

Failure Rate in University Students: Analysis of its Variation in the Transition from Face-to-face Education to Virtual Education

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Abstract—The article presents an exploratory and descriptive study of the failure rate of students of the professional school of mechanical and electrical engineering of a public university in Peru. The purpose is to identify if the level of failure has experienced any positive or negative variation when moving from the context of face-to-face education to virtual education, due to the state of health emergency. This study makes it possible to demonstrate an initial reference state, relevant for decision-making at the level of university academic management, through strategies that will increase the approval rate of this professional school. The results obtained indicate that the level of failure of the students has experienced a positive variation when moving from the face-to-face context to the virtual one, due to the increase in the average rate of failure from 25% to 34%. The results are equivalent to 242 students failed during the context of face-to-face education, and 438 students failed during the context of virtual education. In addition, it is visualized that the specialty subjects, where there are the largest number of failed students, are linked to the area of electrical engineering. Being the subject of Electrical Machines I, the one with the highest failure rate, with a total average of 43% during the context of face-to-face education and 48% during virtual education.

Index Terms—Failure rate, university students, variation, face-to-face education, virtual education.

I. INTRODUCTION

In this context of post-pandemic transition due to the Covid-19 virus, it is preponderant at the educational level to ask ourselves how some indicators linked to failure rates in university educational institutions have evolved [1]-[3]. The study about the failure rate in university education has been scarce, so from the disciplinary perspective, studies carried out in professional engineering schools predominate. [4], [5]. Regarding it, in first of all, the role of personal variables

linked to lack of knowledge in the subjects considered as prerequisites, inadequate strategies for study, high level of absences and lack of academic advice and secondly the variables associated with teaching performance [6]-[8]. In the same line of opinion [9]-[11], point out that the most important reasons that cause university failure are ignorance of the curriculum, attitudes and little or no support in study methods for students.

In Latin America, in particular, the problem linked to the training processes in university students turns out to be quite critical, and one of its most important dimensions is academic performance, since it is considered an indicator of success or failure [12]; thus, academic performance is reflected quantitatively in the failure rates of each subject of the curricular plan of studies [13]. And it is that the failure rates in university students show relevant problems of student retention, becoming one of the quite significant factors linked to the abandonment or desertion of the student [14], [15]. Among the various factors linked to failure at a higher level, economic, social, family, psychological and pedagogical aspects are considered, among others, however, in the academic aspect factors such as untimely academic tutoring, poor pedagogical practices, incorrect study habits influence in academic performance [16], [17]. Academic failure has been identified as an important factor in the dropout of university students in developing countries, and is recognized as a complex phenomenon that university educational institutions currently face, since various factors interact to present themselves [18]. Although the failure rate in university students can intervene in different scenarios that compromise the permanence and success of students in the university, its study was carried out indirectly based on desertion [10], [19]. University educational institutions, considering the supply and demand processes they face, should worry about offering programs incorporating skills and abilities requested in the labor field in order to raise educational quality [20], [21].

Education is one of the activities that arouses the greatest interest in society and it is that over time and with the continuous scientific and technological advance, the educational area has acquired a high level of complexity, leading researchers to carry out studies that allow overcoming the different educational crises observed in the development of students and institutions, identifying that one of the major problems is the failure rate [22]. Student failure that impacts institutional indicators is a problem that is characterized in many public and private education institutions [23].

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A low rate of disapproval accounts for the achievement in learning of the quality of teaching and a favorable academic progress of university students, while a high rate means ineffectiveness in teaching and learning activities, which in government education systems are ultimately translated into incompetence in the exercise of public spending by state-regulated institutions [7]. If the failure rates were reduced, the benefit of reducing the social and economic cost could be obtained not only for the student and his family, but also for the university educational institution and allocate budgets oriented to the improvement of infrastructure with the objective of improving academic quality [8].

In this sense, the objective of the research is to carry out an exploratory and descriptive analysis of the failure rate of students of the professional school of mechanical and electrical engineering of a public university in Peru; in order to identify if the level of failure has experienced any positive or negative variation when moving from the context of face-to-face education to virtual education, due to the state of health emergency. Likewise, through the descriptive analysis, it is sought to identify the subjects with a higher failure rate, so that improvement actions can be taken from the academic point of view. This study will show an initial reference state on this type of indicators related to student dropout, relevant from the point of view of prior knowledge for decision-making at the level of university academic management, even more so when there are no previous studies on this subject, and less in the contexts raised.

