

Treatment outcomes of severe acute malnutrition and Predictors of Recovery in Under-Five children treated within Outpatient Therapeutic Program in Ethiopia: A systematic review and meta-analysis

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Abstract

Introduction Severe acute malnutrition affects around 17 million under-five children in the world, of which the highest burden is accounted by Sub-Saharan Africa where Ethiopia is found. Besides few individualized, inconsistent and inconclusive studies, there is no nationally representative study conducted on treatment outcomes of SAM in outpatient therapeutic feeding programs in Ethiopia. This study aimed at estimating the pooled treatment outcomes and predictors of recovery rate among under-five children with SAM in Ethiopia.

Methods Both electronic databases (PubMed, Medline (EBSCOhost), EMBASE (Elsevier), CINAHL (EBSCOhost), web of science, Scopus, Science Direct and Food Science and Technology Abstracts (FSTA)) and grey literature sources (Google scholar, Mednar, World Cat and google) were used to retrieve articles. The random effect model was used to estimate the pooled treatment outcomes. Hazard ratios were used to determine the predictors of recovery rate. Cochran's Q, I², and univariate Meta regression were done for heterogeneity as well as Begg's & Egger's tests for publication bias.

Results Nineteen articles with a total number of 23395 under-five children with SAM were used for this meta-analysis. The pooled recovery, death, defaulter and non-recovery rates were 70% (95% CI: 64.45, 75.72), 1.69% (95% CI: 1.06, 2.31), 9.7% (95%CI: 7, 12.4), 15.14% (95% CI: 10.11, 20.16), respectively. Diarrhea (HR=0.8, 95% CI: 0.75, 0.94), no edema (HR=0.41, 95% CI: 0.33, 0.50) and amoxicillin (HR=1.81, 95% CI: 1.18, 2.44) were independent predictors of recovery rate of children with SAM in Ethiopia. Publication year was found to be the potential source of heterogeneity among the included studies.

Conclusion The treatment outcomes of children with SAM from outpatient therapeutic feeding programs of Ethiopia are lower than the sphere guidelines, WHO and national recommendations. Diarrhea and no edema antagonized the recovery rate of children while amoxicillin enhanced the recovery rate of children from SAM. Community health workers need to be trained. Especial attention should be given while treating children with diarrhea and severe wasting. Community mobilization is also recommended to increase community awareness about the therapeutic foods.

Background

Severe acute malnutrition is defined as very low weight for height/ length (<-3 z score of the median world health organization growth standards or presence of bilateral edema or Mid Upper Arm Circumference < 115 mm for a child ≥ 6 months age (1). The global rate of SAM remains high with an estimated 17 million under-five children were victims of SAM in 2016, of which the majority were from Africa and Asia where Ethiopia is found (2, 3). Of these, around 16.6 million children were affected by severe wasting (4). The unwanted treatment outcomes of SAM also remained high throughout the globe that increases the risk of death by 12 times as compared to the well-nourished children (5). Despite global progress in the number of children treated for SAM (from 1.1 million in 2009 to 4.4 million in 2017), only one in four children receives treatment (4).

Children with SAM get treatment either in the inpatient units or in the outpatient therapeutic feeding programs. Outpatient therapeutic feeding program (OTP) is part community-based management of acute malnutrition (CMAM) for children with uncomplicated severe acute malnutrition (SAM) (6). The program services include diagnosis and provision of ready-to use therapeutic foods (RUTF) every week for 2 months; supplementation of medications like amoxicillin, folic acid, vitamin-A, measles vaccine and deworming (7).

Prior to the implementation OTP in Ethiopia, children with SAM were treated in the inpatient units though it had many limitations (8, 9). Limited coverage and impact, costliness, cross infections, and high rate of mortality rate were some of the challenges contributing to inefficacy of inpatient management of SAM (10, 11). Due to those shortcomings, OTP was endorsed as a health care system since 2005 (12) to treat children with uncomplicated SAM though the pilot was started in 2000 (13). This is because early detection and OTP management is the cornerstone in the modern management of SAM that can limit the number of children in need of inpatient care (14). Community based management can also help for early detection of children with SAM which could enhance early recovery (15). In addition, treating SAM children in OTP centers could minimize the costs spent in the institution based inpatient based programs (16, 17).

In spite of the fact that OTP has been implemented in Ethiopia from the inception till now, under-five children with SAM are not recovering as expected. This is substantiated by the original studies conducted in different regions of the country with the recovery rates ranging from 32.7% (18) to 92.7% (19). The recovery rates in most of the original studies (12, 18, 20–28) is below the sphere standard (29). The death rates also remain significantly high in some OTP centers of the country reaching as high as fourteen percent (25). Moreover, a remarkable variation is seen in the defaulting rates and non-recovery rates. The defaulting rate ranged from 1.67% (23) to 25.2% (12) and the non-recovery rate ranged from two percent (20) to 61.13% (18). These inconsistent and inconclusive findings implied as there are unfinished tasks in the management process of SAM in Ethiopia. These inconsistencies could be attributed by multiple challenges during the implementation process of OTP. The common challenges that made the country not on the course of meeting the goals include; food sharing, trading of RUTFs as commodity, high cost of standard RUTFs, stigma associated with RUTFs use, lack of antibiotics, inappropriate exit from the program, and disliking the taste of RUTFs (7, 30). In-addition, the determinants of treatment outcomes, particularly the predictors of recovery rate is not addressed comprehensively. Few studies (21, 24–26, 31–35) revealed as edema, diarrhea, deworming, giving antibiotics, vitamin A supplementation, and distance from OTP centers and age as the predictors of recovery of under-five children with SAM in OTPs of Ethiopia.

Therefore, the main purpose of this systematic review and meta-analysis is determining treatment outcomes and predictors of recovery rate among under-five children with SAM in the outpatient therapeutic feeding program in Ethiopia. The findings could help policy makers, stakeholders, and

community health workers for the appropriate management of SAM at the OTPs.

