



Interdisciplinary perspectives on scientific research

Diana Agueda Vargas Velásquez
EDITOR

Universidad Nacional del Altiplano

INTERDISCIPLINARY PERSPECTIVES ON SCIENTIFIC RESEARCH

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1.^a Edición junio de 2026

Tiraje: 50 ejemplares

Depósito Legal N° 2026-05775

ISBN: 978-612-03-2544-5

Se terminó de imprimir en junio de 2026 en:

LUCERO IMPRESIONES

RUC 10411509015

De Antonia Ccama Quispe

Jr. Moquegua 360 – B, Puno - Perú

Teléfono 051 208093 – Cel. 921 431042

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PRESENTATION

Scientific research is one of the fundamental pillars for the sustainable development of contemporary societies. In a context characterized by rapid technological change, social transformations, environmental challenges, and new economic and cultural dynamics, the knowledge generated by academia acquires strategic relevance for understanding reality and proposing innovative solutions to the problems facing humanity.

Universities, especially graduate schools, have the responsibility to promote high-level academic training based on scientific rigor, critical thinking, and the production of interdisciplinary knowledge. In this scenario, the integration of different areas of knowledge enriches analytical perspectives and strengthens the capacity to respond to complex phenomena that require comprehensive approaches.

This book brings together a selection of scientific articles written by master's and doctoral students from various academic disciplines at the Graduate School of the National University of the Altiplano in Puno, Peru. The works compiled here represent the result of research efforts, academic reflection, and the institution's commitment to scientific excellence, demonstrating significant contributions in fields such as social sciences, education, health, engineering, environmental sciences, public administration, technology, and the humanities.

Each article reflects not only the methodological rigor and theoretical soundness characteristic of graduate research, but also an interdisciplinary vision oriented toward generating knowledge relevant to regional, national, and international development. Furthermore, this work seeks to promote academic dialogue,

encourage a research culture, and contribute to the dissemination of scientific output in increasingly globalized spaces.

With this publication, the Graduate School of the National University of the Altiplano reaffirms its commitment to training researchers capable of responding to contemporary challenges with ethics, innovation, and social responsibility. In this way, this book constitutes an academic contribution that strengthens university scientific production and consolidates the role of research as an engine of social transformation and human development.

Finally, I express my gratitude to the authors and editorial team who made this publication possible, as well as to all those who continue to champion science, research, and knowledge as essential paths to building a more just, inclusive, and sustainable society.

Dra. Diana A. Vargas Velásquez
English Teacher



ANALYSIS AND EVALUATION OF THE FATIGUE BEHAVIOR OF RIGID PAVEMENT CONTAINING POLYPROPYLENE PLASTIC FIBERS IN THE ALTIPLANO

Adela Aguilar Alca

adhely125@gmail.com

Orcid.org/0009-0007-7251-312X

Universidad Andina Néstor Cáceres Velázquez



ABSTRACT

The study analyzed the effect of using polypropylene fibers (PPF) as reinforcement on the mechanical properties and fatigue behavior of concrete mixtures intended for rigid pavements in the Altiplano. The main objective was to analyze and evaluate how the behavior of a rigid slab affects concrete fatigue in the Altiplano. The methodology employed was quantitative in nature, involving an experimental approach and experimental design, with the fabrication of 72 cylindrical specimens measuring 6" x 12" (ASTM C31) subjected to compression tests and 45 joists measuring 4" x 4" x 14" (ASTM C78) subjected to flexural testing at 7, 14, and 28 days of curing. In this process, experiments were conducted on the concrete mix design and dosage, incorporating fly ash (FPP) at rates of 500 g/m³, 600 g/m³, and 700 g/m³ in concrete with a compressive strength of $f'_c = 210 \text{ kg/cm}^2$ in both fresh and hardened states. Microsoft Excel was used for data processing (for tabulation and the creation of comparative graphs), and the student's t-test was applied. This test allowed us to determine whether the variations in mechanical properties represented a real difference between the standard mix design and the fiber-modified designs. A normal distribution and Z-scores were used to validate the data obtained in the laboratory. It is concluded that the addition of 600 g/m³ of FPP increases the flexural and compressive strength of concrete, enabling optimized pavement design according to the AASHTO method, with strengths reaching 241.20 kg/cm² and 325 kg/cm².

Keywords: Synthetic fibers, Polypropylene plastic fibers, Compressive strength, Flexural strength, Modulus of rupture.

