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Birth prevalence of omphalocele and gastroschisis in Sub-Saharan Africa: A systematic review and meta-analysis

Chalachew Tiruneh[1], Teshome Gebremeskel[2], Mogesie Necho[3], Yossef Teshome[4], Daniel Teshome[5] and Asmare Belete[3]

Abstract

Objective: To systematically summarize the burden of gastroschisis and omphalocele in Sub-Saharan Africa.

Methods: Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, systematically reviewed and meta-analyzed literatures from Medline (PubMed), Cochrane Library, HINARI, and Google Scholar that investigated at the prevalence of major congenital abdominal wall malformation. The pooled prevalence of major abdominal wall defects was estimated using a weighted inverse variance random-effects model. The Q statistic and the I^2 statistics were used to examine for heterogeneity among the included studies. The funnel plot and Egger's regression test were used to check for publication bias.

Results: A total of 1951 studies were identified; 897 from PubMed, 26 from Cochrane Library, 960 from Google Scholar, and 68 from other sources. Fourteen articles that met the eligibility criteria were selected for this meta-analysis with 242,462 total enrolled participants and 4693 births with congenital anomaly. The pooled prevalence of ompahalocele among congenital defect patients in Sub-Saharan Africa was found to be 4.47% (95% confidence interval: 3.04–5.90; $I^2 = 88.3\%$; $p < 0.001$). The pooled prevalence of omphalocele among births with congenital defect was found to be 4.04% (95% confidence interval: 2.62–5.46) in cross-sectional studies and 4.43% (95% confidence interval: 306–5.81) in cohort studies. The average prevalence of omphalocele among births with congenital defect was found to be 8% (95% confidence interval: 5.53–10.47) in Uganda and 6.65% (95% confidence interval: 4.18–9.13) in Nigeria. The pooled prevalence of gastroschisis among congenital birth defect in Sub-Saharan Africa was found to be 3.22% (95% confidence interval: 1.83–4.61; $I^2 = 33.1\%$; $p = 0.175$).

Conclusion: Based on this review, the pooled prevalence of omphalocele and gastroschisis in sub-Saharan Africa are high. Therefore, a perinatal screening program for congenital anomalies should be implemented. In addition, early referral of suspected cases of congenital anomalies is required for better management until advanced diagnostic centers are established in various locations of Sub-Saharan Africa.

Keywords

Prevalence, abdominal wall defect, omphalocele, gastroschisis

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Introduction

Congenital abnormalities are responsible for 30%–40% of all prenatal deaths, and survivors often have major mental, emotional, and physical disabilities. Despite the fact that the frequency and kind of malformation vary depending on race, ethnicity, socioeconomic status, medical care, maternal lifestyle, and education, it affects people from all walks of life. So, it places a significant physical, financial, and emotional strain on the affected families.[1] Birth defects are a leading source of childhood illness and mortality, with one out of every three babies dying worldwide having a congenital abnormality.[2,3]

[1]Department of Biomedical Science, College of Medicine and Health Sciences, Injibara University, Injibara, Ethiopia
[2]Department of Anatomy, College of Health Sciences, Woldia University, Woldia, Ethiopia
[3]Department of Psychiatry, College of Medicine and Health Sciences, Wollo University, Dessie, Ethiopia
[4]Department of Anatomy, School of Medicine, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia
[5]Department of Anatomy, College of Medicine and Health Sciences, Wollo University, Dessie, Ethiopia

Corresponding author:
Chalachew Tiruneh, Department of Biomedical Science, College of Medicine and Health Sciences, Injibara University, P.O. box 6040, Injibara, Ethiopia.
Email: Chalachewtiruneh19@gmail.com

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The higher burden of death is occurred in low- and middle-income countries (LMIC).[4,5] In the LMIC, major congenital abdominal wall abnormalities (gastroschisis and omphalocele) accounted for up to 21% of emergency neonatal interventions.[6–8] However, etiologic factors contributing to the development of these defects are unknown.[9] Gastroschisis is a birth defect in which an infant's viscera stick out of the body through a defect, which is characterized by a diameter of less than 4 cm, the absence of a covering membrane or sac, and the presence of only the small intestine, sometimes with the stomach or gonad. It is almost always found to the right of the umbilical cord.[10] Patients with gastroschisis, unlike those with omphalocele, are more likely to have bowel abnormalities, such as atresia but do not typically have associated congenital anomalies.[11]

An omphalocele may occur due to failure of the bowel loops to return to the abdominal cavity after the physiologic herniation through the umbilical cord, which occurs between the 6th and 11th weeks of development. The pathophysiology of gastroschisis has been linked to a number of factors. According to one theory, the defect is caused by the inability of the umbilical coelom to form, causing the elongating intestine to rupture out of the body wall to the right of the umbilicus. Another possibility is that the embryonic components do not fully integrate into the umbilical cord. Experts also believe that a variety of environmental exposures and demographic risk factors play a role in its development.[11]

Gastroschisis and omphalocele are the most frequent fetal anterior abdominal wall abnormalities, both with a prevalence of about 3 in 10,000 births.[12] These defects are more common in the United Kingdom and Ireland and accounts an estimated 32 million births per year.[13] The nationwide prevalence of gastroschisis and omphalocele in Iran, according to the Centers for Disease Control and Prevention, is 3.73 and 2.09 per 10,000 live birth, respectively.[14] Both are normally detected prenatally by fetal ultrasonography, and patients who are affected are treated at a center with high-risk obstetric services, neonatology, and pediatric surgery.[11] The reported prevalence of omphalocele in a developed country is 0.9–3.8 per 10,000 live births.[15]

The prevalence of both types of the anterior abdominal wall defects varies by country. According to a study in Iran, the prevalence of omphalocele and gastroschisis were 20.88 and 6.52 per 10,000 live newborns, respectively.[14] Another study in France found that the prevalence rate for omphalocele and gastroschisis, on 265,858 consecutive births, were 2.18 and 1.76/10,000, respectively.[16] Similarly, the prevalence of anterior abdominal wall defects in Africa is different in different countries. So, this review was intended to determine the pooled prevalence of gastroschisis and omphalocele in Sub-Saharan African countries.

