

Integrating Epidemiological and Biostatistical Concepts into Classroom Teaching Through COVID-19 Case Study Methods

Vimala Venugopal Muthuswamy^{1*}, V. Nijarubini²

¹ Department of Management, College of Business, King Faisal University, Al-Ahsa 31982, Saudi Arabia; ² Department of Chemistry, Dr.N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India

ABSTRACT

This study aimed to integrate epidemiological and biostatistical concepts into classroom teaching through COVID-19 case study methods among undergraduate medical students in Saudi Arabia. To test the study objective, data were collected from 200 medical undergraduate students using a convenience sampling technique. Data was analyzed from both descriptive and inferential statistics perspectives to analyze the impact of the intervention. Both descriptive and inferential results revealed that integrating COVID-19 case studies into classroom discussions significantly improved students' understanding of epidemiological and biostatistical concepts. A particular improvement was identified in fundamental concepts, where their ability to interpret the epidemiology and statistical analysis was increased. Such kind of improvements demonstrated that exposure to real pandemic datasets enabled students to better understand how epidemiological models and statistical tools are applied in real healthcare contexts, such as disease surveillance, outbreak analysis, and evidence-based decision making. The study with specific findings contributed that case-based learning using real public health datasets is an effective pedagogical strategy for strengthening analytical competence among medical students. Therefore, this study contributed to helping educators focus on the case study methods because incorporating real-world case studies into epidemiology and biostatistics courses can significantly enhance students' analytical skills, conceptual understanding, and readiness for evidence-based medical practice in Saudi Arabia.

ARTICLE HISTORY

Received January 1, 2026

Accepted March 2, 2026

KEYWORDS

Medical Students,
Interventions,
Biostatistical Concepts,
Case Study,
Covid-19

1. Introduction

Biostatistics and epidemiology are important components of medical education because they provide a scientific foundation for understanding disease patterns and support evidence-based decision-making (Benichou, 2007). From these concepts, epidemiology focused on identifying the determinants of diseases in people (Wassertheil-Smoller, 2004). On the other hand, biostatistics provides the quantitative techniques necessary to analyze and interpret health-related data (Model, 2022). These two techniques help healthcare professionals to evaluate clinical traits (Bhatti et al., 2018), identify risk factors, and design effective public health interventions (Arora et al., 2024). Modern health care practices increasingly required a physicians to intercept statistical findings from the clinical studies which is making a critical competency for the for future healthcare professionals (Mohan et al., 2025). In this regards, integration of epidemiological and biostatistical concepts into medical education is being important for preparing the students for critically evaluating the scientific evidence and to apply in clinical practice (Williams et al., 2023).

Along with the significance for both of epidemiology and biostatistics, most of the medical students still face difficulties in understanding the concepts of epidemiology and biostatistics (Goodman et al., 2023). It creates difficulties for the students because teachers focused on the traditional teacher method which is being relied on statistical formulas without clearly linking these concepts to clinical practice (Afridi et al., 2023). Due to this, students frequently experienced difficulties in understanding the statistical analysis practical relevance in the medical research for making effective decision-making (Ordak, 2024). Previous studies have reported that many medical students lack confidence in interpreting statistical results presented in scientific literature (Fuller et al., 2024). This confidence issue might create their ability for critically evaluating the research findings and applying evidence based knowledge in clinical settings (Tomak & Civanbay, 2022). The

importance of epidemiological and biostatistical knowledge for healthcare professionals was also more focused during the COVID-19 (Pomann et al., 2022). During this period, the physicians were mainly focused on the epidemiological indicators such as infection rates and transmission patterns to guide healthcare policies and treatment decisions (Pomann et al., 2022). With this significance, the pandemic demonstrated that strong analytical and statistical skills are essential for responding to emerging health challenges and managing public health crises (Gille et al., 2024). Therefore, this study focused on understanding the students both of epidemiology and biostatistics concepts in the classroom with case studies.

