essential health services. Lancet Glob Heal. 2018;6(2):e152–68. https://doi.org/10.1016/S2214-109X(17)30472-2

17. Ministry of Health [Ethiopia]. HMIS Indicator Definitions - Technical Standards: Area 1. 2014; Available from: https://www.measureevaluation.org/our-work/routine-health-information-systems/rhis-curriculum-modules/handout-2-2.4b

18. Federal Democratic Republic of Ethiopia Ministry of Health. Ethiopian Health Accounts Household Health Service Utilization and Expenditure Survey Brief 2015/2016. 2017; Available from: http://repository.iifphc.org/handle/123456789/408?show=full

19. Kloos H. Utilization of selected hospitals, health centres and health stations in Central, Southern and Western Ethiopia. Soc Sci Med. 1990;31(2):101–14. https://doi.org/10.1016/0277-9536(90)90052-T

20. World Health Organization. Global Reference List of 100 Core Health Indicators (plus health-related SDGs) [Internet]. Geneva, Switzerland:World Health Organization; 2018. Available from: https://www.who.int/publications-detail-redirect/2018-global-reference-list-of-100-core-health-indicators-(-plus-health-related-sdgs) https://doi.org/WHO/HIS/HSI/2015.3

21. World Health Organization. Monitoring the Building Blocks of Health Systems: A Handbook of Indicators and Their Measurement Strategies. 2010;35(1):1–110. Available from: https://apps.who.int/iris/handle/10665/258734 https://doi.org/10.1146/annurev.ecolsys.35.021103.105711

22. Rieger M, Wagner N, Mebratie A, Alemu G, Bedi A. The impact of the Ethiopian health extension program and health development army on maternal mortality: A synthetic control approach. Soc Sci Med. 2019;232:374–81. https://doi.org/10.1016/j.socscimed.2019.05.037

23. Ministry of Health of Ethiopia. Essential Health Services Package for Ethiopia. 2019;1–156. Available from: https://www.hfgproject.org/essential-package-of-health-services-country-snapshot-ethiopia/

24. Admassie A, Ali SN, May JF, Megquier S, Moreland S. The Demographic Dividend: An Opportunity for Ethiopia's Transformation. Population Reference Bureau. 2015; Available from: https://www.prb.org/resources/report-the-demographic-dividend-an-opportunity-for-ethiopias-transformation/

25. National Academies of Sciences, Engineering, and Medicine. Health-Care Utilization as a Proxy in Disability Determination. Washington, DC: National Academies Press; 2018. https://doi.org/10.17226/24969

26. Dangisso MH, Datiko DG, Lindtjørn B. Identifying geographical heterogeneity of pulmonary tuberculosis in southern Ethiopia: A method to identify clustering for targeted

interventions. Glob Health Action. 2020;13(1):1785737. https://doi.org/10.1080/16549716.2020.1785737

27. Girma F, Jira C, Girma B. Health services utilization and associated factors in Jimma zone, south west Ethiopia. Ethiop J Health Sci. 2011;21(Supp 1):85–94.

28. Cromley EK, McLafferty SL. GIS and Public Health. Second ed. New York: The Guilford Press; 2012.

29. Asemahagn MA, Alene GD, Yimer SA. Geographic Accessibility, Readiness, and Barriers of Health Facilities to Offer Tuberculosis Services in East Gojjam Zone, Ethiopia: A Convergent Parallel Design. Res Rep Trop Med. 2020;11:3–16. https://doi.org/10.2147/rrtm.s233052

30. Hiscock R, Pearce J, Blakely T, Witten K. Is neighborhood access to health care provision associated with individual-level utilization and satisfaction? Health Serv Res. 2008;43(6):2183–200. https://doi.org/10.1111/j.1475-6773.2008.00877.x

31. Begashaw B, Tessema F, Gesesew HA. Health Care Seeking Behavior in Southwest Ethiopia. PLoS One. 2016;11(9):e0161014. https://doi.org/10.1371/journal.pone.0161014

32. Areru HA, Dangisso MH, Lindtjørn B. Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: A facility-based cross-sectional study. BMC Health Serv Res. 2021;21(1):Article 776. https://doi.org/10.1186/S12913-021-06846-X

33. Pol LG, Thomas RK. In: Land KC editor. The Demography of Health and Health Care. 3rd ed. New York, London: Springer; 2013. https://doi.org/10.1007/978-90-481-8903-8

34. Masiye F, Kaonga O. Determinants of healthcare utilisation and out-of-pocket payments in the context of free public primary healthcare in Zambia. Int J Heal Policy Manag. 2016;5(12):693–703. https://doi.org/10.15171/ijhpm.2016.65

35. Yeneneh A, Alemu K, Dadi AF, Alamirrew A. Spatial distribution of antenatal care utilization and associated factors in Ethiopia: Evidence from Ethiopian demographic health surveys. BMC Pregnancy Childbirth. 2018;18(1):Article 242.

https://doi.org/10.1186/s12884-018-1874-2

36. Fantahun M, Degu G. Health Service Utilization in Amhara Region of Ethiopia. Ethiop J Heal Dev. 2004;17(2):141–7. https://doi.org/10.4314/ejhd.v17i2.9855

37. Nsubuga P, White ME, Thacker SB, Anderson MA, Blount SB, Broome C V., et al. Public Health Surveillance: A Tool for Targeting and Monitoring Interventions. In: Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, et al., editors. Disease Control Priorities in Developing Countries. The International Bank for Reconstruction and Development / The World Bank; 2006. p. 997–1015.

38. Tesema AG, Abimbola S, Mulugeta A, Ajisegiri S, Narasimhan P, Joshi R, et al. Health system capacity and readiness for delivery of integrated non-communicable disease services in primary health care: A qualitative analysis of the Ethiopian experience. PLOS Glob Public Heal. 2021;1(10):e0000026. https://doi.org/10.1371/journal.pgph.0000026

39. Lozano R, Fullman N, Mumford JE, Knight M, Barthelemy CM, Abbafati C, et al. Measuring universal health coverage based on an index of effective coverage of health services in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396(10258):1250–84. https://doi.org/10.1016/S0140-6736(20)30750-9/ATTACHMENT/B0A1AA3C-43E0-42E1-924C-F5355DECE722/MMC2.PDF

40. Emadi M, Delavari S, Bayati M. Global socioeconomic inequality in the burden of communicable and non-communicable diseases and injuries: An analysis on Global Burden of Disease Study 2019. BMC Public Health. 2021;21(1):Article 177. https://doi.org/10.1186/S12889-021-11793-7

41. World Health Organization (WHO). Technical Series on Safer Primary Care:Diagnostic errors. 2016;1–32. Available from: https://www.who.int/publications-detail-redirect/9789241511636 https://doi.org/10.1007/978-1-4471-4369-7_4

42. Wilson ML, Fleming KA, Kuti MA, Looi LM, Lago N, Ru K. Access to pathology and laboratory medicine services: A crucial gap. Lancet. 2018;391(10133):1927–38. https://doi.org/10.1016/S0140-6736(18)30458-6

43. Yadav H, Shah D, Sayed S, Horton S, Schroeder LF. Availability of essential diagnostics in ten low-income and middle-income countries: Results from national health facility surveys. Lancet Glob Heal. 2021;9(11):e1553-60. https://doi.org/10.1016/S2214-109X(21)00442-3

44. Ethiopian Public Health Institute (EPHI), Ethiopian Federal Ministry of Health, ICF International. Ethiopia Service Provision Assessment Plus (ESPA+). Addis Ababa, Ethiopia; Rockville, Maryland USA; 2014.

45. Organisation for Economic Cooperation and Development (OECD). Health at a Glance 2019:OECD Indicators [Internet]. Paris; 2019. Available from: https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2019_4dd50c09-en https://doi.org/10.1787/4dd50c09-en.

46. Ethiopian Federal Ministry of Health. Health Extension and Primary Health Service | FMOH [Internet]. 2019. Available from: https://www.moh.gov.et/ejcc/en/hephs

47. Cook N, Siddiqi N, Twiddy M, Kenyon R. Patient and public involvement in health research in low and middle-income countries: A systematic review. BMJ Open. 2019;9(5):e026514. https://doi.org/10.1136/bmjopen-2018-026514

48. Bergmeier H, Vandall-Walker V, Skrybant M, Teede H, Bailey C, Baxter JA, et al. Global Health in Preconception, Pregnancy and Postpartum Alliance: Development of an international consumer and community involvement (CCI) framework. Res Involv Engagem. 2020;1. https://doi.org/10.1186/s40900-020-00218-1

49. Miller CL, Mott K, Cousins M, Miller S, Johnson A, Lawson T, et al. Integrating consumer engagement in health and medical research - an Australian framework. Heal Res Policy Syst. 2017;15(1):9. https://doi.org/10.1186/s12961-017-0171-2

50. Boote J, Baird W, Sutton A. Public involvement in the systematic review process in health and social care: A narrative review of case examples. Health Policy (New York). 2011;102(2–3):105–16. https://doi.org/10.1016/j.healthpol.2011.05.002

51. Regidor E, de la Fuente L, Gutiérrez-Fisac JL, de Mateo S, Pascual C, Sánchez-Payá J, et

al. The role of the public health official in communicating public health information. Am J Public Health. 2007;97(Supp 1):S93-7. https://doi.org/10.2105/AJPH.2006.094623

52. Lindtjørn B, Tadesse M, Loha E. Developing a sustainable PhD programme: Experiences from southern Ethiopia. In: Halvorsen T, Orgeret KS, editors. Sharing Knowledge, Transforming Societies: The Norhed Programme 2013-2020. Bergen,Norway: African Minds; 2019. p. 442–56.

53. Lindtjørn B. Could devolving pneumonia treatment to local health centres reduce mortality in developing countries? Acta Paediatr Int J Paediatr. 2020;110(2):389–90. https://doi.org/10.1111/apa.15584

54. Ministry of Health [Ethiopia]. Realizing Universal Health Coverage Through Primary Health Care: A Roadmap for Optimizing the Ethiopian Health Extension Program 2020-2035. 2020; Available from: http://repository.iifphc.org/handle/123456789/1191

55. Farup PG, Blix I, Førre S, Johnsen G, Lange O, Johannessen R, et al. What causes treatment failure - the patient, primary care, secondary care or inadequate interaction in the health services? BMC Health Serv Res. 2011;11(1):111. https://doi.org/10.1186/1472-6963-11-111

56. Arsenault C, Yakob B, Tilahun T, Nigatu TG, Dinsa G, Woldie M, et al. Patient volume and quality of primary care in Ethiopia: Findings from the routine health information system and the 2014 Service Provision Assessment survey. BMC Health Serv Res. 2021;21(1):485. https://doi.org/10.1186/s12913-021-06524-y

57. MacInko J, Starfield B, Erinosho T. The impact of primary healthcare on population health in low- and middle-income countries. J Ambul Care Manage. 2009;32(2):150–71. https://doi.org/10.1097/JAC.0b013e3181994221

58. World Health Organization (WHO). Primary Health Care [Internet]. 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/primary-health-care

59. Workie NW, Ramana GN V. The health extension program in Ethiopia [Internet]. The Universal Health Coverage Studies Series. Washington, DC; 2013. Available from:

https://openknowledge.worldbank.org/handle/10986/13280

60. Centers for Disease Control and Prevention. What is Population Health? | Population Health Training in Place Program (PH-TIPP) [Internet]. Available from: https://www.cdc.gov/pophealthtraining/whatis.html

61. Kindig D, Stoddart G. What Is Population Health? Am J Public Health. 2003;93(3):380–3. https://doi.org/10.2105/AJPH.93.3.380

62. Shryock HS, Siegel JS. The Methods and Materials of Demography. Condensed. Edward GS, editor. San Diego, California: Academic Press, Inc; 1976. https://doi.org/10.2307/2576436

63. Duffy BJ. Demography and Public Health. Milbank Q. 1964;42(2):276–86. https://doi.org/10.2307/3348667

64. Newell. C. Methods and Models in Demography. New York: The Guilford Press; 1988.

65. Areru HA, Dangisso MH, Lindtjørn B. Births and deaths in Sidama in southern Ethiopia: Findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS). Glob Health Action. 2020;13(1):1833511. https://doi.org/10.1080/16549716.2020.1833511

66. Yusuf F, Martins JM, Swanson DA. Methods of Demographic Analysis. Springer; 2014. https://doi.org/10.1007/978-94-007-6784-3

67. Ethiopian Public Health Association. Ethiopian Universities Health and Demographic Surveillance System: Network Data Sharing and Release Policy. 2013; Available from: https://www.etpha.org/publications/other-publications.html?download=479:hdss-network-policy

68. Owusu-Agyei S, Nettey OEA, Zandoh C, Sulemana A, Adda R, Amenga-Etego S, et al. Demographic patterns and trends in Central Ghana: Baseline indicators from the Kintampo Health and Demographic Surveillance System. Glob Health Action. 2012;5:1–11. https://doi.org/https://doi.org/10.3402/gha.v5i0.19033

69. INDEPTH Network. Population and Health in Developing Countries: Vol 1: Population, Health, and Survival at INDEPTH Sites. 2002; Available from: http://hdl.handle.net/10625/29621

70. Danish National ID Centre. Ethiopian civil certificates issued by the Vital Events Registration Agency [Internet]. Copenhagen, Denmark; 2018. Available from: https://www.nidc.dk/-/media/27CFA7A921B54F8292C5CEB140E1181A.pdf

71. Central Statistical Agency (CSA) [Ethiopia] and ICF. Ethiopia, Demographic and Health Survey 2016. Addis Ababa, Ethiopia and Rockville, Maryland, USA: CSA and ICF.: The DHS Program ,ICF; 2016.

72. Institute of Medicine (US). Committee on the Adequacy of Nursing Staff in Hospitals and Nursing Homes. Implications of Population Change. In: Wunderlich GS, Sloan F, Davis CK, editors. Nursing Staff in Hospitals and Nursing Homes: Is it Adequate? Washington, DC: National Academies Press (US); 1996.

73. Hailemariam A. Ethiopia's Changing Demography. In: Cheru F, Cramer C, Oqubay A, editors. The Oxford Handbook of Ethiopian Economy. New York: Oxford University Press; 2019. p. 366–82.

74. Teller CH, Hailemariam A, Gebreselassie T, Seifu Y. The uniqueness of the Ethiopian demographic transition within sub-Saharan Africa: Multiple responses to population pressure, and preconditions for rural fertility decline and capturing the demographic dividend. African Popul Stud. 2011;25(2):362–80. https://doi.org/10.11564/25-2-236

75. Duffy BJ, Behm H. Demography and Public Health. Milbank Q [Internet]. 1964;42(2):276–86. Available from: https://www.jstor.org/stable/3348667

76. Bollyky TJ, Templin T, Cohen M, Dieleman JL. Lower-income countries that face the most rapid shift in noncommunicable disease burden are also the least prepared. Health Aff. 2017;36(11):1866–75. https://doi.org/10.1377/HLTHAFF.2017.0708/ASSET/IMAGES/LARGE/FIGUREEX5.JPEG

77. Bonfrer I, Van De Poel E, Grimm M, Van Doorslaer E. Does the distribution of healthcare utilization match needs in Africa? Health Policy Plan. 2014;29(7):927–37. https://doi.org/10.1093/heapol/czt074

78. Cerf ME. Sustainable Development Goal Integration, Interdependence, and Implementation: The Environment-Economic-Health Nexus and Universal Health Coverage. Glob Challenges. 2019;3(9):1900021. https://doi.org/10.1002/gch2.201900021

79. Haldane V, Chuah FLH, Srivastava A, Singh SR, Koh GCH, Seng CK, et al. Community participation in health services development, implementation, and evaluation: A systematic review of empowerment, health, community, and process outcomes. PLoS One. 2019;14(5):e0216112. https://doi.org/10.1371/journal.pone.0216112

80. Central Statistical Agency EDRI, International Food Policy Research Institute. Population & Housing Census Atlas of Ethiopia 2007 [Internet]. Washington, DC , USA; Addis Ababa, Ethiopia; 2010. Available from: https://www.ifpri.org/publication/population-housing-census-atlas-ethiopia-2007 https://doi.org/10.2499/9780896299276

81. Central Statistical Agency. 2007 Population and Housing Census of Ethiopia: Section-B Population [Internet]. Addis Ababa, Ethiopia; 2007. Available from: https://rise.esmap.org/data/files/library/ethiopia/Documents/Clean Cooking/Ethiopia_Census 2007.pdf

82. Federal Democratic Republic of Ethiopia Population Census Commisssion. Summary and Statistical Report of the 2007 Population and Housing Census: Population Size by Age and Sex [Internet]. Addis Ababa, Ethiopia; 2008. Available from: https://agris.fao.org/agris-search/search.do?recordID=XF2015048396 https://doi.org/10.16309/j.cnki.issn.1007-1776.2003.03.004

83. Sidama Zone Finance and Economic Development Office. Sidama Zone Administration Socio-Economic Profile 2014/15 [Internet]. Hawassa, SNNPR; 2016. Available from: https://www.scirp.org/(S(czeh2tfqw2orz553k1w0r45))/reference/referencespapers.aspx?referenceid=2619750

84. United States Agency for International Development. Ethiopia Southern Nations ,

Nationalities and Peoples Region (SNNPR) Overview of Livelihood Profiles. Washington, DC, USA; 2005.

85. Dira S, Hewlett B. Learning to Survive Ecological Risks among the Sidama of Southwestern Ethiopia. J Ecol Anthropol [Internet]. 2016;18(1):Article 7. Available from: https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=1183&context=jea https://doi.org/10.5038/2162-4593.18.1.7

86. Federal Democratic Republic of Ethiopia Population Census Commisssion. The 2007 Population and Housing Census of Ethiopia: Statistical Report for Southern Nations, Nationalities and Peoples' Region; Part I: Population Size and Characteristics [Internet]. Addis Ababa, Ethiopia; 2007. Available from: https://rise.esmap.org/data/files/library/ethiopia/Documents/Clean Cooking/Ethiopia_Census 2007.pdf

87. Abebe T, Bongers F. Land-use dynamics in enset-based agroforestry homegardens in Ethiopia. In: Arts B, Bommel S van, Ros-Tonen M, Verschoor G, editors. Forest People Interfaces: Understanding Community Forestry and Biocultural Diversity. Wageningen, Netherlands: Wageningen Academic Publishers; 2012. p. 69–85.

88. Quinlan RJ, Dira SJ, Caudell M, Quinlan MB. Culture and psychological responses to environmental shocks: Cultural ecology of Sidama impulsivity and niche construction in Southwest Ethiopia. Curr Anthropol. 2016;57(5):632–52. https://doi.org/10.1086/688213

89. Dalle Woreda Finance and Economic Development Office. The development of social and economical information of Dalle woreda. Hawassa, SNNPR; 2016.

90. Mengesha AD. The role of Sidama Indigenous Institutions in Conflict Resolution: In the Case of Dalle Woreda , Southern Ethiopia. Am J Sociol Res. 2016;6(1):10–26. https://doi.org/10.5923/j.sociology.20160601.02

91. Lindtjørn B. The role of a mission organization in building a sustainable government hospital in Southern Ethiopia. Christ J Glob Heal. 2020;7(2):133–46. https://doi.org/10.15566/cjgh.v7i2.351

92. World Health Organization (WHO), The World Bank. Tracking Universal Health Coverage: 2017 Global Monitoring Report [Internet]. 2017. Available from: https://apps.who.int/iris/bitstream/handle/10665/259817/9789241513555-eng.pdf https://doi.org/10.1596/978-92-4-151355-5

93. Nicholson D, Yates R, Warburton W, Fontana G. Delivering Universal Health Coverage: A Guide for Policymakers. [Internet]. Report of the WISH Universal Health Coverage Forum 2015. London,UK; 2015. Available from: https://afhea.org/en/2014-02-11-15-47-44/research-dissemination/2014-07-22-11-43-33/32-policy-uhc/1425-delivering-universal-health-coverage-a-guide-for-policymakers

94. Borde MT, Loha E, Johansson KA, Lindtjorn B. Utilisation of health services fails to meet the needs of pregnancy-related illnesses in rural southern Ethiopia: A prospective cohort study. PLoS One. 2019;14(12):e0215195. https://doi.org/10.1371/journal.pone.0215195

95. Umer A, Zinsstag J, Schelling E, Tschopp R, Hattendof J, Osman K, et al. Antenatal care and skilled delivery service utilisation in Somali pastoral communities of Eastern Ethiopia. Trop Med Int Heal. 2019;25(3):328–37. https://doi.org/10.1111/tmi.13346

96. Tukue D, Gebremeskel TG, Gebremariam L, Aregawi B, Hagos MG, Gebremichael T, et al. Prevalence and determinants of modern contraceptive utilization among women in the reproductive age group in Edaga-hamus Town, Eastern zone, Tigray region, Ethiopia, June 2017. PLoS One. 2020;15(3):e0227795. https://doi.org/10.1371/journal.pone.0227795

97. Darega B, Dida N, Tafese F, Ololo S. Institutional delivery and postnatal care services utilizations in Abuna Gindeberet District, West Shewa, Oromiya Region, Central Ethiopia: A community-based cross sectional study. BMC Pregnancy Childbirth. 2016;16:Article 149. https://doi.org/10.1186/s12884-016-0940-x

98. Bazie GW, Adimassie MT. Modern health services utilization and associated factors in North East Ethiopia. PLoS One. 2017;12(9):e0185381. https://doi.org/10.1371/journal.pone.0185381

99. Amsalu ET, Akalu TY, Gelaye KA. Spatial distribution and determinants of acute

respiratory infection among under-five children in Ethiopia: Ethiopian Demographic Health Survey 2016. PLoS One. 2019;14(4):e0215572. https://doi.org/10.1371/journal.pone.0215572

100. Gebreyesus SH, Mariam DH, Woldehanna T, Lindtjørn B. Local spatial clustering of stunting and wasting among children under the age of 5 years: Implications for intervention strategies. Public Health Nutr. 2016;19(8):1417–27. https://doi.org/10.1017/S1368980015003377

101. Kibret KT, Chojenta C, D'Arcy E, Loxton D. Spatial distribution and determinant factors of anaemia among women of reproductive age in Ethiopia: A multilevel and spatial analysis. BMJ Open. 2019;9(4):e027276. https://doi.org/10.1136/bmjopen-2018-027276

102. World Health Organization. Health Facility Survey: Tool to evaluate the quality of care delivered to sick children attending outpatient facilities. Geneva, Switzerland; 2003.

103. United States Agency for International Development (USAID). Indicator Guide. Monitoring and evaluating integrated community case management [Internet]. Washington, DC, USA; 2013. Available from: http://1rqxbs47ujl4rdy6q3nzf554.wpengine.netdna-cdn.com/wp-content/uploads/2016/07/iCCM-Indicator-Guide.pdf

104. Staniszewska S, Brett J, Simera I, Seers K, Mockford C, Goodlad S, et al. GRIPP2 reporting checklists: Tools to improve reporting of patient and public involvement in research. BMJ. 2017;358:j3453. https://doi.org/10.1136/bmj.j3453

105. Rothman KJ, Greenland S, Lash TL, editors. Modern Epidemiology. 3rd ed. Philadelphia, PA, USA: Lippincott Williams & Wilkins; 2008. https://doi.org/10.1136/pgmj.63.739.418-b

106. Pankhurst A, Mariam DH. The iddir in Ethiopia: Historical development, social function, and potential role in HIV/AIDS prevention and control. Northeast Afr Stud. 2000;7(2):35–57. https://doi.org/10.1353/nas.2004.0018

107. Dean AG, Sullivan KM, Soe MM. OpenEpi: Open Source Epidemiologic Statistics for

Public Health, Version 3.01 [Internet]. 2013. Available from: www.OpenEpi.com

108. Lauritsen JM, Bruus M. EpiData (version 3.1). A Comprehensive Tool for Validated Entry and Documentation of Data. Odense, Denmark; 2004.

109. StataCorp. Stata Statistical Software: Release 13. College Station, TX; 2013.

110. Central Statistical Agency. 2007 National Census, Ethiopia [Internet]. Addis Ababa, Ethiopia; 2007. Available from: https://www.statsethiopia.gov.et/census-2007-2/

111. ESRI. ArcGIS 10.3 for Desktop. Redlands, CA, USA; 2014.

112. Kulldorff M. Software for the Spatial and Space-Time Scan Statistics: Version 9.6.1. Calverton, MD, USA; 2020.

113. Bwalya BB, Phiri M, Mwansa C. Digit Preference and Its Implications on Population Projections in Zambia: Evidence From the Census Data. Int J Curr Adv Res. 2015;4(5):92–7.

114. Francis EB, Senyefia BA, Sena BB. Statistical analysis of age reporting errors by insured and uninsured patients in Cape Coast Teaching Hospital of Ghana. Biomed Stat Informatics. 2019;4(2):15–21. https://doi.org/10.11648/j.bsi.20190402.11

115. Bollinger L, Stover J, Hecht K, Podk T, Schmidt J, Wyman J. Spectrum Manual. Glastonbury, CT, USA: Avenir Health; 2019.

116. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. Behav Res Methods. 2009;41:1149–60. https://doi.org/10.3758/BRM.41.4.1149

117. Mann CJ. Observational research methods. Research design II: Cohort, cross sectional, and case-control studies. Emerg Med J. 2003;20(1):54–60. https://doi.org/10.1136/EMJ.20.1.54

118. Levin KA. Study design III: Cross-sectional studies. Evid Based Dent. 2006;7(1):24–5. https://doi.org/10.1038/sj.ebd.6400375

119. Grimes DA, Schulz KF. An overview of clinical research: The lay of the land. Lancet. 2002;359(9300):57–61. https://doi.org/10.1016/s0140-6736(02)07283-5

120. Reichenheim ME, Coutinho ES. Measures and models for causal inference in cross-sectional studies: Arguments for the appropriateness of the prevalence odds ratio and related logistic regression. BMC Med Res Methodol. 2010;10:Article 66. https://doi.org/10.1186/1471-2288-10-66/FIGURES/4

121. Levin KA. Study design VI - Ecological studies. Evid Based Dent. 2006;7(4):108. https://doi.org/10.1038/SJ.EBD.6400454

122. Boulos MNK. GIS in Public Health Practice. Photogramm Rec. 2005;20(111):303–5. https://doi.org/10.1111/j.1477-9730.2005.00333_1.x

123. Hart J. On ecological studies: A short communication. Dose-Response. 2011;9(4):497–501. https://doi.org/10.2203/DOSE-RESPONSE.10-046.HART

124. Elliott P, Wartenberg D. Spatial epidemiology: Current approaches and future challenges. Environ Health Perspect. 2004;112(9):998–1006. https://doi.org/10.1289/ehp.6735

125. Pourhoseingholi MA, Vahedi M, Rahimzadeh M. Sample size calculation in medical studies. Gastroenterol Hepatol From Bed to Bench. 2013;6(1):14–7. https://doi.org/10.22037/ghfbb.v6i1.332

126. Christensen R, Bours MJL, Nielsen SM. Effect Modifiers and Statistical Tests for Interaction in Randomized Trials. J Clin Epidemiol. 2021;134:174–7. https://doi.org/10.1016/j.jclinepi.2021.03.009

127. Bonita R, Beaglehole R, T Kjellström, WHO. Basic Epidemiology [Internet]. 2nd ed. Geneva, Switzerland: World Health Organization; 2006. Available from: https://apps.who.int/iris/handle/10665/43541 https://doi.org/10.1136/bmj.308.6926.483

128. McHugh ML. Lessons in biostatistics: Power analysis in research. Biochem Medica. 2008;18(3):263–74.

129. Grimes DA, Schulz KF. Bias and causal associations in observational research. Lancet.

2002;359(9302):248–52. https://doi.org/10.1016/S0140-6736(02)07451-2

130. Delgado-Rodríguez M, Llorca J. Bias. J Epidemiol Community Health. 2004;58(8):635–41. https://doi.org/10.1136/jech.2003.008466

131. World Health Organization. International Statistical Classification of Diseases and Related Health Problems - 10th revision [Internet]. 5th ed. Vol. 3. Geneva, Switzerland; 2016. Available from: https://www.who.int/standards/classifications/classification-of-diseases

132. Federal Democratic Republic of Ethiopia Ministry of Health. National Classification of Diseases (NCoD). Compact ed. Addis Ababa, Ethiopia: Ministry of Health; 2017.

133. INDEPTH Network. INDEPTH Resource Kit for Demographic Surveillance Systems (Beta Version 0.9) [Internet]. 2008. Available from: http://www.indepth-network.org/Resource Kit/INDEPTH DSS Resource Kit/INDEPTH DSS Resource Kit.htm

134. Verbeek JH, Whaley P, Morgan RL, Taylor KW, Rooney AA, Schwingshackl L, et al. An approach to quantifying the potential importance of residual confounding in systematic reviews of observational studies: A GRADE concept paper. Environ Int. 2021;157:106868. https://doi.org/10.1016/J.ENVINT.2021.106868

135. Wasserstein RL, Lazar NA. The ASA'sstatement on p-values: Context, process, and purpose. Am Stat. 2016;70(2):129–33. https://doi.org/10.1080/00031305.2016.1154108/SUPPL_FILE/UTAS_A_1154108_SM8096.PDF

136. Yaddanapudi L. The American Statistical Association statement on p-values explained. J Anaesthesiol Clin Pharmacol. 2016;32(4):421–3. https://doi.org/10.4103/0970-9185.194772

137. Wasserstein RL, Schirm AL, Lazar NA. Moving to a world beyond "p < 0.05." Am Stat. 2019;73(Supp 1):1–19. https://doi.org/10.1080/00031305.2019.1583913

138. Rothman KJ. Causes. Am J Epidemiol. 1976;104(6):587–92. https://doi.org/10.1093/aje/155.5.478

139. Hill A. The environment and disease: Association or causation? Proc R Soc Med. 1965;58(5):295–300.

140. Rothman KJ, Greenland S. Hill's criteria for causality. Encyclopedia of Biostatistics. John Wiley &Sons; 2005. https://doi.org/10.1002/0470011815.b2a03072

141. Banack HR, Bea JW, Kaufman JS, Stokes A, Kroenke CH, Stefanick ML, et al. The Effects of Reverse Causality and Selective Attrition on the Relationship Between Body Mass Index and Mortality in Postmenopausal Women. Am J Epidemiol. 2019;188(10):1838–48. https://doi.org/10.1093/AJE/KWZ160

142. Noble H, Smith J. Issues of validity and reliability in qualitative research. Evid Based Nurs. 2015;18(2):34–5. https://doi.org/10.1136/EB-2015-102054

143. Daniel BK. Using the TACT framework to learn the principles of rigour in qualitative research. Electron J Bus Res Methods. 2019;17(3):118–29. https://doi.org/10.34190/JBRM.17.3.002

144. Laake P, Benestad HB, Olsen BR. Research in Medical and biological Sciences: From Planning and Preparation to Grant Application and Publication. Academic Press; 2015.

145. Polit DF, Beck CT. Generalization in quantitative and qualitative research: Myths and strategies. Int J Nurs Stud. 2010;47(11):1451–8. https://doi.org/10.1016/j.ijnurstu.2010.06.004

146. Steckler A, McLeroy KR. The Importance of External Validity. Am J Public Health. 2008;98(1):9–10. https://doi.org/10.2105/AJPH.2007.126847

147. United Nations. World Population Prospects. [Internet]. United Nations. 2019. Available from: https://population.un.org/wpp/

148. UNICEF. Child Mortality - UNICEF DATA. [Internet]. UNICEF. 2019. Available from: https://data.unicef.org/topic/child-survival/under-five-mortality/

149. World Health Organization. Eastern Mediterranean Region Indicator and Metadata Registry [Internet]. World Health Organization. 2016 [cited 2020 Mar 5]. Available from:

http://gis.emro.who.int/EMRIMR/Indicators.aspx?i=1

150. Moses MW, Pedroza P, Baral R, Bloom S, Brown J, Chapin A, et al. Funding and services needed to achieve universal health coverage: Applications of global, regional, and national estimates of utilisation of outpatient visits and inpatient admissions from 1990 to 2016, and unit costs from 1995 to 2016. Lancet Public Heal. 2019;4(1):e49–73. https://doi.org/10.1016/S2468-2667(18)30213-5

151. Ethiopian Federal Ministry of Health. Fact Sheets: Fact Sheet - Ethiopia 2015 [Internet]. 2015. Available from: http://www.moh.gov.et/ejcc/en/node/15

152. Hailemariam S, Gebeyehu Y, Loha E, Johansson KA, Lindtjørn B. Inadequate management of pneumonia among children in South Ethiopia: Findings from descriptive study. BMC Health Serv Res. 2019;19(1):426. https://doi.org/10.1186/s12913-019-4242-7

153. Carter JY, Lema OE, Wangai MW, Munafu CG, Rees PH, Nyamongo JA. Laboratory testing improves diagnosis and treatment outcomes in primary health care facilities. Afr J Lab Med. 2011 Dec;1(1):8. https://doi.org/10.4102/ajlm.v1i1.8

154. Alebachew A, Hatt L, Kukla M, Nakhimovsky S. Universal Health Coverage Measurment in a Low-Income Context : An Ethiopian Case Study. Bethesda, MD, USA: Health Finance & Governance Project, Abt Associates Inc.; 2014.

