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Gamification in Emergency Medicine.

Gamificación en Medicina de Urgencia.

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Abstract: Gamification is understood as the use of the principles and elements of the game in non-game activities, using the thought process and its mechanisms to attract the attention of users, in order to solve problems. The objective of this research is to evaluate the impact on learning through gamification in emergency medicine in medical students in Chile. Methods: randomized controlled study with voluntary participation. The participants attended an emergency medicine class. Then, they were randomly assigned to a control group, with traditional clinical case discussion methodology, and another group with gamified methodology, which simulated working in an emergency room, solving clinical cases. The gamification elements incorporated are: narrative, game rules, freedom of choice, time restriction, feedback, freedom to make mistakes, cooperation and competition. Finally, the participants answered an evaluation with which the level of learning achieved will be measured. Results: 17 students participated, from 7 universities in Chile, mainly from the IV and V level of the career. Although the results are not conclusive, the finding of having been able to carry out the activity and pilot it as planned stands out; Even so, more studies are needed to identify the impact of the strategy on learning.

Keywords: gamification; emergency medicine; medical education; online education.

Abstract: Gamification is understood as the use of game principles and elements in non-game activities, using the thought process and its mechanisms to attract the attention of users to solve problems. The objective of this research is to evaluate the impact on learning through gamification in emergency medicine in medical students in Chile. Methods: randomized controlled study with voluntary participation. Participants attended an emergency medicine class. Then, they were randomly assigned to a control group, with traditional methodology of discussion of clinical cases, and another group with gamified methodology, which simulated working in an emergency room, solving clinical cases. The gamification elements incorporated were: narrative, game rules, freedom of choice, time restriction, feedback, freedom to make mistakes, cooperation and competition. Finally, the participants answered an evaluation to measure the level of learning achieved. Results: Seventeen students from seven universities in Chile participated, mainly from the IV and V levels of the degree program. Although the results are not conclusive, it is important to highlight the finding that we were able to carry out the activity and pilot it as planned, even so, further studies are needed to identify the impact of the strategy on learning.

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1. Introduction

Gamification corresponds to the use of game principles and elements in a non-game environment, maintaining game mechanisms and thought processes (1-3). Among the game elements that are used in gamification are the creation of a narrative, the use of incentives, feedback and freedom of choice (4). This strategy is observed to be attractive to students, allowing it to influence their behavior, motivating them to learn (5). Among the advantages of this strategy, a better learning experience with a focus on student feedback regarding their decisions stands out (6-7). Also, the diversity of elements allows the gamification strategy to be carried out in conjunction with other innovative educational strategies such as role-playing games or virtual reality (8). It is important to keep in mind that the use of gamification in an incorrect way may not present advantages over a traditional learning environment (9). To deal with student demotivation in gamified activities, it is important not only to use badges or points as central elements, but also to reward effort over mastery of knowledge (7-9).

This learning strategy can be carried out both in person and online (5-6,10). The review carried out on learning based on gamification in a virtual way identifies a great social support in the students, managing to approach and connect with their peers remotely, observing good results with respect to their perspective in relation to learning (11). In medical education, gamification has also been implemented in different types of games available for educational purposes, which can be played both face-to-face and virtually (5-6, 8). This strategy has been applied in different areas of health sciences (6, 12, 16), applying both to undergraduate and postgraduate medical students (17). Among the benefits observed in the use of gamification with digital technology is that it provides a safe environment to acquire skills and experiences, with the ability to repeat and correct mistakes during practice. (6, 8, 17). Although extensive research has been carried out on the application of online gamification in medical education, most studies measure the subjective perception of students. Few studies cover the impact in terms of learning (9). Identifying whether these strategies generate an impact on learning is relevant, especially in the context of the COVID-19 pandemic where clinical practices were interrupted.

Therefore, the objective of this research is to evaluate the impact of learning through the use of gamification in the subject of emergencies in undergraduate medical students. The research team has already made a first approximation, carrying out the experimental phase with a small sample of two universities in Chile, the results are published in the International Academy of Technology, Education and Development (IATED) (18). On this occasion, the final phase was held, with a sample corresponding to seven universities in the country.

