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Review Article

Endoscopic third ventriculostomy versus ventriculoperitoneal shunt insertion for the management of pediatric hydrocephalus in African centers – A systematic review and meta-analysis

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ABSTRACT

Background: Ventriculoperitoneal shunt (VPS) insertion and endoscopic third ventriculostomy (ETV) are common surgical procedures used to treat pediatric hydrocephalus. There have been numerous studies comparing ETV and VPS, but none from an African perspective. In this study, we sought to compare outcomes from African neurosurgical centers and review the associated complications.

Methods: The Preferred Reporting Items for Systematic Reviews and Meta-Analyses were used in conducting this study. PubMed, Google Scholar, and African Journal Online were searched. Data on treatment successes and failures for ETV and VPS were pooled together and analyzed with a binary meta-analysis. A clinically successful outcome was defined as no significant event or complication occurring after surgery and during follow-up (e.g., infection, failure, CSF leak, malfunction, and mortality). Seven studies fully satisfied the eligibility criteria and were used in this review.

Results: There was no statistically significant difference between the outcomes of ETV and VPS (OR- 0.27; 95% CI −0.39–0.94, $P = 0.42$). After reviewing the rates of complications of ETV and VPS from the identified studies, four were recurrent. The infection rates of ETV versus VPS were 0.02% versus 0.1%. The mortality rates were 0.01% versus 0.05%. The reoperation rates were 0.05% versus 0.3%, while the rates of ETV failure and shunt malfunction were 0.2% versus 0.2%.

Conclusion: This study concludes that there is no significant difference between the outcomes of ETV and VPS insertion.

Keywords: Endoscopy, Infection, Malfunction, Ventriculostomy

INTRODUCTION

There are not many neurosurgeons in Africa; it has the second highest neurosurgical workforce deficit reported globally.[8] A recent estimate put the ratio of neurosurgeons in Africa to the population at one neurosurgeon to 4,000,000 people. This means that neurosurgical services are unavailable to a large number of people.[24] In addition, the innovations seen in neurosurgery and the neurosciences are not commensurate with the current practices in the developing world, especially in Africa.[24] A lack of health-care funding, lack of neurosurgical equipment, poor health-care planning, lack of resources, lack of encouragement to establish local neurosurgery training, and a lack of adequate local conditions or facilities to enable neurosurgeons to practice properly are some of the factors responsible for the paucity of neurosurgeons and neurosurgery access in Africa.[9,16,18] This situation is worse with pediatric neurosurgery as there are fewer than 15 fellowship-trained pediatric neurosurgeons in Africa.[2]

Hydrocephalus is an enlargement of the ventricles resulting from the inadequate passage or absorption of cerebrospinal fluid (CSF).[17] The prevalence of infantile hydrocephalus varies between one and 32/10,000 births. Today, the population of African children that are <15 years is >535.1 million, and there are about 100,000–200,000 new cases of pediatric hydrocephalus each year in sub-Saharan Africa.[26] Hydrocephalus can be classified in different ways: acquired versus congenital, syndromic versus nonsyndromic,[19] and communicating versus noncommunicating.[6] When hydrocephalus occurs without an obvious extrinsic cause, it is referred to as congenital. When it occurs as a complication of another condition such as hemorrhage, infection, or neoplasm, it is acquired or secondary.[22]

Ventriculoperitoneal shunt (VPS) insertion and endoscopic third ventriculostomy (ETV) are common surgical procedures used to treat pediatric hydrocephalus. In emergency cases, however, external ventricular drainage can be used as a lifesaving procedure while a definitive treatment plan is arranged.[27] ETV involves the creation of a new CSF pathway. This permits the third ventricle to communicate with the CSF spaces surrounding the brain stem. It avoids the risk of hardware infection, colonization, and malfunction associated with shunts, especially useful in low-resource settings.[25] ETV and choroid plexus cauterization (CPC), per Benjamin Warf's reports, has been shown to have promising results in Africa. As a result, this procedure has gained eager attention and cautious support in the developed world.[7,13,25] There have been numerous studies comparing ETV and VPS, but none from an African perspective. In this study, we sought to compare outcomes from African neurosurgical centers and review the associated complications.

