Bottlenecks and met needs for the treatment of severe acute malnutrition in pastoralists: Doolo zone of Somali region, Ethiopia.

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Abstract

Background

There is high burden of malnutrition worldwide, including wasting that is compromising growth and development of children and nations. In Ethiopia, severe acute malnutrition (SAM) remains a public health problem. Prevalence of acute malnutrition i.e. wasting is highest (22.7%), (17.5 %) in Somali region of Ethiopia. This study assessed the bottlenecks and met needs for SAM treatment coverage in Doolo zone Somali regional state of Ethiopia.

Methods

This study used Tanahashi model of service coverage to identify bottlenecks for SAM treatment coverage at health facility platform using multi-stage sampling in Doolo zone, Somali regional state of Ethiopia. T racer interventions were selected to make the analysis more manageable and systematic. The collected data were entered in to excel then thoroughly cleaned and analysed. Indicators for supply-side, demand and quality were calculated. The shortest bar of the graph was considered as a bottleneck for supply-side while sharp decline or drop-in between one bar of the graph to the next was considered as a bottleneck in demand and quality sides. Performance thresholds were set for the indicators as (Good, fair and poor) and met need for SAM was then calculated.

Result

The analysis identified bottlenecks across the six determinants of coverage for the treatment of SAM. Major supply-side bottlenecks identified were commodity stock-outs, mainly ready to use therapeutic foods (RUTF) and shortage of trained health extension workers in three of the four districts studied. On the demand side, despite reasonable initial utilizations in most of the districts studied, there were poor continuity of services (high defaulter rate) and low quality of SAM treatment (effective coverage). The met need was lowest in Bokh district (12%) and highest in Danod district (70%). Despite average treatment coverages of 85% and above for Geladi, Warder and Danod districts, yet the met need was found to be 54%, 60% and 70% respectively which was not commensurate with average treatment coverages

Conclusion

The identified bottlenecks for SAM treatment coverage cut across the supply side, demand and quality aspects. The low quality for SAM treatment could have resulted from a combination of supply and demand bottlenecks i.e. frequent stock out of basic commodities (RUTF), shortage of trained health extension workers and poor health-seeking behaviour and/or poor continuity of service or high defaulter rate). The overall met need for SAM program was found to be 37% which could imply high unmet need and poor impact of the program. It is recommended that further causality analysis be undertaken for the major bottlenecks discovered in this study to establish root causes of bottlenecks and devise appropriate solutions adapted to the local setting.

Introduction

There is a high burden of malnutrition worldwide, including wasting and severe wasting, that are compromising growth and development of children and nations. Good nutrition allows children to grow, develop, learn, play, participate and contribute to national development—while malnutrition robs children of their futures and leaves young lives hanging in the balance. Wasting in children is the life-threatening result of hunger and/or disease. Children suffering from wasting have weakened immunity, are susceptible to long term developmental delays, and face an increased risk of death: they require urgent treatment and care to survive[1, 2]. In 2018, wasting continued to threaten the lives of estimated 7.3 per-cent or 49 million children under-five globally. More than two thirds of all wastedchildren under-five lived in Asia and more than one quarter lived in Africa.[2].

Globally, SAM treatment coverage ois inadequate and usually treatment progress is very slow. In 2015, about 3.5 million children were admitted for SAM treatment. Despite rising global trend of admission to SAM programs observed between 2009 and 2015, only one in five children with severe acute malnutrition have access to treatment globally which is only 20% of the global burden[3].

In Ethiopia, severe acute malnutrition remains a public health problem. Prevalence of acute malnutrition i.e. wasting is highest (22.7%), (17.5 %) in Somali region of Ethiopia [4, 5] - a rate much higher than the national average of 9.9% and has shown 7% increment from 15.8% to 22.7% in the period from 2000 to 2016 [4]. This could have been contributed by repeated rain failures that led to recurrent droughts in Somali region which in turn devastated the livelihoods and increased food insecurity over the years.

In 2017 Horn of Africa drought, Somali region had seen the highest SAM admissions since the inception of the Community-based Management of Acute Malnutrition (CMAM) programme. About 59,769 children under the age of five were enrolled for treatment between January and August 2017. An average of 7,500 children was admitted every month in 2017, a four-fold increase from average monthly admissions in previous years. The region has managed 26 per cent of the SAM cases nation-wide, a radical increase from 5 per cent in normal years [6].

Access and effective coverage of SAM treatment is a big challenge in developing countries. Improving access and utilization of existing health interventions will avert millions of preventable deaths[7, 8]. Community based Management of Acute Malnutrition (CMAM) program was rolled-out in developing countries including Ethiopia with the aim of maximizing access and minimizing risk of malnutrition. This approach has successfully increased access, coverage and greatly reduced the deaths in malnourished children[9]. It did not only improve access and sustainability but it was found to be more cost effective than the therapeutic feeding centres model[10]. In Somali region of Ethiopia however; the percentage of health facilities providing SAM treatment service was (62%) according to Service Availability and Readiness Assessment done in 2016[11].

Some of the actors behind low effective coverage of CMAM programs includes high opportunity costs, lack of awareness about malnutrition and the treatment program, previous rejection explained [13]. Additionally, Factors like distance, knowledge of services, knowledge of malnutrition and child's refusal of ready-to use foods were also major barriers to access of SAM treatment in Ethiopia [14, 15].

On the other hand, the current routine monitoring systems for SAM service are not designed to indicate bottlenecks/obstacles to effective coverage. Similarly, existing coverage methods, such as SQUEAC (Semi Quantitative Evaluation of Access and Coverage) and SLEAC (Simplified Lots quality assurance Evaluation of Access and Coverage) are only implemented sporadically or not conducted at all due to the cost and time required for implementation. Thus, it is essential to complement existing methods with Bottleneck Neck Analysis (BNA) approach, a tool that can support routine (or more frequent) monitoring of bottlenecks. [12].

The bottleneck analysis approach is used to identify barriers, bottlenecks and enabling factors that either constrain or advance the achievement of desired outcomes for vulnerable populations. It is based on the principle that certain conditions or determinants need to be fulfilled in order to achieve effective coverage of services, practices and systems[13, 14].

Good coverage is a key determinant in meeting need. Investigating coverage, and the factors influencing coverage, is essential to improving both coverage and effectiveness and, through them, to meeting need[15]. This study aimed at determining bottlenecks for SAM treatment coverage and met need of SAM treatment services in Doolo zone Somali regional state of Ethiopia.