Methods

Review question

This systematic review and meta-review analysis question was:

What is the pooled prevalence of omphalocele and gastroschisis in Sub-Saharan African context?

Study selection and screening

To eliminate duplicate studies, the retrieved studies were exported to Endnote version 8 reference managers. Before retrieving full-text papers, three investigators (C.T., T.G., and D.T.) independently reviewed the selected research using article titles and abstracts. To further screen the full-text publications, we employed pre-specified inclusion criteria. Disagreements were discussed with other reviewers during a consensus meeting for the final selection of studies to be included in the systematic review and meta-analysis.

Inclusion and exclusion criteria

In this systematic review and meta-analyses, we included cross-sectional and cohort studies of populations living in Sub-Saharan African countries that reported at least the prevalence of one of the major abdominal wall defects (omphalocele and gastroschisis) or enough data to compute these estimates, regardless of stillbirth. This review included studies published in English language between January 2000 and December 2020. The analysis excluded citations without an abstract and/or complete text, editorials, letters, commentary, reviews, anonymous reports, and qualitative studies. Non-accessible papers due to un-published, un-retrievable from the Internet, and research conducted among populations of African origin living outside Africa were also excluded. Furthermore, papers that did not report our primary outcome of interest were excluded following a thorough analysis of their full texts.

Study area. Only studies conducted in Sub-Saharan African countries.

Study design. All cross-sectional, case–control, and cohort observational studies with original data on the prevalence of omphalocele and gastroschisis in Sub-Saharan African nations were included.

Language. Literatures written in English language were included.

Population. Studies conducted among newborns were incorporated.

Publication condition. Both published and unpublished articles which reported the prevalence of omphalocele and gastroschisis among newborns in Sub-Saharan African countries were incorporated.

Search strategy

The purpose of this review was to find studies that provide information on the prevalence of omphalocele and gastroschisis in Sub-Saharan Africa. We searched the literatures in PubMed, Google Scholar, and Cochrane library with keywords that are the combinations of population, condition/outcome, and context. A snowball search of relevant papers' references for related articles was also carried out. Those search terms or phrases including were: "Birth," "newborn," "infant," and "birth defect," "Birth anomaly," "congenital anomaly," "congenital Abnormality," "congenital malformations," "congenital abdominal wall defects," "abdominal wall anomaly," "omphalocele," "gastroshisis," prevalence," "magnitude," "incidence," "Sub-Saharan African countries." Thus, the PubMed search combines #1 AND #2 AND #3. These search terms were further paired with names of each Sub-Saharan African country. On both Cochran Library, and Google scholar, a build in text search were used on the advanced search section of the sources.

Quality assessment

The Newcastle–Ottawa Scale tool, as adjusted for cross-sectional studies' quality assessment, was used to assess the quality of the studies included in this review.[17] The tool contains three main parts; the first part has five stars and evaluates the methodological quality of each study. The second part of the tool evaluates the comparability of the studies. The last part determines the quality of the original papers in terms of statistical analysis. The qualities of each of the original articles were assessed using the tool as a checklist. Articles with medium quality (50% of quality evaluation criteria met) and high quality (⩾6 out of 10 scales) were considered to be included for the analysis.[17]

Data extraction

The authors developed data extraction form on the excel sheet in country, year of publication, study design, and prevalence of congenital abdominal wall defects such as omphalocele and gastroschisis reported. The data extraction sheet was piloted using four papers at random, and the template was adjusted after the pilot. Two authors (T.G. and C.T.) extracted the data using the extraction form in collaboration and any discrepancy resolved through discussions with the third and fourth author (Y.T. and D.T.) as needed. These authors independently verified the data's accuracy. The mistyping of data was resolved through crosschecking with the included papers.

Statistical analysis

After extracting the data in an excel sheet, the authors exported it to STATA 14 for analysis. A random effect meta-analysis model was used to pool the overall prevalence estimates of omphalocele and gastroschisis. The Q statistic and the I^2 statistics were used to investigate effect size heterogeneity. In this study, the I^2 statistic value of zero showed real homogeneity, whereas the values 25%, 50%, and 75% represented low, moderate, and high heterogeneity, respectively.[18] Subgroup analysis for omphalocele was done by the study country, study design, and year of publication. Sensitivity analysis was employed to examine the effect of a single study on the entire estimation. The presence or absence of a publication bias was checked by funnel plot test and more objectively through Egger's regression test.[19]

Results

A total of 1951 studies were identified; 897 from PubMed, 26 from Cochrane Library, 960 from Google Scholar, and 68 from other sources. After removal of duplication, a total of 731 articles remained (1220 removed by duplication). Finally, 74 full-text studies were reviewed and 14 articles who met the inclusion criteria were selected for this meta-analysis with 242,463 total enrolled participants and 4693 births with congenital anomaly (Figure 1).