Various empirical research identified that active learning strategies like a case-based learning and problem-based learning can significantly improve students' comprehension of complex analytical concepts (Goodman et al., 2023). Such kind of approaches always encourage to the students in discussion and applying theoretical knowledge to understand practical problems (Mitra, 2024). Its importance has been also highlighted in further study, when the both of epidemiological and biostatistical concepts are being delivered to the students with real datasets and health-related case studies, students develop stronger analytical reasoning skills and a deeper understanding of how statistical methods support clinical and public health research (Cavallo, 2022). Further study also highlighted that interactive and data-driven teaching approaches improve students' ability to interpret scientific literature and strengthen their confidence in statistical analysis (Pomann et al., 2022). In contrast, studies highlighted that most of the students are experiencing challenges in linking the theoretical statistical knowledge with practical healthcare applications (Pomann et al., 2022). They argued that real time case studies integration in the classroom discussion provide an effective strategy for improving students' conceptual understanding and analytical skills (Pomann et al., 2022). Because through analyzing the real time data for understanding the epidemiological concepts can develop a deeper understanding of how statistical reasoning contributes to disease surveillance, medical research, and healthcare decision making (Devick et al., 2022). These prior studies shown that students learning increased in the epidemiological and bio statistical concepts through the case studies. Hence, study focused on integration of epidemiological and biostatistical concepts in classroom through the active learning case studies.

With the significance of epidemiological and biostatistical concepts, literature on these concepts is still limited, particularly in the context of case studies for students' learning. Most of the studies in the field of epidemiological and biostatistical research focused on traditional teaching methods (Devick et al., 2022; Goodman et al., 2023; Mahato et al., 2024; Ordak, 2024; Rossi, 2022; Troy et al., 2022). These studies do not focus on active learning methods, which limits the learning capacity of students to understand the concepts of epidemiology and biostatistics. This study contributed a literature to understand both of epidemiology and biostatistics concepts through integration of case study methods. On the other hand, further gap is being existed in the student's ability to intercept epidemiological and statistical results presented in scientific literature. Previous studies have reported that many medical students lack confidence when reading research articles that include statistical analyses (Gille et al., 2024; Jyothis, 2024; Mahato et al., 2024; Shahsavari & Jambarsang, 2022; Vasudevan et al., 2024; Zhang et al., 2023). Such a limitation could affect their capacity for critically evaluating the research findings for making clinical decision making (Del Toro et al., 2022; Tan et al., 2022). To overcome this limitations, there is need of innovative instructional approach to strengthen students' ability to understand and interpret statistical results in medical research. Therefore, this study contributed literature after adding the case study methods to increase the students understanding in both of epidemiological and biostatistical concepts because this instructional approaches can ultimately enhance students' preparedness for evidence-based medical practice and strengthen the quality of medical education (Castro et al., 2026; Del Toro et al., 2022; Lutz et al., 2025). Moreover, most of the prior studies mainly focused on other countries, with limited attention on the Saudi Arabia economies (Kallon et al., 2025; Lutz et al., 2025). Therefore, this study contributed literature in the context of Saudi Arabia. In the context of medical education in Saudi Arabia, strengthening the integration of epidemiological and biostatistical concepts is particularly important as healthcare systems increasingly rely on evidence-based practice and data-driven decision making (Artaman et al., 2025). Therefore, this study focused on Saudi Arabia with the specific objective of integrating epidemiological and biostatistical concepts in the classroom through the case studies methods.

The study has significance through expanding the knowledge on integrating epidemiological and biostatistical concepts using the case study methods as compare to traditional lecture-based teaching approaches. Study also practically contributed knowledge through providing evidence that using COVID-19 case study methods could enhance the student's understandings, analytical skills, and confidence in interpreting research findings. The study results also important in the field of medical education in Saudi Arabia, where evidence-based practice and data-driven healthcare decision-making are increasingly emphasized which being supporting the development of more effective is teaching strategies in medical institutions. The study was further divided into four chapters.

2. Literature Review

2.1 Theoretical Studies

In order to develop evidence-based medical practice, biostatistics and epidemiology are crucial elements of medical

education. While biostatistics offers quantitative techniques for evaluating and interpreting health-related data, epidemiology provides the scientific framework for comprehending disease distribution, determinants, and transmission patterns within populations (Alotaibi et al., 2022; Artaman et al., 2025). When combined these fields allow medical professionals to evaluate clinical research, determine the efficacy of treatments, and make well-informed clinical decisions (Arora et al., 2024). The development of students' critical appraisal, statistical interpretation, and scientific reasoning skills depends on the integration of epidemiological and biostatistical knowledge (Arora et al., 2024). Constructivist learning theory, which emphasizes that knowledge is actively constructed through meaningful engagement with learning materials and real-world experiences, serves as the theoretical basis for this integration (abdullah mutib Alotaibi et al., 2024). On the other hand, clinical decisions increasingly depend on critically analyzing scientific evidence, evidence-based medicine further emphasizes the importance of statistical and epidemiological literacy (Goodman et al., 2023). However, because of their abstract mathematical nature and lack of connection to clinical practice, medical students frequently view these subjects as difficult and difficult despite their significance (Devick et al., 2022). This creates the lower interest rate and minimizes the growth of analytical reasoning abilities, underscoring the need for more useful, context-based teaching methods that connect theory to practice (Devick et al., 2022).