2. Methods

This research corresponds to a randomized controlled study with voluntary participation. All participants gave their informed consent before the start of the activity, which is not part of their curricular activities. The primary objective of the study was to measure the impact on learning with the gamification methodology, this through the score obtained in the brief development test carried out at the end of the activity and by analyzing the number of failed attempts during the activity itself applying the gamification. Other parameters to analyze were: the demographic characteristics of the population (sex, year of study, university).

To carry out the recruitment, different social networks were used, including Instagram and WhatsApp, to publicize the activity and invite them to participate. In this step, along with the invitation to participate in the study, a brief questionnaire was attached through

Google Forms, which included the following questions: contact, sex, career level, subjects taken (semiology, internal medicine or their counterparts), university and prior knowledge of the emergency department, in addition to including the inclusion and exclusion criteria shown in Table 1, to determine the final study participants.

Table 1. Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
- Medical students in Chile. - Students who have completed the subjects of Semiology and/or Internal Medicine.	- Students who passed the subject of Emergency Medicine. - Students who passed the Emergency Medicine internship.

To start the activity as such, all participants received a synchronous expository class through a 45-minute videoconference on "Introduction to Cardiopulmonary Resuscitation (CPR)" with the following learning outcome: Initially manage cardiorespiratory arrest in context emergency for general practitioner. The class was led by a general practitioner graduated from the University of Chile. Subsequently, the students were randomly assigned to two learning modalities. The randomization strategy used corresponds to block randomization (19): the size and number of blocks to be used were chosen by the research team, in this case the group of participants was divided in half into two blocks; a control group, with traditional methodology and a second group with gamified methodology. Subsequently, the same process was carried out in the group with gamified methodology for the generation of blocks with a population size between 2 and 3 people. This was generated through a randomization program according to the selection order of each block, once completed, it was ensured that a similar number was maintained between each group of individuals.

In the control group, the students attended a discussion session of three clinical cases conducted by videoconference guided by Dr. Ortiz, a general practitioner graduated from the University of Chile, through an expository methodology with immediate feedback. The second group attended a gamified session. In this case, the students were subdivided into teams of two to three people, in addition to a monitor to moderate the session, to solve different clinical cases simulating working in a hospital emergency room. Through the Google Forms platform, each team was given three clinical cases sequentially, receiving patients in different contexts of cardiorespiratory arrest. Thus, the students had 5, 8 and 10 minutes to carry out cases 1, 2 and 3, respectively. In the case of failing and getting an erroneous result, they could start the same case again with the same amount of time, with a maximum of 3 failed attempts per case. Once answered adequately, a short video of the feedback was shown and they advanced to the next scenario, which had a higher level of difficulty. In the case of failing all attempts, the team was allowed to watch the feedback video to continue with the next exercise.

The final score for the activity was calculated by adding 1 point for each correct attempt and subtracting 0.25 for each wrong attempt. The gamification elements incorporated into the modality are the following:

- Narrative : It refers to contextualizing the participants as if they were characters in a game, where each one of them represents a general doctor who attends the emergency service of a very busy hospital, where a big accident has occurred with multiple injured to attend.

- Rules of the game: 1) As in real emergency experiences, you cannot undo the decisions made while the clinical case progresses: once the case is over, you can

start the game again until you reach a favorable result. 2) It is necessary to finish the construction of the story before advancing to the following ones. 3) The decisions and answers taken must be those of the group, collaboration between groups is not allowed except at established moments of the activity.

- Freedom to choose options: The group of students were given different treatment and patient management alternatives that led to different results.

- Time restriction : Each of the cases presented has a time limit for completion. Because the difficulty is greater at each level, a time limit of 5, 8 and 10 minutes, respectively, was defined.

- Levels: The difficulty of the cases is ascending. Each group faced 3 clinical cases, where the first case had less difficulty, with fewer questions and less time to complete, while the last case presented greater difficulty, more questions and more time to complete. The access link to the next case is found at the end of the previous case but the case is only accessed if they present an optimal result. In the case of a failed result, the participants must start the case over again.

- Immediate feedback: At the end of a clinical case, the feedback of the case is made, showing the learning achievements waiting and justifying the adequate management of the patient through a video of maximum 5 minutes.

- Freedom to make mistakes : As it is not a real scenario, there is no danger in making mistakes, groups can make mistakes in the different scenarios without fear of negative consequences and with the possibility of amending them.