Characteristics of included studies

A total of 14 studies were included in this systematic review and meta-analysis, encompassing 4693 births with congenital anomaly. Of them nine studies were done in Nigeria,[20–28] while two were in Ethiopia,[29,30] one in Tanzania,[31] one in Uganda, and one in Democratic Republic of Congo (DRC).[32] Based on the study design used, 10 studies were done by cross-sectional study,[20–24,29–33] while the other four studies were conducted by cohort study design.[25–28] Three out of 14 (21.4%) were published in the year 2000–2014, and majority 11 out of 14 (78.6%) were published in the year 2015–2020. The total numbers of enrolled participants in the included under this review ranged from 100[33] to 100,189[34] and the total number of births with congenital anomaly ranged from 24[27] to 1518[30] (Table 1).

Meta-analysis

Omphalocele

Prevalence of omphalocele among congenital defect patients. All the studies (n = 14) have reported the birth prevalence of omphalocele in sub-Saharan Africa. The prevalence of omphalocele

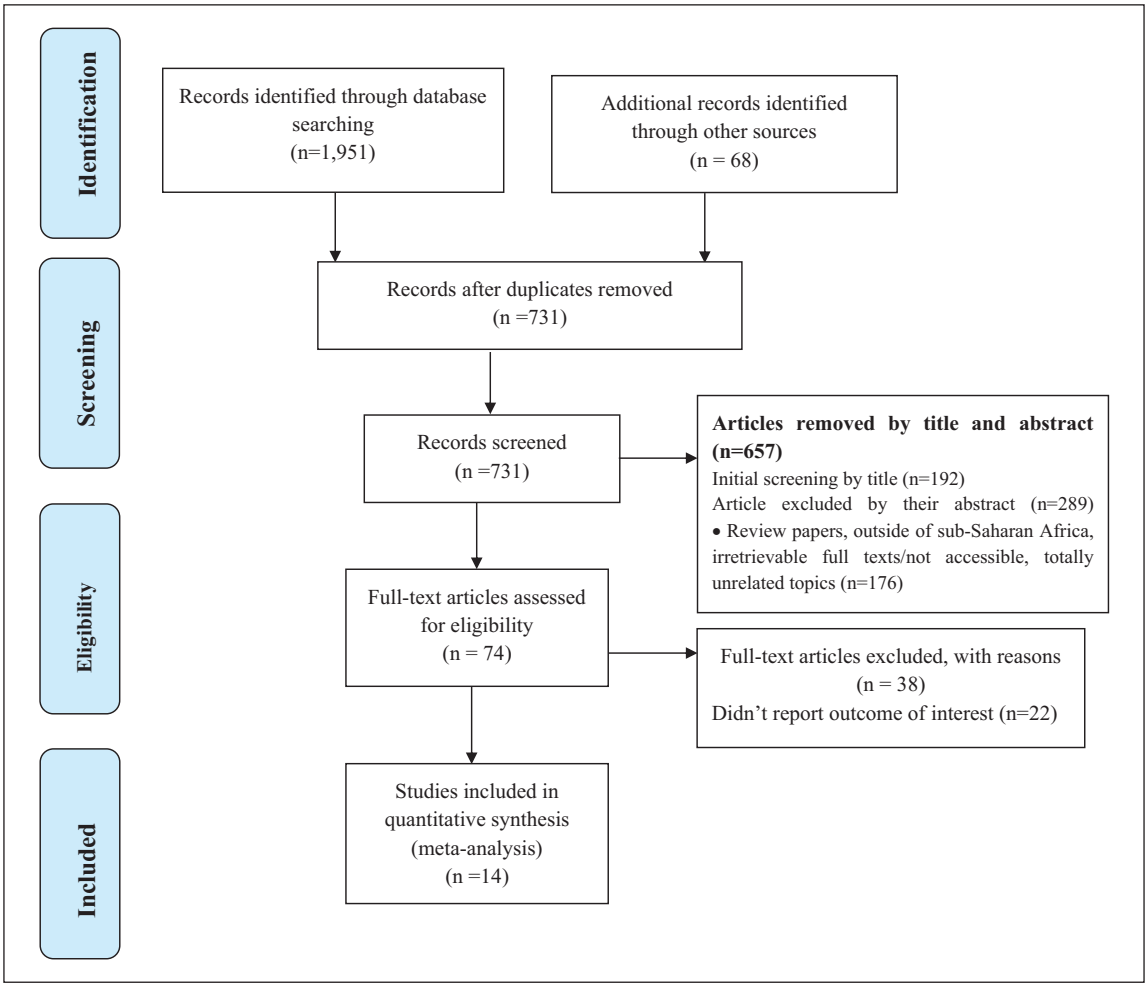

Figure 1. PRISMA—adapted flow diagram showed the results of the search and reasons for exclusion [45].

ranged from 0.76%[32] to 20.5%.[21] The random-effects model analysis from those studies revealed that the pooled prevalence of ompahalocele among congenital defect patients in Sub-Saharan Africa was found to be 4.47% (95% confidence interval (CI): 3.04–5.90; $I^2 = 88.3\%$; $p < 0.001$; Figure 2).

Subgroup analysis for the pooled prevalence of omphalocele among congenital defect patients in Sub-Saharan Africa. The subgroup analysis was done through stratified by country, study design and year of publication. Based on the study design, the pooled prevalence of omphalocele among births with congenital defect was found to be 4.04% (95% CI: 2.62–5.46) in cross-sectional studies and 6.92% (95% CI: 1.94–11.91) in cohort studies (Table 2 and Figure 3).