II. LITERARY REVIEW

In [24], in their research, establishes a comparative analysis of the variation of the failure rate, defining this indicator with a quantitative approach. They state that dropout and failure in higher education are phenomena of great magnitude, which have effects at the institutional, personal and social levels.

In this regard, in [24] their research on dropout rates in the context of the pre-pandemic, whose study population is undergraduate students in applied mathematics, point out that the factors associated with high failure rates are classified as school, economic and personal. Within the school includes the lack of interest in studies, the low averages that the students obtained in the upper secondary level, which translates into low basic knowledge.

In [25] in his research on failure rates in the pre-pandemic context of a population of 135 students in the faculty of science, concludes that no higher education institution is exempt from high failure and dropout rates in the first years of the various degree programmes. It is during the first years that mathematics and technology basics are taught, which are the subjects with the highest failure rates.

O. M. A. Fernández, *et al.* [26] focus their research on the variable failure rate in university medical students, carrying out an exploratory, cross-sectional, retrospective and comparative study with a universe of 388 students, in which they conclude that the research reinforces the findings identified in other investigations. In addition, it provides novel information on the close relationship between university students' failure and school performance.

In [27], point out in their research on the failure rate of university students, which is quantitative, descriptive in scope and has a non-experimental, cross-sectional, retrospective design, that failure is a complex reality that can be analyzed from various angles. It is evident that it is a relevant problem in the university system, and that it demands a greater number of systematic and in-depth investigations on the subject, in order to provide information on the main causes, which will enable pertinent and timely management, as well as the design of academic interventions that will contribute positively to more successful educational trajectories for the students of this institution.

In [28] their research associated with the failure rate in university students, in the pre-pandemic context, set out to determine the failure rate as a study objective, finding a level of 21.77% as a result. Therefore, it concludes that a high level of failure can lead to student dropout, affecting their development and personal fulfillment. Emphasizing that it is important that a student who abandons their academic training represents a space that another student could have taken advantage of by obtaining a certificate.

In [8] in their research related to the failure rate from the perspective of teacher performance, of an analytical, observational and prospective type, whose study sample consisted of 90 teachers. They conclude that an approach is required that prioritizes the teacher as an active agent, from the potential of their development, with a self-transforming and transforming character of the social reality, which contributes to the reduction of university student failure.

In [29] in their research linked to the failure rate, in the context of the health emergency and whose timeframe was the academic period from January to June 2021. They point out as one of the results, that the personal factor turned out to be a key element in the achievement of academic performance, being insufficient the time dedicated to study, both for exams and to carry out the different school activities, as it requires much more effort and dedication to attend a professional career; a situation that seems to be ignored or unknown by the students.

III. METHODOLOGY

A. Level and Research Design

The level of research is exploratory and descriptive, with a retrospective study design. Descriptive, because the failure rate of students from the mechanical and electrical engineering professional school of a public university in Peru is identified; the retrospective research design, collects information from data from the past, in order to analyze, compare and understand what could have led to the obtained result. In the present investigation, the number of failures and the number of students enrolled in different academic semesters were analyzed, in order to identify if the failure rate has experienced any positive or negative variation when moving from the context of face-to-face education to virtual education due to the state of health emergency.

B. Delimitation of the Investigation

In relation to the temporal delimitation, the analysis in the

context of face-to-face education focuses specifically on four academic semesters, 2018-I, 2018-II, 2019-I and 2019-II, while the analysis in the context of the virtual education, focuses specifically on the academic semesters, 2020-I, 2020-II, 2021-I and 2021-II. In relation to the spatial delimitation, the study was developed in a Public University located in Peru.

In relation to the population delimitation, which tries to choose in an argued way which will be the objects of analysis, to limit its scope. The research is based on analyzing the number of failed students from the professional school of mechanical and electrical engineering, who take specialty subjects, which range from fourth to tenth cycle. This analysis will allow us to focus on the specialty subjects, with the highest number of failed students, and that have experienced some negative or positive variation when moving from the context of face-to-face education to virtual education.