Material And Methods

Study setting

The study was conducted in Doolo Zone, Somali region of Ethiopia. Doolo Zone is one of the eleven zones constituting the Somali region, located in east of region bordering with south central & Puntland of Somalia and is purely in habited by pastoralists. The zone has seven administrative districts, one zonal hospital, 15 health centres, and 77 health posts supporting an estimated total population of 346,009.

Study Duration

The study was conducted from 15th June–10th July 2018.

Study Design

A modified *Tanahashi model* [13] of service coverage and its evaluation was adopted at facility level platform to do bottlenecks analysis on SAM treatment coverage in public health facilities of Doolo zone (Fig1).

The model evaluates six determinants of effective coverage of an intervention and is grouped in to:

1. Supply determinants of services which are predominantly controlled by the health care delivery system and have three important components: commodities, human resources and geographic access.
2. Demand determinants of services are predominantly controlled by the community and have two important components: initial utilization and continuous utilization of services.
3. Quality determinants of services are predominantly controlled by the health care delivery system and relate to the services being able to meet the quality standards set within national guidelines.
4. Environmental (Enabling) determinants of services are cross- cutting factors that include the policy and regulatory frameworks, management, coordination and the socio-cultural as well as economic related factors (not assessed for this study as it focused on service delivery).

Target population

All health facilities in Doolo zone, Somali Regional State of Ethiopia

Study subjects

Randomly selected health facilities providing SAM treatment service in the selected districts

Inclusion criteria

Health facilities providing SAM treatment service

Exclusion criteria

Health facilities not providing SAM treatment service,

Sample size

The formula for single population proportion was applied using Epi-info version 7, Proportion of health facilities providing treatment for malnutrition in Somali region (P) was 0.62 taken from the 2016 Service Availability and Readiness Assessment[11].

Total health facilities in the study zone (N) is 93 (77 HPs+ 15HC+1 Hospital), Confidence interval of 95% assumed ($Z\alpha/2 = 1.96$) with a margin of error of 5%, and design effect of 1.

The sample size formula was applied $n = Z^2 p (1-P)/d^2 = 74$. Since the population (N<10,000), the correction formula is applied $n = n/ (1+ (n/N)$ which results a sample of 41.

It was also assumed that 5% of the health facilities may either be closed, or staff is absent thus non-response rate of 5%was taken to arrive at a final sample size of n = 43.

Sampling Methods

Multi-stage sampling technique was applied with primary sampling unit (PSU) being districts in the zone and secondary sampling unit (SSU) being health facilities in the selected districts (Fig 2).

Data collection technique

The data was collected using interviewer administered questionnaire which was adapted to the context. Data of the last six months was collected from each health facility.

Method of data analysis

The collected data was entered in to an excel database, cleaned and thoroughly analysed.. Indicators for supply-side, demand and quality were calculated, and the findings were presented in a bar graph fashion to facilitate identification of the bottlenecks

The shortest bars of the graph were considered as a bottleneck for supply side and a sharp decline or a drop-in coverage between one bar of the graph to the next. Performance threshold was set for the indicators: (Good, fair and poor).

- Treatment coverage was calculated by number of SAM children receiving therapeutic care (OTP) divided by estimated SAM caseload in each district
- Geographic coverage was calculated as the proportion of all health facilities in each district which are providing SAM treatment.
- Met need was calculated as the product of SAM treatment coverage percentage and effective coverage (cure rate) percentage multiplied by 100.

Assumptions in analysis

- There is no assumption of a linear causal relationship among the three supply side determinants: the adequacy of commodities, trained personnel and access points are usually not directly related, though trends in their levels tend to be positively correlated.

- The common denominator for demand-side indicators is the estimated burden of malnutrition which in turn is the estimation of the total number of SAM cases in a population over a specific period (i.e. prevalent cases + incident cases in the year). Or simply, Burden = Population 6–59m x (Prevalence +prevalence x1.6) [16]. The prevalence taken in this case for Somali region is 6.3% [4%–9.7%] [17].

Table1: Selected tracer indicators for SAM coverage bottleneck analysis.

Determinants	Indicators	Definition of indicator
Supply	Commodities	% of health facilities providing OTP services and did not encounter stock outs of (RUTF) for two or more consecutive weeks in the last 6 months.
	Human Resource	% of Health workers trained on SAM treatment during the last year
		% of Health Extension Workers trained on SAM management during the last year
	Geographic access	% of Heath facilities providing OTP services in a district
Demand	Initial utilization	% of children 6 -59 months with SAM who were admitted in the SAM management service in the last 6 months in a district
	Continues utilization	% of children 6-59 months who did NOT default from SAM management service in the last 6 months in a district
Quality	Effective coverage	% of children 6 -59 months with SAM who were cured in the SAM management service in the last 6 months in a district.

Data quality control

Training of data collectors was done, supervisors were assigned to respective teams to follow up the enumerators, check the completeness, correctness and consistency of data and take necessary action/correction on spot.

Definition of Terms

Bottleneck- is a factor that hinders full coverage of an intervention. A 'barrier', also known as a 'bottleneck' is anything that restrains, obstructs, or delays access to a program or restrains coverage[13].

Burden of malnutrition: estimated total number of SAM cases in a population over a specific period (i.e. prevalent cases + incident cases in the year).

Treatment coverage for community-based management of acute malnutrition (CMAM) is the proportion of children with severe acute malnutrition (SAM) who receive therapeutic care[15].

Geographic coverage: is most commonly defined as the ratio of healthcare facilities in a catchment area delivering services for the management of SAM to the total number of healthcare facilities in the catchment area[15].

Recovered/cured: If severely wasted children gained 15% of their weight after admission, and if those oedematous lost the swelling after 2 consecutive weeks of admission.

Defaulter: A SAM case who is absent for 2 consecutive weeks after getting admitted to OTP and confirmed as alive by home visit were reported as defaulter.

Result

This study was conducted in four districts of Doolo zone in Somali region of Ethiopia. The total assessed health facilities were 43 (1 hospital, 12 health centres, 30 health posts). The research analysis used bottleneck analysis tool using modified Tanahashi model to identify bottlenecks across the six determinants of coverage for the treatment of severe acute malnutrition. Major supply side bottlenecks identified are stock out of RUTF and shortage of trained health extension workers in three of the four districts studied (Table 2). Similarly, poor continuity of service (high defaulter rate) and poor effective coverage was reported as shown in Table 3.

