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# Gender difference in secondary school students' retention in algebra: A computer simulation approach

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**Abstract**

This research examined how well learners retained algebra concepts after using a computer simulation program. Two research questions and two hypotheses guided the study. A quasi-experimental design was employed. The population consisted of 2,152 junior secondary school two (JSS 2) students from the Udenu Local Government Area in Enugu State. 115 students from two co-educational schools were the study's sample. Each school had two streams of JSS 2 classrooms, with the experimental and control groups being randomly assigned. The algebra achievement test, which has a reliability score of 0.88, was used to gather the data for this study. The statistical package for social sciences software was used to analyze the collected data. According to the data, students taught algebra using computer simulation had considerably higher average retention scores compared to learners taught utilizing the traditional method. The data revealed furthermore that, a significant gender difference occurred in the mean retention scores of students taught algebra concepts utilizing computer simulation.

**Keywords:** computer simulation, gender, mathematics, retention, school students

## INTRODUCTION

Mathematics is the study of structures, patterns, change, and space. It also involves the study of numbers and statistics. Learners receive the necessary training in mathematics to solve related mathematical problems in their daily lives. The importance of mathematics in daily life cannot be overemphasized. The secondary mathematics curriculum in Nigeria is structured on a few main subjects, including number and numeration, algebra, and so forth (Inweregbuh et al, 2020; Okeke et al., 2022a, 2022b). However, at the junior secondary school level, learners' achievement and retention in mathematics, particularly algebra, have generally been low (Nzeadibe et al., 2019, 2020). For instance, Onyeka and Arokoyu (2018) looked at the trend of students' mathematics performance in Nigeria's West Africa certificate examination from 2010 to 2015 and discovered that students' mathematics performance in Nigeria has remained consistently poor over time, with less than half of the candidates passing at credit. Students' mathematics achievement was dismal, as evidenced by the chief examiners' reports from 2014 to 2018 (West African Examination Council [WAEC], 2018).

Mathematics scholars have identified factors that cause poor achievement and retention of secondary school students in mathematics over the years, some of which have been linked to the following; math anxiety and students' negative attitudes toward mathematics (Sarfo et al., 2020, 2022), the harshness of the mathematics teacher while teaching mathematics, students' laziness and indiscipline towards mathematics, teachers' negative attitudes toward mathematics, students' poor mathematical foundations, overcrowded mathematics courses, lack of instructional materials, poor/inappropriate teaching method adopted by teachers and worn-out mathematics resources (Egara et al., 2018, 2022; Evans et al., 2019; Jameel & Ali, 2016; Karigi et al., 2015; Kumah et al., 2016; Okeke et al., 2023a, 2023b; Osakwe et al., 2023a, 2023b; Wachira, 2016). One of the factors listed as the cause of learners' poor mathematics achievement was the adoption of inappropriate teaching methods by teachers (Mosimege & Egara, 2022). These inappropriate teaching methods,


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**Contribution to the literature**

- This research study makes a significant contribution to the field of mathematics education because it is the first to the effect of computer simulation on students' retention in algebra in Udenu LGA in Enugu State, Nigeria.
- The study revealed a significant gender difference in students' retention of algebra concept using of the computer simulation approach.

which do not improve students' retention, have been attributed to the continued use of the traditional method in mathematics instruction and learning (Nzeadibe et al., 2022).

Retention in this study refers to the capacity to remember tasks or knowledge acquired. The capacity to recall knowledge or information learned after learning is known as retention (Bichi, 2002). It is a crucial component of learning, especially in the subject of mathematics, where solving new problems necessitates both the application of previously taught concepts and the synthesis of new notions. The capacity to comprehend what has been learned or observed determines the capacity to remember or forget. Thus, retention is an essential component of learning (Ogbonna, 2007; Samuel, 2009). The effectiveness of the teaching strategy adopted, according to Ugwuanyi (2009), has a significant impact on how well students retain and remember what they are taught. According to Nneji (2011), retention is largely influenced by the teaching approach used by mathematics instructors. Using an efficient educational delivery method rather than rote memorization will increase retention (Iji, 2012). Given that computer simulations are a successful teaching tool for improving students' mathematics achievement (Egara et al., 2018), students' mathematics retention could be preserved by the implementation of a suitable teaching method such as the computer simulation approach.

