Obstet Gynecol Res 2020; 3 (4): 251-263 DOI: 10.26502/ogr047

Research Article

# Birth by Cesarean Section and Academic Achievement in Adolescents: A Randomized Control Trial

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**Received:** 03 October 2020; **Accepted:** 10 November 2020; **Published:** 11 December 2020

**Citation:** Lydia I Eleje, Nkechi PM Esomonu, Florence N Ufearo, Adeline N Anyanwu, Chinyere C Okoye, Okoi A Okoi, Emmanuel O Ugwu, Ekene A Emeka, Onyecherelam M Ogelle, Osita S Umeononihu, Joseph C Umeobika, George U Eleje. Birth by Cesarean Section and Academic Achievement in Adolescents: A Randomized Control Trial. Obstetrics and Gynecology Research 3 (2020): 251-263.

## Abstract

**Background:** Despite the cesarean section (CS) associated morbidities, only few studies have focused on long-term associations for children delivered by CS. Although some previous studies have suggested association between CS and neurodevelopmental disorders leading to poor academic achievement, none were randomized in design and findings could be at high risks of performance or detection bias. Also, most previous studies suffer from a long-term follow-up time and a lack of adjustment for major confounders.

**Objectives:** To determine the impact of CS birth route on academic achievement among adolescents.

**Materials and methods:** A randomized control trial was conducted in consenting 210 senior secondary 3 students offering economics in four coeducational schools. The mode of delivery was categorised as: vaginal delivery (VD), and cesarean section (CS). Following an initial base line pretest assessment, coeducational schools were randomized into 4 different arms viz Diagnostic Quantitative Economics Skill Test (DQEST) with feedback and remediation (CS=8; VD=52), DQEST with feedback (CS=4; VD=58), DQEST without feedback and remediation (CS=8; VD=35), and no DQEST, (CS=8; VD=37). Seven weeks post-intervention, posttest was done on all the participants to ascertain effect of CS on academic performance. The exclusion criteria were refusal of follow-up and students inability to know their route of birth. The students' pretest and posttest scores were obtained using a Test of Achievement in Quantitative Economics (TAQE) comprising of 20 multiple-choice questions. Analysis was by SPSS version 23. A p-value ≤0.05 was taken as significant.

**Results:** Of the 210 students randomized, 28 were delivered via CS while 182 were delivered via VD. The mean age was 18.6 ± 3.1 years (16-20 years). The result of pretest revealed no significance difference in the performance between adolescents that were delivered via CS and those delivered via VD in each of the group (P>0.05, for all). Post test results showed that among participants that were randomized into the control group that did not receive any of diagnostic test, feedback or remediation, adolescents delivered via CS performed significantly lower compared with those that had VD (p=0.0393).

**Conclusion:** Without diagnostic test, feedback and/or remediation, adolescents delivered by CS had significantly lower academic achievement. Further research is needed to check the consistency of findings and to identify whether the relationship is causal.


**Keywords:** Academic; Adolescent; Diagnostic Test; Feedback; Remediation

## 1. Background

Delivery by cesarean section (CS) is a common global obstetrics procedure. The increasing admiration and demand for the procedure has become a societal concern in many countries [1]. Cesarean section was originally a surgical solution to solve the problems associated with problematic labor, but at present, the procedure knows no bounds. This increasing popularity has led to a rapid growth in the number of CS operations worldwide. Recent studies have revealed an alarming increase in the incidence of CS [2] and its repeat following a previous CS [3]. The incidence currently ranges between 20–30% [4]. In the United Kingdom, the proportion of births delivered by CS has increased from 18% in 1997 to 25% in 2010 [5], and in the USA, CS rates vary from 7% to 70% between different hospitals [6, 7]. A recent World Health Organization report has shown that the CS rate in high-income countries have far exceeded the 15% recommended by the WHO [5]. It has been

hypothesized that birth by CS leads to changes in psychological development, due to preterm births [8, 9] or modifications in anxiety response or micro biota [10].