Table2. Supply side bottlenecks of SAM treatment coverage in four districts of Doolo zone, Somali region of Ethiopia

		Supply side												
		Commodities				Human Resource						Geographic Access		
District	Population	% of HFs providing OTP-SAM services with no stock outs (RUTF) >=2 consecutive weeks in the last 6 months =(A-B)/C	# HFs providing OTP (A)	HFs with OTP and with RUTF stock-outs >=2 consecutive weeks (B)	# HFs with OTP service (C)	% of HWs trained on SAM treatment last 2 years =(E/F)	# of HWs trained on SAM treatment (E)	Total # of HWs (F)	% of HEWs trained on SAM treatment last 2 years =(G/H)	# of HEWs trained on SAM treatment (G)	Total # of HEWs in the District (H)	% of HFs providing OTPservices =(I/J)	# of HFs providing OTP (I)	Total HFs targeted for SAM (J)
Geladi	134,661	64%	11	4	11	83%	10	12	79%	11	14	90%	18	20
Bokh	118,277	40%	10	6	10	90%	9	10	67%	8	12	76%	13	17
Warder	43,042	94%	16	1	16	78%	18	23	69%	11	16	90%	26	29
Danod	30,115	67%	6	2	6	88%	7	8	100%	3	3	82%	9	11

The estimated SAM burden or case load calculated shows that there is a total of 5341 estimated SAM children living in the four districts assessed. Despite good initial utilizations recorded in the review period, the continuity of utilization and effective coverage (cure rate) has diminished. The cure rate (effectiveness) is highest in Danod district (74%) and lowest in Bokh district (25%) as shown in (Table 3).

Table 3: Demand and quality side bottlenecks of SAM services in four districts of Doolo zone, Somali region of Ethiopia

		Demand side						Quality side		
		Initial Utilization			Continues utilization			Effective coverage		
District	Population	% of children 6 - 59 months with SAM who were admitted in the SAM management service in the last 6 months. =(K/L)	# of SAM admissions. (K)	Estimated SAM burden (L)	% of children 6-59 months who did NOT default from SAM management service in the last 6 months =(M/N)	# SAM admissions (–) defaulters (M)	Estimated SAM burden (N)	% of children 6 -59 months with SAM who were cured in the SAM management service for the last 6 months =(O/P)	# SAM Cured (O)	Estimated SAM burden (P)
Geladi	134,661	85%	1868	2206	80.9%	1785	2206	64%	1408	2206
Bokh	118,277	47%	913	1937	43.6%	845	1937	25%	481	1937
Warder	43,042	85%	602	705	78.3%	552	705	71%	498	705
Danod	30,115	95%	466	493	78.3%	386	493	74%	367	493

In (Fig 3), availability of commodities (RUTF) is found to be a medium bottleneck with 36% of health facilities facing stock-outs of more than two consecutive weeks in six months. On the demand side, there was good access to SAM treatment services in this district (90%) and the initial utilization of service was also good, however, the there is a bottleneck in the quality of treatment (effective coverage) of service as there is a drop of 21% is observed between first contact or utilization and completion of the service.

Availability of commodities, initial utilization, continuity and quality of service (effective coverage) were major bottlenecks in Bokh district (Fig 4). Sixty percent (60%) of the assessed health facilities had encountered stock outs for two or more weeks in six months. Despite good geographical access (76%) in the district, only 47% of SAM cases sought treatment (poor care seeking) out which only 25% have received appropriate treatment or completed the course of the treatment.

In warder district (Fig 5), as far as the supply side is concerned, there is an observed partial bottleneck in the availability of trained human resource particularly health workers (69%) who normally work in health centres unlike health extension workers in health posts (78%). On the other hand, notwithstanding the good initial utilizations observed, there is a 14% drop between the initial users of treatment service (85%) and effective coverage (71%) signalling some quality bottlenecks.

In Danod (Fig 6), commodities (RUTF) is the lowest bar showing medium bottleneck where 33% of the health facilities have had stock outs in two or more consecutive weeks with in a period of six months. The continuity of service and quality are little bit decreased compared to initial utilization showing 21% drop between initial utilization (first contract) and completion of the treatment service.

Table 4: Thresholds for rating tracer/coverage indicators for SAM treatment, Doolo zone, Somali region, Ethiopia.

Tracer Interventions	Threshold			Districts			
	Poor	Fair	Good	Geladi	Bokh	Warder	Danod
Commodities	<50%	50%- 79%	>=80%	64%	40%	94%	67%
HR (HWs)	<40%	40%-59%	>=70%	83%	90%	78%	88%
HR (HEWs)	50%	50%- 69%	>=70%	79%	67%	69%	100%
Geographic Access	<40%	40%-59%	>=60%	90%	76%	90%	82%
Initial Utilization	<50%	50-69%	>=70%	85%	47%	85%	95%
Continues Utilization	> 5% drop from Initial Utilization	2%-5% drop from [1]Initial Utilization	< 2% drop from Initial Utilization	81%	44%	78%	78%
Quality/effective coverage	> 8 % drop from Initial Utilization	3 % - 8% drop from Initial Utilization	< 3% drop from Initial Utilization	64%	25%	71%	74%

[1]

With regards to the thresholds and performance of tracer indicators of different districts[12], the supply side determinants fit in a fair and good category in all except Bokh district which showed poor threshold in commodities calling for further causality analysis. On the demand and quality side, despite satisfactory performance in the initial utilizations, the continuity of utilizations and quality (effective coverage) determinants declined to fair and poorer thresholds signalling close attention and the need to do further causal analysis.

The geographic coverages for Geladi and Warder district were 90% and their corresponding treatment coverages had a difference of 5%. In Bokh district however, there was a reduction of 29% between geographic and treatment coverages whilst in Danod district, unlike other districts, the geographic coverage was lower than its treatment coverage (Fig 7).

The met need for SAM treatment is the product of effectiveness (cure rate) and treatment coverage. The met need was lowest in Bokh district (12%) and highest in Danod district (70%). Despite average

treatment coverages of 85% and above for Geladi, Warder and Danod districts, yet the met need was found to be 54%, 60% and 70% respectively which was disproportionately low (Fig 7).