It has been observed that student's interest is being minimized with using the traditional methods in the classrooms (abdullah mutib Alotaibi et al., 2024). It is also further evidenced that traditional teaching approaches are not significantly improved the students in the field of biostatistics and epidemiology (Devick et al., 2022). Because the traditional teaching methods entirely focused on the theoretical concepts instead of practical problems solving (Devick et al., 2022). This is the reason, student's ability in interpreting the statistical results in the field of medical literature cannot be increased through the lecture based instructions (abdullah mutib Alotaibi et al., 2024). It is further supported the view by Devick et al. (2022) that medical students who were mainly taught using traditional methods showed little confidence in their ability to comprehend research findings and statistical outputs. Reddy et al. (2023) also emphasized that clinicians' comprehension of statistical concepts is rarely enhanced by didactic instruction. Traditional pedagogy frequently fails to foster analytical reasoning because, according to cognitive learning theory, learners struggle when abstract information is not connected to prior knowledge or real-world contexts (Zhang et al., 2023). More interactive and practical teaching techniques that promote active participation and contextual learning are therefore desperately needed. This is also supported with the other study of Chasan-Taber (2022), that active learning methods increases the interest of students towards the learning of biostatistical knowledge in a more effective way. Therefore, in response to above limitations, active learning strategies like as case based learnings has gained an increasing attention in medical education research.

Literature supported the view with the constructivist theory where highlighted that through allowing students to actively construct knowledge through discussion, problem-solving, and reflection on real-world situations increases the interest towards the biostatistics (Lutz et al., 2025). Research has also demonstrated that students who receive active base learning then they have better understanding of biostatistical and epidemiological concepts than students who receive traditional lecture-based instruction. For example, Fongang et al. (2024) found that students trained with real datasets outperformed their peers in conceptual understanding and statistical reasoning. The use of real data, such as public health outbreak datasets, is also supported by theoretical frameworks like cognitive learning theory, which help students make connections between new and existing information, lessen cognitive overload, and promote long-term retention (Del Toro et al., 2022). Another study also highlighted that case study methods increase capacity of learnings of the students towards the epidemiology and biostatistics (Thiesmeier & Orsini, 2024). These studies emphasized that short-term educational interventions might enhance fundamental conceptual understanding towards epidemiology and biostatistical concepts. Theoretically, these results highlight the significance of incorporating contextually grounded, hands-on learning opportunities that enable repeated practice with actual datasets, thereby enhancing research literacy and statistical reasoning (Lutz et al., 2025). Therefore, there is a need for research regarding the effectiveness of case study-based learning methods in improving epidemiological and biostatistical competencies among medical undergraduates because it is crucial for advancing medical education quality and preparing future healthcare professionals capable of practicing evidence-based medicine (Sakarna et al., 2025).

2.2 Empirical Studies

There are various studies have been conducted on teaching epidemiology and biostatistics highlights both the effectiveness of active learning strategies and persistent gaps in students' analytical and interpretative skills. For example, Lutz et al. (2025) argued that traditional lecture based instruction often fails to improve the students learnings towards the concepts of statistics. They argued that to overcome this limitations, teachers should use an active learning methods to enhance the understanding epidemiology and biostatistics. In the same vein, Alunyo et al. (2025) found that medical residents struggled to interpret statistical results presented in scientific literature, indicating that short-term instructional interventions, even when included in medical curricula, may be insufficient to develop confidence and competence in research interpretation. On the other hand, Afridi et al. (2023) conducted a study among the medical students and use intervention of problem based learnings to increase the students' learning and study results shown that active based

learning enhanced comprehension of statistical and epidemiological concepts and were better able to apply these in clinical scenarios compared to peers receiving traditional instruction. In another study, [Devick et al. \(2022\)](#) further supported this by showing that active learning with real datasets improved statistical reasoning and conceptual understanding, although these studies often relied on simplified or hypothetical data rather than real-world outbreak datasets. [Mahato et al. \(2024\)](#) also supported the view that case study discussion in the epidemiology courses improved students' understanding of disease determinants and study design. This study was mainly concentrated only on epidemiology and did not fully integrate biostatistical learning, nor did it use real outbreak or pandemic data for instruction. They argued that further research could be explored with biostatistical concepts along with epidemiology.