Methods

Searching strategies

In this systematic review and meta-analysis, the preferred reporting items for systematic review and meta-analysis (PRISMA) (36) was followed in the write up process of the whole document. All possible studies were retrieved comprehensively from the reputable databases (PubMed, Medline (EBSCOhost), EMBASE (Elsevier), CINAHL (EBSCOhost), web of science, Scopus, Science Direct and Food Science and Technology Abstracts (FSTA)) and grey literature sources (Google scholar, Mednar, World Cat and google). The reference lists of included studies were also checked and searched accordingly. Two author (ZWB & TW) searched studies independently using the key terms: (a) population (infants, Toddlers, preschoolers, under-five children); (b) exposure (severe acute malnutrition, SAM, severe malnutrition, protein energy malnutrition, PEM, uncomplicated severe acute malnutrition) (c) outcome (recovery, survival, cure rate, death, non-recovery, non-responder, transfers); (d) study design (cohort, cross-sectional, prevalence, epidemiology, observational); (e) study setting (outpatient treatment program, OTP, community based management of acute malnutrition, CMAM, health posts, health centers) and (f) location (Ethiopia, regions of Ethiopia, parts of Ethiopia). The Boolean search operators as "OR", "AND", "AND/OR" were used during the searching process. The appropriateness of key terms was corroborated before the actual search was conducted. Literature searches were limited to articles conducted in English language. EndNote X8 reference manager was used to manage the literatures. In this systematic review and meta-analysis, studies conducted from 2007 to January 20, 2020 were included.

Eligibility criteria

Inclusion Criteria

The two investigators (ZWB & AA) independently assessed the contents of each of the included studies and articles which met the upcoming criteria are included in the final analysis.

Population

Studies, which were done among under-five children, were included.

Study setting

The studies conducted in areas where OTPs are implemented (health posts, health centers) were considered.

Study area

The studies conducted in Ethiopia were included.

Study design

The original articles which were conducted both in cross-sectional and cohort study designs measuring the treatment outcomes and associated factors were considered for this systematic review and meta-analysis.

Language

Only studies conducted in the English language were considered.

Publication condition

Studies fulfilling the pre-setted criteria, including published or unpublished studies were included.

Exclusion Criteria

The two authors (ZWB & AA) did data extraction blindly and independently after reviewing the abstracts and full texts of the included. In addition, the methodological quality of the included studies was assessed by the three authors (ZWB, AA, & TW) independently. We excluded studies that were difficult to access the full text following failing to communicate the corresponding authors.

Data abstraction and critical appraisal of the studies

Structured checklist and pre-tested data extraction checklist was employed to extract the data by the two authors (ZWB & AA). The included terms in the extraction checklist were; the name the first author & publication year, study region, study design, study period, study setting, age of study subjects, sample size, treatment outcomes (recovery, death, defaulting, non-recovery, unknown), median recovery days, average weight gain, and predictors of recovery. The third author (TW) actively involved in resolving disagreements arose between the two authors. The qualities of included studies were assessed using the Joana Briggs Institute checklists of cross-sectional and cohort studies (37). The two authors (ZWB & AA), did critical appraisal of the included studies independently and blindly. The tools have Yes/No questions and 1 was given for Yes and 0 for No. The scores were summed up and changed to percentages. Studies with > 50% were included in the meta-analysis (See additional file 3). The mean scores of the two

reviewers were used for final decision of inclusion of the studies in this systematic review and meta-analysis. During critical appraisal, the third author (TW) played a crucial role in solving the discrepancies arose between the two authors. The asymmetry of the funnel plot and/or statistical significance of Egger's regression test ($p < 0.05$) (38) were considered as presence publication bias.

Operationalization of the outcomes

The primary outcome of this study is the recovery rate of under-five children from severe acute malnutrition who were treated from OTP centers of Ethiopia. It was computed by dividing the number of children recovered to the total sample then multiplying it by 100. The second outcome was the predictors of recovery using the hazard ratios from the included studies. The other outcomes were death rate, defaulter rate, non-recovery rate and all were calculated in the same fashion recovery rate was calculated. The binomial distribution formula was used to compute the standard errors for each original study. In the current review, children who didn't respond to the therapeutic food, those who were referred to the inpatient units due to medical complication and those transferred out before the discharge date were considered as non-recovered cases.

Data analysis and assessment of certainty in the findings

The data has been extracted using the extraction format prepared in Microsoft excel 2016 (Table 1). The data were imported into STATA Version 15 (STATA Corporation, College Station Texas) software for analysis of the pooled estimates of recovery rates, death rates, defaulter rates, non-recovery rates and predictors of recovery rate of under-five children with SAM in Ethiopia. The meta-analyses results were presented using forest plot and summery tables. The pooled estimates of outcomes and predictors were analyzed with 95% CI. Heterogeneity among studies was explored by using forest plot and I^2 test and Cochran Q statistics (39). The I^2 values of 25%, 50% and 75% were interpreted as low, medium and high heterogeneity, respectively. For this review $I^2 \geq 50\%$ and a P value of < 0.05 heterogeneity was declared and justified. The statistical tests pinpointed that there was heterogeneity (40) among the studies ($I^2 = 98.7\%$, $P = 0.000$). To reduce heterogeneity, sensitivity analysis were done, in addition random effect and fixed effect models were used interchangeably in the analyses. Since there was no a significant difference were observed, a random effects model was used to estimate the Der Simonian and Laird's pooled effect of recovery rate (41, 42).

Table 1

Summary of 19 included studies on treatment outcomes of SAM among under-five children admitted to outpatient therapeutic feeding programs in Ethiopia.