MATERIALS AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA guidelines) were used in conducting this study. A guide that included the review question, search strategy, eligibility criteria, and risk of bias assessment was established before the commencement of this review. Papers that compared ETV with VPS in the management of pediatric hydrocephalus in African surgical centers were included in this study. Studies that were not in the English language, from non-African countries and studies that did not compare ETV with VPS systems were excluded from the study. Reviews, meta-analyses, abstracts, conference presentations, commentaries, case reports, and letters to the editors were excluded from the study. Studies that reported data on ETV or VPS alone were excluded from the study. Studies that failed to report disaggregated data on ETV and VPS were also excluded from the study. To identify all eligible articles, a search was conducted from inception to August 2022. PubMed, Google Scholar, and African Journal Online were searched. During the screening process, the references of similar review articles were manually searched for studies that may have been missed by our initial search. The search strategy was jointly devised by the authors and is summarized in Table A1 in Appendix A. The final search results were exported into Rayyan.ai where duplicates were detected and removed after scrutiny.

To ensure consistency, two authors screened each article twice. Where conflicts existed, they were resolved by the third author. The search was broad and it aimed to identify all papers with information on ETV and VPS. The titles and abstracts were screened first, followed by a full-text screening. We extracted the following data: the author, publication year, country, study design, study arms, age, gender, cause of the hydrocephalus, period of follow-up, CSF leak, infection, mortality, reoperation, shunt malfunction, failure of ETV, and successful outcomes. For this meta-analysis, a clinically successful outcome was defined as no significant event or complication occurring after surgery and during follow-up (e.g., infection, failure, CSF leak, malfunction, and mortality). Failure was defined as the occurrence of a postoperative significant event (e.g., infection, failure, CSF leak, malfunction, shunt erosion, and mortality). The primary outcome was defined as the success or failure of the procedure. Raw data on clinically successful outcomes for ETV and VPS were pooled together and analyzed with a binary meta-analysis. All studies were first analyzed together, and then, all observational studies (6/7) were analyzed together. Subgroup analysis based on the risk of bias was also carried out. Tests of heterogeneity were also carried out with the Egger's test and a funnel plot. The meta-analysis feature of IBM SPSS versus 28.0.1 was used. The analysis was carried out with inverse variance, and a random effects meta-analysis was used to account for the heterogeneity of studies. The level of significance was set at 0.05 with a 95% confidence interval.

RESULTS

Seven hundred and fifty papers were excluded after the titles and abstracts were screened, and 16 more studies were excluded after reading and assessing the full texts. Nine studies were excluded because they did not report the outcome of interest, two studies were excluded because they did not report disaggregated data on ETV and VPS, one study was excluded because the study was conducted in a non-African country, while four studies were excluded because the focus of their paper was on ETV alone. Seven articles fully satisfied the eligibility criteria and were used in this review and meta-analysis.[1,5,10-12,14,23] The PRISMA chart is shown in Figure 1. The characteristics of the identified studies are presented in Table 1. The list of excluded studies is reported in the supplementary information.

The observational studies used in this review were evaluated with the Newcastle Ottawa Scale evaluation to determine the risk of bias. The studies are shown in Table 1. Four of the studies scored 8, two scored 7, and one study scored 6.