The influence of births by CS on children's psychology is not fixed but may vary at different stages of development and periods of growth [1]. Considering the rate at which CS is swiftly increasing, does this obstetric mode of childbirth among adolescents have any academic implications? This answer is yet to be addressed fully in randomized studies. Despite the CS associated morbidities, only few studies have focused on long-term associations for children delivered by CS [5, 11, 12]. Although some previous studies have suggested association between CS and neuro-developmental disorders leading to poor academic achievement, most were cohort in design (without randomization) and thus, the study findings could be at high risks of performance and/or detection biases [5, 11, 12]. Also, most previous studies suffer from a long follow-up time and a lack of adjustment for major confounders. A randomized control trial involving CS births and academic achievements at long follow-up time (adolescent period) is thus required. This study was therefore aimed at filling the research gaps. We therefore decided to assess the impact of birth by CS on academic achievement among adolescents.

## 2. Methods

### 2.1 Study site

The study site involved four secondary schools drawn from the four local government areas (LGAs) in Anambra State, Nigeria.

### 2.2 Study design

A randomized controlled trial.

### 2.3 Study population

This involved a population of 755 Senior Secondary 3 (SS3) students offering economics in the 37 public coeducational secondary schools in the four LGA during the 2018/2019 academic session.

### 2.4 Sample and sampling technique

A 'sample' of 210 SS3 students that offer economics from the four coeducational schools were drawn. From each LGA, a school was selected using purposive sampling technique. Thereafter, participants' allocation of the selected schools to four experimental groups was done by randomization which was performed by using randomly permuted blocks with the software available online at http://www.randomization.com. The participants' allocation never changed after assignment. The first group (Experimental group I) was exposed to diagnostic test with feedback and remediation intervention, the second group II (Experimental group II) received Diagnostic Quantitative Economics Skill Test (DQEST) with feedback intervention, the third group (Experimental group III) was given diagnostic test only intervention, and the control group (Experimental group IV) had no intervention (neither diagnostic test with feedback and remediation, diagnostic test with feedback only, nor diagnostic test only).

### 2.5 Instrument for data collection

The two validated instruments titled DQEST and Test of Achievement in Quantitative Economics (TAQE) were used in this study. DQEST and TAQE were existing instruments developed by experts in test construction as reported by Esomonu and Eleje in 2017, and Eleje and Esomonu in 2018 respectively [13, 14]. DQEST and TAQE were made up of 50 and 20 multiple choice questions respectively in the nine sub-skills of secondary school quantitative economics. DQEST served as the intervention to the treatment groups while TAQE served as the pretest and posttest.

### 2.6 Inclusion criteria

All consenting SS3 students, offering economics in the four selected schools were included.

### 2.7 Exclusion criteria

This included inability of a student to complete the experimental procedure, and students' failure to know their route of birth.

### 2.8 Procedure

The trained research assistants (economics class teachers) in each of the selected schools administered the pretest (TAQE) to the groups to ascertain the extent of students' Achievement prior to the intervention proper. Intervention was provided for 7 weeks. A week afterwards, posttest was given to the students. The posttest was the same as the pretest but the item numbers were rearranged. The interventions which lasted for seven weeks during the school usual periods was given by the research assistants with the researchers monitoring and supervising. The interventions given to the experimental groups were as follows:

**2.8.1 Experimental group I (diagnostic test with feedback and remediation group):** In this group, DQEST was administered, followed by feedback (knowledge of their performance in the DQEST) with remediation. The feedback method was in the form of verification- simply stating whether the answer is correct or incorrect.