Based on country study, the prevalence of omphalocele among births with congenital defect was found to be 8% (95% CI: 5.53–10.47) in Uganda and 6.65% (95% CI: 4.18–9.13) in Nigeria (Table 2 and Figure 4). Based on the year of publication, the prevalence of omphalocele among births with congenital defect was found to be 7.50% (95% CI: −1.27–16.26) from studies conducted from January 2000 to December 2014, while it was 4.34% (95% CI: 2.84–5.85) from studies conducted from 2015 to 2020 (Table 2 and Figure 5).

Sensitivity analysis for omphalocele. We employed a leave-one-out sensitivity analysis to identify influence of individual study on the pooled prevalence of omphalocele in Sub -Saharan Africa. The results of this sensitivity analysis showed that our findings were not dependent on a single study. The pooled estimated prevalence of omphalocele varied between 3.79%[34] and 5.59%[24] after deletion of a single study (Figure S1).

Publication bias. A funnel plot showed symmetrical distribution. The Egger's regression test value was 0.001, which indicated the presence of publication bias (Figure 6 and Figure S2).

Gastroschisis

Prevalence of gastroschisis among congenital birth defect. Of the total included studies, seven (n = 7) studies have reported the prevalence of gastroschisis in sub-Saharan Africa among

Table 1. Distribution of included studies on birth prevalence of congenital abdominal defects in Sub-Saharan Africa, from January 2000 to December 2020.

Author name	Year	Country	Design	Sample size	Congenital anomaly cases	Omphalocele	Gastroschisis
Mashuda et al.[31]	2014	Tanzania	CRS	445	131	1.8	1.34
Seyoum et al.[29]	2019	Ethiopia	CRS	19,650	317	5.86	
Serunjogi et al.[34]	2019	Uganda	CRS	100,189	462	8	3.67
Taye et al.[30]	2019	Ethiopia	CRS	76,201	1518	0.92	
Abbey et al.[20]	2017	Nigeria	CRS	7670	159	3.77	
Kalisya et al.[32]	2015	DRC	CRS	1301	1301	0.76	
Oluwafemi et al.[21]	2019	Nigeria	CRS	8307	39	20.5	2.56
Ochoga et al.[22]	2018	Nigeria	CRS	843	72	9.72	11.1
Takai et al.[23]	2019	Nigeria	CRS	6990	305	5.57	2.95
Ajao et al.[24]	2019	Nigeria	CRS	1057	67	7.5	
Okonkwo et al.[25]	2011	Nigeria	Cohort	1513	85	14.1	4.7
Anyanwu et al.[26]	2015	Nigeria	Cohort	1456	41	2.5	4.8
Onankpa et al.[27]	2014	Nigeria	Cohort	6578	24	8.3	
Singh et al.[28]	2015	Nigeria	Cohort	10,163	72	5.6	

CRS: cross-sectional; DRC: Democratic Republic of Congo.

