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Review Article

Magnitude and determinants of complementary feeding practices in Ethiopia: A systematic review and meta-analysis

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ABSTRACT

Background & aim: Concurrent estimates on the magnitude and evidence on the determinants of complementary feeding (CF) practices in Ethiopia are currently disparate. Hence, this systematic review and meta-analysis assessed the magnitude and determinants of CF among children age 6–23 months in Ethiopia.
Methods: Studies from various databases published until July 2018 were identified, selected, extracted and assessed for risk of bias by two authors independently. A random-effects model was used to pool the prevalence and odds ratios (ORs).
Results: 26 studies with 17, 383 children were included. The pooled prevalence estimate of timely initiated CF, minimum dietary diversity (DD), minimum meal frequency and minimum acceptable diet were 61.0%, 18.0%, 56.0%, and 10.0% respectively. The pooled prevalence of timely initiation and minimum DD were higher in Northern Ethiopia. On the other hand, except for the minimum meal frequency, all the three core indicators of CF were better in urban than rural settings. Child age, maternal and/or paternal education, paternal involvement, maternal DD, antenatal and postnatal care, and place of delivery were the main determinants that can increase appropriate CF practices.
Conclusion: The reported estimates of the prevalence of core CF indicators in Ethiopia remained poor. Therefore, the authors would like to acknowledge the effort that has been done by the minister of health and its partners including Alive & Thrive to improving CF practices in the country, however, these programs should be done more thoroughly, and scaled up by applying and adapting tested, proven approaches and tools in contexts.

1. Introduction

Complementary feeding (CF) is the process that started when breast milk alone insufficient to meet the nutritional requirements of infants and so that other foods and liquids are required alongside with breast milk (WHO, 2003). It also is known as weaning and it should begin by the age of 6 months or 26 weeks but not begin before 17 weeks. Mother breast milk feeding should continue during the CF period with amounts gradually decreased as the variety of foods increases (Kathy, 2010).

The period of transition from exclusive breast milk feeding to consuming a variety of foods along with breast milk is known as the period of CF, usually from six months to 24 months of age (Dewey and Brown, 2003; Michaelsen, 2000). The first two years after birth is the important window of opportunity for avoiding under-nutrition and its long-term adverse consequences. Therefore, ensuring appropriate nutrition during the period of CF is the main priority of global health (Dewey, 2013).

Appropriate CF is the main factor to ensure healthy growth and survival of young children in their early years of life. It has the potential to prevent 6% of all under-five mortality, mainly in developing countries (Lutter, 2003). Although appropriate complementary feeding has important benefits, it was rarely practiced in many low- and middle-income countries and these contribute to child growth retardation and under-nutrition, morbidity and mortality (Victoria, 2000). In Ethiopia, according to the recent demographic and health survey report, the estimated infant mortality was 48 per 1,000 live births, while the overall under-5 mortality rate was 67 deaths per 1,000 live births (CSA,

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2016). The data also shows that 38%, 24% and 10% of children under 5 are stunted, underweight and wasted, respectively.

The World Health Organization (WHO) recommends an introduction of complementary foods when an infant reaches 6 months of age, minimum dietary diversity (intake of foods that are at least 4 or more varieties from the seven standard food groups for children aged 6–23 months), minimum meal frequency (provision of a minimum of two or three meals with one to two snacks and three or four meals with one to two snacks per day, respectively for breastfed infants of age 6–8 and 9–23 months, and provision of milk products at least twice a day for non-breastfed infants of age 6–23 months), and minimum meal frequency (breastfed children 6–23 months of age who had at least the minimum dietary diversity and the minimum meal frequency, and non-breastfed children 6–23 months of age who received at least two milk feedings and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency during the previous day) (WHO., 2008).

According to the Ethiopian Demographic Health Survey report of 2016 (CSA, 2016), 7% of children aged 6–23 months was achieved a minimum acceptable diet (either four or more food groups and minimum meal frequency). Moreover, 8.7 % of the minimum acceptable diet reported in the study from the Welayta zone (Epheson et al., 2018). It also reported that 8.5% and 47.0% of infants and young children aged 6–23 months fed appropriate complementary foods and fed with the minimum meal frequency respectively (Epheson et al., 2018). A study from the southern part of Ethiopia showed that 67.3%, 18.8%, and 9.5% of children aged 6–23 months received minimum meal frequency, fed minimum DD and practice of appropriate CF respectively (Kassa et al., 2016b).

Previous studies on CF practices revealed that younger mother, unemployment, lower maternal education level (Sika-Bright, 2010; Joshi et al., 2012; Kabir et al., 2012; Senarath et al., 2012b; Victor et al., 2014), and few antenatal care visits (Senarath et al., 2012a, 2012b; Patel et al., 2012; Abera, 2012) were identified as factors associated with CF practices.

Moreover, no postnatal care visits (Senarath et al., 2012a, 2012b; Abera, 2012; Victor et al., 2014), young infant age (Kabir et al., 2012; Patel et al., 2012; Senarath et al., 2012b; Abera, 2012; Victor et al., 2014), poor household wealth status (Kabir et al., 2012; Patel et al., 2012; Senarath et al., 2012b; Abera, 2012; Victor et al., 2014), place of delivery (Rao et al., 2011) and insufficient maternal exposure to mass media (television, radio, or newspapers) (Joshi et al., 2012; Patel et al., 2012; Abera, 2012; Senarath et al., 2012a; Victor et al., 2014) were the factors associated with inappropriate complementary feeding practices the in developing countries.