Regarding the data collection technique and instrument, documentary analysis was used, using the qualification records as a secondary source, using a registration form as an instrument. The instrument transferred the following indicators: specialty subject, academic cycle, number of students enrolled, number of approved and number of disapproved. By means of these indicators, the failure rate was determined.

C. Study Population

The study population is made up of university students from the professional school of mechanical and electrical engineering, enrolled in specialty subjects, which range from fourth to tenth cycle. All 4,725 students enrolled in the 14 specialty subjects were collected. Table I shows the number of students enrolled per semester and for each specialty subject. It should be noted that this amount is the sum of all semesters, face-to-face context (2018-I, 2018-II, 2019-I and 2019-II) and virtual context (2020-I, 2020-II, 2021-I and 2021-II).

TABLE I: NUMBER OF STUDENTS ENROLLED BY SPECIALTY SUBJECT

Code	Course	Face-to-face education	Virtual education
EEC1	Electrical drawing	272	187
EEC2	Electrical Circuits I	206	244
EEC3	Electrical measurements	233	217
EEC4	Electrical installations I	170	282
EEC5	Electrical Circuits II	19	245
EEC6	Electrical machines I	183	250
EMC1	Design of machine elements	164	254
EEC7	Electrical installations II	0	203
EMC2	Heat transfer	138	190
EMC3	Industrial machines and systems	153	163
EMC4	Internal combustion engines	124	134
EMC5	Welding technology	59	115
EEC8	Lines of transmission	151	113
EMC6	Maintenance engineering	149	107

Also, to specifically present the population, Table II shows the number of students per academic semester. Also, to

specifically present the population, Table II shows the number of students per academic semester. Being the total number of students enrolled per semester, the following: 436 (2018-I), 447 (2018-II), 531 (2019-I), 607 (2019-II), 648 (2020-I), 722 (2020-II), 716 (2021-I) and 617 (2021-II). Giving a total of 4725 students enrolled in specialty subjects.

TABLE II: NUMBER OF STUDENTS ENROLLED PER SEMESTER

Code	2018		2019		2020		2021	
	I	II	I	II	I	II	I	II
EEC1	50	75	76	71	63	46	42	36
EEC2	43	52	60	51	81	63	47	53
EEC3	30	28	93	82	66	64	42	45
EEC4	35	50	20	65	82	71	71	58
EEC5	0	0	0	19	57	66	67	55
EEC6	44	62	40	37	38	65	70	77
EMC1	44	24	32	64	89	77	59	29
EEC7	0	0	0	0	26	57	52	68
EMC2	36	31	37	34	36	57	53	44
EMC3	38	35	36	44	25	29	60	49
EMC4	32	38	28	26	35	20	42	37
EMC5	0	0	33	26	0	28	57	30
EEC8	42	32	35	42	22	45	24	22
EMC6	42	20	41	46	28	34	30	15
Total	436	447	531	607	648	722	716	618

IV. RESULTS

Fig. 1 shows the specialty subjects with the highest failure rate in the professional career of mechanical and electrical engineering, during face-to-face education (2018-2019). It should be noted that for the investigation, the EEC code and EMC mechanics were assigned to the specialty subjects in the electrical area.

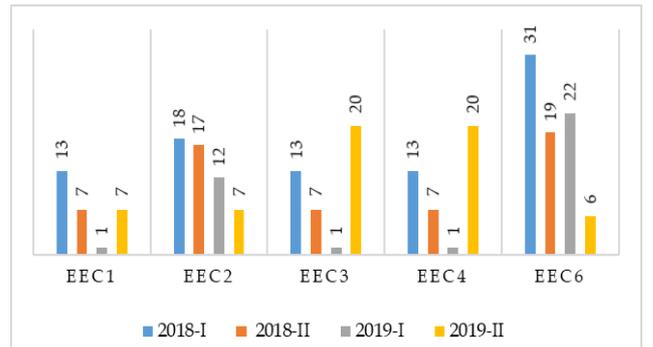


Fig. 1. Failure rate according to specialty subjects during face-to-face education.