1. INTRODUCTION

Contemporary research has refined our understanding of how polypropylene affects mechanical behavior. They laid the groundwork for understanding flexural strength (Boada & Pérez, 2011). Recent research shows that polypropylene fiber (PPF) not only improves strength but also extends fatigue life. by limiting the formation of microcracks at the nanoscale (Chen et al. 2022). have investigated the “matrix-fiber interface” (ITZ) in high-altitude climates with low humidity and high radiation (Li & Zhang, 2021). have demonstrated, through numerical and experimental models, that the incorporation of fibers into high-strength mixtures reduces the propagation of microcracks (Nguyen et al., 2022), defined as “the fiber bridging mechanism” (Al-Akhras, 2021), have optimized the thicknesses of concrete slabs and increased the flexural strength (modulus of rupture) provided by the fibers (Zhang and Li, 2023). The use of polypropylene fibers alters the fatigue behavior of concrete in a rigid pavement by changing its mechanical properties, such as compressive and flexural strength. However, in the Altiplano, roadways are subject to severe operating conditions, characterized by elevations exceeding 3,800 meters above sea level. Recurring problems with rigid pavement are caused by settlement, poor soil bearing capacity, poor pavement design, mix proportions, drainage issues, construction deficiencies, and, especially, repetitive excessive traffic loads (fatigue). The latter leads to pavement deterioration and cracking of the slab in the form of transverse, longitudinal, corner, and block cracks, making it necessary to develop a more appropriate and realistic model of concrete fatigue behavior (Altamirano, 2007; Council of Highway Directors of Iberia and Ibero-America, 2002). On the other hand, to optimize pavement design, the goal is typically to reduce the thickness of the layers that make up the pavement without compromising its structural integrity. Recent research shows that polypropylene fiber (PPF) not only improves strength but also extends fatigue life. This weakness in terms of tensile strength and fracture can be overcome by adding a sufficient amount of polypropylene fibers.

The variables considered are the maximum size of the coarse aggregate, the fines in the sand, and the fiber content. Eight concrete mixes were prepared and tested in the fresh and hardened states at 7 and 28 days. For the fresh concrete, slump, air content, unit weight, and plastic shrinkage cracking were determined; for the hardened concrete, compressive strength, modulus of elasticity, Poisson’s ratio, tensile strength, toughness, impact strength, and drying shrinkage were determined. The authors conclude that the presence of fibers in fresh concrete alters the consistency of the mixture and reduces plastic shrinkage cracking; and in the hardened state, it increases toughness and impact resistance while reducing drying shrinkage and cracking (Mendoza & Dávila 2011).

This study examined the influence of polypropylene fibers on compressive strength testing, for which cylindrical concrete specimens were tested; a statistical analysis

concluded that the addition of polypropylene fibers to concrete minimally reduced compressive strength (Montes de Oca, 2011). comparative tests between a standard concrete without fiber and concrete with diferente percentages of added fiber, ranging from 5% to 20% by weight of the cement. comparative tests between a standard concrete without fiber and concrete with different percentages of added fiber, ranging from 5% to 20% by weight of the cement. However, in the hardened state, the addition of polypropylene fiber has no significant effect on the increase in the concrete's compressive strength; on the contrary, increasing the amount (Muñoz, 2010).

2. METHODS

The research was conducted at the Professional School of Civil Engineering (EPIC), Faculty of Civil Engineering and Pure Sciences, at the Universidad Andina “Néstor Cáceres Velásquez” (UANCV) in Puno, in the UANCV Villa Laboratory in southern Peru. The study was carried out over the course of one year.

The study was experimental in nature, as its purpose was to quantify and compare the performance of concrete incorporating polypropylene fibers in the mix design and production process, including its compressive and flexural strength. To understand the behavior of concrete, tests were conducted on both fresh and hardened concrete (Hernández, Fernández, and Baptista, 2014).

Samples were taken of both concrete with polypropylene fibers and concrete without fibers. In this case, the concrete was prepared taking into account the different fiber content percentages to be used. Each batch was calculated for 1 cubic meter of concrete. The total number of concrete cylinders was 72; that is, 18 cylinders were tested for each mix design (18 for 0% fiber [control concrete], 18 for 500 g/m³, 18 for 600 g/m³, 18 for 700 g/m³ for each specimen, using the specifications (ASTM C-39, 2015) for each curing age of 7, 14, and 28 days.

According to the standard (ASTM C 1018, 2015), the number of test specimens with dimensions of (4"x 4" x 14") is 45, with 15 specimens tested for each mix design (18 for 0% fiber [control concrete], 9 for 500 g/m³, 9 for 600 g/m³, and 9 for 700 g/m³). For each test, three joists were selected for the Standard Test Method for Determining the Flexural Strength of Concrete. Samples were taken at curing ages of 7, 14, and 28 days.

All samples were taken using the same mix design with a compressive strength of 210 kg/cm² for all mix proportions, in order to provide a consistent comparative result; this highlights the characteristics of the concrete based on the mix proportions of different fiber percentages relative to the design mix characteristics per 1 m³. It is also important to note that the samples were cured in two different ways (exposed to the elements and submerged) for testing purposes.

At the time of production, the temperature, slump, and setting time of each fresh concrete mix were measured. Once cured, the cast concrete specimens were subjected to compressive and flexural loads at different ages in order to determine the optimal mix design for our environment.

Therefore, incorporating the appropriate amount of polypropylene fibers (600 g/m^3) increases the concrete's flexural and compressive strength; in turn, designing a rigid pavement with these properties makes it possible to reduce its thickness without compromising its functionality and without significantly altering its production costs, according to results obtained from cost analyses for typical traffic conditions in the city of Puno.

Materials Used:

- **Aggregates:** Sourced from the “Río Cutimbo” quarry. They were physically characterized, resulting in a nominal maximum size of 3/4" for the coarse aggregate.
- **Cement:** Type IP Portland cement (Mishky) was used, selected for its frequent use in regional infrastructure projects.
- **Fiber:** 12 mm long monofilament polypropylene microfibers, designed for plastic cracking control and secondary reinforcement.
- **Water:** Potable water from the Villa Universitaria (UANCV) supply.