- Visible status : Participants can see the time bar in each clinical case.

- Cooperation and competition: Cooperation as teamwork and competition with other groups of students facing the same challenges.

Both groups carried out the respective activities in parallel for 1 hour and 15 minutes and then proceeded to an evaluation of 9 short essay questions lasting 20 minutes. The evaluation had 5 factual questions and 4 knowledge application questions. This evaluation corresponds to the input that allowed measuring the impact on learning in both methodologies. Each of the steps of the activity is presented in an orderly manner in Figure 1. All the elements and materials used during the study were created by the research team and subsequently validated by senior members Dr. Marcos Rojas and Dr. Luis Ortiz. .

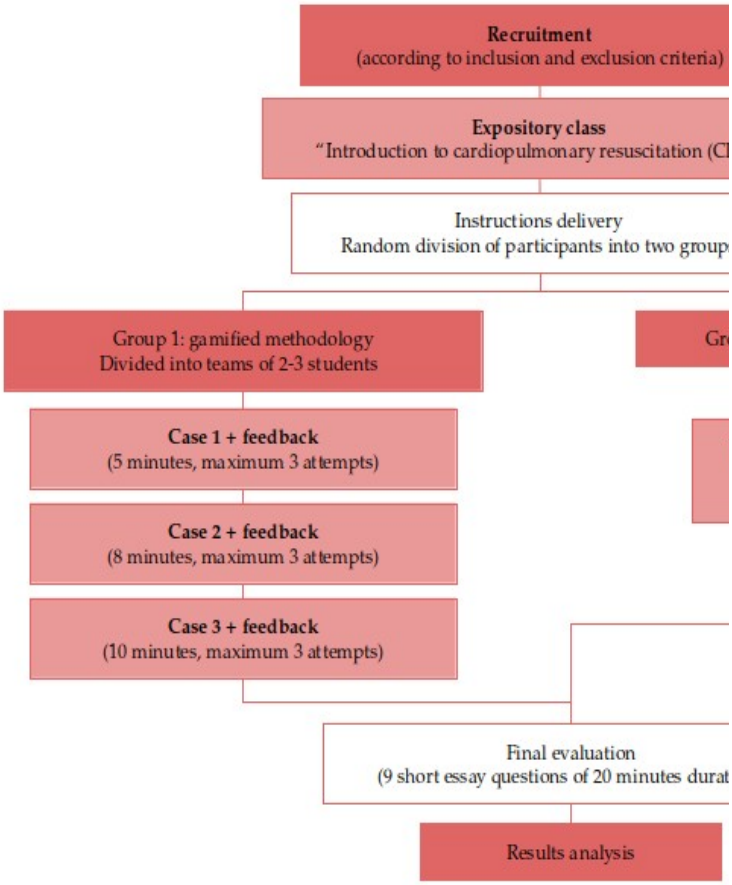

Figure 1. Schedule of activities.

3. Results

Starting with the recruitment, a total of 47 voluntarily registered were obtained. Of these, on the day of the activity, 17 participants attended. Table 2 shows a description of the categorical variables of the sample used.

Table 2 . Description of categorical variables

	Characteristic	Frequency	Percentage
Cluster	Traditional	8	47%
	Gamified	9	52.9%
Gender	Male	10	58.8%
	Female	7	41.2%
University	University of Chile	6	35.3%
	Major university	5	29.4%
	Northern Catholic University	2	11.7%

	University of Concepcion	1	5.8%
	University of Santiago, Chile	1	5.8%
	Andres Bello University	1	5.8%
	University of Talca	1	5.8%
career level	III	1	5.8%
	IV	7	41.2%
	V	8	47.1%
	VI	0	0%
	VII	1	5.8%
Previous experience	Yes	6	35.3%
	No	11	64.7%

Regarding the characteristics of the sample, the participation of students from 7 different faculties was obtained, being mainly from the Universidad de Chile and Universidad Mayor with 35.3% and 29.4% respectively. Likewise, it was identified that 88.3% of the participants belonged to level IV and V of the medical career of their respective universities. On the other hand, only 6 of the participants refer to previous experience with the subject of Emergency Medicine by taking extracurricular training courses to their curriculum of their respective university. Continuing with the activity, all the participants were present in the expository synchronous class carried out by the teacher in charge. The instructions were then delivered by the research team and the participants were randomly assigned to their respective groups.