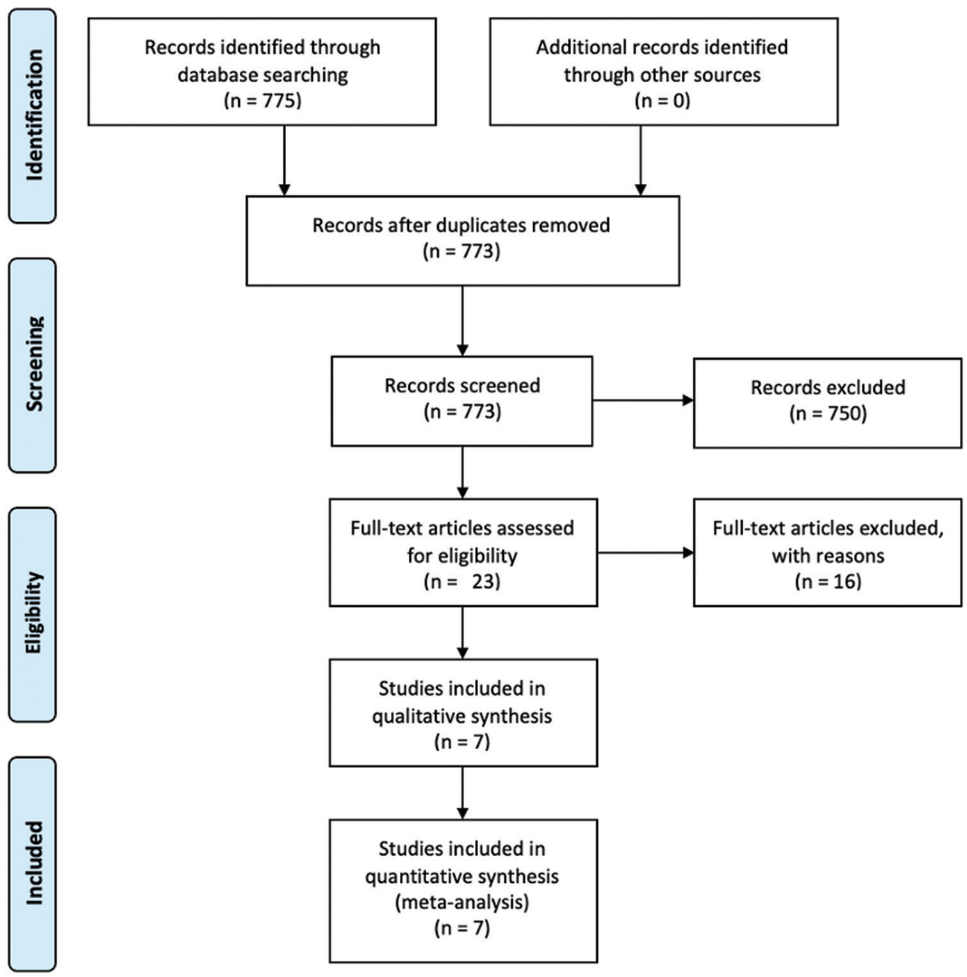

Figure 1: Prisma flow chart

Table 1: Summary of studies.

Studies	Country	Nature of study	Type of study	Study arms	Male (%)	NOS score
Adebayo *et al.*, 2021[1]	Nigeria	Prospective	Cohort	ETV-CPC/VPS	60	7
Uche *et al.*, 2017[23]	Nigeria	Prospective	Cohort	ETV/VPS	67	8
El-Ghandour, 2011[10]	Egypt	Prospective	Cohort	ETV/VPS	ND	8
Kulkarni *et al.*, 2017[12]	Uganda	Prospective	RCT	ETV-CPC/VPS	61	Low risk
Cairo *et al.*, 2018[5]	DRC	Retrospective	Cohort	ETV-CPC/VPS	48	6
Idowu *et al.*, 2009[11]	Nigeria	Retrospective	Cohort	ETV/VPS	59	8
Laeke *et al.*, 2017[14]	Ethiopia	Retrospective	Cohort	ETV/VPS	59	8

CPC: Choroid plexus cauterization, ETV: Endoscopic third ventriculostomy, VPS: Ventriculoperitoneal shunt insertion

Five studies were of high quality while one study had a high risk. There was one RCT among the selected studies. For that study, we used the Cochrane tool. There was no statistically significant difference between the outcomes of ETV and VPS (OR- 0.27; 95% CI −0.39–0.94) $P = 0.42$) after analysis of the seven studies. As there were six observational studies and one RCT, we decided to exclude the RCT from the second analysis and see if there would be any substantial difference. After analysis, there was still no statistically significant difference (OR- 0.47; 95% CI −0.25–1.19) $P = 0.20$); the forest plot can be seen in the appendix as Figure A1 in Appendix A.

We went further to do a subgroup analysis by including only high-quality observational studies (scores of 7–9 on the NOS scale – low risk of bias studies), and still, there was still no significant difference (OR–0.47; 95% CI −0.29 −1.24, $P = 0.23$). The forest plot can be seen in the appendix as Figure A2 in Appendix A. The initial I^2 was 49%, indicating moderate heterogeneity and the Q-statistic was 11.0, $P = 0.088$. After the RCT was removed, however, the I^2 was 41% while the Q-statistic was 7.9, $P = 0.159$ indicating some degree of homogeneity; the funnel plot of the observational studies alone is shown in Figure A3 in Appendix A. Using only the observational studies, we went ahead to test for bias using the Egger's test. The Egger's test for a regression intercept gave $P = 0.852$, indicating no evidence of possible bias. The data showing the summary of clinically successful outcomes for ETV versus VPS are summarized in Table 2. After reviewing the rates of complications of ETV and VPS from the identified studies, four were recurrent. The infection rates of ETV versus VPS were 0.02% versus 0.1%. The mortality rates were 0.01% versus 0.05%. The reoperation rates were 0.05% versus 0.3%, while the rates of ETV failure and shunt malfunction were 0.2% versus 0.2%. The summary data of the complication and their rates are shown in Tables 3 and 4. The forest plot of the seven studies is shown in Figure 2.

