

Effects of Peer Tutoring, Teaching Quality and Motivation on Mathematics Achievement in Senior High Schools

Yarhands Dissou Arthur, Samuel Kwaku Boadu and Bright Asare

Department of Mathematics Education, Akonten Appiah-Menka University of Skills Training and Entrepreneurial Development, Kumasi, Ghana

E-mail: ¹<day1981boyy@gmail.com>, ²<boadukwakusamuel@gmail.com>, ³<asarebright6592@gmail.com>

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ABSTRACT This study assessed the direct effects of peer tutoring, teaching quality and motivation, on the mathematics achievement of senior high school students in Ghana. The study adopted a descriptive survey, which comprised a sample of 321 senior high school students in Kumasi Senior High Technical School. Preliminary analyses, including Confirmatory Factor Analysis, convergent validity, discriminant validity, and internal consistency (Cronbach's Alpha), were estimated before the main model estimation. To test the various hypotheses, Amos (v.23) was used to do Structural Equation Modelling (SEM). Findings revealed that peer tutoring, teaching quality and motivation, all had significant positive effect on mathematics achievement among senior high school students in Ghana. All three hypotheses were therefore supported by this study.

INTRODUCTION

The study of mathematics is significant in one's everyday lives. It helps with perceiving designs and comprehending one's general surroundings. Because mathematics is an abstract discipline, many students at all levels of education find it tough and challenging. As a result, math educators strive to establish an environment that is math-friendly in order to assist their pupils in meeting this challenge. Giving pupils the opportunity to learn and study together is one method to accomplish this. Peer tutoring is a strategy for supportive learning centred on the formation of groups with a higher-level relationship, which is obtained from errands of their individual duties, guide, and tutee, where the two understudies have a collective goal and obtain curricular limit through an association set up by the educator (Arthur et al. 2022).

As a result, peer tutoring is a kind of elective education in which the understudy adopts a demeanour of obligation to speculate, think and exchange information (Alzaabi et al. 2021). Peer teaching, according to Ngamskulrunroj et al. (2018), is beneficial for both quick and slow learners. It enables quick learners to grasp course content and successfully communicate their thoughts. As they grow, slow learners improve performance and gain an improved comprehension of termi-

nologies used in class. Peer tutoring equally enables quick and slow learners to develop important qualities like sharing, self-discipline, and self-esteem. According to Arthur et al. (2022), peer tutoring influences students' academic achievement in mathematics.

Teaching quality refers to tutoring techniques that satisfy students' needs for autonomy (a sense of self-determination and independence from control), competence (a sense of efficiency and confidence in social interactions), and relatedness (a sense of being connected to and saved by others) (Williams 2021). According to Fenster (2014), highly effective teachers ensure long-term and short-term changes in students' intellectual learning. As a result, in any school setting, teacher quality is an utmost debatable issue in advancing student achievement and closing achievement gaps (Hachfeld and Lazarides 2021).

Motivation has a considerable impact on the understudies' learning achievements as per Ikhlas et al. (2021). Students who are motivated to learn mathematics, attentively follow lessons, check group discussions, learn extremely to accomplish their goals, induce higher scores, are desirous to learn at school, recognise the importance of maths in other subjects, and attend school for all mathematics lessons. Motivation is seen as a significant influence on human behaviour and enactment (Kian et al. 2014). According to scholastic

researchers and experts (Hosen et al. 2021; Howard et al. 2021), motivation is one of the greatest important factors in student development and ensuring continual success.

Lin (2012) defines motivation as natural needs that exist in a private situation or that are replicated in a private setting when obtaining new information and learning. Various studies show that elements including instructors' cognitive ability, subject matter expertise, teaching and learning knowledge, and classroom teaching behaviours are linked to teaching quality and enhanced student achievement. Students who work in groups, according to Ganesh (2021), achieve well on examinations, particularly those that require cognitive and serious intelligent skills.

Peer tutoring, a form of cooperative learning, occurs frequently among students. Educationalists have established over experience and study that peer tutoring is a successful technique for assisting students in achieving their educational goals (Bozzi et al. 2021). A survey of related writing over the years showed a significant role within the area of many related articles, components driving to poor performance in mathematics subjects, and the sort of investigations included. These areas required in-depth examination to illuminate the components for poor performance in mathematics subjects.