A program that seeks to mimic or simulate an abstract system model is known as a computer simulation. Non-human equipment called a computer simulation package is in charge of providing new subjects in a well-structured way and effortlessly integrating practice and drill into the learning process (Olaniyan & Salman, 2015). Computer simulation involves creating a model of a real-world scenario and using a computer to anticipate how that scenario will turn out (Jayantha, 2018). It is designed specifically to help students visualize abstract concepts and developmental models of an observed phenomenon as a result of the integration of new information obtained in the simulation learning environment with previous information, making it useful for both teaching and learning abstract concepts (Akhigbe & Ogufere, 2019). A computer simulation is a program that replicates or simulates a non-concrete model of a specific subject to assist pupils in grasping complex ideas and applying what they have learnt (Ibezim & Asogwa, 2020). A computer simulation is a program that develops animated, interactive, and game-like environments to link actual events with the science that supports them (Lasisi et al., 2021). Computer simulation models can replicate features of the world or the universe that would be prohibitively expensive, dangerous, complicated, slow-moving, or fast-moving for students to experience directly (Nkok, 2021).

Computer simulation possesses the following educational characteristics:

1. Model-based: A model is used in computer simulations. This implies the simulation has pre-programmed calculations and rules.
2. Interactive: The computer simulation model is used by students to enter data, and they then observe how the simulation's variables change as a result of the output.
3. Interface driven: Both the output's observed value and the values of the variables that were impacted changed. The computer simulation's interface contains the variables that have been impacted as a result.
4. Scaffolded: Support features or scaffolds should be included in computer simulations developed for educational purposes to assist learners and make the learning experience more valuable (Ton & Wouter, 2007).

There are three different ways to use a computer for simulation exercises, as follows:

1. running a simulation program on a computer, which is the primary focus of the study,
2. using a web-based simulation, and
3. adding realism to numerous simulations using a computer.

Images and photos can be displayed on a computer screen to add realism to numerous simulations (Egara et al., 2018). According to Lunce (2006), the goal of computer simulation is to inspire students to participate in problem-solving activities. A computer simulation, according to Lunce (2006), is created using an internal model of a system or phenomenon that exists in the real world, with some components reduced or removed to facilitate learning. Computer simulations in the classroom can be used to assist learners to comprehend the problem better. Computer simulations can also be beneficial for a more in-depth experience while thinking about various scenarios (Tambade & Wagh, 2008).

Simulations on computers do have some drawbacks. First off, when combined with "problem-based learning" strategies, computer simulations allow students to immerse themselves in a complex topic and test out various solutions (Heinich et al., 1999). Second, this method of learning could take a long time compared to other teaching strategies. Thirdly, research has shown that "discovery learning" computer simulations are useless without coaching (Heinich et al., 1999; Min, 2001). Fourth, constructivists contend that computer simulations "oversimplify the intricacies of real-life contexts," giving students a fictitious sense of security (Heinich et al., 1999). Last but not least, developing computer simulations may need extensive planning, as well as a significant investment of time and money. Gender is a significant factor that this study is interested in.

Gender is a behavioral, social, and cultural trait connected to sex. The duties, behaviors, activities, and characteristics that are socially arranged as being proper for men and women in a community are referred to as gender (World Health Organization [WHO], 2011). Roles and behaviors that are imposed by society or culture as appropriate lead to gender inequality (WHO, 2011). Determining the mean retention scores of male and female students taught algebra using the computer simulation approach and assessed by the algebra achievement test (AAT) is crucial in this study.

## RELATED WORKS

Olaniyan and Salman (2015) investigated how computer simulation instructional packages might affect math students' retention in arithmetic progression in Lavun, Niger State, Nigeria. They found that, compared to students who received instruction using the traditional method, students who received instruction using the computer simulation approach recalled the concept and learnt more. According to Olorukooba et al. (2016)'s investigation into how computer simulations might affect students' performance and retention during instruction on qualitative analysis revealed that students who were taught using computer simulations outperformed those who were taught using lecture methods in terms of performance and concept retention. Olalekan and Oludipe (2016) investigated the impact of the computer simulation approach on students' achievement and retention of biology concepts. They found that simulation was successful in raising students' achievement and retaining biology concepts. A different study by Nkok (2021) examined students' achievement and retention when sexual reproduction in plants was taught using computer simulation. It was found that students who were taught using the computer simulation strategy retained the material better than those who were taught using the traditional teaching approach. The data show that, despite the favorable results in the examined areas and the benefits of computer simulation as described above, little to no research has been done to determine the effectiveness of computer simulation on the retention of male and female secondary school students in algebra. Therefore, there is a need to determine the gender influence on students' retention of algebra concepts when the computer simulation approach is utilized.