Experimental Procedure:

- **Mix Design:** This was performed using the ACI 211.1 method for a design strength of $f'_c = 210 \text{ kg/cm}^2$, adjusted for durability to $f'_{cr} = 294 \text{ kg/cm}^2$.
- **FPP Dosage:** Three study groups were established: reference mix (0%), standard dosage recommended by the manufacturer (0.6 kg/m^3), and a higher experimental dosage.
- **Tests:** ASTM C-39 was applied for simple compression and ASTM C-78 for flexural strength with loading in the upper thirds. Statistical analysis was performed in SPSS V.25, analyzing the correlation between fiber density and the increase in the Modulus of Rupture (M_r).

3. RESULTS AND DISCUSSION

3.1. Results

The study was conducted using a quantitative approach and an experimental design. A test concrete mix was prepared with an expected compressive strength of $f'_c = 210 \text{ kg/cm}^2$ and a slump of 3“to 4”.

IP-type pozzolanic cement (Mishky), potable water from the Uancv housing complex's water supply system, and fine (sand) and coarse (gravel with a maximum nominal size of 1 inch) aggregates from the Cutimbo River quarry (Puno) were used. The reinforcement consisted of multifilaments made of 100% virgin polypropylene fiber (Sika Fiber), with a length of 19 mm and a melting point of 160°C.

Mix Design and Test Specimens Four FPP dosages per cubic meter of concrete were evaluated: 0 g/m³ (control concrete), 500 g/m³, 600 g/m³, and 700 g/m³. A total of 72 cylindrical specimens measuring 4"x 8" (ASTM C31) were manufactured for compression tests, and 45 prismatic joists measuring 4" x 4" x 14" were manufactured for flexural tests (ASTM C1018). the specimens were subjected to two types of curing: submerged curing and open-air curing (simulating on-site conditions), and were tested at 7, 14, and 28 days.

It was determined that adding 600 g/m³ of FPP results in a significant improvement in mechanical properties compared to the standard concrete. In terms of pavement design using the AASHTO method, the improvement in flexural strength (modulus of rupture) allowed for a reduction in the thickness of the concrete slab, resulting in cost savings.

Tests and Evaluation

- **Fresh concrete:** Workability was measured using the Abrams cone (ASTM C143) and internal temperature (ASTM C1064).
- **Hardened concrete:** Compression tests (ASTM C39) and flexural strength or modulus of rupture (Mr) tests were performed by applying loads at one-third of the test span.
- **Design and Costs:** The AASHTO (1993) rigid pavement design equation was used to calculate the difference in required thicknesses using the Modulus of Rupture of the standard concrete compared to the optimal concrete with FPP, ultimately evaluating the production cost per cubic meter

Discusión

When comparing the results with previous findings, we agree with Montes de Oca (2011) that the compressive strength decreases almost imperceptibly, which is acceptable in the design of pavements where bending is the predominant load. The observed improvement in ductility exceeds the findings of Muñoz (2010), likely because curing in the open air on the Altiplano helps control the initial thermal shrinkage caused by the fibers.

Compressive Strength

The results showed that submerged curing yields higher strengths than open-air curing. At 28 days (cured in the open air), the control concrete reached 274.64 kg/cm², while the mixture with 600 g/m³ of FPP reached its maximum peak at 319.82 kg/cm², showing an increase of 16.45%. It is noteworthy that when the dosage was increased to 700 g/m³, the strength decreased to 264.53 kg/cm², validating the hypothesis that there is a saturation point where an excess of fines and fibers impairs the concrete matrix.

Flexural Strength (Modulus of Rupture - Mr)

The flexural test confirmed the improvement in ductility. At 28 days, the fiber-free specimens cured in the open air yielded an Mr of 28.65 kg/cm². With the addition of 600 g/m³ of FPP, the Modulus of Rupture rose to 32.66 kg/cm², achieving an increase of 13.99%. The stress-strain curves showed that the mixture with 600 g/m³ reached a maximum strain of 0.38 mm before failure, dissipating more energy compared to the control concrete. Using nonlinear regression, it was calculated that the exact theoretical addition to achieve the maximum Mr is 600.11 g/m³, empirically confirming the manufacturer's recommendations.

The sharp drop in strength when using 700 g/m³ is attributed to the “hedghehog effect” or fiber agglomeration. An excess of FPP hinders consolidation, traps air voids, and disrupts the homogeneity of the mixture, acting as points of weakness rather than reinforcement.

From a pavement design perspective, increasing the modulus of rupture is essential. The AASHTO method is highly sensitive to the S'c (Mr) variable. By increasing this resistance in the wearing course, the structure better dissipates the energy from vehicle loads (fatigue), allowing designers to reduce slab thicknesses without sacrificing service life, which represents a considerable technical and economic advantage for road projects in the Altiplano.

4. CONCLUSIONS

- The addition of polypropylene plastic fibers positively alters the mechanical properties of concrete against fatigue under Altiplano conditions. It was determined that the optimal dosage is 600 g/m³, which produces the maximum structural benefits, with its effectiveness decreasing at higher dosages (700 g/m³).
- Concrete modified with the optimal dosage achieved a significant increase in mechanical strength at 28 days, increasing compressive strength by 16.45% and the modulus of rupture (flexural strength) by 13.99% under open-air curing conditions.