DISCUSSION

Our study included 580 African children who had procedures done in African centers. In this study, we sought to compare the successful outcomes between ETV and VPS insertion in the management of pediatric hydrocephalus. Although this subject has been widely published in the literature, we intended to compare these two from an African perspective while paying attention to the findings and experiences from neurosurgical centers across the continent. Interestingly, we found no statistically significant difference in the outcomes. Studies conducted in some African centers also found no significant difference in outcomes between ETV–CPC and ventriculoperitoneal shunting.[12] The rates of complications, when pooled together, were also very low. The rates of CSF leaks, infections, mortality, and failure/malfunction were all below 1%. This is a very important finding and it has clinical

Table 2: Summary of clinically successful outcomes versus complications.

Studies	Sample size ETV/VPS	Clinically successful ETVs	ETV with complications	Clinically successful VPS insertions	VPS with complications
Adebayo *et al*., 2021[1]	23/22	14	9	13	9
Uche *et al*., 2017[23]	25/30	20	5	18	15
El-Ghandour, 2011[10]	32/21	29	3	13	8
Kulkarni *et al*., 2017 [12]	51/49	33	18	37	12
Cairo *et al*., 2018[5]	3/113	3	0	91	22
Idowu *et al*., 2009[11]	29/36	25	4	31	5
Laeke *et al*., 2017[14]	24/77	10	14	38	39

ETV: Endoscopic third ventriculostomy, VPS: Ventriculoperitoneal shunt insertion

Table 3: Summary of complications and complication rates for ETV.

Studies	Sample size ETV	Infection (ETV)	Mortality (ETV)	Reoperation (ETV)	Failure (ETV)
Adebayo *et al*., 2021[1]	23	0	0	ND	0
Uche *et al*., 2017[23]	25	1	1	1	ND
El-Ghandour, 2011[10]	32	0	0	2	2
Kulkarni *et al*., 2017[12]	51	2	1	ND	18
Cairo *et al*., 2018[5]	3	0	0	0	0
Idowu *et al*., 2009[11]	29	1	0	1	0
Laeke *et al*., 2017[14]	24	ND	0	ND	14

ETV: Endoscopic third ventriculostomy

Table 4: Summary of complications and complication rates for VPS.

Studies	Sample size VPS	Infection VPS	Mortality VPS	Reoperation VPS	Malfunction VPS
Adebayo *et al*., 2021[1]	22	4	0	ND	5
Uche *et al*., 2017[23]	30	4	2	6	5
El-Ghandour, 2011 [10]	21	2	1	8	8
Kulkarni *et al*., 2017[12]	49	2	1	ND	12
Cairo *et al*., 2018[5]	113	6	11	0	8
Idowu *et al*., 2009[11]	36	1	2	0	0
Laeke *et al*., 2017[14]	77	18	0	39	21
Total	348	37/348 (0.1%)	17/348 (0.05%)	53/200 (0.3%)	59/348 (0.2%)

VPS: Ventriculoperitoneal shunt insertion

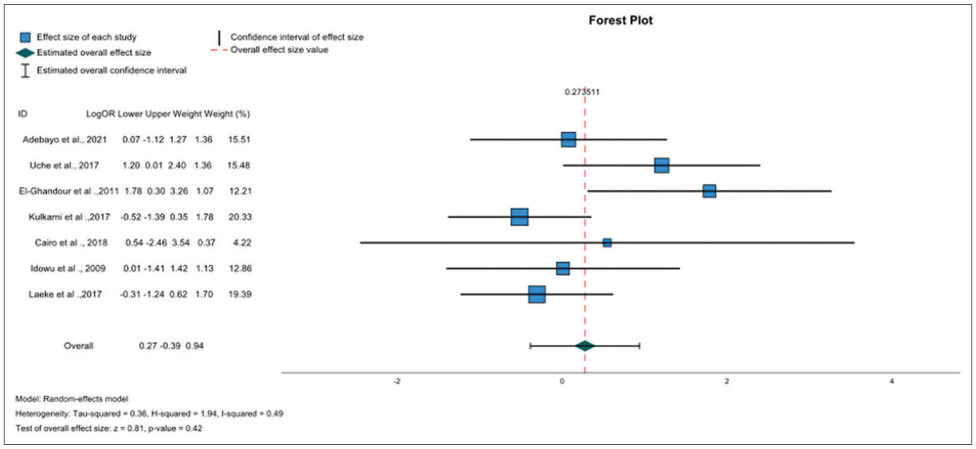

Figure 2: Forest plot of studies.