Gender is an important element to consider in this study. Olaniyan and Salman (2015) compared how well male and female mathematics students remembered the arithmetic progression after utilizing a computer simulation tool, and they found no statistically significant differences in the mean retention scores between the sexes. The average retention scores of male and female students who were taught using computer simulations did not significantly differ, according to Olorukooba et al. (2016), who examined the impact of computer simulation strategy on male and female undergraduate biology students' retention in DNA replication and transcription. The average retention scores of male and female students did not significantly differ, according to Olalekan and Oludipe's (2016) research. Male and female students' mean retention scores did not significantly differ in Nkok's (2021) study on the impact of computer simulation on retention in sexual reproduction in plants. Therefore, computer simulation raises retention and academic achievement rates for both male and female students. Determining whether male and female students will retain the learned materials (algebra concepts) similarly or differently when the computer simulation approach is applied is therefore important.

## THEORETICAL BASES

Jerome Bruner's learning theory, which he proposed in 1966, forms the foundation of this work. Bruner was fascinated by the variety of ways that people present and arrange their knowledge. Three modalities of representation were put out by Bruner in his studies on the cognitive growth of children. Three categories can be found in Bruner's theory of intellectual development: Iconic, which uses models and photos to teach individuals about the world; enactive in which a person learns about their surroundings by interacting with objects. The capacity to think abstractly is symbolic. The fundamental tenet of Bruner's educational philosophy is that activities that combine concrete, visual, and symbolic components are necessary for more efficient learning. Start with a concrete experience, then go on to images, and last, symbolic expression. Bruner's approach, which integrates discovery, readiness, intuition, and analytical language, can be applied in mathematics teaching and learning. As a result, this approach motivates and inspires learners to be inquisitive, exploratory, creative, and self-aware while learning. The computer simulation approach is designed to make sure that students' learning is sustained

throughout time and that they can recall the things they have learned.

### Purpose of the Study

The major objective of this investigation was to find out the effect of computer simulation on junior secondary school two (JSS 2) learners' ability to remember algebra concepts. Specifically, the objective was to ascertain:

(1) the effect of computer simulation on JSS 2 students' retention scores in algebra and

(2) the effect of computer simulation on male and female JSS 2 students' retention scores in algebra.

### Research Questions

These research questions served as the direction for this investigation:

1. Is there a difference in the mean retention scores of JSS 2 students taught algebra utilizing the computer simulation approach and those taught using the traditional method?
2. Is there a gender difference in the mean retention scores of JSS 2 students taught algebra utilizing a computer simulation approach?

### Hypotheses

The following hypotheses were developed and tested at a significance level of 0.05:

1. There is no significant difference between the mean retention scores of JSS 2 students taught algebra utilizing the computer simulation approach and those taught utilizing the traditional method.
2. There is no significant gender difference between the mean retention scores of J SS 2 students taught algebra utilizing the computer simulation approach.

## METHOD

### Study Design and Sample

The research was set up in a quasi-experimental fashion. A quasi-experiment is a study in which participants are not randomly assigned to experimental or control groups, but instead are placed in pre-existing groups (Nworgu, 2015). The study was conducted in Enugu State's Udenu Local Government Area (LGA). In Udenu LGA, there are 20 secondary schools. Two of the 20 public secondary schools are single-sex (females exclusively), while the other 18 are co-educational (Post Primary Schools Management Board, 2021). 2,152 learners from JSS 2 in LGA made up the study's population. Their ages range from 12-14 years. The sample included 68 students from two co-educational schools. Each student gave their consent before taking part in the study.