Table 3. Description of the categorical variables of the two groups.

		Traditional Group	**Gamified Group**
	Characteristic	**Frequency, %**	**Frequency, %**
Gender	Male	5, 62.5	6, 66.6
	Female	3, 37.5	3, 33.3
University	University of Chile	3, 37.5	3, 33.3
	Major university	0, 0	5, 55.5
	Northern Catholic University	2, 25	0, 0
	University of Concepcion	1, 12.5	0, 0

	University of Santiago, Chile	1, 12.5	0, 0
	Andres Bello University	1, 12.5	0, 0
	University of Talca	0, 0	1, 11.1
Career level	III	1, 12.5	0, 0
	IV	3, 37.5	4, 44.4
	V	3, 37.5	5, 55.5
	VI	0, 0	0, 0
	VII	1, 12.5	0, 0
Previous experience	Yes	3, 37.5	3, 33.3
	No	5, 62.5	6, 66.6

The group with traditional modality consisted of 8 people (41.2%). As can be seen in Table 3, its members were characterized by belonging to 5 faculties, with the University of Chile being the most prevalent with 3 students (37.5% of the sample). Regarding the level, the participating students of the traditional modality correspond to the levels of IV and V year of study (corresponding to 37.5% each one). Most of the volunteers, corresponding to 62.5%, did not have previous experience in the subject of Emergencies. On the other hand, it can be seen in Table 3 that the group with gamified modality consisted of 9 people (58.8% of the total participants), those who belong mainly to the faculties of the Universidad Mayor (55.5%) and the Universidad from Chile (33.3%). The levels of study to which the students belonged correspond to the IV and V level of study (44.4% and 55.5% respectively), presenting a similar distribution with the traditional modality. 66.6% of the students of this modality refer not to present previous experience.

The students of the gamified group were subsequently subdivided into 4 teams randomly through the block randomization strategy. From this strategy, three teams made up of 2 people and a fourth team made up of 3 students were obtained. We can see the results of each subgroup in Table 4. Breaking it down, it can be seen that CASE 1 had a greater number of failed attempts compared to the rest of the cases, with CASE 2 having the highest success rate compared to CASE 2. rest. When calculating the final score of each team, it was found that teams "2" and "3" obtained the highest scores (2 points each), with Team 3 being the one with the best final score, but in less time, with 26 minutes.

Table 4 . Results table: Gamified seminar

Equipment	CASE 1		CASE 2		CASE 3		Final score	Total Time
	failed attempts	correct attempt	failed attempts	correct attempt	failed attempts	Try Right		
1	3	0	1	1	1	1	0.75	39 minutes
2	1	1	1	1	2	1	2	54 minutes
3	2	1	1	1	1	1	2	26 minutes
4	3	0	2	1	2	1	0.75	54 minutes

Subsequently, an evaluation was carried out to measure the impact on learning in the different modalities, corresponding to 9 short essay questions (4 knowledge application questions and 5 factual questions). The final scores obtained during the activity are described, which were calculated assigning a score of 1 to the correct questions and 0 to the incorrect ones. In addition, the mean, median and standard deviation were calculated for each group, which is shown in Table 5.

Table 5. Description of numerical variables of the final score

	Traditional Group			Gamified Group		
	Factual Question Score (Max Point: 5)	Knowledge Application Question Score (Max Point: 4)	**Total score**	Factual Question Score (Max Point: 5)	Knowledge Application Question Score (Max Point: 4)	**Total score**
Range	2	2	3	2	2	4
Minimum	3	1	6	3	1	4
Maximum	5	4	9	5	3	8
Half	2.83	4.25	7.13	2.4	4.44	6.88
Median	4.5	3	7.5	5	3	7
Standard deviation	0.88	0.99	1.73	0.88	0.72	1.05

When analyzing the content of Table 5, it can be seen that the group with the traditional modality obtained a higher maximum score and better average compared to the group with the gamified modality, with a difference of 1 and 0.25 points, respectively. In addition, a higher standard deviation was identified in the traditional group. A frequency histogram of the final test scores was made for both traditional and gamified groups, observed in Figure 2 and Figure 3, respectively. It is observed that the distribution of scores of the group with gamified modality tends to an ascending curve, where 66.6% of the students have a high score between 7 and 8 points. While the group with traditional modality has a rather bimodal distribution, having 50% of the students within the score 8 and 9, but with 12.5% who present a low score of 4.

