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Project-Based Learning and Self-Management: A training modality for Pharmaceutical Services in Villa Clara, Cuba

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Abstract

The evolution of the pharmacist's role towards care functions requires developing problem-solving skills, where traditional methods focused on memorization do not prevail, which is why PBL is presented as a key pedagogical methodology. To demonstrate the change in the perception of first-year students in the Short-Cycle Higher Education Program in Pharmaceutical Services at the Faculty of Health Technology and Nursing, University of Medical Sciences of Villa Clara, Cuba, regarding key dimensions of PBL. This mixed-methods (qualitative and quantitative) study included a sample of all first-year students enrolled in the Short-Cycle Higher Education Program in Pharmaceutical Services (N=8). A pre-experimental pretest/posttest design with a single group was used. Data analysis integrated quantitative methods, ranging from descriptive statistics (means and percentages), where pretest and posttest scores were compared, to the Objective Regression Method. Qualitative data were processed through category analysis, allowing for methodological triangulation to identify convergences between quantitative and qualitative findings. All five dimensions analyzed showed significant improvement from the pre-test to the post-test, with notable gains in communication skills and autonomy and management. All eight students increased their total score, with an average increase of 30.5 points (from a pre-test mean of 36.8 to a post-test mean of 67.3). All students improved their post-test scores, achieving higher final scores, particularly students 4 and 6. It is concluded that the implementation of Problem-Based Learning (PBL) is confirmed as a robust pedagogical methodology that not only optimizes logistics but also enriches the training process for future pharmacists, aligning with the current demands of the profession.

Keywords: Pedagogical methodology; Pharmaceutical Services; Project-Based Learning; Self-directed learning; Villa Clara

1. Introduction

In a world that never stops changing, education faces the challenge of preparing students for an uncertain future, where traditional skills are no longer sufficient. The 21st century demands citizens capable of addressing complex problems, collaborating in diverse teams, and adapting to dynamic environments (Cyrulies and Schamne, 2021; Cancino, 2024; Sosa *et al*., 2025).

In the current context of higher education, self-directed learning has become an essential component for the development of professional competencies. Therefore, the university teaching and learning process must foster student

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empowerment, with an approach that not only promotes autonomy but also encourages creativity and problem-solving skills (Azpilicueta, 2020; Sosa *et al*., 2025; Zaita *et al*., 2025).

It is the teacher's responsibility to achieve the proposed objective through the development of the content they teach. To do so, they must employ teaching resources, organize and evaluate the process according to the chosen approach: the teaching-learning method, in such a way that it integrates projects and self-directed learning (Barbachán *et al*., 2020; Gavilanes *et al*., 2022; Guaicha *et al*., 2024).

Furthermore, for students to achieve self-directed learning, strategies are required that develop autonomy and initiative and provide guidelines for students to strengthen both cognition and motivation, thus improving academic performance (Calcines *et al*., 2017; Espinosa *et al*., 2020; Da Costa and Goicochea, 2023).

Self-management not only involves the ability to learn independently, but also the development of critical skills such as self-assessment, planning, and informed decision-making (Botella and Ramos, 2019; Azpilicueta, 2020; Zapata *et al*., 2024). Furthermore, it has a direct impact on critical thinking, communication, collaboration, and creativity, thereby strengthening students' preparedness for the challenges of today's world (Moreno *et al*., 2018; Meneses, 2023; Tapia *et al*., 2025). In this context, innovative pedagogical methodologies have gained importance by promoting active and meaningful learning; through these strategies, students not only acquire knowledge, but also develop key competencies such as critical thinking, creativity, and effective communication (López *et al*., 2020; Zambrano *et al*., 2022; Sosa *et al*., 2025).

In Cuba, the continuing education of professionals is crucial to guaranteeing public health, making it imperative to explore innovative and productive methods (Addine, 1998; MINSAP, 2018). Therefore, special attention must be paid to lesson planning, considering the close relationship between all the components of the process, to enhance students' active participation (Dinsmore, 2017; Leiva *et al*., 2022; Recalde *et al*., 2023).

In the context of Short-Cycle Higher Education in Pharmaceutical Services, a growing need has been observed to adapt traditional pedagogical approaches to the demands of the current work environment (PAHO, 2017; MINSAP, 2018).