In appreciation of these uncertain discoveries, the researcher considered adding to existing literary works, the mediating impact of teaching quality and motivation on the relationship between peer tutoring or collaborative learning among students and achievement in mathematics, which is an identified gap and inconsequential within the check on literary works. Based on the approach, this study is among a few existing works, which made use of the Structural Equation Model (SEM). Hence, the main objective is to find out peer tutoring and mathematics achievement in secondary schools, and the effects of teaching quality and motivation.

Objectives of the Study

The objectives of the study were:

1. To assess the effect of peer tutoring on mathematics achievement of senior school students in Ghana.
2. To ascertain the effect of teaching quality on mathematics achievement of senior school students in Ghana.

3. To determine the effect of motivation on mathematics achievement of senior school students in Ghana.

Hypotheses Development

Peer tutoring method of learning is related to social constructivism, since understudies use their own knowledge to help each other with tasks and class appraisals (Núñez-Andrés et al. 2021). Cole (2004) defined motivation as the instinctive and thinking processes by which individuals pursue to fulfil the basic, perceived and individual objectives needs that drive human activity. Teaching quality refers to tutoring techniques that satisfy students' needs for autonomy (a sense of self-determination and independence from control), competence (a sense of efficiency and confidence in social interactions), and relatedness (a sense of being connected to and saved by others).

To decide the indicators of mathematics achievement among different gatherings of people, a huge assemblage of studies has been directed in the course of recent many years. It is grounded in the writing that mathematics achievement is impacted by various components, including teaching quality and motivation, which are often not independent. Besides, a portion of the affecting elements is exceptionally intricate, so it is important to isolate them into sub-factors and discover how each sub-variable is identified with math achievement. The relationships of conceptual framework between the factors that determine mathematics achievement are shown in Figure 1.

Over the last few decades, a number of peer tutoring meta-analyses and literature reviews have been undertaken, with some of them focused explicitly on peer tutoring in mathematics. Years later, Butler et al. (2001) released a review on the benefits of teaching mathematics to students with learning impairments, or learners who have the nervous deficiencies in certain brain procedures that make mastering specific skills, primarily reading and arithmetic, challenging. Butler et al. (2001) concluded from a qualitative investigation that when peer tutoring was used, children with learning difficulties were able to successfully use cognitive techniques. Furthermore, the authors argued that this paradigm should be used in the secondary schools. Meta-analysis was done by Leung (2015) to evaluate the characteristics that influenced students' academic achievement during

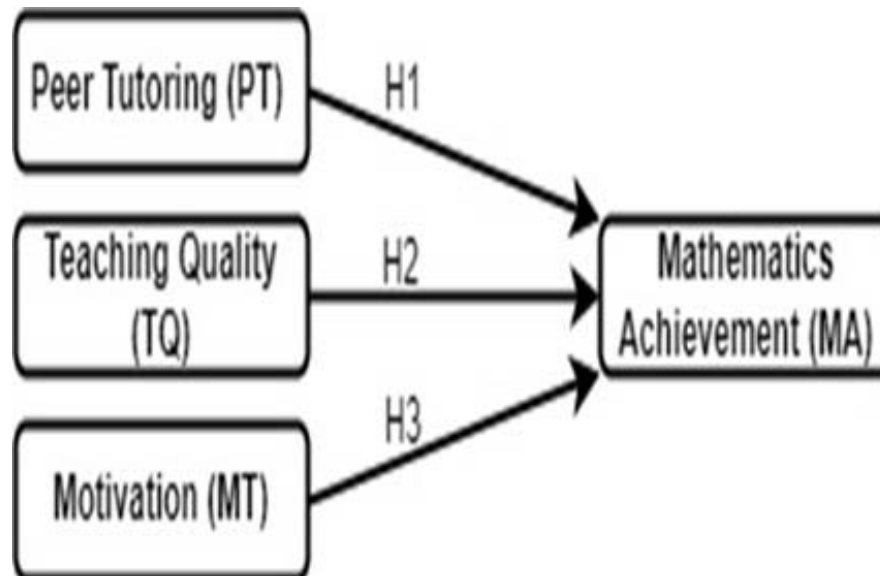


Fig. 1. Conceptual framework
 Source: Authors' Construct 2021

peer teaching sessions, and his research included fifteen studies in mathematics.

