



EVALUATING THE EFFECTIVENESS OF CASE-BASED LEARNING IN LARGE GROUP ANATOMY TEACHING FOR PHASE 1 MBBS STUDENTS

P R Prefulla¹, Nisha S R Manuel², R. Rathika³, V. Deepanchakravarthi⁴

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Corresponding Author:

Dr. P R Prefulla,
Email: drprefullarajiv@gmail.com

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¹Associate Professor, Department of Anatomy, Government Stanley Medical College, Chennai, Tamil Nadu, India.

²Professor, Department of Anatomy, Government Thiruvallur Medical College, Thiruvallur, Tamil Nadu, India.

³Assistant Professor, Department of Anatomy, Government Thiruvallur Medical College, Thiruvallur, Tamil Nadu, India.

⁴Assistant Professor, Department of Community Medicine, Government Stanley Medical College, Chennai, Tamil Nadu, India.

ABSTRACT

Background: The National Medical Commission's Competency-Based Medical Education (CBME) curriculum emphasizes learner-centred, outcome-based education and clinically relevant learning. Although anatomy is fundamental to medical practice, traditional lectures often promote passive learning and limited clinical application, reducing motivation and long-term retention. Constructivist Learning Theory and Knowles' Adult Learning Theory support active, contextual learning through authentic clinical problems. Case-Based Learning (CBL) enhances engagement, clinical reasoning, and knowledge integration, with demonstrated educational benefits. However, evidence for Case-Based Large Group Learning (CBL), particularly within Indian CBME anatomy education, remains limited. This study compared CBL with traditional lectures regarding knowledge gain, retention, learner perception, and satisfaction. **Materials and Methods:** One hundred Phase I MBBS students were randomly allocated into study (CBL) and control (traditional lecture) groups (n=50 each). Four anatomy topics were taught by the same faculty using a crossover design. In the CBL sessions, validated real patient video-based clinical scenarios were introduced at the beginning of each lecture. Knowledge gain was assessed using identical validated five-item Multiple Choice Questions (MCQ) as pre- and post-tests for each topic, while knowledge retention was evaluated four weeks later using an MCQ test. Student perceptions and satisfaction with CBL were assessed using a validated 5-point Likert-scale questionnaire and open-ended feedback. **Results:** Both Case-Based Large-Group Learning (CBL) and traditional lectures significantly improved post-test scores ($p < 0.05$). CBL produced significantly greater cumulative knowledge gain than traditional lectures ($p < 0.05$; Cohen's $d = 0.34$) and demonstrated superior knowledge retention in three of four topics. Students rated CBL as more informative, clinically relevant, and effective for understanding anatomy. Overall, 96–98% of students agreed or strongly agreed that CBL enhanced engagement, improved understanding, achieved the learning objectives, and provided a satisfactory learning experience. **Conclusion:** Case-Based Large-Group Learning provided measurable educational advantages over traditional lectures by improving cumulative knowledge gain, knowledge retention, and learner engagement. Positive student perceptions and high satisfaction support its use as an effective complementary teaching strategy for clinically relevant, active learning within Competency-Based Medical Education. Further multicentric studies are needed to confirm its long-term educational impact and generalizability.

INTRODUCTION

Medical education in India has undergone a paradigm shift with the introduction of the Competency-Based Medical Education (CBME) curriculum by the National Medical Commission in 2019. CBME emphasizes outcome-based, learner-centred education, early clinical exposure, integration of disciplines, and application of knowledge in clinical practice, necessitating innovative teaching-learning strategies that promote active and meaningful learning.^[1] Anatomy is fundamental to medical education and underpins clinical practice, diagnostic imaging, and surgical procedures. However, first-year MBBS students often perceive anatomy as challenging because of its extensive content and complex three-dimensional relationships. Although traditional didactic lectures remain the predominant teaching method for large student cohorts, they frequently promote passive learning, factual memorization, and limited integration of anatomical concepts with clinical practice, resulting in reduced motivation and poor long-term knowledge retention.^[2-4]