Two co-educational schools were sampled using the purposive sampling technique. This is so because there are just two co-educational schools with computers and power. The two chosen schools each had up to two streams of JSS 2 students, and one class from each school was chosen using a simple random sample method and a coin flip to represent either the experimental or control groups. AAT was used in the study to collect data. AAT consists of 20 multiple-choice test items with four possibilities from which a student must select the proper option for each item. Seven of the 20 questions were of higher order, while the other thirteen were of a lower level. The instrument was validated by three experts from Department of Science Education at University of Nigeria, Nsukka. The instrument's reliability was evaluated using the Kuder Richardson formula 20 (K-R 20) method. The statistical package for social sciences (SPSS) version 23 was used to determine AAT's internal consistency, which was 0.88.

### Experimental Procedure and Data Analysis Method

The experimental group was taught using a computer simulation approach, whereas the control group was taught using the traditional method by their regular mathematics teachers who also functioned as study research assistants. The researchers gave the mathematics instructors a one-week training on using computer simulation to teach the study's selected algebraic concepts. Following the instruction, they were given lecture notes for future reference. The researchers produced two lesson plans for use in the study; one lesson plan was produced for the experimental group and the other lesson plan was produced for the control group. Equations by the balance technique, equations with brackets, and equations with fractions are some of the topics covered in algebra. The experimental group received lecture notes that included a presentation using computer simulation software (Microsoft Math Solver). The subjects took a pre-test and completed PRE-AAT before the actual study. The actual instruction (treatment) occurred during the first, second, third, and fourth weeks; POST-AAT was administered in the fifth week after being rescheduled. To give the items a distinctive appearance and prevent memory effects, POST-AAT was reorganized after four weeks before being utilized for the post-post-test (retention) (see **Figure 1** for summary of the experimental procedure). Data on student retention by gender and treatment group was compiled based on post-post-test findings. The research questions were reported utilizing the data using the mean (M) and standard deviation (SD), and the analysis of covariance (ANCOVA) was utilized to evaluate the hypotheses at the 0.05 level of significance.