Peer tutoring studies exhibited moderate to moderate effect sizes across a range of categories, according to (Ngamskulrunroj et al. 2018). Alegre-Ansuategui et al. (2018) conducted a meta-analysis of peer tutoring in math from kindergarten to tertiary. The effect sizes for the academic achievement variable were found to be positive in eighty-eight percent of the trials. According to Mazurek et al. (2021), peer-tutoring courses done outside of school hours are not as effective as those held within periods in school. Additionally, these writers conducted a writings analysis on peer tutoring in primary schools, concluding that ninety-one percent of studies testified significant outcome sizes and variables such as participant age or study design in both qualitative and quantitative analyses, and had no significant impact on the final result of peer tutoring practices (Alegre-Ansuategui et al. 2018). Previously noted, the majority of the meta-analyses and reviews focused on the educational assistances of peer tutoring in mathematics.

Other than academic accomplishment, there were other encouraging results. Peer tutoring, for example, has been shown in several studies to

reduce students' self-esteem, attitudes and anxiety toward arithmetic (Knight et al. 2018). Despite the fact that there is a wealth of current material on mathematics peer tutoring, the implications for secondary school practice have not been adequately studied. According to Cai and Hwang (2020), the findings on the academic accomplishment variable are influenced by study techniques and students' attitudes toward mathematics. Active learning tactics that permit students to partake in the learning process are favoured in this instance (Zhao and Ding 2019). The aims stated specify the established potentiality of peer tutoring in math, and it is required to offer secondary education experts such as scholars and tutors with training procedures which helps to exploit students' educational achievements, that is the fundamental drive for piloting this meta-analysis. The researchers therefore hypothesised that:

H1: Peer tutoring has a direct positive effect on mathematics study achievement among senior high school students.

Researchers have used a number of frameworks to study the features and activities of teachers who appear to be effective in their classes for the past 40 years (Fauth et al. 2019; Arthur et al. 2021). Academics frequently use diverse words

used for the same constructs while using similar phrases for distinct ideas. Other terminology includes class quality (Hamre et al. 2014), class setting (Day et al. 2015), and class organisation because teachers' instructional techniques correspond to variables at the class level (Wagner et al. 2013) in the literature. Teaching quality in SDT refers to teacher behaviours that support students' aspirations for autonomy (a sense of self-determination and independence from control), competence (a sense of efficiency and confidence in social interactions), and relatedness (a sense of belonging) (Kelcey et al. 2019). A number of writers have examined various factors of teaching quality (Liu et al. 2016). Arthur et al. (2017) found that student teacher variables significantly influenced students' interest and performance. The various dimensions are summarised in Table 1. In the following sections, this will be explained in further depth. The researchers therefore hypothesised that:

H2: Teaching quality has a direct positive effect on mathematics study achievement among senior high school students.

Motivational elements of learning are a well-studied topic in terms of cognitive success. Many studies have discovered that a student's motivation has a substantial impact on their academic progress (Yulika et al. 2019). Researchers have identified the discrepancy between intrinsic and extrinsic motivation. External rewards for well-executed tasks are the focus of extrinsic or instrumental motivation. Intrinsically motivated students are more inclined to study for a variety of explanations, including good instructor feedback, higher school grades, and better job prospects and extrinsic motivation is a difficult topic to grasp (Liang and Kelsen 2018). External, identifiable, and integrated regulations are the categories of extrinsic behavioural control identified by the self-determination theory (SDT) (Wu et al. 2020).

The lowest level of motivation is external regulation, whereas the highest level of self-determination is integrated regulation (Ryan and Deci 2009). Extrinsic motivation's effects on academic accomplishment have been investigated, and it has been revealed that extrinsically motivated students are more likely to have reduced academic achievement (Law et al. 2019). It is critical that the action be joyful without any expectation of monetary reward. Even if a task is too tough or com-

plex for them, intrinsically driven students devote a significant amount of time and effort to completing it.

Intrinsically driven behaviour is frequently associated with the concept of interest, that is, when someone is interested in something, they are involved in it for its own sake. Intrinsic motivation, in the same way is a subset of interest. When a person interacts with an activity, their interest is strongly tied to their needs, goals and capacities (Ikhlās et al. 2021). Researchers distinguish individual and situational interests. A specific activity or task activates individual interest, whereas a specific activity or task induces situational interest (Becker et al. 2010).