155. Mwami MN, Oleche MO. Determinants of Utilization of Health Care Services in Kenya. Int J Acad Res Bus Soc Sci. 2017;7(10):132–56. https://doi.org/10.6007/ijarbss/v7-i10/3367

156. Kruk ME, Lewis TP, Arsenault C, Bhutta ZA, Irimu G, Jeong J, et al. Optimising Child and Adolescent Health and Development 4: Improving health and social systems for all children in LMICs: Structural innovations to deliver high-quality services. Lancet. 2022;399:1830–44. https://doi.org/10.1016/ S0140-6736(21)02532-0

157. Amri M, Chatur A, O'Campo P. Intersectoral and multisectoral approaches to health policy: An umbrella review protocol. Heal Res Policy Syst [Internet]. 2022;20:Article 21. Available from: https://health-policy-systems.biomedcentral.com/articles/10.1186/s12961-

022-00826-1 https://doi.org/10.1186/S12961-022-00826-1/PEER-REVIEW

158. James PB, Wardle J, Steel A, Adams J. Traditional, complementary and alternative medicine use in sub-Saharan Africa: A systematic review. BMJ Glob Heal. 2018;3(5):e000895. https://doi.org/10.1136/bmjgh-2018-000895

159. Ethiopian Federal Ministry of Health. Ethiopia's Health Sector: Excellent Returns on Your Development Funding [Internet]. Addis Ababa, Ethiopia: Federal Ministry of Health; 2013. Available from: https://www.uhc2030.org/fileadmin/uploads/ihp/Documents/Country_Pages/Ethiopia/Ethiopias_Health_Sector_Excellent_Returns_Feb2013.pdf

160. Ethiopian Federal Ministry of Health. Health and Health-Related Indicators: Better Information, Better Decision, Better Health; Version 1. Addis Ababa, Ethiopia: Policy Planning Directorate, Federal Ministry of Health; 2015.

161. Mebratie AD, Van De Poel E, Yilma Z, Abebaw D, Alemu G, Bedi AS. Healthcare-seeking behaviour in rural Ethiopia: Evidence from clinical vignettes. BMJ Open. 2014;4(2):e400020. https://doi.org/10.1136/bmjopen-2013-004020

162. Medhanie AA, Spigt M, Kifle YT, Schaay N, Sanders D, Blanco M, Dinant G, Berhane Y. The Contribution of Health Extension Workers in Improving the Utilization of Maternal Health Services in Rural Areas of Tigray, Ethiopia. In: Labonté R, Sanders D, Packer C SN, editor. Revitalizing Health for All: Case Studies of the Struggle for Comprehensive Primary Health Care. Canada: University of Toronto Press Toronto, Canada; 2017. p. 237–54.

163. Tariku A, Okwaraji YB, Worku A, Biks GA, Åke Persson L, Berhane Y. Prevention and treatment of suspected pneumonia in Ethiopian children less than five years from household to primary care. Acta Paediatr. 2020;110(2):602–10. https://doi.org/10.1111/apa.15380

164. Donnelly J. Ethiopia gears up for more major health reforms. Lancet. 2011;377(9781):1907–8. https://doi.org/10.1016/S0140-6736(11)60795-2

165. Ahmed S, Choi Y, Rimon JG, Alzouma S, Gichangi P, Guiella G, et al. Trends in contraceptive prevalence rates in sub-Saharan Africa since the 2012 London Summit on Family Planning: Results from repeated cross-sectional surveys. Lancet Glob Heal. 2019;7(7):e904–11. https://doi.org/10.1016/S2214-109X(19)30200-1

166. Endriyas M, Eshete A, Mekonnen E, Misganaw T, Shiferaw M, Ayele S. Contraceptive utilization and associated factors among women of reproductive age group in Southern Nations Nationalities and Peoples' Region, Ethiopia: Cross-sectional survey, mixed-methods. Contracept Reprod Med. 2017;2(10). https://doi.org/10.1186/s40834-016-0036-z

167. Ethiopian Public Health Institute (EPHI) and ICF. Ethiopia Mini Demographic and Health Survey 2019: Key Indicators. Rockville, Maryland, USA: EPHI and ICF.; 2019.

168. Regassa N. Antenatal and postnatal care service utilization in Southern Ethiopia: A population-based study. Afr Health Sci. 2011;11(3):390–7.

169. Worku AG, Yalew AW, Afework MF. Factors affecting utilization of skilled maternal care in Northwest Ethiopia: A multilevel analysis. BMC Int Health Hum Rights. 2013;13:20. https://doi.org/10.1186/1472-698X-13-20

170. Tesfaw N, Gizachew A, Kassa GM, Abajobir AA. Skilled Delivery Service Utilization and Associated Factors among Mothers Who Gave Birth in the Last Two Years in Northwest Ethiopia. Ethiop J Health Sci. 2018;28(4):423–32. https://doi.org/10.4314/ejhs.v28i4.8

171. Belachew A, Tewabe T, Miskir Y, Melese E, Wubet E, Alemu S, et al. Prevalence and associated factors of hypertension among adult patients in Felege-Hiwot Comprehensive Referral Hospitals, northwest Ethiopia: A cross-sectional study. BMC Res Notes [Internet]. 2018;11:Article 876. Available from: https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-018-3986-1 https://doi.org/10.1186/s13104-018-3986-1

172. Kibret KT, Mesfin YM. Prevalence of hypertension in Ethiopia: A systematic meta-analysis. Public Health Rev [Internet]. 2015;36:Article 14. Available from: https://publichealthreviews.biomedcentral.com/articles/10.1186/s40985-015-0014-z

https://doi.org/10.1186/s40985-015-0014-z

173. Zekewos A, Egeno T, Loha E. The magnitude of hypertension and its risk factors in southern Ethiopia: A community based study. PLoS One. 2019;14(8):e0221726. https://doi.org/10.1371/journal.pone.0221726

174. Chuka A, Gutema BT, Ayele G, Megersa ND, Melketsedik ZA, Zewdie TH. Prevalence of hypertension and associated factors among adult residents in Arba Minch Health and Demographic Surveillance Site, Southern Ethiopia. PLoS One. 2020;15(8):e0237333. https://doi.org/10.1371/journal.pone.0237333

175. Østebø MT, Cogburn MD, Mandani AS. The silencing of political context in health research in Ethiopia: Why it should be a concern. Health Policy Plan. 2018;33(2):258–70. https://doi.org/10.1093/heapol/czx150

176. Croke K, Telaye Mengistu A, O'Connell SD, Tafere K. The impact of a health facility construction campaign on health service utilisation and outcomes: Analysis of spatially linked survey and facility location data in Ethiopia. BMJ Glob Heal. 2020;5(8):e002430. https://doi.org/10.1136/bmjgh-2020-002430

177. INDEPTH Network. Profile of Dabat Health and Demographic Surveillance System [Internet]. Gondar, Ethiopia; 2012. Available from: http://www.indepth-network.org/sites/default/files/content/centres/files/dabat hdss.pdf

178. INDEPTH Network. Gilgel Gibe Field Research Centre [Internet]. Jimma, Ethiopia; 2011. Available from: http://www.indepth-network.org/Profiles/Gilgel HDSS.pdf

179. Assefa N, Oljira L, Baraki N, Demena M, Zelalem D, Ashenafi W, et al. HDSS profile: The Kersa Health and Demographic Surveillance System. Int J Epidemiol. 2016;45(1):94–101. https://doi.org/10.1093/ije/dyv284

180. Mekonnen W, Worku A. Determinants of fertility in rural Ethiopia: The case of Butajira Demographic Surveillance System (DSS). BMC Public Health [Internet]. 2011;11(1):Article 782. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-11-782

https://doi.org/10.1186/1471-2458-11-782

181. Assefa N, Semahegn A. Fertility is below replacement in Harar Health and Demographic Surveillance System (Harar HDSS), Harar town, Eastern Ethiopia. Fertil Res Pract. 2016;2(1):10. https://doi.org/10.1186/s40738-016-0023-8

182. Zelalem D, Semahegn A, Tesfaye G, Sileshi B. The level and patterns of fertility among women in Kersa Demographic Surveillance and Health Research Center (KDS-HRC) Field site, Kersa District, East Ethiopia. Fertil Res Pract [Internet]. 2015;1:Article 18. Available from: https://fertilityresearchandpractice.biomedcentral.com/articles/10.1186/s40738-015-0010-5 https://doi.org/10.1186/s40738-015-0010-5

183. United Nations, Population Division. Fertility Levels and Trends in Countries with Intermediate Level of Fertility [Internet]. New York; 2001. Available from: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/unpd_egm_200203_backgroundpaper_fertility_levels_and_trends_population_division.pdf

184. Jalovaara M, Neyer G, Andersson G, Dahlberg J, Dommermuth L, Fallesen P, et al. Education, gender, and cohort fertility in the Nordic countries. Eur J Popul. 2019;35(3):563–86. https://doi.org/10.1007/S10680-018-9492-2/FIGURES/6

185. Götmark F, Andersson M. Human fertility in relation to education, economy, religion, contraception, and family planning programs. BMC Public Health. 2020;20(1):265. https://doi.org/10.1186/S12889-020-8331-7/FIGURES/7

186. Ariho P, Nzabona A. Determinants of change in fertility among women in rural areas of Uganda. J Pregnancy. 2019;6429171. https://doi.org/10.1155/2019/6429171

187. Lerch M. Fertility decline in urban and rural areas of developing countries. Popul Dev Rev. 2019;45(2):301–20. https://doi.org/10.1111/padr.12220

188. Yihdego M, Amogne A, Desta S, Choi Y, Shiferaw S, Seme A, et al. Improving the demand for birth registration: A discrete choice experiment in Ethiopia. BMJ Glob Heal. 2020;5(5):e002209. https://doi.org/10.1136/bmjgh-2019-002209

189. Plan International. Universal Birth Registration - A Universal Responsibility [Internet]. Woking, Surrey, UK; 2005. Available from: https://asksource.info/resources/universal-birth-registration-a-universal-responsibility

Original articles Paper I-III, Supplementary information, and Appendices

Original articles Paper I-III and Supplementary files

Paper I

Areru et al. BMC Health Services Research (2021) 21:776
https://doi.org/10.1186/s12913-021-06846-x

BMC Health Services Research

RESEARCH Open Access

Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: a facility-based cross-sectional study

Hiwot Abera Areru[1,2*], Mesay Hailu Dangisso[1] and Bernt Lindtjørn[1,2]

Abstract

Background: Outpatient department visits per individual for each year are one of the core indicators of healthcare delivery to assess accessibility or quality of services. In addition, this study aimed to assess health service utilisation and disease patterns in southern Ethiopia, by including the health authorities' suggestions to improve the services. No study has assessed this in Ethiopia previously.

Methods: An institution-based cross-sectional design study was done in 65 primary health care units in Dale and Wonsho districts, in Sidama region, for all patients visiting health facilities from 1 July 2017 to 30 June 2018. We estimated the utilisation rate as visits per person per year, the odds ratio for health use and proportions of diseases' diagnoses. The results of our study were presented to local health authorities, and their suggestions for improvements were incorporated into the analysis.

Result: A total of 81,129 patients visited the health facilities. The annual outpatient health service utilisation was 0.18 (95% CI: 0.18–0.19) new visits per person per year. The health service utilisation rate per year for the rural population was lower than the urban utilisation by 91% (OR = 0.09; 95% CI: 0.08–0.09). Children in the age group of 5–14 years had lower odds of health service utilisation by 78% (OR = 0.22; 95% CI: 0.21–0.23), compared to children under 5 years of age. Females were four times (OR = 4.17; 95% CI: 4.09–4.25) more likely to utilise health services than males. Febrile illness constituted 17.9% (14,847 of 83,148) of the diagnoses in all age groups. Almost half of the febrile cases, 46.5% (3827 of 8233), were among children under 5 years of age. There were very few cases of non-communicable diseases diagnosed in the health facilities. The health authorities suggested improving diagnostic capacities at health centres, enhancing health professionals' skill and attitudes, and improving affordability and physical accessibility of the services.

Conclusion: The health service utilisation rate was low in Sidama. The use of health services was lower among rural residents, men, children and elderly, and health post users. Improving the quality, affordability and accessibility of the health services, by involving responsible stakeholders could increase service usage.

* Correspondence: hiwotab_2005@yahoo.com
[1]School of Public Health, College of Medicine and Health Sciences, Hawassa University, P.O.BOX: 1560, Hawassa, Ethiopia
[2]Global Public Health and Primary Care, Centre for International Health, University of Bergen, Bergen, Norway

Keywords: Health service utilisation, Outpatient department visit, Service users' involvement, Patient and public involvement, Health authorities, Diagnostic capacity, Sidama, Southern Ethiopia

Background

According to the World Health Organization, "health services include all services dealing with the promotion, maintenance and restoration of health. They include both personal- and population-based health services" [1]. Half of the world's people lack some or all essential health services [2]. Health service utilisation data can be obtained from national population surveys, health facility reports and routinely collected demographic and health surveys [3]. The health system indicators used to measure the health service utilisation in Ethiopia include, annual outpatient (OPD) attendance per individual, admission rates, bed occupancy rates and average length of stay [4].

Primary healthcare units constitute health centres and health posts, which are the foundation of the Ethiopian health system; primary hospitals are also included in the primary-level healthcare system [5]. Even though the Ethiopian health and health service system has improved in the last 20 years, most of the goals related to healthy lives and well-being have not yet been achieved [6–8]. Advances have been made in interventions like family planning, antenatal care, maternal healthcare, and hygiene and sanitation since the introduction of health extension workers who are deployed in health posts [9]. However, like other low- and middle-income countries, Ethiopia is still facing a triple burden of disease, with communicable diseases, non-communicable diseases and injuries being the main challenges [5]. The essential health service package of Ethiopia serves as a primary framework of achieving universal health coverage through quality primary health care services. The newly revised Ethiopian essential health service package included nine priority areas based on the burden of disease in the country. These includes reproductive, maternal, neonatal, child and adolescent health, major communicable diseases (HIV/AIDS, tuberculosis and malaria), non-communicable diseases, surgical and injury care, emergency and critical care, neglected tropical diseases, hygiene and environmental health services, health education and behaviour change communication services and multi-sectoral nutrition interventions [10].

Ethiopia aims at improving utilisation of healthcare services in an equitable and accessible manner [5]. Besides, universal health coverage aims to guarantee that all individuals get access to needed, important and adequate quality health services, while being protected from undue financial hardships [5, 11]. The Federal Ministry of Health has given priority to maternal and child health, and also to family planning, followed by malaria eradication [6, 7]. Although official documents suggest that the health service coverage of the country has reached 98%, the performance on major health indicators remains far below the targets set by the government [5, 8]. In addition, a recent study on universal health coverage showed a national coverage of 34%, with great regional variability [12]. Moreover, the national household health service utilisation survey showed that among people who reported being ill, only 53% visited health facilities. The common reasons for not seeking care were cost, proximity, self-medication and the thought of diseases as not series [13].

Outpatient service utilisation, as measured by the number of outpatient department (OPD) visits per person per year, is one of the recommended core indicators of health service delivery [14]. Low rates of outpatient visits are indicative of limited accessibility or low quality of services [15]. A study done in 130 countries in 2016 showed that the global outpatient age-standardised utilisation rate was 5.4 visits per individual per year [16]. In 2015, the average OPD visits rate in Ethiopia was 0.48 visit per person per year; however, the target was two visits per person per year by 2020 [5, 17]. The World Health Organization recommends around three to four OPD visits per person per year [18].

The rate and type of health service utilisation can be directly or indirectly affected by certain demographic attributes; these include age, sex, marital status, education, and income. The change that occurred in the health service utilisation pattern in the developed world, like the United States of America, is partly due to such changes in demographic characteristics of the population [19]. The same holds true in other Sub-Saharan Africa countries [20, 21].

Even though involving stakeholders, such as health service providers and authorities, has been a common practice in developed nations' studies, it has only recently been given some attention in Africa [22, 23]. The combined effort of the service providers or health authorities, users and researchers can be useful in creating insight into the problems and provide a framework for remedial implementation, thereby improving the quality and impact of health research [23–25]. It is believed that health authorities will make decisions with policy implications after they critically evaluate the potential benefits for the improvement of primary health services [26]. Therefore, to ensure the implementation of research findings and bring change in legislation that can impact

the quality of healthcare, it is mandatory to make such a process interactive and evidence-based, to build trust and understanding between the researchers and policy-makers at local, regional and national levels [27, 28]. In this study, the stakeholders were given the result from their own facilities, and were asked to comment and suggest possible ways to improve the services at their institutions [29].

To our knowledge, in Ethiopia, there has been only one study 30 years ago that assessed the overall utilisation of health services as visits per individual per year. Besides this, there are no studies that presented the result of a study to the health authorities and included their opinions and recommendations as part of the investigation in Ethiopia. The objective of this study was to assess the health service utilisation and disease patterns in southern Ethiopia. In addition, we sought to get the local health authorities' suggestions to improve the health services in the area.

Methods

Study design and period

The study employed an institution-based cross-sectional study design and included all patients visiting these public health centres and health posts from 1 July 2017 to 30 June 2018 (1 year).

Setting

The Sidama region is one of the most densely populated areas in Ethiopia, with 533 persons/km^2 [30, 31]. The region constitutes about 4.0% of the national population [32]. Agriculture is a prominent economic sector with 'enset' (*E. ventricosum*) and maize as the main foods, and coffee and fruits as the most important cash products. 'Khat', a form of chewable stimulant, is another cash crop widely produced [33].

We did the study in Dale and Wonsho districts (woredas). In 2017, the Dale district has a total population of 268,839 people and an estimated 53,768 households. It has 36 rural and two urban kebeles (the lowest administrative structures). Yirga Alem town is the main town in the district and has five urban kebeles. Wonsho district has 129,730 people living in 17 rural and one urban kebeles in 21,857 households [33, 34]. There are ten health centres and 33 health posts in Dale, and the Wonsho district has five health centres and 17 health posts [33, 34]. Even though there are two private clinics in rural Dale and one in Wonsho district, we believe most rural communities seek health services from governmental institutions [35]. Therefore, we studied all 65 governmental healthcare facilities available in Dale and Wonsho districts.

Participants

All sixty-five primary health care units (15 health centres and 50 health posts) in Dale and Wonsho districts were included in our study. Moreover, the health officials, from local to regional health facilities and offices, participated in this study. Seven health professionals were selected purposively so that they could comment and suggest ways to improve the health services of the primary health care institutions. These health professionals were: one from each of the district health departments, one from rural health centres from each district, one from urban health centres from each district, and one health professional from the Sidama Regional Health Bureau.

Study size

Assuming the national individual utilisation rate per year of OPD visit, as 48% prevalence, a power of 80, 95% confidence interval, a margin of error of 1.4% and the ratio of sample size in unexposed/exposed of 1, the required sample size was 4869 patients. The cases included in this study, however, were 81,129. Participants from health facilities and offices were selected purposively due to their position and involvement in decision-making processes.

Variables and data collection procedure

The main outcome measures were visits to primary health care units per person per year and the proportions of diagnoses. The exposure variables were gender, age, residence (urban or rural), district, type of health facility, disease types and visit types (new or repeat).

Fifteen local data collectors with a diploma in nursing and two supervisors with BSc degrees were trained to collect the data from the institutional registries at each health centre and health post. Standard registers supplied by the Federal Ministry of Health to the health centres and health posts were reviewed. Each unit or department had registry with the registration, identification and service-related information. The lists of the registries and the major components reviewed are attached as Table 8, additional file 1.

The diagnoses made by the health workers in health centres were mainly clinically, using guidelines, such as Integrated Management of Childhood Illness (IMCI), and sometimes supported by laboratory services. The health extension workers made diagnoses based on the working manuals, such as Integrated Community Case Management (iCCM) of malaria, pneumonia and diarrhoea, and TB (tuberculosis) screening guidelines. Then, the diagnoses obtained from the registry of health facilities were categorised according to the national or international disease classification (ICD) during data cleaning [36, 37].

At three institutions, complete data couldn't be found; in the delivery unit of Gidamo health centre, and the registration record for 5 months was not found. Similarly, in Bera health centre, data on delivering mothers for 5 months were missing. Besides, the information from the eye clinic at Bokaso health centre was not found because it was locked during the data collection period.

Since involvement of the health authorities was a secondary focus of this study, the Guidance for Reporting Involvement of Patients and the Public 2-short form were used as guides to collect, analyse and present the data from the health authorities [29]. After analysis, the results were presented to Dale and Wonsho district health office managers, and to the urban and rural health centre managers, and to the Sidama Regional State Health Bureau. They were informed about the results of our study and were asked to suggest areas of possible improvements. Two data collectors with BSc degree interviewed the respondents (one for each district). They were all encouraged to give their feedback based on the results and to suggest possible areas of improvements.

Data analysis

The data collection instruments were pretested on health centres and health posts outside of both districts. The data collectors were trained for 2 days about the protocol and how to extract the data from the registries. Re-checking was done by the principal investigator on 5% of the cases in each health facility, to assure the quality of the data.

The data were double entered and validated in EpiData version 3.1 software (EpiData Association Odense, Denmark). The analysis was done by STATA software version 13 (Stata Corp., LLC. College Station, Texas, USA). Descriptive statistics were done for all cases and variables. Stratification was done based on background characteristics of the clients on service utilisation and disease diagnosis. We used the number of new visitors to calculate the odds ratio and 95% confidence interval and compare the rate of utilisation for each explanatory variable. The WHO core health indicators manual was used to calculate outpatient utilisation rate [14].

The denominators for the utilisation rate calculations were based on projections of the 2007 census done in Sidama [38]. Thus, we obtained the estimated population for the year 2017/18 for women, children under 5 years of age, infants (under 1 year of age), people older than 5 years of age, and sex ratio.

Based on these population estimates, we calculated the utilisation rates as new visits per person per year for each age group, sex, family planning, antenatal care, postnatal care, delivery, pneumonia, diarrhoea and malnutrition. Microsoft Excel and MedCalc Software version 19.2.6 (MedCalc Software Ltd., Ostend,Belgium) were used to calculate these rates. Tables and figures were used to display the findings.

Missing information was identified on three of the variables (visit type, sex and age). We coded the missing values as "not recorded". Hence, the utilisation rate was calculated for new cases only.

Each of the health staff gave their feedback on the results. Their feedback was analysed manually. First, we read and re-read their responses to identify similar ideas and then we categorised them based on the emerging themes. Following this, we separately organised them as district and regional authorities' responses under each themes. Finally, the quotes were organised under each theme in the summarised table.

Operational definitions

More definitions are attached in additional file 2.

Outpatient utilisation rate: The number of new outpatient visits to health facilities per year relative to the total population of the same geographical area.

We calculated the utilisation rates for each variable as: The number of disease events divided by the eligible population of the same geographic area. We estimated the proportion of eligible population by multiplying the total population of the districts by the percentage of a particular category obtained from census and surveys.

For annual immunisation utilisation rate the denominator was the cohort of children in a year. We divided the number of under-five year children in the study area by five to obtain a single year children since we collected the data for children immunised in 1 year.

New visitors were defined as those patients who attended the health facility for the first time. Repeat visitors were those who attended the health facility for multiple times for the same diagnoses or illness within the reporting period, one Ethiopian fiscal year (July to June) and registered once as new visitor [39].

For family planning service: "New acceptors" refers to the number of modern contraceptive method acceptors who receive family planning services from a recognised family planning providing facility for the first time irrespective of the method used. Each such acceptor was counted once. Each "repeat acceptor" is counted once, irrespective of number of times family planning services were received during that fiscal year [39].

For immunisation services, new visitors were those who received their first dose of vaccines and repeat visitors were those who received more than one dose in 1 year.

For antenatal care service those clients who present for the first follow-up visit in a year were considered as new visitors. Those clients who came for subsequent

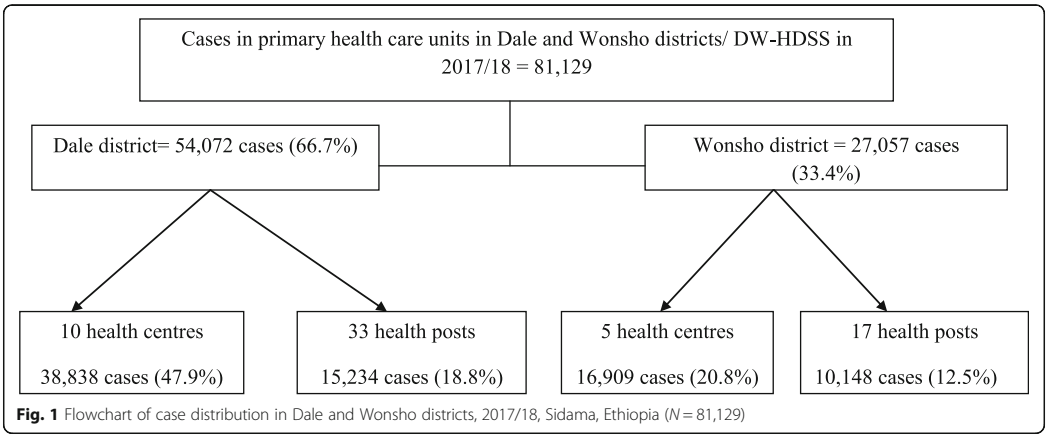


Fig. 1 Flowchart of case distribution in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia (*N* = 81,129)

Table 1 Background characteristics of clients visiting health facilities in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia (*N* = 81,129)

Variables	Number of cases (*N* = 81,129)	%
Type of health facility		
Health centres' cases	55,747	68.7
Health posts' cases	25,382	31.3
Residence		
Rural	66,341	81.8
Urban	14,788	18.2
District		
Wonsho	27,057	33.3
Dale	54,072	66.7
Sex		
Female	59,822	73.7
Male	20,232	25.0
Not recorded	1075	1.3
Type of visit		
New	73,513	90.6
Repeat	1048	1.3
Not recorded	6568	8.1
Age group (in years)		
Under 5	13,112	16.2
5–14	4788	5.9
15–24	17,729	21.9
25–34	30,172	37.2
35–44	5268	6.5
45–54	1754	2.2
55–64	826	1.0
65–74	335	0.4
75+	208	0.3
Age missing	6937	8.6

follow-ups were repeat visitors; however, they are counted only once.

Results

Background information

More than two-thirds of the cases (69%) received service or treatment from health centres. Two-thirds (67%) of the cases were from Dale district (Fig. 1).

The total number of the clients who visited the health facilities was 81,129. Most of the clients were female (74%) and were from rural areas (82%).The mean age of the clients was 21.9 years (range: 0–120). About a third (37%) of the cases were in the age group of 25–34 years (Table 1).

Utilisation rates

The annual outpatient health service utilisation rate was 0.18 (95% CI: 0.18–0.19) for new visitors. The number of new visits per year for rural people was 0.16 (95% CI: 0.15–0.16) and 0.68 (95% CI: 0.67–0.69) for urban population. Therefore, the rural population visited health institutions 11 times less than urban people (OR = 0.09; 95% CI: 0.08–0.09). Children in the age group of 5–14 years had lower odds of health service utilisation by 78% (OR = 0.22; 95% CI: 0.21–0.23), when compared to children under 5 years. Similarly, the odds of health service utilisation was lower for people aged above 75 years by 69% (OR = 0.31; 95% CI: 0.27–0.36), compared to children under 5 years. Females were 4.17 (95% CI: 4.09–4.25) times more likely to utilise health services than males (Table 2).

Prevalence of maternal health services utilisation

The prevalence of family planning utilisation was 28.3% (22,384 family planning users divided by the number of fertile women in the districts which was 79,076 (398,569

Table 2 Utilisation rates by new clients' characteristics in Dale and Wonsho district primary health care units (PHCUs), 2018, Sidama, Ethiopia ($N = 73,513$)

Variables	Utilised health service		Estimated total number of eligible population	% (out of 73,513 new cases)	Rates of utilisation (95%CI)	Odds ratio (95%CI)	*P*-value
	Yes	No					
Health facilities							
Health centres' cases	50,275	348,294	398,569	68.7	0.13 (0.12–0.13)	2.33 (2.29–2.37)	$P < 0.0001$
Health posts' cases	23,238	375,331	398,569	31.3	0.06 (0.05–0.06)	1	
Residence							
Rural	59,929	318,712	378,641	81.8	0.16 (0.15–0.16)	0.09 (0.08–0.09)	$P < 0.0001$
Urban	13,584	6345	19,929	18.2	0.68 (0.67–0.69)	1	
Districts							
Wonsho	25,066	104,664	129,730	34.1	0.19 (0.19–0.20)	1	$P < 0.0001$
Dale	48,447	220,392	268,839	65.9	0.18 (0.17–0.18)	0.92 (0.90–0.93)	
Sex							
Female	55,159	141,180	196,339	75.0	0.28 (0.27–0.28)	4.17 (4.09–4.25)	$P < 0.0001$
Male	17,334	184,896	202,230	23.6	0.09 (0.08–0.09)	1	
Not recorded	1020	–	–	1.4	–		
Age group							
Under 5	8936	53,293	62,229	12.2	0.14 (0.14–0.15)	1	
5–14	4508	124,039	128,547	6.1	0.04 (0.03–0.04)	0.22 (0.21–0.23)	$P < 0.0001$
15–24	17,125	59,678	76,803	23.3	0.22 (0.22–0.23)	1.71 (1.66–1.76)	$P < 0.0001$
25–34	28,816	25,178	53,994	39.2	0.53 (0.53–0.54)	6.83 (6.64–7.02)	$P < 0.0001$
35–44	4512	31,517	36,029	6.1	0.13 (0.12–0.13)	0.85 (0.82–0.89)	$P < 0.0001$
45–54	1536	19,036	20,572	2.1	0.07 (0.07–0.08)	0.48 (0.45–0.51)	$P < 0.0001$
55–64	762	9896	10,658	1.0	0.07 (0.07–0.08)	0.46 (0.43–0.50)	$P < 0.0001$
65–74	312	5624	5936	0.4	0.05 (0.05–0.06)	0.33 (0.29–0.37)	$P < 0.0001$
75+	189	3652	3801	0.3	0.05 (0.04–0.06)	0.31 (0.27–0.36)	$P < 0.0001$
Age missing	6817	–	–	9.3	–		
Total	73,513	331,873	398,569	100	0.18 (0.18–0.19)		

*19.84%)). Most of the family planning service clients, 73.6% (16,481 of 22,384 clients), used short-acting contraceptives, which include Depo-Provera or medroxy progesterone acetate, contraceptive pills (combined or progesterone-only oral contraceptives), and condoms. Long-acting contraceptives, such as Intra-Uterine Contraceptive Device (IUCD) and implants, were used by 26.3% (5894 of 22,384 clients). Yet, only nine of 22,384 (0.04%) patients chose a permanent contraceptive method such as bilateral tubal ligation.

The utilisation of antenatal care service in this study was 45% (6206 antenatal care clients per an estimated 13,791 pregnant mothers in the districts (398,569 *3.46%)) and delivery service utilisation was 40.7% (5619 delivering mothers per an estimated 13,791 pregnant mothers in the districts). Postnatal care service utilisation in this study was 14.3% (1973 mothers and children who received postnatal care per an estimated 13,791 pregnant mothers in the districts).