Discussion

This paper has presented an analysis and synthesis of bottlenecks and met needs associated with the coverage for the treatment of Severe Acute Malnutrition (SAM). From the supply side, the identified bottlenecks were to do with stock-outs of key commodities (i.e. ready-to-use therapeutic food (RUTF)) in two out of the four districts assessed and shortage of trained health workers in three out of the four districts. This stock out of key commodities (i.e. RUTF) is a key challenge affecting performance[18, 19] and contributes to poor compliance which in turn have a negative impact on effectiveness of the nutrition program[20]. There is often enough RUTF at country/regional level but the situation in the field can be very different; related to challenges with logistics/distribution of supplies[15]. This finding is in line a study in southern nations region of Ethiopia where Health Extension Workers (HEWs) indicated lack of RUTF as the biggest problem they face in the OTP [21]. Other studies reported similar challenge inside and outside of Ethiopia[22].

On the supply-side aspects, shortage of trained staff from health facilities especially Health ExtenstionWorkers were identified as a bottleneck which could be related to the lack of proper retention mechanism for health workers. This finding is in line with a study in Ethiopia which found out that unavailability of Health Extension Workers(HEW) in the health posts was among the most common barriers to the utilization of Integrated community case Management (iCCM) and nutrition services that was mentioned by care-givers. [23].

The *geographic coverage* for SAM services reported for the study area ranges from 82% in Danod to 90% in Geladi district. This indicator measures only the availability of services for the treatment/management of SAM. This is higher than the findings (62%) of the 2016 service availability and readiness assessment in Ethiopia[11]. This variation could be related to sample size differences in addition to the efforts made to expand the availability of SAM treatment services in response to 2017 humanitarian emergency in the study zone by government and international organizations.

On the other hand, the SAM *treatment coverage* for the study area also ranged from 47% in Bokh to 95% in Danod district and is well above the minimum SPHERE threshold for coverage in rural settings[24]. This indicator (treatment coverage) unlike geographic coverage measures the actual utilization of the SAM services and is always lower than the geographic coverage as the availability of SAM services does not equate with service access and uptake[15]. It is however, unique that the treatment coverage in Danod district (95%) is greater than its geographic coverage (82%) which could be attributed to the massive movement of pastoralists across the border during drought time who were not included in the caseload estimation on top of the availability of outreach services (supported by MSF) that increased admissions.

Despite satisfactory levels of initial utilizations for SAM services in all districts, there are challenges in the continuity of service (i.e. high defaulter rate) in two out of four districts which is above the SPHERE

threshold for defaulters (<15%). This could be explained by multitude of factors: Of note is the prevailing lifestyle of pastoralism in the area where some children in the program tend to default once their families move in search of water and pasture. Other reasons could be stock-outs of RUTF at facility level which does not take very long for mothers to become discouraged and to stop attending the program. This is even more evident when other barriers to receiving treatment such as distance, long waiting times to be served, quality of the service, etc. are also involved[15]. Other contributing factors could be lack of awareness of malnutrition, lack of awareness of the program, high opportunity costs, inter-program interface problems, and previous rejection[18, 22, 25] plus inconsistent community sensitizations in remote areas with less program exposure[22, 25]. There are other studies in conformity with the poor continuity of service or defaulter level above the SPHERE threshold[1] and other studies against this finding which reported lower defaulting rates of 2.2% [26, 27] and 13.85% [28] in Ethiopia and Burkinafaso respectively.

Effective coverage (completion of treatment or cure rate) in this study was 52% ranging from 25%–74% across study districts. This shows that none of the study districts have met the minimum acceptable threshold (Cure rate > = 75%) as per the SPHERE standards[24]. There are studies in Ethiopia which are in line with this sub-standard threshold[26, 28–33] and others meeting the SPHERE standards including one study in Burkina Faso [27, 34, 35]. This could be related to poor case finding and early-treatment seeking, lower levels of compliance to the treatment protocol both from provider and beneficiary side, poor retention from admission to cure (i.e. high defaulting [15, 20]. The sub-standard cure rate influences the program success since the product of coverage and effectiveness (cure rate) defines the impact of an intervention[13, 20]. Other reasons of low cure rate could be improper management of co-morbidities [29],inadequate provision and unintended usage of RUTFs, lack of antibiotics [21] inappropriate exit from the program[21, 33] as well as sharing and selling of therapeutic foods due to rampant household food insecurity in rural areas[33, 35].

Met need for the SAM treatment program is the product of effectiveness (cure rate) and SAM treatment coverage. [13, 20]. The effectiveness or cure rate in this case was on average 52% [25%–74%] and the average treatment coverage was 72% [47%–95%] which has resulted a met need of 37% implying extremely high unmet need for SAM treatment and poor impact of the program.

A limitation for this study was the quality of the available data which revealed existence of the data system weaknesses and highlighted under-utilization of routinely collected data. The BNA tool used in this study did not explicitly capture indicators on policy, legal, social norms and budget-related factors that shape the determinants of health service coverage as the assessment took place at service delivery level.

Conclusion

Bottlenecks for SAM treatment coverage cut across the supply side, demand and quality aspects. The low quality for SAM treatment could have resulted from a combination of supply and demand bottlenecks

(frequent stock out of basic commodities (RUTF), shortage of trained health extension workers and poor health-seeking behaviour and poor continuity of service or high defaulter rate).

The coverage of SAM services and effectiveness they achieve are directly linked. The met need for SAM program was found to be 37% which implies high un met need and poor impact of the program. Maximizing coverage maximises effectiveness and met need.

Further causality analysis is recommended to be undertaken for the major bottlenecks discovered in this study to establish root causes of bottlenecks and devise appropriate solutions adapted to the local setting.

List Of Abbreviations

- CMAM———-Community based Management of Acute Malnutrition
- SAM————Severe Acute Malnutrition
- SLEAC———Simplified Lots quality assurance Evaluation of Access and Coverage
- SQUEAC——Semi Quantitative Evaluation of Access and Coverage
- SSU————-Secondary Sampling Unit
- PSU————-Primary Sampling Unit
- OTP————-Outpatient Therapeutic Program

Declarations

Ethical approval and consent to participate

Ethical clearance was granted by Ethics Review Committee of Jigjiga University, Ethiopia. Support letter was given by the university addressed to study districts and verbal consent was given by heads of each district health offices and staff in charge of health facilities after being given information about the study. More-over, anonymity and confidentiality were kept by not collecting personal identifiers from the health facility registers.

Consent for publication

N/A

Availability of data and material

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Competing Interests

The authors declare that there are no competing interests.