- The incorporation of fibers slightly reduces the slump of fresh concrete (14% reduction); however, it remains within acceptable workability ranges for paving.
- From a structural design perspective (AASHTO Method), the improvement in the modulus of rupture allows for the design of thinner pavement slabs. This geometric optimization translates into a more cost-effective alternative, achieving reductions of up to 11% in direct production costs compared to conventional rigid pavement.

5. ACKNOWLEDGMENTS

To the Graduate School of the National University of the Altiplano, for the academic resources provided. To the Language Program, for the methodological tools provided to help complete this article. I would also like to express my gratitude to the English course led by Dr. Diana Vargas Velásquez. Thank you for your patience, your teaching methods, and for sharing your experience with such dedication.

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SERVICE QUALITY IN RELATION TO DINER SATISFACTION AT THE UNIVERSITY CAFETERIA OF THE JOSÉ MARÍA ARGUEDAS NATIONAL UNIVERSITY

Margot Zulema Apaza Velasquez

mapazavelasquez@gmail.com

ORCID: 0000-0003-2405-8736

National University of the Altiplano - Puno



ABSTRACT

Service quality is a key factor in evaluating and improving university services, particularly those focused on student well-being, such as university dining halls. In this context, the objective of this study was to determine the relationship between service quality and diner satisfaction at the university dining hall of the José María Arguedas National University in Andahuaylas. The study employed a quantitative, descriptive-correlational approach with a non-experimental, cross-sectional design. The sample was selected using stratified sampling with proportional allocation, taking into account the different university campuses. Data collection was conducted using a survey method, employing a structured questionnaire based on the SERVQUAL model, consisting of 22 items distributed across the dimensions of tangibility, reliability, responsiveness, assurance, and empathy. Statistical analysis of the data was performed using IBM SPSS software, applying Pearson's correlation coefficient to test hypotheses. The results showed that service quality is predominantly average, while diner satisfaction is mostly at a moderate level. Furthermore, a positive and significant correlation was found between the two variables ($r = 0.673$), demonstrating that improvements in service quality directly influence user satisfaction. It is concluded that strengthening service, infrastructure, and food quality will significantly contribute to the well-being of student diners.

Keywords: service quality, customer satisfaction, SERVQUAL, university cafeteria, correlation.

1. INTRODUCTION

Today, service quality is a strategic factor in evaluating organizational performance, particularly in institutions that provide direct services to the student population (Muskat B, Zehrer A, 2016). Within the university context, wellness services play a fundamental role in students' holistic development, with the university dining hall being one of the most important services due to its influence on nutrition, health, and academic performance (SUNEDU, 2014). In this regard, the quality of food service involves not only the provision of food but also the assurance of adequate conditions regarding service, infrastructure, hygiene, and organization factors that directly influence user perception and satisfaction (Álvarez y Aguirre, 2015).

On the other hand, user satisfaction is currently one of the main indicators used to assess the efficiency and quality of services. Various studies suggest that the level of satisfaction depends on a comparison between user expectations and the perception of the service received, making it a key factor in measuring institutional performance (Parasuraman et al., 2015). In this context, service quality and user satisfaction are closely related variables, since deficiencies in service delivery, organization, or provision directly impact users' perceptions.

In the university setting, the dining hall is one of the most widely used student support services, especially among students who rely on this benefit to ensure adequate nutrition during their academic studies. However, in many university settings, there are limitations related to the quality of service, infrastructure conditions, wait times, and perceptions of the food offered, leading to dissatisfaction among diners and affecting the overall evaluation of the service (Álvarez y Aguirre, 2015). These issues highlight the need to implement evaluation mechanisms that allow for the identification of weaknesses and the establishment of strategies aimed at continuous improvement. Various authors note that service quality can be assessed using the SERVQUAL model, which has established itself as one of the most widely used tools for measuring user perception of the services received (Zeithaml et al., 2015). This model considers dimensions related to tangibility, reliability, responsiveness, assurance, and empathy, allowing for a comprehensive evaluation of the quality of the service provided. Likewise, previous research has shown that improvements in these dimensions significantly influence increased user satisfaction and a positive perception of the service (Mejías et al., 2012).

At the José María Arguedas National University in Andahuaylas, the need to evaluate the quality of service provided in the university dining hall was identified, given its importance within the student welfare system and the diverse perceptions expressed by users regarding its operations. The lack of ongoing evaluations of service quality makes it difficult to identify factors that affect student satisfaction

and limits the implementation of strategies aimed at strengthening the university food service.

In this context, the purpose of this study was to determine the relationship between service quality and student satisfaction at the university dining hall of the José María Arguedas National University, as it assesses students' perceptions of the dining hall's service quality with the aim of improving that service and contributing to the strengthening of service management, thereby ensuring students' well-being.

2. METHODS

The research was conducted at the José María Arguedas National University, located in the city of Andahuaylas in the Apurímac region of Peru, a public institution of higher education focused on professional training and the overall well-being of its students. The study was carried out specifically in the university dining hall, a student support service designed to provide meals to students at the university's various campuses.

The research lasted one academic term (semester), during which the necessary arrangements and approvals were obtained from the Office of Student Welfare and the head of the university dining hall.