Constructivist Learning Theory and Knowles' Adult Learning Theory provide a strong educational foundation for learner-centred teaching. These theories propose that knowledge is constructed through active engagement, discussion, reflection, and problem-solving in authentic contexts, with learning being most effective when it is relevant and applicable to future professional practice.^[5,6] Case-Based Learning (CBL) is a learner-centred instructional strategy which helps students to apply knowledge in basic sciences like Anatomy to clinical scenarios, under faculty guidance. CBL enhances conceptual understanding of Anatomy as it promotes active participation, clinical reasoning, and noteworthy integration of basic and clinical sciences. Previous studies and systematic reviews have demonstrated that CBL improves academic performance, learner engagement, satisfaction, and integration of knowledge compared with traditional lectures, aligning well with the objectives of the CBME curriculum.^[7,8]

Despite these advantages, the scope of CBL has been researched and utilised predominantly in small-group teaching.^[9-13] Medical colleges in India face many challenges in routine small group teaching including increasing student intake, limited faculty, infrastructure constraints, and restricted curricular time. Adapting CBL to large-group classrooms may provide a practical and scalable learner-centred alternative. Evidence regarding the effectiveness of Case-Based Large Group Learning (CBLL) in anatomy remains limited, particularly within the Indian CBME context. Therefore, this study evaluated the effectiveness of CBLL compared with traditional lectures among Phase I MBBS students by assessing immediate knowledge gain, cumulative

learning, knowledge retention, learner perception, and student satisfaction.

Objectives

1. To develop, design and implement Case based learning (CBLL) module in Large group teaching of Anatomy of General Histology and Upper Limb.
2. To assess the impact of CBLL on knowledge gain, acquisition of clinical reasoning skills and knowledge retention of students
3. To assess student engagement and satisfaction with CBLL in Large group teaching of Anatomy.

MATERIALS AND METHODS

This prospective quasi-experimental mixed-method cross-over educational study was conducted after obtaining Institutional Ethics Committee approval. The mixed-methods approach was selected to provide complementary information regarding both learning outcomes and students' experiences of the intervention.^[14] The crossover approach was chosen for each student to experience both instructional methods, thereby allowing comparison of learning outcomes across the two interventions.^[15] Written informed consent was obtained from all participating students and from the patients whose clinical videos were used for teaching.

The study population comprised the entire batch of Phase I MBBS (academic year 2025-26) cohort enrolled during the study period (n=100). As the accessible cohort consisted of 100 students, all eligible students were invited to participate in the study.

Participants were randomly allocated into two groups (Group A and Group B; n=50 each). The quantitative component assessed knowledge gain and knowledge retention, while the qualitative component evaluated learner perception, engagement, and satisfaction with Case-Based Large-Group Learning (CBLL).

Four clinically relevant anatomy topics were selected based on the availability of authentic realtime clinical cases, two each from General Histology and Upper limb: Histology of lymphoid tissue- AN 70.2, AN 43.2 (Adenotonsillitis), Elbow joint- AN 13.3, AN 11.6 (Posterior dislocation of elbow), Histology of skin- AN 4.1, 4.2,4.3,4.4,4.5 (Pemphigus vulgaris), and Ulnar nerve- AN 11.2, 12.2, 12.7, 12.8 (Claw hand). Four CBLL modules were developed using real patient video-based clinical scenarios, in consultation with anatomy and respective clinical specialists. The videos included history taking, clinical examination, and relevant investigation findings where applicable. Validated case vignettes based upon the same patients were prepared and presented at the beginning and end of each CBLL session.

Each group attended four large-group anatomy sessions delivered by the same faculty member (Table 1). During CBLL sessions, the clinical case

was discussed before the didactic lecture to facilitate contextual learning (Appendix 1). The control group received traditional lecture-based teaching without case discussion. After completion of two topics, a crossover design was implemented, with Group A receiving CBLL for the first two topics and traditional lectures for the remaining two topics, while Group B followed the reverse sequence. Following knowledge-retention assessment, the clinical case discussions were also provided to the control group to ensure equitable educational exposure.