Older age of mothers (>35 years), educated mothers, and educated fathers were associated with the recommended dietary diversity. Mothers who had attended four or more ANC visits were more likely to feed their child with the recommended meal frequency (Khanal et al., 2013). Attending ≥4 antenatal visits, as well as mother and father who had secondary education were associated with recommended acceptable diet standards (Khanal et al., 2013). A numerous number of studies conducted on the magnitude of complementary feeding in Ethiopia although the results were inconsistent. Moreover, existing literature on the determinants of complementary feeding practices is currently disparate. Thus, we carried out this systematic review and meta-analysis to elucidate the magnitude and determinants of CF among children aged 6–23 months in Ethiopia.

2. Methods

A prespecified protocol (Participants, Interventions, Comparisons, Outcomes and Time (PICOT)) was used to conduct this systematic review. This review evaluated the available evidence on the magnitude and determinants of complementary feeding practices among Ethiopian children, 6–23 months of age. The statement of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) has been used for reporting this study (Moher et al., 2009).

2.1. Search strategy

A comprehensive literature search was performed on electronic databases on 29 March 2017 and updated on 8 July 2018. The databases searched were PubMed, Web of Sciences, Scopus, EMBASE and Grey literature databases. Google search was also done on the bibliographies of retrieved articles. Search terms such as 'infant feeding', 'infant nutrition', 'young child feeding', 'complementary feeding', 'determinants', 'risk factors', 'prevalence', 'magnitude', and 'Ethiopia' were included. Restrictions were not used on sample size, study design, language and exposure or outcome measurement method (Supplemental Table 1A).

2.2. Identification and selection of studies

Those studies done on Ethiopian children (6–23 months), which assessed the determinants of complementary feeding practices and their magnitude were included. On the contrary, animal studies, reviews articles, case reports, letters, conference abstracts, abstracts with no detailed information and studies on mothers or infants with medical problems were excluded.

2.3. Data collection and synthesis

Two authors retrieved potentially relevant full-text articles independently and conducted screening by title and abstract. They have also done article reassessment for eligibility during the full-text review in accordance with the listed criteria. Moreover, a bibliographic search of the downloaded full-text documents was done. In addition, the two authors have done quality and contents appraisal of the included studies independently. The level of agreement of the reviewers during the selection was measured using kappa statistic.

2.4. Data extraction

A standard data acquisition form was utilized to extract the data based on: author's name, the year the study published, country, study design, population. In addition, the study population's characteristics like the sex and age of the participants, sample size, data collection tool, prevalence of core CF indicators, determinants, adjusted ORs, 95% confidence interval, covariance and outcome variable (timely initiation of CF, minimum dietary diversity score, minimum meal frequency score, minimum acceptable score) were extracted. In cases of multiple publications of the same data, the data of the newest article was extracted.

2.5. Study quality assessment

The modified Newcastle-Ottawa Scale (NOS) for cross-sectional study design (GA Wells et al., 2000; Herzog et al., 2013) was used to check the quality and strength of the studies included. The parameters assessed include sampling strategy, inclusion/exclusion criteria, sample size, cut-offs and reference for the assessment of household food insecurity, criteria to identify diabetes and covariates included in statistical models. The scoring format used contain 11 criteria for ranking the eligible studies out of 12 based on quality elements (Supplementary materials Table 3). As it's customary in meta-analysis the authors suggested scale weights for scoring each element assessed in the quality study. Based on the result of the assessment the studies were categorized into three quality subgroups. The first category comprises those studies with a 9-12-point score and is labelled A, the second group being 5–8 points is labelled B while the third group contains studies with a score point of less than 5 and named C. The studies in the first category, referred to as 'A', were considered high-quality studies with less risk of bias and thus used to perform the sensitivity analyses.

2.6. Statistical analyses

In order to accommodate the variations in study design, study population and setting of the study pooled ORs with its corresponding 95% confidence interval were estimated using a DerSimonian and Laird random-effects model, where the study weight is inversely proportional to the study variance (DerSimonian and Laird, 1986). The heterogeneity between studies was assessed via $\chi 2$ test, in order to obtain the Q statistics and its p-value, and the Higgins' test to get the I^2. In the present study, the I^2 statistics range from 0 to 100% as described (Higgins and Thompson, 2002). A large I^2 indicates that the total variation between studies is mainly because of true heterogeneity rather than chance. In this study analysis, where $p \leq 0.1$ or $I^2 \geq 50\%$ was observed, subgroup analyses were conducted. The source of heterogeneity was assessed using subgroup analyses and to examine the robustness of the pooled effect estimate, where subgroup analyses were defined based on geographical regions of study and residence (urban vs. rural). The sensitivity analysis was done after excluding the poor- and low-quality studies were useful in determining the effect of deviant studies on the overall result. This was performed as it is classified in the quality of the study (based on NOS quality assessment). To identify publication bias funnel plot, Begg's test and Egger's test were conducted (Egger et al., 2008). All Statistical analyses were conducted using STATA (Stata Corporation, Version 12.0, and College Station, Texas, USA).

This systematic review was registered at PROSPERO, International prospective register of systematic review with registration number PROSPERO CRD42017060813 (http://www.crd.york.ac.uk/PROSPERO/register_new_review.asp).