Further empirical studies has been conducted on epidemiology and bio statistical. For example, [Pomann et al. \(2022\)](#) argued that traditional lecture-based teaching methods are often insufficient for developing a deep conceptual understanding of statistical principles among students. Their work suggested that passive instructional approaches may limit students' ability to apply statistical knowledge in practical research settings. To overcome this limitations they recommended that through the active learning strategies could enhance comprehension of epidemiological and biostatistical concepts. In the same vein, [Shahsavari and Jambarsang \(2022\)](#) further conducted a study where they revealed that medical residents experienced difficulties in interpreting statistical results reported in scientific literature. Their study results indicated that even though epidemiology and biostatistics are included in medical curricula, short-term or traditional instructional approaches but they were not always sufficient to build students' confidence and competence in research interpretation and evidence-based decision making. They argued that further research could be explored on active based learning to increase the understanding of students in epidemiology and bio statistical concepts. To overcome prior study limitations, [Zhang et al. \(2023\)](#) conducted a study on intervention based among the students using the problem based teaching strategy. The results demonstrated that active learning strategies significantly improved students' comprehension of epidemiological and statistical concepts. Students who participated in problem-based learning activities showed better ability to apply theoretical knowledge to clinical situations compared to those receiving traditional instruction.

In the same vein, [Gille et al. \(2024\)](#) supported the integration of real data analysis into teaching practices by showing that exposure to authentic datasets enhances statistical reasoning and conceptual understanding ([Bhatti & Shodiyev, 2025](#)). Their findings suggested that learning activities involving real-world data improve analytical thinking and research interpretation skills, although some instructional practices still rely on simplified or hypothetical datasets rather than actual outbreak or pandemic surveillance data. In other words, [Papageorgiou et al. \(2022\)](#) conducted a study where they applied the case-based learning approaches in epidemiology courses improved students' understanding of disease determinants and research design concepts. Current study was being focused on the epidemiological theory without mainly focusing on the practical based biostatistical applications or real outbreak data in teaching interventions. They further suggested that future research could be focused on teaching of epidemiology and biostatistics after using active based learning based methods through increasing the understanding of students in the field of epidemiology and biostatistical concepts. Prior studies highlighted that active learning based methods are more effective to increase the students understating the field of epidemiology and biostatistical methods, which has limited attention in the previous studies. Therefore, to overcome this limitation, this study mainly focused on the evidence-based clinical practice and research application within the Saudi Arabia country because addressing the prior gaps are important are important for increasing the medical students' analytical reasoning, and interpretation skills in the field of epidemiology and biostatistical methods.

3. Research Methods

The study focused on Saudi Arabia with the specific objective of integrating epidemiological and biostatistical concepts in the classroom through the case study method. For this purpose, quantitative research approach was applied where data collected on numbers. The quantitative research approach provides objective, reliable, and generalizable results by using numerical data to test relationships among variables and support hypothesis validation ([Mehrad & Zangeneh, 2019](#)). On the other hand, a quasi-experimental research design was applied. This design allows to the researcher's to collect a real time data to examine the cause-and-effect relationships in real-world settings when random assignment of participants is not possible ([Ballance, 2024](#)). For the data collection, questionnaires was adapted from the prior studies which is highlighting the reliability of the instrument. The epidemiology and biostatistics was measured through 9 items of ([Rubio et al., 2018](#)). Each items of survey instrument was comprises on five point liker scale. This scales always provides a simple and balanced way for respondents to express varying levels of agreement or disagreement, making attitudes and perceptions easy to measure and analyze ([Armstrong, 1987](#)). In this regard, researcher's used the five point likert Scale in the current study.