Fig. 1 shows that the specialty subjects with the highest number of failures during face-to-face education were Electrical Drawing (EEC1), belonging to the IV cycle, Electrical Circuits I (EEC2) and Electrical Measurements (EEC3), both belonging to the V cycle, Electrical Installations I (EEC4) and Electrical Machines I (EEC6), both belonging to the VI cycle of the mechanical and electrical engineering career. From what was obtained, we can point out that there is a link between the specialty subjects with the highest number of failures, due to the fact

that, to take the subject of Electrical Measurements I, the prerequisite is to have passed the subject of Electrical Drawing, in the same way to take the subject of Electrical Installations I, the prerequisite is to have passed the subject of Electrical Circuits I, and to take the subject of Electrical Machines I, the prerequisite is to have passed the subjects of Electrical Circuits I and Electrical Measurements. Given the above, the specialty subject with the highest failure rate is the subject of Electrical Machines I, with a total average of 43% of students who have failed this subject, during the academic semesters 2018-I, 2018-II, 2019 -I and 2019-II. Following are the subjects of Electrical Circuits I, Electrical Measurements, Electrical Installations I and Electrical Drawing, with a failure rate of 27%, 23%, 22% and 11%, respectively.

According to Fig. 1, in the subject of Electrical Machines I, 78 students failed during the academic semesters of face-to-face education, in the subject of Electrical Circuits I, there were 54 students failed, in the subjects of Electrical Installations I and Electrical Measurements I, there were 41 failed students, while in the Electrical Drawing subject, there were 28 failed students. Likewise, according to each academic semester, the largest number of failed students is identified; Regarding the subject of Electrical Machines I, 31 students, representing 70%, failed in the academic semester 2018-I, 22 students, representing 55%, failed in the academic semester 2019-I. Regarding the subject of Electrical Measurements, 13 students, representing 43%, failed in the academic semester 2018-I. Regarding the subject of Electrical Circuits I, 18 students, representing 42%, failed in the academic semester 2018-I. Regarding the subject of Electrical Installations I, 13 students, representing 37%, failed in the academic semester 2018-I. Regarding the subject of Electrical Drawing, 13 students, representing 26%, failed in the academic semester 2018-I. Therefore, it can be said that in the 2018-I semester, there was a greater number of failed students, this being a total of 88.

Fig. 2 shows the specialty subjects with the highest failure rate, during virtual education (2020-2021).

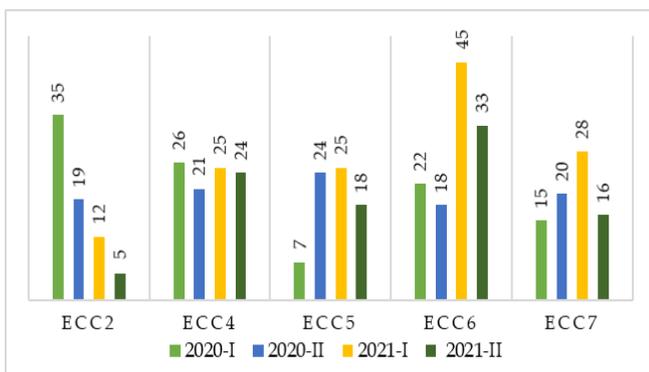


Fig. 2. Failure rate according to specialty subjects during virtual education.

Fig. 2 shows that the specialty subjects with the highest number of failures during virtual education were Electrical Circuits I (EEC2), belonging to the V cycle, Electrical Installations I (EEC4), Electrical Circuits II (EEC5) and Electrical Machines I (EEC6), belonging to the VI cycle, and Electrical Installations II (EEC7), belonging to the VII cycle of the mechanical and electrical engineering career. From

what was obtained, we can point out that there is a link between the specialty subjects with the highest number of failures, due to the fact that, to take the subject of Electrical Installations I, Electrical Circuits II and Electrical Machines I, the prerequisite is to have passed the subject of Electrical Circuits I, and to take the subject of Electrical Installations II, the prerequisite is to have passed the subject of Electrical Installations I. Given the above, the specialty subject with the highest failure rate is the subject of Electrical Machines I, with an average total of 48% of students who have failed this subject, during the academic semesters 2020-I, 2020-II, 2021-I and 2021-II. Next are the subjects of Electrical Installations I, Electrical Installations II, Electrical Circuits II and Electrical Circuits I, with a failure rate of 34%, 33%, 30% and 27%, respectively.