Author, Publication year	Study region	Study design	Study period	Study setting	Age (months)	Sample size	Recovery rate N (%)	Death rate N (%)	Defaulter rate N (%)	Non-recovery N (%)	Quality Scores*
Degebas, 2017 (1)	Tigray	Cohort	2011–2015	HC	6–59	2009	1406 (70)	1 (0.06)	74 (3.66)	40 (1.99)	7
Mamo, 2019 (2)	Amhara	Cohort	2017	HC	6–59	389	254 (65.3)	-	17 (4.37)	41 (10.54)	10
Boltena, 2008 (3)	SNNP	Cross sectional	2008	HC	< 59	355	329 (92.7)	11 (3)	7 (2)	8 (2.3)	6
Kabalo, 2017 (4)	SNNP	Cross sectional	2014	HP	6–59	776	504 (64.9)	9 (1.2)	17 (2.2)	246 (31.7)	8
Yabyo, 2013 (5)	Tigray	Cohort	2008–2012	HC & HP	6–59	628	388 (61.78)	87(13.85)	19 (3.02)	56 (8.91)	10
Kabalo,2018 (6)	SNNP	Cohort	2014–2015	HP	0–59	582	396 (68)	6 (1.57)	10 (1.72)	170 (29.2)	9
Kabalo,2016 (7)	SNNP	Cross sectional	2015	HP	< 59	600	396 (66)	4 (0.7)	10 (1.7)	-	8
Shanka, 2015 (8)	SNNP	Cohort	2011–2013	HC & HP	< 59	711	522 (67.7)	13 (1.8)	175 (24.6)	13 (1.83)	10
Atnafe, 2019 (9)	Dre Dawa	Cohort	2013–2016	HC & HP	6–59	713	569 (79.8)	4 (0.6)	80 (11.2)	42 (5.9)	10
Mengesha,2016 (10)	SNNP	Cohort	2008–2009	HP	6–59	348	274 (78.7)	-	-	74 (21.3)	9
Teshome,2019 (11)	SNNP	Cohort	2015	HP	6–59	216	172 (79.6)	-	8 (3.7)	36 (16.7)	9
Liben, 2019 (12)	Afar	Cohort	2017	HC & HP	6–59	286	238 (83.2)	8 (2.8)	18 (6.3)	22 (7.7)	10
Tadesse, 2018 (13)	SNNP	Cohort	2011	HP	6–59	759	248 (32.7)	17 (2.2)	18 (2.4)	464 (61.1)	6
Beletew, 2019 (14)	Amhara	Cohort	2016–2019	HP	0–59	600	390 (65)	12 (2)	96 (16)	102 (17)	8
Yorra, 2016 (15)	SNNP	Cohort	2013–2015	HC & HP	6–59	602	414 (68.8)	8 (1.3)	145 (24.1)	21 (3.5)	7
Massa, 2016 (16)	Tigray	Cohort	2012	HC & HP	6–59	332	255 (76.8)	2 (0.6)	58 (17.5)	17 (5.1)	10
Mokgatle,2015 (17)	Oromia	Cross sectional	2010	HP	6–59	163	114 (69.9)	-	36 (22.1)	-	6
Teferi,2009 (18)	SNNP	Cohort	2003–2005	HC & HP	0–59	12316	9871(80)	217 (2.5)	-	-	8
Belachew, 2007 (19)	AA, SNNP & Oromia	Cross sectional	2006	HC	< 59	1010	554 (55)	4 (0.4)	255 (25.2)	197 (19.5)	6

AA, Addis Ababa; SNNP, Southern Nations,Nationalities and Peoples; HC, Health Center; HP, Health Posts; *, The quality scores for cohort studies were computed out of 11 indicators while for cross sectional studies from 8 indicators.

To identify the possible sources of heterogeneity, meta-regression analysis was done using the sample size and publication year as the possible source of variability. However, sample size was found to be statistically insignificant ($P = 0.064$) and publication year was found to be the possible source of variation ($P < 0.001$) (Table 2). Funnel plot was drawn using recovery rate and standard error of recovery rate it revealed as there is a publication bias (Fig. 3). The possible source of publication bias was also objectively examined using Egger's weighted correlation and Begg's regression tests (43). The result showed that as there is publication bias ($P = 0.036$) in the Egger test and Begg's test was found to be insignificant ($P = 0.944$). Hence, the pooled estimate of recovery rate was determined using Duval and Tweedie's Trim and Fill analysis in the Random-effects model. In addition, subgroup analysis was done using the study region and study year. This is done to minimize the random variations between the point estimates of the included studies.

Table 2
Factors associated with heterogeneity of
recovery rate of children with SAM in
Ethiopia (univariate meta-regression)

Variables	Coefficient	P-value
Publication Year	2015.4	< 0.001
Sample Size	1231	0.064

Results

Selection of eligible studies

In the first search, 694 studies were found from both electronic databases and grey literature sources. Of the total studies, 150 of them were duplicated files while 455 of them were removed after screening based on titles and abstracts. The full texts of 89 articles were reviewed. Finally, 19 articles (12, 18-28, 31-35, 44, 45) which fulfilled the inclusion criteria were included in the final analysis of this systematic review and meta-analysis (Figure 1).

Study characteristics of the original studies

The details of all the included studies are clearly summarized in table 1. Both cohort (18, 20, 21, 24-27, 31-35, 44, 45) and cross-sectional (12, 19, 22, 23, 28) studies were included in this review. Coming to the regional distribution of studies, most of the studies were done in Southern Nations, Nationalities and Peoples regions of Ethiopia (SNNP) (18, 19, 22-24, 26, 32, 33, 44, 45). While, three were from Tigray region (20, 25, 35) and two of them were conducted in Amhara region (21, 27). The others were done DireDawa Administration (31), Afar region (34) and Oromia region (28). One study was conducted from patient records in Addis Ababa, SNNP and Oromia (12). The studies were done with review of documents from health centers and health posts and the sample sizes ranged from 163 in Oromia region (28) to 12316 in SNNP (44). The maximum recovery rate (92.7%) was recorded in SNNP while the minimum one (55%) was from the study done in Oromia region, Addis Ababa and SNNP (12). In this systematic review and meta-analysis, a total of 23395 under-five children with SAM who were treated in OTPs of different regions of Ethiopia were included. The included studies were conducted from 2007 to 2019. Regarding the quality scores of the included studies, eleven of them were classified under high quality, whereas, seven and one of them were classified under medium and low qualities, respectively.