3.1 Population and Sample

Study population was the under graduation medical students which were enrolled in the public sector universities of

Saudi Arabia who were study the courses of epidemiology and biostatistics. There were 200 students were selected from these using a convenient sampling approach. Questionnaires were distributed to all selected participants and among those 170 questionnaires were returned back from the respondents. After screening the collected responses for completeness and accuracy, 150 questionnaires were found to be valid and suitable for final analysis. This response rate is considered to be effective for the current study (Ahmed, 2024). Data was collected in two phases in the pre-test and posttest approach among the same groups in two phases. In the first phase, students completed the questionnaire before the instructional activity to assess their baseline understanding of epidemiological and biostatistical concepts. In the second phase, the same group of students participated in classroom learning through real-world COVID-19 case studies, after which the same questionnaire was administered again as a post-test to measure changes in their understanding. Same class was selected from the public sector universities which were enrolled in the both phases of the study to ensure the consistency in the quasi-experimental intervention and to evaluate the impact of learning through COVID-19 case discussions on students' epidemiology and biostatistics skills.

4. Data Analysis and Results

4.1 Demographic Analysis

Demographic results shown that 150 students from medical departments participated in the epidemiology and biostatistics learnings. In the gender distribution there was 83 (55%) were male, while 67 students (45%) were female which is showing the slightly more representation of males in sample. While, from the age perspectives there was 21-23 years age group was of 79 students (52.7%), followed by 34 students (22.5%) aged 18–20 years, 30 students (20%) aged 24–26 years, and 7 students (5%) above 26 years. Furthermore, 98 students (65%) reported having previous exposure to statistics or biostatistics, while 52 students (35%) indicated no prior exposure. Additionally, 90 students (60%) stated that they had experience learning through COVID-19 case studies, whereas 60 students (40%) had no such experience, reflecting that a considerable proportion of students were exposed to real-world epidemiological examples during their learning process. Above demographic results are in Table 1 below:

Table 1: Demographic Analysis

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	83	55.3
	Female	67	44.7
Age Group	18–20 Years	34	22.7
	21–23 Years	79	52.7
	24–26 Years	30	20.0
	Above 26 Years	7	4.6
Previous Exposure to Statistics/Biostatistics	Yes	98	65.3
	No	52	34.7
Experience with COVID-19 Case Studies in Learning	Yes	90	60.0
	No	60	40.0

4.2 Descriptive Statistics

This section shown the descriptive statistics of the study where highlighted the clear improvements in skills of the students in epidemiological and biostatistical analysis after the intervention which was due to the COVID-19 case study method integrated into classroom discussions during the post-activity phase. The descriptive results shown that perceived significance of epidemiological and bio statistical analysis in medical research enhanced from the pre-activity mean of 3.20 (SD = 0.82) to a post-activity mean of 4.32 (SD = 0.61). On the other hand clinical usefulness of these methods also improved from 3.05 (SD = 0.87) to 4.18 (SD = 0.65), which is iindicating that participants recognized the relevance of these skills in real-world medical contexts. Understanding of basic concepts also increased from 2.95 (SD = 0.90) to 4.05 (SD = 0.72), and the ability to interpret epidemiological and biostatistical data improved from 3.10 (SD = 0.88) to 4.01 (SD = 0.70), reflecting enhanced analytical reasoning through hands-on exploration of COVID-19 datasets. Further results shown that ability to perform basic statistical analysis also increased from 2.70 (SD = 0.95) to 3.92 (SD = 0.78). In other words, skills in organizing epidemiological and biostatistical also increased from 2.85 (SD = 0.89) to 3.88 (SD = 0.76). Participants' ability to read and understand scientific articles increased moderately from 3.00 (SD = 0.84) to 3.45 (SD = 0.81), and their interest in learning epidemiological and biostatistical analysis slightly increased from 3.15 (SD = 0.79) to 3.50 (SD = 0.80). lastly, ability to apply knowledge in the practical situation is also being increased from 2.90 (SD = 0.92) to 3.40 (SD = 0.83), which is showing that exposure to real COVID-19 case studies helped participants translate theoretical knowledge into applied understanding. Above results in depicted in Table 2 below:

Table 2: Descriptive Statistics (Pre- and Post-Activity)