According to Fig. 2, in the subject of Electrical Machines I, 118 students failed during the academic semesters of virtual education, in the subject of Electrical Installations I, there were 96 failed students, in the subject of Electrical Installations II, there were 79 failed students, in the subject of Electrical Circuits II, there were 74 failed students, while in the subject of Electrical Circuits I, there were 71 failed students. Likewise, according to each academic semester, the largest number of failed students is identified; Regarding the subject of Electrical Machines I, 48 students, representing 64%, failed in the academic semester 2021-I, 22 students, representing 58%, failed in the academic semester 2020-I and 33 students, representing 43 % failed in the academic semester 2021-II. Regarding the subject of Electrical Installations II, 28 students, representing 54%, failed in the academic semester 2021-I. Regarding the subject of Electrical Circuits I, 35 students, representing 43%, failed in the academic semester 2020-I. Regarding the subject of Electrical Installations I, 24 students, representing 41%, failed in the academic semester 2021-II. Regarding the subject of Electrical Circuits II, 25 students, representing 37%, failed in the academic semester 2021-I and 24 students, representing 36%, failed in the academic semester 2020-II. For this reason, it can be said that in the 2021-I semester, there was a greater number of failed students, this being a total of 135.

Likewise, Fig. 3 shows the variation of the failure rate of the specialty subjects that both, in the context of face-to-face and virtual education, have continued to present a greater number of failures.

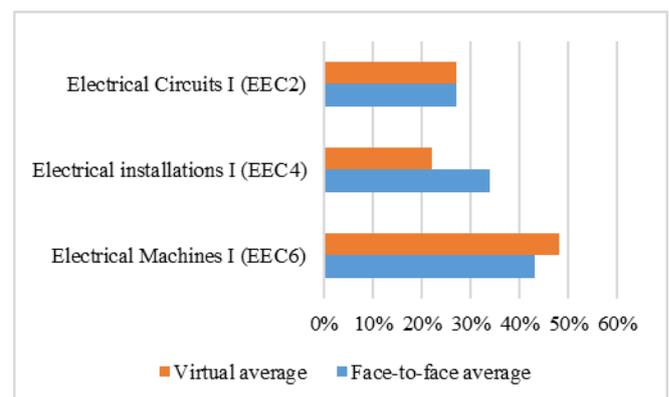


Fig. 3. Variation of the subjects that have continued to present a greater number of failures in face-to-face and virtual education.

According to Fig. 3, the specialty subject that has experienced the greatest positive variation when moving from the context of face-to-face education to virtual education is the subject of Electrical Installations I, with an increase in the failure rate of 12%, followed by finds the subject of Electrical Machines I, with an increase in the failure rate of 5%, while the subject of Electrical Circuits I, remains with a failure rate of 27%.

According to these results, in general, it can be pointed out that the specialty subjects where there are the largest number of failed students are linked to the area of electrical engineering. Likewise, it was identified that the level of failure of the students has experienced a positive variation when moving from the context of face-to-face education to the virtual one, due to the increase in the average rate of failure from 25% to 34%; This is equivalent to 242 students failed during the context of face-to-face education, and 438 students failed during the context of virtual education.

V. DISCUSSION

The results obtained indicate that the level of failure of the students has experienced a positive variation when moving from the context of face-to-face education to the virtual one, due to the increase in the average rate of failure from 25% to 34%. From a planning perspective of learning sessions and mastery in the management of virtual pedagogical tools, it is possible to understand this increase in the level of disapproval, since the transition from face-to-face to virtual in many university educational institutions was sudden, until perhaps unforeseen. Based on this, seeking the continuity of the educational service in Peru was not easy, neither for the teacher nor for the student. Another aspect to take into account is that in the specialty of Mechanical and Electrical Engineering, all the subjects of its study plan are linked to laboratory sessions, in which training modules are used and workshops are held that seek to analyze data collected. through analog and digital measuring instruments, which reinforce the theoretical aspects, however it is possible to link that initially the laboratory sessions were linked to the use of simulation software and in other cases simply with presentations of academic works that consisted of the monograph development. In addition, it is visualized that the specialty subjects of the mechanical and electrical engineering career, where there are the largest number of failed students, is linked to the electrical area.