Treatment outcomes of children with SAM in Ethiopia

A total of 19 studies (12, 18-28, 31-35, 44, 45) were used to compute the pooled estimate of recovery rate of under-five children with SAM who were treated in the OTPs of Ethiopia. The recovery rate was found to be 70% (95% CI: 64.45, 75.72, $I^2=98.7\%$ & $P=0.000$) (Figure 2). The I^2 statistic shows significant heterogeneity among the included studies. Due to this, the possible sources were checked using univariate meta-regression analysis by using publication year and sample size (Table 2). Sample size was found to be insignificantly associated ($P=0.064$) and publication year was found to be the possible source of variation ($P<0.001$). Publication bias was checked using funnel plots which showed the possibility of bias (Figure 3). The publication bias was confirmed by objective measures using Begg's and Egger's test. The Egger's test revealed the presence of significant publication bias ($P=0.036$), while Begg's test was found to be insignificant ($P=0.944$). Therefore, Trim and Fill analysis was done to adjust the final pooled recovery rate of children with SAM who were treated in OTPs of Ethiopia.

The other treatment outcomes of interests were death rate, defaulter rate, and non-recovery rates based on the random effect model due to the presence of significant heterogeneity. In this review, 15 studies (12, 18-20, 22-27, 31, 34, 35, 44, 45) were used to compute the pooled estimate of the death rate. The minimum (0.05%) (20) and the maximum (13.85%) (25) death rates were reported from the studies conducted in Tigray region. In the meta-analysis, the pooled death rate was found to be 1.69% (95% CI: 1.06, 2.31, $I^2=95.7\%$, $P=0.000$) (Figure 4).

To compute the pooled estimates of defaulter rate of SAM children from OTPs of Ethiopia, 17 studies (12, 18-28, 31, 33-35, 45) were used. The minimum defaulting rate (1.67%) was reported from the study conducted in SNNP (23) and the maximum one (25.2%) was from the study done in 2007 (12). In our study, the defaulter rate was 9.7% (95%CI: 7, 12.4, $I^2=98\%$, $P=0.000$) (Figure 5).

In this systematic review and meta-analysis, the pooled estimate of non-recovery rate was computed from 16 studies (12, 18-22, 24-27, 31-35, 45). From the included studies, the study conducted at the SNNP revealed as the majority (61.13%) of children were non-recovered cases and the lowest (1.83%) non-recovery rate was reported from the study done in the other part of SNNP of the country. In this analysis the on-recovery rate was 15.14% (95% CI: 10.11, 20.16, $I^2=99.2$, $P=0.000$) (Figure 6).

Subgroup Analysis

As it is depicted in **table 3**, subgroup analysis was done using publication year, study region and study settings. This is done to explore the possible sources of heterogeneity of the included studies. Accordingly, six studies were done from 2007 to 2015 with the recovery rate 72.22% (95% CI: 62.35, 82.10) and the pooled recovery rate was lower in studies conducted after 2015 in Ethiopia (69.1%, 95% CI: 62.05, 76.15). In accordance with the region where the studies were done, the highest recovery rate (72%, 95% CI: 57.39, 86.55) was recorded from regions which were classified as others (Oromia, Afar, Dire Dawa, and (Oromia, Addis Ababa & SNNP)). The second higher recovery rate (70.5%, 95% CI: 61.34, 79.64) was in SNNP which could be due to the large number of studies were from this region. Lower recovery rates were recorded in Amhara and Tigray regions. In addition, the recovery rate was computed based on the study region and children who treated at health posts (65.54%, 95% CI: 54.41, 76.66) had poor recovery rates as compared to those children who were treated in the health centers (70.78%, 95% CI: 55.12, 86.44) (**Table 3**), (**Figure 7**).

Table 3: Subgroup analysis of the recovery rate of under five children with SAM in the outpatient treatment programs of SAM in Ethiopia (n=19)

Variables	Characteristics	Number of studies	Recovery rate (95% CI)
Publication year	≤2015	6	72.22 (62.35, 82.10)
	>2015	13	69.10 (62.05, 76.15)
Study Region	Tigray	3	69.45 (62.45, 76.45)
	Amhara	2	65.12 (62.15, 68.09)
	SNNP	10	70.49 (61.34, 79.64)
	Others	4	71.97 (57.39, 86.55)
Study setting	HC	4	70.78 (55.12, 86.44)
	HP	8	65.54 (54.41, 76.66)
	HC & HP	7	74.89 (69.96, 79.81)

Predictors of recovery rate of SAM children in Ethiopia

In the current review, eight studies (21, 24-26, 31-34) revealed the independent predictors of recovery rate using hazard ratios. The predictors which were reported by the original studies were diarrhea (21, 25, 31, 33), age>24 months (26, 32, 33), no edema (31-33), deworming (21, 24, 25, 31, 34) and giving amoxicillin (21, 25, 34) as part of SAM process. The pooled estimates of hazard ratios revealed that age>24 months (HR=0.98, 95% CI: 0.81, 1.15, $I^2=80.8$, $P=0.006$) and deworming (HR=1.04, 95% CI: 0.79, 1.28, $I^2=43.3$, $P=0.133$) were not significantly associated with recovery rate. However, diarrhea, no edema and Amoxicillin were found to be independent predictors of recovery rate (**Figure 8**). The recovery rate of SAM children with diarrhea 16% less likely compared with those children with no diarrhea (HR=0.8, 95% CI: 0.75, 0.94). Similarly, the presence of no edema was found to be a prohibiting factor that decreased recovery rate by 41% (HR=0.41, 95% CI: 0.33, 0.50). In addition, those children who took amoxicillin were approximately two times more likely to recover from SAM as compared to the counterparts (HR=1.81, 95% CI: 1.18, 2.44).