Treatment at departments

Of the departments that provided health services, 30% (24,388 of 81,129 cases) received service from the adult outpatient department. Family planning service was the next most utilised service, constituting 28% (22,423 of 81,129) of the cases. The stabilisation centre for malnutrition was the least common of the services, utilised by 33 of 81,129 (0.04%) of the visitors (Table 6 is attached as additional file 3).

Caseloads/diagnosis

Table 3 shows that clients coming to get contraceptive services constitute 26.9% (22,384 of 83,149) of the caseload. Typhoid and typhus fever were the most common

Table 3 Recorded diagnoses by age group, sex, type of health facility and visit type of the cases in Dale and Wonsho districts primary health care units in 2018, Sidama, Ethiopia ($N = 83,149$)

Diagnosis	Number of diagnoses	%	Age group			Sex			Type of health facility		Type of visit			Total number of clients
			< 5 years	5–14 years	≥ 15 years	Male	Female	Missing	Health centre	Health post	New	Repeat	Missing	
Family planning	22,384	26.9	0	0	18,936	0	22,384	0	12,039	10,345	22,384	0	0	22,384
Immunisation	7549	9.1	4193	0	540	3188	3471	890	1197	6352	7549	0	0	7549
Antenatal care	6206	7.5	0	0	5878	0	6206	0	2915	3291	6206	0	0	6206
Delivery	5619	6.8	0	0	5600	0	5619	0	5619		5619	0	0	5619
Typhoid and Typhus fever	4931	5.9	6	337	4210	1948	2604	3	4931		4672	86	173	4555
Pneumonia	4072	4.9	2828	495	713	2071	1992	9	2735	1337	2695	240	1137	4072
Parasitic and helminthic infections	3660	4.4	287	840	2519	1790	1854	7	3620	40	3298	72	290	3651
Fever and febrile illness	3895	4.7	527	629	2709	1703	2181	11	3844	51	3363	97	435	3895
Upper and lower respiratory disorders	2930	3.5	877	487	1516	1446	1457	9	2645	285	2262	48	620	2912
Accident (burn, trauma, injury, road traffic accident)	2609	3.1	80	567	1952	1708	880	21	2608	1	2465	24	120	2609
Screening for cancer, human immunodeficiency virus and helminths	2567	3.1	78	2	2464	24	2540	3	2437	130	1148	0	1419	2567
Diarrhoea	2311	2.8	1371	199	718	1132	1175	4	1768	543	1659	96	556	2311
Postnatal care and home visit	1973	2.4	1079	0	830	583	1347	43	585	1388	1783	11	179	1973
Malaria (all types)	1949	2.3	388	523	984	1017	913	19	1520	429	1649	55	245	1949
Genito-urinary disorders and complaints	1820	2.2	2	81	1731	781	1035	3	1820		1715	47	59	1819
Gastro-intestinal disorders and complaints	1733	2.1	76	84	1564	645	1084	1	1733		1577	46	110	1730
Skin disorders	1240	1.5	302	329	603	691	547	1	1180	60	1054	35	151	1239
Malnutrition	729	0.9	705	22	0	351	372	6	59	670	256	70	403	729
Tuberculosis (all types)	561	0.7	6	36	516	285	269	6	488	73	442	26	93	560
Abortion	553	0.7	0	0	547	0	553	0	553		138	0	415	553
Musculoskeletal disorders	412	0.5	1	17	392	264	147	0	412		394	4	13	411
Eye problems	389	0.5	41	34	310	208	151	27	381	8	330	4	55	386
Hypertension	304	0.4	0	5	299	114	190	0	304		270	27	7	304
Obstetric and gynaecologic cases	270	0.3	0	3	265	0	269	0	270		233	1	38	269
Bacterial infection	366	0.4	267	30	63	179	185	2	154	212	236	30	100	366
Ear and mastoid disorders	185	0.2	87	23	73	83	99	2	152	33	149	5	31	184
Sexually transmitted infections or human immunodeficiency virus	185	0.2	0	5	175	72	108	0	185		177	5	2	180

Table 3 Recorded diagnoses by age group, sex, type of health facility and visit type of the cases in Dale and Wonsho districts primary health care units in 2018, Sidama, Ethiopia (*N* = 83,149) *(Continued)*

Diagnosis	Number of diagnoses	%	Age group			Sex			Type of health facility		Type of visit			Total number of clients
			< 5 years	5–14 years	≥ 15 years	Male	Female	Missing	Health centre	Health post	New	Repeat	Missing	
Dental and oral disorders	83	0.1	10	5	68	43	40	0	82	1	75	3	5	83
Anaemia	51	0.1	3	1	47	12	39	0	51		47	1	3	51
Other	1613	1.9	138	193	1267	602	1002	8	1454	158	1432	45	135	1612

registered ailments, contributing to 5.9% (4931 of 83,149) of the diagnoses, with 92% (4210 of 4555 cases) above the age of fifteen; 57% of these were females (2604 of 4555 cases). From non-communicable diseases, hypertension was diagnosed in 0.4% (304 of 83,149) and 63% (190 of 304) of these were females.

Caseloads in children

Of the 16,331 cases of children below 5 years of age, 42.9% (7010 of 16,331) visited the health facilities for immunisation, and 35.9% (2520 of 7010) of them were fully immunised. The annual immunisation utilisation rate was 56 (95% CI: 55–58) visit per 100 children per year (7010 visits for an estimated average of 12,446 children in the actual cohort in a single year). For neonates, 6.7% (1088 of 16,331) came for assessment of danger signs and weight measurements. The rest, 50.4% (8233 of 16,331 cases), visited the health facilities for different types of illnesses and complaints. Out of these, more than 87% (7184 of 8233) were registered as new visitors. The most common registered diagnosis among children who visited the health facilities was pneumonia, contributing to 2635 of 7184 (36.7%) of the caseloads (Table 4).

Service provision by sex

From the departments giving services to both genders, in adult OPD there were more female patients (54%) than men, whereas in emergency OPD, more than two-thirds (68.0%) of the patients were male. In the community health day services (CHD), in which services like vitamin A supplementation, de-worming and malnutrition screening are given to the community, the majority (82%) were female (Table 7 is attached as additional file 4).

Table 4 Prevalence of the ten most common disease diagnoses of under-five years of age children in Dale and Wonsho districts primary health care units, in 2018, Sidama, Ethiopia (*N* = 7184)

Diagnosis	Total cases Number (%)	Number of cases in Wonsho district	Number of cases in Dale district	Total under-five years children in both districts	Prevalence rate/ 1000 population
Pneumonia[a]	2635 (36.7)	996 (45.8)	1639 (32.7)	62,228	42.3
Diarrhoea[b]	1281 (17.8)	467 (21.5)	814 (16.3)	62,228	20.6
Other respiratory problems[c]	830 (11.6)	68 (3.1)	762 (15.2)	62,228	13.3
Febrile illnesses[d]	502 (7.0)	96 (4.4)	406 (8.1)	62,228	8.1
Malaria[e]	376 (5.2)	0 (0)	376 (7.5)	62,228	6.0
Malnutrition[f]	350 (4.9)	169(7.8)	181(3.6)	62,228	5.6
Skin problems[g]	257 (3.6)	96(4.4)	161 (3.2)	62,228	4.1
Parasitic and helminthic infections[h]	253 (3.5)	94 (4.3)	159 (3.2)	62,228	4.1
Bacterial infections[i]	273 (3.3)	88 (4.0)	147 (2.9)	62,228	4.4
Accidents[j]	78 (1.0)	47 (2.2)	31 (0.6)	62,228	1.3
Other	387 (5.4)	56(2.6)	331 (6.6)	62,228	6.2

[a]Pneumonia = all types of pneumonia; [b]Diarrhoea = dehydration and all types of diarrhoea; [c]Other respiratory problems = upper and lower respiratory disorder; [d]Febrile illnesses = all acute febrile illnesses; [e]Malaria = all types of malaria; [f]Malnutrition = Severe acute and moderate malnutrition, and underweight; [g]Skin problems = specific and unspecific skin problems; [h]Parasitic and helminthic infections = all types of helminths, parasites; [i]Bacterial infection = local and unspecific bacterial infection and sepsis; [j]Accidents = all kinds of injury, trauma and road traffic accidents

Table 5 Solutions and recommendations forwarded by health professionals in Sidama region on the health service utilisation of Dale and Wonsho districts, 2018, Sidama, Ethiopia

Recommendation from district health officials and health centre managers	Recommendation from Sidama Regional Health Bureau
Theme 1: Budget allocations and alternative sources	
Ensuring and creating awareness on the community-based health insurance scheme. *"Most of the rural community thinks why would I have the community-based insurance, I might not be sick at all. But in reality our community spends more out of pocket.... Therefore, if we could convince and create awareness about the insurance, the frequency of the visit will increase."*	
Allocating enough budgets for health facilities; and support those people who are very poor and orphans, and unable to pay for health services through healthcare financing. *"The kebeles should identify genuinely those who are the "poorest of the poor" and provide all services free of charge. Most people don't come to health facility due to financial issue."*	
Theme 2: Sustainable drug and material supply	
Supplying and ensuring availability of medical supplies or equipment like essential medications, laboratory reagents (diagnostic materials), physical examination apparatuses to provide quality health service. *"The main problem I think is lack of medications in the health centres, because of repeated encounter to get some of the medications from us, the community tends to go to other facilities."*	Ensuring availability of different laboratory tests with high specificity; including hematologic tests for accurately identifying anaemia, diabetes, other infections and febrile illnesses; blood chemistry; urine analysis and culture. *"At the primary health level the availability and quality of laboratory tests in doubtful. The tests, if available, lack specificity. They mostly rely on making diagnosis based on signs or symptoms, and this could lead to misdiagnose or make wrong diagnosis"*
"We don't have functioning blood pressure measurement apparatus, such issues makes it to make accurate diagnosis."	Shortage of drugs and other supplies may affect service utilisation, because patients may prefer private clinics rather than government health facilities for these reasons. *"One of the issues here is if someone didn't get drugs or laboratory test from the nearby health centre, he or she will go to other places."*
Theme 3: Health workers capacity building	
Creating a compassionate, respectful and caring (CRC) health workforce by giving training and supervision to improve their attitudes. *"Training on CRC will improve the health professionals attitude and patients need such services"*	Augment the knowledge and skill of health workers through short- and long-term training.
Preparing manuals and give training on different components like community mobilisation. *"Health extension workers need more training so that they can equip the community about the services being given at health post and health centre level"* *"Strengthening integrated community case management, community-based newborn care, and integrated management of neonatal and childhood illness services are important to improve the diagnostic capacity."*	To improve the diagnostic capacity of health facilities, further training, provision of more laboratory technicians and test kits may be recommended. *"Training whether short term or long term will improve the knowledge and skill of the health professionals, to make accurate diagnoses"*
Provide counselling and on-the-job and refreshment training to health professionals to halt negligence or malpractice by health professionals. *"Regular counselling and refreshment trainings should be given to health professionals, this will help in improving malpractices in their day to day practice"*	
Theme 4: Quality of services	
	Working to make the health facilities function per the standards will increase the quality of care, which intern will improve the utilisation. *"For example, stabilisation centre service utilisation for severely malnourished children is low. This may be due to the fact that not all health centres and hospitals are providing services as per standard due to shortage of meals for caretakers, lack of trained staff and shortage of stabilisation centre kits. Therefore, working to mitigate these factors in collaboration with other stakeholders might be a solution."*
Theme 5: Access of health facilities	
Strengthening linkages between the district health offices and health centres, and between health centres and health posts, by creating timely and smooth lines of communication.	Building maternity waiting rooms will improve access related problem. *"The lower postnatal care utilisation shows that almost all primary health care units are not keeping mothers at the health facilities at least for 24 h after delivery. This may be due to a shortage of maternity waiting rooms*

Table 5 Solutions and recommendations forwarded by health professionals in Sidama region on the health service utilisation of Dale and Wonsho districts, 2018, Sidama, Ethiopia *(Continued)*

	because most government health facilities have incomplete premises and infrastructure."
Plan to increase the number of health facilities. *"Due to the geographical inaccessibility of our woreda (Wonsho), more health facilities should be constructed to increase utilisation"*	Some health facilities are not accessible throughout the week for 24 h. *"Even though health-seeking behaviour of the community was improved, most health posts may be closed during working hours and health centres do not provide some services the entire week. Therefore, ensuring delivery of service at all times could increase utilisation."*
Theme 6: Public and stakeholders involvement and collaboration	
The public should be involved from planning to implementation of health services. The health extension workers also should focus on creating awareness on health care seeking behaviour. Every gathering should be taken as a venue for awareness creation. Moreover, collaboration with other non-governmental organisations might alleviate problems with capacity building, material supply and infrastructure. *"Involving women health development armies, who are volunteer community health workers responsible for mobilising the community, during planning and training them on implementation issues."* *"Encourage health extension workers to strictly work on house-to-house visits and educating the community about health service utilisation."* *"Giving health education about health services in different locations like health facilities, schools, community gatherings* etc." *"Creating and strengthening communication with other stakeholders like non-governmental organisations."*	
Theme 7: Supervision and record keeping	
Enhance recording and reporting system by giving on-the-job and refreshment training and supportive supervision.	
Timely supportive supervision, follow-up and feedback (monitoring and evaluation) should be strengthened to enhance the commitment of health professionals. *"We have missed information due to poor documentation and negligence; anything not recorded is considered as not being done. Therefore, training and supervisions should focus on these areas too."*	

Health professionals' opinions on health service utilisation

Table 5 shows the opinions of health officials in terms of improving health service utilisation. The health professionals' opinions were categorised into seven thematic areas for local and regional health professionals separately. These themes were: budget allocations and alternative sources, sustainable drug and material supply, health workers capacity building, quality of services, access of health facilities, public and stakeholders involvement and collaboration, and supervision and record keeping.

Discussion

This study shows a low health service utilisation rate in one of the most densely populated areas of Ethiopia (Sidama), especially among the rural population. Febrile illnesses were prevalent diseases, and family planning cases constituted the largest proportion of the recorded diagnoses. Yet, very few non-communicable diseases were diagnosed.

Health professionals accountable for the delivery of health services in the area suggested improving the low health service utilisation by improving the quality, affordability, and accessibility of health services, improving the health professionals' skills, and introducing better diagnostic modalities. However, further studies are desired to find out if the involvement of health workers may possibly result in improved resource allocations and enhanced services.

A key strength of this study is the inclusion of all primary health care units covering the urban and rural populations. The data for the services were collected for a period of a whole year, for all types of services given, and included all governmental health centres and health posts. In addition, the comments and suggestions of health officials to improve health service utilisation were included as part of the study.

This study is not without limitations. Due to the loss of some data in three of the health centres, there might be some information bias, and there could be some underreporting for delivery and eye services. However, given the large study population, the proportion of missing data from these units is small, and this information bias is therefore probably negligible. There were also missing data on visit information. However, the number of missing cases was few compared to the total cases, therefore, they would not

change the results. In addition, children who started their vaccination in previous fiscal year were recorded as repeat. This might cause under-reporting in vaccination coverage.

Even though the involvement of the health professionals in the research process was a new and a good experience, the political context might have introduced methodological biases. A social-desirability bias in which the health professionals responded by considering the expectations of the researchers is one of the potential biases in a country where a bureaucratic and hierarchical structure prevails. The health professionals might not have critically evaluated the day-to-day services at their institution by considering the results from the study. Instead, their focus was mainly on general, administrative, and structural solutions, overlooking some of the findings that required local or institutional recognition [40].

Moreover, the diagnosis at primary health care units was mainly based on clinical findings, as very few diagnoses were supported by laboratory findings at the health centres. Thus, the lack of laboratory support and clinical skills to diagnose, for example, typhoid fever, typhus, anaemia, diabetes mellitus, malignant disorders, and hypertension, may explain why such diseases apparently occurred rarely. There were also a few cases that came to seek health services from other areas outside the study districts, and their population was not considered in the denominator during the calculation. We assume that some people from our study districts might seek care outside their catchment. People who primarily went to private clinics and hospitals farther away were, however, not recorded, and this may be a cause of under-reporting of use of health services in the area.The overall health service utilisation rate expressed in our study is higher than the rate of primary healthcare visits in central, southern and western Ethiopia recorded 30 years ago [41]. Yet, in our study, the utilisation rate is far lower than the targeted individual outpatient visits per year of the country and of other community-based studies in Oromia and Amhara regions [5, 20, 42]. This may partly be due to the methodological difference between the studies, closure of health posts for some periods during working hours and inability to provide some services by the health centres for the entire week [43]. Patients may also prefer traditional medicine or self-treatment [42], private clinics or self-referral to higher-level health facilities outside their catchment area. This might be due to poor quality health services in government health facilities, such as the unavailability of drugs and laboratory tests, as well as unskilled staff or an unwelcoming attitude of health professionals [13, 43, 44].

Our study indicated that the urban population used the health services more than their rural counterparts, as has been reported by others [42, 45]. This urban-rural difference might be attributed to a higher poverty, lower accessibility and lower education for the rural population [46].

The health service utilisation by children and older age people is lower than for adult people in our study, as has been reported by others [42]. One of the explanations for this may be because these age groups are usually dependent on other people to transport them to the health facilities. Another explanation could be that older people still rely more on traditional medicine [47]. Furthermore, the unavailability of some child health services for several days of the week could also have reduced the number of cases in these groups [43].

Our study showed that more people visited health centres than health posts. This finding is in agreement with other studies done in Ethiopia and Zambia showing preference of health centres over hospitals, health posts and private facilities [21, 48]. This might be due to the proximity of health centres to the community, besides the limited services availability and absence of qualified professionals at the health posts [13]. Moreover, the community often considers the health extension workers to be involved mainly in preventive health services, such as health education and sanitation, than the curative services [49].

Consistent with our finding, some studies showed a higher health service utilisation by women than men [20, 50]. The possible explanation for this might be the reproductive needs of women requiring separate services than men. Since most women take their children to health facilities, they might also get services or treatment for themselves [20]. The other reason might be the higher self-medication tendency of men than women [21].

The most common causes of morbidity in this study were consistent with the national study of health and health-related indicators in 2015 [51]. Diarrhoeal diseases were at the top of the list on a study done 30 years ago [41]. However, among children below 5 years of age, pneumonia was the major cause of morbidity in our study [51]. The recorded causes of morbidity may also be inaccurate due to the inadequate knowledge or skills of health professionals which may have contributed to incorrect diagnoses or over-diagnosis [52].

Family planning is the main maternal and child health service registered in our study. This finding is lower than for other sub-Saharan countries but similar to other studies done in Ethiopia [53–55]. The lower fertility rate found in the area documented in a recent study might also be an indication of improved family planning usage [56]. Besides, family planning services are available free of charge in governmental health facilities.

Antenatal care utilisation in our study was lower than most local and national studies done in the country

except for pastoral regions [57–59]. Similarly, delivery service utilisation in this study is higher than other studies done in the country but lower than the national study of health facility delivery [58–60]. This difference might arise because our study used health facility data, whereas the other studies were community based.

Postnatal care was much lower than for other maternal health services but is similar to other national and regional studies [57, 58, 61]. This might be due to the absence of maternity waiting rooms in almost all primary health care units to admit the mother for at least 24 h.

Even though recent studies showed an increase in the prevalence of hypertension, there were few cases of hypertension in our study [62–64]. The discrepancy in the results might be due to the inability or lack of skills or materials to make an accurate diagnosis at the primary health care units. Similarly, in the last national Ethiopian demographic and health survey (EDHS) report, the prevalence of anaemia in women of reproductive age has increased to 24% and to 57% in children [65]. However, in our study, there were very few cases with anaemia. This might be attributed to the inability to measure haemoglobin at the institutions in the study area. Likewise, the number of diabetes mellitus cases diagnosed in our study area was negligible. Similar to hypertension and anaemia, the prevalence of diabetes is most likely under-diagnosed due to the lack of clinical skills and diagnostic materials at the institutions.

Conclusion

The Ethiopian government aims to enhance the coverage of primary healthcare services in the rural communities [5]. However, there is low and unequal health service utilisation in Ethiopia. We observed low annual health service utilisation rate among rural residents, men, children and elderly, and health post users. Among the reported cases, family planning constituted the largest proportion, and non-communicable diseases were the least diagnosed group. Pneumonia was the most common recorded diagnosis among children younger than 5 years of age. Even if there is no complete agreement between registry data and the health professionals' opinions, most of the ideas overlap and give direction to improving health service utilisation. The findings of this study will help in the effort the government is undertaking to make quality health services accessible and affordable to the underserved population. Ensuring availability of drugs or medical supplies, laboratory tests and standard working procedure could increase the service usage. Moreover, supportive supervision needs to be provided, and the knowledge and skills of healthcare professionals and their diagnostic capacity need further improvement. In addition, the quality of health services should also be assessed and given priority so that the health services can be utilised by every segment of the population.

Abbreviation

OPD: Outpatient department

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-021-06846-x.

Additional file 1. List of registers.
Additional file 2. Operational definitions.
Additional file 3. Treatment at departments.
Additional file 4. Service provision by sex.

Acknowledgements

We acknowledge the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED) for funding this study. We are grateful for the contributions of Sidama Regional Health Bureau, Dale and Wonsho district health offices, and managers of the urban and rural health centres. We also like to extend our gratitude for all data collectors and supervisors, Mr. Lamalo Sonbala and Mr. Abera Shunkaro, for their unreserved effort during supervision. We also thank Dr. Tadiwos Hailu for his technical support during data cleaning and analysis.

Authors' contributions

HA conceptualised the idea, designed the study, acquired and analysed the data, wrote the protocol and drafted the manuscript. BL conceptualised the idea, guided the study design, the proposal writing, helped to analyse the data, drafted and validated the manuscript. MD helped in conceptualising the idea, the proposal writing, provided constructive comment in drafting the manuscript. All of the authors read and approved the submitted version of the manuscript.

Funding

The research has been funded by the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED). The funder has no role in the design, data collection, analysis, interpretation and writing of the manuscript.

Availability of data and materials

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

Ethical clearance was obtained from the Institutional Review Board at the College of Medicine and Health Sciences of Hawassa University (Reference number IRB/022/10) and the Regional Ethics Committee for Medical and Health Research in Norway REK Vest (2018/67/REK vest). Permission letters were obtained from the Sidama Zone Health Department, Dale and Wonsho woreda (district) health offices to access the secondary data from all health facilities. The above mentioned ethical committees ruled that no formal consent is required for secondary data use. For the qualitative study participants, a written informed consent was obtained after giving information about the objective of the study, the role of the participant, risk or discomfort, benefit, confidentiality, and voluntary participation. The interview took place in separate room after getting their permission. All the methods used in this study were in accordance with relevant guidelines and regulations. No minors were asked or involved directly. There is no personal identifier in the data set. The data collection tool was kept in a secure place to maintain the confidentiality of information obtained from the participants.

Consent for publication

Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 22 November 2020 Accepted: 28 July 2021
Published online: 06 August 2021

References

1. World Health Organization. Framework on integrated, people-centred health services:Sixty-ninth World Health Assembly Provisional agenda item 16.1. Geneva: World Health Organization; 2016.
2. World Health Organization. Universal health coverage (UHC). 2019 [cited 2020 Mar 4]; Available from: https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc).
3. Bhuiya A, Hanifi SMA, Urni F, Mahmood SS. Three methods to monitor utilization of healthcare services by the poor. Int J Equity Health. 2009;8(1):29. https://doi.org/10.1186/1475-9276-8-29.
4. Abayneh S, Lempp H, Alem A, Kohrt BA, Fekadu A, Hanlon C. Developing a theory of change model of service user and caregiver involvement in mental health system strengthening in primary health care in rural Ethiopia. Int J Ment Health Syst. 2020;14(1):1–17.
5. Ethiopian Federal Ministry of Health. Health sector transformation plan (2015/16–2019/20). Addis Ababa: Federal Ministry of Health; 2015.
6. Donnelly J. Ethiopia gears up for more major health reforms. Lancet. 2011;377(9781):1907–8. https://doi.org/10.1016/S0140-6736(11)60795-2.
7. Ethiopian Federal Ministry of Health. Ethiopia's health sector: excellent returns on your development funding. Addis Ababa, Ethiopia: Federal Ministry of Health; 2013.
8. National Planning Commission. Ethiopia 2017 Voluntary National Review on SDGs: Government Commitments, National Ownership and Performance Trends. Addis Ababa: Federal Democratic Republic of Ethiopia National Planning Commission; 2017. p. 1-45.
9. Alebachew A, Waddington C. Improving health system efficiency: Ethiopia: human resources for health reforms. Geneva: World health Organization; 2015.
10. Ministry of Health of Ethiopia. Essential Health Services Package for Ethiopia. 2019.
11. World Health Organization. World Health statistics 2014: Health service coverage. Geneva: World Health Organization; 2014.
12. Eregata GT, Hailu A, Memirie ST, Norheim OF. Measuring progress towards universal health coverage: national and subnational analysis in Ethiopia. BMJ Glob Heal. 2019;4(6):1–9.
13. Federal Democratic Republic of Ethiopia Ministry of Health. Ethiopian Health Accounts Household Health Service Utilization and Expenditure Survey Brief 2015/2016. Addis Ababa: Federal Democratic Republic of Ethiopia Ministry of Health; 2017. p. 1-9.
14. World Health Organization. Global Reference List of 100 Core Health Indicators (plus health-related SDGs). Geneva: World Health Organization; 2018.
15. World Health Organization. Monitoring the Building Blocks of Health Systems: a Handbook of Indicators and Their Measurement Strategies, vol. 35. Geneva: World Health Organization; 2010.
16. Moses MW, Pedroza P, Baral R, Bloom S, Brown J, Chapin A, et al. Funding and services needed to achieve universal health coverage: applications of global, regional, and national estimates of utilisation of outpatient visits and inpatient admissions from 1990 to 2016, and unit costs from 1995 to 2016. Lancet Public Heal. 2019;4(1):e49–73. https://doi.org/10.1016/S2468-2667(18)30213-5.
17. Ethiopian Federal Ministry of Health. Fact Sheets: Fact sheet-Ethiopia 2015. 2019 [cited 2020 Mar 4]; Available from: http://www.moh.gov.et/ejcc/en/node/15 .
18. World Health Organization. Eastern Mediterranean Region Indicator and Metadata Registry. 2016 [cited 2020 Mar 5]. Available from: http://gis.emro.who.int/EMRIMR/Indicators.aspx?i=1
19. Louis G. Pol, Richard K. Thomas. The demography of health and health care. 3rd. Kenneth C. Land. New York: Springer; 2013 p. 1-295. https://doi.org/10.1007/978-90-481-8903-8.
20. Girma F, Jira C, Girma B. Health services utilization and associated factors in Jimma zone, south West Ethiopia. Ethiop J Health Sci. 2011;21(Suppl 1):85–94.
21. Masiye F, Kaonga O. Determinants of healthcare utilisation and out-of-pocket payments in the context of free public primary healthcare in Zambia. Int J Heal Policy Manag. 2016;5(12):693–703. https://doi.org/10.15171/ijhpm.2016.65.
22. Cook N, Siddiqi N, Twiddy M, Kenyon R. Patient and public involvement in health research in low and middle-income countries: a systematic review. BMJ Open. 2019;9:e026514.
23. Bergmeier H, Vandall-Walker V, Skrybant M, Teede H, Bailey C, Baxter J-A, et al. Global Health in preconception, pregnancy and postpartum Alliance: development of an international consumer and community involvement (CCI) framework. Res Involv Engagem. 2020;1:1–13.
24. Miller CL, Mott K, Cousins M, Miller S, Johnson A, Lawson T, et al. Integrating consumer engagement in health and medical research - an Australian framework. Heal Res Policy Syst. 2017;15(1):1–6.
25. Boote J, Baird W, Sutton A. Public involvement in the systematic review process in health and social care: A narrative review of case examples. Health Policy. 2011;102:105–16.
26. Regidor E, de la Fuente L, Gutiérrez-Fisac JL, de Mateo S, Pascual C, Sánchez-Payá J, et al. The role of the public health official in communicating public health information. Am J Public Health. 2007;97(Suppl 1):S93.
27. Lindtjørn B, Tadesse M, Loha E. Developing a sustainable PhD programme: experiences from southern Ethiopia. In: Halvorsen T, Orgeret KS, editors. Sharing knowledge, transforming societies: the Norhed Programme 2013–2020: Bergen, African Minds; 2019. p. 442–56.
28. Lindtjørn B. Could devolving pneumonia treatment to local health centres reduce mortality in developing countries? Acta Paediatr Int J Paediatr. 2020;00:1–2. https://doi.org/10.1111/apa.15584.
29. Staniszewska S, Brett J, Simera I, Seers K, Mockford C, Goodlad S, et al. GRIPP2 reporting checklists: tools to improve reporting of patient and public involvement in research. BMJ. 2017;358:1–7.
30. Central Statistical Agency, Ethiopian Development Research Institute, International Food Policy Research Institute. Population & Housing Census: ATLAS OF ETHIOPIA 2007. Washington, DC; Addis Ababa: International Food Policy Research Institute (IFPRI), Central Statistical Agency; 2010. https://doi.org/10.2499/9780896299276.
31. Central Statistical Agency. 2007 Population and Housing Census oF Ethiopia: Section-B Population. Addis Ababa, Ethiopia: Office of the Population Census Commission; 2007.
32. Federal Democratic Republic of Ethiopia Population Census Commisssion. Summary and Statistical Report of the 2007 Population and Housing Census: Population Size by Age and Sex. Addis Ababa: Office of the Population Census Commision; 2008.
33. Sidama Zone Finance and Economic Development Office. Sidama zone administration socio-economic profile 2014/15. Hawassa: SNNPR; 2016.
34. Dalle Woreda Finance and Economic Development Office. The development of social and economical information of Dalle woreda. Hawassa: SNNPR; 2016.
35. Workie NW, Ramana GNV. The health extension program in Ethiopia. Washington, DC: The Universal Health Coverage Studies Series; 2013.
36. World Health Organization. International statistical classification of diseases and related health problems- 10th revision, vol. 3. 5th ed. Geneva: World Health Organisation; 2016.
37. Federal Democratic Republic of Ethiopia Ministry of Health. National Classification of diseases (NCoD). Compact Ed. Addis Ababa: Ministry of Health; 2017.
38. Central Statistical Agency. National Census. Ethiopia, Addis Ababa: Office of the Population Census Commission; 2007.
39. Federal Ministry of Health. HMIS Indicator reference guide technical standards: area 1. Addis Ababa, Ethiopia: Ethiopian Ministry of Health; 2017.
40. Østebø MT, Cogburn MD, Mandani AS. The silencing of political context in health research in Ethiopia: Why it should be a concern. Health Policy and Planning. 2018;33:258–70.
41. Kloos H. Utilization of selected hospitals, health centres and health stations in central, southern and Western Ethiopia. Soc Sci Med. 1990;31(2):101–14. https://doi.org/10.1016/0277-9536(90)90052-T.
42. Fantahun M, Degu G. Health service utilization in Amhara region of Ethiopia. Ethiop J Heal Dev. 2004;17(2):141-7. https://doi.org/10.4314/ejhd.v17i2.9855.
43. Hailemariam S, Gebeyehu Y, Loha E, Johansson KA, Lindtjørn B. Inadequate management of pneumonia among children in South Ethiopia: findings from descriptive study. BMC Health Serv Res. 2019;19(1):1–14.
44. Carter JY, Lema OE, Wangai MW, Munafu CG, Rees PH, Nyamongo JA. Laboratory testing improves diagnosis and treatment outcomes in primary

health care facilities. Afr J Lab Med. 2011;1(1):1-6. https://doi.org/10.4102/ajlm.v1i1.8.
45. Alebachew, Abebe, Laurel Hatt, Matt Kukla SN. Universal health coverage low-income Context: an Ethiopian case study. Bethesda: Health Finance & Governance Project, Abt Associates Inc; 2014. p. 1-94.
46. Begashaw B, Tessema F, Gesesew HA. Health care seeking behavior in Southwest Ethiopia. PLoS One. 2016;11(9):e0161014. https://doi.org/10.1371/journal.pone.0161014.
47. James PB, Wardle J, Steel A, Adams J. Traditional, complementary and alternative medicine use in sub-Saharan Africa: a systematic review. BMJ Glob Heal. 2018;3(5):895.
48. Mebratie AD, Van De Poel E, Yilma Z, Abebaw D, Alemu G, Bedi AS. Healthcare-seeking behaviour in rural Ethiopia: Evidence from clinical vignettes. BMJ Open. 2014;4(2):e004020. https://doi.org/10.1136/bmjopen-2013-004020.
49. Medhanie AA, Spigt M, Kifle YT, Schaay N, Sanders D, Blanco M, et al. The Contribution of Health Extension Workers in Improving the Utilization of Maternal Health Services in Rural Areas of Tigray, Ethiopia. In: Labonte R, PC SD, SN, editors. Revitailizing health for all: Case Studies of the Struggle for Comprehensive Primary Health Care. Canada: University of Toronto Press Toronto; 2017. p. 237–54.
50. Bazie GW, Adimassie MT. Modern health services utilization and associated factors in north East Ethiopia. PLoS One. 2017;12(9):e0185381. https://doi.org/10.1371/journal.pone.0185381.
51. Federal Ministry of Health. Health and Health Related Indicators: Better Information, Better Decision, Better Health: Version 1. Addis Ababa, Ethiopia: Policy Planning Directorate, Federal Ministry of Health; 2015.
52. Tariku A, Okwaraji YB, Worku A, Biks GA, Åke Persson L, Berhane Y. Prevention and treatment of suspected pneumonia in Ethiopian children less than five years from household to primary care. Acta Paediatr. 2020;00:1–9.
53. Bayray A, Meles KG, Sibhatu Y. Magnitude and risk factors for hypertension among public servants in Tigray. Ethiopia: A cross-sectional study PLoS One. 2018;13(10):e0204879. https://doi.org/10.1371/journal.pone.0204879.
54. Endriyas M, Eshete A, Mekonnen E, Misganaw T, Shiferaw M, Ayele S. Contraceptive utilization and associated factors among women of reproductive age group in southern nations nationalities and peoples' region, Ethiopia: cross-sectional survey, mixed-methods. Contracept Reprod Med. 2017;2(10):1–9.
55. Ahmed S, Choi Y, Rimon JG, Alzouma S, Gichangi P, Guiella G, et al. Trends in contraceptive prevalence rates in sub-Saharan Africa since the 2012 London summit on family planning: results from repeated cross-sectional surveys. Lancet Glob Heal. 2019;7(7):e904–11. https://doi.org/10.1016/S2214-109X(19)30200-1.
56. Areru HA, Dangisso MH, Lindtjørn B. Births and deaths in Sidama in southern Ethiopia: findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS). Glob Health Action. 2020;13(1):1833511.
57. Regassa N. Antenatal and postnatal care service utilization in southern Ethiopia: a population-based study. Afr Health Sci. 2011;11(3):390–7.
58. Ethiopian Public Health Institute (EPHI)[Ethiopia] and ICF. Ethiopia Mini Demographic and Health Survey 2019: Key indicators. Rockville: EPHI and ICF; 2019.
59. Umer A, Zinsstag J, Schelling E, Tschopp R, Hattendof J, Osman K, et al. Antenatal care and skilled delivery service utilisation in Somali pastoral communities of eastern Ethiopia. Trop Med Int Heal. 2019;25(3):328–37.
60. Tesfaw N, Gizachew A, Kassa GM, Abajobir AA. Skilled delivery service utilization and associated factors among mothers who gave birth in the last two years in Northwest Ethiopia. Ethiop J Health Sci. 2018;28(4):423–32. https://doi.org/10.4314/ejhs.v28i4.8.
61. Worku AG, Yalew AW, Afework MF. Factors affecting utilization of skilled maternal care in Northwest Ethiopia: a multilevel analysis. BMC Int Health Hum Rights. 2013;13(20):1–11.
62. Belachew A, Tewabe T, Miskir Y, Melese E, Wubet E, Alemu S, et al. Prevalence and associated factors of hypertension among adult patients in Felege-Hiwot comprehensive referral hospitals, northwest, Ethiopia: a cross-sectional study. BMC Res Notes. 2018;11(876):1–6.
63. Kibret KT, Mesfin YM. Prevalence of hypertension in Ethiopia: a systematic meta-analysis. Public Health Rev. 2015;36:1–12.
64. Zekewos A, Egeno T, Loha E. The magnitude of hypertension and its risk factors in southern Ethiopia: a community based study. Wang W. PLoS One. 2019;14(8):e0221726.
65. Central Statistical Agency (CSA) [Ethiopia] and ICF. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia, and Rockville, Maryland: CSA and ICF; 2016.