There is evidence that a student's interest in a subject is linked to academic success. According to Lepola et al. (2005), there is a link between children's arithmetic achievement and motivation, with great math achievement and motivation also predicting children's performance in the following school years. Interest has a major impact on accomplishment, according to Hosen et al. (2021), and high achievers have a higher level of interest than low achievers. Some situational interest research has focused on academic assignment qualities that can spark students' attention, as well as give good evidence for the relationship between text, situational interest, recall and comprehension (Howard et al. 2021). The researchers therefore hypothesised that:

H3: Motivation has a direct positive effect on mathematics study achievement among senior high school students.

METHODOLOGY

Sample and Data Collection

Data were obtained from 321 students enrolled in Kumasi Senior High Technical School in Ghana's Ashanti region. These students took mathematics as a core subject as part of their academic requirements. The students chosen were from SHS 1, SHS 2 and SHS 3, with 172 males and 149 females. The data collection tool was a structured questionnaire, and the data was collected over a three-week period. In the sample selection process, simple random sampling was used for the study.

Questionnaire and Measures

The study looked at peer tutoring and mathematics achievement, the effect of teaching quality and motivation. There were three independent variables (peer tutoring or PT, teaching quality or TQ and motivation or MT) with (mathematics achievement or MA) as the dependent variable. The four variables were rated on a Likert scale ranging from one (Strongly Disagree) to five (Strongly Agree). Based on the four constructs, there were 40 measurement items. Students' age, gender, occupation and form were also accounted for in the study (form 1, form 2 and form 3).

Reliability and Validity of the Constructs

Reliability test is important for determining the abilities of the items in the instruments that are being used. The study used Amos (v.23) to do a Confirmatory Factor Analysis (CFA) as part of the reliability and validity assessments. The Confirmatory Factor Analysis measured how the data fit the model of the study. In Confirmatory Factor Analysis, measuring items with low factor loadings (less than 0.5) existed excluded from further analysis. Six (6) measuring items from peer tutoring were removed, as were seven (7) measurement

items from teaching quality, motivation, and mathematical achievement. Using the retained measurement items, Cronbach's Alpha (CA) analysis was used to analyse the internal consistency of measurement items. For all four constructions studied, the minimum predicted CA value was 0.7, which was met (Table 1). The constructs' convergence validity was tested using the Average Variance Extracted (AVE) method.

According to Fornell and Larcker (1981), convergent validity is achieved when the construct has an Average Variance Extracted of at least 0.5 and a composite reliability (CR) of at least 0.7. The Average Variance Extracted and composite reliability for all constructs met the corresponding thresholds, indicating that convergent validity was attained in this investigation. Another key factor to consider when running CFA is the model's fitness. As part of the fitness assessments, CMIN/DF should be less than 3, CFI should be greater than 0.9, RMSEA and RMR should be less than 0.08, and P-Close should be statistically insignificant at five percent (Hair et al. 2010). The Confirmatory Factor Analysis model for the constructs provides a good fit for the data, as shown in Table 1.

The discriminant validity was assessed by matching the square root of the AVEs (HAVES)

Table 1: Confirmatory factor analysis

<i>Model Fit Indices: CMIN = 136.666; DF = 56; CMIN/DF = 2.440; CFI = .960; TLI = .944; RMR = .003; RMSEA = .067; PClose = .052; GFI = .940; AGFI = .902</i>		<i>Std. factor loading</i>
<i>PEER TUTORING (PT): CA=0.843; CR=0.858; AVE=0.613</i>		
(PT4) Peer tutoring establishes a cordial learning climate in the class		0.508
(PT6) Peer tutoring assists instructor with connecting all understudies of the class in learning action as per their individual requirement		0.791
(PT8) Students learn through instructing and procure freedom to address their mistakes		0.993
(PT10) Students consistently help each other in solving math problems		0.763
<i>MATHEMATICS ACHIEVEMENT (MA): CA=0.707; CR=0.782; AVE=0.546</i>		
(MA2) I feel most satisfied when I feel sure about the content in a math course		0.648
(MA3) During peer tutoring in mathematics, I feel most satisfied when I am ready to tackle a troublesome problem		0.797
(MA6) I participate in mathematics class during peer tutoring to perform better compared to different understudies in normal class		0.763
<i>TEACHING QUALITY (TQ): CA=0.764; CR=0.804; AVE=0.582</i>		
(TQ5) Support to understudy learning to work efficiently		0.904
(TQ7) Assist to organisations and management of programs at peer level		0.678
(TQ9) Funds to promote motivational teaching		0.685
<i>MOTIVATION (MO): CA=0.866; CR=0.879; AVE=0.711</i>		
(MO4) Feedback is aimed at motivating the learner intrinsically		0.812
(MO5) I am motivated to go the extra mile when taught by my peers		0.982
(MO6) I can explain the things I learned in my own words in mathematics subject		0.713