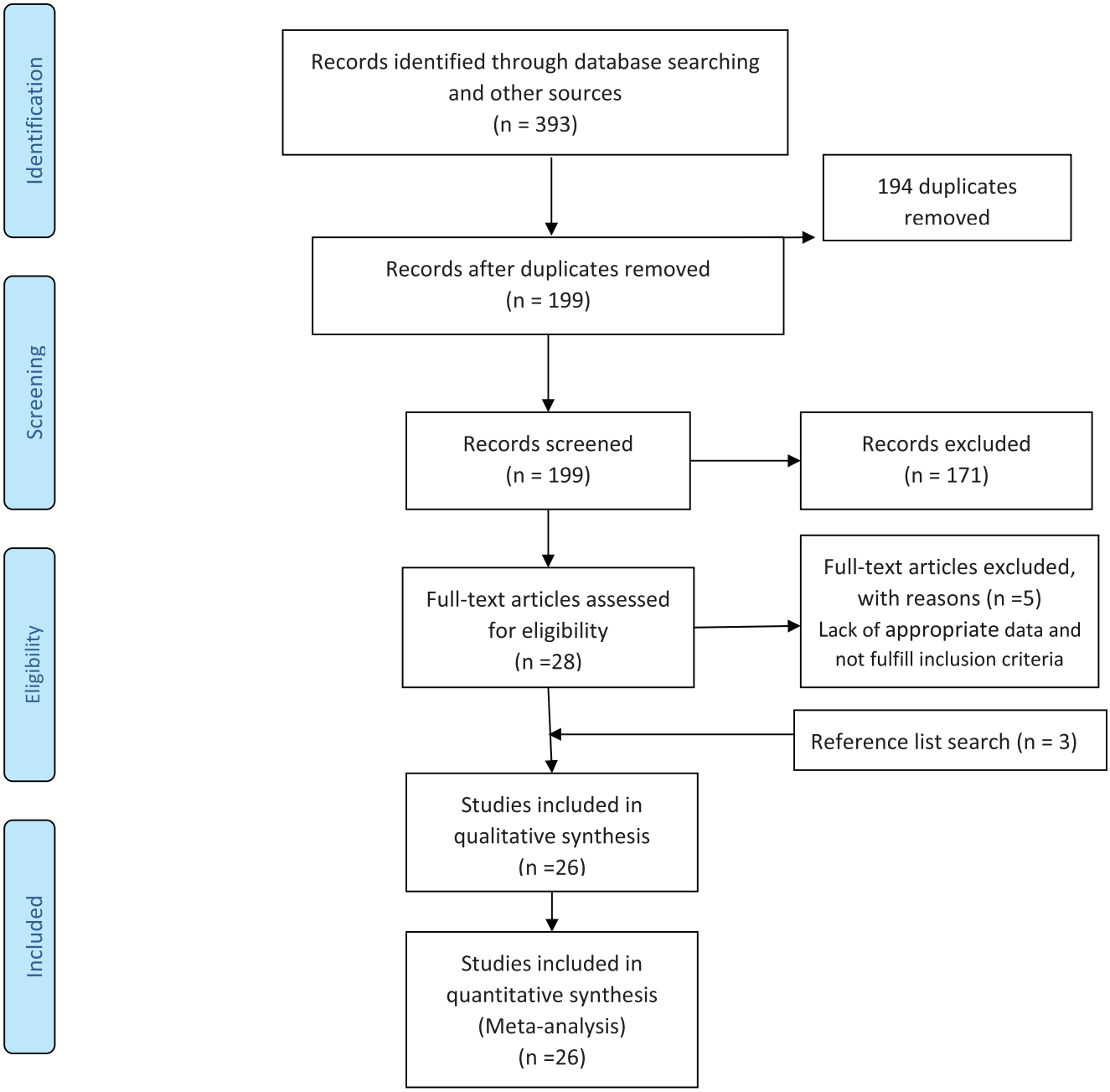

Fig. 1. PRISMA flow diagram through the different phases of the systematic review and meta-analysis.

3. Results

3.1. Study selection and data extraction

The initial search was undertaken on 29 March 2017 and was updated subsequently on 08 July 2018. The searches identified 393 potentially relevant citations (320 in the original search, and 73 in the updated search). From the total of 393 downloaded items, 194 were duplicates and consequently, authors reviewed the remaining 199 articles by title and abstract. Based on the criteria 171 articles were excluded and the full text of the rest 28 articles were examined. 5 articles were removed after examination of the full text. Moreover, 3 more articles were included after bibliographic search and screening among the reference of the relevant reviews. There was close agreement between reviewers on the included studies (kappa score of 0.81). Therefore, we included 26 articles, 25 cross-sectional studies (Shumey et al., 2013; Sisay et al., 2016; Nguyen et al., 2013; Regassa, 2014; Semahegn et al., 2014a, 2014b; Gebremedhin et al., 2017; Kassa et al., 2016a; Moges et al., 2016; Bilal et al., 2016; Dangura and Gebremedhin, 2017; Ersino et al., 2016; Aemro et al., 2013; Beyene et al., 2015; Roba et al., 2016; Gibson et al., 2009; Demilew et al., 2017; Mekonnen et al., 2017; Yohannes et al., 2018; Hibstu et al., 2018; Kumera et al., 2018; Ayana et al., 2017; Tegegne et al., 2017; Agedew et al., 2014; Mekbib et al., 2014), and 1 case-control study (Wubante, 2017), with 17,383 0–23 month old children in this systematic review and meta-analysis. The flow diagram of studies identified for review was shown in detail in Fig. 1.

3.2. Characteristics of the studies

Out of 26 studies included in this review, 14 contributed data on the prevalence of timely initiation of CF, 19 contributed data about prevalence of minimum dietary diversity score (achieves ≥4 groups per day), 13 about prevalence of minimum meal frequency, 8 on the prevalence of minimum acceptable diet and 15 contributed data regarding determinants of complementary feeding. The key characteristics of the prevalence and determinant studies are provided in Table 1.

The included studies represent three geographical regions of Ethiopia including South, North and East, and mixed (country level). The highest number of studies was reported from South Ethiopia i.e. 11, followed by 9 from North, 4 from mixed and, and the least was from East Ethiopia covering only two studies. The total sample size of the 26 included studies were 17,383 children aged 0–23 months, where the original the sample sizes of individual study range from 97 in South Ethiopia to 2,836 in the country-level study. The publication year of these studies ranged from 2013-2018.