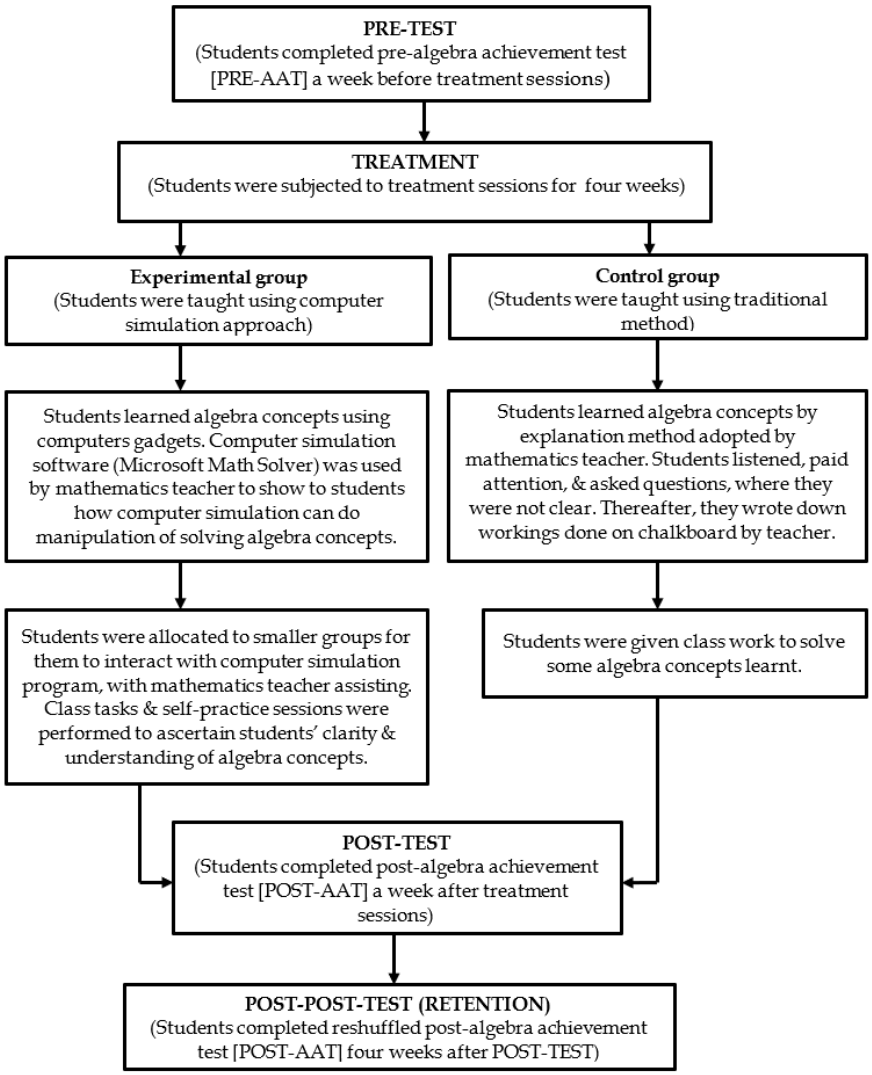


**Figure 1.** Summary of the process of experimental procedure (Source: Authors' own elaboration)

## RESULTS

The study's findings are presented in accordance with the research questions and hypotheses.

### Research Question 1

Is there a difference in the mean retention scores of JSS 2 students taught algebra utilizing the computer simulation approach and those taught using traditional method?

According to **Table 1**, the mean post-test score for students who received algebra instruction using computer simulation was 74.42 with an SD of 10.74 and the mean retention score was 71.15 with an SD of 14.16. On the other hand, students who were taught using the traditional method had mean post-test scores of 66.83 with an SD of 11.33 and mean retention scores of 57.94 with an SD of 16.70. Between the two groups, the experimental group outperformed the control group by a 13.21 mean retention scores difference. This indicates that the computer simulation approach helped JSS 2 students retain algebra concepts better than those that used the traditional method.

**Table 1.** Mean retention scores of JSS 2 students taught algebra utilizing computer simulation approach & those taught using traditional method

| Treatment | n | Post-test | | Retention | |
|---|---|---|---|---|---|
| | | M | SD | M | SD |
| Experimental | 52 | 74.42 | 10.74 | 71.15 | 14.16 |
| Control | 63 | 66.83 | 11.33 | 57.94 | 16.70 |
| Total | 115 | | | | |
| Mean difference | | | | 13.21 | |

### Hypothesis 1

There is no significant difference between the mean retention scores of JSS 2 students taught algebra utilizing the computer simulation approach and those taught utilizing the traditional method.

**Table 2** demonstrates that treatment has a considerable impact on students' retention of algebra. $F(1, 110)=11.111$ and $p=.001$. This led to the rejection of the null hypothesis, which stated that there was no

**Table 2.** ANCOVA of JSS 2 students' mean retention scores in algebra subjected to both experimental & control groups

| Source of variation | Type III sum of squares | df | Mean sum of square | F calculated | Sig. | Partial eta squared |
|---|---|---|---|---|---|---|
| Corrected model | 11,337.018[a] | 4 | 2,834.255 | 14.739 | .000 | .349 |
| Intercept | 1,452.525 | 1 | 1,452.525 | 7.554 | .007 | .064 |
| Post-test | 4,719.411 | 1 | 4,719.411 | 24.543 | .000 | .182 |
| Gender | 1,335.877 | 1 | 1,335.877 | 6.947 | .010 | .059 |
| Treatment | 2,136.461 | 1 | 2,136.461 | 11.111 | .001 | .092 |
| Treatment*gender | 2.086 | 1 | 2.086 | .011 | .917 | .000 |
| Error | 21,152.112 | 110 | 192.292 | | | |
| Total | 502,250.000 | 115 | | | | |
| Corrected total | 32,489.130 | 114 | | | | |

Note. [a]R-squared=.349 (adjusted R-squared=.325)

statistically significant difference between the mean retention scores of JSS 2 students who received instruction using the computer simulation approach and those who received instruction using the traditional method. This is because the exact probability value of .001 is less than the 0.05 significance level. As a result, the researchers concluded that there is a significant difference in the mean retention scores of JSS 2 students who were taught algebra using computer simulation and those who were taught algebra using the traditional method.

### Research Question 2

Is there a gender difference in the mean retention scores of JSS 2 students taught algebra utilizing a computer simulation approach?