Despite having a curriculum designed to provide students with the necessary knowledge (MINSAP, 2018), the reality is that many graduates lack practical skills and the ability to self-manage their learning, which prevents them from successfully performing various tasks and responding to complex demands. This hinders the development of their competencies and affects their clinical work. This poses a significant challenge for educational institutions, since the training of competent professionals is crucial to guaranteeing the quality of pharmaceutical services in Cuba.

The application of Problem-Based Learning (PBL) in the context of Pharmaceutical Services is natural and extremely enriching (Zaita *et al*., 2024). A project such as "Designing and implementing a protocol for a Pharmacotherapeutic Follow-up Service for patients with diabetes in a community pharmacy" requires students to mobilize knowledge of pharmacology, pathophysiology, communication, and management. They learn the theory because they need it to solve a specific problem, giving meaning and applicability to the content. Furthermore, PBL inherently fosters self-directed learning: students must plan their work, search for and filter relevant information, manage their time, and self-assess their progress—all essential skills for lifelong learning (Cascales and Carillo, 2018; Caballero, 2020; Mariscal *et al*., 2023).

The objective of the research was to demonstrate the change in the perception of first-year students of the Short Cycle Higher Education in Pharmaceutical Services of the Faculty of Health Technology and Nursing, University of Medical Sciences of Villa Clara, Cuba in key dimensions of Project-Based Learning (PBL).

2. Methodology

2.1. Sample and context selection and diagnosis

The sample consisted of all first-year students enrolled in the Short-Cycle Higher Education Program in Pharmaceutical Services (N=8), Faculty of Health Technology and Nursing, University of Medical Sciences of Villa Clara, Cuba, none of whom had prior experience in PBL. This homogeneous condition of noviceness with the method allowed the observed changes to be attributed primarily to the intervention, minimizing the effect of previous experiences.

2.2. Data analysis and processing

A pre-experimental pretest/posttest design with a single group was adopted in this study, characteristic of exploratory research in real educational contexts where random assignment or the inclusion of control groups is not feasible (López, 2018; de la Puente *et al*., 2020; López *et al*., 2021).

A perception survey, supplemented with open-ended questions for the students comprising the study sample, was used as the data collection method. The instruments were administered at two points in time: before the implementation of the PBL methodology (the pretest) and after its completion (the posttest).

The pedagogical intervention consisted of the systematic implementation of the PBL methodology, designed to foster self-directed learning over 18 weeks, focusing on projects applied to the pharmaceutical field based on the content of the Pharmaceutical Services I course.

The impact assessment was conducted using a perception survey with a rating scale (1-5), organized into five dimensions (motivation, collaboration, self-directed learning, communication, and application), administered at two points in time: before the intervention began, week 1 (pretest), in a controlled environment with guaranteed anonymity. The intervention took place from week 1 to week 18, with sequential implementation of the PBL methodology in each of its phases and structured weekly sessions, recording participation and progress. After the project concluded in week 18, the posttest was administered under the same conditions as the pretest. Open-ended reflective questions were also included.

The qualitative analysis considered content interpretation, where the data were processed through category analysis, ultimately triangulating the results. The design, while acknowledging inherent limitations of a pre-experimental study (absence of a control group and small sample size), provides valid initial evidence regarding the feasibility and potential impact of PBL in the specific context of Pharmaceutical Services training.

The data analysis integrated quantitative methods, ranging from descriptive statistics (means and percentages), where pre-test and post-test scores were compared, to the methodology of Objective Regressive Repression (Osés and Grau, 2011). Qualitative data were processed through category analysis. Integration was achieved through methodological triangulation in the search for convergences between quantitative and qualitative findings.

In the case of the ROR methodology, it is a linear model in which the dichotomous variables DS, DI, and NoC must first be created, where: NoC: Number of cases in the base (its coefficient in the model represents the trend of the series). DS = 1 if NoC is odd; DI = 0 if NoC is even, and vice versa. DS represents a sawtooth function, and DI represents the same function but inverted, such that the variable to be modeled is trapped between these parameters, thus explaining a large amount of variance. Subsequently, the regression analysis module of the SPSS statistical package is executed, specifically the ENTER method, which yields the predicted variable and the ERROR. Then, the autocorrelograms of the ERROR variable are obtained, paying attention to the maximum values of the significant partial autocorrelations (PACF), to then calculate the new variables considering the significant lag of the PACF. Finally, these regressed variables are included in the new regression in a process of successive approximations until white noise is obtained in the regression errors.