The implementation process began with the identification of factors related to food service quality and user satisfaction. Subsequently, evaluation instruments based on the SERVQUAL model were designed and administered, allowing for the collection of information on students' perceptions and expectations regarding the service provided in the university dining hall. The surveys were administered in person to students using the university dining hall during regular meal service hours. Before administering the survey, the research objective was explained to participants, and confidentiality and the exclusively academic use of the collected information were guaranteed. Participation was voluntary, and verbal consent was requested from each student.

The data collection tool was a structured questionnaire covering the following dimensions: Reliability (5 items), which measures the ability to provide the service correctly, safely, and on time; Responsiveness (4 items), which assesses the staff's willingness and speed in assisting users. Safety (4 items): Considers the knowledge, courtesy, and confidence conveyed by staff. Empathy (5 items).

It should be noted that, during the data collection process, some users declined to participate in the assessment due to lack of time, lack of interest, or leaving the facility immediately after receiving the service; however, this did not significantly affect the conduct of the study, as a representative number of valid surveys was obtained for the corresponding analysis.

The completed questionnaires were then reviewed to ensure they had been filled out correctly and to identify any inconsistencies in the responses. The data collected was subsequently coded and entered into a database for statistical analysis. Finally, the results were analyzed and interpreted using tables and graphs, which made it possible to determine the relationship between service quality and the level of satisfaction among university cafeteria patrons.

Table 1

Meaning of the dimensions of the SERVQUAL model.

Dimensions	Meaning
Tangible elements (T)	Appearance of the physical facilities, equipment, employees, and communication materials
Reliability (RY)	Ability to deliver the promised service accurately
Responsiveness (R)	A desire to help customers and serve them quickly
Safety (A)	Knowledge of the service provided and the courtesy of the staff, as well as their ability to instill confidence in customers
Empathy (E)	Personalized customer service

Note: Office of Student Wellness at José María Arguedas University

Table 2

Meaning of the dimensions of the SERVQUAL model

LOCATIONS	POPULATION	NUMBER OF STUDENTS
CCOYAHUACHO CAMPUS	411	157
SANTA ROSA CAMPUS	370	141
TOTAL	781	298

Note: Office of Student Wellness at José María Arguedas University

3. RESULTS AND DISCUSSION

3.1. Results

Table 3

Quality of service provided at the UNAJMA university dining hall in Andahuaylas, by campus.

CCOYAHUACHO CAMPUS				
SERVICE QUALITY	Frequency	Percentage	Valid percentage	Cumulative percentage
Good	61	39	39	68
Fair	79	50	50	78
Poor	17	11	11	100
TOTAL	157	100	100	

SANTA ROSA CAMPUS				
SERVICE QUALITY	Frequency	Percentage	Valid percentage	Cumulative percentage
Good	48	34	34	34
Fair	80	57	57	84
Poor	13	9	9	100
TOTAL	141	100	100	

Note: Data obtained from guest records

The table shows that, at both locations of the José María Arguedas National University dining hall, most students rate the quality of service as fair. At the Ccoyahuacho location, 50.0% rated the service as fair, while at the Santa Rosa location, 57.0% did so. Likewise, a smaller percentage considered the service to be poor, highlighting the need to implement improvements to increase user satisfaction.

Table 4

Level of satisfaction among diners with the university dining hall service at UNAJMA in Andahuaylas, by campus.

CCOYAHUACHO CAMPUS					
	SUMMARY	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	High	32	20	20	20
	Medium	120	77	77	92
	Low	5	3	3	100
	TOTAL	157	100	100	

SANTA ROSA CAMPUS					
	RESUMEN	Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	High	27	19	19	19
	Medium	98	70	70	68
	Low	16	11	11	100
	TOTAL	141	100	100	

Nota: datos obtenidos de registro de comensales

The table shows that the level of satisfaction among diners at the José María Arguedas National University cafeteria is predominantly moderate at both campuses. At the Ccoyahuacho campus, 77.0% of students reported moderate satisfaction, 20.0% reported high satisfaction, and 3.0% reported low satisfaction. Similarly, at the Santa Rosa campus, 70.0% reported moderate satisfaction, 19.0% high satisfaction, and 11.0% low satisfaction. Overall, the results indicate that most users maintain moderate satisfaction with the service provided.

Table 5

Pearson's correlation coefficient (r) for the variables “Service Quality” and “Diner Satisfaction” regarding the university dining hall service at UNAJMA in Andahuaylas.

		SERVICE QUALITY	DINER SATISFACTION
SERVICE QUALITY	Pearson's correlation	1	0,673
	Significance (two-tailed)		,000
	N	298	298
DINER SATISFACTION	Pearson's correlation	0,673	1
	Significance (two-tailed)	,000	
	N	298	298

Note: Data obtained from guest records

The table shows that there is a significant positive relationship between service quality and diner satisfaction at the José María Arguedas National University cafeteria, as evidenced by a Pearson correlation coefficient (r) of 0.673. Furthermore, the significance level ($p = 0.000$) indicates that the relationship is statistically significant. This means that as service quality improves, user satisfaction also increases.