Discussion

In this systematic review and meta-analysis, the treatment outcomes of under-five children with SAM admitted in outpatient therapeutic feeding programs of Ethiopia are determined. The treatment outcomes were recovery rate, death rate, defaulter rate and non-recovery rate. In addition, the predictors of recovery rate were analyzed using hazard ratios as an effect size estimator.

In the current review the proportion of recovery is found to be 70.8%, which is below the recommended sphere standard, WHO and the national SAM management protocols (recovery rate > 75%) (29, 46). The possible elucidation for the low proportion of recovery could be associated with non-adherence of care givers of children to SAM treatment guidelines. Food sharing, trading of RUTFs as commodity, high cost of standard RUTFs, stigma associated with RUTFs use, lack of antibiotics, inappropriate exit from the program, and disliking the taste of RUTFs could also be the possible rationales for this lower recovery rate (7, 30). This finding is comparable with the result of the systematic review about the recovery rate (70.5%) (47) of under five children in the inpatient therapeutic feeding programs in Ethiopia but lower than another review with the pooled recovery rate of 72.02% (48). This could be due to high comorbidity rates in the inpatient therapeutic feeding programs as compared to the children in the OTPs. This finding is comparable with finding of a study done in Ghana with the recovery rate of 70.9% (346 out of 488) (49), but significantly higher than the findings of the study conducted in Nigeria where only 58% (4492 of 7742) of children get cured from SAM (50). The current recovery rate is also lower than the findings of a retrospective studies conducted in Cameroon and Pakistan where 72.8% (185 of 254) & 89% (28,882 of 32,458) of children get recovered, respectively (51, 52). The discrepancies could be attributed by differences in the number of study population, study design and the sociodemographic characteristics of the study participants as well as variation in the clinical expertise of health care providers.

In the present systematic review and meta-analysis, the pooled estimates of death rate (1.69%), defaulting rate (9.7%) and non-recovery rate (15.14%) were determined. The death rate is in line with the sphere and national standards (29, 46) as well as the study finding from Ghana (1.6%) (49) and Cameroon (0.8%) (52). Nonetheless, the current finding is relatively higher as compared to the finding of a Pakistan study (0.4%) (51), and lower than the death rate reported from Nigeria (2%) (50). The possible explanation for the differences might be due to disparity in the organization of OTP centers, sociodemographic differences in study subjects and difference in the background of care takers of children. Regarding the defaulter rate, this finding coincides with what is recommended by the sphere standard, WHO and national SAM management protocols (i.e. defaulting rate < 15%) (29,

46). But the present result is below the findings of the study results in Pakistan (51), Ghana (49) and Nigeria (50) with defaulting rates of 10.6%, 28.5% and 40%, respectively. All those findings are from the primary studies and this might be the possible reason for the variation. Differences in the therapeutic areas could also account for the discrepancies. This finding is also significantly lower than the original studies done in different parts of Ethiopia (12, 26–28, 35, 45), of which the proportion of defaulting range from 16–25.2%. Moreover, the proportion of non-recovery is considerably high in this meta-analysis. This is higher than most of the original studies included for this meta-analysis, but lower than the non-recovery rate from the study conducted in Cameroon (26, 8%) (52). This significant non-recovery rate could be attributed by high burden of comorbidities, inappropriate feeding process of the RUTFs, non-adherence to follows due to long distance to access RUTFs and drugs in some OTP centers of the country (7, 33–35). Similarly, food insecurity could contribute to sharing food among family members and this may affect recovery rate of children (33).

Regarding the predictors of recovery rate, the presence of diarrhea, no edema and giving amoxicillin are independent predictors of recovery rate of children. The presence of diarrheal diseases as a comorbidity compromises recovery rate of under-five children by 16%. This is due to the fact that diarrhea and SAM has bidirectional relationship. It delays the recovery rate of children with SAM as a result of metabolic disturbances, fluid and electrolyte losses and dehydration. These evidences are supported multiple studies that implied diarrhea as a major determinant affecting the recovery rate of children with SAM (53–56). Similarity, children with non-edematous SAM are found have lower recovery rate as compared to the counterparts edematous children. Those children having edema at admission are 59% more likely to recover within a short duration. This could be substantiated by the likelihood that children with edema might get better care by the health care providers and family members than wasted children (24, 57–59). Moreover, giving amoxicillin for children with SAM as an empirical management is found to enhance survival of children. The likelihood of recovery of children who took amoxicillin is two times compared with children who didn't take it. Severe acute malnutrition affects the whole system and it primarily compromises the immune system of children due to reductive adaption (60). This paves the way for multicausal infections which could delay the time of recovery of children (61). Hence, empirical treatment of infections in the management process of SAM both in the inpatient and outpatient therapeutic feeding programs has a pivotal implication for improving the survival of children (62). Currently, the recommended antibiotic is amoxicillin and this is supported the systematic review and meta-analyses findings which were conducted prior to this systematic review (63, 64).