Publisher's Note

Supplementary files for Paper I

Additional file 1: Operational definitions

Health service utilisation: Defined as the use of the existing modern health services per year in primary health care units by individuals for their psychological, physical and social health problems, whether this is for preventive or curative purpose, measured as the quantity of health care services used (6,37,174).

Antenatal care: Care given to pregnant women by a skilled provider expressed by the number of visits to the health facility during her last pregnancy (152).

Immunisation: A service given to a child for all recommended vaccines, including Bacillus-Calmette-Gueri (BCG), Diphtheria-Pertussis-Tetanus, Hepatitis B and Haemophilus influenza type B (Penta-valent vaccine), Pneumococcal Conjugated Vaccine (PCV), Oral Polio Vaccine (OPV), Monovalent human rotavirus vaccine (RV1), Inactivated Polio Virus (IPV) and Measles vaccines. In addition, Tetanus Toxoid (TT) vaccine for pregnant women (152,175).

Skilled delivery: Births delivered with the assistance of doctors, nurse or midwives, health officers, and health extension workers (152).

Postnatal care: Care given to the mother and the newborn within 24 hours, day 3 (48-72 hours), between days 7 and 14, and six weeks after birth with integration of home visits (176).

Outpatient utilisation rate: The number of new outpatient visits to health facilities per year relative to the total population of the same geographical area (37).

We calculated the utilisation rates for each variable as: The number of disease events divided by the eligible population of the same geographic area. We estimated the proportion of eligible

population by multiplying the total population of the districts by the percentage of a particular category obtained from census and surveys.

Departments/Units: Structures of health facilities used to deliver standard health services in an organised manner (177).

New visitors were defined as those patients who attended the health facility for the first time (178). Repeat visitors were those who attended the health facility for multiple times for the same diagnoses/illness within the reporting period, one Ethiopian fiscal year (July to June), recorded once as new visit previously (178).

For family planning service: “New acceptors” refers to the number of modern contraceptive method acceptors who receive family planning services from a recognised family planning providing facility for the first time irrespective of the method used. Each such acceptor was counted once. Each “repeat acceptor” is counted once, irrespective of number of times family planning services were received during that fiscal year (178).

For immunisation services, new visitors were children who received their first dose of vaccines and repeat visitors were those who received more than one dose in one year.

Additional file 2: Treatment at departments

Table 6: Distribution of cases per unit or department in Dale and Wonsho district primary health care units in2018, Sidama, Ethiopia (N=81,129)

	Unit/Department	Number of cases	%
1.	Adult OPD	24,388	30.1
2.	Family planning (FP)	22,423	27.6
3.	Expanded Program of Immunisation (EPI)	7,010	8.6
4.	Under 5years OPD	6,316	7.8
5.	Delivery	5,659	7.0
6.	Antenatal care (ANC)	4,482	5.5
7.	Cervical cancer screening	2,289	2.8
8.	Antenatal care with Tetanus Toxoid immunisation (ANC with TT)	1,828	2.3
9.	Emergency OPD	1,578	2.0
10.	Postnatal care	1,442	1.8
11.	Under 2months OPD	984	1.2
12.	TB clinic	565	0.7
13.	Tetanus Toxoid (TT)	492	0.6
14.	Abortion	521	0.6
15.	Outpatient Therapeutic Feeding Program (OTP)	496	0.6
16.	Prevention of mother-to-child transmission (PMTCT)	341	0.4
17.	Eye clinic	156	0.2
18.	Community health day services (CHD)	126	0.2
19.	Stabilisation centre (SC)	33	0.04
	Total	81,129	100.0

Additional file 3: Service provision by sex

Table 7: Distribution of cases by sex in departments serving both genders in Dale and Wonsho districts, 2018, Sidama, Ethiop

Unit /Department	Sex			Total
	Female	Male	Missing	
	Number (%)	Number (%)	Number (%)	Number (%)
Adult OPD	13,129 (53.8)	11,220 (46.0)	39 (0.2)	24,388 (100.0)
Emergency OPD	475 (30.1)	1,078 (68.3)	25 (1.6)	1,578 (100.0)
Under 5years OPD	2,976 (47.1)	3,304 (52.3)	36 (0.6)	6,316 (100.0)
Under 2months OPD	468 (47.6)	514 (52.2)	2 (0.2)	984 (100.0)
TB clinic	271 (48.0)	288 (51.0)	6 (1.1)	565 (100.0)
EPI	2,932 (41.8)	3,188 (45.5)	890 (12.7)	7,010 (100.0)
OTP	250 (50.4)	245 (49.4)	1 (0.2)	496 (100.0)
SC	21 (63.6)	8 (24.2)	4 (12.1)	33 (100.0)
Eye clinic	56 (35.9)	74 (47.4)	26 (16.7)	156 (100.0)
Community health day services	103 (81.8)	20 (15.8)	3 (2.4)	126 (100.0)

Additional file 4: List of registers

Table 8: List of registers reviewed to extract the data from health centres and health posts in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia

Registers from health centres	Registers from health posts
ANC register	ANC register
Delivery register	Family planning register
Family planning register	PNC register
Infant immunization and growth monitoring register	TB suspected case screening and treatment register
PNC register	Malaria Assessment
Cervical cancer screening and prevention register	Infant immunization
Safe/Post abortion Care register	ICCM 0-2months
Comprehensive abortion care register	ICCM 2months-5years
Outpatient department (OPD) register/ OPD abstract register	Registration book for therapeutic feeding
Emergency department register	Community health day services (CHD) register
Unit TB register	Forms below are from family folders • Integrated Antenatal, Labor, Delivery, Newborn and Postnatal Card • Health card: FP and Immunization
Integrated under-five registration book : from birth to 2 months	
Integrated under-five registration book : from 2 months up to 5 years	
Stabilization centre and Outpatient therapeutic feeding program register	
Referral register	• Health posts disease information tally
Diabetes and Hypertension treatment register	
Eye clinic registration	
*Some health facilities registered TT and PMTCT separately from ANC registers	

NB: The information extracted from each registers were, name of the district, name of health facility, address of the health facility (rural or urban), unit or department, card number, date of visit, sex, age (in days, months, years or date of birth), address (kebele), diagnosis, and visit type.

Paper II

PLOS GLOBAL PUBLIC HEALTH

RESEARCH ARTICLE

Large local variations in the use of health services in rural southern Ethiopia: An ecological study

Hiwot Abera Areru[1,2☯]*, **Mesay Hailu Dangisso**[1☯], **Bernt Lindtjørn**[1,2☯]

1 School of Public Health, College of Medicine and Health Sciences, Hawassa University, Hawassa, Ethiopia, **2** Global Public Health and Primary Care, Centre for International Health, University of Bergen, Bergen, Norway

☯ These authors contributed equally to this work.
* hiwotab_2005@yahoo.com

OPEN ACCESS

Citation: Areru HA, Dangisso MH, Lindtjørn B (2022) Large local variations in the use of health services in rural southern Ethiopia: An ecological study. PLOS Glob Public Health 2(5): e0000087. https://doi.org/10.1371/journal.pgph.0000087

Editor: Alinane Linda Nyondo-Mipando, Kamuzu University of Health Sciences (formerly College of Medicine), MALAWI

Received: August 19, 2021

Accepted: May 1, 2022

Published: May 25, 2022

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pgph.0000087

Data Availability Statement: We have deposited the dataset used for this manuscript in a repository called Zenodo. The URL and DOI of the dataset can be found from "Hiwot Abera Areru. (2021). Health

Abstract

Ethiopia is behind schedule in assuring accessible, equitable and quality health services. Understanding the geographical variability of the health services and adjusting small-area level factors can help the decision-makers to prioritize interventions and allocate scarce resources. There is lack of information on the degree of variation of health service utilisation at micro-geographic area scale using robust statistical tools in Ethiopia. Therefore, the objective of this study was to assess the health service utilisation and identify factors that account for the variation in health service utilisation at kebele (the smallest administrative unit) level in the Dale and Wonsho districts of the Sidama region. An exploratory ecological study design was employed on the secondary patient data collected from 1 July 2017 to 30 June 2018 from 65 primary health care units of the fifty-four kebeles in Dale and Wonsho districts, in the Sidama region. ArcGIS software was used to visualise the distribution of health service utilisation. SaTScan analysis was performed to explore the unadjusted and covariate-adjusted spatial distribution of health service utilisation. Linear regression was applied to adjust the explanatory variables and control for confounding. A total of 67,678 patients in 54 kebeles were considered for spatial analysis. The distribution of the health service utilisation varied across the kebeles with a mean of 0.17 visits per person per year (Range: 0.01–1.19). Five kebeles with health centres had a higher utilisation rate than other rural kebeles without health centres. More than half (57.4%) of the kebeles were within a 10 km distance from health centres. The study found that distance to the health centre was associated with the low health care utilisation. Improving the accessibility of health services by upgrading the primary health care units could increase the service use.

Introduction

Globally, in the last three decades, considerable improvements have been observed in most public health interventions, but with substantial regional variability [1]. Ethiopia is making an

service use_spatial_ dataset [Data set]. Zenodo. https://doi.org/10.5281/zenodo.5213926".

Funding: Norwegian Programme for Capacity Development in Higher Education and Research for Development/ South Ethiopia Network of Universities in Public Health (NORHED/SENUPH) project provided funding in the form of a grant awarded to BL (ETH-13/0025). URL: https://www.uib.no/en. The sponsors or funders have no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

increasing effort to improve the health services [2], yet remains behind schedule on meeting Sustainable Development Goals (SDG), like SDG 3, which is about healthy lives and well-being [3]. Sustainable Development Goal 3 aims to improve the health and well-being of the population through universal health coverage [4]. Universal health coverage encompasses the provision of accessible, equitable and quality health services without incurring financial hardship [5].

In Ethiopia, primary health care coverage is used as a proxy indicator for service access. Primary health coverage is defined as access to primary health care (health centres and health posts) in relation to the total population [6]. Service access consists availability, affordability, and acceptability, accommodation, affordability and acceptability dimensions [7, 8]. Health care utilization is the description or quantification of health care service usage [9]. R. Andersen proposed a behavioural health service use model with major components that influence the health outcome. Population factors were considered as major predictors for health service use and health outcomes. These factors include predisposing (demographic, health beliefs, values, attitude, and knowledge), enabling (availability of health service, income, travelling and waiting time) and need factors. The other determinants in the model were the health care system and external environmental factors. Health service use was considered as an outcome on previous version of the model, but it is considered as a determinant of subsequent health outcome in the latest version [10, 11].

Major indicators used for quantification of health service utilisation in Ethiopia include outpatient attendance per individual, rate of admission, rate of bed occupancy and average length of stay [12]. According to the national criteria, areas within 2 hours of walking distance or less than 10 km away from the primary health care unit are considered physically accessible [6]. A study conducted 30 years ago in 26 health facilities in central, southern and western Ethiopia, showed that substantial variations in health service utilisation rates occurred in regions, district, and local communities. Furthermore, the geographic determinants for the health service utilisation rate were physical accessibility, such as the presence of all-weather roads, size and location of the health facilities, and distance of households away from the health facilities, distribution of other health services in the area, population density and urbanisation [13]. However, the Federal Ministry of Health launched roadmap in 2020 which was designed to improve the coverage, access, and quality of primary health care units. The health posts and health centres will be upgraded. According to the Ethiopian three-tire health service delivery system, one health centre serves 25,000 rural population up to 40,000 urban population. There are five community health posts under each health centre. Each health posts serve 3,000–50000 population. Five health posts and one referral health centre comprise a primary health care unit [14, 15]. The scale-up was initiated to tackle the challenges observed in the health extension program in addressing universal health coverage and delivering quality services. The upgraded health facilities will be equipped with better health professionals, clinical services, infrastructure, governance and leadership, and information systems [15–17]. In this new plan, health posts that are far (>1 hour) from health centres, and in geographically inaccessible areas, will be upgraded to "comprehensive health posts". In addition to the basic health extension packages, the comprehensive health posts will provide improved clinical and curative services. During this 15 years plan (2020–2035), a health centre and health post will be merged if they are close to each other. These improvements could increase the coverage, accessibility, quality and service usage [17].

Geographical analyses are used for variables having a spatial structure and it is helpful in public health decision-making by illustrating health events and health services [18]. Thus, Geographic Information System (GIS) could be used by health planners to examine the level of health service utilisation and to visualize over-and underutilised areas. Different studies

showed a variation in health care utilisation patterns from place to place even at the small-area level [19]. Even if primary health services are available, they are usually underutilized [20].

Studies elsewhere in Ethiopia, showed that accessibility of the health facilities was better for urban residents and for those with shortest distance to the nearest health facilities [21, 22]. However, the geographical distributions of health services, disparities in health service utilisation at the kebele (smallest administrative units) level have not been investigated. Moreover, understanding geographical factors contributing to uneven distribution of health service utilisation at a small area (kebele) level might help to plan targeted intervention. We also integrated the determining factors in the context of the behavioural model of health service use by Ronald M. Andersen (S1 Fig). Specific questions we seek to investigate are: (1) How is health service utilisation distributed at kebele level? (2) What kinds of kebele level geographic factors affect the service usage? The answer to these questions might give direction to policy-makers on improving the health service accessibility. Therefore, this study aims to assess the health service utilisation and identify geographical factors contributing to the low service usage in the Dale and Wonsho districts of the Sidama region in southern Ethiopia.

Materials and methods

Ethics statement

Ethical clearance was obtained from the Institutional Review Board at the College of Medicine and Health Sciences of Hawassa University (Reference number IRB/022/10) and the Regional Ethics Committee for Medical and Health Research in Norway REK Vest (2018/67/REK vest). The then Sidama Zone Health Department, Dale and Wonsho woreda (district) health offices provided permission letters to collect secondary data from all health facilities. The ethical committees mentioned above ruled that no informed consent was required for secondary data use. All the methods used in this study were according to relevant guidelines and regulations. There was no personal identifier in the data set. The confidentiality of the data was maintained.

Study area, setting and design

This study was conducted in the Sidama region in southern Ethiopia. The region has three agro-ecologic or climatic zones, such as wet or moist highland areas (with altitudes above 3,001 metres), semi-arid midland areas (with altitudes ranging from 2,001 metres to 3,000 metres) and dry lowland areas (1,501 metres to 2,000) [23, 24]. The Sidama region is one of the most densely populated areas in Ethiopia, with a total area of 6981 km^2 and a population density of 533 persons/km^2 [23]. The region constitutes about 4.0% of the national population, 95% of the population lives in rural areas and 94% of the population speak the local language called "*Sidaamu Afoo*". Females compose 49.5% of the population. Under-five years of age children constitute 15.8% of the population [25]. Based on the regional reports, pneumonia was considered the most common cause of morbidity in under-five children [23]. An earlier study from southern-central Ethiopia showed malaria as a major perceived cause of death among adults [26].

The livelihood of the population depends on the farming of perennial crops including maize and Enset (*Ensete ventricosum*) as a staple food and coffee as a cash crop. These crops constitute more than half of the backyard gardening areas and the share of other produces, like maize, khat (*Catha edulis*), fruits, vegetables, pulses, roots, tubers and spices is smaller. Even though Enset plays a pivotal role in Sidama culture and identity, recently the society is changing to maize farming [23, 27, 28]. The home garden of the Sidama people also includes trees and livestock species, such as cattle, goats, sheep, donkeys, horses, mules and chickens. The

presence of livestock in the home garden shows the integrated farming system in Sidama [27]. The Sidama society is known for its indigenous traditional institutions of conflict resolution mainly due to land issues, but they also make use of the formal government structures, such as courts [29].

The modern health care service started in the region during the late 1930s in Yirga Alem and the use of traditional medicine reduced gradually afterwards [30]. The region had 658 functioning public health facilities (three hospitals, 132 health centres and 523 health posts) and seven non-governmental organization led clinics in 2015 [23].

We did the study in Dale and Wonsho districts (woredas). In 2017, the Dale district had a total population of 268,839 people and an estimated 53,768 households. It had 36 rural and two urban kebeles (the lowest administrative structures). Yirga Alem town was the main town in the district and had five urban kebeles. Wonsho, which was the smallest district in the region had 129,730 people living in 17 rural and one urban kebeles in 21,857 households [23, 31]. There were ten functional public health centres and 33 health posts in Dale, and the Wonsho district had five health centres and 17 health posts. There were nine privately owned primary and medium clinics in Dale district and Yirga Alem town, while only one primary clinic gave service for Wonsho district [23, 31].

This study employed an exploratory ecological study design [32] by using an aggregated data at a population level. This method compares rates in different places to search for spatial patterns that might imply environmental or other etiologic hypotheses. We collected the data from 1 July 2017 to 30 June 2018.

Study participants

We used all new cases or patients who sought health services from all health centres and health posts in the Dale and Wonsho districts. The national health management information guide indicates to use new cases as a numerator for morbidity calculations [12]. We selected the districts purposively since they were the study sites for the previous demographic study done by the same authors [33]. A total of 67,678 (92%) cases from 73,513 new cases had confirmed addresses [34]. The rest of the cases either didn't have an address or were from other districts. Therefore, we performed the spatial analysis on the 67,678 cases from 54 kebeles having an address at the kebele level.

To confirm the sample adequacy, we performed sample size calculation on Open Epi version 3.01 (Dean AG, Sullivan KM, Soe MM, Open Source Epidemiologic Statistics for Public Health, Version, 2013) statistical software. We used a formula for estimating a single population proportion with a prevalence of 48% utilization, 80% power, 95% confidence interval, a precision of 1% and design effect of 1.5. The required sample size was 14,246 patients. Hence, we have included the 67,678 cases with addresses for the analysis (Fig 1).

Study variables

The outcome variable was the health service utilisation rate calculated as the number of new visits to the health facilities in the kebele divided by the total population of the kebele. The exposure variables were altitude, population density, family size and distance from the health centre to the centre of the kebele.

Operational definitions

Health service utilisation rate is the number of new visits to health facilities per year relative to the total population of the same geographical area.

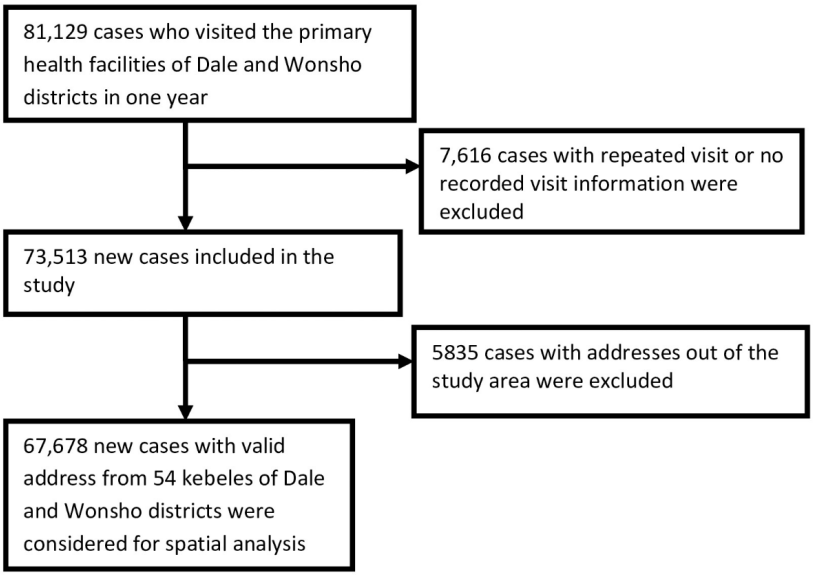


Fig 1. A flow-chart of number of cases included for the spatial analysis in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia.

https://doi.org/10.1371/journal.pgph.0000087.g001

Family size refers to the average number of people living together in a household in a kebele.

Distance from the health centre to the centre of the kebele is the distance measured in kilometres from the health centre in the kebele to the centre of the kebele. It is a proxy indicator for access [12].

Data collection tools and procedures

The data were collected from registries of 15 health centres and 50 health posts in the Dale and Wonsho districts. Secondary data was collected from the standard registers supplied by the Federal Ministry of Health to the health centres and health posts. Each unit or department had a registry with the registration, identification, and service related information. The information reviewed from the registries is attached in S1 Table. The data collection instruments were pretested on health centres and health posts outside of both districts [34]. Fifteen data collectors were trained for two days about the protocol and how to collect the data from the registries. The data collectors went to the service delivery units with permission letters from each district and copied the information in to the data collection format from the respective registries in the study period. The data were double entered and validated in EpiData version 3.1 software (EpiData Association; Odense, Denmark, 2004). The data cleaning and analysis were done by STATA software version 13 (Stata Corp LP., College Station, Texas, USA, 2013) and Microsoft Excel. Re-checking was done by the principal investigator on 5% of the cases in each health facility to assure the quality of the data. These steps have been described in a previous paper [34].

Geographical information for the study kebeles was collected from different sources. Geographically weighted central locations were indicated by the kebele central locations as coordinates. We extracted the geographical coordinates (latitudes and longitudes) of the kebeles from a previous study done in the region collected by using the geographic positioning system (GPS) tools [35]. These coordinates were used to build the base-maps of the study area and point-maps of the health centres. The Central Statistical Agency of Ethiopia collects geographical data and distributes to the regions. Therefore, population density, family size and altitude information were obtained from the Central Statistical Agency, Hawassa branch, and Sidama Region Plan Commission. The distance information was generated by the ArcGIS 10.3 (Esri Inc., Redlands, CA, USA, 2014) analysis tool by proximity-near command from the kebele central location and health centre location files. We used distance from health centres to the centre of the kebele because our unit of analysis was at kebele level not household level.

Data analysis

We calculated the health service utilisation rate for each kebele by dividing the number of new visits during one year by the total population in the kebeles using OpenEpi Version 3.01 software.

We made an attribute table having information about the population, kebele codes, number of visits to the health facilities, number of people in each kebele, area coverage of each kebele, health service utilisation rates, population density, family size, altitude, distance from health centres, the coordinates of each kebele and health centres. Then, it was exported to ArcGIS 10.3 for visualization. The World Geodetic System (WGS) 1984, Universal Transverse Mercator (UTM) Zone 37˚N was used to define the coordinates' projection. The layer map and the attribute table were joined during the analysis. We used a five scales classification, indicated by high (dark colour) to low (light colour) rates, created with the natural break method for clustering maps. The attribute tables created for ArcGIS was then exported to SaTScan version 9·6·1 software for further analysis of the presence of areas with unusually low rates of health service utilisation or clustering. We used four different types of files for SaTScan analysis. We used the case file, the population file and the coordinate file for initial SaTScan analysis, and covariate files for adjustment analysis. To identify locations and estimate cluster sizes, we used Kulldorf's spatial scan statistics [36]. We assessed the distribution of health centres using the network analyst extension. We prepared a new dataset consisting of the road map, the location of health centres and the central location of the kebeles for network analysis. We assessed service area coverage using a 2 km, 5 km, and 10 km distance away from the facility as a cut of point. Service area coverage is defined in this study as the area measured through physical distance between the service area (health centres) and the people benefiting from the service (kebele centre) [37, 38]. We performed the location-allocation analysis to understand how the kebele centres were within a 10 km distance from the health centres. The Federal Ministry of Health of Ethiopia was used to consider an area to be physically accessible if it is within 10 km distance or 2 hours travel time from the health facility [6]. The setting "maximize coverage" was selected with the fifteen health centre locations.

Analysis of the geographic grouping of health service utilisation or clustering. We mapped and labelled the health service utilisation rates in each kebeles using ArcGIS 10.3 (Esri Inc., USA) software. For local clustering analysis, the scan statistics evaluated if the health service utilisation were randomly distributed over a defined area. If the process was not random, the scan statistics helped to identify significant spatial clusters, the log-likelihood ratio (LLR), the relative risk (RR) and P-value. The statistical significance of the largest likelihood ratio was assessed through the Standard Monte Carlo simulation (999 simulations performed). We used a purely spatial Poisson probability model to identify and locate areas with high rates. The

most likely cluster and secondary clusters were identified based on the log-likelihood ratio. No geographic overlap was selected as criteria for reporting secondary clusters. A circular window was used by Kulldorf's spatial scan to identify significant clusters of health service utilisation over the study area. The maximum reported cluster size was set at a radius of less than 50% of the total population at risk. For each scanning window, a likelihood ratio test was conducted to test whether there is an increased rate of health service utilisation as compared with the distribution outside, the window at a P-value <0.05 [19].

Analysis of determinants of the geographic grouping of health service utilisation. After identifying the presence of clustering of health service utilisation rate, we considered the geographical factors as covariates. The geographic grouping observed on health service utilisation might be due to aggregation of known geographic covariates not randomly distributed among the kebeles or due to the presence of spatial dependency. For the Poisson probability model, it is recommended to make the covariates as categorical variables [36], therefore, we categorized the variables accordingly. Then, we adjusted the covariates, such as altitude, population density, and distance from the health centre in the advanced input feature of SaTScan software. We left the variable family size out of the analysis because it was similar in all kebeles. We checked for multicollinearity among exposure variables by using Variance Inflation Factor (VIF). We also performed bivariate and multivariable linear regression to identify the association between the covariates and the outcome (rate of health service utilisation).

We included all three variables in the multivariable regression even if the P-value was >0.2 during bivariate analysis. We used a P-value of 0.05 and the 95% confidence interval as a measure of significance.

Finally, the results of the analyses were presented in tables and on the maps to show the locations where higher rates of service utilisation exist.

Results

Spatial distribution of health service utilisation at kebele level

The annual health service utilisation rate per person varied across the kebeles. Bokaso town from Wonsho district showed the highest annual health service utilisation rate 1.19 visits per person per year (95% CI: 1.15 1.23). Masincho kebele from Dale district had the lowest utilisation rate, 0.01 visits per person per year (95% CI: 0.004 0.01). The mean annual health service utilisation rate was 0.17 visits per person per year (S2 Table).

Fig 2 showed four of the five kebeles with the highest utilisation rate had a health centre. These included two kebeles from Wonsho district namely Hunkute and Bokaso urban kebeles; and two kebles from Dale district, Semen Kege and Bua Bedagelo.

Distribution of health centres

There were 15 health centres in Dale and Wonsho districts during the study period. We demonstrated their distribution and performed a network analysis to identify the areas that were distant from the nearby health centre location based on the road network of the study site. We identified most areas were within a 5 km distance, yet there were areas without health centres located more than 10 km away. The location-allocation analysis showed that 31 out of 54 (57.4%) kebele centres were within a 10 km distance from a health centre (Fig 3 and S2 Fig). This analysis shows the areas that are deprived of nearby health centres in their district.