Knowledge gain was assessed using validated five-item multiple-choice question (MCQ) pre-tests and post-tests administered before and immediately after each session. The same MCQs were used for pre- and post-testing. Knowledge retention was evaluated four weeks later using a different validated five-item MCQ test for each topic. Student perceptions and satisfaction with CBLL were assessed immediately after each CBLL session by a questionnaire containing questions designed to assess student engagement, understanding of the topic, clinical relevance, achievement of learning objectives, and overall acceptability of the teaching method. Responses were recorded using a five-point Likert scale ranging from strongly disagree to strongly agree. Two open-ended questions were also included to obtain students' qualitative comments regarding the perceived benefits of the intervention and scope for improvement. The questionnaire was reviewed by faculty members with experience in anatomy and medical education for relevance, clarity, appropriateness and comprehensiveness of the items. Based on the expert feedback, necessary modifications were made before administration, thereby establishing content validity.

The primary outcome measures were immediate knowledge gain, cumulative learning, and knowledge retention. Secondary outcomes included students'

perceptions of usefulness, engagement, and satisfaction with CBLL.

Outcome Measures and Statistical Analysis

Educational outcomes were evaluated using the first two levels of the Kirkpatrick model.

Level 1 (Reaction) was assessed through student perceptions and satisfaction using a validated 5-point Likert-scale questionnaire supplemented with open-ended questions.

Level 2 (Learning) was assessed using pre-test, post-test, and knowledge retention tests conducted four weeks after the intervention.

Knowledge gain was calculated as the difference between post-test and pre-test scores for each topic and compared between the Case-Based Large-Group Learning (CBLL) and traditional lecture (TL) groups. Cumulative knowledge gain across all four topics was also analysed. The magnitude of the difference between teaching methods was determined using Cohen's d effect size.

Knowledge retention was evaluated by comparing knowledge retention test scores with post-test scores. Retention was classified as stable (retention score = post-test score), improvement (retention score > post-test score), or decline (retention score < post-test score).

Statistical analysis was performed using IBM SPSS Statistics version 23.0. Continuous variables were summarized as median (interquartile range) or mean $\pm$ standard deviation, as appropriate and Categorical variables were expressed in proportions. Within-group comparisons were performed using the Wilcoxon signed-rank test, while between-group comparisons were analysed using the Mann–Whitney U test. Chi square test was used for identifying statistical significance between categories and Cohen's D was used to assess the effect size. A two-tailed p value <0.05 was considered statistically significant.

Table 1: Showing the Methodology of this study

METHODOLOGY				
Design: Quasi experimental study with cross over				
100 students divided into 2 groups: Group A (n= 50) and Group B (n=50)				
Pre- test	Pre- test	CROSS OVER	Pre- test	Pre- test
CBLL for Group A, TL for Group B for Topic 1 (Histology of lymphoid tissue)	CBLL for Group A, TL for Group B for Topic 2 (Elbow joint)		CBLL for Group B, TL for Group A for Topic 3 (Histology of skin)	CBLL for Group B, TL for Group A for Topic 4 (Ulnar nerve)
Post- test, feedback form	Post- test, feedback form		Post- test, feedback form	Post- test, feedback form
Knowledge retention test	Knowledge retention test		Knowledge retention test	Knowledge retention test

RESULTS

Student learning with CBLL

Both Case-Based Large-Group Learning (CBLL) and traditional lectures (TL) produced significant improvements in post-test scores compared with pre-test scores across all four topics ($p < 0.05$) (Table 2). On comparing CBLL and traditional lecture topic wise, CBLL demonstrated significantly greater knowledge gain than TL in Topics 2 and 4 (Table 3).

Although the median cumulative knowledge gain was 2 in both groups, CBLL showed significantly greater overall improvement than TL, as reflected by the higher 95% confidence interval (2.01–2.63 vs. 1.29–1.85; $p < 0.05$) (Table 4). The magnitude of this difference was small (Cohen's $d = 0.34$), indicating a modest educational effect (Table 4). The box-and-whisker plot showed greater variability and more outliers in the TL group (Fig. 1).