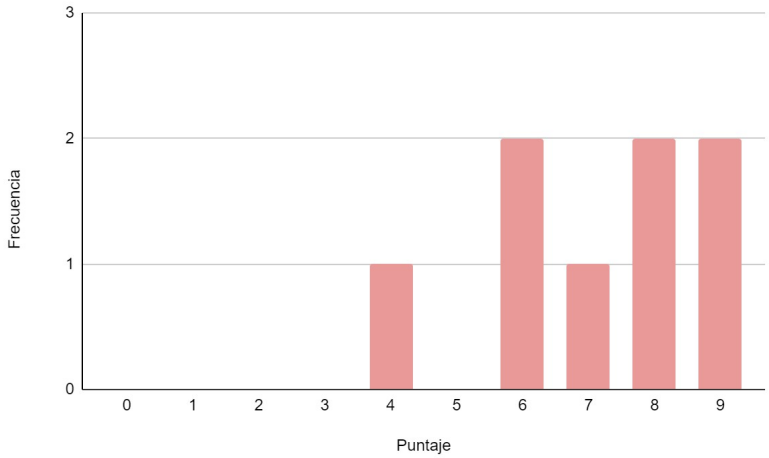

Figure 2. Final points histogram – Traditional group.

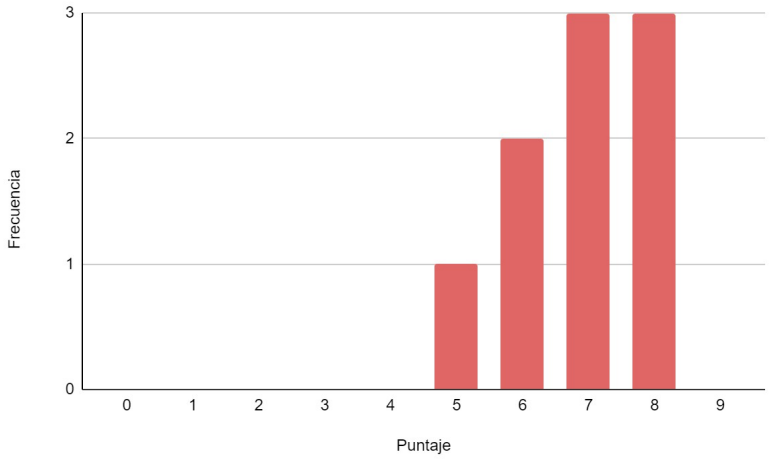

Figure 3. Final points histogram – Gamified group.

A study of the sample was carried out with an expert in the field to carry out a statistical analysis itself and it was determined that, due to its small size, it does not have sufficient statistical power to be able to apply a statistical test that demonstrates a significant difference between both groups, without requiring an increase in the sample size, so a statistical analysis cannot be performed. However, a visually comparative analysis can be performed using histograms and measures of central tendency.

4.Discusión

La gamificación es una estrategia educacional, donde a través de elementos del juego se pueden adquirir conocimientos (1). Dentro de los estudios revisados, se destaca la gamificación como una metodología innovadora e interesante, por lo que los estudiantes valoran positivamente (5). Shawaqfech et al. realizó una revisión de la literatura sobre trabajos donde se utiliza la metodología de gamificación en la enseñanza de farmacología, destacando un mayor desarrollo comunicativo y participación de los estudiantes en la actividad, los cuales también se percibieron más confiados en la aplicación de sus habilidades durante la metodología, sin embargo, no percibió una mejora en sus calificaciones, por lo cual los autores refieren la necesidad de estudios randomizados, con mayor número de participación para concluir con respecto a este punto (14). En el área de

la medicina, Nevin et al. refiere el uso de un programa computacional basado en la aplicación de gamificación para involucrar a residentes de medicina en competencias de conocimiento, refiriendo evidencia cualitativa como cuantitativa de beneficios del uso de estrategias de gamificación digital con aumento significativo de retención de conocimiento durante el tiempo (17).