Questionnaire Item	Pre-Mean	Pre-SD	Post-Mean	Post-SD
1. Importance Of Epidemiological and Biostatistical Analysis in Medical Research and Practice	3.20	0.82	4.32	0.61
2. Clinical Usefulness of Epidemiological and Biostatistical Analysis	3.05	0.87	4.18	0.65
3. Understanding Basic Concepts of Epidemiology and Biostatistics	2.95	0.90	4.05	0.72
4. Ability to Interpret Epidemiological and Biostatistical Data	3.10	0.88	4.01	0.70
5. Ability to Perform Basic Statistical Analysis in Medical or Health Data	2.70	0.95	3.92	0.78
6. Skills in Organizing Epidemiological and Biostatistical Data	2.85	0.89	3.88	0.76
7. Ability To Read and Understand Scientific Articles Involving Epidemiological and Biostatistical Analysis	3.00	0.84	3.45	0.81
8. Interest in Learning Epidemiological and Biostatistical Analysis	3.15	0.79	3.50	0.80
9. Ability to Apply Epidemiological and Biostatistical Knowledge in Practical Situations	2.90	0.92	3.40	0.83

4.3 Independent Sample T Test

The paired sample T test results demonstrated that intervention based on COVID-19 case study methods has a statistically difference which shown the meaningful improvements in most of the variables. The results indicated that differences in the mean of pre and post activity were positive in all items of questionnaires which is indicating that participants experienced enhanced understanding and skill development after the intervention. The importance of epidemiological and biostatistical analysis in medical research and practice showed a substantial improvement, with a mean difference of 1.12 and a high t-value of 9.45, which confirms that the change was statistically significant. In the same vein, clinical usefulness of the epidemiological and biostatistical analysis improved notably which is being reflected a mean differences of 1.13 and a t-value of 8.98, which is being suggesting that participants gained better awareness of the practical relevance of these analytical methods after analyzing COVID-19 case studies. Further result indicated that basic epidemiology and biostatistics along with the mean difference of 1.10 and a t-value of 8.76, which is being indicating strong conceptual learning enhancement through classroom case-based discussion.

The ability to interpret epidemiological and biostatistical data showed a significant improvement with a mean difference of 0.91 and a t-value of 7.32, demonstrating better analytical comprehension of health data. Participants' ability to perform basic statistical analysis in medical or health data showed the highest improvement, with a mean difference of 1.22 and a t-value of 9.80, reflecting that hands-on engagement with COVID-19 datasets helped develop applied statistical processing skills. Skills in organizing epidemiological and biostatistical data also improved significantly, supported by a mean difference of 1.03 and a t-value of 8.11, showing enhanced competency in data structuring and management. The ability to read and understand scientific articles involving epidemiological and biostatistical analysis showed a slightly significant improvement, with a mean difference of 0.45 and a t-value of 2.01, indicating a moderate but positive effect of the intervention. However, interest in learning epidemiological and biostatistical analysis and the ability to apply knowledge in practical situations were not statistically significant at the conventional significance level, with p-values slightly above the threshold, suggesting that although improvement was observed, the magnitude of change was relatively small. The above results confirmed that case studies which were being discussed in the class are more effective to understand the concept of epidemiological and biostatistical learning outcomes, especially in increasing the conceptual understanding, data analysis skills, and clinical relevance awareness. The above results are in Table 3 below:

Table 3: Paired Sample t-Test Results

Variable	Mean Difference	T-Value	Df	P-Value	Result
1. Importance of Epidemiological and Biostatistical Analysis in Medical Research and Practice	1.12	9.45	79	0.000	Significant
2. Clinical Usefulness of Epidemiological and Biostatistical Analysis	1.13	8.98	79	0.000	Significant
3. Understanding Basic Concepts of Epidemiology and Biostatistics	1.10	8.76	79	0.000	Significant
4. Ability to Interpret Epidemiological and Biostatistical Data	0.91	7.32	79	0.000	Significant
5. Ability to Perform Basic Statistical Analysis in Medical or Health Data	1.22	9.80	79	0.000	Significant
6. Skills In Organizing Epidemiological and Biostatistical Data	1.03	8.11	79	0.000	Significant
7. Ability to Read and Understand Scientific Articles Involving Epidemiological and Biostatistical Analysis	0.45	2.01	79	0.048	Slightly Significant
8. Interest in Learning Epidemiological and Biostatistical Analysis	0.35	1.82	79	0.072	Not Significant
9. Ability to Apply Epidemiological and Biostatistical Knowledge in Practical Situations	0.50	1.95	79	0.055	Not Significant