Knowledge retention was more stable or showed improvement following CBLL, with significantly better retention than TL in three of the four topics. Although both groups showed a decline in retention

over time, the reduction was less pronounced in the CBLL group. No statistically significant difference was observed for Topic 4. [Table 5]

Table 2: Describing the Pre and Post test difference in scores of Case Based Learning Lecture sessions and Traditional Lecture sessions and its statistical significance

Teaching sessions and its statistical significance							
Teaching Learning Method		Mean	Median (IQR)	Std. Deviation	95% CI	Z value	p value
CBLL	CBLL 1	1.96	2 (1-3)	1.60	1.5-2.4	-5.421	0.000*
	CBLL 2	2.68	3(2-4)	1.43	2.27-3	-5.971	0.000*
	CBLL 3	1.26	1(0-2)	1.43	0.85-1.66	-4.678	0.000*
	CBLL 4	1.80	2(1-3)	1.44	1.39-2.21	-5.396	0.000*
TL	TL 1	1.54	2(1-2)	1.34	1.19-1.96	-5.275	0.000*
	TL 2	1.56	1.5 (1-3)	1.48	1.13-1.98	-5.260	0.000*
	TL 3	0.64	1(0-2)	1.46	0.22-1	-3.211	0.001*
	TL 4	1	1(0-2)	1.56	0.59-1.48	-3.978	0.000*

Table 3: Describing the statistical significance between pre and post test score difference of Case based learning (CBLL) and Traditional Lecture (TL) students across the topics covered (n=100)

Topic	Teaching Learning Method	Median (IQR)	95% CI	Z value	p value
Topic 1	CBLL	2(1-3)	1.50- 2.41	-1.344	0.179
	TL	2(1-2)	1.19- 1.96		
Topic 2	CBLL	3(2-4)	2.27- 3.08	-3.638	0.000*
	TL	1.5(1-3)	1.13- 1.98		
Topic 3	CBLL	1(0-2)	0.85- 1.66	-1.923	0.054
	TL	1(0-2)	0.22- 1.05		
Topic 4	CBLL	2(1-3)	1.39- 2.21	-2.463	0.014*
	TL	2(1-2)	0.59- 1.48		

Table 4: Cumulative score improvement/ knowledge gain based on Post test and Pre test scores difference of CBLL and TL of all the study participants (n=100)

Teaching Learning Method	Median (IQR)	95% CI	Z value [#]	p value
CBLL	2(1-3)	2.01-2.63	-3.30	0.01*
TL	2(1-2)	1.29-1.85		

The Mean and Pooled Standard Deviation of final difference of scores between two groups is Mean $\pm$ SD = 0.75 $\pm$ 2.15. Cohen's d = 0.34- small effect
Effect size: Cohen's d = 0.34: small effect

Table 5: Knowledge Retention trend across CBLL and TL groups for all the topics (n=100)

Topic	Knowledge retention trend	CBLL n(%)	TL n(%)	Total n=100	Chi-square value	p value
Topic-1	Stable	18(36)	12(24)	30	8.320	0.016*
	Improvement	14(28)	6(12)	20		
	Decline	18(36)	32(64)	50		
Topic-2	Stable	11(85)	2(15)	13	9.634 [#]	0.008*
	Improvement	10(62.5)	6(37.5)	16		
	Decline	29(40.8)	42(59.2)	71		
Topic-3	Stable	18(69.2)	8(30.8)	26	7.400	0.025*
	Improvement	17(53.1)	15(46.9)	32		
	Decline	15(35.7)	27(64.3)	42		
Topic-4	Stable	12(52.2)	11(47.8)	23	1.098	0.578
	Improvement	20(55.6)	16(44.4)	36		
	Decline	18(43.9)	23(56.1)	51		

Students' perception of usefulness of CBLL

Students perceived the likable qualities of CBLL in comparison with TL as being informative (20%), provides more practical knowledge (20%), helps in better understanding (18%), with real life experience scenarios (12%), early clinical exposure (8%), makes session more interesting (8%), more interactive (6%), usage of visual media (4%), none (4%) - Table 6. Students' suggestions for improvement of CBLL were to use models (4%), quizzes (8%), simpler explanation (6%), extend CBLL to cover more topics (6%), include more videos (8%), none or to maintain the same (68%) - Table 7.