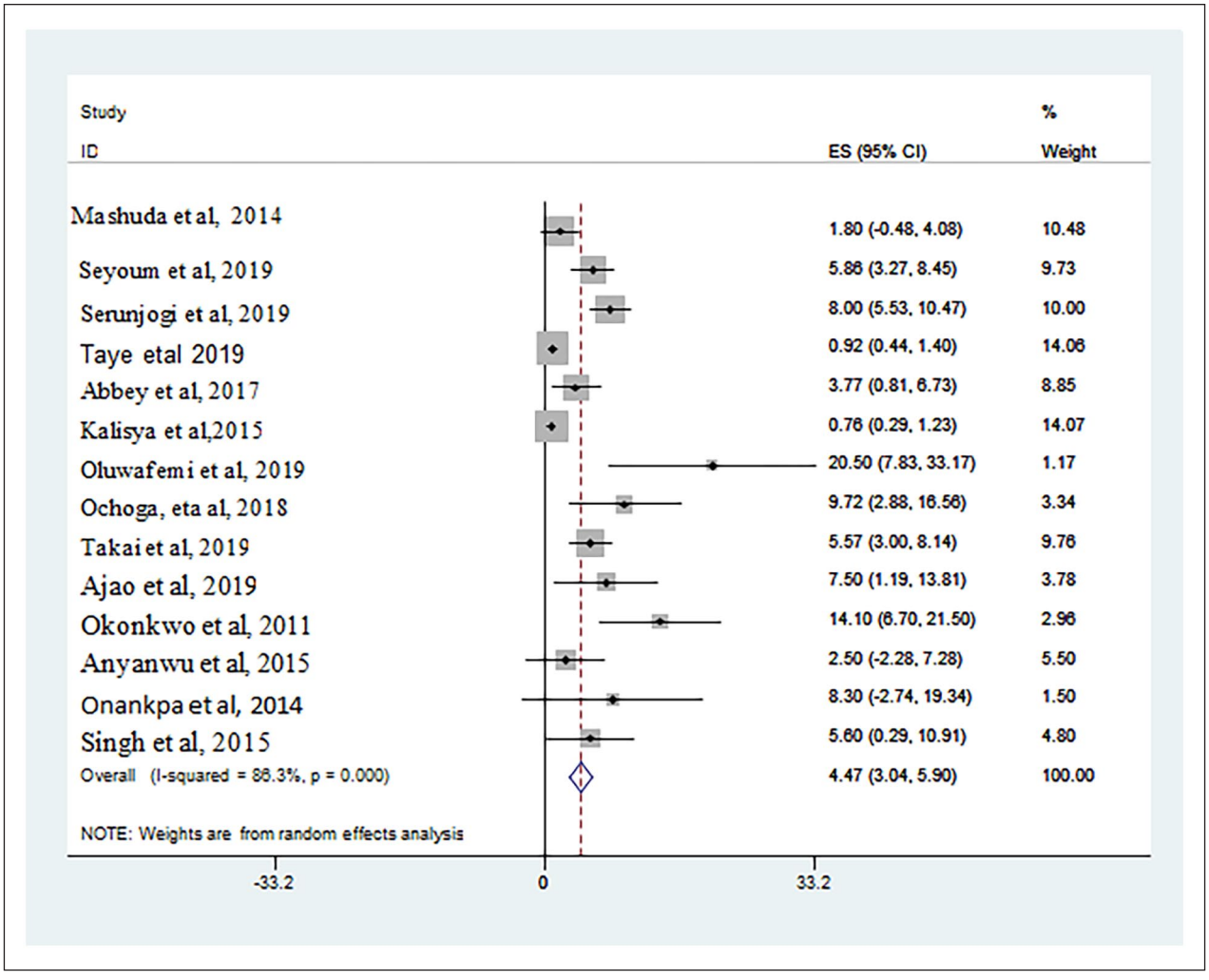

Figure 2. Forest plot showing the pooled prevalence of omphalocele among congenital defect patients in Sub-Saharan Africa, from January 2000 and December 2020.

Table 2. Subgroup analysis on the pooled birth prevalence of major congenital abdominal wall defects in Sub-Saharan Africa from January 2000 to December 2020.

Variables	Characteristics	Pooled prevalence	I^2 (p-value)
By country	Nigeria	6.65 (4.18, 9.13)	48.1% (0.052)
	Uganda	8.0 (5.53,10.47)	–
	Ethiopia	3.22 (−1.61, 8.05)	92.6 (<0.001)
By study design	Cross-sectional	4.04 (2.62, 5.46)	87.7% (<0.001)
	Cohort	6.92% (1.94, 11.91)	85.6% (<0.001)
By year of publication	2000–2014	7.5% (−1.27, 16.26)	81.1 (<0.005)
	2015–2020	4.34 (2.84, 5.85)	87.8 (<0.001)

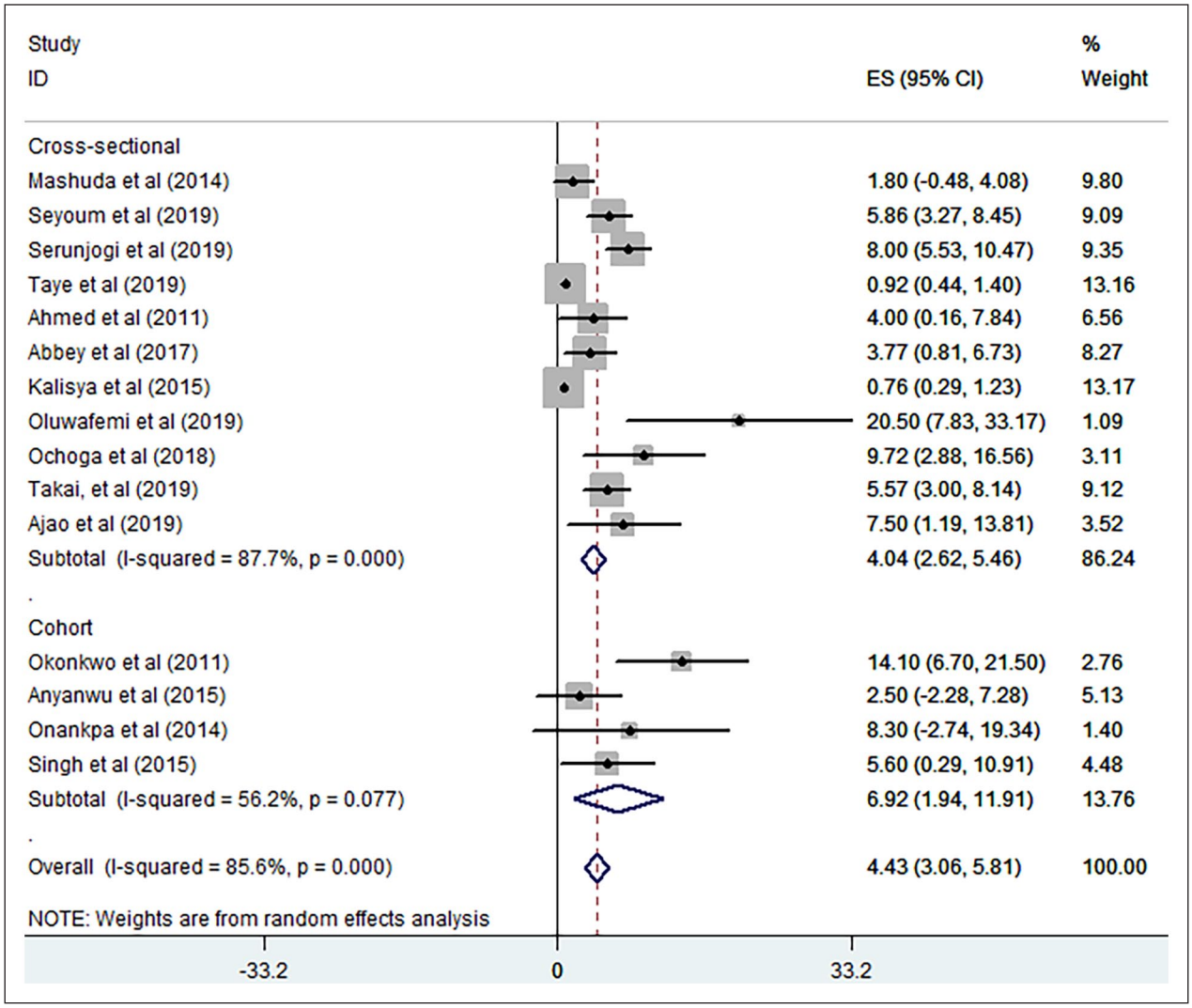

Figure 3. Forest plot showing the subgroup analysis of the pooled prevalence of congenital omphalocele among congenital defect patients based on study design in Sub-Saharan Africa, from January 2000 and December 2020.

congenital defect patients. The prevalence of gastroschisis ranged from 1.34%[31] to 11.10%.[22] The random-effects model analysis from those studies revealed that the pooled prevalence of gastroschisis among congenital birth defect in Sub-Saharan Africa was found to be 3.22% (95% CI: 1.83–4.61; I^2=33.1%; p=0.175; Figure 6).