2.3. Ethical aspects

For the conduct of the research, informed consent was taken into account, as well as the ethical standards that made it possible to promote and ensure respect for all participants in the study, so that their criteria/opinions and individual rights were respected, in order to generate new knowledge without violating the ethical principles of privacy and confidentiality of personal information (DHAMM, 2024).

3. Results and Discussion

3.1. Student Survey (Pre and Post-test)

This survey was designed to measure the change in students' perceptions of key dimensions affected by PBL, such as collaborative work, autonomy, knowledge application, and soft skills.

3.2. Instructions for the student

Below, you will find a series of statements about your learning and working style. Please read them carefully and mark the option that best represents your opinion before starting the Pharmaceutical Services project. There are no right or wrong answers; we are looking for your honest perception.

3.2.1. Section 1:

Have you previously participated in a course that predominantly used Project-Based Learning? Yes / No

All 8 students answered NO

3.2.2. Section 2: Perception of Learning and Skills (Scale 1-5)

Instructions: Mark with an (X) the box that best represents your level of agreement or disagreement with each statement, according to the following scale:

- 1: Strongly disagree
- 2: Disagree
- 3: Neutral
- 4: Agree
- 5: Strongly agree

No	**Affirmation**	**Pretest**				
		1	**2**	**3**	**4**	**5**
A	Dimension A: Motivation and Interest					
A1	I am motivated to learn in this subject			1	7	
A2	I believe the content of this subject is relevant to my future professional life					8
A3	Learning by solving real problems is more interesting than memorizing theory				8	
B	Dimension B: Collaborative Work					
B1	I feel comfortable working in a team	1	5	1	1	
B2	I know how to distribute tasks fairly and efficiently within a group	3	3	1	1	
B3	I believe I can resolve conflicts that arise within my work team	2	3	1	2	
C	Dimension C: Autonomy and Management					
C1	I am able to plan my work to meet a deadline	2	2	1	2	1
C2	I can search for and select reliable information on my own to solve a problem	4	2		2	
C3	When I face a new problem, I trust in my ability to find a solution	3	3	1	1	
D	Dimension D: Communication Skills					
D1	I feel confident explaining my ideas orally in front of others	3	3		2	
D2	I can synthesize complex information and present it clearly	4	4			
D3	I am able to defend my arguments with solid foundations	3	4	1		
E	Dimension E: Application of Knowledge					
E1	I understand how to connect theoretical concepts from different areas to solve a problem	4	3		1	
E2	I feel that what I learn in class I can apply in practical situations	2	3		2	1
E3	At the end of a topic, I am able to explain "what it is for" what I have learned.	1	4	1	2	

3.2.3. Section 3: Open-ended questions for reflection

Pretest:

- Expectations: What do you expect from the Project-Based Learning method? What would you like to achieve?
- Concerns: What doubts or fears do you have about this learning method?

3.2.4. Section 2: Perception of Learning and Skills (Scale 1-5)

Posttest: You have completed the project _____! Now, answer the same statements reflecting on your experience after participating in this learning method. Compare how you felt before and how you feel now.

Instructions: Mark with an (X) the box that best represents your level of agreement or disagreement with each statement, according to the following scale:

- 1: Strongly disagree
- 2: Disagree
- 3: Neutral
- 4: Agree
- 5: Strongly agree

No	**Affirmation**	**Post-test**				
		1	**2**	**3**	**4**	**5**
A	Dimension A: Motivation and Interest					
A1	I am motivated to learn in this subject					8
A2	I believe the content of this subject is relevant to my future professional life					8
A3	Learning by solving real problems is more interesting than memorizing theory					8
B	Dimension B: Collaborative Work					
B1	I feel comfortable working in a team		1		5	2
B2	I know how to distribute tasks fairly and efficiently within a group		1		6	1
B3	I believe I can resolve conflicts that arise within my work team				7	1
C	Dimension C: Autonomy and Management					
C1	I am able to plan my work to meet a deadline				6	2
C2	I can search for and select reliable information on my own to solve a problem.				7	1
C3	When I face a new problem, I trust in my ability to find a solution				7	1
D	Dimension D: Communication Skills					
D1	I feel confident explaining my ideas orally in front of others			1	6	1
D2	I can synthesize complex information and present it clearly		1		7	
D3	I am able to defend my arguments with solid foundations			1	6	1
E	Dimension E: Application of Knowledge					
E1	I understand how to connect theoretical concepts from different areas to solve a problem				6	2
E2	I feel that what I learn in class I can apply in practical situations				8	
E3	At the end of a topic, I am able to explain "what it is for" what I have learned				7	1

3.2.5. Section 3: Open-ended questions for reflection

Post-test:

- Overall Assessment: In your opinion, what was the greatest achievement or lesson you gained from this PBL experience?
- Challenges and Strengths: Describe the biggest challenge you faced during the project and how you overcame it.
- Continuous Improvement: If you had to recommend one change to improve the PBL experience for future students, what would you suggest?

For the analysis of the 5-point rating scale survey, average scores were calculated for each item and dimension, for both the pre-test and post-test, and are described by dimension (Table 1).

Table 1 Comparison of means and statistical significance by dimensions (Pretest vs. Posttest)

Dimensions	Pretest means	Post-test average	Differences in means	Significance(p)
A. Motivation and Interest	4.25	5.00	+0.75	<0.01
B. Collaborative Work	2.54	4.04	+1.50	<0.001
C. Autonomy and Management	2.79	4.33	+1.54	<0.001
D. Communication Skills	2.13	3.96	+1.83	<0.001
E. Application of Knowledge	2.67	4.38	+1.71	<0.001

3.3. Dimension A. Motivation and interest

The students began with a positive perception (Pretest Mean = 4.25). After the intervention, this perception reached its maximum possible (Posttest Mean = 5.00), with all students responding "strongly agree" to items A1 (motivation), A2 (relevance), and A3 (preference for learning by solving problems). The change, although numerically smaller than in other dimensions, is statistically significant and shows a consolidation of interest on the part of the students, results that coincide with those obtained by other authors on this subject (Fernández, 2017; Leyva and Lariot, 2019; Puenayan *et al*., 2024).

3.4. Dimension B. Collaborative work

This dimension showed one of the most notable increases (Δ +1.50). In the pretest, discomfort and insecurity were observed (e.g., in B1, 6 out of 8 students disagreed or strongly disagreed with feeling comfortable working in teams). In the posttest, this perception reversed, with 7 out of 8 students expressing agreement or strong agreement on the items regarding task distribution (B2) and conflict resolution (B3) (Nino *et al*., 2024).

3.5. Dimension C. Autonomy and management (Self-management)

This is the core dimension and showed a very significant improvement (Δ +1.54). Item C2 stands out: "I can search for and select reliable information on my own." In the pretest, six students disagreed, and in the posttest, eight agreed. A similar positive evolution is observed in planning (C1) and confidence to solve problems (C3) (Chavez, 2014; Chois *et al*., 2023; Carmona *et al*., 2024).

3.6. Dimension D. Communication skills

This dimension showed the greatest absolute growth (Δ +1.83), starting from the lowest initial mean score (2.13). Items D2. Synthesizing Information and D3. Defending Arguments, went from having all students disagree or be neutral, to having the vast majority (seven out of eight students) agree in the post-test (Barria *et al*., 2017; Del Salto and Giraldo, 2025).

3.7. Dimension E. Application of knowledge

A solid improvement was recorded (Δ +1.71). Students progressed from a perception of difficulty in connecting concepts (E1) and seeing applicability (E2, E3), to a majority perception of competence in these skills after the project (Leyva and Lariot, 2019; Leyva *et al*., 2022; Puenayan *et al*., 2024).

3.8. Qualitative analysis: perceptions, challenges and achievements

The content analysis of the open questions allowed for triangulation and further exploration of the quantitative findings.