3.2. Discusión

The results show that the quality of service at the university dining hall was predominantly rated as fair at both campuses evaluated. At the Ccoyahuacho campus, 50.0% of students rated the service as fair, while at the Santa Rosa campus, 57.0% gave the same rating. These results indicate that there are still shortcomings in areas related to customer service, infrastructure, and the organization of the food service. They also align with previous research conducted in university dining halls, which reported average and unsatisfactory perceptions regarding the quality of service provided. The results are consistent with the findings of Tan et al. (2016), who argue that user satisfaction with university services depends directly on perceptions

of the quality and efficiency of the service received. Similarly, Soto Justiniano et al. (2021) found that improvements in service, organization, and infrastructure have a positive influence on the perceptions and satisfaction of university dining hall users.

Regarding diners' satisfaction levels, the results show that most students reported moderate satisfaction. At the Ccoyahuacho campus, 77.0% of students reported moderate satisfaction, while at the Santa Rosa campus, 70.0% reported the same level of satisfaction. These findings indicate that the service partially meets users' expectations, particularly in areas related to service staff, dietary options, and infrastructure. The results align with similar studies indicating that user satisfaction depends directly on perceptions of the quality and efficiency of the service received.

With regard to the relationship between the variables, Pearson's correlation coefficient revealed a positive and significant relationship between service quality and customer satisfaction ($r = 0.673$). This result demonstrates that as service quality improves, customer satisfaction also increases. Furthermore, the findings support the SERVQUAL model proposed by Parasuraman et al. (1988), which posits that the perception of quality directly influences customer satisfaction. Therefore, improving aspects such as reliability, responsiveness, assurance, and empathy will significantly contribute to the well-being and satisfaction of student diners.

It is concluded that the university dining hall is a fundamental service within student welfare policies; therefore, it is necessary to implement strategies aimed at enhancing the quality of the service by improving aspects related to infrastructure, customer service, organization, and food quality, thereby contributing to the well-being and academic development of university students.

4. CONCLUSIONS

- It was determined that there is a positive and significant relationship between service quality and the satisfaction of university cafeteria patrons, as evidenced by a Pearson correlation coefficient of $r = 0.673$. This result demonstrates that the two variables are directly related, implying that any improvement in service quality will have a positive impact on user satisfaction.
- The analysis found that service quality is generally average, indicating that the service provided only partially meets expected standards. However, opportunities for improvement were identified in specific dimensions of the SERVQUAL model, such as tangibility, responsiveness, and empathy, all of which directly influence user perception.
- The findings showed that most students reported a moderate level of satisfaction, indicating that, while the service meets basic needs, it has not yet managed to

exceed users' expectations. This result highlights the need to implement continuous improvement strategies aimed at optimizing the dining experience.

- It is concluded that improving service quality will directly contribute to increasing the satisfaction levels of university cafeteria users, enhancing not only their perception of the service but also their overall well being. In this regard, implementing measures aimed at improving customer service, food quality, and infrastructure will lead to higher levels of satisfaction.
- Finally, it is established that evaluating service quality using the SERVQUAL model is an effective tool for identifying shortcomings and guiding decision-making in the management of university services, thereby contributing to continuous improvement and the strengthening of institutional quality.

5. ACKNOWLEDGMENTS

To my alma mater, the National University of the Altiplano School of Human Nutrition for providing me with a high-quality academic education and for contributing significantly to my professional development. I would also like to express my sincere gratitude to the faculty for sharing their knowledge, experiences, and guidance throughout my studies.

To my family, for their unconditional support, understanding, and constant encouragement they have been a cornerstone in helping me achieve my goals and objectives.

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DEEP LEARNING ARCHITECTURES FOR AUTOMATED CLASSIFICATION OF THE ANDEAN WEEVIL: A COMPARATIVE EVALUATION

Edgar Centeno Huamani

edgar.centeno@unsaac.edu.pe

<https://orcid.org/0000-0002-7736-1299>

National University of the Altiplano - Puno



ABSTRACT

The objective of this study was to evaluate the performance of four Convolutional Neural Network (CNN) architectures – ResNet-50, DenseNet-121, VGG-16, and EfficientNetB3 – for the automated classification of the Andean weevil (*Premnotrypes* spp.) in potato crops in the Cusco region of Peru. The research employed a quantitative, comparative, and non-experimental design, with algorithmic partitioning of the data into training and test sets. The initial dataset consisted of 410 real images. Through the application of data augmentation techniques, synthetic images were generated, resulting in a total of 1,000 images resized to 224×224 pixels. Training was performed using the Python programming language and included transfer learning and fine-tuning strategies, as well as the incorporation of custom layers and regularization techniques. The results showed that DenseNet-121 and VGG-16 achieved very high and statistically equivalent performance, with an accuracy of 99%, an F1-score of 99%, and an AUC-ROC of 1.00, significantly outperforming EfficientNet-B3 and ResNet-50. In conclusion, both the architectures used and the proposed methodology represent a solid foundation for developing accurate Andean weevil classification systems, where what matters most is effectiveness with real-world data, rather than whether the architecture is new or flashy.

Keywords: deep learning; Andean weevil; image classification; convolutional neural networks.