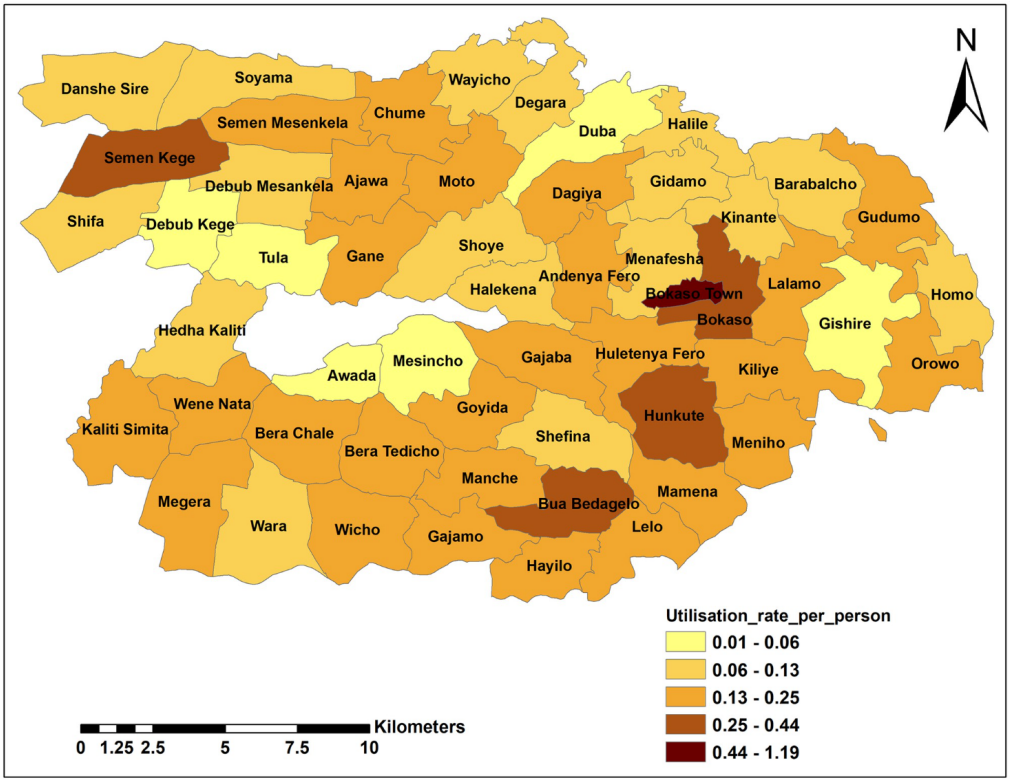


Fig 2. Spatial distribution of annual health service utilisation rate by kebeles in Dale and Wonsho districts, Sidama, southern Ethiopia, 2017/18 (Unit: Rate per person per year).

https://doi.org/10.1371/journal.pgph.0000087.g002

Purely spatial analysis of health service utilisation

We applied Kulldorff's scan statistics to explore the spatial clustering of health service utilisation. The purely spatial analysis identified significant most-likely cluster and secondary clusters for the low health service utilisation rates. The most-likely cluster revealed the cluster which is least likely to be due to chance. Secondary clusters showed other clusters detected in the data with a p-value <0.05. There were 23 kebeles in the most-likely cluster area for the low health service utilisation (Fig 4 and Table 1).

The relative risk (RR) of the low health service utilisation rate for a most likely cluster area was 0.61 with an observed number of 23572 cases, compared with 31663.5 expected cases. Gishire, Kinante, Barabalcho, Shefina, and Gajamo kebeles were secondary cluster areas. Compared to people living in other kebeles, those living in the most likely cluster window were 0.61 times less likely to use health services (Table 1).

Relationship of geographic variables with health service utilisation

After including other kebele-level covariates, such as altitude, distance from a health centre and population density, we performed the analysis in SaTScan software. The kebeles included

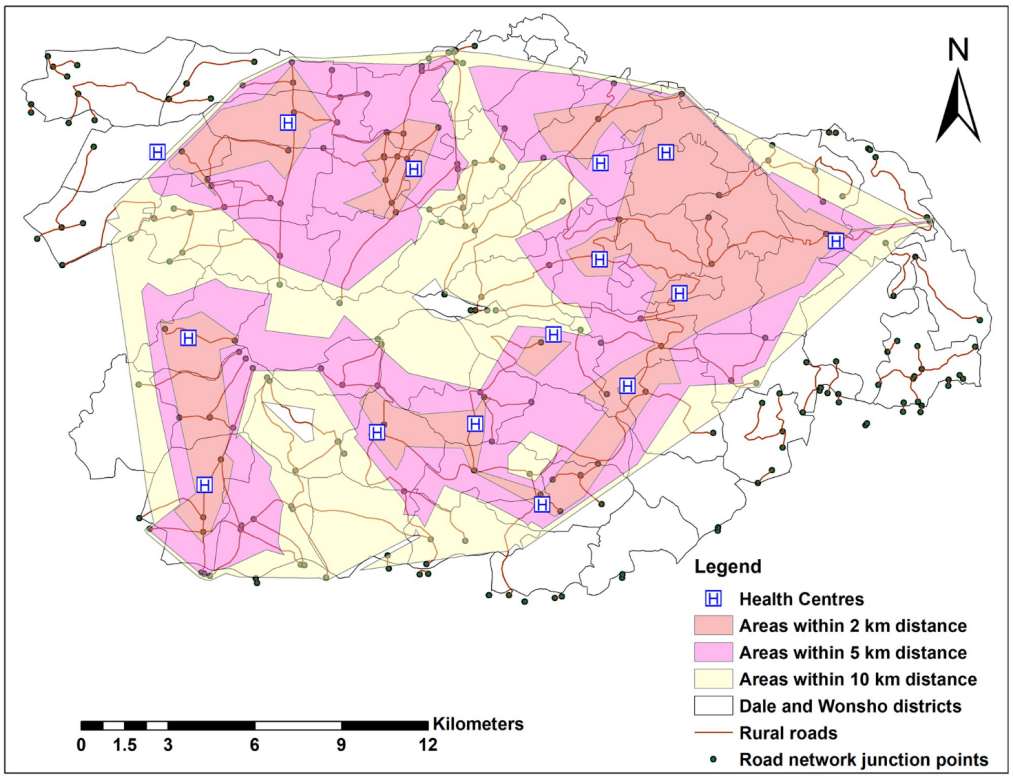


Fig 3. Distribution of health centres and distance of areas away from the health centres based on the road networks in Dale and Wonsho districts, Sidama, Ethiopia, 2017/18.

https://doi.org/10.1371/journal.pgph.0000087.g003

in the most likely cluster and secondary cluster remained the same as unadjusted purely spatial analysis, except one additional kebele from the Wonsho district was incorporated as a secondary cluster (Fig 5 and S3 Table).

The linear regression analysis showed an inverse relationship between distance from the health centre to the kebele central location and the health service utilisation rate (b-estimate = -0.05, p-value = 0.02, 95% CI (-0.08, -0.01)). This means, for every 1 km increase in mean

Table 1. Most likely and secondary spatial clusters of low health service utilisation detected by purely spatial analysis in Dale and Wonsho districts, Sidama, southern Ethiopia, 2017/18.

Cluster	Number of cluster locations	Observed cases	Expected cases	Relative risk	Likelihood ratio	P_value
Most likely cluster	23	23572	31663.50	0.74	1982.93	0.001
Secondary cluster	1	255	733.06	0.35	210.49	0.001
Secondary cluster	2	1385	2227.62	0.62	189.82	0.001
Secondary cluster	1	1381	1674.93	0.82	28.10	0.001
Secondary cluster	1	1395	1558.16	0.90	9.06	0.004

https://doi.org/10.1371/journal.pgph.0000087.t001

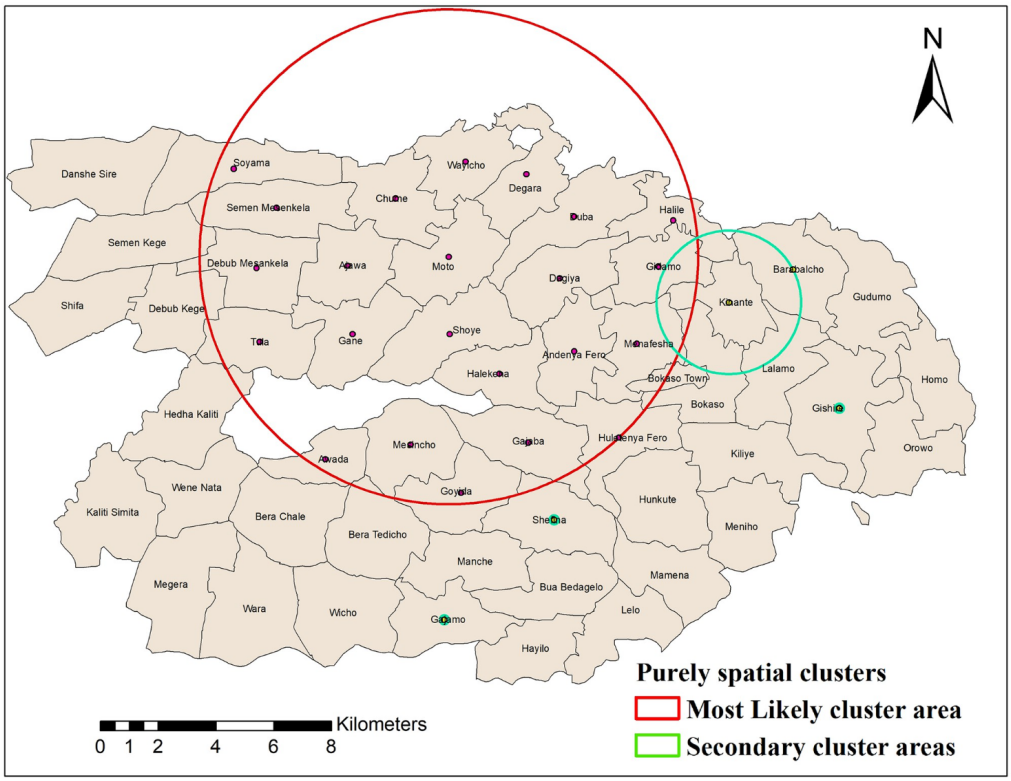


Fig 4. Purely spatial clustering of low health service utilisation in Dale and Wonsho districts, Sidama, Ethiopia, 2017/18.

https://doi.org/10.1371/journal.pgph.0000087.g004

distance from the nearest health centre, the health service utilisation rate decreased by an average of 0.05 visits per 1000 people (S4 Table).

Discussion

We found that the health service utilisation rate was not randomly distributed at the kebele level in the Dale and Wonsho districts. Urban areas and kebeles with a health centre had higher health service utilisation rates compared with rural kebeles and kebeles that do not have a health centre. This might be due to proximity or better physical accessibility of health centres to urban areas and the availability of services on all days of the week at the health centres, unlike the health posts.

In the previous study done by the same authors, a low health service utilisation rate was identified in the study area. However, urban populations used health services more than rural people. The current study confirmed that higher rates of health service utilisation concentrated around an urban kebele. Areas far away from health centre locations had lower health service utilisation rates.

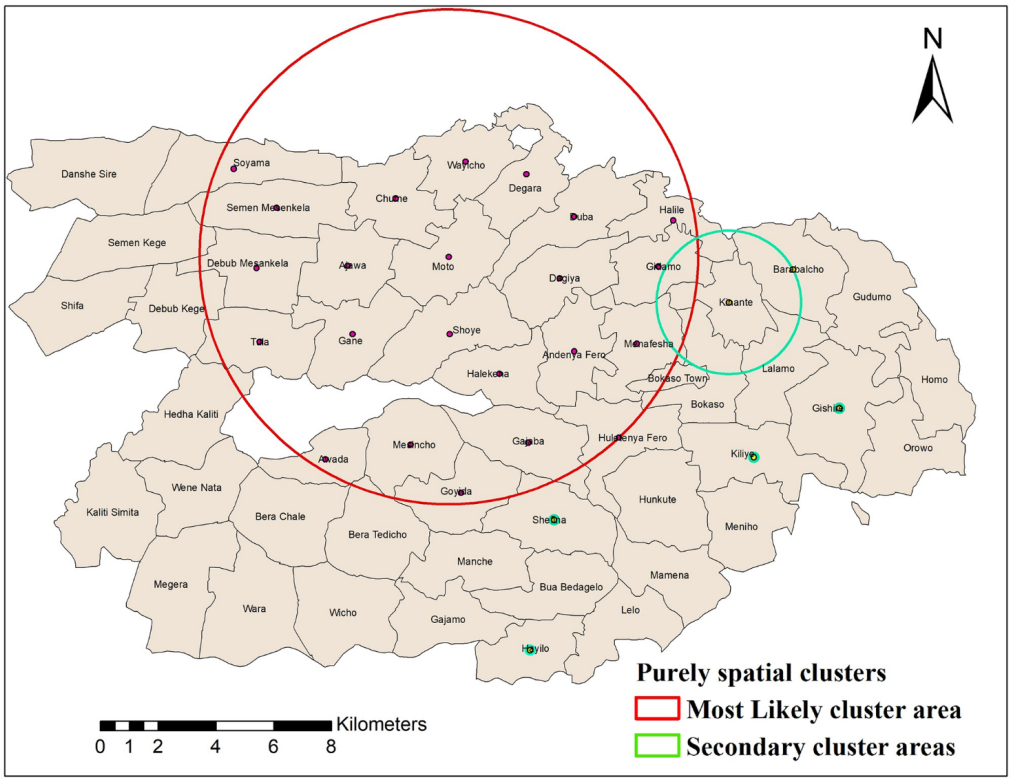


Fig 5. Covariate adjusted spatial clustering of low health service utilisation in Dale district, Sidama, Ethiopia, 2017/18.

https://doi.org/10.1371/journal.pgph.0000087.g005

One of the strengths of this study was including all geographical centres of the kebeles in both districts to assess the health service utilisation rate. Similarly, performing analysis at the lowest scale minimizes the ecological bias. Including available kebele level variables for covariate adjustment and multivariable regression analysis has ruled out some area-level determinants for the low health service utilisation.

Our study has potential limitations that arise from the methodology we used. First, the nature of this exploratory study couldn't identify a causal relationship. Second, we didn't collect data for each individual but at the kebele level. However, kebeles are the lowest spatial units involved in health care planning through their administrative and community representatives in Ethiopia [39]. Third, the health facility registry data lacks comprehensive information to assess determining factors for clustering of health service utilisation. For this reason, our analysis was limited to the identification of clustering and some geographic determinants only. Moreover, the quality of data from the health service information system might be poor [40]. However, since we used all registries from all health centres and health posts from Dale and Wonsho districts, there might not be selective information bias. An ecological bias that arises from the aggregation of data is another concern. However, we performed the analysis at

the lower administrative level which is closer to the individual level which reduces the ecological bias [41]. Besides, most of the exposure variables included in this study, altitude, population density, and distance from the health centre to the centre of the kebele, were unlikely to be different at kebele and individual levels. This implies that the findings observed at kebele level holds true at individual level as well. As we did not collect data from hospitals, private health facilities and for cases that sought services outside the study area, this might result in the underestimation of cases in kebeles closer to these facilities or Yirga Alem town, where the hospital and other private clinics are located. However, the population in those kebeles were around 6% of the study area (23,313/398,569 people) and may not change the utilisation rate.

We also did not consider other individual and biological factors that could contribute to the aggregation of health services in this study. Hence, we refrained from making inferences at an individual level to avoid the ecological fallacy. Furthermore, since there was no census conducted in recent years, we used the 2007 census projection estimate for the current population size in the study area, which might result in an inaccurate denominator estimate for our calculations.

Our study showed better health service utilisation at urban kebeles. This finding is consistent with different studies conducted in Ethiopia [13, 21, 42, 43]. Contrary to our finding, a study done in Kenya found that urban dwellers utilising health care services less than rural residents [44]. This inconsistency might be due to the societal difference portrayed by the Kenyan study as having a habit of self-medication by the over-the-counter drugs, in addition to the differences in the study design.

Kebeles with better access to health centres had a higher health service utilisation rate than other kebeles that didn't have a health centre. This finding is similar to other community-based studies done in Ethiopia that depicted people living close to health centres or hospitals as having a better health service utilisation [22, 43]. Similarly, a recent study from the same study area showed that people preferred to use health centres over health posts [34]. Therefore, the government's initiative to scale up the health posts to a level in which they can give good health service with better-trained professionals and equipments, is in line with our findings [17]. Hence, we believe that changing the health system from basic to comprehensive health post level might improve health service utilisation.

Constructing health centres within a 5 km distance was reported to increase service delivery significantly in Ethiopia [45]. Similarly, another study in Amhara region showed that access to health services was affected by the lower health service coverage and geographically inaccessible location of health facilities [46]. The national standard also states a physically accessible health facility if it is within a 10 km or 2 hours walking distance. In our study, we found that more than half (57.4%) of the locations were within a 10 km distance from the health centres. One of the explanations for this finding might be the exclusion of the 50 health post locations from our analysis, which might have increased the coverage substantially. Yet, the recommendation for the construction of health centres within a 5 km reach was not achieved in our study area. Our study might give insight into geographic areas in which people lack access to better health services. Furthermore, this finding implies constructing health institutions nearer to the homes to improve accessibility as a proxy for better service usage. Besides, this result supports the expansion and upgrading of health facilities in Ethiopia to meet the population needs, as indicated by the new Ministry of Health initiative to optimise the health primary health care units [17].

Different studies in Ethiopia found that geographical variables, such as distance from the health facilities, altitude and population density as determinant factors for clustering of specific diseases [13, 22, 35]. In this study, we only found the distance from the health centre having an inverse relationship with the health service utilisation rate. The geographic similarity of the

adjacent districts we studied might have contributed to the non-significant finding on altitude and population density. Moreover, in our study, we used institution-based study taking measurements from the kebeles' central location while the other studies used individual or household level measurements.

Conclusions

This study showed considerable geographical variability in terms of health service utilisation in the study area. The geographical accessibility of the health centres significantly affected the health service utilization rate. Therefore, our findings support the government's initiative of upgrading the primary health care units to improve the physical accessibility and the health services to the rural community. Moreover, understanding the variations and investigating other geographical factors responsible for this aggregation could give some valuable insights to the health planners in allocating limited resources and devising targeted interventions specific to the local areas.

Supporting information

S1 Table. List of registers reviewed to extract the data from health centres and health posts in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia. NB: The information extracted from each registers were, name of the district, name of health facility, address of the health facility (rural or urban), unit or department, card number, date of visit, sex, age (in days, months, years or date of birth), address (kebele), diagnosis, and visit type.
(DOCX)

S2 Table. The annual health service utilisation rate of new cases in kebeles of Dale and Wonsho districts, 2017/18, Sidama, Ethiopia.
(DOCX)

S3 Table. Most likely and secondary spatial clusters of low health service utilisation detected after adjustment of covariates in purely spatial analysis in Dale and Wonsho districts, Sidama, southern Ethiopia, 2017/18.
(DOCX)

S4 Table. Multivariable linear regression analysis of geographic factors affecting the health service utilisation in Dale and Wonsho districts, Sidama, southern Ethiopia, 2017/18. We did the analysis using aggregated data from 54 kebles (n = 54 kebeles), R-squared = 0.15, P-value = 0.04.
(DOCX)

S1 Fig. Conceptual framework based on the behavioral model of health service use by Ronald M. Andersen, 1995.
(TIF)

S2 Fig. The areas within 10 km distance coverage of the health centres in Dale and Wonsho district, Sidama, Ethiopia, 2017/18.
(TIF)

Acknowledgments

We would like to acknowledge University of Bergen and Hawassa University for supporting this study. We are also grateful for Sidama Regional Health Bureau, Dale and Wonsho district health offices, Sidama Region Plan Commission and Central Statistical Agency, Hawassa

branch, and personnel at the health facilities in Dale and Wonsho districts for their cooperation. We wish to thank all our data collectors and supervisors for their involvement in this study.

Author Contributions

Conceptualization: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Data curation: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Formal analysis: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Funding acquisition: Bernt Lindtjørn.

Investigation: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Methodology: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Project administration: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Resources: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Software: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Supervision: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Validation: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Visualization: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Writing – original draft: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

Writing – review & editing: Hiwot Abera Areru, Mesay Hailu Dangisso, Bernt Lindtjørn.

References

1. World Health Organization. World Health statistics 2014: Health service coverage. Geneva, Switzerland:World Health Organization; 2014.
2. Donnelly J. Ethiopia gears up for more major health reforms. Lancet. 2011; 377(9781):1907–8. https://doi.org/10.1016/s0140-6736(11)60795-2 PMID: 21648121
3. National Planning Commission. Ethiopia 2017 Voluntary National Review on SDGs: Government Commitments, National Ownership and Performance Trends. Addis Ababa, Ethiopia; 2017.
4. Cerf ME. Sustainable Development Goal Integration, Interdependence, and Implementation: the Environment–Economic–Health Nexus and Universal Health Coverage. Glob Challenges. 2019 Sep 29; 3 (9):1900021.
5. Alebachew, Abebe, Laurel Hatt, Matt Kukla SN. Universal Health Coverage Low-Income Context: an Ethiopian Case Study. Bethesda, MD: Health Finance & Governance Project, Abt Associates Inc.; 2014.
6. Ministry of Health [Ethiopia]. HMIS Indicator Definitions- Technical Standards: Area 1. Addis Ababa, Ethiopia; 2014. p. 136.
7. Ethiopian Public Health Institute. Ethiopia Service Availability and Readiness Assessment 2016 Summary Report. 2016;123.
8. Higgs G. A literature review of the use of GIS-based measures of access to health care services. Heal Serv Outcomes Res Methodol. 2004; 5(2):119–39.
9. Orbell S, Schneider H, Esbitt S, Gonzalez JS, Gonzalez JS, Shreck E, et al. Health Care Utilization. In: Carrasquillo Olveen, editor. Encyclopedia of Behavioral Medicine. New York, NY: Springer New York; 2013. p. 909–10.
10. Andersen RM. Revisiting the Behavioral Model and Access to Medical Care: Does it Matter? J Health Soc Behav. 1995; 36(1):1–10. PMID: 7738325
11. Ryvicker M. A Conceptual Framework for Examining Healthcare Access and Navigation: A Behavioral-Ecological Perspective. Soc Theory Health. 2018 Aug 1; 16(3):224. https://doi.org/10.1057/s41285-017-0053-2 PMID: 31007612

12. Federal Ministry of Health. HMIS Indicator Reference Guide-Technical Standards: Area 1. Addis Ababa, Ethiopia; 2017.

13. Kloos H. Utilization of selected hospitals, health centres and health stations in Central, Southern and Western Ethiopia. Soc Sci Med. 1990 Jan 1; 31(2):101–14. https://doi.org/10.1016/0277-9536(90)90052-t PMID: 2389147

14. Tesema AG, Abimbola S, Mulugeta A, Ajisegiri S, Narasimhan P, Joshi R, et al. Health system capacity and readiness for delivery of integrated non-communicable disease services in primary health care: A qualitative analysis of the Ethiopian experience. PLOS Glob Public Heal. 2021; 1(10):1–16.

15. Ministry of Health [Ethiopia]. Realizing Universal Health Coverage Through Primary Health Care: A Roadmap for Optimizing the Ethiopian Health Extension Program 2020–2035. Addis Ababa, Ethiopia; 2020.

16. Ethiopian Federal Ministry of Health. Health Extension and Primary Health Service | FMOH [Internet]. 2019 [cited 2021 Jul 29]. https://www.moh.gov.et/ejcc/en/hephs

17. Federal Ministry of Health. An Implementation Manual for Optimizing Health Extension Program. Addis Ababa, Ethiopia; 2021.

18. World Health Organization (WHO). Disease Mapping and Risk Assessment for Public Health Decision-Making: Report on a WHO Workshop. Copenhagen, Denmark; 1999.

19. Cromley Ellen K. and McLafferty Sara L. GIS and Public health. Second edi. New York: The Guilford Press; 2012. 1–222 p.

20. Hiscock R, Pearce J, Blakely T, Witten K. Is neighborhood access to health care provision associated with individual-level utilization and satisfaction? Health Serv Res. 2008 Dec; 43(6):2183–200. https://doi.org/10.1111/j.1475-6773.2008.00877.x PMID: 18671752

21. Fantahun M, Degu G. Health Service Utilization in Amhara Region of Ethiopia. Ethiop J Heal Dev. 2004 Mar 25; 17(2):141–7.

22. Girma F, Jira C, Girma B. Health services utilization and associated factors in jimma zone, South west ethiopia. Ethiop J Health Sci. 2011 Aug; 21(Suppl 1):85–94. PMID: 22435012

23. Sidama Zone Finance and Economic Development Office. Sidama zone administration socio-economic profile 2014/15. Hawassa, SNNPR; 2016.

24. Quinlan RJ, Quinlan MB, Dira S, Caudell M, Sooge A, Assoma AA. Vulnerability and resilience of Sidama Enset and Maize Farms in Southwestern Ethiopia. J Ethnobiol. 2015; 35(2):314–36.

25. Federal Democratic Republic of Ethiopia Population Census Commisssion. The 2007 Population and Housing Census of Ethiopia: Statistical Report for Southern Nations, Nationalities and Peoples' Region; Part I: Population Size and Characteristics. Addis Ababa, Ethiopia; 2007.

26. Molla M, Byass P, Berhane Y, Lindtjorn B. Mortality Decreases among Young Adults in Southern Central Ethiopia. EthiopJHealth Dev. 2008; 2001(22):218–25.

27. Abebe Tesfaye and Bongers Frans. Forest-people interfaces: Land-use dynamics in enset-based agroforestry homegardens in Ethiopia. Arts B, van Bommel S, Ros-Tonen M, Verschoor G, editors. Netherlands: Wageningen Academic Publishers; 2012. 1–303 p.

28. Quinlan RJ, Dira SJ, Caudell M, Quinlan MB. Culture and psychological responses to environmental shocks: Cultural ecology of sidama impulsivity and niche construction in Southwest Ethiopia. Curr Anthropol. 2016 Oct 1; 57(5):632–52.

29. Mengesha AD. The Role of Sidama Indigenous Institutions in Conflict Resolution: In the Case of Dalle Woreda, Southern. Am J Sociol Res. 2016; 6(1):10–26.

30. Lindtjørn B. The role of a mission organization in building a sustainable government hospital in Southern Ethiopia. Christ J Glob Heal. 2020; 7(2):133–46.

31. Dalle Woreda Finance and Economic Development Office. The development of social and economical information of Dalle woreda. Hawassa, SNNPR; 2016.

32. Rothman KJ, Greenland S, Lash Timothy L. Modern Epidemiology. 3rd editio. Seigafuse S, Bierig Louise, editors. Philadelphia, USA: Lippincott Williams & Wilkins; 2008.

33. Areru Hiwot Abera, Dangisso Mesay Hailu & Lindtjørn Bernt. Births and deaths in Sidama in southern Ethiopia: findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS). Glob Health Action. 2020; 13(1):1833511. https://doi.org/10.1080/16549716.2020.1833511 PMID: 33115376

34. Areru HA, Dangisso MH, Lindtjørn B. Low and unequal use of outpatient health services in public primary health care facilities in southern Ethiopia: a facility-based cross-sectional study. BMC Heal Serv Res. 2021 Aug; 21(1):1–14. https://doi.org/10.1186/s12913-021-06846-x PMID: 34362376

35. Hailu Dangisso M, Gemechu Datiko D, Lindtjørn B. Identifying geographical heterogeneity of pulmonary tuberculosis in southern Ethiopia: a method to identify clustering for targeted interventions. Glob Health Action. 2020; 13(1):1785737. https://doi.org/10.1080/16549716.2020.1785737 PMID: 32746745

36. Kulldorff M, Information Management Services I. SaTScan User Guide Version 9.6: Software for the spatial and space-time scan statistics. Boston; Calverton, Maryland; 2018. p. 1–122.

37. Tanahashi T. Health service coverage and its evaluation. Bull World Health Organ. 1978; 56(2):295. PMID: 96953

38. Asemahagn MA, Alene GD, Yimer SA. Geographic Accessibility, Readiness, and Barriers of Health Facilities to Offer Tuberculosis Services in East Gojjam Zone, Ethiopia: A Convergent Parallel Design. Res Rep Trop Med. 2020 Feb; 11:3. https://doi.org/10.2147/RRTM.S233052 PMID: 32099509

39. Ethiopian Federal Ministry of Health. Health Sector Transformation Plan (2015/16-2019/20). Addis Ababa, Ethiopia: Federal Ministry of Health; 2015.

40. Adane A, Adege TM, Ahmed MM, Anteneh HA, Ayalew ES, Berhanu D, et al. Routine health management information system data in Ethiopia: consistency, trends, and challenges. Glob Health Action. 2021; 14(1):1868961. https://doi.org/10.1080/16549716.2020.1868961 PMID: 33446081

41. Elliott P, Wartenberg D. Spatial epidemiology: Current approaches and future challenges. Vol. 112, Environmental Health Perspectives. Public Health Services, US Dept of Health and Human Services; 2004. p. 998–1006.

42. Yeneneh A, Alemu K, Dadi AF, Alamirrew A. Spatial distribution of antenatal care utilization and associated factors in Ethiopia: Evidence from Ethiopian demographic health surveys. BMC Pregnancy Childbirth. 2018 Jun; 18(1):242. https://doi.org/10.1186/s12884-018-1874-2 PMID: 29914403

43. Begashaw B, Tessema F, Gesesew HA. Health Care Seeking Behavior in Southwest Ethiopia. PLoS One. 2016; 11(9):e0161014. https://doi.org/10.1371/journal.pone.0161014 PMID: 27626804

44. Mwami MN, Oleche MO. Determinants of Utilization of Health Care Services in Kenya. Int J Acad Res Bus Soc Sci. 2017; 7(10):132–56.

45. Croke K, Telaye Mengistu A, O'Connell SD, Tafere K. The impact of a health facility construction campaign on health service utilisation and outcomes: analysis of spatially linked survey and facility location data in Ethiopia. BMJ Glob Heal. 2020 Aug; 5(8):e002430. https://doi.org/10.1136/bmjgh-2020-002430 PMID: 32859649

46. Asemahagn MA, Alene GD, Yimer SA. Geographic Accessibility, Readiness, and Barriers of Health Facilities to Offer Tuberculosis Services in East Gojjam Zone, Ethiopia: A Convergent Parallel Design. Res Rep Trop Med. 2020; Volume 11:3–16.

Supplementary files for Paper II

S1 Table: List of registers reviewed to extract the data from health centres and health posts in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia

Registers from health centres	**Registers from health posts**
ANC register	ANC register
Delivery register	Family planning register
Family planning register	PNC register
Infant immunization and growth monitoring register	TB suspected case screening and treatment register
PNC register	Malaria Assessment
Cervical cancer screening and prevention register	Infant immunization
Safe/Post abortion Care register	ICCM 0-2months
Comprehensive abortion care register	ICCM 2months-5years
Outpatient department (OPD) register/ OPD abstract register	Registration book for therapeutic feeding
Emergency department register	Community health day services (CHD) register
Unit TB register	Forms below are from family folders • Integrated Antenatal, Labor, Delivery, Newborn and Postnatal Card • Health card: FP and Immunization
Integrated under-five registration book : from birth to 2 months	
Integrated under-five registration book : from 2 months up to 5 years	
Stabilization centre and Outpatient therapeutic feeding program register	
Referral register	• Health posts disease information tally
Diabetes and Hypertension treatment register	
Eye clinic registration	
*Some health facilities registered TT and PMTCT separately from ANC registers	

NB: The information extracted from each registers were, name of the district, name of health facility, address of the health facility (rural or urban), unit or department, card number, date of visit, sex, age (in days, months, years or date of birth), address (kebele), diagnosis, and visit type.

S2 Table:The annual health service utilization rate of new cases in kebeles of Dale and Wonsho districts, 2017/18, Sidama, Ethiopia.