- First, the researcher and the teacher confirmed whether students' response to an item is correct or incorrect. The researcher and the teacher conveyed this information by marking each student's answer script (responses to items) to indicate its correctness (e.g., with a check mark).
- Marked answer script of students' responses to the items in DQEST were given back to each student in the treatment groups I and II as a feedback.
- As part of the feedback, research assistant provides direct information to each student about the sum of their correct response to the items by writing their total score on their answer script.
- The aim of the remediation was to provide learning support to students who gave an incorrect answer to DQEST items for an improved performance. The remediation was in the form of class discussion to solve and to identify correct answer to each item of the nine sub-skills in the DQEST.
- To enhance meaningful learning situations during the remediation, seat arrangements of students were flexible to meet the specific purposes of each remediation session/learning activity. For example, students who performed poorly in each sub-skill were allowed to sit on the front row of the class during the remediation session.
- Any of the students with good performance in a sub-skill were called upon to become 'little teachers' who lead the class discussion in solving the items in each sub-skill on the board.
- The teacher provided guide or assisted where the need arises.
- Teachers encouraged students' active participation in class by solving more examples/excises on a sub-skill that the students find very difficult/had poor performance. That is, where forty percent (40%) of the students could not answer correctly at least half of the questions in each of the nine sub-skills in DQEST.
- Students were encouraged to provide answers to the questions among themselves.

- Students were allowed to ask questions on difficult (or gray) area(s).
- The teacher summarized the main steps in solving.
- The teacher encouraged remedial students to write on their note books the steps in solving a problem so that every student may understand the instructions.
- Another student was called upon to lead the class discussion in solving the items in the next sub-skill and the steps above were repeated.
- At the end, students' scripts were collected back from them.

**2.8.2 Experimental group II (diagnostic test with feedback group):** In this group, DQEST was administered, followed by feedback (knowledge of their performance in the test). There was no provision for remediation.

**2.8.3 Experimental group III (diagnostic test only group):** In this group, there was an application of the DQEST with no provision of feedback from students' performance and no discussion (remediation).

**2.8.4 Experimental group IV (on-diagnostic test group):** In this group, only the pretest and posttest was partaken by the students. This group did not receive any of diagnostic test, feedback or remediation. The students in all the groups received the posttest at the same time, that is, 7 weeks after initiation of the intervention.

### 2.9 Outcome assessment

The primary outcome measures were the mean scores for students following diagnostic test with feedback and remediation, and mean scores for students following diagnostic test with feedback only. The secondary outcome measures were the mean scores for students following diagnostic test only and mean scores for students following no intervention (neither diagnostic test with feedback and remediation, diagnostic test with feedback only, nor diagnostic test only).

### 2.10 Sample size determination

No formal sample size calculations were made because of the pilot nature of the study.

### 2.11 Ethical consideration

Permission to conduct this study was obtained from the State ministry of Education and the Local government Educational Commission (approval number AN/18/008; Approval date: 2nd February, 2018). The Principals of each of the schools that participated in the study also gave consent. For children between 12 and less than 18 years, the assent was obtained. Written consent was obtained for those 18 years and older.

### 2.12 Statistical analysis

The collected data were analyzed with t–test and ANCOVA using Statistical Package for Social Sciences version 23.0 (SPSS Inc., Chicago, IL, USA) and the rejection or acceptance of the stated hypotheses was at p-value <0.05 level of significance. Where a null hypothesis was not accepted, Bonferroni's Post Hoc analysis was conducted.

## 3. Results

Of the 219 adolescents that were assessed for eligibility for the study, 7 declined to participate in while 2 did not meet the inclusion criteria. Therefore, 210 adolescents offering economics as a subject were randomized into study groups. Of the 210 students randomized, 28 were delivered via CS while 182 were delivered via VD. Of those delivered via CS, 17 (60.7%) was by emergency CS while 11 (39.3%) was by elective CS. The socio-demographic characteristic of the participants is shown