1. INTRODUCTION

Agriculture in the Cusco region of Peru is a cornerstone of the local economy and food security, with the potato being one of its most representative crops (Central Reserve Bank of Peru [BCRP], 2023). However, this sector faces critical phytosanitary challenges, among which insect pests stand out for their ability to cause substantial losses (BCRP, 2023). In this context, the Andean weevil (*Premnotrypes* spp.) is one of the most destructive threats, with reported losses reaching up to 40% of production in the Andean region (National Institute of Agricultural Innovation [INIA], 2016). Effective control of this pest depends largely on its early and accurate identification. However, traditional monitoring methods, based predominantly on visual inspection, have significant limitations: they are subjective, time-consuming, and require specialized knowledge, making them inefficient and difficult to scale for small and medium-sized farmers (Buitrago Bolívar et al., 2024).

This challenge has spurred the search for innovative technological solutions. The application of deep learning techniques, specifically Convolutional Neural Network (CNN) models, enables the automation of pest identification with far greater accuracy and speed than conventional methods (Zhang et al., 2021; Lee et al., 2023). The scientific community has actively explored various architectures for insect identification tasks. For example, Li et al. (2020) implemented EfficientNet for real-time pest identification, highlighting the model's robustness and how increased data improves its generalization. Likewise, Mishra et al. (2023) compared ResNet50, EfficientNetB7, and InceptionV3, concluding that EfficientNetB7 achieved the highest accuracy (99%) with manageable computational requirements. Chen & Lin (2021), for their part, compared VGG-16 and MobileNet for insect classification, concluding that lighter architectures such as MobileNet are viable for implementation on mobile devices a crucial aspect for field accessibility.

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Meanwhile, Kaushik et al. (2025) demonstrated that Gaussian filtering, histogram normalization, and lighting balancing significantly improve the performance of the algorithms. To address the challenge of data scarcity, Yun et al. (2024) proposed the use of progressive GANs to generate high-quality synthetic images, improving classification accuracy by 2.56%.

In the Peruvian context, Avalos et al. (2021) and Huarote et al. (2023) demonstrated the feasibility and positive impact of AI-integrated applications for diagnosing pests in potato crops. Avalos et al. (2021) implemented a mobile application that reduced pest identification time by 6 minutes and decreased pest incidence by 21%. Similarly, Huarote et al. (2023) developed a deep learning-based system that achieved 99.42% accuracy in classifying potato pests and diseases. Furthermore, Lozada-Portilla et al. (2021) proposed a CNN model to identify late blight in potatoes, achieving 90% accuracy and demonstrating the effectiveness of these tools in assisting farmers.

Despite these advances, there is a lack of specific research that systematically compares the performance of multiple advanced CNN architectures focused exclusively on classifying the Andean weevil under the specific conditions of the southern Peruvian highlands, where factors such as altitude and weather conditions affect image quality (Zhang et al., 2023). This gap is critical, given that identifying this specific pest requires models capable of handling variations in lighting, size, and position of the insects in complex field images.

Therefore, this study aims to conduct a comparative evaluation of CNN architectures for the automated classification of the Andean weevil, with the goal of determining an optimized model to transform traditional agricultural practices in Cusco.

2. METHODS

The research was conducted at the entomology laboratory of the National University of San Antonio Abad in Cusco (UNSAAC). These specimens were previously collected by the laboratory in potato-growing areas of the Cusco Region, Peru (reference coordinates: 13°31'20"S, 71°59'00"W), at altitudes between 3,200 and 4,200 m.a.s.l., with an average annual temperature of 8-15°C and relative humidity of 60–80%. To capture the images, the laboratory used 45-megapixel Canon EOS R5 cameras paired with an RF 100mm f/2.8L IS USM macro lens, which allowed for high-resolution, detailed photographs of the specimens. The research was conducted during the second half of 2025.

The methodological design consisted of a controlled computer simulation in which four pre-trained Convolutional Neural Network (CNN) architectures –ResNet-50, DenseNet-121, VGG-16, and EfficientNetB3– were comparatively evaluated under a standardized protocol. This process included the preparation of an image dataset, the application of data augmentation techniques to expand the sample, and the

implementation of a two-phase protocol (Transfer Learning and Fine-Tuning) to train and fine-tune the models, with the aim of identifying the best-performing architecture for the automated classification task.

The dataset of 410 images in JPG format was divided into two classes: 205 images of Andean weevils (*Premnotrypes* spp.) and 205 images of other non-weevil insect species. All images maintained a 1:1 aspect ratio to ensure consistency in processing.

We generated 1,000 synthetic images per class using Keras' ImageDataGenerator to supplement the limited number of original images and prevent overfitting. We applied geometric and color transformations that preserve the insects' key biological features (rotations, translations, horizontal/vertical flips, zooming, shearing, brightness adjustments, and channel modifications).

The data augmentation process resulted in a final dataset of 2,410 images (1,205 per class), increasing the original size by approximately six times. All images were resized to 224×224 pixels, the standard format required by pre-trained CNN architectures.

The dataset was stratified into: training set: 70% (1,687 images), validation set: 15% (361 images), and test set: 15% (362 images). This division ensured proportional representation of both classes across all subsets. Four pre-trained CNN architectures on ImageNet were evaluated:

ResNet-50: Uses skip connections and bottleneck blocks (1x1, 3x3, 1x1) to prevent vanishing gradients and reduce the number of parameters.

DenseNet-121: Connects each layer to all preceding layers, improving gradient flow and feature reuse while using fewer parameters.