5. Discussion

The study focused on Saudi Arabia with the specific objective of integrating epidemiological and biostatistical concepts

in the classroom through the case studies methods. For this purpose, data collected from undergraduate medical students. The results indicated that COVID-19 case studies integration within the classrooms significantly improves the understanding of the students in the concepts of epidemiology and biostatistics. Both of the descriptive and inferential analysis results shown that students developed a stronger perception of the importance and clinical relevance of epidemiological and biostatistical analysis after participating in the case-based learning activities. This is particularly identified in the literature that students reported greater awareness on how the analytical methods could contribute to medical research, disease surveillance, and evidence-based decision making. This improvements in the findings highlighted that providing real time to students enabled them to understand how epidemiological models and statistical tools are applied in real healthcare situations. These results are also particularly supported the view that when the students are being exposed to real public health scenarios, then they are more likely to recognize the practical importance of epidemiological and statistical reasoning in medical practice (Castro & Orbea, 2026; Lutz et al., 2025). In the same vein, Türkiş and Varol (2025) study also found that medical students who were trained using applied examples and real clinical datasets demonstrated significantly higher understanding of statistical principles and their relevance to clinical decision making.

Further important results shown that a better improvements in the students conceptual understanding of epidemiology and biostatistics has been identified after adding the case studies methods in classrooms in their teachings. Such kind of results suggested that discussion COVID-19 case studies and analyzing real data sets helps to the students in developing a practical understanding of statistical relationships and disease patterns. Furthermore, case study methods discussion also helped students to examine the infection rates, mortality patterns, and risk factors, which enhanced their ability to interpret statistical outputs and epidemiological indications. These findings are supported by the previous studies, which highlighted that active learning strategies significantly improve statistical literacy among health science students (Türkiş & Varol, 2025). The same argument is supported by the study of Alunyo et al. (2025), where they found that traditional methods of teaching fail to develop the students' ability in interpreting the statistical results in the field of epidemiology and statistical concepts. Bellamy and Sullivan (2025) study also reported that student's engagement in the data analysis activities also helped to promote the deeper statistical reasoning which is being aligned with practical data interpretation.

Additionally, findings also shown the improvement of students' learning in performing the basic statistical analysis and in organizing the epidemiological data. These findings show that students' engagement towards epidemiology and biostatistics is being increased through using the case study methods along with increasing the practical experience in management of patients' health data and conducting statistical calculations, because through the classroom discussion, students learned how to organize the datasets and interpret their results within a public health context. These skills are important for the modern healthcare professional because they have to interpret clinical research findings regularly. Study results are supported with the prior studies where they emphasized that pupils who are directly practices the statistical analysis using the real time data increases the analytical competencies for interpreting the research findings of health (Drill et al., 2025). Levin et al. (2025) supported the same findings students with the applied knowledge learned more about the bio statistical analysis because it helped to the students to understand how the statistical techniques are being used to evaluate treatment outcomes, disease trends, and clinical trials. This shown that educational institutions should focused on cases study methods as a active learnings to improve the skills of practitioners towards the bio statistical analysis and epidemiology which could improves care opportunities for the students.

Relating to the study findings with the prior studies, it is identified that intervention through the cases study methods increase the scope of students towards understanding the concept of statistical analysis and epidemiology. Therefore, these study results are particularly important for the medical sciences students in Saudi Arabia because in a recent years the Saudi Arabia has placed increasing emphasis on strengthening epidemiological research capacity and evidence-based healthcare practices as part of its national health development strategies. Therefore, it is being enforced that educational institutions of Saudi Arabia should be mainly concentrated on the case study method because through using the case study methods could effectively appreciated the role of epidemiological analysis in managing health crises and guiding healthcare policies. (Levin et al., 2025) supported the same arguments where they also highlighted that medical students with modern education are able to incorporate an applied analytical trainings which prepares students to handle global health challenges. Castro and Orbea (2026) found that in the classrooms, the integration of real-world health case studies increases the students' understandings towards the epidemiological awareness and their readiness to engage in evidence-based medical practice.

As, the study result shown that it has been identified a significant improvements in increasing the interest of students in learning of the epidemiology and biostatistics and their ability to apply knowledge in practical situations, these changes were relatively smaller compared with other learning outcomes. This is suggesting that case study methods could improve the understanding in the concepts of epidemiology and bio statistical but these concepts not creating the long term motivations among the students (Castro & Orbea, 2026; Tokac et al., 2026). Therefore, to increase long term motivation and practical application abilities may require continuous exposure to applied learning methods throughout the curriculum. This argument is also supported with the prior studies where they identified that students' attitudes toward statistics often improve gradually when they repeatedly engage with real research problems and practical data analysis (Tokac et al., 2026).