Discussion

Worldwide, lifelong disability, and mortality of children are the outcome of the adverse effects of congenital birth defects.[35] The prevalence of birth defects among newborn infants was also varied widely in sub-Saharan African

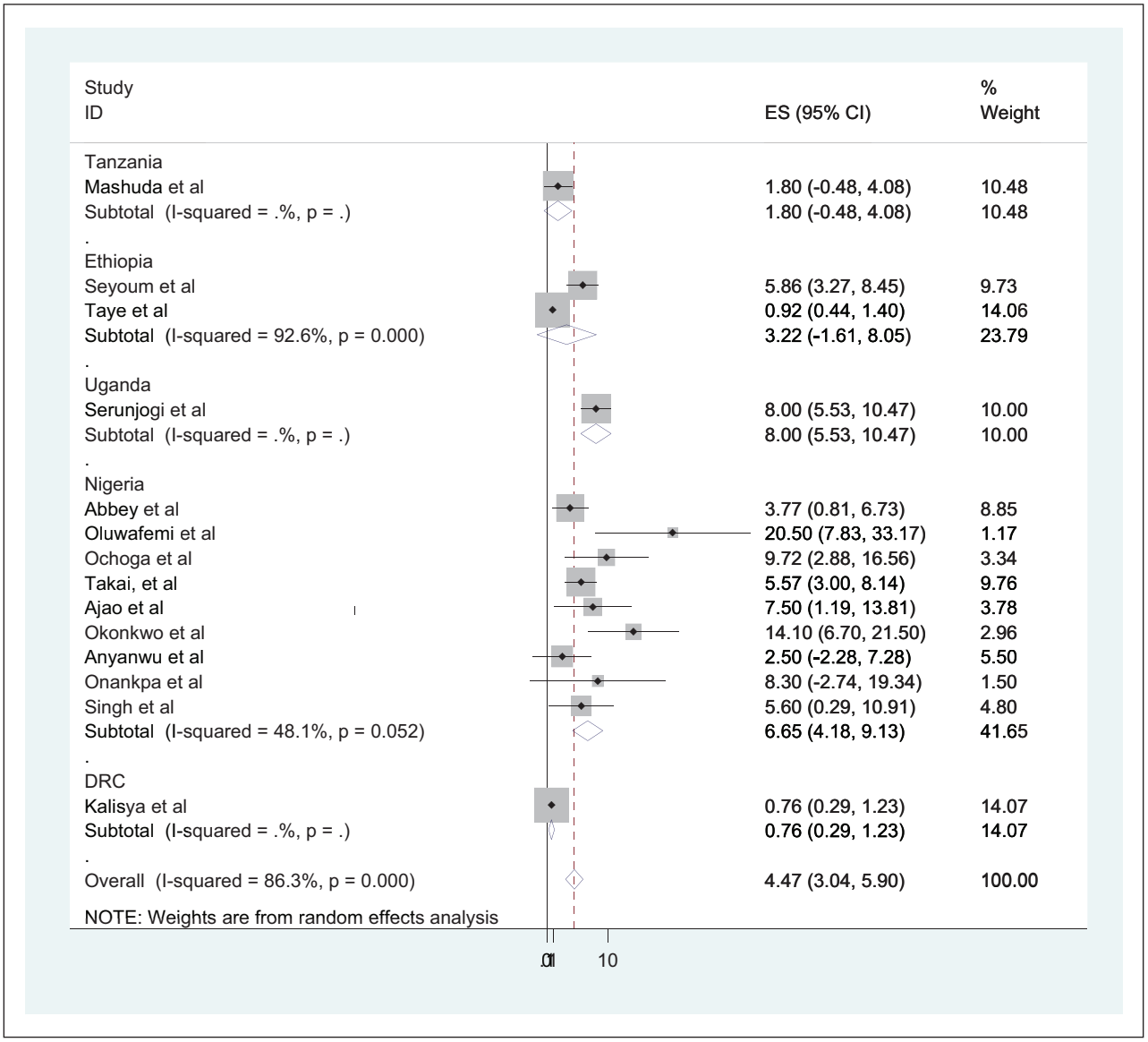

Figure 4. Forest plot showing subgroup analysis of the pooled prevalence of omphalocele among congenital defect patients by country/region in Sub-Saharan Africa, from January 2000 and December 2020.

countries. Gastrointestinal defects are the fourth leading cause of birth defects in Sub-Saharan Africa.[36] The current meta-analyses was tried to estimate the pooled prevalence of major abdominal wall defects (omphalocele and gastroschisis) in Sub-Saharan African countries. This review revealed that the pooled prevalence of omphalocele in Sub-Saharan Africa among births with congenital defect was 4.47% (95% CI: 3.04–5.90). The reason might be due to lack of access to antenatal care and diagnosis in Sub-Saharan Africa contributes to this problem; that is, mothers from low-income countries receives insufficient medical care compared to mothers from high-income countries during pregnancy.[37] Compared with high-income countries, women living in poverty were more likely to smoke, to have poorer dietary habits, lower levels of education, decreased prenatal care attendance, and engage in higher risk and health-demoting practices.[38,39] These factors contribute the risk of developing birth defect. The current review is higher compared to the large scale study conducted in Pretoria, South Africa, in which 0.64% of congenital births were reported.[40] This might be due to the fact that the frequency of pregnancy termination following a prenatal diagnosis of a congenital anomaly is lower in many low-income countries. In part, this difference stems from the fact that elective pregnancy termination following prenatal diagnosis may be less available in certain low-income countries like sub-Saharan countries;[5] 3.22% (95% CI: 1.83–4.61; $I^2 = 33.1\%$; $p = 0.175$).