in Table 1. The mean age was 17.6 ± 3.1 years (range: 16-20 years); 17.7 ± 3.7 years for those born by CS and 17.5 ± 4.8 years for those born by VD. Of the 210 students, 86 (41.0%) were males and 124 (59.0%) were females. Overall, the result of pretest revealed no difference in the academic achievement between students delivered via CS and those delivered via VD (P=0.210). Post test results showed that among adolescents that were in on-diagnostic test group or the group that did not receive any of feedback or (control group), those delivered via CS performed significantly lower compared with those that had VD (p=0.0393). Table 1 also shows the mean scores from posttest which was compared by route of delivery. In Table 2, the primary and secondary outcomes by experimental groups were compared. The summary of interpretations from Table 2 were that the differences in the performance between the CS and VD in groups 1, 2 and 3 were not significant. The result is the same for the three experimental groups. This strengthens the summary of interpretation in Table 1 for baseline characteristics. The analysis of covariance (ANCOVA) between pretest and posttest scores within the groups is shown in Table 3. Table 4 shows the pairwise comparisons between the four groups. The summary of the interpretations in Table 4 is that, only group 14 had significant effect when compared with groups 2, 3, and 4. Figure 2 shows the graphical covariates between mean posttest scores and birth route.

| Variables | CS Group (N=28) | VD group (N=182) | RR (95%CI) | P-value |
|---|---|---|---|---|
| Mean Age | 17.7 ± 3.7 years | 17.5 ± 4.8 years | | 0.833 |
| Gender | | | | |
| Male | 16 (57.1) | 70 (38.5) | 1.92 (0.96-3.86) | 0.062 |
| Female | 12 (42.9) | 112 (61.5) | | |
| Mean Pretest score | 5.1 ± 2.0 | 5.4 ± 2.0 | | 0.461 |
| Mean Posttest score | 6.0 ± 2.0 | 6.6 ± 2.4 | | 0.210 |

**Table 1:** Socio-Demographic Characteristics of the Participants.

| Parameter | Caesarean section | Vaginal Delivery | P-value |
|---|---|---|---|
| Primary outcomes | | | |
| Experimental group I (Diagnostic test with feedback & remediation) | 8.25 ± 0.886 | 8.60 ± 2.098 | 0.6452 |
| Experimental group II (Diagnostic test with feedback) | 4.50 ± 0.577 | 6.09 ± 2.327 | 0.1808 |
| Secondary outcomes | | | |
| Experimental group III (Diagnostic test only) | 6.25 ± 1.282 | 5.54 ± 1.837 | 0.3079 |
| Experimental group IV (No treatment group) | 4.05 ± 1.389 | 5.57 ± 1.908 | 0.0393 |

**Table 2:** Comparison of Primary and Secondary Outcomes By Study Group.

| | | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|---|
| Posttest * Expgroups | Between Groups | (Combined) | 359.181 | 3 | 119.727 | 29.528 | .000 |
| | | Linearity | 271.648 | 1 | 271.648 | 66.995 | .000 |
| | | Deviation from Linearity | 87.534 | 2 | 43.767 | 10.794 | .000 |
| | Within Groups | | 835.276 | 206 | 4.055 | | |
| | Total | | 1194.457 | 209 | | | |
| Pretest * Expgroups | Between Groups | (Combined) | 24.203 | 3 | 8.068 | 2.148 | .095 |
| | | Linearity | 10.790 | 1 | 10.790 | 2.873 | .092 |
| | | Deviation from Linearity | 13.413 | 2 | 6.706 | 1.786 | .170 |
| | Within Groups | | 773.721 | 206 | 3.756 | | |
| | Total | | 797.924 | 209 | | | |