implications when deciding on the right surgical modality of management for a patient with pediatric hydrocephalus. VPS devices are expensive for families in LMICs, and this is one of the factors that have allowed for the development and widespread use of the Chhabra shunt, which is manufactured in India; the shunt device costs 90 USD.[7] The malfunctioning of this shunt poses a great risk, especially in the developing countries, where rapid emergency systems are often deficient. This complication is responsible for a large percentage of hydrocephalus-related deaths.[4,21] ETV is now gaining popularity in the developing countries because of the ability to leave the patient shunt-free and free of shunt-related complications.

In our study, the failure rates were consistently lower with ETV than they were with VPS. This finding is consistent with other studies in the published literature.[3,10,15,20] This is likely due to the nature of the procedure itself. While VPS involves the use of a foreign body, which is prone to infection and blockage, ETV does not. ETV has become more preferred to VPS because of the lack of a need for foreign body insertion. The failure rates of ETV and shunts have been reported to be very high in low-resource settings and unwanted postoperative surgical events have been said to occur more frequently in LMICs than in high-income countries.[14] This study, however, shows that the overall incidence of complications is low and similar to what has been reported in developed countries. In low-income countries, a VPS is often used as the first choice for managing pediatric hydrocephalus,[14] however, this poses a major challenge as a shunt malfunction can quickly become a neurosurgical emergency and many of these African countries have neither the infrastructure nor workforce to ensure that these cases are managed swiftly. Considering the similarity in outcomes between VPS and ETV, where indicated, it may be beneficial to use ETV as the first choice in managing pediatric hydrocephalus.

The amount of existing research on this subject is exhaustive and many systematic reviews and meta-analyses have provided evidence on this topic. This study, however, is the first to look exclusively at the African literature, to generate evidence that may guide local practices. Regardless, more studies may need to be done on a geographic basis to generate locally relevant guidelines and practices that will improve patient care. Despite the comprehensive nature of this study, we had some limitations. The small sample size and the few African studies covered in this review make generalization difficult. Because we included articles only in the English language and searched three databases, we may have missed potentially relevant papers from nonanglophone countries. The heterogeneity of the studies in terms of how the complications were defined makes it hard to generalize the complications across the board.

CONCLUSION

This study concludes that there is no significant difference between the outcomes of ETV and VP shunt insertion. Considering the findings of this study, it would depend on other factors such as cost, accessibility, the skill, experience, and preference of the operating neurosurgeon when determining a surgical modality for the management of pediatric hydrocephalus. This paper contributes immensely to the African pediatric neurosurgical front and adds more evidence to local practices when managing pediatric hydrocephalus.

Data availability

Data are available on reasonable request.

Ethical approval

Ethical approval was not needed for this paper.

Acknowledgments

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Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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APPENDIX A

Table A1: Search strategy.

Database	Search	Papers
PubMed	(Endoscopic third ventriculostomy) and (ventriculoperitoneal shunt) (“ventriculostomy”[MeSH Terms] or “ventriculostomy”[All fields] OR (“endoscopic”[All fields] and “third”[All fields] and “ventriculostomy”[All fields]) or “endoscopic third ventriculostomy”[All fields]) and (“ventriculoperitoneal shunt”[MeSH Terms] OR (“ventriculoperitoneal”[All Fields] and “shunt”[All fields]) or “ventriculoperitoneal shunt”[All fields])	775
Google Scholar	“Endoscopic third ventriculostomy and ventriculoperitoneal shunt”	The first 100 pages was searched. No additional studies seen.
African journal online	“Endoscopic third ventriculostomy and ventriculoperitoneal shunt”	45 results were seen. No additional study was identified