Kebele Name	Kebeles with health centre	District Name	Annual visits per each kebele	Population size per kebele	Annual utilization rate per person
Semen Mesenkela	Yes	Dale	1493	8958	0.17 (0.16 0.18)
Gidamo	Yes	Dale	809	8672	0.09 (0.09 0.1)
Dagiya	Yes	Dale	2212	10647	0.21 (0.20 0.22)
Moto	Yes	Dale	1806	10909	0.17 (0.16 0.17)
Semen Kege	Yes	Dale	3264	7390	0.44 (0.43 0.46)
Wene Nata	Yes	Dale	908	3984	0.23 (0.21 0.24)
Goyida	Yes	Dale	1383	8991	0.15 (0.15 0.16)
BeraChale	Yes	Dale	2508	10877	0.23 (0.22 0.24)
Megera	Yes	Dale	1497	8146	0.18 (0.17 0.19)
Bua Bedagelo	Yes	Dale	2996	8548	0.35 (0.34 0.36)
Bokaso town	Yes	Wonsho	3491	2944	1.19 (1.15 1.23)
AndenyaFero	Yes	Wonsho	2110	8588	0.25 (0.24 0.26)
Gudumo	Yes	Wonsho	1659	8226	0.20 (0.19 0.21)
Gajaba	Yes	Wonsho	1472	9706	0.15 (0.14 0.16)
Hunkute	Yes	Wonsho	3127	9839	0.32 (0.31 0.33)
Danshe Sire	No	Dale	744	8798	0.08 (0.08 0.09)
Soyama	No	Dale	691	10128	0.07 (0.06 0.07)
Chume	No	Dale	1383	8447	0.16 (0.16 0.17)
Wayicho	No	Dale	725	9154	0.08 (0.07 0.09)
Degara	No	Dale	1140	13560	0.08 (0.08 0.09)
Duba	No	Dale	770	13254	0.06 (0.05 0.06)
Halile	No	Dale	803	8595	0.09 (0.09 0.10)
Shoye	No	Dale	608	7271	0.08 (0.08 0.09)
Gane	No	Dale	644	3394	0.19 (0.18 0.20)
Ajawa	No	Dale	1270	6891	0.18 (0.17 0.19)

S2 Table continued

Kebele Name	Kebeles with health centre	District Name	Annual visits per each kebele	Population size per kebele	Annual utilization rate per person
Debub Mesankela	No	Dale	901	7151	0.13 (0.12 0.13)
Shifa	No	Dale	317	4631	0.07 (0.06 0.08)
Debub Kege	No	Dale	308	4981	0.06 (0.06 0.07)
Tula	No	Dale	193	5037	0.04 (0.03 0.04)
HedhaKaliti	No	Dale	370	4344	0.09 (0.08 0.09)
KalitiSimita	No	Dale	1109	7396	0.15 (0.14 0.16)
Awada	No	Dale	31	3536	0.01(0.006 0.01)
Masincho	No	Dale	34	5359	0.01 (0.004 0.01)
BeraTedicho	No	Dale	1829	9050	0.20 (0.19 0.21)
Wara	No	Dale	1109	10606	0.10 (0.10 0.11)
Wicho	No	Dale	1635	8632	0.15 (0.15 0.16)
Gajamo	No	Dale	1395	9701	0.14 (0.14 0.15)
Shefina	No	Dale	1381	10428	0.13 (0.13 0.14)
Lelo	No	Dale	1428	6731	0.21 (0.20 0.22)
Hayilo	No	Dale	1331	8494	0.16 (0.15 0.17)
Manche	No	Dale	1546	8879	0.17 (0.17 0.18)
Halekena	No	Wonsho	726	8697	0.08 (0.08 0.09)
Menafesha	No	Wonsho	850	9949	0.09 (0.08 0.09)
Kinante	No	Wonsho	625	6744	0.09 (0.09 0.10)
Barabalcho	No	Wonsho	760	7125	0.11 (0.10 0.11)
Homo	No	Wonsho	396	3746	0.11 (0.10 0.12)
Orowo	No	Wonsho	593	3108	0.19 (0.18 0.21)
Gishire	No	Wonsho	255	4564	0.06 (0.05 0.06)
Lalamo	No	Wonsho	1377	7119	0.19 (0.18 0.20)
Bokaso rural	No	Wonsho	2321	6997	0.33 (0.32 0.35)
HuletenyaFero	No	Wonsho	1518	10241	0.15 (0.14 0.16)
Kiliye	No	Wonsho	1262	7699	0.16 (0.16 0.17)
Meniho	No	Wonsho	1177	6771	0.17 (0.16 0.18)
Mamena	No	Wonsho	1388	7726	0.18 (0.17 0.19)
Total			67678	421359	

***Mean Annual utilization rate per person =0.17 (Range 0.01-1.19)**

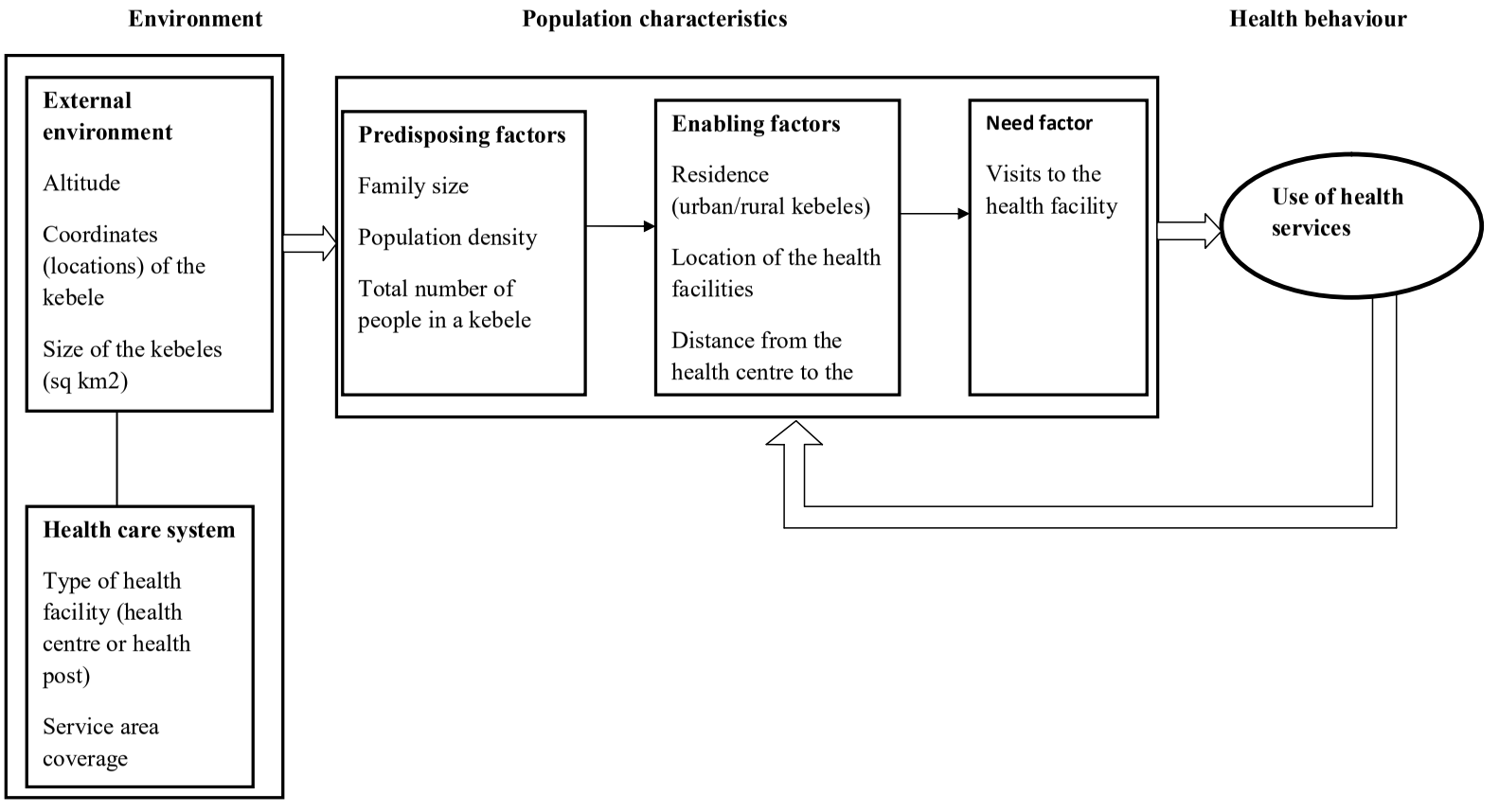
S3 Table: Most likely and secondary spatial clusters of low health service utilisation detected after adjustment of covariates in purely spatial analysis in Dale and Wonsho districts, Sidama, southern Ethiopia, 2017/18.

Cluster	Number of cluster locations	Likelihood ratio	P_value
Most likely cluster	23	3834.32	0.001
Secondary cluster	2	466.10	0.001
Secondary cluster	1	186.45	0.001
Secondary cluster	1	24.62	0.001
Secondary cluster	1	12.78	0.001
Secondary cluster	1	10.86	0.002

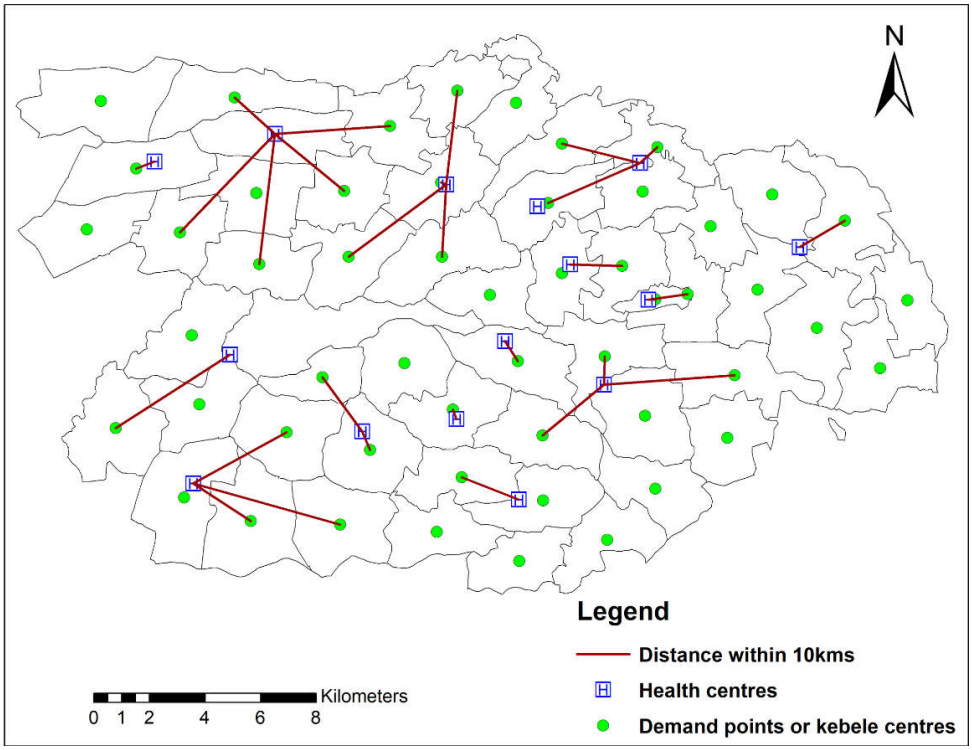
S4 Table: Multivariable linear regression analysis of geographic factors affecting the health service utilisation in Dale and Wonsho districts, Sidama, southern Ethiopia, 2017/18.

Geographic variables	Beta	Standard error	P-value	95% CI	Variance inflation factor
Attitude (Elevation)	0.10	0.07	0.12	-0.03, 0.25	1.24
Population density	0.05	0.07	0.43	-0.09, 0.20	1.21
Distance from the health centre	-0.05	0.02	0.02	-0.08, -0.01	1.32

We did the analysis using aggregated data from 54 kebles (n=54 kebeles), R-squared=0.15, P-value=0.04



S1 Fig: Conceptual framework based on the behavioral model of health service use by Ronald M. Andersen, 1995.



S2 Fig: The areas within 10 km distance coverage of the health centres in Dale and Wonsho district, Sidama, Ethiopia, 2017/18.

Paper III

Global Health Action

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/zgha20

Births and deaths in Sidama in southern Ethiopia: findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS)

Hiwot Abera Areru , Mesay Hailu Dangisso & Bernt Lindtjørn

To cite this article: Hiwot Abera Areru , Mesay Hailu Dangisso & Bernt Lindtjørn (2020) Births and deaths in Sidama in southern Ethiopia: findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS), Global Health Action, 13:1, 1833511, DOI: 10.1080/16549716.2020.1833511

To link to this article: https://doi.org/10.1080/16549716.2020.1833511

GLOBAL HEALTH ACTION
2020, VOL. 13, 1833511
https://doi.org/10.1080/16549716.2020.1833511

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

OPEN ACCESS Check for updates

Births and deaths in Sidama in southern Ethiopia: findings from the 2018 Dale-Wonsho Health and Demographic Surveillance System (HDSS)

Hiwot Abera Areru [a,b], Mesay Hailu Dangisso [a] and Bernt Lindtjørn [a,b]

[a]School of Public Health, Hawassa University, Hawassa, Ethiopia; [b]Centre for International Health, University of Bergen, Bergen, Norway

ABSTRACT

Background: Sidama is one of the most densely populated areas in Ethiopia. Information about the demographic characteristics is scarce, and most studies were census based on interviews. Earlier population studies from Ethiopia did not sufficiently address the validity of measuring births, deaths, and age-composition.

Objective: To investigate the population characteristics in Sidama with an emphasis on fertility estimates, age, and death reporting.

Methods: This is a mixed-method cross-sectional study, conducted in Sidama in southern Ethiopia, using baseline data of newly established Dale-Wonsho Health and Demographic Surveillance System site in 2018. We used quantitative data of 5179 randomly selected households having 25,144 individuals. We collected information on deaths in the same study period and population from the traditional burial associations (*Iddir*). Qualitative data were collected using focus group discussions, and in-depth interviews. Life tables, age reliability indices and logistic regression were used to analyse the data.

Results: The total fertility rate was 2.9 children/woman, the crude birth rate was 22.8/1000 population and the crude death rate was 5.2/1000 population. The dependency ratio was 66/100 working-age population. Urban residents had higher birth rates (OR = 1.4 (95% CL: 1.05–1.78), and women with basic education had lower birth rates (OR = 0.6 (95% CL: 0.46–0.78) compared to those with no education. The age accuracy indices showed unreliable age reporting. The number of deaths increased from 29 to 132 when death reports from the *Iddirs* were included. There was under-reporting of neonatal and deaths of young children. Substituting national and regional mortality estimates, the life expectancy declined to an average of 53 years (range 48–58 years).

Conclusion: The fertility rate in Sidama is lower than previously reported and is affected by age, residence and education. As we have identified important measurement and reporting errors, future demographic surveillance sites should consider these limitations.

ARTICLE HISTORY
Received 10 June 2020
Accepted 5 October 2020

RESPONSIBLE EDITOR
Stig Wall, Umeå University, Sweden

KEYWORDS
Demographic transition; fertility; age reliability index; qualitative; southern Ethiopia

Background

Although fertility started to decline in Asia and Latin America about 60 years ago, it has only started to fall in Africa over the past decade. Thus, an increase in the projected population of Africa is still high, mainly because of the high levels of fertility [1].

Demographic transition theory describes a series of stages that a population experiences due to changes in birth and death rates. During these stages, the population growth and demographic structure shift from a high to a low state of mortality and fertility. Most often, the decline in mortality precedes the decline of fertility [2].

Ethiopia, has during the past decades, experienced high economic growth [3,4] and is undergoing a demographic transition from high to low mortality and fertility since the 1990s. The population growth rate is expected to decline further, and life expectancy is expected to increase. The reductions in mortality and fertility rates are more rapid in Ethiopia than in other sub-Saharan African countries [3–5]. This also creates a window of opportunity for the country by increasing the proportion of the working-age group population to accelerate economic growth [6].

In addition to population size, fertility, mortality and migration, age and sex structure can also influence the number of births, deaths, and moves of the population taking place [2]. Under such a view, reduced fertility can be viewed as an important factor contributing to economic development [7–9]. Some even argue that reduced population growth is a necessary condition for achieving the development aims, such as the Sustainable Development Goals 1–4 [10,11]. However, other scholars believe that fertility reduction is a consequence, rather than a cause, of other underlying changes, such as wealth and literacy, that produce development [12,13]. Births, deaths, and migration are considered the determinants of population change. Change in one or more of these components will result in a change in the population size or

CONTACT Hiwot Abera Areru hiwotab_2005@yahoo.com School of Public Health, Hawassa University, PO Box 1560, Hawassa, Ethiopia
Supplemental data for this article can be accessed here.

structure [2]. Countries generate information from census, vital events registration, population-based surveys, and surveillance systems. This is crucial for evidence-based policy formulation and decision, program planning, and practice. Most developed nations have regular and well-established registration systems as sources of information [14]. Unfortunately, in many developing countries, there is a deficiency in national civil registration and vital statistics system. Ethiopia launched a vital event registration system in August 2016, yet the coverage of birth registration in southern Ethiopia is only 3% [15–17]. Therefore, such countries still depend on data from health facility reports, census and demographic and health surveys for planning and allocation of resources [15,18–22].

Health and Demographic Surveillance Systems (HDSSs) can provide valuable data for long term follow-up of the specifically defined population [23–25]. To get an accurate measure of fertility and mortality, eliminating the effect of age structure and population size is essential. Distortion in age distribution may be caused by past changes in the level of mortality, fertility, and migration or it may be due to errors. The error may also be due to omission or misreporting of individuals' age. This is a common problem in developing countries [2].

In Ethiopia, the crude birth rate has fallen from 48.3 to 32.3 per 1000 population from 1985 till 2015, and the total fertility rate is now 4.3 children per woman [26]. The crude death rate also has fallen from 19.0 per 1000 population in 1985, to 6.7 per 1000 population in 2015. The infant mortality rate has decreased by 70%, and the under-five mortality decreased by 74% since 1985 [26]. However, neonatal mortality decreased by 52% [16,27]. Correspondingly, the median life expectancy has risen to 66 years in 2015, from 46 years in 1985 [26]. Various studies done in Ethiopia have shown that women who are more educated, having better income and living in urban areas, have lower fertility than their counterparts [16,28].

Even though there were different health and demographic surveillance conducted in Ethiopia, the findings are inconsistent across the country. The study currently conducted in Sidama in southern Ethiopia focus on mortality and fertility, where no demographic studies had been done before. A study done in Butajira rural health project in Ethiopia showed the acceptable level of error for measuring births, deaths and age. However, they failed to show the errors encountered in the baseline population because of measurement or program errors and considered them as limitations [29]. We believe that addressing such potential measurement errors in data collection in demographic studies is crucial to avoid inaccuracies in subsequent data collections on the same populations. It also helps to get estimates that reflect the real population dynamics [30,31].

This study aims to investigate the population characteristics in Sidama with an emphasis on fertility estimates, age, and death reporting.

Methods

Study area

This study was done in two districts in Sidama Region, one of the most densely populated areas of southern Ethiopia with 533 persons/km^2 [32,33]. The Region accounts for 4.0% of the National population [34]. Ninety-five per cent of the population speaks the native Sidama language. More than 84% of the population is protestant in their religion, and the traditional religion followers constitute almost 3% of the total population [35]. The Dale district (woreda) covers an area of 30,212 km^2, with a population of 268,839 people and an estimated 53,768 households. It has 36 rural and 2 urban kebeles (the lowest administrative structures). Wonsho district covers 14,528 km^{2,} and 129,730 people live in 17 rural and one urban kebele in 21,857 households. Even if agriculture is a prominent economic sector of the region, farming is traditional [35,36] Both districts are known for their coffee and crop production. Dale district has 10 health centres and 33 health posts, while Wonsho district has 5 health centres and 17 health posts [35,36].

Dale and Wonsho Health and Demographic and Surveillance site

There has been an increase in the number of HDSSs in Ethiopia [20]. And in 2017, Hawassa University established its own Health and Demographic Surveillance System site in Sidama in Dale and Wonsho districts. This site aims to fill evidence gaps by generating community-based health data in southern Ethiopia. The D-W HDSS also signed a memorandum of understanding with the Ethiopian Public Health Institute (EPHI) and is considered as one of the surveillance sites which generate longitudinal health and demographic data in Ethiopia.

Ten of the kebeles were selected by simple random sampling technique from Dale and Wonsho districts, which were incorporated based on their agricultural practice and environmental characteristics. The urban kebeles were selected purposively; one from each district to incorporate population from towns. The estimated households in the sample are around 12,500, with a population of 60,000 people. The surveillance site is called Dale-Wonsho Health and Demographic Surveillance Site (D-W HDSS). (The

map of the study area is attached as supplementary material 3).

Study design

This study used a mixed-method design, using both quantitative and qualitative data. A cross-sectional study design was employed to identify the population characteristics. A qualitative study was undertaken to explore perceptions regarding age reporting, during vital events such as births, deaths, and to triangulate these findings with the quantitative findings. Triangulation is the planned use of two or more methods independently, in investigations of the same event, to strengthen the validity of the results. It helps in mitigating the biases and limitations faced by using a single method [37]. It was done through focused group discussions (FGD) and in-depth interviews (IDI) on variables that required a comprehensive understanding of the community about reporting of events.

Sample size and sampling procedure for quantitative data

In this study, we used a subsample of the D-W HDSS census data. The D-W HDSS policy allowed us to use about 40% of their data for this study. We checked for sample adequacy by taking the national crude death rate estimate of 6.7 per 1000 population, 95% confidence interval, power of 80%, and unexposed/exposed ration of 1. The sample size required using these assumptions was 14,600; the margin of error for this sample was 0.13%. The sample size used for the current study was 25,144 individuals. We initially took a weighted sample from each kebele based on their population size. Then simple random sampling using a random number generator was used to select the specific house numbers from each kebele. For this study, we included 41% of randomly selected households from the D-W HDSS baseline census, and we used the collected data of the variables we wanted to analyse. These processes made our sample representative. (Refer supplementary material 2 for detailed sampling procedure).

The source population for this study were all households in Dale and Wonsho districts, and the study population were the households in the twelve randomly selected kebeles of D-W HDSS.

Study unit

The households were selected by a random number generator and included 5,179 households constituting 41% of the total households (Table 6 is attached as a supplementary material 2).

Sampling procedure for the qualitative study

Purposive sampling was used to select participants (community leaders, religious leaders, experts) for the in-depth interview (IDI) and Focus Group Discussions (FGD) to explore the communities' perception and experience on mortality, birth and age reporting. This method was used to supplement and strengthen the quantitative findings of this paper. A total of 8 IDIs, four from each district, were conducted. A total of 48 individuals, who came from each of the 12 kebeles participated in four different FGDs. Two of the FGDs were for males and the other two for females, having both younger and older age categories to address the issues across the different segment of the population.

Data collection procedure

Data were extracted from the Dale-Wonsho Health and Demographic Surveillance site (D-W HDSS) database in Hawassa University. The database consists of six tables which contain background characteristics, birth information, death information, maternal information (FP and ANC), disease information and household characteristics. For this study, we used all except maternal and disease information tables.

A de-facto census for a population who actually is present during the enumeration [2], was done in 2017 from the selected 12 HDSS kebeles over 6 month period. There were two local data collector and one supervisor assigned for house visits in each kebele to collect the data. The baseline information consisted of background characteristics, information on births, deaths, diseases, and household characteristics. Data on migration were not collected at baseline. Then data were entered into HRS-2 software [38] by four trained data clerks. For this study, 41% of the households were selected and exported to Stata version 13 for cleaning and analysis.

Mortality data on the same population and for the same period (deaths occurring within 12 months before the HDSS survey) was collected from 'Iddirs' of all kebeles. *Iddirs* are traditional voluntary organizations created with a primary purpose of offering mutual aid in burial issues, even though they may be involved in dealing with other community matters [39]. The *Iddirs*' death records were used to find out missed mortality cases from HDSS and to cross-check the accuracy of what was reported. However, the *Iddirs* had only the names, sex and dates of deaths of the deceased individuals. After having obtained the addresses of the households, the data collectors went to the deceased family's household to confirm and get additional information on the age of the deceased, and the possible cause of death.

Operational definitions are attached as supplementary material 1 [60–63].

Data analysis

The analysis was done using Stata/IC version 13.0 software (StataCorp LP., College Station, Texas, USA) and Microsoft excel. Descriptive analysis was done on variables describing the population characteristics. The population pyramid was constructed to see the age and sex composition of the population. Age reliability was calculated using Whipple's index for ages ending by zero and five, Myer's blended index for all ages ending from zero to nine, and United Nations Joint Score for five years age groups up to age 70 years for both sexes [2,40,41]. Principal component analysis (PCA) was done to establish a wealth index. Eighteen variables were dichotomized and considered for PCA. The variables were ownership of radio, television, refrigerator, telephone, bicycle, motorcycle, car, cattle, carriage animals, sheep/goats, chickens and land; and material of the roof and the floor, source of light, source of drinking water, toilet facilities and cooking material. Sensitivity analysis for children's mortality and crude birth rates was done by substituting estimates from regional and national studies, to crosscheck the consistency of the results. For mortality, the infant mortality rate (IMR) of 43 deaths/1000 live births and child mortality rate of 12 deaths/1000 live births from the national estimate were used. Besides, the southern Ethiopia's IMR of 65 deaths/1000 live births and 25 deaths/1000 live births were used to create different scenarios [16,42]. To calculate the life expectancy for our study, we used southern Ethiopia's numbers of IMR of 65 deaths/1000 live births with corresponding 42 infant deaths and child mortality of 25 deaths/1000 live births with corresponding 39 child deaths [16]. Similarly, the national IMR of 43 deaths/1000 live births with corresponding 28 infant deaths and child mortality of 12 deaths/1000 live births with corresponding 19 deaths were substituted to calculate different life expectancy scenarios [42]. For births, the national crude birth rate (CBR) of 31.8 births/1000 population and Dabat HDSS's CBR of 28 births/1000 population were used for comparison [16,43]. Spectrum, a modelling and planning software for improved health, version 5.761 software (Avenir Health, Glastonbury, CT, USA) was used to estimate the projected total fertility rate by comparing our data (2.9 births/woman) with the national numbers that are used in the software [44]. Bivariate and multivariable logistic regression was done to assess factors associated with fertility.

For qualitative data, the recorded audio in *Sidamu Afoo* was translated to Amharic by fluent speakers of both languages. Then the Amharic version was translated and transcribed into English. We used ATLAS. ti 6.2 qualitative analysis software (ATLAS. ti, GmbH, Berlin) to code and analyse the data by two of the researchers. Several emerging themes were generated, such as ways of age estimation, culture on death reporting and roles in a community.

Data management and quality control

The data clerks were trained about the protocol and how to extract the data from the central database. The data were initially cleaned manually by the principal investigator. The consistency was checked for the completeness of the variables and mismatch between the questionnaire and the data entered in the HRS-2 for the selected households. When inconsistencies were found, the PI went to the study site and asked the data collectors for clarification. For incomplete data like mortality, data was recollected by visiting the local community's organizations performing burial services called '*Iddir*' from all the kebeles. The PI also assured the quality of the data on 10% of randomly selected deaths reports by going back to the selected households.

For qualitative data, after reviewing the literature, an interview guide was prepared in consultation with an experienced researcher who knew the Sidama culture and lived in the locality. Then, it was formatted in English and translated to the local language (*Sidamu Afoo*) and back-translated to English to check its consistency. One experienced interviewer having a BSc degree in public health and an assistant, who spoke the local language fluently were trained by the principal investigator on the contents of the interviews. Moreover, the assistant was trained in recording and taking field notes. A tape recorder was used to capture all information from the participants, and this was later translated into English.

Results

Description of background characteristics

The total number of households in this study was 5179, and the number of individuals living in these households was 25,144 people. Six out of ten people were below the age of 25 years (15,542 people), and half of the population were not married (10,063 people). Most of the population, 96.5% (24,258 people) were Sidama by ethnicity, 89% (22,322 people) were Protestants by religion and 83% (20,817 people) lived in rural areas. From those eligible for educational assessment, 35% (7,596 people) had attended grade 1–4 (primary cycle), and only 2.0% (492) had attended higher education. (Table 7 is attached as supplementary material 3).

Demographic descriptions

Table 1 describes some of the demographic indicators of the population. The average number of individuals

Table 1. Some demographic indicators of Dale and Wonsho districts, 2017/18, Sidama, Ethiopia.

Indicators	Calculations	Value
Total number of live births in a year	572 live births/573 births	99.8%
Crude Birth Rate (CBR)	573 annual birth/25,144 mid-year population	22.8 births per 1000 population
Total Fertility Rate (TFR)	TFR = 5*ASFR/1000	2.9 child per woman
General fertility rate (GFR)	573 births/6,628 reproductive age women	86.5 per 1000 live birth
Gross Reproductive Rate (GRR)	GRR = 5*Female ASFR/1000	1.33 daughters per woman
Net Reproduction Rate (NRR)	GRR*Probability of surviving to the mean of age specific fertility distribution (30.06 years in our case) 1.33*0.964	1.28 daughters per woman
Crude Death Rate (CDR)	132 annual deaths/25,144 mid-year population	5.2 per 1000 population
Infant Mortality Rate	7 deaths of infants/573 live births in a year	12.2 per 1000 live birth
Child Mortality Rate 1–4	3 deaths of children aged 1–4 years/573 live births in a year	5.2 per 1000 live birth
Under five morality rate	10 deaths of under five years children/573 live births in a year	17.5 per 1000 live birth
Crude rate of natural increase	22.8 deaths-5.2 deaths	1.8 per 100 population
Median age		18 years
Dependency ratio	9,335 under 15 years + 664 elderly/ 15,145 working-age population	0.660 (66.0/100 working population)
Young dependency ratio	9,335 under 15 years/15,145 working-age population	0.616 (61.6/100 working population)
Old dependency ratio	664 elderly/15,145 working-age population	0.044 (4.4/100 working population)
Women of reproductive age group	Women aged 15–49 years of age	6,628 (26.4%)
Child/woman ratio	2217 under five year children/6628 reproductive age women	0.334 (334 per 1000)
Sex ratio (birth)	305 male infants/268 female infants	114
Sex ratio (total)	12,848 male population/ 12,296 female population	104
Life expectancy at birth (both sexes)	The detail is annexed as a supplementary file 7, Table 10	62 years
Life expectancy at birth (Male)	The detail is annexed as a supplementary file 7, Table 11	63 years
Life expectancy at birth (Female)	The detail is annexed as a supplementary file 7, Table 12	60 years
Persons per households	25,144 individuals/5179 houses	4.9

in a household was 4.9. The total fertility rate was 2.9 children per woman. The crude death rate of the population was 5.2 deaths per 1000 population. The dependency ratio of the population was 66 dependents per 100 working-age population.

The population pyramid was typical of developing countries with a wider base and narrow tip (Figure 1).

Age preference of Dale and Wonsho districts' population

The Whipple's index for age with the terminal digit of five was 274 and for terminal digit zero was 323. The Myers' blended index for each age ending from zero to nine was 32. Similarly, the United Nations Age-sex Accuracy Index (UNAI) or Joint Score

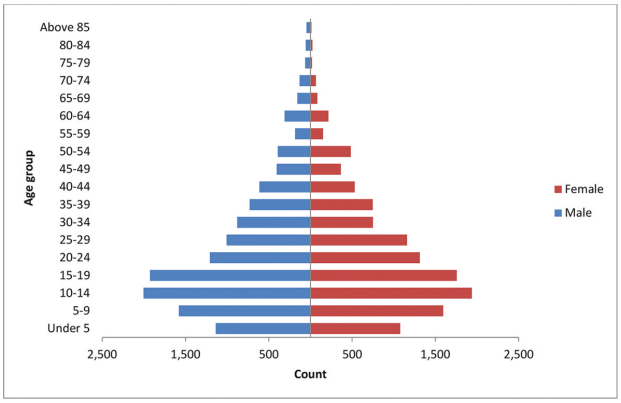


Figure 1. Population pyramid of Dale and Wonsho districts 2017/18.

(UNJS) was 110. These indices showed that the age estimation as being unreliable, falling into the very rough category. (Please see the supplementary material 1 for detail information of the indices).

Result from qualitative study on age and death reporting

The common themes that emerged from FGDs and IDS were: the traditional way of age estimation, annual holidays, historical events, birth certificate, infant death, death of elderly, taboo, social security, full human being, mourning, reducing age, exaggerating age, respect, approval and role in a community.

In Sidama, age determination was estimated by considering historical and cultural events occurring in the communities. The major traditional way of estimating age was using the age-generation 'Luwa', which is a system of local leadership changed in a fixed interval. The Sidama new year festival, 'Fichee Chambalala', regime changes, and wars were important landmarks for calculating the age of a person. These all gave the approximate age of the person. However, currently, because many people were getting educated, they have certificates documenting their children's birth date. Only nine out of 56 respondents said the community uses birth certificate for age estimation.

Death of the infants was usually considered a taboo in the community. There was a belief not to consider infants as 'a full human being', or 'a mature person' and mourning their deaths might bring another bad event for the family. This means deaths of infants might not have been recorded.

The age reporting among males and females had also some differences, mainly due to cultural factors. Young women tended to reduce their age, especially when they are yet to get married or expected to bear many children and get approval by the in-laws. However, males tend to exaggerate their age, especially at young and old age due to security and social respect obtained.

Description of births

Of the 573 births, 563 (98.3%) were singleton deliveries, 572 (99.8%) were live births, and 248 (43.3%) were deliveries outside health institutions (Table 8 is attached as supplementary material 4).