In this review, the pooled prevalence of gastroschisis is 3.22% (95% CI: 1.83–4.61). The reason might be due to the

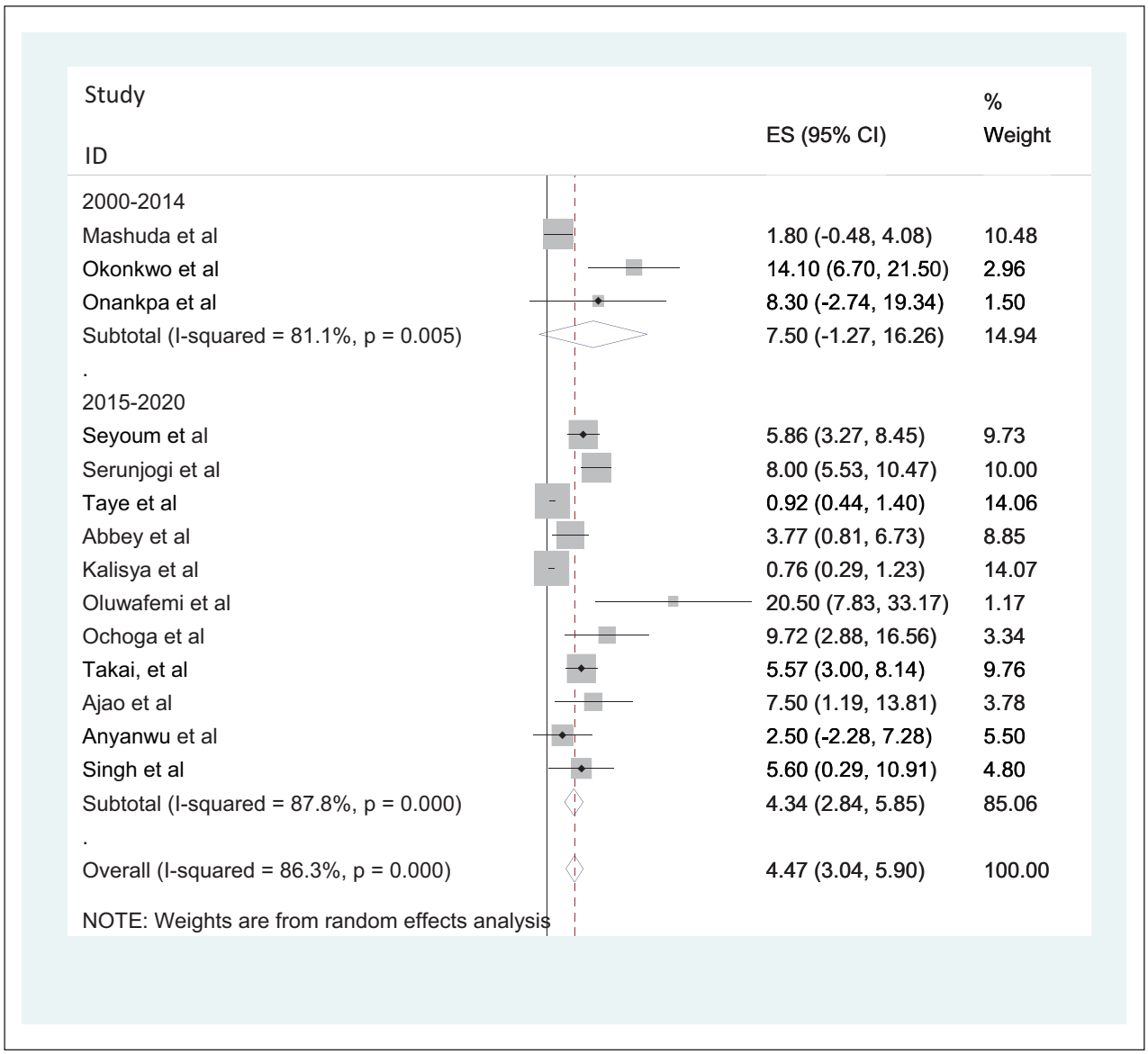

Figure 5. Forest plot showing subgroup analysis of the pooled birth prevalence of omphalocele patients by year of publication in Sub-Saharan Africa, from January 2000 and December 2020.

inaccessibility of prenatal diagnosis and availability of holistic health care between the regions. In addition, very low maternal age is associated with gastroschisis;[41] this supports the current finding that early marriage is most prevalent in Sub-Saharan Africa.[42] Rise in the pooled prevalence of abdominal wall defects in this review might also be associated with taking pregnancy danger drugs, drinking much alcohol, cigarette smoking, and exposure to certain environmental chemicals implicated as causation of congenital anomalies. In addition, parental consanguinity, increasing birth order, and low birth weight might also be the factors contributed for this high occurrence.[43,44]

As a limitation, there may be publication bias because not all gray literatures are included; and language bias since all included studies are published in English. Another foreseeable limitation of this meta-analysis is that it might not really cover the entire sub-Saharan African population. Data from each country were scarce, and studies often do not include indigenous inhabitants and tribes. Moreover, it was not discussed depth since there were no more published literatures related to this study.