**Table 3:** The ANCOVA Between Pretest and Posttest Scores Within The Groups.

| (I) Expgroups | (J) Expgroups | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| expg1 | expg2 | 2.969* | .623 | .000 | 1.309 | 4.630 |
| | expg3 | 2.545* | .529 | .000 | 1.136 | 3.954 |
| | expg4 | 3.455* | .528 | .000 | 2.049 | 4.861 |
| expg2 | expg1 | -2.969* | .623 | .000 | -4.630 | -1.309 |
| | expg3 | -.424 | .630 | 1.000 | -2.104 | 1.255 |
| | expg4 | .485 | .628 | 1.000 | -1.188 | 2.159 |
| expg3 | expg1 | -2.545* | .529 | .000 | -3.954 | -1.136 |
| | expg2 | .424 | .630 | 1.000 | -1.255 | 2.104 |
| | expg4 | .910 | .536 | .547 | -.519 | 2.339 |
| expg4 | expg1 | -3.455* | .528 | .000 | -4.861 | -2.049 |
| | expg2 | -.485 | .628 | 1.000 | -2.159 | 1.188 |
| | expg3 | -.910 | .536 | .547 | -2.339 | .519 |

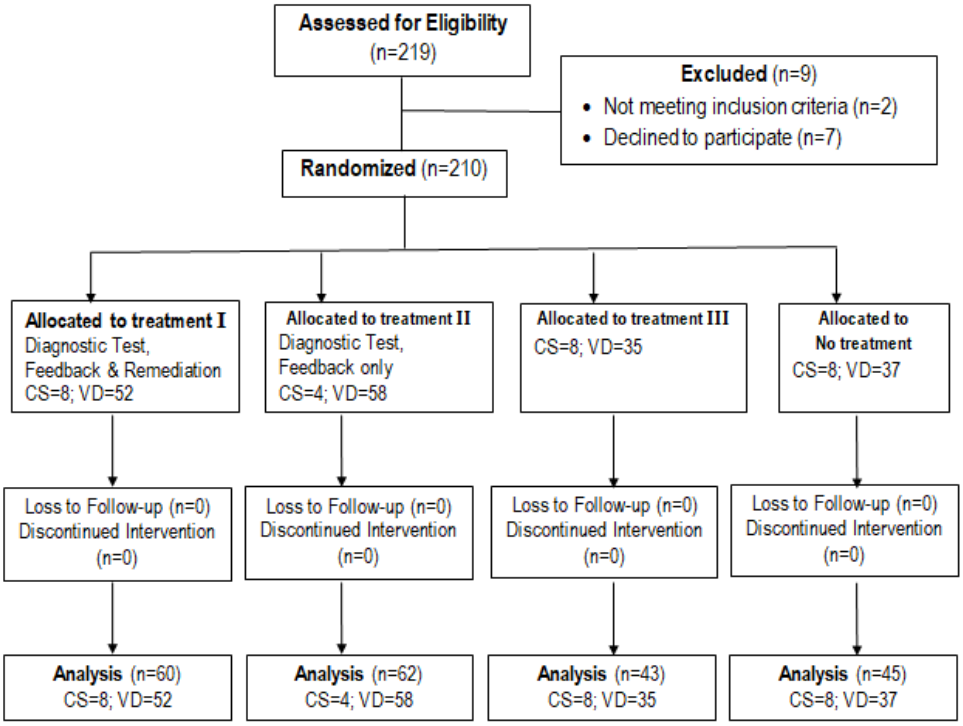
Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

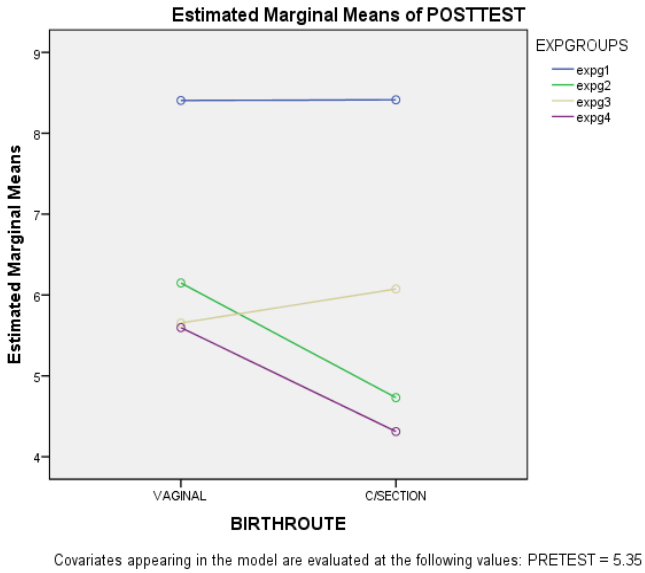
Abbreviations: expg1: Experimental group I (Diagnostic test, feedback & remediation); expg2: Experimental group II (Diagnostic test & feedback); expg3: Experimental group III (Diagnostic test only); expg4: Experimental group IV (No treatment)