All studies used the tool WHO developed for 'optional feeding practice indicators' to evaluate the adequacy of IYCF practices. The prevalence of timely initiation of CF, minimum dietary diversity score, minimum meal frequency and minimum acceptable diet ranged from 20.5% to 86.2%, 3.1–77.9%, 3.3–20.7% and 3.1%–82.0% respectively in individual studies. The highest prevalence of timely initiation of CF was reported in North Ethiopia 86.2%, and the least was in South 20.5%. Both the highest and the least prevalence of minimum meal frequency was reported in South Ethiopia 77.9% and 3.1%, respectively. Similarly, both the highest and the least prevalence of minimum acceptable diet was reported in South Ethiopia 20.7% and 3.3%, respectively. The highest prevalence of minimum dietary diversity score was reported in North Ethiopia 82.0%, and the least was in South 3.1%.

Table 1
Summary of main characteristics of the included studies.

S/N	First Author Last Name	Year of Publication	Year of data collection	Study Region	Place Study	Study type	Sample size	Age	TI Preval. (%)	MDD Preval. (%)	MMF Preval. (%)	MAD Preval. (%)	Quality Score
1	Wubante AA.	2017	2013	North Gondar	Rural	CC	400	0–12m	86.3	NR	NR	NR	7
2	Sisay W.	2016	2015	Northeast	Both	CS	421	6–23m	62.9	12.1	51.5	NR	9
3	Shumey A	2013	2011	Northern	Urban	CS	422	6–12m	62.8	NR	NR	NR	8
4	Semahegn A	2014	2013	Harar town	Both	CS	200	25.4 ± 14.9	60.5	NR	NR	NR	7
5	Regassa N.	2014	NR	Southern	Both	CS	1094	<24m	71.5	42.4	71.9	NR	7
6	Nguyen PH.	2013	NR	North and South	Both	CS	875	6–24m	NR	6.3	NR	NR	5
7	Moges D.	2016	NR	Southern	Rural	CS	180	6–23m	20.6	3.3	56.1	3.3	4
8	Kassa T.	2016	2015	Southern	Rural	CS	611	6–23m	72.5	18.8	67.3	12.3	10
9	Gebremedhin S.	2016	2014	South Wollo	Rural	CS	2080	6–23m	NR	7.0	NR	NR	5
10	Ersino G.	2016	2013	Southern	Rural	CS	279	0–24m	NR	8.2	58.2	6.5	8
11	Dangura D.	2017	2015	Southern	Rural	CS	417	6–23m	NR	10.6	77.9	8.4	6
12	Bilal SM.	2016	2013	Northern	Both	CS	840	6–23m	NR	82.0	NR	NR	7
13	Beyene M.	2015	2014	Northwest	Urban	CS	920	6–23m	NR	12.6	50.4	NR	10
14	Aemro M.	2013	2011	DHS (country)	Both	CS	2836	6–23m	NR	10.3	44.7	NR	4
15	Roba KT.	2016	2014	Mixed (country)	Both	CS	216	6–23m	NR	22.2	50.5	12.0	6
16	Gibson RS.	2015	2006	Southern	NR	CS	97	6–23m	NR	3.1	NR	NR	7
17	Yohannes B.	2018	2015	Southwest	Rural	CS	543	6–23m	34.3	NR	NR	NR	10
18	Tegegne M.	2017	2016	Southeast	Both	CS	801	6–23m	NR	28.5	68.4	NR	9
19	Mekonnen TC.	2017	2015	Southern	Urban	CS	623	6–23m	NR	27.1	67.6	20.7	10
20	Hibstu DT.	2018	2016	Southern	Urban	CS	320	6–23m	57.8	NR	NR	NR	10
21	Demilew YM.	2017	2016	Northwest	Urban	CS	278	6–23m	78.1	7.2	47.1	7.2	9
22	Ayana D.	2017	2015	Northwest	R&U	CS	785	6–23m	61.8	10.7	NR	NR	10
23	Kumera G.	2018	2016	North west	R&U	CS	955	6–23m	NR	13.6	NR	NR	10
24	Mekbib E.	2014	2013	Northern	Urban	CS	428	6–23m	79.7	17.8	39.7	11.9	9
25	Agedew E.	2014	2014	Southern	Rural	CS	562	6–24m	40.6	NR	NR	NR	11
26	Semahegn A.	2014	2013	East	Urban	CS	200	6–23m	60.5	NR	NR	NR	7

Abrevations: CC: case-control, CS: Cross-sectional, NR: Not reported, TI: Timely initiation, MDD: Minimum dietary diverstiy, MMF: Minimum meal frequency, MAD: Minimum acceptable diet, m: month.