Description of deaths

There were 58 deaths recorded in the census of 12 kebeles from the HDSS database of which 29 were in our subsample. However, when we collected the data from the '*Iddirs*', we found a total of 265 deaths (78% of the deaths were not found in the database), of which 132 were in our sub-sample. Of the132 deaths, 66.7% (88 deaths) occurred outside health institutions. There were 10 deaths (7.6%) among children under the age of five years. From the oral report of the participants, for 22.7% (30 deaths) the cause of death is unknown (Table 2). (See the causes of deaths in supplementary material 5).

Table 2. Death characteristics of Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N = 132).

Variables	Male N (%)	Female N (%)
Deaths in the last one year	74 (56.1)	58 (43.9)
Place of death		
Health institution	28 (63.6)	16 (36.4)
Home	41 (50.6)	40 (49.4)
On the road	3 (75.0)	1 (25.0)
Others	2 (66.7)	1 (33.3)
Age at death		
0–4	4 (5.4)	6 (10.3)
5–14	3 (4.1)	1 (1.7)
15–24	2 (2.7)	2 (3.4)
25–34	4 (5.4)	3 (5.2)
35–44	6 (8.1)	7 (12.1)
45–54	7 (9.5)	9 (15.5)
55–64	10 (13.5)	6 (10.3)
65–74	9 (12.2)	10 (17.2)
75–84	11 (14.9)	9 (15.5)
≥85	18 (24.3)	5 (8.6)

Because we registered under-reporting of deaths in the census, we did a sensitivity analysis to evaluate age-specific mortality and crude birth rate. Using information from earlier national and regional estimates, we estimated the under-reporting of infant and child deaths and the number of live births in our study (Table 3).

Table 4 shows that the life expectancy at birth reduced from 62 years to an average of 53 years (range 48 to 58 years) when substituting previous national and regional estimates of infant and child mortalities. (The life table information is presented in supplementary material 7).

Determinants of fertility

Table 5 showed that age, educational status, religion, and area of residence were associated with fertility. The odds of women aged 25–29 giving birth were 6.2 (4.37–8.72) times higher than the odds of women aged 15–19 giving birth. Women who had attended basic education had lower odds of giving birth by 40% (OR = 0.6; 95% CI: 0.46–0.78) when compared to those who were uneducated. The odds of urban residents giving birth were 1.4 (1.05–1.78) higher than the odds of rural residents giving birth.

Discussion

Our study shows that fertility in Sidama is lower than in previous studies. Low fertility was associated with individual factors of the women such as age,

Table 3. Sensitivity analysis of birth and death estimates using different age specific mortality rates and crude birth rates, 2017/18, Sidama, Ethiopia.

		Rates used for comparison		
Age group	Assumptions	Age specific mortality rates	Number of deaths	Difference from the current cases (possible number of unreported deaths)
Infant (<1 years)	Current study	11	7	
	EDHS national	43	28	21
	EDHS regional (Southern Nations, Nationalities and Peoples Region)	65	42	35
Children (1–4)	Current study	2	3	
	EDHS national	12	19	16
	EDHS regional (Southern Nations, Nationalities and Peoples Region)	25	39	36
All population	Current study	Crude birth rate	Number of births	
		22.8	573	
	EDHS national	31.8	700	127
	Dabat HDSS	28	704	131

Table 4. Sensitivity analysis of life expectancy at birth by substituting different mortality estimates, 2017/18, Sidama, Ethiopia.

x	n	P_x	D_x	e_x
Scenario 1: Using infant and child mortality of current study				
0	1	641	7	61.79769
1	4	1576	3	61.96097
Scenario 2: Using infant and child mortality of EDHS, SNNPR 2016 estimates				
0	1	641	42	48.04314
1	4	1576	39	53.0278
Scenario 3: Using national infant and child mortality of 2019 mini EDHS estimates				
0	1	641	28	54.63236
1	4	1576	19	57.99067

Where; X = exact age; n = interval between two exact ages stated in years; Px = Population in x, x + n age group; Dx = number of deaths in x, x + n age group; $e_{x=}$Average Number of years a person aged x has to live.

educational status and area of residence. This study also revealed that there is inaccuracy in age and death reporting.

One of the strengths of this study is using a standard INDEPTH Network approved tools [45], and using a random sampling of the population in Sidama. Secondly, this study included both mortality and fertility with major demographic indicators. Thirdly, we used both qualitative and quantitative data collection methods, which allow us to triangulate and identify the information gaps in the data set.

The first limitation of this study was using respondents own word for age reporting. Age was estimated based on a memory of different events than recordings, therefore, resulting in unreliable age indices. We believe there was a severe under-reporting of deaths of infants, children and stillbirths. Sometimes it is difficult to distinguish between stillbirths and neonatal deaths. And as it is seen from the sensitivity analysis, if there were hidden stillbirths and neonatal deaths, the number of births could be higher than recorded. Therefore, the fertility rates could be higher than we report. We supplemented the DHS data by collecting data from burial groups and by doing a qualitative study as a form of verifying and validating the data. Furthermore, there was no information collected on migration, so we could not calculate the population change due to population movements. From other areas of southern Ethiopia, we know that migrations can be seasonal and large [46,47].

Around one-fifth of the population in this study didn't attend formal education. However, in studies done in Gilgel gibe HDSS in Ethiopia, and Ghana, an uneducated population constituted more than half of the population [18,48]. This difference could be ascribed to the time gaps between the studies and the governments' strategy to expand educational coverage in the last decades.

In this study, the total dependency ratio was lower than the 2015 national estimate and the 2012 Kersa HDSS [26,49]. This might be due to the regional variations in fertility and the misreporting of age on lower and higher age group in our study site. It also might be an indication of fertility transition where there is a decline in fertility, which leads to an increase in the working-age group.

The crude birth rate (CBR) in this study was lower than the findings of EDHS, and other HDSS sites in Ethiopia [16,43,48,50]. This difference might be explained by the use of three years of data preceding the survey in EDHS and the use of censuses in other HDSS sites. Moreover, this study used twelve months of data preceding the census. Besides, our study population is more rural than urban, so it's expected to have higher CBR than urban HDSSs [51]. The cultural issues related to probable severe under-reporting of stillbirths and neonatal deaths probably explain a part of our low CBR.

The Total Fertility Rate (TFR) in Sidama was 4.1 children per woman in the 2007 national census, which is lower than the 2016 National Demographic and Health Survey report [16,52]. Yet, the total fertility rate in our study was 2.9, which is lower than both estimates. This might suggest that there might

Table 5. Crude and Adjusted Odds Ratio of the associations between characteristics of reproductive age group women and fertility in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia (N = 6628).

	Gave birth last year				
	Yes	No			
Variables	N (%)	N (%)	COR (95% CI)	AOR (95% CI)	P-value
Age Group					
15–19	44 (7.7)	1713 (28.3)	Ref	Ref	
20–24	167 (29.1)	147 (18.9)	5.67 (4.03–7.97)	5.41 (3.84–7.62)	<0.001
25–29	166 (29.0)	994 (16.4)	6.50 (4.62–9.15)	6.18 (4.37–8.72)*	<0.001
30–34	97 (16.9)	654 (10.8)	5.77 (4.00–8.34)	5.54 (3.80–8.08)*	<0.001
35–39	72 (12.6)	676 (11.2)	4.15 (2.82–6.10)	3.76 (2.52–5.61)*	<0.001
40–44	24 (4.2)	508 (8.4)	1.84 (1.11–3.05)	1.67 (0.99–2.82)	0.05
45–49	3 (0.5)	363 (6.0)	0.32 (0.10–1.04)	0.28 (0.08–0.91)*	0.03
Ethnicity					
Sidama	555 (96.9)	5818 (96.1)	Ref.	Ref.	
Non Sidama	18 (3.1)	237 (3.9)	0.80 (0.49–1.30)	0.77 (0.42–1.41)	0.41
Religion					
Protestant	522 (91.1)	5367 (88.6)	Ref.	Ref.	
Orthodox	12 (2.1)	223 (3.7)	0.55 (0.31–1.00)	0.47 (0.23–0.96)*	0.04
Muslim	6 (1.0)	143 (2.4)	1.02 (0.69–1.51)	1.14 (0.75–1.71)	0.54
Others	29 (5.1)	293 (4.8)	0.60 (0.31–1.14)	0.61 (0.32–1.18)	0.14
Educational Status					
Illiterate & read-write	191(33.3)	1806 (29.8)	Ref.	Ref.	
Basic education	107 (18.7)	1608 (26.6)	0.63 (0.49–0.81)	0.60 (0.46–0.78)*	<0.001
Primary cycle	170 (29.7)	1726 (28.5)	0.93 (0.75–1.16)	0.85 (0.67–1.09)	0.21
Secondary cycle	79 (13.8)	778 (12.8)	0.96 (0.73–1.26)	0.84 (0.61–1.16)	0.29
Higher Education	26 (4.5)	137 (2.3)	1.79 (1.15–2.80)	1.18 (0.72–1.93)	0.51
Wealth Index					
Lower quantile	166 (29.0)	2033 (33.6)	Ref.	Ref.	
Middle quantile	187 (32.3)	2019 (33.3)	1.13 (0.91–1.41)	1.16 (0.92–1.45)	0.20
Upper quantile	220 (37.0)	2003 (33.1)	1.35 (1.09–1.66)	1.23 (0.94–1.60)	0.13
Residence					
Rural	436 (8.1)	4970 (91.9)	Ref.	Ref.	
Urban	137 (11.2)	1085 (88.8)	1.44 (1.18–1.76)	1.37 (1.05–1.78)*	0.02

* Significant association

be a lower fertility trend in the area. The structure of the population pyramid may also suggest declining fertility rates.

The crude death rate (CDR) in this study was lower than the result of other HDSS sites in Ethiopia and Africa. The CDR ranged from 6.1 to 8.0 per 1000 population in other HDSS sites [43,48,50]. It might be due to the under-reporting of neonatal and children deaths in the study area. Moreover, the deaths missed by both the HDSS data and *Iddirs* records might also lower the CDR in the area.

There was discrepancy between the number of deaths collected by the D-W HDSS and collected from *Iddirs*. The reason for this difference might be due to the data collection methods implemented. D-W HDSS used face to face interviews, while our study went to the traditional institution where deaths are recorded. In a community where death reporting is associated with a taboo, the number of death reported by the family of the deceased might yield a lower number.

In this study, the rate of crude natural increase was below 2 per 100 populations which is lower than other HDSS sites in Ethiopia and Africa [48,50,53]. In addition to an earlier explained under-reporting of births, the difference between these results might be due to the lower crude birth rate attributed to increased contraceptive utilization over the past decades especially in rural population [16,54], and the time difference between the studies that could not consider the current level of fertility and mortality in other HDSSs elsewhere.

By substituting the national and regional infant and child death rates, the life expectancy at birth ranged from 48 years up to 55 years [16,42]. This is different from what we got from our study using the census data (Table 7; 62 years), and the current Ethiopian life expectancy of 66 years [26]. Since there is confirmed under-reporting of neonatal and children deaths in the community, we have a reason to believe that the life expectancy in Sidama is lower than the national estimates. Similarly, due to the possible omission of stillbirths and neonatal deaths, the number of births Sidama is smaller when compared to different scenarios of national and other HDSS studies [16,43].

As expected, women in the age group 25–29 years had a higher fertility rate when compared to younger age groups; as has been recorded elsewhere [16,51,55].

This study showed that there was no difference in fertility between highly educated women and uneducated women. This is different from the national health survey and study done in Butajira in 2009, in which uneducated women had more children when compared with women who completed secondary and above education [16,28]. The difference in this result might be the methodology used. The Butajira study used fertility as a count data to assess total children ever born to women

in the reproductive age group and the national survey used data three years before the survey, whereas this study used births one year before the census. However, it could also be explained by the fact that uneducated women have an improvement in their contraceptive use, while educated women are having enough financial support to raise more children [52].

In the current study urban resident were more likely to give birth than their rural counterparts. This finding is contrary to other studies [16], in which urban residents had lower fertility except in Guatemala [56]. Moreover, the increasing rural- to- urban migration in Africa might contribute to higher fertility in urban areas [57]. This result might partially be explained also by disparity in utilizing birth registration between urban and rural communities [58,59].

The current study combined with previous studies suggests lower fertility, leading to demographic dividend. So the policymakers need to consider this transition and focus on interventions towards the increased working-age population. There is a significant gap in the community with age reporting and stillbirth and neonatal death reporting. This needs to be addressed by improving the vital registration systems in the community. Other demographic sites and subsequent rounds should consider possible measurement errors and try to lessen such limitations.

Acknowledgments

We acknowledge the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED) for funding this study. We also thank the D-W HDSS staffs for their willingness to access the data, especially Dr, Andargachew Kassa and Mr, Alemu Tamiso. We are grateful to Dr, Eskindir Loha and Mr Befikadu Tariku for their contribution during exporting and analysing the data.

Author contributions

HA conceptualized the idea, designed the study, acquired and analysed the data, wrote the protocol and drafted the manuscript.

BL conceptualized the idea, guided the study design, the proposal writing, helped to analyse the data, drafted and validated the manuscript.

MD helped in conceptualizing the idea, the proposal writing, provided constructive comment in drafting the manuscript.

All of the authors read and approved the submitted version of the manuscript.

Disclosure statement

The views expressed in the submitted article are the authors and not an official position of the institution or funder.

Ethics and consent

The ethical clearance was obtained from the Institutional Review Board at the College of Medicine and Health Sciences of Hawassa University (Reference number IRB/022/10), and from the Regional Ethics Committee for Medical and Health Research in Norway (2018/67/REKvest). Permission was obtained from Hawassa University Research and Community Service Directorate to access the data from D-W HDSS database. For qualitative study a formal letter was written to district health offices from Sidama zone health office. The participants were asked for their permission to participate with a written consent and given a chance to withdraw from the interview at any time. The data was kept in a secure place to maintain the confidentiality.

Funding information

The research has been funded by the Norwegian Programme for Capacity Development in Higher Education and Research for Development (NORHED) through the SENUPH (Southern Ethiopia Network of University in Public Health) project (ETH-13/0025). The Funder has no role in the design, data collection, analysis, interpretation and writing of the manuscript.

Paper context

There is neither any demographic study done in Sidama recently, nor the quality of the data is assessed for its validity. The lower fertility rate is one sign of demographic transition that gives opportunity to utilize the work force created for development. However, the personal reporting of vital events has flaws that can be corrected by establishing a strong civil registration system supplemented by quality health and demographic surveillance data.

Data availability statement

The data that support the findings of this study are openly available in Zenedo at https://zenodo.org/record/3888986#.X1-C3WgzbI, md5:32011f7c9ada1731854a964236e1beff [md5:79554c05f51dbe0177225b6794306cc3].

ORCID

Hiwot Abera Areru http://orcid.org/0000-0002-3049-7236
Mesay Hailu Dangisso http://orcid.org/0000-0003-1245-8839
Bernt Lindtjørn http://orcid.org/0000-0002-6267-6984

References

[1] Gerland P, Raftery AE, Ševčíková H, et al. World population stabilization unlikely this century. Science. 2014;346:234–237.
[2] Newell C. Methods and models in demography. New York, USA: The Guilford Press; 1988.
[3] Hailemariam A. Ethiopia's changing demography. In: Cheru F, Cramer C, Oqubay A, editors. The Oxford handbook of Ethiopian economy. New York: Oxford University Press; 2019. p. 366–382.

[4] Hailemariam A. Demographic transition and demographic dividend in Ethiopia: opportunitiesand challenges; country case study. Addis Ababa: Addis Ababa University; 2012.
[5] Teller CH, Hailemariam A, Gebreselassie T, et al. The uniqueness of the Ethiopian demographictransition within sub-Saharan Africa: multipleresponses to population pressure,and preconditions for rural fertility declineand capturing the demographic dividend. Afr Popul Stud. 2011;25: 362–380.
[6] Admassie A, Ali SN, May JF, et al. The demographic dividend: an opportunity for Ethiopia's transformation. Washington, DC: Population Reference Bureau and Ethiopian Economics Association; 2015.
[7] Hailemariam A. Population dynamics and development in Ethiopia. Addis Ababa: The Ministry of Planning and Economic Development; 1994.
[8] Lakshminarayanan R. Population issues in the 21st century: the role of the World Bank. Washington, DC: The World Bank; 2007.
[9] Casterline JB. Determinants and consequences of high fertility: a synopsis of the evidence. Washington, DC: The World Bank; 2010.
[10] Starbird E, Norton M. Investing in family planning: key to achieving the sustainable development goals. Glob Heal Sci Pract J. 2020;4:191–210.
[11] Robin Maynard GF. Population growth slows progress towards sustainable development goals, says UN | population matters | every choice counts | sustainable world population. Project Syndicate [Internet]. 2019 [cited 2020 Aug 14]. Available from: https://populationmatters.org/news/2019/04/05/population-growth-slows-progress-towards-sustainable-development-goals-says-un
[12] Morland P. The human tide: how population shaped the modern world. 1st ed. London: John Murray; 2019.
[13] Gurmu E, Mace R. Fertility decline driven by poverty: the case of Addis Ababa, Ethiopia. J Biosoc Sci. 2008;40:339–358.
[14] Ethiopian Public Health Association. Ethiopian universities health and demographic surveillance system: network data sharing and release policy. Addis Ababa, Ethiopia: Ethiopian Universities Research Centers Network; 2013.
[15] Danish national ID Centre. Ethiopian civil certificates issued by the vital events registration agency [Internet]. Copenhagen, Denmark; 2018. Available from: https://www.nidc.dk/-/media/27CFA7A921B54F8292C5CEB140E1181A.pdf
[16] Central Statistical Agency. Ethiopia, demographic and health survey 2016. Addis Ababa; Rockville, Maryland: The DHS Program, ICF; 2017.
[17] Federal Negarit Gazzette. Proclamation-no.1049/2017: vital events registartion and national identity card proclamation (amendment). 2017 Aug 7:9811–9817.
[18] Owusu-Agyei S, Nettey OEA, Zandoh C, et al. Demographic patterns and trends in Central Ghana: baseline indicators from the Kintampo health and demographic surveillance system. Glob Health Action. 2012;5:1–11.
[19] Jia P, Sankoh O, Tatem AJ. Mapping the environmental and socioeconomic coverage of the INDEPTH international health and demographic surveillance system network. Health Place. 2015 Nov;36:88–96.
[20] Ye Y, Wamukoya M, Ezeh A, et al. Health and demographic surveillance systems: a step towards full civil registration and vital statistics system in sub-Sahara Africa? BMC Public Health. 2012 Dec 5;12:741.
[21] INDEPTH Network. Population and health in developing countries:Population, health, and survival at INDEPTH sites. Vol. 1. Ottawa, ON, Canada: International Development Research Centre; 2002.
[22] WORLD BANK, World Health Organization. Global civil registration and vital statistics: scaling up investment plan 2015–2024. Washington, DC: World Bank Group; 2014.
[23] Carrel M, Rennie S. Demographic and health surveillance: longitudinal ethical considerations. Vol. 86, Bulletin of the World Health Organization. Geneva, Switzerland: World Health Organization; 2008 Aug.
[24] Kahn K, Tollman SM, Collinson MA, et al. Research into health, population and social transitions in rural South Africa: data and methods of the Agincourt Health and Demographic Surveillance System. Scand J Public Health Suppl. 2007 Aug;69:8–20.
[25] Kaneko S, K'opiyo J, Kiche I, et al. Health and demographic surveillance system in the Western and coastal areas of Kenya: an infrastructure for epidemiologic studies in Africa. J Epidemiol. 2012;22:276–285.
[26] Uited Nations. World population prospects - population division. New York, USA: United Nations; 2019.
[27] UNICEF. Child mortality - UNICEF DATA [Internet]. 2019. Available from: https://data.unicef.org/topic/child-survival/under-five-mortality/
[28] Mekonnen W, Worku A. Determinants of fertility in rural Ethiopia: the case of Butajira Demographic Surveillance System (DSS). BMC Public Health. 2011 Dec 10;11:782.
[29] Fottrell E, Byass P, Berhane Y. Demonstrating the robustness of population surveillance data: implications of error rates on demographic and mortality estimates. BMC Med Res Methodol. 2008 Dec 25;8:13.
[30] Chemhaka GB, Odimegwu C, Zwane EN, et al. Is Swaziland census data suitable for fertility measurement? Genus. 2016 Jul 14;72:1–13.
[31] Barua RK. Detection of digit preference and age misreporting by using demographic techniques. Dhaka, Bangladesh: East West University; 2015.
[32] Central Statistical Agency, Ethiopian Development Research Institute, International Food Policy Research Institute. Population & housing census: ATLAS OF ETHIOPIA 2007. Washington, DC; Addis Ababa: International Food Policy Research Institute (IFPRI), Central Statistical Agency; 2010.
[33] Central Statistical Agency. 2007 population and housing census of Ethiopia: section-B population. Addis Ababa, Ethiopia: Population Census Commission; 2007.
[34] Federal Democratic Republic of Ethiopia Population Census Commisssion. Summary and statistical report of the 2007 population and housing census: population size by age and sex. Addis Ababa, Ethiopia: Population Census Commission; 2008.
[35] Sidama Zone Finance and Economic Development Office. Sidama zone administration socio-economic profile 2014/15. Hawassa: SNNPR; 2016.
[36] Dalle Woreda Finance and Economic Development Office. The development of social and economical information of Dalle woreda. Hawassa: SNNPR; 2016.
[37] Greene JC, Caracelli VJ, Graham WF. Toward a conceptual framework for mixed-method evaluation designs. Educ Eval Policy Anal. 1989;11:255–274.

[38] MacLeod B, Phillips JF. The HRS2 technical manual. New York: Population (English Edition); 1998.
[39] Pankhurst A, Mariam DH. The iddir in Ethiopia: historical development, social function, and potential role in HIV/AIDS prevention and control. Northeast Afr Stud. 2000;7:35–57.
[40] Bwalya BB, Phiri M, Mwansa C. Digit preference and its implications on population projections in Zambia: evidence from the census data. Int J Curr Adv Res. 2015;4:92–97.
[41] Francis E-B, Senyefia B-A, Bridget Sena B. Statistical analysis of age reporting errors by insured and uninsured patients in Cape Coast Teaching Hospital of Ghana. Biomed Stat Inf. 2019 Aug 15;4:15.
[42] Ethiopian Public Health Institute (EPHI) [Ethiopia] and ICF. Ethiopia mini demographic and health survey 2019: key indicators. Rockville, MD: EPHI and ICF; 2019.
[43] University of Gondar. Profile of Dabat health and demographic surveillance system/dabat research center/. Gondar: University of Gondar; 2012.
[44] Bollinger L, Stover J, Hecht K, et al. Spectrum Manual. Glastonbury, Connecticut: Avenir Health; 2019.
[45] INDEPTH Network. INDEPTH resource kit for demographic surveillance systems (Beta Version 0.9). 2008.
[46] Fassil E, Mohammed B. Dynamics and determinants of rural-urban migration in Southern Ethiopia. J Dev Agric Econ. 2017;9:328–340.
[47] Fransen S, Kuschminder K Migration in Ethiopia: history, current trends and future prospects paper series: migration and development country profiles. 2009 Dec:41.
[48] Jimma University. Gilgel Gibe field research centre. Jimma, Ethiopia: Jimma University; 2011.
[49] Coates MM, Kamanda M, Kintu A, et al. A comparison of all-cause and cause-specific mortality by household socioeconomic status across seven INDEPTH network health and demographic surveillance systems in sub-Saharan Africa. Glob Health Action. 2019 Jan 1;12:1608013.
[50] Assefa N, Oljira L, Baraki N, et al. HDSS profile: the Kersa health and demographic surveillance system. Int J Epidemiol. 2016 Feb;45:94–101.
[51] Assefa N, Semahegn A. Fertility is below replacement in Harar health and demographic surveillance system (Harar HDSS), Harar town, Eastern Ethiopia. Fertil Res Pract. 2016 Dec;2. DOI:10.1186/s40738-016-0023-8.
[52] Central Statistical Agency. 2007 national census, Ethiopia. Addis Ababa: Office of the Population Census Commission; 2007.
[53] Mrema S, Kante AM, Levira F, et al. Health & demographic surveillance system profile: the Rufiji health and demographic surveillance system (RUFIJI HDSS). Int J Epidemiol. 2015 May 27;44:472–483.
[54] Worku AG, Tessema GA, Zeleke AA. Trends of modern contraceptive use among young married women based on the 2000, 2005, and 2011 Ethiopian demographic and health surveys: a multivariate decomposition analysis. PLoS One. 2015 Jan 30;10:e0116525.
[55] Zelalem D, Semahegn A, Tesfaye G, et al. The level and patterns of fertility among women in Kersa demographic surveillance and health research center (KDS-HRC) field site, Kersa District, East Ethiopia. Fertil Res Pract. 2015 Dec;1. DOI:10.1186/s40738-015-0010-5.
[56] United Nations, Population Division. Fertility levels and trends in countries with intermediate level of fertility. New York: United Nations; 2001.
[57] Lerch M. Fertility decline in urban and rural areas of developing countries. Popul Dev Rev. 2019 Jun 19;45:301–320.
[58] Yihdego M, Amogne A, Desta S, et al. Improving the demand for birth registration: a discrete choice experiment in Ethiopia. BMJ Glob Heal. 2020;5:1–10.
[59] PLAN. Universal birth registration-a universal responsibility. UK: Plan Limited; 2005.
[60] Central Statistical Agency. 2007 population and housing census of Ethiopia: administrative report. Addis Ababa: Office of the Population Census Commission; 2012.
[61] Adamu Y, Macleod C, Adamu L, et al. Prevalence of Trachoma in Benishangul Gumuz Region, Ethiopia: results of seven population-based surveys from the Global Trachoma Mapping Project. Ophthalmic Epidemiol. 2016;23:70–76.
[62] Mengesha AD. The role of Sidama indigenous institutions in conflict resolution: in the case of Dalle Woreda, Southern. Am J Sociol Res. 2016;6:10–26.
[63] World Bank. Education in Ethiopia: strengthening the foundation for sustainable progress. Washingiton, DC: The International Bank for Reconstruction and Development/The World Bank; 2005.

Supplementary files for Paper III

Supplementary material 1: Operational definitions

Household: A person or group of related or unrelated persons who live together in the same dwelling unit(s), who acknowledge one adult male or female as the head of the household, who share the same housekeeping arrangements, and who are considered a single unit (179).

Kebele: the smallest administrative unit in the governmental structure (180).

"got": sub-division of kebele (181).

"**Luwa**": Is cultural institution based on age grading system in which leaderships are changed every eight years (84).

Under-age for educational status: based on the HDSS's data collection format educational status is collected for those who are seven years of age and older. So under-age represents those below seven years of age (67,179).

Under age for marital status: based on the HDSS's data collection format marital status is collected for those who are ten years of age and older. So under age represents those below ten years of age (179).

Under age for occupational status: based on the HDSS's data collection format occupational status is collected for those who are ten years of age and older. So under age represents those below ten years of age (179).

Basic education: In the Ethiopian education system basic education refers to a formal education from grade 1-4 (182).

Primary cycle: In the Ethiopian education system basic primary cycle refers to a formal education from grade 5-8 (182).

Secondary school: In the Ethiopian education system secondary school education refers to a formal education from grade 9-10 (182).

Preparatory school: In the Ethiopian education system preparatory school education refers to a formal education from grade 11-12 (182).

Higher education: In the Ethiopian education system higher education refers to a formal education that ends up by awarding diploma or degree (182).

Mortality: Death of the children (neonatal, infant and under five years of age), adults and mothers occurring in the last one year before the survey (179).

Birth outcomes: All live births, still births or abortions encountered during the last 1 year before the survey (179).

Skilled delivery: A delivery care provided by skilled health professionals (doctors, midwives, health officer, nurses or health extension worker) during the last one year birth before the survey (67).

Wealth index

Households are given scores based on the number and kinds of consumer goods they own; ownership of radio, television, refrigerator, telephone, bicycle, motorcycle, car, cattle, carriage animals, sheep (goats), chicken (poultry) and land were considered. In addition, housing characteristics was assessed by material of the roof and the floor, source of light, source of drinking water, toilet facilities and cooking material. All the variables are dichotomized and the scores are derived using principal component analysis and ranked in three quintiles (67).

Lowest quintile: those who score below the 3rd quintile in wealth index ranking.

Middle quintile: those who score the middle 3rd quintile in wealth index ranking.

Highest quintile: those who score the upper 3rd quintile in wealth index ranking.

Whipple's index: a measure of preference for ages ending in 0 and 5 (57).

Whipple's index for ages ending in 5 = $\frac{\text{Population age } 25+30+35\ldots..+55+60}{\text{Population age } 23+24+\ldots\ldots..61+62} * 100 * 5$

Whipple's index for ages ending in 0 = $\frac{\text{Population age } 30+40+50+60}{\text{Population age } 23+24+\ldots\ldots..61+62} * 100 * 5$

The range of values for Whipple's index is <105 as highly accurate to >175 as very rough estimate on assessing reliability of age data (57).

Myer's blended index: Is a more complex measure of age heaping. It considers preference (or avoidance) of age ending in each of the digits 0 to 9 in deriving overall age accuracy score (57).

The theoretical range of Myer's Index is from 0 to 90, where 0 indicates no age heaping and 90 indicates the extreme case where all recorded ages end in the same digit.

United Nations Joint Score: Uses both age and sex ratio for computation up to the age of 70 by five year age group. Sex ratio is calculated by taking the difference between consecutive age groups taking the average of the absolute sum. Age ratio is calculated separately for male (ARM) and female (ARF) and the deviation from 100 is calculated. The mean of the absolute deviations of the two age ratios ARF and ARM are then summed to 3 times of the mean of the sex ratio differences (SR). UNJS= ARM+ARF +3(SR). UNJS between 0 and 19.9 is accurate, inaccurate if it is between 20 and 39.9, and highly in accurate if it is above 40 (106,107).

Crude Birth Rate (CBR): Births in a year divided by midyear population expressed per 1000 population (57).

Total Fertility Rate (TFR) is the number of children a woman would have if she survived to age 50 and throughout her reproductive life she experienced exactly the age specific fertility rates for the year in question (57).

General fertility rate (GFR): Births during a year divided by midyear women population aged 15-49 expressed per 1000 women (57).

Gross Reproductive Rate (GRR): The average number of daughters a woman would have if she survived to at least age 50, and experienced the given female age specific fertility rate (57).

Net Reproduction Rate (NRR): The average number of daughters a woman would have during her reproductive years given the fertility and mortality at the given rate (57).

Crude Death Rate (CDR): The number of deaths in a year divided by the total midyear population expresses per 1000 population (57).

Infant Mortality Rate: number of deaths of under age of one year in a year divided by live births in the year expressed per 1000 live births (57).

Child Mortality Rate: The number of deaths of children between age one and five years old divided by the number of live births in a year expressed per 1000 live births (67).

Under five morality rate: The number of deaths of children <5 years old divided by the number of live births in a year expressed per 1000 live births (67).

Crude rate of natural increase: the difference between crude birth rate and crude death rate. It is a measure of current rate of population growth if net migration is not substantial (57).

Median age: Age that divides the population in two parts of equal size, that is, there are as many persons with ages above the median as there are with ages below the median (135).

Dependency ratio: is the ratio of children and elderly population per working-age population expressed per 100 working population (57).

Young dependency ratio: is the ratio of children population per working-age population expressed per 100 working population (57).

Old dependency ratio: is the ratio of elderly population per working-age population expressed per 100 working population (57).

Women of reproductive age group: Women with in age group 15-49 years (67).

Child /woman ratio: The ratio of children aged 0-4 over women aged 15-49 (57).

Sex ratio (birth): the number of males births per 100 females births (57).

Sex ratio (total): the number of males per 100 females (57).

Average household size: The average number of individuals in a household (67).

Life expectancy at birth: The average number of years of life expected by a hypothetical cohort of individuals who would be subject during all their lives to the mortality rates of a given period. It is expressed as years (135).

How Life expectancy is calculated: Abridged life table is used, where most of age groups are five years, it considers mortality data and some assumptions mentioned below (57).