As shown in **Table 3**, the analysis showed that the post-test mean scores for the males were 69.91 and with an SD of 11.97, while the post-test mean scores for the females were 70.59 and with an SD of 11.45. The mean retention score for male students was 60.45 with an SD of 18.72, whereas the mean retention score for female students was 67.20 with an SD of 14.33. The mean retention score difference between the males and females was established to be 6.75 in favor of females. As a result, the females had a higher mean retention rate than the males.

### Hypothesis 2

There is no significant gender difference between the mean retention scores of J SS 2 students taught algebra utilizing the computer simulation approach.

The findings of the study in **Table 2** were used to test hypothesis 2 as well. **Table 2** shows that gender is a significant factor of JSS 2 students' retention in algebra: F (1, 110)=6.947 and p=.010. The null hypothesis that there is no significant difference was rejected since the precise probability value (.010) is less than the level of significance established at 0.05. The researchers concluded that there is a significant gender difference in the mean retention scores of JSS 2 students who were taught algebra using a computer simulation approach, with the female students faring better.

**Table 3.** Mean retention score of male & female JSS 2 students taught algebra utilizing computer simulation approach

| Treatment | n | Post-test | | Retention | |
|---|---|---|---|---|---|
| | | M | SD | M | SD |
| Male | 56 | 69.91 | 11.97 | 60.45 | 18.72 |
| Female | 59 | 70.59 | 11.45 | 67.20 | 14.33 |
| Total | 115 | | | | |
| Mean difference | | | | 6.75 | |

## DISCUSSION

According to **Table 1**, students who learned algebra via a computer simulation approach scored better than those who learned it the traditional way in terms of mean retention scores. Accordingly, the first hypothesis examined if retention mean scores significantly differed between JSS 2 students who were taught algebra using the computer simulation approach and those who were taught identical ideas using the traditional method. Concerning hypothesis 1, the analysis in **Table 2** showed a significant difference between students who received algebra teaching using the computer simulation and those who received it using the traditional methodology. The finding corroborates the results of Nkok (2021), Olalekan and Oludipe (2016), Olaniyan and Salman (2015), and Olorukooba et al. (2016) that found the computer simulation approach effective in enhancing students' retention as compared to their counterparts that were taught same concepts utilizing the traditional method. This notable difference may have been caused by the student's active participation in the learning process and interpersonal contact. Additionally, since the computer simulation approach is a successful teaching strategy, it may help to enhance students' mathematical achievement and retention.

The result from **Table 3** showed that the mean retention scores were in favor of the female students. Further analysis showed, with regards to hypothesis 2, that gender was significant at .010 as shown in **Table 2**, which implies that when algebra was taught through computer simulation, female students retained the algebra concepts taught more than their male counterparts. This finding contradicts the findings of

Nkok (2021), Olalekan and Oludipe (2016), Olaniyan and Salman (2015), and Olorukooba et al. (2016) that found no statistically significant difference between male and female students taught with the computer simulation approach. This contradiction observed in this study could be that the female students showed more interest by participating actively in the treatment session than the males, which led to their retention of the algebra concepts taught using a computer simulation approach.

Notwithstanding the favorable outcome, this research report has limitations. The researchers acknowledge that the study's sample size was limited because it only included JSS 2 learners from Udenu LGA. Because of this, the study can be thought of as a preliminary one. Therefore, to ascertain whether the results are generalizable, prospective studies must include large sample sizes and students from other levels of education. Given the findings of this research, the following recommendations are offered considering the researchers' findings:

1. To increase learners' retention of algebra concepts, the government should expose mathematics teachers to training on how to use the computer simulation approach.
2. The gender difference observed in this study is an eye-opener for mathematics teachers.

As a result, mathematics teachers should pay special attention to the needs of male and female students in the classroom equally, especially when computer simulation programs are used.

## CONCLUSIONS

The use of the computer simulation approach significantly increased JSS 2 students' retention of the provided algebraic concepts when compared to the traditional method. This was demonstrated by the fact that the mean retention scores for the experimental group were higher than those for the control group. There was a gender difference in the mean retention scores of JSS 2 students taught algebra using the computer simulation approach, in favor of the female students. This suggests that the female students benefitted more from the computer simulation's effectiveness in enhancing their retention of algebra concepts than their male counterparts.

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**Declaration of interest:** No conflict of interest is declared by authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

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