Source: Field Data 2021

against the correlation coefficients (Bamfo et al. 2018). Discriminant validity is achieved when the HAVEs are bigger than the correlation coefficients. The lowest AVE (teaching quality) was 0.762, while the greatest correlation value was 0.693 (between mathematics achievement and peer tutoring). Since the highest correlation coefficient of 0.693 was less than 0.7, it was concluded that multicollinearity was not a challenge.

Table 2: Discriminant validity

Variables	PT	TQ	MT	MA
PT	0.783			
TQ	0.492**	0.762		
MT	0.570**	0.447**	0.843	
MA	0.693**	0.523**	0.414**	0.739

Source: Field Data 2021

RESULTS

To evaluate the numerous paths hypothesised in the study, Amos (v.23) was used to run Structural Equation Modelling (SEM) and the outcomes are presented in Table 3. The study took into account the students' gender, age and course. Table 3 shows that the study program had a significant favourable effect on students' mathematical achievement. The pupils were around 14.8 percent more likely than other students to have superior mathematics achievement. Gender also had a strong favourable impact on math achievement. As a result, male students around 12.3 percent were more probable than female students who excel in math. Age, the final control variable, had a negative but statistically insignificant effect on math performance. This means that the finding was rejected, despite the fact that older pupils performed worse in math. According to the findings, peer tutoring had a considerable favourable impact on mathematics success for the main paths. This suggests that peer tutoring enhanced mathematics achievement by 70.1 percent as a dimension.

Results on the hypothesised paths indicate that peer tutoring had a direct positive effect on mathematics study achievement among senior high school students ($\beta = 0.701$; C.R. = 6.315). That is, about 70.1 percent improvement in senior high school students' mathematics achievement is experienced, when students are taught by their

colleagues. Hence, hypothesis 1, that is, *peer tutoring has a direct positive effect on mathematics study achievement among senior high school students*, was supported by this study. The researchers further identified that teaching quality had a direct positive effect on mathematics study achievement among senior high school students ($\beta = 0.234$; C.R. = 3.296). That is, about 23.4 percent improvement in senior high school students' mathematics achievement is experienced, when perceived teaching quality is high. Hence, hypothesis 2, that is, *teaching quality has a direct positive effect on mathematics study achievement among senior high school students*, was supported by this study. Finally, the study ascertained that motivation had a direct positive effect on mathematics study achievement among senior high school students ($\beta = 0.313$; C.R. = 3.557). That is, about 31.3 percent improvement in senior high school students' mathematics achievement is experienced, when motivation is high. Hence, hypothesis 3, that is *motivation has a direct positive effect on mathematics study achievement among senior high school students*, was supported by this study.

Table 3: Path estimates

Direct paths	Un Std. estimate	Std. Error	C.R
Course→MA	0.148	0.065	2.277*
Gender→MA	0.123	0.054	2.278*
Age→MA	-0.041	0.069	-0.594
PT→MA	0.701	0.111	6.315**
TQ→MA	0.234	0.071	3.296**
MT→MA	0.313	0.088	3.557**

** ~ P-value significant at 1% (0.01); *~ P-value significant at 5% (0.05)

Source: Field Data 2021

DISCUSSION

The peer tutoring method is extremely effective at improving students' knowledge of mathematics subjects, as pupils perform much better, as evidenced by their grades, and it builds trust, allowing them to collaborate and share their ideas (Alzaabi et al. 2021; Bozzi et al. 2021). A study conducted by Ganesh (2021) shows peer tutoring upgrades their inclination to impart their perspectives to their friends, which they cannot impart to their instructors. When an understudy assists other students in demonstrating their learning, their

smugness and self-assurance grow (Mazurek et al. 2021). In this study, peer tutoring was revealed as a major predictor of students' mathematics achievement. This means that a peer tutor's capability provides instructions on time, deal with peers' mathematics learning problems and delivers error-free content, all of which predicted students' mathematical proficiency (Ngamskulrungrroj et al. 2018; Núñez-Andrés et al. 2021).