3.9. Perceived achievements and positive evaluation

The students highlighted the development of practical skills as their main achievements: "I learned to research on my own and apply theory to a real pharmacy case," improved teamwork: "I learned to listen and reach agreements," and satisfaction with a tangible product: "Seeing the finished project and presenting it was the most rewarding part." This corroborated the quantitative improvements in dimensions B, C, and E.

3.10. Challenges faced and overcoming strategies

The most frequently cited challenge was time management and initial group coordination ("At first, we struggled to organize ourselves and divide the work effectively"). The students reported overcoming these obstacles through planning meetings, clear role assignment, and constant communication, demonstrating procedural learning in self-management and collaboration.

3.11. Suggestions for continuous improvement

The suggestions focused on providing more initial guidance on the PBL methodology and allowing more time for project development. These observations do not contradict the positive results but rather offer valuable benchmarks for optimizing future implementations.

3.12. Integration of results and overall measurement of change

To quantify the overall change in each student's perception, the scores for all questionnaire items were summed (15 items, maximum theoretical score: 75). As shown in figure 1, all eight students increased their total score, with an average increase of 30.5 points (from a pretest mean of 36.8 to a posttest mean of 67.3). Student number six had the lowest initial score but showed the greatest absolute growth, which was also corroborated using the ROR methodology.

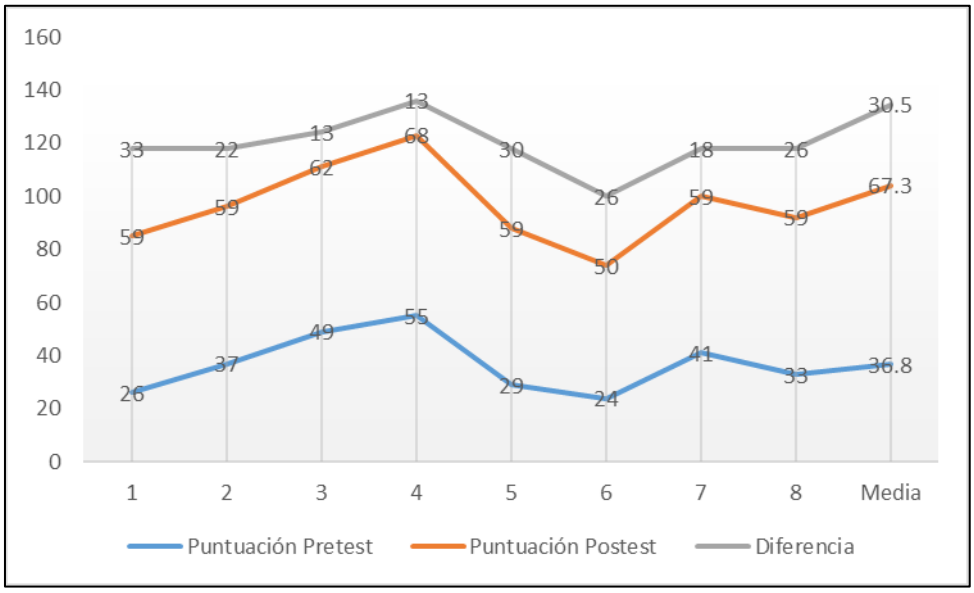

Figure 1 Individual evolution of the total score of the eight students (pretest to post-test)

It can be seen that all students improved their post-test scores, obtaining higher values at the end. Student 4 had the highest pre-test score and continued to have the highest post-test score, while student 6 had the lowest pre-test score and continued to have the lowest post-test score, but improved their score at the end of the test (Figure 2). This is evident when differentiated instruction is continuous and sustained over time, which coincides with several authors on the subject (Mora *et al*., 2019; Zambrano *et al*., 2022; Nino *et al*., 2024).