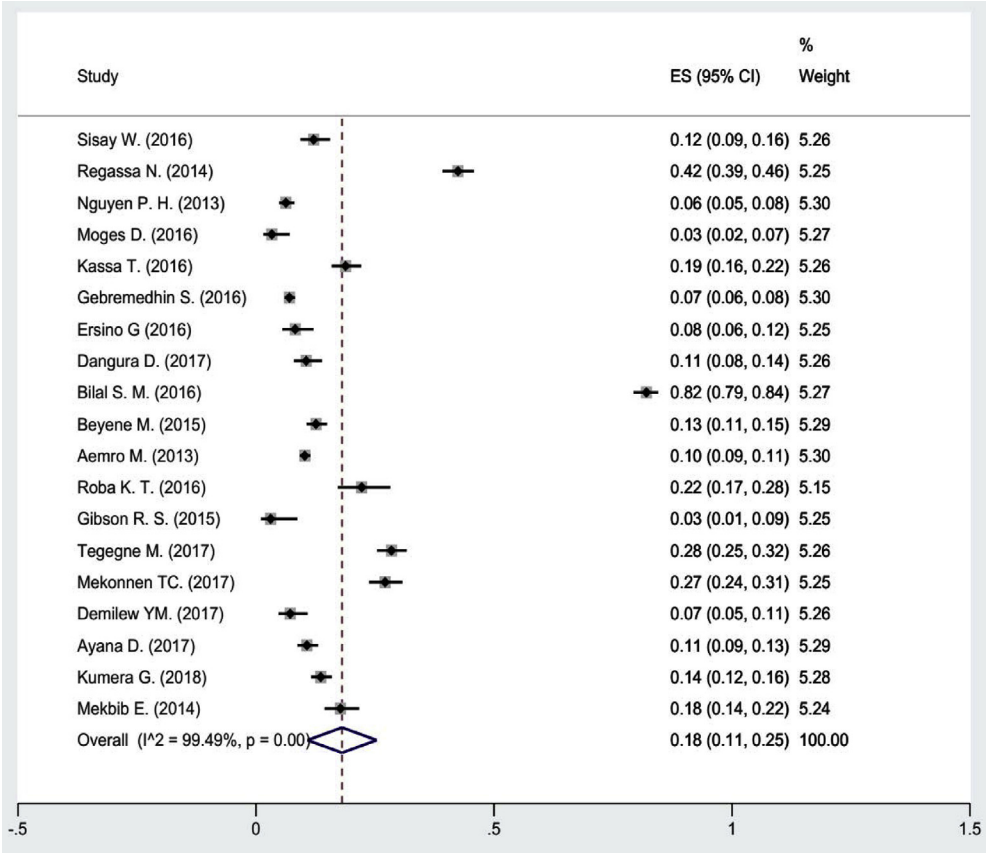

Fig. 2. Forest plot of the prevalence of minimum dietary diversity with the corresponding 95% confidence intervals (CIs). According to the author and year, the midpoint of each line illustrates the estimated prevalence in each study. The diamond design shows the prevalence throughout the studies.

Table 2
Collective results of the random pooled, subgroups and sensitivity analyses of prevalence of core complementary feeding indicators.

	TI		MDD		MMF		MAD	
	#study	Prev. (95% CI), I^2	#study	Prev. (95% CI), I^2	#study	Prev. (95% CI), I^2	#study	Prev. (95% CI), I^2
Random pooled analysis	14	61.0 (52.0, 70.0), 98.5	19	18.0 (11.0, 25.0), 99.5	14	56.0 (45.0, 66.0), 99.2	8	10.0 (7.0, 14.0), 91.5
Sensitivity analysis	9	61.0 (51.0, 72.0), 98.2	10	16.0 (12.0, 20.0), 95.3	8	59.0 (51.0, 68.0), 97.0	5	12.0 (7.0, 16.0), 91.9
Subgroups								
Region								
North	6	72.0 (63.0,81.0), 96.7	8	20.0 (5.0, 36.0), 99.7	4	53.0 (38.0, 68.0), 97.9	2	10.0 (7.0, 12.0), 0.0
South	6	50.0 (33.0, 66.0), 94.0	8	18.0 (8.0, 27.0), 98.7	8	59.0 (40.0, 77.0), 99.4	5	10.0 (5.0, 16.0), 94. 8
East	2	61.0 (56.0, 65.0), 0.0	NA	NA				
Mixed (country)	NA	NA	3	12.0 (7.0, 17.0), 0.0	2	45.0 (43.0, 47.0), 0.0	1	12.0 (8.0, 17.0), 0.0
Resident								
Urban	5	68.0 (59.0, 77.0), 94.0	4	16.0 (8.0, 24.0), 96.2	5	42.0 (18.0, 65.0), 99.4	3	13.0 (6.0, 21.0), 0.0
Rural	5	51.0 (27.0, 75.0), 99.4	7	10.0 (6.0, 14.0), 93.9	5	62.0 (53.0, 72.0), 94.1	4	8.0 (4.0, 11.0), 87.1

Abrevations: MAD: Minimum acceptable diet, MMF: Minimum meal freaquency, MDD: Minimum dietary diversity, TI: Timely initiation of complemnetary food.
study number of study.

4. Quantitative synthesis

4.1. Prevalence of complementary feeding practices

Fourteen studies involving 6,444 participants were included in the prevalence of timely initiation of CF meta-analysis. The overall pooled prevalence estimate was 61.0% (95% CI: 52.0, 70.0) with large heterogeneity (I^2 = 98.5%; p < 0.001). Nineteen studies involving 14,502 participants were included in the prevalence of minimum dietary diversity score meta-analysis. The overall pooled prevalence estimate was 18.0% (95% CI: 11.0, 25.0) with large heterogeneity (I^2 = 99.5%; p < 0.001) (Fig. 2). Fourteen studies involving 8,889 participants were included in the prevalence of minimum meal frequency meta-analysis. The overall pooled prevalence estimate was 56.0% (95% CI: 45.0, 66.0) with large heterogeneity (I^2 = 99.2%; p < 0.001). Eight studies involving 2,983 participants were included in the prevalence of minimum acceptable diet meta-analysis. The overall pooled prevalence estimate was 10.0% (95% CI: 7.0, 14.0) with large heterogeneity (I^2 = 91.5%; p < 0.001) (Table 2).

4.2. Subgroup analysis

Subgroup analysis by geographical regions and residence (urban vs rural) was performed to identify the true sources of between study heterogeneity. The analysis by geographical regions showed that the pooled prevalence estimate of timely initiation of CF was high in Northern

Table 3
Summary of Data extracted for determinants of complementary feeding by study.