Strengths and limitations of the study

To our knowledge, this is the first systematic review and meta-analysis is the first of its type in Ethiopia with many strengths. The main strength of this systematic review and meta-analysis was that multiples reputable journals were retrieved comprehensively and exhaustively to retrieve all the original articles. All possible efforts are also made to communicate the primary authors to get articles that were difficult to access the full texts. The data were extracted using standardized and pretested extraction checklist. All possible analyses were done to estimate the pooled treatment outcomes and predictors of recovery rate of children with SAM in OTP centers of Ethiopia. These findings will also help policy makers, stakeholders, nongovernmental organizations and community health workers to modify their approaches in the management process of children in OTPs. Despite these strengths, the current study has some limitations. Only articles that were published in English were included in this meta-analysis, which might affect the true estimates of treatment outcomes. To estimate the pooled predictors, limited number of studies were obtained and this might be the cause for under estimation predictors of recovery rates. In addition, the predictors were calculated using hazard ratios, but some studies reported factors using odds ratios and this could make difficult to control confounders.

Conclusion

This meta-analysis revealed that the proportion of recovery and non-recovery were significantly higher than the sphere standard, WHO and national SAM management protocols. This finding is comparable with the recovery rate form inpatient units of the country which should not be really the case. This finding is alarming for policy makers and program implementers in Ethiopia. The presence of diarrheal disease as comorbidity and being non-edematous at admission were found to be prohibiting factors of time to recovery of children with SAM. In contrary, empirical treatment of children with amoxicillin was found to shorten the duration of recovery from SAM. Policy makers, community health workers, and program planners need to reconsider the community based management approaches of children with SAM.

Abbreviations

CI
confidence interval; CMAM:community based management of acute malnutrition; HR:hazard ratio; OTP:outpatient therapeutic feeding program; RUTF:ready to use therapeutic food; SAM:severe acute malnutrition; SNNP:southern national, nationalities and peoples in Ethiopia; WHO:world health organization

Declarations

Ethics approval and consent to participate

Not applicable for this study.

Consent for publication

Not applicable.

Availability of data and material

All-important data for this study are included in the manuscript. If in need of additional data, they are available and can be accessed from the corresponding author.

Competing interests

The authors have declared no conflicts of interest in this work.

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Authors' Contribution

ZBW, TW and AA conceived and designed the review. ZWB prepared the draft of the manuscript. The final version of the manuscript is approved by all the three authors.

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Figures

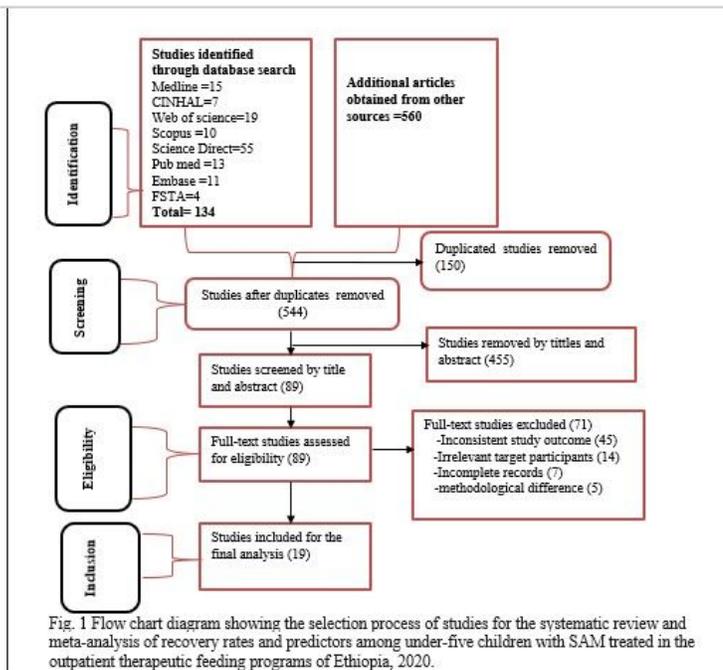


Figure 1

Flow chart

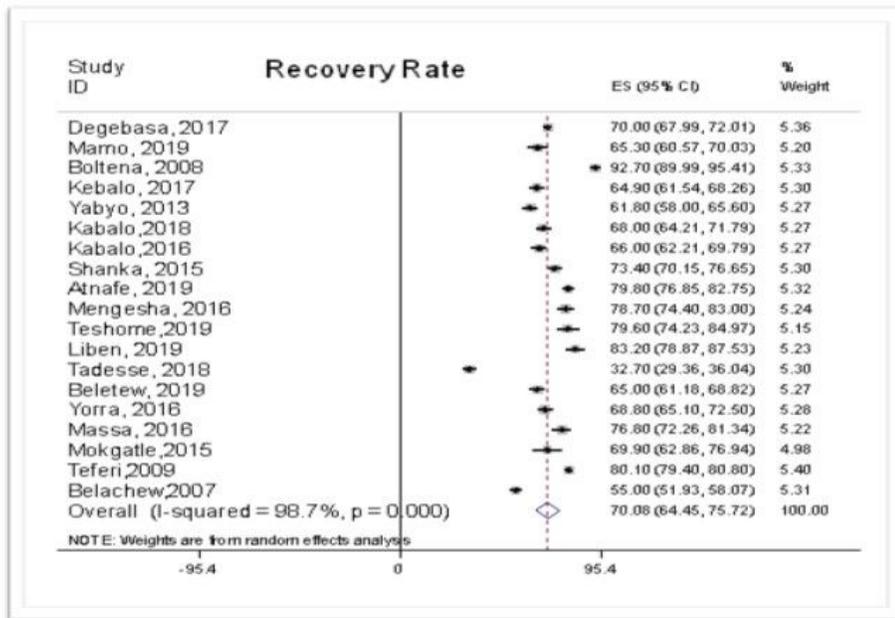


Figure 2

forest plot showing the recovery rate of children with SAM treated in OTPs of Ethiopia, 2020.