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Authors' contributions

- Conceptualization: AEF.
- Data curation: AEF.
- Formal analysis: AEF, AHA, ATA.
- Methodology: AEF, AHA, ATA.
- Supervision: AEF.
- Writing ± original draft: AEF.
- Writing ± review & editing: AEF, AHA, ATA

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Author's Information

N/A.

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Figures

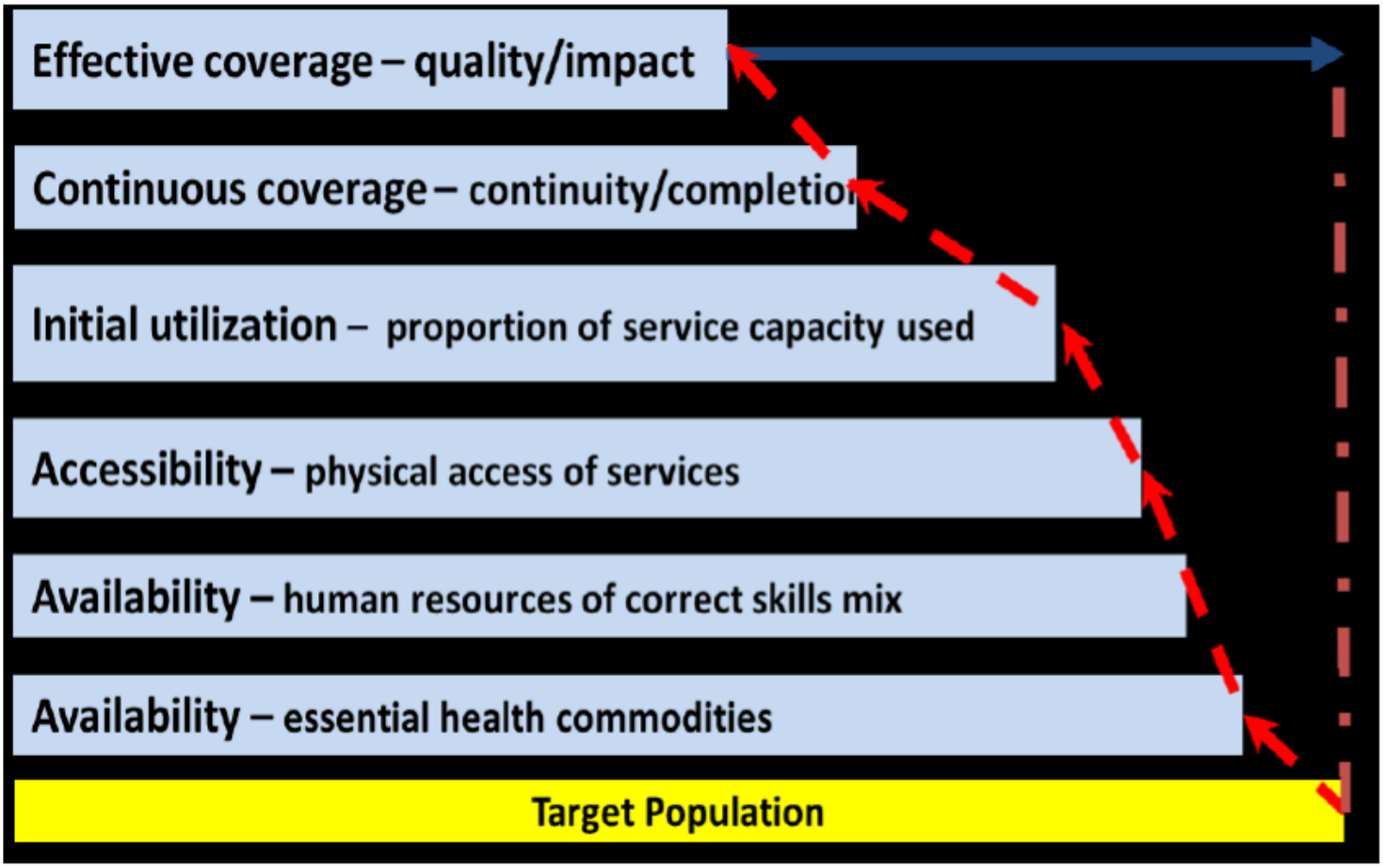

Figure 1

A modified Tanahashi model based on analysing determinants of effective coverage

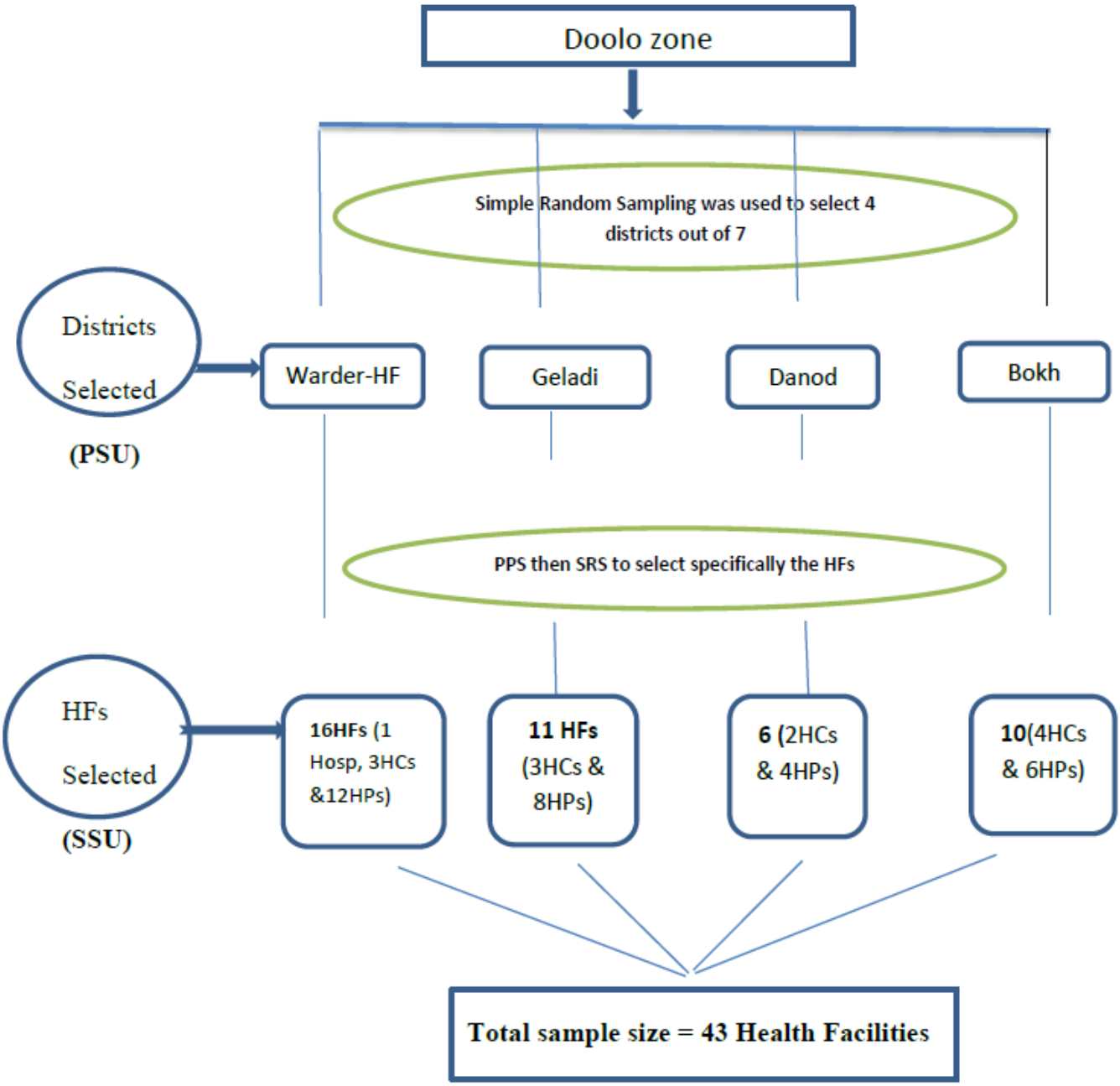

Figure 2

Schematic presentation of sampling procedure

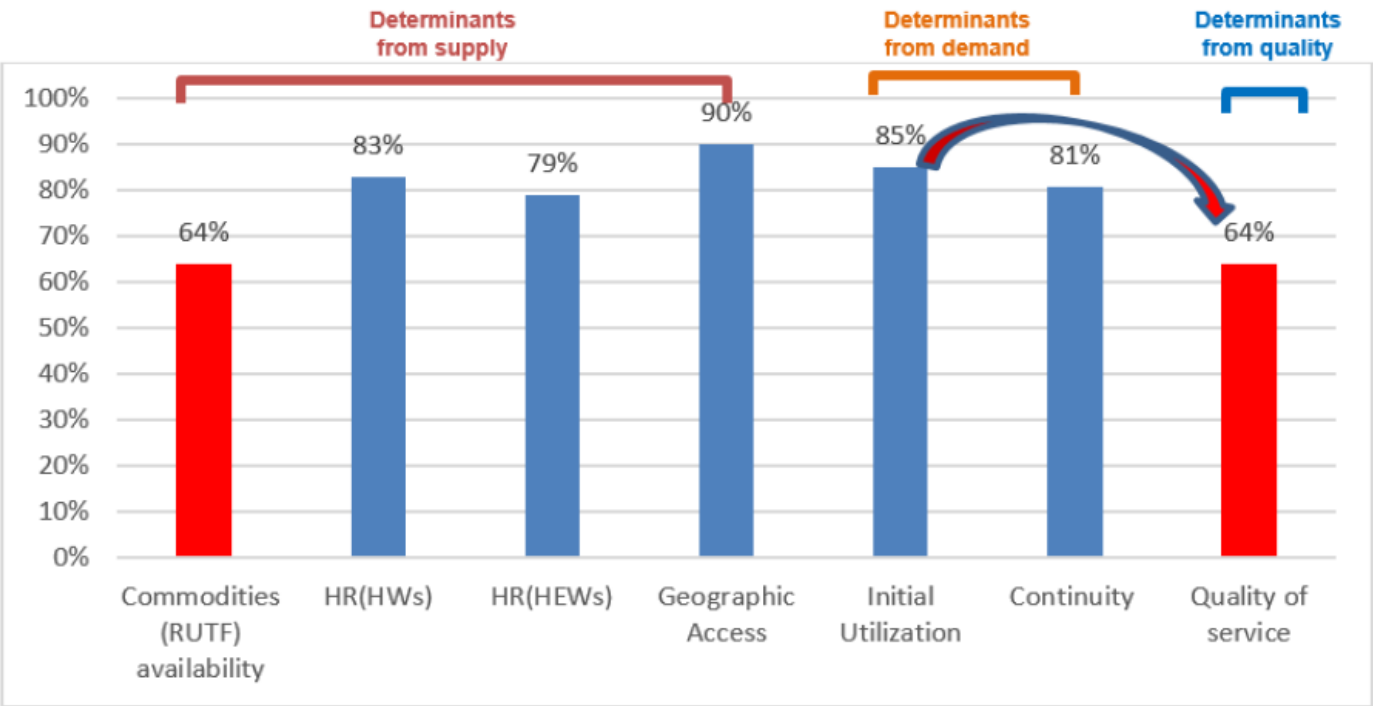

Figure 3

Coverage bottlenecks for SAM services in Geladi district, Somali region Ethiopia, 2018.