Study's First Author last Name, (Year)	Determinants of minimum dietary diversity								
	Child age	Maternal education	Maternal knowledge on IYCF	Paternal involvement	Mass media	Maternal DD	SES	Cooking demo	Home gardening
Dangura D. et al. (2017)	√		√	√	√			√	√
Roba KT. et al. (2016)	√					√			
Aemro M. et al. (2013)	√	√					√		
Beyene M. et al. (2015)	√	√			√				√
Tegegne M. et al. (2017)		√	√						
Regassa N. (2014)	√	√							
Nguyen P.H. et al. (2013)	√		√			√			
Gebremedhin S. et al. (2016)	√	√	√	√	√		√	√	
Bilal S.M. et al. (2016)				√					
Mekonnen TC. et al. (2017)	√								

Study's First Author last Name, (Year)	Determinants of timely initiation of complementary feeding					
	Maternal education	Paternal education	ANC follow up	PNC follow up	Place of delivery	Number of <5 years children
Sisay W. et al. (2016)	√		√		√	
Shumey A. et al. (2013)	√	√	√			√
Yohannes B. et al. (2018)	√	√		√		
Hibstu DT. et al. (2018)	√					
Ayana D. et al. (2017)				√		√
Agedew E. et al. (2014)	√			√		
Semahegn A. et al. (2014)		√	√	√	√	

Abrevations: DD: Dietary diversity, SES: Socioeconomic status, demo: demonstration, ANC: Antinatal care, PNC: Postnatal care.

Table 4
Pooled odds ratios for the determinants of timely initaition of complementary feeding.

Determinants	Comparison	Number of studies	Sample size	OR (95% CI), I^2 (%)
Maternal education	More edu (vs. less)	5	2268	2.67 (1.80, 3.54), 0.0
PNC follow up	Yes (vs. No)	4	2090	1.76 (1.34, 2.18), 0.0
Paternal education	More edu (vs. less)	3	1165	2.67 (1.33, 4.00), 0.0
ANC follow up	Yes (vs. No)	3	1043	3.08 (1.58, 4.57), 0.0
Number of children	More (vs. less)	2	1207	1.76 (1.01, 2.50), 34.7
Place of Delivery	Health Inst. (vs. Home)	2	621	2.46 (1.32, 3.59), 0.0

Abrevations: edu: education, Inst: Institute.

Table 5
Pooled odds ratios for the determinants of minimum dietary diversity.

Determinants	Comparison	Number of studies	Sample size	OR (95% CI), I^2 (%)
Child age	Older (vs. younger)	8	9061	1.29 (1.19, 1.38), 95.5
Maternal education	More edu (vs. less)	5	7731	1.36 (1.09, 1.62), 88.8
Maternal knowledge	knows IYCF (vs. not)	4	4173	1.07 (0.98, 1.17), 72.4
Paternal involvement	Involved (vs. not)	3	3337	1.18 (1.07, 1.29), 41.2
Media	IYCF info. (vs. not)	3	3417	1.25 (1.01, 1.49), 83.8
Maternal DDS	Yes (vs. No)	2	1091	1.26 (1.19, 1.34), 0.0
SES	Higher (vs. lower)	2	4916	1.18 (1.02, 1.33), 54.2
Cooking demo	Yes (vs. No)	2	1337	1.23 (1.11, 1.36), 0.0
Home gardening	Yes (vs. No)	2	2497	1.39 (1.23, 1.54), 0.0

Abrevations: edu: education, demo: demonstration.

Ethiopia, 72.0 % (95% CI: 63.0, 81.0; $I^2 = 96.7\%$), and the least was in South Ethiopia, 50.0% (95% CI: 33.0, 66.0; $I^2 = 99.1\%$). Similarly, subgroup analysis based on residence showed that the pooled prevalence estimate of timely initiation of CF was better in urban than the rural area (68.0% vs. 51.0%). In a subgroup analysis based on geographical regions showed that the pooled prevalence estimate of minimum dietary diversity score was high in Northern Ethiopia, 20.0% (95% CI: 5.0, 36.0; $I^2 = 99.7\%$), and the least was in country level, 12.0% (95% CI: 7.0%, 17.0%; $I^2 = 96.6\%$). Subgroup analysis based on residence showed that the pooled prevalence estimate of minimum dietary diversity score was better in urban than the rural area (16.0% vs. 10.0%) as shown in Table 2.

Subgroup analysis based on geographical regions showed that the pooled prevalence estimate of minimum meal frequency was high in South Ethiopia, 59.0% (95% CI: 40.0, 77.0; $I^2 = 99.4\%$), and the least was in country level, 45.0% (95% CI: 43.0, 47.0; $I^2 = 94.6\%$). Subgroup analysis based on residence showed that the pooled prevalence estimate of minimum meal frequency was better in rural than the urban area (62.0% vs. 42.0%). Moreover, subgroup analysis based on geographical regions showed that the pooled prevalence estimates of minimum acceptable diet was high at country level, 12.0% (95% CI: 8.0, 17.0; $I^2 = 94.8\%$), and the least was in South Ethiopia, 10.0% (95% CI: 5.0, 16.0; $I^2 = 91.6\%$). subgroup analysis based on residence showed that the pooled prevalence estimate of minimum acceptable diet was better in urban than rural area (13.0% vs. 8.0%) represented in Table 2.