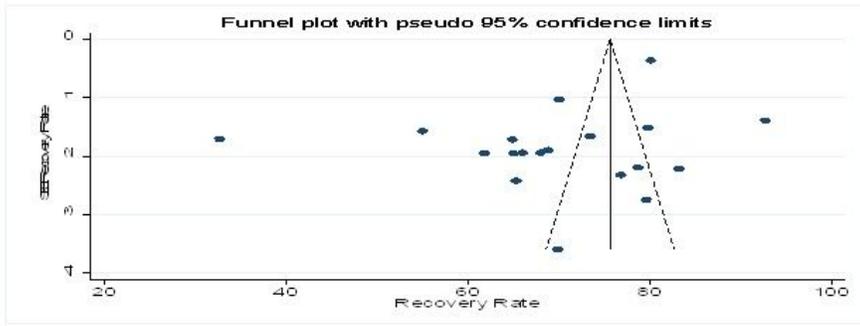


Figure 3

Funnel plot showing the possible source's bias of recovery rate of children from SAM in OTPs in Ethiopia, 2020.

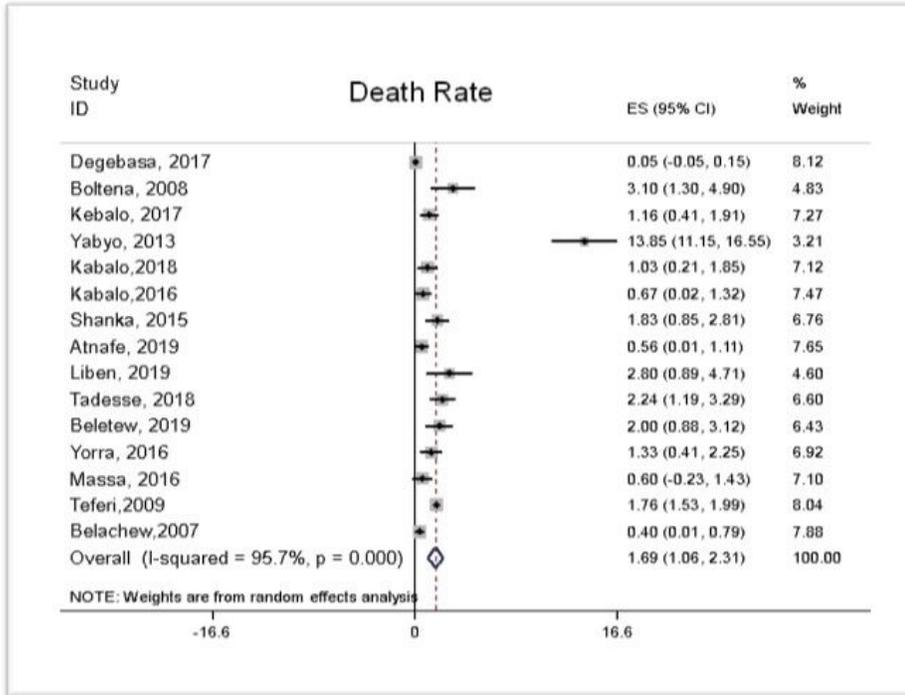


Figure 4

Forest plot showing the death rate of children with SAM treated in OTPs of Ethiopia

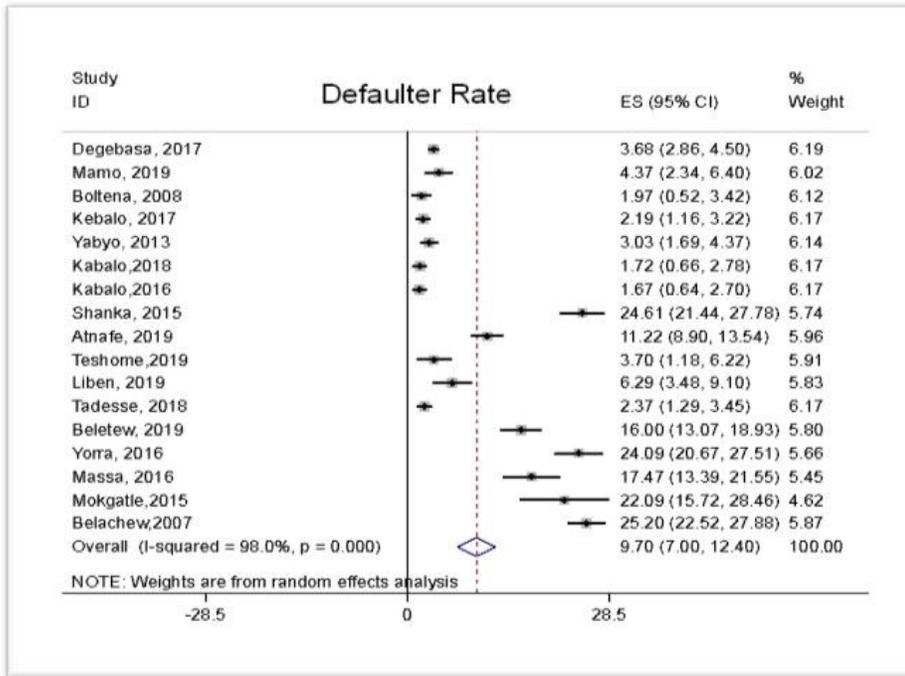


Figure 5

Forest plot showing the defaulter rate of children with SAM treated in OTPs of Ethiopia