Conclusion

Based on the current review, it can be concluded that the pooled prevalence of omphalocele and gastroschisis are high in Sub-Saharan Africa. Therefore, this result assures pregnant women should attend antenatal care service for early detection and management while the healthcare delivery system needs to be accessible and affordable.

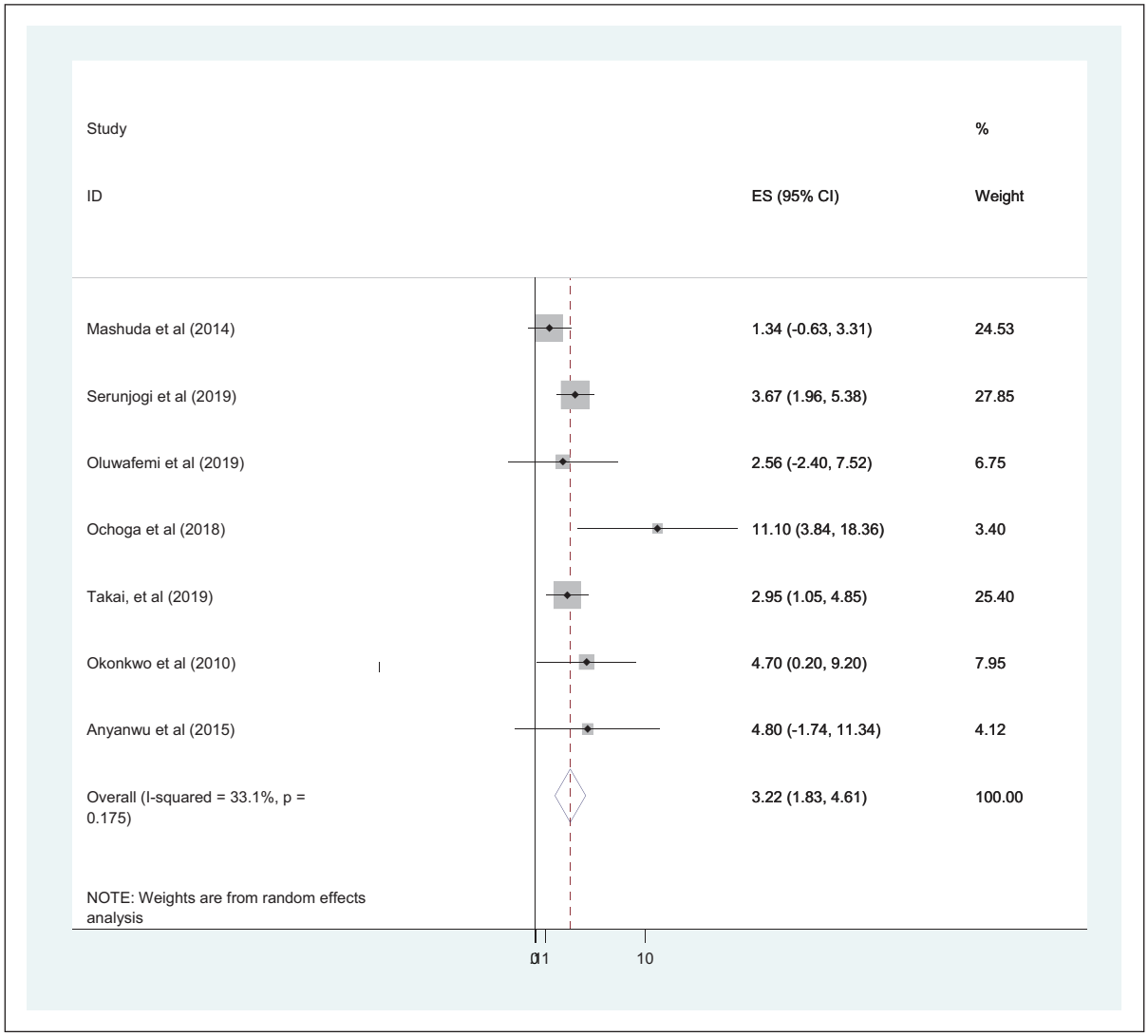

Figure 6. Forest plot showing the pooled birth prevalence of gastoschisis in Sub-Saharan Africa, from January 2000 to December 2020.

Special attention and efforts should be applied for early detection to prevent serious complications and for better prognosis of all forms of abdominal wall defects to reduce the burden in Sub-Saharan Africa. Routine prenatal ultrasonography, determination of biomarkers, and mobilization of the multidisciplinary team should be instituted during perinatal period. Furthermore, early referral of cases of congenital abdominal wall defects is mandatory for better management till establishment of advanced diagnostic centers at different regions of the continent.

Author contributions

All authors contributed significantly to the conception and design, data collection, analysis and interpretation, drafting the article, and critically revising it for important intellectual content, agreeing to submit to the current journal, giving final approval of the version to be published, and agreeing to be accountable for all aspects of the work.

Availability of data and materials

Data are available and it can be accessed from the corresponding author with a reasonable inquiry.

Declaration of conflicting interests

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ORCID iDs

Chalachew Tiruneh https://orcid.org/0000-0003-1976-840X
Mogesie Necho https://orcid.org/0000-0003-0961-7835
Daniel Teshome https://orcid.org/0000-0002-9124-3045

Supplemental material

Supplemental material for this article is available online.

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