4.3. Sensitivity analysis

To examine the impact of low quality and high-bias-risk studies on the overall estimate, a sensitivity analysis was done by omitting data from the meta-analytic model. Only high-quality studies (n = 12, 54.5%) based on the quality score were considered in the sensitivity analysis. The result of the sensitivity analyses demonstrated that prevalence of timely initiation of CF, 61.0% (95% CI: 51.0, 72.0; $I^2 = 98.2\%$), prevalence of minimum dietary diversity score, 16.0 % (95% CI: 12.0, 20.0; $I^2 = 95.3\%$), prevalence of minimum meal frequency, 59.0 % (95% CI: 51.0, 68.0; $I^2 = 97.0\%$) and prevalence of minimum acceptable diet, 12.0% (95% CI: 7.0, 16.0; $I^2 = 91.3\%$). Thus, the results of the sensitivity analysis revealed the quality score didn't affect the outcome of the meta-analysis and there was no significant difference in the overall pooled

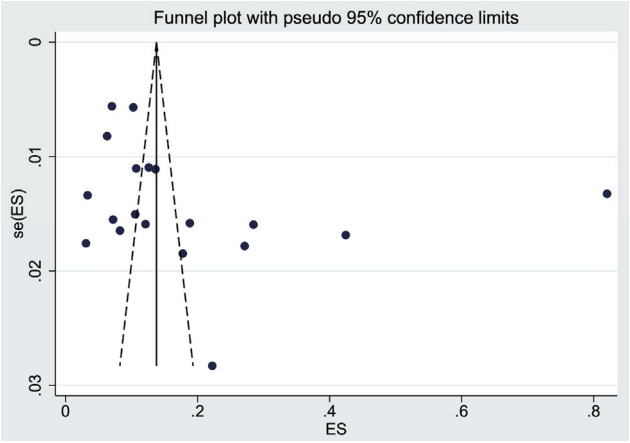

Fig. 3. Funnel plot of the prevalence of minimum dietary diversity studies.

prevalence as well as the heterogeneity between the studies (Table 2).

4.4. Determinants of complementary feeding practices

A summary of data extracted for the determinants of CF is shown in Table 3. In this review, we included two categories for the determinants of CF, i.e. determinants of timely initiation of CF and determinants of minimum dietary diversity. 16 studies were used in the meta-analysis of the determinants of CF, 9 for minimum dietary diversity score, and 7 for timely initiation of CF, the determinants that were considered in the meta-analysis were reported at least in two studies. Accordingly, six key determinants of timely initiation of CF were found to have a pooled odds ratio between 1.76 to 3.08 (number of children to ANC follow up) with no evidence of heterogeneity among studies. These determinants were maternal education, paternal education, the number of children under 5 years in the household, place of delivery, antenatal care and postnatal care follow up (Table 4).

Timely initiation of CF was lower among less educated mothers and/or fathers compared to more educated mothers and/or fathers. More specifically, mothers and/or fathers who attended secondary school and above were more likely to introduce solid, semi-solid and soft foods than uneducated parents. Mothers who had PNC follow up were nearly two times more likely to timely initiate CF than mothers with none follow up. Moreover, those mothers who had fewer children in the household were nearly twice more likely to timely initiate CF than those with more children.

The meta-analysis of determinants of minimum dietary diversity score comprised 10 studies and nine determinants with data available for the meta-analysis. These determinants were child age, maternal education, maternal knowledge on IYCF, paternal involvement in IYCF, maternal exposure to IYCF information on the mass media, maternal dietary diversity score (DDS), SES, mother's participation in cooking demonstration, and possession of home gardening. The pooled OR is between 1.07 to 1.39 (maternal knowledge on IYCF to home gardening). Between study heterogeneity was higher among studies assessing child age, maternal education, maternal knowledge of IYCF, maternal exposure to IYCF information on the mass media and SES (Table 5).

The odds of obtaining the minimum dietary diversity was lower in the younger ones as compared to older children. Mothers with more education (primary and secondary school) had higher odds of practicing the trends of minimum dietary diversity compared with less educated mothers. Moreover, children with parents that have home gardening were at higher odds of obtaining the expected minimum dietary diversity in comparison with those whose parents did not have. Those children whose mothers had knowledge on IYCF, and whose fathers had been directly involved in IYCF practice had higher odds to practice the minimum dietary diversity than those children of mothers had no knowledge on IYCF, and fathers who had not been involved in IYCF. Children whose mothers have higher DDS, and have media exposure are at higher odds to diversify diet. Where as, those children of mothers who had no access to diversified diet, and exposed to media are at lower odds to diversify diet. Children of mothers which participated in cooking demonstration were at better odds and meet the minimum dietary diversity than children of mothers that have not been participated in cooking demonstration.

4.5. Publication bias

The funnel plot assessment by visual inspection revealed that it is quite symmetrical and has not demonstrated publication bias. Similarly, the Egger's test also showed there was no publication bias (Egger's test, $p = 0.15$) (Fig. 3).

5. Discussions

Our analysis showed a comprehensive and systematic review of the literature, and up-to-date estimations of the prevalence of core complementary feeding indicators and its determinants in population-based studies in Ethiopia. In this study, we found that 61.0% of children aged 6–8 months received solid, semi-solid, or soft foods, 18.0% of children received a diverse diet with the appropriate number of food groups, 56.0% feed the minimum number of times suitable for their age, and 10.0% of the children meet the recommended minimum acceptable diet. These results show there was a small improvement compared to Ethiopian DHS 2016 (CSA, 2016), which reported that the percentage of children aged 6–23 months who initiated CF timely, minimum DD, minimum meal frequency and minimum acceptable diet was 60.0%, 14.0%, 45.0%, and 7.0% respectively. In the present study, all the core indicators of CF were lower than reports from Nepal and Bangladesh DHS reports (Kabir et al., 2012; Khanal et al., 2013). These indicate, although the overall proportion of timely initiation of CF, and minimum meal frequency were good, the overall proportion of minimum DD and minimum acceptable diet remained poor.

The combined results of 16 observational studies of determinants for timely initiation of CF, and minimum DD among children aged 6–23 months indicate that child age, maternal education, mother's knowledge on Infant and Young Child Feeding (IYCF), paternal education, paternal participate in IYCF, ANC follow up, PNC follow up, maternal exposure to IYCF information through mass media, maternal DDS, place of delivery, number of under 5 years children in the house, socio-economic status, mother's participation in cooking demonstration, and possession of home gardening were the main determinants that can increase appropriate complementary feeding practice, i.e. timely initiation of CF and minimum dietary diversity.