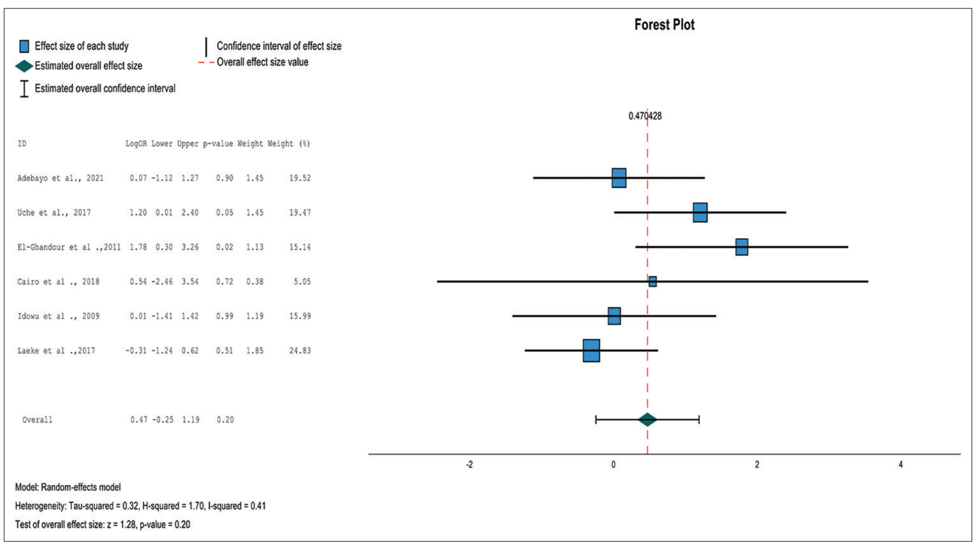

Figure A1: Forest plot depicting only the observational studies.

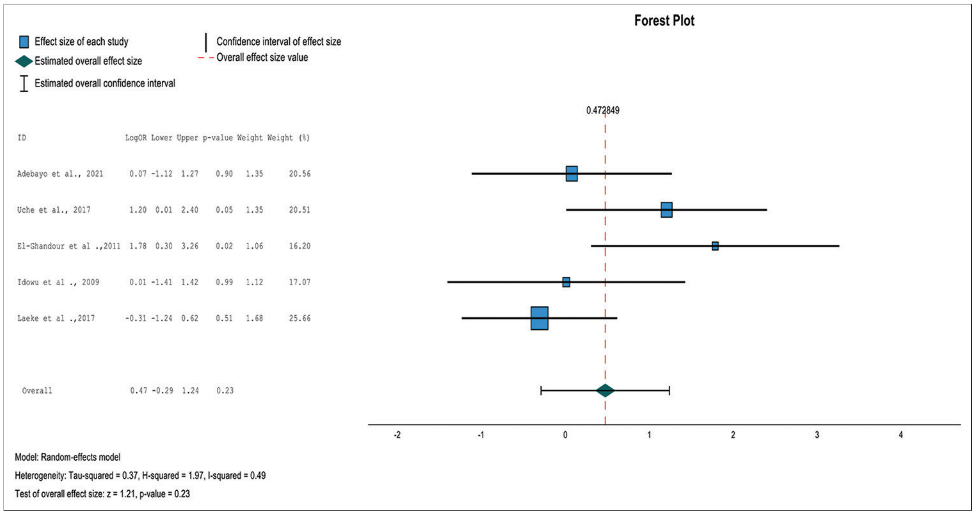

Figure A2: Forest plot depicting only the high-quality observational studies.

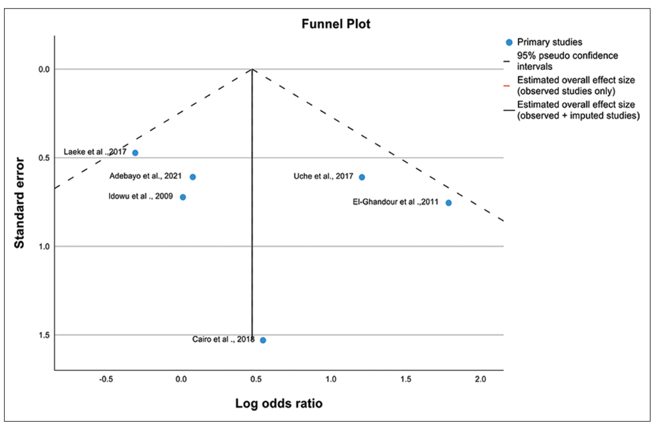

Figure A3: Funnel plot of the observational studies.