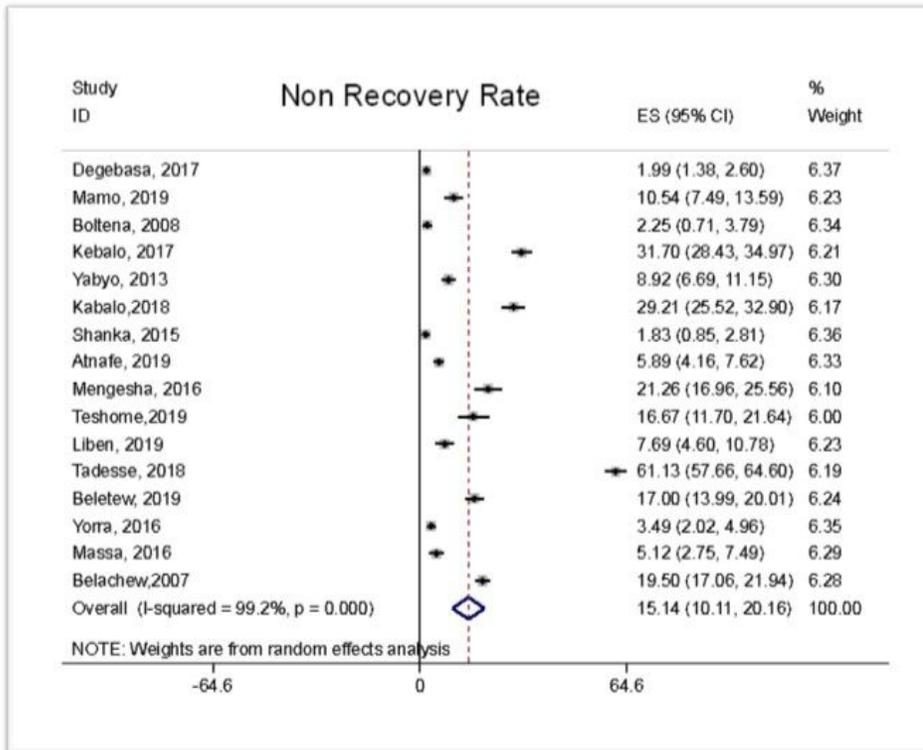


Figure 6

Forest plot showing the non-recovery rate of children with SAM treated in OTPs of Ethiopia.

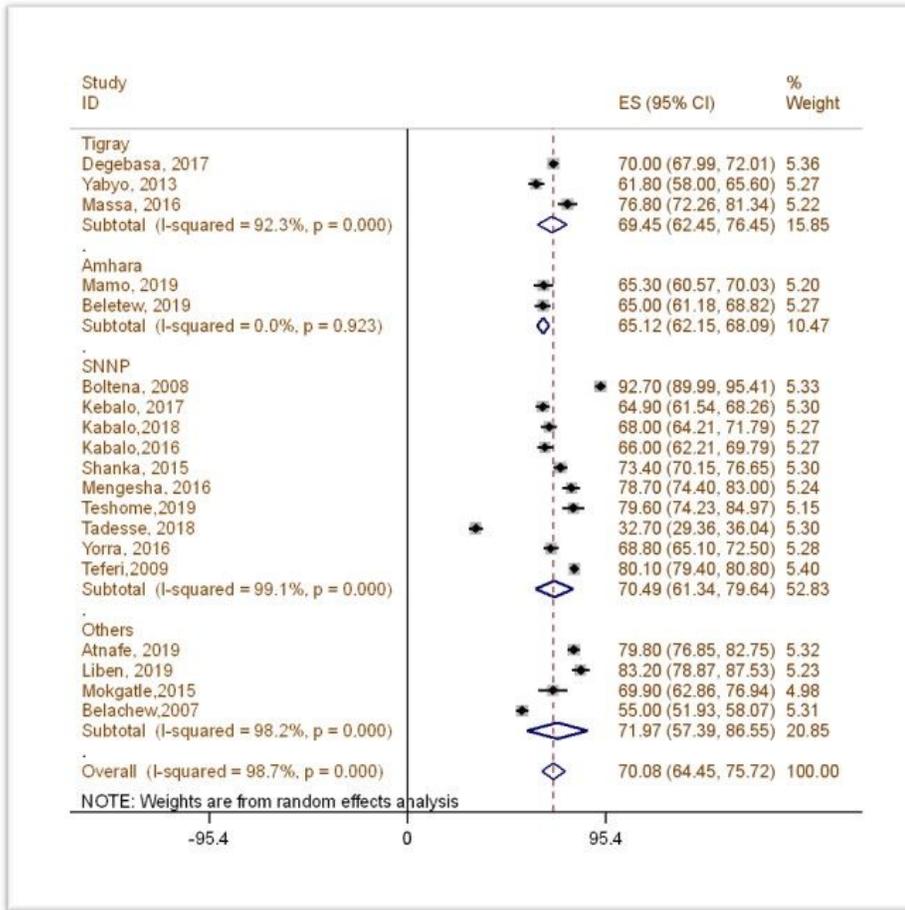


Figure 7

Forest plot showing subgroup analysis of recovery rate based on study region.

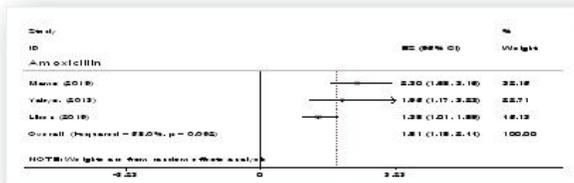
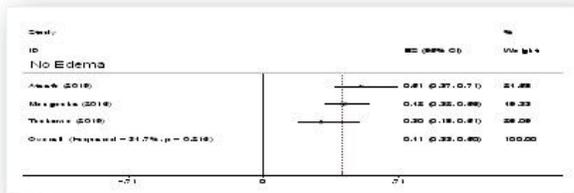
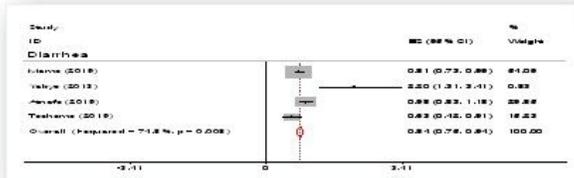


Figure 8

Forest plot showing predictors of recovery rate among under five children with SAM in Ethiopia.

Supplementary Files

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