In this study, the random-effects model was used in the meta-analysis, to take in to account the likelihood heterogeneity between studies which were tested with the Q test. Accordingly, the geographical classification results revealed that North Ethiopia had a higher proportion of timely initiation of CF and minimum DD as compared to other regions. A higher proportion of minimum meal frequency was also seen in South Ethiopia as compared with other regions. However, the prevalence of minimum acceptable diet was similar across all regions. On the other hand, except for the minimum meal frequency, all the three core indicators of CF were better in urban than rural settings. All most the same results were reported by studies from Pakistan and South Africa (Khokhar et al., 2017; Faber et al., 2016). The differences in the proportion of the core CF indicators between regions, and urban and rural areas noted in our study could be explained by the differences in sociodemographic, socioeconomic conditions, cultural barriers, risk factors, health care access disparities and quality of health care services provided. However, for the observed huge differences between the North and the South of the country in the prevalence of timely initiation of CF and minimum dietary diversity in the present study is surprising and difficult to explain thus further investigations are needed.

We found strong evidence indicating that a timely initiation of solid, semi-solid and soft foods was relatively high among more educated (secondary and above) mothers and/or fathers, mothers received ANC and PNC visits, those mothers who gave birth at health facilities, and those households who had less number of under 5 children. Besides, children whose diet was adequately diversified were high among children older child age, more educated mothers, mothers who had better knowledge on IYCF, fathers who involved in IYCF practices, mothers who had exposed to IYCF information through mass media, mothers who had diversified their diet, household with better SES, mothers who had participated in a cooking demonstration, and those households who possessed of home gardening. Consistent to our findings, a report from the analysis of Malawi DHS showed child age, maternal education, SES and maternal exposure to mass media were significantly associated with higher odds of receiving minimum meal frequency, minimum DD and minimum acceptable diet (Nkoka et al., 2018).

These may be due to that educated mothers known more about the importance of appropriate CF practice and had better information. Moreover, education may be enriching the status of the mothers and empower them to make decisions about their child feeding practice. In addition, these mothers might be influenced by media advertising about CF (Khanal et al., 2013; Bich et al., 2016). On the other hand, health workers have a great role in protecting, promoting and supporting IYCF (Awumbila, 2003). The advice from healthcare workers has been recognized as one of the main determinants affecting mothers' feeding practices. Thus, healthcare workers should have the necessary knowledge and skills to counsel mothers/caregivers and help them overcome feeding difficulties when they occurred. Hence, health providers should provide health, and nutrition counseling on IYCF during maternal ANC, institutional delivery and PNC service visits, which is a vital intervention to improve IYCF practices. The time from conception to 2 years of life is a period of critical nutritional needs and the key period for physical growth, motor, and intellectual development of a child (Victora et al., 2010). Poor nutrition within this critical period predispose child not only to undernutrition but also to a greater risk of dying from infections, increasing severity of infections, impaired cognitive development and decreased school performance (Unicef., 2015). In this regards, WHO IYCF core indicators were used extensively to address gaps in knowledge and pattern of understanding, factors, and consequences of poor IYCF practices (WHO, 2010). Minimum DD assesses food intake of at least four food groups by children 6–23 months. These 4 food groups are the result of 7 food groups: grains, roots, and tubers; legumes and nuts; dairy products; meat; eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables. Minimum meal frequency is also examining the number of times children non-breastfeed. The recommendation of minimum number is specific to child age and breastfeeding status. Therefore, appropriate age-specific IYCF practices with a minimum acceptable diet can ensure proper growth and development.

This study has certain limitations as a result of the inherent biases of eligible studies. First, there was significant heterogeneity between included studies, and a limited number of variables were considered in subgroup analysis to identify source of this heterogeneity. Second, there were insufficient studies to entirely represent the regions of Ethiopia, for example, no study from West Ethiopia. Third, although the further disaggregate and report of indicators recommended by age groups specific, that is 6–11.9 months, 12–17.9 months and 18–23.9 months, none of the studies reported their results in such format. Furthermore, these results were not segregated based on breastfeeding status of the children, that is breastfeed and non-breastfeeding. Regardless of these limitations, the strength of this study includes, using a comprehensive search strategy that permitted the identification of a large number of studies, and also the number searched databases. Two independent reviewers were used to limit the reviewer bias during the assessment of inclusion criteria. Reporting of included studies was assessed for quality, and reporting quality for the majority of studies was assessed to be fair. The results of this study with data on determinants of CF were entirely congruent with findings from previous studies and provided no new or surprising results, and the inclusion of these studies did not change the study findings.

6. Conclusion

In conclusion, the findings from this study provide contemporary estimates that reflect the current prevalence of core IYCF indicators in Ethiopia. The percentage of children 6–23 months who timely initiated CF, and minimum DD was good, however, the percentage of the minimum meal frequency and minimum acceptable diet was remained poor. The findings of this study are useful for the Ministry of Health and its partners to design interventions and programs that improve the CF practices in the Ethiopia. Meanwhile, the authors would like to acknowledge the effort that has been done by the minister of health and its partners including Alive & Thrive to improving complementary feeding practices in the country, however, these programs should be done more thoroughly, and scaled up by applying and adapting tested, proven approaches and tools in contexts. The present study, recommends to strength families and communities capacity as well as to strength the health care system and healthcare services to promote and support optimal IYCF practices. Further, a well-designed longitudinal study is needed to elucidate the possible causations between key determinants and complementary feeding practices in Ethiopia.

Declarations

Author contribution statement

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The authors declare no conflict of interest.

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