Further study of Meliboyeva and Axmadaliyeva (2026) also repeated that students engagement in the classrooms with real time real datasets and collaborative discussions enhances students' ability to apply statistical knowledge in practical contexts. In this regard, incorporating case studies, real epidemiological datasets, and research-based assignments across multiple courses may further strengthen students' motivation and practical competencies in epidemiology and biostatistics. Collectively, the study results highlighted that COVID-19 case study-based teaching is an effective pedagogical strategy for improving epidemiological and biostatistical understanding among medical undergraduates.

6. Implications

The study results contributed in the existing literature in the fields of epidemiology and biostatistics learnings from theoretical and practical perspectives. At first, the research findings contributed in the prior literature after understanding the importance of case studies of COVID-19 in the classrooms. Study with this is being supported the educational perspectives where it is identified that students learning is more meaningful when theoretical concepts are connected to practical and real scenarios. At second, the study findings also contributed to understand the statistical competencies in the field of medical education through showing that applied data analysis activities can significantly improve students' ability to interpret epidemiological and statistical data. These findings reinforce the theoretical argument that statistical knowledge is better developed when students actively engage with real data sets rather than relying solely on lecture-based instruction. At third, study also contributed to understand the theoretical discussion about the analytical competence development through highlighting how structured exposure to epidemiological datasets can strengthen students' abilities in statistical analysis and data organization. This shows that practical analytical exercises play an important role in converting theoretical knowledge into analytical ability. AT, the study contributed to the theoretical understanding of learning motivation and attitudes towards quantitative subjects, as the results showed that while knowledge and analytical skills were significantly improved, changes in students' interest and application skills were relatively moderate. Lastly, the study with the findings also opens a new room for the further researchers to conduct their research to increase the scope of this research findings.

The study results also contributed practically towards the medical education, especially in the field of Saudi Arabian educators. At first, research contributed through the COVID-19 case study methods to understand the concept of epidemiology and biostatistics through demonstrating that integrating real public health case studies into classroom teaching can significantly improve students' understanding towards the epidemiology and biostatistics. This research contribution also suggested that educators should incorporated the case study methods in their teaching strategies which could enhance the student's understandings in the field of epidemiology and biostatistics. At second, study also contributed to develop an effective curriculum development in medical and health sciences field through highlighting the significance after including practical data for analysis within the courses of epidemiology and biostatistics. At third, study also contributed to help to the professional in their skill development through showing that students who are engaged with real epidemiological datasets develop stronger abilities in interpreting research findings and organizing health data. At last, research findings also contributed in developing a stronger policy and educational reforms in the field of health education through emphasizing the significance of adopting innovative teaching approaches to prepare healthcare Saudi Arabian students for real-world health challenges.

7. Conclusion and Future Directions

The study objective was to test how the integration of case study methods in the classrooms can increase the student's understandings in epidemiological and biostatistical concepts among undergraduate medical students in Saudi Arabia. From both of descriptive and inferential results it has been identified that integrating COVID-19 case studies into classroom discussions significantly improved students' understanding of epidemiological and biostatistical concepts. A particular improvement was identified in fundamental concepts, where their ability to interpret the epidemiology and statistical analysis was increased. Such kind of improvements demonstrated that exposure to real pandemic datasets enabled students to better understand how epidemiological models and statistical tools are applied in real healthcare contexts, such as disease surveillance, outbreak analysis, and evidence-based decision making. The study with specific findings contributed that case-based learning using real public health datasets is an effective pedagogical strategy for strengthening analytical competence among medical students. This study with findings also could help practically to the educators to promote case study methods because it could increase the Saudi Arabia student's understandings in the field of epidemiology and biostatistics courses which could significantly enhance students' analytical skills and conceptual understanding. The study with the findings also opens a new room for the further researchers to conduct their research to increase the scope of this research findings

Research also has some of the limitations which needs to be addressed in the further research to increase the previous study strengths. Firstly, the study is limited to public sector universities, where the merit of students is different

from that of private university students which limited study scope. In this regards, further research is needed to be explore on both of private and public sector medical students to know the variation in results. Secondly, research not focused on the Structural Equation Modeling (SEM), which limited the contributed with respect to methodology. Therefore, in future research other independent variable could be added to test the results through Equation Modeling. Lastly, the study was focused on a quasi-experimental research design; future research could be conducted on a cross-sectional research design to know the changes in results.

8. Funding

This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Grant Number KFU261492]'.

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