**Table 4:** Pairwise Comparisons Between The Four Groups.




List of abbreviations: Treatment I: Diagnostic Test with feedback and Remediation; Treatment II: Diagnostic Test with Feedback; Treatment III: Diagnostic test only; CS: Caesarean Section; VD: Vaginal Delivery

**Figure 1:** Flow chart of the participants.




Abbreviations: expg1: Experimental group I (Diagnostic test with feedback & remediation); expg2: Experimental group II (Diagnostic test with feedback); expg3: Experimental group III (Diagnostic test only); expg4: Experimental group IV (No treatment)

**Figure 2:** Graphical Covariates between mean Posttest scores and Birth route.

## 4. Discussion

We assessed the impact of obstetric mode of delivery, and in particular birth by CS on students' achievement in quantitative economics. We have provided the significant insight into the academic success of adolescents that can be modulated by delivery options. The principal finding is that birth by CS was significantly associated with poor academic achievement among the control group that did not receive any intervention/treatment (i.e. diagnostic test with feedback and remediation, diagnostic test with feedback, and diagnostic test only). However, birth by CS was not significantly associated with poor academic achievement among the students that received at least one of the interventions - diagnostic test with feedback and remediation, diagnostic test with feedback, and diagnostic test only. The mean scores among adolescents born by elective and emergency CS was not significantly different ($p>0.05$). These observations were similar to a previous study by Curran et al which showed that there was an association between birth by CS and school performance [5]. However, as shown in Curran et al study, this effect was quite small and was only seen among adolescents that did not receive any of the interventions. This study finding not only suggests that diagnostic test with feedback and remediation, diagnostic test with feedback, and diagnostic test only appears to be an academic achievement enhancer in cases of children born by CS but further affirms the positive impact diagnostic testing have on students' academic achievement [15].

There are several plausible elucidations for an observed significant association between birth by CS and lower academic achievement in ordinary classroom setting. This is because a number of factors could influence academic achievement, such as cognitive ability, personality and anxiety [5, 16]. It could also be influenced by indications for the CS in the first place. For instance, apart from maternal indications, fetal heart rate abnormalities or fetal distress may be indications for elective or emergency CS [17], and this may also have an impact on academic achievement [18-20]. Additionally, it should be noted that this study was conducted in a country where the populations have relatively high aversion for CS [21]. This is corroborated in this study as a greater number (60.7%) of adolescents born by CS was done as emergency cases. It could be that their mothers resorted to CS as their last resort after initial refusal to the surgery. Cases with elective CS could also be due to strong medical indications or contraindications to vaginal deliveries. It has been shown that delay in taking decisions for CS is related to adverse neonatal outcomes following CS. Our findings may therefore not be spontaneously generalizable in settings where there is less aversion for CS.

Nor is it all. Another conceivable reason for lower academic achievement in children delivered through CS compared to the normal controls could be traceable to the impact of nutrition on brain development during the period of infancy [22, 23]. Physiologically, brain development is never complete in-utero but continues after birth. Cholesterol is a critical requirement for brain development in infants especially during the first few weeks of life as demonstrated in a previous study [23]. In a previous study by Hardy et al, it was noted that deficiency in the amount of long-chain fatty acids in the diet during infancy may affect the maturation of the central nervous system, including visual development and intelligence [23]. In their studies on the impact of CS on human lactational physiology, Ufearo et al were able to show that CS procedures induced a significant depression in the ability of the mammary gland to secrete cholesterol and lactose in the breast milk during the first few weeks of postpartum [24]. The depression was strong enough to induce a "cholesterol escape" or

an outburst in breast milk cholesterol secretion as part of a recovery process after about seven weeks of depression. It is possible that the CS-induced alteration in cholesterol secretion in breast milk during this critical period of infant brain development may have contributed to the observed lower academic achievement in CS-delivered subjects in this study.