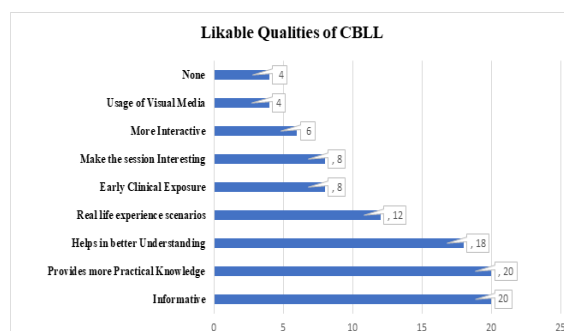


Figure 1: Student's perception of Likable qualities of CBLL (N=100)

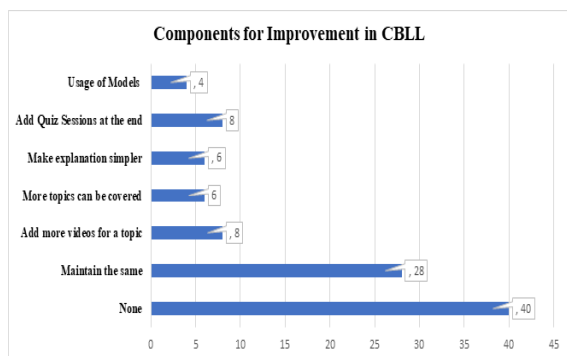


Figure 2: Students' suggestions for improvement of CBLL (N=100)

Table 6: showing students' feedback on CBLL (N=100)

Feedback Component	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)
Objectives were clear	60	38	2	0	0
Helped in better understanding	60	36	4	0	0
Improved engagement	61	35	4	0	0
Satisfied with the session	57	41	2	0	0

DISCUSSION

The present study provides evidence that Case-Based Large Group Learning (CBLL) can be effectively implemented in large group teaching of Anatomy and offers measurable advantages over traditional lectures (TL). Although both teaching methods significantly improved immediate post-test scores, CBLL emerged to be superior in terms of cumulative learning, enhanced knowledge retention, and greater learner engagement.

Both CBLL and TL significantly improved knowledge acquisition. This shows that structured teaching facilitates learning irrespective of the instructional approach. Similar findings have been reported by Nair et al,^[16] Ghosh,^[17] and Srinivasan et al¹⁸, who demonstrated significant improvements in post-test performance following case-based learning. They also reported case-based learning to promote better application of knowledge and higher learner satisfaction than conventional teaching. These findings suggest that while lectures remain effective and the mainstay for delivering foundational knowledge, CBLL can take it to the next higher level by promoting deeper understanding by encouraging learners to apply anatomical concepts in clinically relevant contexts.

Interestingly, CBLL produced significantly greater knowledge gain than TL only in Topics 2 and 4, indicating that its effectiveness may be topic dependent rather than universally applicable. This can be interpreted as Anatomical topics requiring integration of structure with function, clinical reasoning, and interpretation of patient scenarios are likely to benefit more from CBLL than topics primarily involving rote learning or merely a factual recall. Similar observations have been reported by Thistlethwaite et al,^[7] who concluded that the educational benefit of case-based learning depends on the suitability of the content for clinical

Students' feedback on CBLL

Student feedback regarding the CBL session was overwhelmingly positive. The majority of participants either agreed or strongly agreed that the session objectives were clear (98%), the session enhanced understanding of the topic (96%), improved engagement (96%), and was satisfactory overall (98%). Strong agreement was highest for improved engagement (61%), followed by clarity of objectives (60%) and better understanding (60%). No participant reported disagreement with any of the feedback items. [Table 6]

application. These findings recommend selective integration of CBLL into undergraduate anatomy rather than replacing conventional lectures entirely. Although the median cumulative knowledge gain was similar between groups, cumulative score improvement was significantly greater following CBLL. The CBLL exhibited narrower confidence interval with fewer outliers. This suggests that CBLL facilitated more consistent learning across students with varying academic abilities. This can be attributed to the incorporation of real patient videos with clinical interactions, photos of patients as well as investigation images in the CBLL sessions, thereby appealing to students following various styles of learning. This finding is consistent with systematic reviews by Thistlethwaite et al,^[7] and McLean⁸, which concluded that case-based learning promotes deeper conceptual understanding, integration of knowledge, and collaborative learning. The observed effect size (Cohen's $d = 0.34$) represents a small educational effect. However, modest effect sizes are common in educational research because learning outcomes are influenced by multiple learner, teacher, and environmental factors. Hattie,^[19] has argued that even small educational effects may be meaningful when implemented across large student cohorts and repeated throughout a curriculum. Therefore, the statistically significant improvements observed in the present study remain educationally worthwhile.