Age interval (years) **(x,x+n)**	**$_nq_x$**	**$_nP_x$**	**$_na_x$**	**l_x**	**$_nd_x$**	**$_nL_x$**	**T_x**	**e_x**

Where:

(x,x+n): interval or period of life between two exact ages stated in years.

$_nq_x$:Probability of dying in the interval [x, x+n], given survival to age x

$_nP_x$: Probability of surviving in the interval [x, x+n], given survival to age x

$_na_x$=average proportion of the time lived in the interval x to x+n by those who die during that interval

l_x: The number of persons alive at exact age x. l_0 is an arbitrary number called the radix, usually set at 100,000

$_nd_x$: The number of persons in the cohort who die in the age interval (x, x+ n)

$_nL_x$: Person-years lived between exact ages x and x+n

T_x: Total person-years of life contributed by the cohort after attaining age x

e_x: Average number of years a person aged x has to live.

Supplementary material 2:Sampling

Table 6: The study units of Dale and Wonsho districts, 2017/18, Sidama, Ethiopia.

Kebele	Woreda	Rural / Urban	Random Sampling of population Proportional to size	Random sampling of HH Proportional to size	Sampled percentage
Danshe sire	Dale	Rural	3,688	799	6.4
Wayicho	Dale	Rural	2,716	570	4.6
Gidamo	Dale	Rural	1,654	314	2.5
Dagiya	Dale	Rural	821	169	1.4
Shoye	Dale	Rural	3,085	625	5.0
Hidakaliti	Dale	Rural	1,970	381	3.0
Magara	Dale	Rural	2,661	576	4.6
Aposto 01	Dale	Urban	2,972	646	5.2
Mamana	Wonsho	Rural	1,889	363	2.9
Gishire	Wonsho	Rural	1,355	258	2.1
Bokaso rural	Wonsho	Rural	978	198	1.6
Bokaso 01	Wonsho	Urban	1,355	280	2.2
Total			**25,144**	**5,179**	**41.4**

Supplementary material 3: Map of the study area

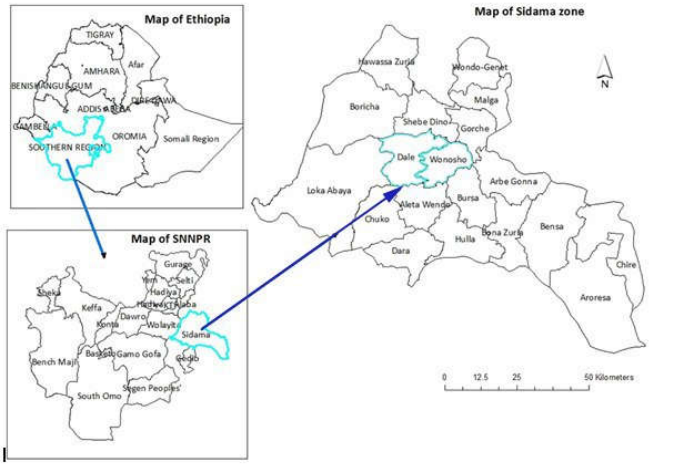


Figure 2: Map showing the study area

Supplementary material 4: Background

Table 7: Socio-economic and demographic characteristics of Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=25144).

S.N	Variable	Category	N	%
1.	Sex	Male	12,848	51.1
		Female	12,296	48.9
2.	Age	0-4	2,217	8.8
		5-14	7,117	28.3
		15-24	6,208	24.7
		25-34	3,799	15.1
		35-44	2,625	10.4
		45-54	1,650	6.6
		55-64	864	3.4
		65-74	438	1.7
		75-84	166	0.7
		≥85	60	0.2
3.	Ethnicity	Sidama	24,258	96.5
		Amhara	438	1.7
		Gurage	64	0.3
		Oromo	150	0.6
		Wolayita	141	0.6
		Others	93	0.3

Table 7: Socio-economic and demographic characteristics of Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=25144).

≠Educational status: Illiterate refers to those who cannot read and write and never at attended any form of education;

S.N	Variable	Category	N	%
4.	Religion	Protestant	22,322	88.8
		Muslim	1,340	5.3
		Orthodox	849	3.4
		Catholic	517	2.0
		Others	116	0.5
5.	Educational status	Illiterate≠	4,842	19.3
		Read and Write≠	710	2.8
		1-4	7,596	30.2
		5-6	3,434	13.7
		7-12	4,677	18.6
		Higher level	492	2.0
		Children <7 years old	3,386	13.5
6.	Marital status	Married	8,987	35.7
		Single	10,063	40.0
		Divorced	99	0.4
		Widowed	602	2.4
		Children <10 years old	5,393	21.5
7.	Occupation	Civil servant	597	2.4
		Merchant	1,531	6.1
		Driver	56	0.2
		Farmer	3,424	13.6
		Daily labourer	1,125	4.5
		Housewife	4,046	16.1
		Student (enrolled in school from primary to university level)	8,088	32.2
		Housemaid	128	0.5
		Others	756	3.0
		Children <10 years old	5,393	21.5
8.	Wealth Index	Lowest quintile	8,398	33.4
		Middle quintile	8,515	33.9
		Highest quintile	8,231	32.7
9.	Residence	Rural	20,817	82.8
		Urban	4,327	17.2

Read and write refers to those who did not attend formal school but can read and write.

Supplementary material 5: Description of Birth

Table 8: Birth characteristics of Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=573).

Variables		Male	Female
		N (%)	N (%)
Born in the last one year		305 (53.2)	268 (46.8)
Type of birth			
	Single	299 (98.0)	264 (98.5)
	Twins	4 (1.3)	4 (1.5)
	Multiple	2 (0.7)	0 (0.0)
Status of birth			
	Live birth	304 (99.7)	268 (100.0)
	Still birth	1 (0.3)	0 (0.0)
Place of birth			
	Home	121 (49.4)	124 (50.6)
	Health institution	183 (56.3)	142 (43.7)
	Other places	1 (33.3)	2 (66.7)
Who attended the delivery			
	Skilled Birth Attendants	183 (60.0)	143 (53.4)
	Traditional Birth Attendants	6 (2.0)	16 (6.0)
	Relatives	20 (6.6)	17 (6.3)
	Neighbours	93 (30.5)	91 (34.0)
	Others	3 (1.0)	1 (0.4)

Supplementary material 6: Causes of deaths

Table 9: Causes of death in Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=132).

Causes of death	Male	Female
	N (%)	N (%)
Unknown cause	15 (50.0)	15 (50.0)
Heart Failure	9 (81.8)	2 (18.2)
Aging	5 (45.5)	6 (54.6)
DM	9 (90.0)	1 (10.0)
Cancer + Liver cancer	4 (40.0)	6 (60.0)
Hypertension	5 (62.5)	3 (37.5)
TB	3 (42.9)	4 (57.1)
Sudden death & illness	5 (71.4)	2 (28.6)
Malaria	2 (50.0)	2 (50.0)
Gastro intestinal problem	0 (0.0)	7 (100.0)
Eye disease	1 (50.0)	1 (50.0)
Falling	1 (50.0)	1 (50.0)
Headache	0 (0.0)	2 (100.0)
Mental illness (suicide)	1 (50.0)	1 (50.0)
Renal disease	1 (50.0)	1 (50.0)
Battle fight	1 (100.0)	0 (0.0)
Car and Motor accident	2 (100.0)	0 (0.0)
Chocking	0 (0.0)	1 (100.0)
Drowning	0 (0.0)	1 (100.0)
Goiter	0 (0.0)	1 (100.0)
Hemorrhoid	1 (100.0)	0 (0.0)
Hunger and Malnutrition	2 (100.0)	0 (0.0)
Hypertension with Tumor	1 (100.0)	0 (0.0)
Liver disease	1 (100.0)	0 (0.0)
Liver disease with Malaria	0 (0.0)	1 (100.0)
Pneumonia + Lung damage	2 (100.0)	0 (0.0)
Nerve disease	1 (100.0)	0 (0.0)
Sharp object	1 (100.0)	0 (0.0)
Vomiting	1 (100.0)	0 (0.0)

Supplementary material 7: Life tables (Table 10-12)

Table 10: Life expectancy for both sexes in Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=25144).

x	n	Px	Dx	nmx	nax	nqx	npx	lx	ndx	nLx	Tx	ex
0	1	335	3	0.008955	0.3	0.015224	0.984776	100000	1522.388	98934.33	6321721	63.21721
1	4	803	1	0.001245	0.4	0.00797	0.99203	98477.61	784.8776	392026.7	6222786	63.18986
5	5	1581	1	0.000633	0.5	0.004744	0.995256	97692.73	463.438	487305.1	5830760	59.68468
10	5	2005	2	0.000998	0.5	0.007481	0.992519	97229.3	727.4012	484328	5343455	54.95725
15	5	1928	2	0.001037	0.5	0.00778	0.99222	96501.9	750.7928	480632.5	4859127	50.35266
20	5	1208	0	0	0.5	0	1	95751.1	0	478755.5	4378494	45.72787
25	5	1008	4	0.003968	0.5	0.029762	0.970238	95751.1	2849.735	471631.2	3899739	40.72787
30	5	880	0	0	0.5	0	1	92901.37	0	464506.8	3428108	36.90051
35	5	731	2	0.002736	0.5	0.02052	0.97948	92901.37	1906.321	459741	2963601	31.90051
40	5	614	4	0.006515	0.5	0.04886	0.95114	90995.05	4446.012	443860.2	2503860	27.51644
45	5	406	2	0.004926	0.5	0.036946	0.963054	86549.03	3197.624	424751.1	2059999	23.80153
50	5	393	5	0.012723	0.5	0.09542	0.90458	83351.41	7953.379	396873.6	1635248	19.61872
55	5	185	3	0.016216	0.5	0.121622	0.878378	75398.03	9170.031	354065.1	1238375	16.4245
60	5	312	7	0.022436	0.5	0.168269	0.831731	66228	11144.13	303279.7	884309.6	13.3525
65	5	158	6	0.037975	0.5	0.28481	0.71519	55083.87	15688.44	236198.2	581030	10.5481
70	5	131	3	0.022901	0.5	0.171756	0.828244	39395.42	6766.389	180061.1	344831.8	8.753092
75	5	64	5	0.078125	0.5	0.585938	0.414063	32629.03	19118.57	115348.7	164770.6	5.049816
80	5	58	6	0.103448	0.5	0.775862	0.224138	13510.46	10482.25	41346.66	49421.88	3.658046
85+		48	18	0.375		1	0	3028.206	3028.206	8075.217	8075.217	2.666667

Table 11: Life expectancy for males in Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=12,848).

x	N	Px	Dx	nmx	Nax	nqx	npx	lx	ndx	nLx	Tx	ex
0	1	641	7	0.01092	0.3	0.018565	0.981435	100000	1856.474	98700.47	6179769	61.79769
1	4	1576	3	0.001904	0.4	0.012183	0.987817	98143.53	1195.657	389704.5	6081068	61.96097
5	5	3175	1	0.000315	0.5	0.002362	0.997638	96947.87	229.0107	484166.8	5691364	58.7054
10	5	3943	3	0.000761	0.5	0.005706	0.994294	96718.86	551.9083	482214.5	5207197	53.83849
15	5	3685	2	0.000543	0.5	0.004071	0.995929	96166.95	391.453	479856.1	4724982	49.13312
20	5	2522	2	0.000793	0.5	0.005948	0.994052	95775.5	569.6401	477453.4	4245126	44.32372
25	5	2168	7	0.003229	0.5	0.024216	0.975784	95205.86	2305.492	470265.6	3767673	39.57396
30	5	1631	0	0	0.5	0	1	92900.36	0	464501.8	3297407	35.49402
35	5	1479	5	0.003381	0.5	0.025355	0.974645	92900.36	2355.486	458613.1	2832905	30.49402
40	5	1146	8	0.006981	0.5	0.052356	0.947644	90544.88	4740.57	440873	2374292	26.22227
45	5	772	7	0.009067	0.5	0.068005	0.931995	85804.31	5835.138	414433.7	1933419	22.53289
50	5	878	9	0.010251	0.5	0.076879	0.923121	79969.17	6147.972	384475.9	1518986	18.99464
55	5	336	6	0.017857	0.5	0.133929	0.866071	73821.2	9886.768	344389.1	1134510	15.36835
60	5	528	10	0.018939	0.5	0.142045	0.857955	63934.43	9081.595	296968.2	790120.7	12.3583
65	5	241	8	0.033195	0.5	0.248963	0.751037	54852.84	13656.31	240123.4	493152.5	8.990465
70	5	197	11	0.055838	0.5	0.418782	0.581218	41196.53	17252.35	162851.8	253029.1	6.142
75	5	83	8	0.096386	0.5	0.722892	0.277108	23944.18	17309.04	76448.27	90177.33	3.766149
80	5	83	12	0.144578	0.5	1.084337	-0.08434	6635.133	7194.722	15188.86	13729.06	2.069146
85+		60	23	0.383333		1	0	-559.59	-559.59	-1459.8	-1459.8	2.608696

Table 12: Life expectancy for females in Dale and Wonsho districts' population, 2017/18, Sidama, Ethiopia (N=12,296)

x	n	Px	Dx	nmx	nax	nqx	npx	lx	ndx	nLx	Tx	ex
0	1	306	4	0.013072	0.3	0.022222	0.977778	100000	2222.222	98444.44	6001394	60.01394
1	4	773	2	0.002587	0.4	0.016559	0.983441	97777.78	1619.089	387225.3	5902950	60.37108
5	5	1594	0	0	0.5	0	1	96158.69	0	480793.4	5515725	57.36065
10	5	1938	1	0.000516	0.5	0.00387	0.99613	96158.69	372.1311	479863.1	5034931	52.36065
15	5	1757	0	0	0.5	0	1	95786.56	0	478932.8	4555068	47.55436
20	5	1314	2	0.001522	0.5	0.011416	0.988584	95786.56	1093.454	476199.2	4076135	42.55436
25	5	1160	3	0.002586	0.5	0.019397	0.980603	94693.1	1836.72	468873.7	3599936	38.01688
30	5	751	0	0	0.5	0	1	92856.38	0	464281.9	3131062	33.71941
35	5	748	3	0.004011	0.5	0.03008	0.96992	92856.38	2793.14	457299.1	2666780	28.71941
40	5	532	4	0.007519	0.5	0.056391	0.943609	90063.24	5078.754	437619.3	2209481	24.53255
45	5	366	5	0.013661	0.5	0.102459	0.897541	84984.49	8707.427	403153.9	1771862	20.84924
50	5	485	4	0.008247	0.5	0.061856	0.938144	76277.06	4718.169	369589.9	1368708	17.9439
55	5	151	3	0.019868	0.5	0.149007	0.850993	71558.89	10662.75	331137.6	999118.3	13.96218
60	5	216	3	0.013889	0.5	0.104167	0.895833	60896.14	6343.348	288622.4	667980.7	10.96918
65	5	83	2	0.024096	0.5	0.180723	0.819277	54552.8	9858.939	248116.6	379358.3	6.953967
70	5	66	8	0.121212	0.5	0.909091	0.090909	44693.86	40630.78	121892.3	131241.7	2.936459
75	5	19	3	0.157895	0.5	1.184211	-0.18421	4063.078	4811.54	8286.541	9349.356	2.301053
80	5	25	6	0.24	0.5	1.8	-0.8	-748.462	-1347.23	-374.231	1062.816	-1.42
85+		12	5	0.416667		1	0	598.7694	598.7694	1437.047	1437.047	2.4

Where; X=exact age, n= interval between two exact ages stated in years; Px=Population in x, x+n age group; Dx= number of deaths in x, x+n age group; nmx=age specific mortality rate in x, x+n age group; ${}_na_x$=average proportion of the time lived in the interval x to x+n by those who die during that interval ; ${}_nq_x$:Probability of dying in the interval [x, x+n], given survival to age x; ${}_nP_x$ Probability of surviving in the interval [x, x+n], given survival to age x; l_x: The number of persons alive at exact age x, ; ${}_nd_x$:The number of persons in the cohort who die in the age interval (x, x+ n);${}_nL_x$:Person-years lived between exact ages x and x+n; T_x: Total person-years of life contributed by the cohort after attaining age x;- e_x:Average Number of years a person aged x has to live.

Supplementary material 8: ASFR and FASFR

Table 13: Estimates of annual ASFRs and FASFRs for all women 15-49 years in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia

Age-group	Births	Number of women	Rate/woman	Rate/1000 women
ASFR				
15-19	44	1757	0.025	25
20-24	167	1314	0.127	127
25-29	166	1160	0.143	143
30-34	97	751	0.129	129
35-39	72	748	0.095	95
40-44	24	532	0.045	45
45-49	3	366	0.008	8
Female ASFR				
15-19	22	1757	0.013	13
20-24	82	1314	0.062	62
25-29	74	1160	0.064	64
30-34	43	751	0.057	57
35-39	35	748	0.047	47
40-44	11	532	0.021	21
45-49	1	366	0.003	3

Supplementary material 9: GRR and NRR

Table 14: Estimates of annual GRR and NRR for all women 15-49 years in Dale and Wonsho districts, 2017/18, Sidama, Ethiopia

Age group	No of Women of reproductive age group	Male birth	Female birth	total birth	Female ASFR	mid point of age group	FASFR*mid point of age group	Prob.surviving(lx)	Lx(stationary popn)	exp. female birth
15-19	1757	22	22	44	0.012521	17.5	0.219123506	0.979489266	4.89744633	0.061322606
20-24	1314	85	82	167	0.062405	22.5	1.404109589	0.979489266	4.882882156	0.304715629
25-29	1160	92	74	166	0.063793	27.5	1.754310345	0.973663596	4.843055723	0.308953555
30-34	751	54	43	97	0.057257	32.5	1.860852197	0.963558693	4.817793464	0.275852355
35-39	748	37	35	72	0.046791	37.5	1.754679144	0.963558693	4.781146962	0.22371677
40-44	532	13	11	24	0.020677	42.5	0.878759398	0.948900092	4.682399669	0.096816535
45-49	366	2	1	3	0.002732	47.5	0.129781421	0.924059775	2.310149439	0.006311884
					0.266177		8.001615601			1.277689334

GRR= 5*sum(ASFR)= 5*0.26617=1.33

NRR= GRR*Probability of surviving to the mean of age specific fertility distribution (30.06 years in our case)1.33*0.964 = 1.28 or Sum of (exp female birth)

Appendices

Appendix I: Data collection tool for Paper I

Part 1: **Data collection sheet for health service utilisation from health facility registries**

Name of the health facility _____Rural/Urban _____Woreda _____Kebele _____

Data collector's name _____Signature _____Date_____Unit /department_____

S.N	Date of visit	Card number	Age in years	Sex	Address (Kebele)	Diagnosis	Visit (N/R)	Remark

Name of the supervisor_____**Signature**_____ **Date**_____

Part 2: **In-depth interview guide for health professionals**

First I would like to thank you for participating in this study. My name is _____I'm conducting the interview for the study called "health service utilisation pattern in primary health care facilities in Dale and Wonsho districts". This interview is part of a joint PhD study between Hawassa University and University of Bergen.

Are you volunteer to participate in this interview?

Thank you very much!

Q1: Have you received the findings on health service utilisation by either hard or soft copy?

Q2: If Yes, do you understand the results?

Q3: What are your suggestions or areas of improvement to make the health services used by the rural community in your working area?

Appendix II: Data collection tool for Paper II

Attribute table for spatial analysis of health service utilisation in Dale and Wonsho districts

FID	Shape	R_NAME	R_CODE	Z_NAME	Z_CODE	W_NAME	W_CODE	T_NAME	T_CODE	RK_NAME	RK_CODE	Visits_perkebele	Population_size	X_Cor	Y_Cor	Distance	Pop_dens	Altitude	family size

Key:

FID= Feature Id

Shape= Shape of the feature (point or polygon)

R_Name= Region Name

R_Code= Region Code

Z_Name= Zone name

Z_Code= Zone code

W_Name= Woreda(district) name

W_Code= Woreda Code

T_Name= Town Name

T_Code= Town Code

RK_Name= Rural Kebele Name

RK_Code= Rural Kebele Code

Visits_perkebele= Number of health facility visits in each kebele

Population_Size= The number of people living in each kebele

X_Cor= Longitude(X-coordinate)

Y_Cor= Latitude (Y-coordinate)

Distance= The distance from the health centre to the centre of the kebele

Pop_dens= Population desnity in each kebele

Atlitude= Altitude of each kebele measured as meters above sea level

Family size= The average number of people living together in each households in each kebele

Appendix III: Data collection tool for Paper III

Questionnaire for paper three: Births and deaths in Sidama in southern Ethiopia

Instruction: Based on the HDSS data filled, extract the following variables and put the responses of families from the site according to specific instructions and choices in each part of the questionnaire. This questionnaire has three parts.

Family Id. Number: _____ Rural/Urban _____ Woreda ____ Kebele _____ Village Name _____ House Number _____

Name of Head of Household _____ data extractor's name _____ Date_____

Part 1: **Basic demographic characteristics**

Pers. No.	Q100 Name of family members	Q101 Relation to head of HH	Q102 Sex	Q103 Age	Q104 Ethnicity	Q105 Religion	Q106 Educational level†	Q107 Marital Status ‡	Q108 Occupation ‡	Q109 Monthly income of the family $
.01										
.02										
.03										
.04										
.05										
.06										
.07										
.08										
.09										

.10										

Relation to HH: 1. Head 2. Spouse 3. Son/Daughter 4. Brother/Sister 5. Grand Child 6. Parent 7. House maid 8. Others (specify)
Sex: 1. Male 2. Female
Ethnicity: 1. Sidama 2. Amara 3. Gurage 4. Oromo 5. Wolayita 6. Tigre 7. Others (specify)
Religion: 1. Orthodox 2. Protestant 3. Catholic 4. Muslim 5. Others (specify)
Marital Status: 1. Married 2. Single 3. Divorced 4. Widowed
Educational level 1. Illiterate 2. Read and write (1-4 grade) 3. 5-6 grade 4. 7-8 grade 5. 9-12 grade 6. Higher level
Occupation: 1. Civil servant 2. Teacher 3. Merchant 4. Driver 5. Farmer 6. Daily laborer 7. Housewife 8. Student 9. House maid 10. Other (specify) (ǂ) for individuals who are 10 years and above (†) for individuals who are 7 years and above
Monthly income: ($) for the head and spouse only in Ethiopian Birr

Part 2. **Fertility related questions**

201. Was there any live birth occurred during the last one year in the household? Yes _ 1 No _ 2

202. If yes to 201, complete the following form for each birth:

Family Id. No.	Name of the mother	Age of mother	Sex of newborn	Date of birth	Type of birth	Status of birth	Place of birth	Attendant of birth
					1. Single 2. Twin 3. Multiple	1. Live birth 2. Stillbirth 3. Abortion	1. Home 2. HI 3. Other	1. Doctor 2. Nurse 3. HA/HEW 4. TBA/CHA 5. Relative 6. Neighbor 7. Other

Part III: **Mortality related questions**

301. Was there any death occurred during the last one year in the household? Yes __ 1 No ___2

302. If yes to 301, complete the following form for each death:

Name of the deceased	Age at death	Sex of the deceased	Place of death	Perceived cause of death	Date of death
		1. Male 2. Female	1. Home 2. HI 3. On the road 4. On the field 5. Other		

Part IV: **Mortality data collection tool from Iddirs (traditional voluntary organizations) and family of the dead person**

Serial no	Name of the dead person	Sex	Date of death	Age of the dead person	Possible cause of death
1.					
2.					
3.					

Part V: **FGD Guides**

1. What do you think of age reporting in your community? How do they calculate age?
2. Do you think ages are accurately reported? How do you know?
3. How do you calculate the age of children in your community?
4. How do you calculate the age of the deceased for (elderly, children and infant)?
5. How are old age females treated in your community?
6. How are old age males treated in your community?
7. Which age group and sex tends to reduce their age? Why?
8. Which age group and sex tends to exaggerate their age? Why?

9. What do you think of recognition given based on age on both sexes in your community?
10. Is there any issue that you want to raise regarding age that we have not discussed yet? Please?

Part VI**: In-depth Interview Guides**

1. How is age calculated and reported in the society?
2. How is the age of the deceased calculated for elderly, infant and children?
3. State common incidents/events on the area used as a reference? Cultural or historical?
4. Is there any pattern of reporting age among male and female? Reducing, increasing or preference of some digits? What is the reason behind?
5. What kind of value is given for old ages? For men and women?
6. Is there any form discrimination or recognition based on the age? For men and women? If so, please explain.
7. Is there any issue that you want to raise regarding age that we have not discussed yet? Please?

Appendix IV: Ethical approvals

ሀዋሳ ዩኒቨርሲቲ
ህክምናና ጤና ሳይንስ ኮሌጅ
የምርምር ስነ-ምግባር ገምጋሚ
ቦርድ

HAWASSA UNIVERSITY
COLLEGE OF MEDICINE AND
HEALTH SCIENCES
Institutional Review Board

Ref. No: IRB/022/10
Date: 20/12/2017

Name of Researcher(s): ***Hiwot Abera, Bernt Lindtjorn, Mesay Hailu, Hallgeir Kismul***

Topic of Proposal: ***Health and Demographic Surveillance System of Dale and Wensho woredas (districts): A potential for enhancing health care delivery system.***

Dear researcher(s),

The Institutional Review Board (IRB) at the College of Medicine and Health Sciences of Hawassa University has reviewed the aforementioned research protocol with special emphasis on the following points:

1. Are all principles considered?
   - 1.1. Respect for persons: Yes ☑ No ☐
   - 1.2. Beneficence: Yes ☑ No ☐
   - 1.3. Justice: Yes ☑ No ☐
2. Are the objectives of the study ethically achievable? Yes ☑ No ☐
3. Are the proposed research methods ethically sound? Yes ☑ No ☐

Based on the aforementioned ethical assessment, the IRB has:

A. Approved the proposal for implementation ☑
B. Conditionally Approved ☐
C. Not Approved ☐

Yours faithfully,

Ayalew Astatkie (PhD),
Institutional Review Board Chairperson.

☎ +046 820 92 90
Fax + 046 2208755
✉ 1560 Hawassa

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK vest	Jessica Svärd	55978497	09.03.2018	2018/67/REK vest
			Deres dato:	Deres referanse:
			21.02.2018	

Vår referanse må oppgis ved alle henvendelser

Bernt Lindtjørn
Postboks 7804

2018/67 Demografiske endringer i Sidama i sør Etiopia

Intitution responsible for the research: Universitetet i Bergen
Project manager: Bernt Lindtjørn

With reference to your application regarding the abovementioneded project. The Regional Committee for Medical and Health Research Ethics (REC Western Norway) reviewed the application in the meeting 12.04.2018, pursuant to The Health Research Act § 10. The response was reviewed by the committee chair, pursuant to The Health Research Act § 11.

Project description
Ethiopia, and especially south Ethiopia, lacks vital registries which are necessary for building a modern and equitable health system. Population changes are determined by births, deaths, and net migration. The general objective of the study is to describe the population characteristics and measure its effect on population dynamics and health service utilisation in Sidama Zone in south Ethiopia. The study will be conducted an established health and demographic surveillance site (HDSS) that includes twelve communes with 17,225 households. Paper I shall describe the population characteristics of Dale and Wonsho districts. In Paper II, we shall find out how socio-demographic factors influence population dynamics such as birth, death and migration rates. In Paper III we shall assess factors affecting the health care utilisation. In Paper IV, we shall examine the consistency of the Kebele registry system with HDSS. For all studies we shall use cross-sectional and cohort study designs.

Ethical review
Responsible conduct
The Committee has no objections to the research questions, the purpose of the project or the proposed questionnaire.

Data will be extracted from the existing HDSS central database by selecting relevant variables. Repeated data will be collected by a questionnaire to analyse changes over time.

Post approval
It is required that every project that falls within the scope of the Act, following §§ 2 and 3, applies for an approval from REC before the project starts. Only on certain strict conditions does REC give approval for a project that is ongoing.

The committee therefore wants to know whether the University of Bergen was involved in planning of the Health and Demographic Surveillance System (HDSS) in Sidama. The Committee also wants to know

whether the repeated data collection will be collected by the PhD student in this project, or if this is also already performed.

Local ethical permission
The submitted approval by the Institutional review board at Hawassa University covers "Dale Health and Demographic Research". Does this approval cover the repeated data collection outlined in this project? Why is the name of the project manager, Bernt Lindtjørn, not on the submitted IRB approval?

Questionnaire/Interview
This is an extensive questionnaire, but the questions seem relevant for the purpose of the project. The committee has no objections to the questionnaire. Informed consent Informed consent has already been collected. Does this consent cover the repeated data collection?

Data processing and confidentiality
All storage of data must be in accordance to routines by the institution responsible for the study (University of Bergen). The project ends at 31.12.2019, and all project specific data must then by deleted or anonymized.

Postponed decision
REC Western Norway needs a response to the following questions in order to make a decision. Was the University of Bergen involved in the planning of the Health and Demographic Surveillance System (HDSS) in Sidama? If not, how and when did UiB become involved in the project? Why is the name of the project manager, Bernt Lindtjørn, not on the attached IRB approval? Does the attached IRB approval cover the repeated data collection outlined in this project? Will the repeated data be collected in this project or is this already performed?

Response by the project manager

1. Was the University of Bergen involved in the planning of the Health and Demographic Surveillance System (HDSS) in Sidama? If not, how and when did UiB become involved in the project?

The University of Bergen was not involved in the planning or design of the HDSS in Dale in Sidama. UiB was involved in the planning of the PhD work for Hiwot Abera, and this planning work started with her protocol writing in the latter half of 2017. Accordingly, she submitted the research plan to the Institutional Review Board in Hawassa, and later to Rek Vest.

2. Why is the name of the project manager, Bernt Lindtjørn, not on the attached IRB approval?

Since I (Bernt Lindtjørn) was not involved in the planning or in the project management group of the demographic surveillance site, my name is not on the IRB letter regarding the Dale HDSS.

3. Does the attached IRB approval cover the repeated data collection outlined in this project?

INDEPH (http://www.indepth-network.org) is a global network of health and demographic surveillance systems (HDSSs) that provide a more complete picture of the health status of communities. Since these sites collect data from whole communities over extended time periods, they more accurately reflect health and population problems in low- and middle-income countries. The Dale HDSS is developed based on the models and experience from these many sites; see http://www.indepth-network.org/member-centres. Our understanding is that the Dale HDSS will join this network of seven sites in Ethiopia. The very nature of a HDSS is to monitor the health and demographic patterns of populations (sentinel sites) over many years. Ethiopia is a country without a vital registration system. The government has therefore encouraged universities to set up several HDSS covering the large and diverse populations of the country, at present of over 100 million people. Thus, the Dale HDSS aims to follow the selected population in Dale (representative of the large Sidama population) for many years to come. Therefore, the site plans do repeated measurements on the same population to follow the demographic dynamics of this population. The setup of this demographic surveillance site is based on previous experiences from Ethiopia, especially the

Butajira HDSS; which is a long-term member of the of the INDEPTH network. Hawassa University owns and finances the Dale HDSS. The DHSS aims to make the data available to future masters and PhD students, and Hiwot Abera is the first PhD student to get permission to use some of these data.

4. Will the repeated data be collected in this project or is this already performed?

Hawassa University has collected data for the initial census. When the data entry is done, PhD student Hiwot Abera will get access to some of these data. Hawassa University plans to repeat the census and with smaller follow up surveys every year. Hiwot Abera plans to use data planned to be collected during 2018 and in early 2019.

The committee chair has reviewed the response.

Review

REC western Norway is satisfied with the response from the project manager.

Descision
REC western Norway approves the project.

Final report and amendments
A final report must be sent no later than 30.06.2020. If amendments need to be made to the study, the project manager is required to submit these amendments for approval by REC via the amendment form. The decision of the committee may be appealed to the National Committee for Research Ethics in Norway. The appeal should be sent to the Regional Committee for Research Ethics in Norway, West. The deadline for appeals is three weeks from the date on which you receive this letter.

Sincerely,

Marit Grønning
Prof. Dr.med.
committee chair

Jessica Svärd
committee secretary

Copy to: post@uib.no

Graphic design: Communication Division, UiB / Print: Skipnes Kommunikasjon AS

uib.no

ISBN: 9788230847350 (print)
9788230858639 (PDF)