In [23], the average failure rate is 42.1%, and the dropout or desertion rate is 51.3%, in the first 4 years of analysis, while, in the following 4 years, the rate average failure rate is 72.0%; and the rate of abandonment or desertion of 46.1%. When comparing the two studies, a significant increase in the failure rate, and abandonment or desertion rate is observed, which indicates a slight deterioration of the situation in this aspect. In addition, the Civil, Electrical and Electronic Engineering, Mechanics and Computer Systems careers were the ones that increased their dropout rates by 11.0, 1.1, 3.6 and 14.3%, respectively. Similarly, in [30] it is pointed out that from 2005 to date, the dropout rate is between 27% and 30%, this is related to socioeconomic or psych pedagogical factors. In [31] it is pointed out that the failure rate found was

43.22 ± 7.65 , above that recommended by the evaluating agencies in Mexico, highlighting the importance of continuing to study this problem with greater depth and to generate a line of research, to design academic-administrative interventions to reduce it, with a favorable impact on school dropout. A lower percentage of failure was obtained in [28], in this work, the general failure rate was moderate equal to 21.77%, for the period of February - June 2019. Regarding this in [32], it is pointed out that there are failure rates considered normal, the guidelines of the Teaching Career Program in State Public Universities (UPES) suggest approval rates of 70% or more, that is, an acceptance of failure not greater than 30%.

The results reveal that the specialty subject with the highest rate of failure is the subject of Electrical Machines I, with a total average of 43% of students who have failed during the context of face-to-face education and 48% of students who have failed during virtual education. Finding, the most critical results of up to 70% of students who failed in the academic semester 2018-I and 64% failed in the academic semester 2021-I. Likewise, the specialty subject that has experienced the greatest positive variation when moving from the context of face-to-face education to virtual education, is the subject of Electrical Installations I, with an increase in the failure rate of 12%, followed by the subject of Electrical Machines I, with an increase in the failure rate of 5%.

Regarding the high rate of failure of subjects that are the central axis of the study plans, in [4], they point out that, during five consecutive semesters, a failure rate of 35% is identified in the subject of projects in the totally virtual modality, this does not allow to continue with the other subjects of the curricular plan, because its approval is a prerequisite for the development of necessary competences of the following subjects and that will also be applied in their work environment. A study that obtains different results is the one carried out by [32], in which although a failure rate of 23.36% was determined, this focuses on the generic skills of the learning units, also, according to the student's perception, the two main causes are related to the student himself 49.5% and the teacher 26.6%. Similarly, in [10], the results of their research showed that the highest proportion of students lagging behind are in programs in the area of Engineering and Technology, followed by the area of Natural and Exact Sciences, and in the Common Core that is taught during the first university year in various areas.

VI. CONCLUSION

The continuity of the educational service in Peru during virtualization was not easy, neither for the teacher nor for the student. In the present investigation, the results indicate that the level of disapproval of the students has experienced a positive variation when passing from the context of face-to-face education to the virtual one, it is possible to understand this increase in the level of disapproval, since the passage of face-to-face to virtual in many university educational institutions was sudden, perhaps even unforeseen. Taking into account, in addition, that all the subjects of its study plan are linked to laboratory sessions, in which training

modules are used and practical workshops are carried out, however, it is possible to link that initially the laboratory sessions they were linked with the use of simulation software and in other cases simply with presentations of academic works that consisted of the development of monographs. In this sense the findings of this research demand the design of academic interventions that contribute positively to the achievement of learning. In addition, with what is obtained, it is possible to identify the subjects where more attention should be paid in order to favorably influence the failure rates, through updates of the thematic contents of each subject, improvement of the evaluation processes, diversification of the strategies of teaching-learning. All this through the use of technological tools, which allow the proper development of the activities, and responsibilities of the teacher and the student, in this return of the blended teaching-learning process. Taking into account that, by recognizing the weaknesses and abilities of the students, it will be possible to improve the efficiency of productivity in education, obtaining graduates with a good performance in the workplace.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Omar Chamorro-Atalaya formulated the problem as well as the research objectives and wrote the article as main author. Salvador Trujillo-Pérez was in charge of writing the introduction. Edison Perez-Linares developed the literary review. Almintor Torres-Quiroz carried out the research design as well as the data collection process. Yurfa Medina-Bedón carried out the fieldwork and participated in the data collection process. Lourdes Quevedo-Sánchez developed the processing and analysis of the collected data. Maritte Fierro-Bravo was in charge of the interpretation of results as well as the discussion with the results of other investigations. Antenor Leva-Apaza carried out the review of styles and verification of the format established by the journal.

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