Various studies have measured its subjective impact with respect to the students' experience in the use of the methodology and their perception during its development (6,11). However, there is little evidence about the effect on learning, quantitatively measuring the impact of the methodology. In 2021, our research team carried out a pilot test with the same methodology used in the current study, observing that the gamified group presented slightly better results than the traditional methodology group, both in the score of the factual questions and in the score of the final evaluation, but no major differences were observed and no statistical analysis was performed due to the small number of participants in the activity (18).

This study was carried out in a small convenience sample of 17 students, from 7 Chilean universities, with the primary objective of measuring the impact on learning with the gamification methodology, through a development evaluation that was applied after the study. exercise. During the development of the activity, the participants were divided into two methodologies: Traditional and gamified modality. In the gamified modality, 3 clinical cases were carried out with a history construction methodology, observing at the end of the process an inconsistency with respect to one of the objectives of the activity, corresponding to the progressive increase in the difficulty of the clinical cases. A greater number of errors was identified in level 1 compared to levels 2 and 3. The last question of level 1 was considered as the cause, where only 2 groups had them correct. Therefore, we can conclude that gamification allows the easy identification of areas that need to be addressed in greater depth for their incorporation into student learning, a facility that is difficult to identify in other instances of more expository-traditional learning.

Regarding the results of the final evaluation, when analyzing them, a difference of 0.5 was obtained in the final score between the gamified group and the traditional group, with a greater difference in the factual questions of 0.23 points, but presenting a better final average in the gamified group with a difference of 0.19 points, however, the average score obtained in the application questions is similar.

Another element to highlight is the standard deviation of each group, with the dispersion being greater in the traditional group. As previously stated, due to the small size of the sample, it does not have sufficient statistical power to carry out such an analysis, without requiring that the total number be increased. In any case, a visual comparison can be made through histograms and measures of central tendency, which show an ascending distribution in the gamified modality, identifying a greater number of students with a high score in the gamified modality than in the traditional modality.

As stated above, the methodological framework that is approachable and reproducible in a real study stands out among the strengths of the study, allowing measurable and subsequently analysable quantitative results to be collected. During the study, it is possible to identify areas where students need a greater level of depth and review of some content, presenting immediate feedback to teachers on the application of the activity. One weakness the team recognized was sample size. Due to the low participation, a real statistical analysis was not achieved, but a visual analysis based on histograms was possible.

Although the results are not conclusive, statistically speaking, the finding of having been able to carry out the activity and pilot it without major problems as planned should be highlighted, demonstrating the possibility of carrying it out. In addition, we have the possibility of projecting the research by having a scalable methodology, since larger samples do not imply a higher cost in the use of human resources. In addition, by doing it with the help of a free platform, it allows the saving of material and virtual resources.

The research group believes that an innovative methodology is not enough, but that it must be useful and effective in improving the learning of students in the area of health. The study on the learning impact of methodologies that use technology in the health area should continue to be promoted and strengthened in order to have evidence to make important decisions regarding which activities really have a positive impact on learning and consolidation. of knowledge.

5. Conclusions

- During the development of the gamified activity, it is possible to identify areas that need to be addressed in greater depth for their incorporation into student learning.

- After the visual comparison by frequency histograms, an ascending curve with a greater number of maximum scores in the gamified group is identified.

- Although in this instance the results are not conclusive, we believe that the research can be projected due to the fact that it is a scalable methodology and that it uses free tools.

- An innovative methodology is not enough, but it must be effective in improving learning and have a positive impact on the acquisition of knowledge.

Supplementary material: File: "Tables.docx".

Ethical considerations: In the generation of the following study, there is no conflict of interest on the part of the researchers. All students participate voluntarily in the activity, with total protection of anonymity in the final evaluation, this through the generation of random code carried out through the Google Forms platform to protect the results obtained in the final evaluation. The data obtained both during the gamified activity and the final evaluation are safeguarded and in possession only by the research team, data which are saved in the Excel program and stored only on an external disk, with the sole purpose of research.

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Declaration of conflict of interest: The authors declare that they have no conflict of interest.

Author contributions: Alejandro Fica, Valentina Burgess, and Tamara González contributed to the conduct and analysis of the study, as well as to the writing and review of the manuscript. Marcos Rojas contributed to the supervision and review of the manuscript. All authors read and approved the final manuscript.

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