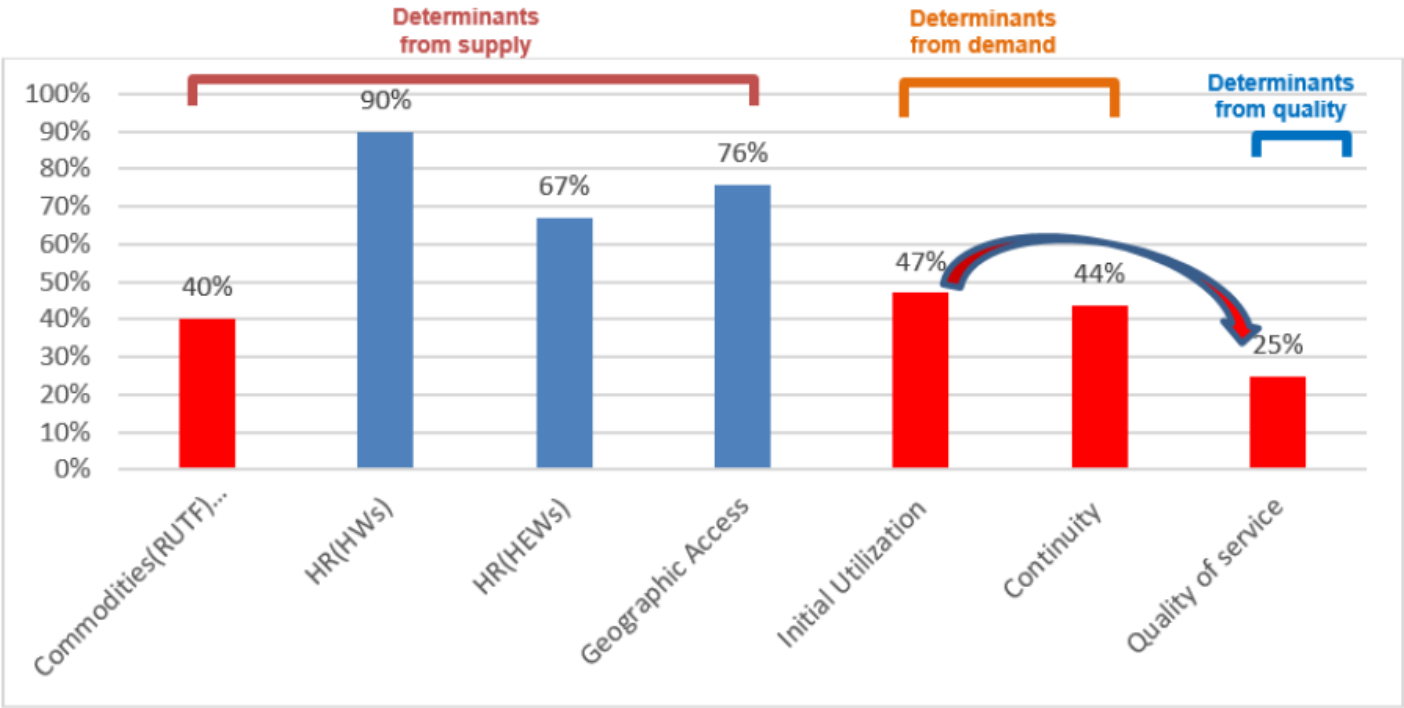

Figure 4

Coverage bottlenecks for SAM services in Bokh district, Somali region Ethiopia, 2018.

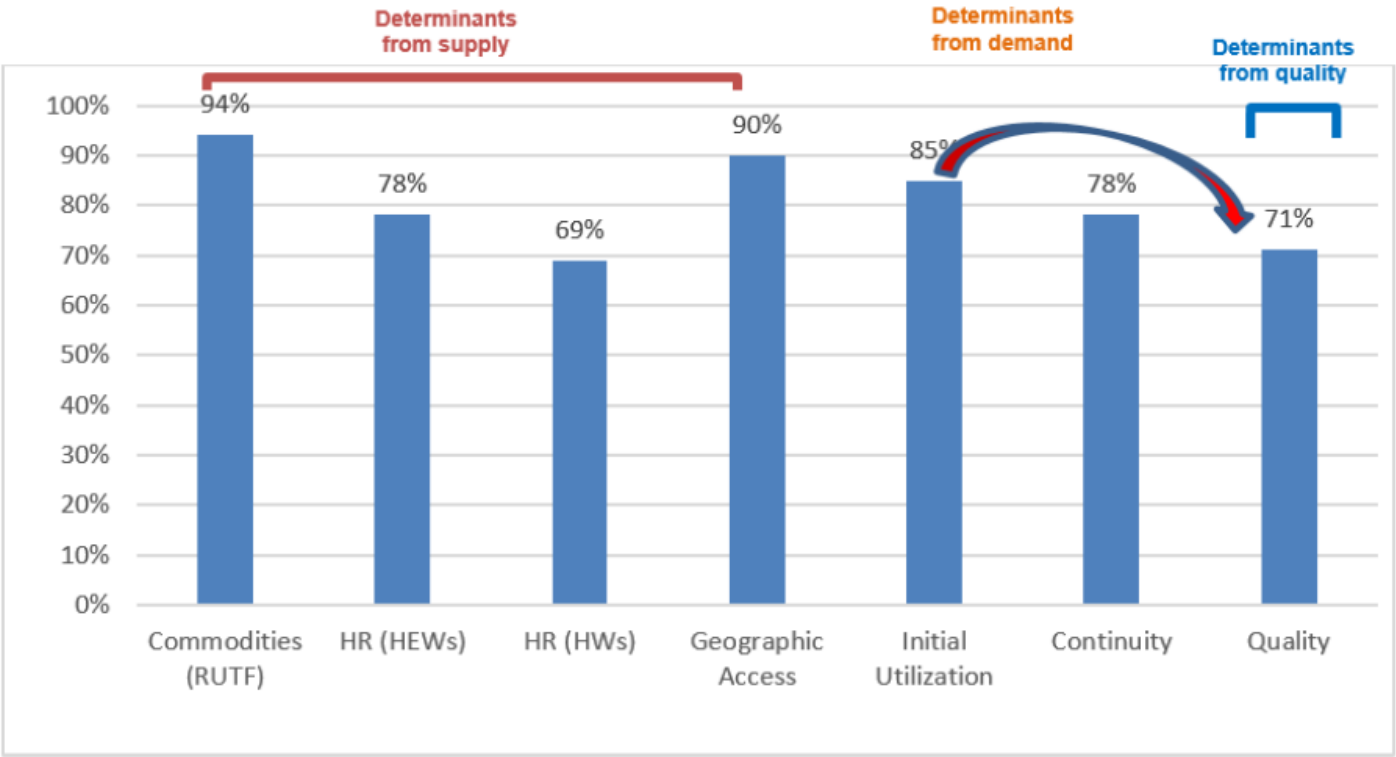

Figure 5

Coverage bottlenecks for SAM services in Warder district, Somali region Ethiopia, 2018.