Researchers have looked into the effect of teaching quality on the achievement of students to enhance student achievement (Hachfeld and Lazarides 2021; Williams 2021). It is possible that for students, peer tutoring measurements may be more useful than teaching development measurements such as general curriculum arrangement, and that when there is a significant degree of teaching quality by peers, it will result in higher mathematics achievements. Arthur et al. (2017), for example, found that teacher-student variables significantly predicted students' interest and performance in mathematics. Similarly, Arthur et al. (2021) found that among university students, mathematics study achievement was significantly enhanced by perceived teaching quality. Further, Fauth et al. (2019) found that teacher competence and teaching quality significantly influenced student outcomes in elementary science education, while Kelcey et al. (2019) also concluded that teacher mathematical knowledge and instructional quality influenced students' performance.

According to educational researchers and practitioners, one of the major essential elements in an understudy's progress towards ensuring continued achievement is motivation (Arthur et al. 2022). The impacts of extrinsic motivation on academic achievement have been studied, and it has been discovered that pupils motivated extrinsically are more probable to have an inferior academic achievement (Becker et al. 2010; Howard et al. 2021). The teachers' outward inspiration is possibly the most important consideration for mathematics achievement, and the procedures teachers can use to propel their understudies incorporate being commended for great execution, financial prizes, granting endorsement of legitimacy, a healthy and balanced eating regimen, scholastic excursions, and amusement that can lead to higher mathematics achievement (Law et al. 2019; Wu et al. 2020; Yulika et al. 2019).

CONCLUSION

The study sought to identify the factors that influenced senior high school students' performance in mathematics. Based on literature review, some potential variables were identified and tested, by sampling 321 senior high school students. The study concluded that peer tutoring had a significant positive effect on mathematics study achievement of senior high school students in Ghana. Similarly, teaching quality had a significant positive effect on mathematics study achievement of senior high school student in Ghana. Finally, motivation had a significant positive effect on mathematics study achievement of senior high school student in Ghana.

RECOMMENDATIONS

Mathematics is a must pass subject, if a senior high school graduate wants to enter into the tertiary education. A graduate needs at least grade C6 in core mathematics, before they could gain admission into mainstream university degree courses. Statistics from the 2021 West African Senior School Certificate Examination (WASSCE) indicated that only 54.11 percent of graduates had from A1 to C6 when they sat for the examination. This percentage was less than the pass rate during 2020 WASSCE, which makes it a worrying situation. This present study identified some variables, which could be useful in salvaging the situation of poor performance in mathematics at the senior high schools.

Management of senior high schools should encourage peer tutoring and learning. Students should be put into groups, and be made to teach each other during free periods or when teachers are absent from school. This could help improve their performance. Also, teaching quality enhanced students' performance in mathematics. Headmasters should ensure that mathematics teachers are well trained in the subject area, and are well equipped to teach the subject. Teachers must have the necessary academic qualifications, attend workshops and seminars on capacity building, and be willing to learn new methods of teaching mathematics. Finally, motivation is a driving force, which also affects students' performance in mathematics. Mathematics is generally perceived as a difficult subject, which is reflected

in the WASSCE results. Students must therefore be motivated and encouraged to study mathematics. Students must be made aware of the benefits of studying mathematics.

LIMITATIONS AND FUTURE RESEARCH SUGGESTIONS

The researchers only looked at the direct effects of peer tutoring, instructional quality, and motivation on secondary school mathematics achievement. Future research should focus on the factors that influence teaching quality and motivation. The study also relied on descriptive survey data, which may not be suitable for causal analysis. The study, on the other hand, was based on theories, literature and methods, and thus the results can be trusted. Future research should, however, take into account longitudinal data. Data was acquired from Kumasi Senior High Technical School pupils in Kumasi for the study. The study included a number of methodological tests that demonstrated that the outcome of the study was valid and reliable. However, the source of data should be considered when interpreting and applying the results.

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