Another explanation is that CS births influence cognitive outcomes via the gut-brain axis as demonstrated by the alteration in the composition of the early infant gut microbiota. Thus, a very recent study by Slykerman et al that evaluated whether birth by CS was associated with academic achievement revealed that National Certificate of Educational Achievement examination undertaken by secondary students in New Zealand were lower in adolescents delivered by CS (Estimate = -0.37, 95% CI: -0.69 to -0.06), although this was not significantly associated following a fixed effect sibling analysis [25]. The authors of Slykerman et al study further concluded that even if the infant gut microbiota is reformed during CS, it does not seem to have a measurable impact on adolescent academic achievement [25]. This appears to differ from our present study probably due to the randomized control design of our study or due to different study location.

This study has a number of strengths. For instance, it is randomized controlled in design and this may have reduced the risks of detection and performance bias. This is also the second time the issue on the effect of birth by CS and academic achievement among adolescents is being studied. Thus, this study has provided an interesting argument that CS may cause impairment of the academic achievement of the children to compare to normally delivered children. The present study also has several limitations. First, we had no data on breastfeeding, nutritional status, body mass index, and intelligent quotient which have been correlated with academic achievement in a previous study [22]. Second, a range of factors affect students' achievement, and we cannot rule out a potential effect on more specific outcomes, such as anxiety and intelligent quotient. Although some previous studies have revealed that mode of delivery did not have an impact on childhood neurodevelopment [26, 27], results on behavioral difficulties are conflicting [28]. In fact a recent systematic review and meta-analysis by Zhang et al concluded that children born by CS are associated with an increased risk of autistic syndrome, regardless of the modality of CS, compared to those born by VD [29]. Though we did not have data on the indications for the CS in this study, we were able to separate emergency and elective CS, which had no influence on our findings.

## 5. Conclusion

Without diagnostic test, diagnostic test with feedback, and diagnostic test with feedback and remediation, adolescents delivered by CS had significantly lower academic achievement compared to those born by VD. Establishment of diagnostic tests with or without, feedback and or remediation improves their schools' achievement to be at par with those that were born vaginally. This suggests that diagnostic tests with feedback and remediation should be introduced in all curriculums to enhance maximum academic achievement for all adolescents regardless of birth route. This is a pilot study, so further research is needed to check the consistency of these findings and to identify whether the relationship is causal.

## Acknowledgements

The authors appreciate the help of the principals and teachers of the Secondary Schools that participated in the trial. We also appreciate the parents and guardian of the students that agreed for the study. We would like to acknowledge the efforts of all the students who partici-

pated in the study.

## Authors' Contributions

LI Eleje, NPM Esomonu, FN Ufoaroh, AN Anyanwu and GU Eleje were involved in the overall conceptual design and implementation of the project, and overall revision of the manuscript. CC Okoye, OA Okoi, EO Ugwu, EA Emeka, OM Ogelle, OS Umeononihu and JC Umeobika were involved in the writing of this manuscript and overall revision. The authors read, approved the final manuscript and agree to be accountable for all aspects of the work.

## Funding

The research was self-sponsored by researchers.

## Availability of Data and Materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Ethics Approval and Consent to Participate

Approvals and permissions were obtained from the authorities of the selected facilities. An informed consent were obtained from each study participant prior to the involvement in the study. The collected data were kept confidential and accessed only by the research team member.

## Consent for Publication

Not applicable.

## Competing Interests

The authors declare that they have no competing interests.

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