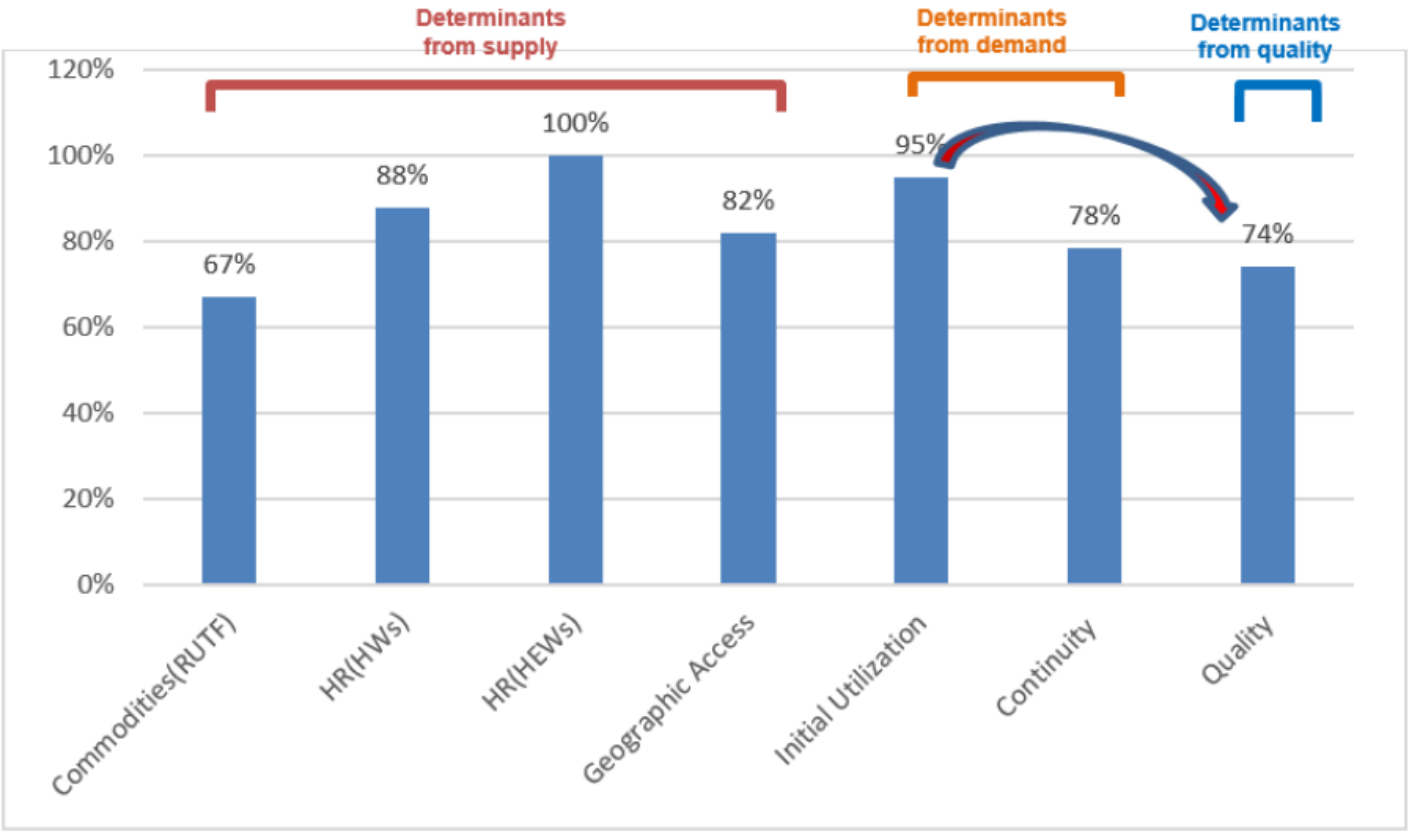

Figure 6

Coverage bottlenecks for SAM services in Danod district, Somali region Ethiopia, 2018.

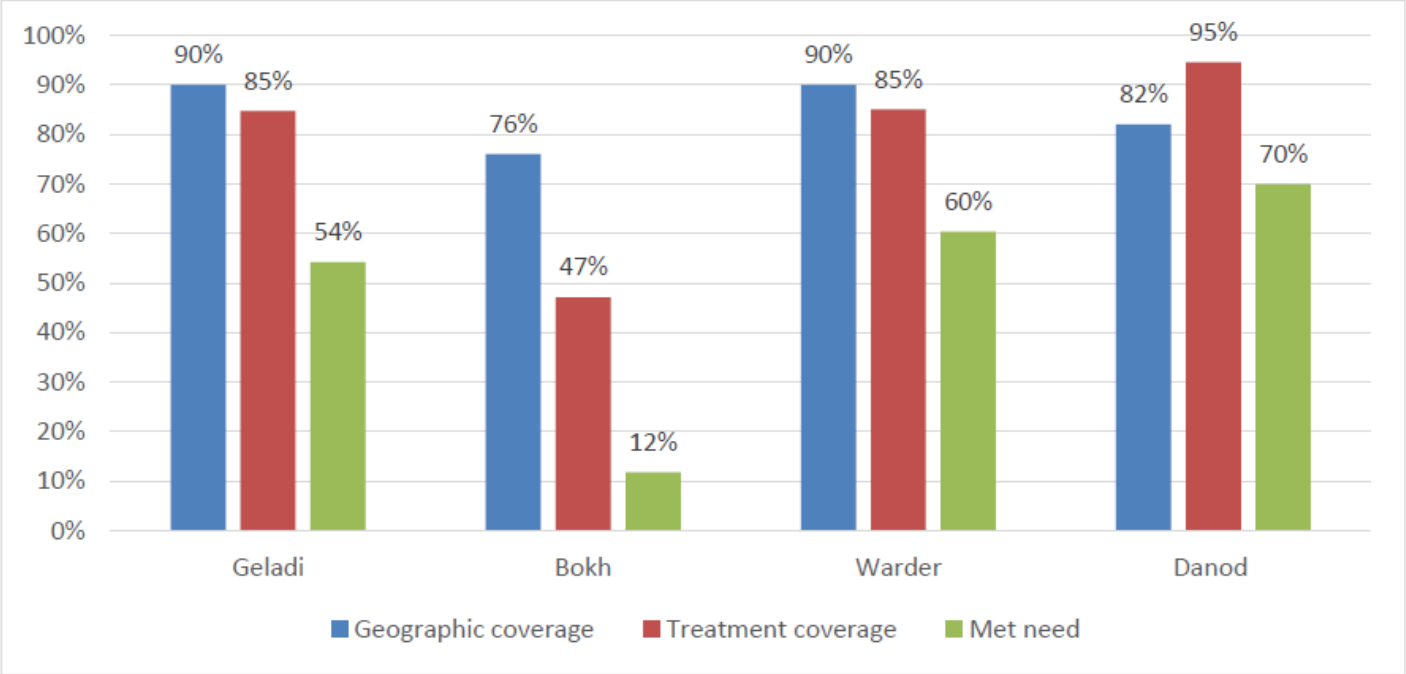

Figure 7

Comparison of geographic coverage, treatment coverage and met need in Doolo zone, Somali region, Ethiopia, 2018.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Dataset.xlsx