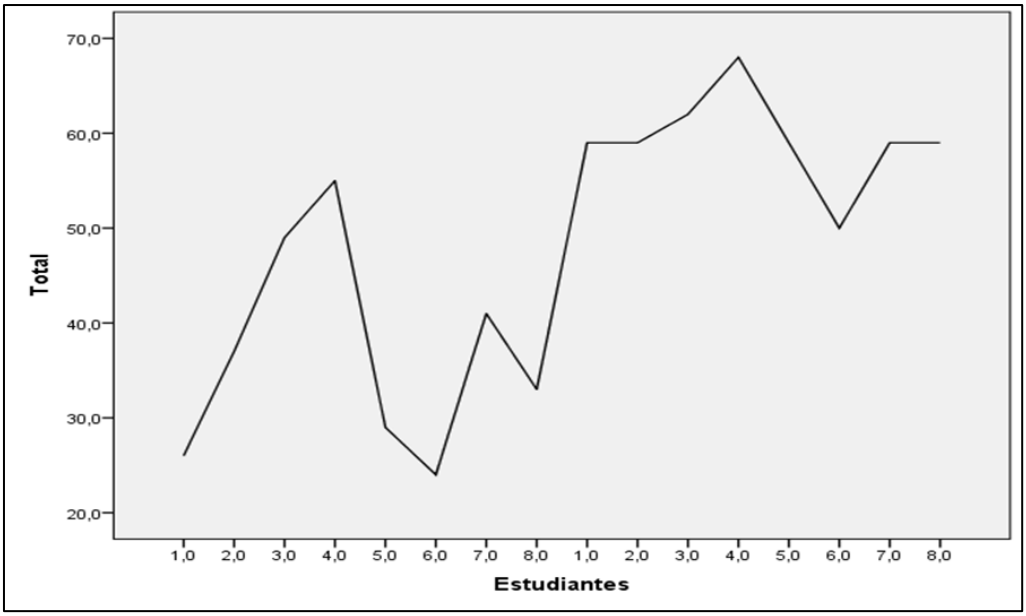

Figure 2 Student behavior (pretest on the left and post-test on the right)

The ROR model explains 99% of the variance, with an error of only 8.5, while the Durbin Watson statistic is close to 2, very beneficial for the model (Table 2).

Table 2 Results of applying the ROR model

Model summary [c, d]					
Model	**R**	**R square** [b]	**Adjusted R-squared**	**Standard error of the estimation**	**Durbin-Watson**
1	0.990[a]	0.980	0.973	8.4928	1.922
a. Predictors: Impact, DI, SD, NoC b. For regression through the origin (the model without an intercept), R-squared measures the proportion of the variability in the dependent variable about the origin explained by the regression. This CANNOT be compared to the R-squared for models that include an intercept. c. Dependent variable: Total d. Linear regression through the origin					

Fisher's F test was highly significant at 100%. Its value was 133.7 (Table 3).

Table 3 ANOVA test results according to regression and residual

ANOVA[a, b]						
Model		**Sum of squares**	**gl**	**Mean square**	**F**	**Sig.**
1	Regression	38561.589	4	9640.397	133.656	0.000[c]
	Residue	793.411	11	72.128		
	Total	39355.000[d]	15			
a. Dependent variable: Total b. Linear regression through the origin c. Predictors: Impact, DI, SD, NoC d. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.						

In table 4, the coefficients are almost all significant, except for the NoC trend, which shows a non-significant decrease. The impact of the transition from before the test to after the test resulted in an increase of 29 points, almost 30 on average for each student, highly significant for 100% of the students. The data range between 43.6 and 44.0 points in the ROR model; this demonstrates that well-implemented PBL, considering both teaching performance and students' research skills, can positively influence the perception and development of teaching among students in Pharmaceutical Services, as well as in other subjects (Azpilicueta, 2020; Zambrano *et al*., 2022; Zaita *et al*., 2025).

Table 4 Coefficient results (before and after the test)

Coefficients[a, b]						
Model		**Non-standardized coefficients**		**Standardized coefficients**	**t**	**Sig.**
		B	**Standard error**	**Beta**		
1	DS	44.496	6.300	0.593	7.063	0.000
	DI	43.589	6.520	0.621	6.686	0.000
	NoC	-1.138	1.023	-0.222	-1.113	0.290
	Impact	29.562	8.882	0.421	3.328	0.007
a. Dependent variable: Total b. Linear regression through the origin						

4. Conclusion

The implementation of PBL is confirmed as a robust pedagogical methodology that not only optimizes logistics but also enriches the training process for future pharmacists, in line with the current demands of the profession. Therefore, when PBL is well implemented, both in terms of teaching performance and students' research skills, it has a positive impact on the perception and academic progress of students in Pharmaceutical Services, as well as in other subjects.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest exists among the Authors.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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