A major finding of this study was the superior knowledge retention following CBLL, with significantly better retention observed in three of the four topics. Because anatomical knowledge underpins subsequent clinical learning, improved retention has implications beyond immediate examination performance. These findings are consistent with McLean,^[8] and Thistlethwaite et al,^[7] who attributed the durability of learning in case-based approaches to active retrieval, discussion, and

application of knowledge within authentic clinical contexts.

The present findings can be explained by constructivist learning theory, which proposes that learners actively construct knowledge by integrating new experiences with prior understanding.^[5] In CBLL, students had the opportunity and exposure to analyse clinical scenarios, discuss anatomical concepts, and collaboratively solve analytical problems. These enabled meaningful learning of Anatomy and schema formation in the Phase I MBBS students. The findings also align with Knowles' Adult Learning Theory,^[6] which emphasises that adult learners are more motivated when learning is relevant to future professional practice.^[20-22] Integrating clinical knowledge into anatomy classes or in other words, embedding anatomy within authentic clinical cases therefore provides a plausible explanation for the improved cumulative learning, retention, and learner engagement observed in the CBLL group. Students' perceptions further supported these findings. Participants consistently considered CBLL as informative, clinically relevant, interactive, and helpful in improving conceptual understanding. Similar positive perceptions have been reported by Srinivasan et al¹⁸, McLean,^[8] and Nair et al,^[16] who found that students considered case-based learning more engaging and clinically meaningful than traditional lectures. Some of the suggestions received from students were to incorporate anatomical models, quizzes, videos, and request for additional CBLL sessions. This reiterates the value and preference for multimodal and interactive learning environments among the learners.

The findings have important implications in CBME. CBLL is in alignment with the National Medical Commission's emphasis on learner-centred teaching, early clinical exposure, integration, active participation, and clinical reasoning. Importantly, its successful implementation in a large-group setting demonstrates that CBLL is a practical strategy for institutions with large student cohorts and limited faculty resources, embodying CBLL as the light at the end of the tunnel.

We would like to cite the following as the strengths of this study- its crossover design, evaluation of immediate learning, cumulative knowledge gain, knowledge retention, and learner perceptions, as well as assessment of knowledge retention four weeks after instruction. However, as the study was conducted at a single institution, there is limited generalisability. Future multicentric studies with longer follow-up are suggested to evaluate the impact of CBLL on long-term knowledge retention, clinical reasoning, and academic performance, as in this study, knowledge retention was assessed only over four weeks.

Overall, the present study demonstrates that CBLL is a feasible and educationally effective learner-centred instructional strategy for undergraduate anatomy. Although both CBLL and traditional lectures improved immediate knowledge acquisition, CBLL

provided measurable educational advantages in cumulative learning, knowledge retention, learner engagement, and student satisfaction. These findings support its use as a complementary teaching strategy alongside conventional lectures. This is recommended particularly for anatomy topics requiring clinical integration and application within competency-based undergraduate medical education.

CONCLUSION

The present study demonstrated that Case-Based Large Group Learning (CBLL) provided measurable educational advantages over traditional lecture-based teaching for selected learning outcomes. While both teaching methods proved to bring about significant immediate knowledge acquisition, CBLL was associated with significantly greater cumulative learning, enhanced knowledge retention, higher learner engagement, and overwhelmingly positive student perceptions. Although the magnitude of this educational effect was small, there was a consistent improvement in retention and learner satisfaction. This suggests that incorporating clinically relevant case discussions within large-group teaching of Anatomy facilitates meaningful learning and promotes the application of anatomical knowledge in clinically relevant contexts.

Importantly, the successful implementation of CBLL in a large-class setting demonstrates its feasibility within resource-constrained medical colleges. By promoting active participation, contextual learning, and integration of basic sciences with clinical practice, CBLL offers itself as a complementary teaching strategy rather than a replacement for conventional lectures. The optimal strategy for delivering undergraduate Anatomy teaching of such quality as envisioned in the CBME would be a blended approach that combines the efficiency of traditional lectures with the learner-centred advantages of CBLL.

Further multicentre studies involving larger cohorts and longer follow-up periods are recommended to evaluate the long-term impact of CBLL on knowledge retention, clinical reasoning, competency attainment, and transfer of learning to clinical practice.

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Conflicts of Interest:

There are no conflicts of interest.

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