VGG-16: A simple, sequential architecture based on 3x3 convolutions and 2x2 max-pooling, used as a baseline.

EfficientNetB3: Balances depth, width, and resolution through composite scaling and neural architecture search (NAS).

The standardization of the original images to a resolution of 224x224 pixels is shown in Figure 1, ensuring the homogeneity of the input dataset.

Figure 1

Images of weevil-infested and non-infested samples during pre-training



Note. Standardized images, 224x224 pixels

To adapt images to pre-trained architectures, the resolution was standardized (Krizhevsky et al., 2012). In addition, synthetic images were generated using affine and color transformations to simulate real-world variations (illumination, orientation, perspective).

Training was conducted in two phases: first, transfer learning using ImageNet weights and frozen convolutional layers; second, fine-tuning by unfreezing the deep layers with a low learning rate to adapt the model to the Andean weevil domain.

Training used batches of 32, up to 100 epochs with early stopping (patience 20 on val_accuracy), the Adam optimizer, and cross-entropy loss. Regularization was applied with adaptive learning rate reduction (factor 0.5, patience 10), checkpointing of the best model by val_accuracy, and real-time data augmentation.

The evaluation of the architectures was performed using standard metrics: accuracy, precision, recall, and F1-score. The confusion matrix and two metrics based on AUC-ROC and AUC-PR curves were also included.

To identify the architectures, a one-way analysis of variance (ANOVA) was used, followed by Tukey's HSD post-hoc test to identify significant differences between specific pairs.

All experiments were run on Google Colaboratory Pro using a Tesla V100 GPU with 16GB of VRAM. The total estimated training time for the three architectures was 3–4 hours.

3. RESULTS AND DISCUSSION

3.1 Results

Performance Evaluation of CNN Architectures

In the comparative evaluation, DenseNet-121 and VGG-16 achieved the best results: 99% accuracy, 100% precision, 98% sensitivity, a 99% F1-score, and a perfect AUC-ROC of 1.00. In contrast, EfficientNet-B3 achieved only 49% accuracy, while ResNet-50, although it had 51% accuracy, scored 0% on precision, sensitivity, and F1-score, indicating a complete failure on one of the classes. In terms of training time, VGG-16 was the slowest (14,418 s), followed by DenseNet-121 (6,179 s), ResNet-50 (5,823 s), and EfficientNet-B3 (5,256 s), which was the fastest.

Table 1

Performance results for CNN architectures

Architecture	Accuracy	Precision	Recall	F1-Score	AUC-ROC	Training time (s)
EfficientNet-B3	0.4902	0.4900	1.0000	0.6580	0.695	5256.424
ResNet-50	0.5100	0.0000	0.0000	0.0000	0.745	5823.145
DenseNet-121	0.9900	1.0000	0.9800	0.9900	1.00	6178.620
VGG-16	0.9900	1.0000	0.9800	0.9900	1.00	14417.911

Note. Results generated using Python 3.12 and the TensorFlow, Keras, and scikit-learn libraries

Analysis of the Training and Generalization Process

The learning curves exhibited distinct patterns. DenseNet-121 (Figure 2) and VGG-16 (Figure 3) showed convergent and stable curves, with decreasing loss and increasing accuracy, and no signs of overfitting. In contrast, EfficientNet-B3 and ResNet-50 exhibited more volatile validation curves and significantly lower final performance. The comparative ROC curve (Figure 4) visually confirmed the superiority of DenseNet-121 and VGG-16 (curves clustered in the upper-left corner), while EfficientNet-B3 and ResNet-50 exhibited curves close to the baseline.

Figure 2

Learning curves - DenseNet-121

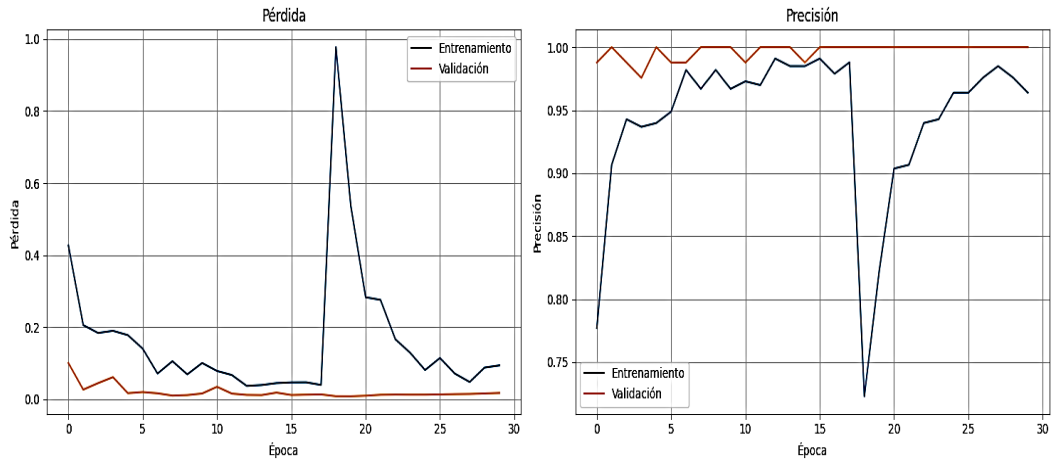


Figure 3

Learning curves - VGG-16

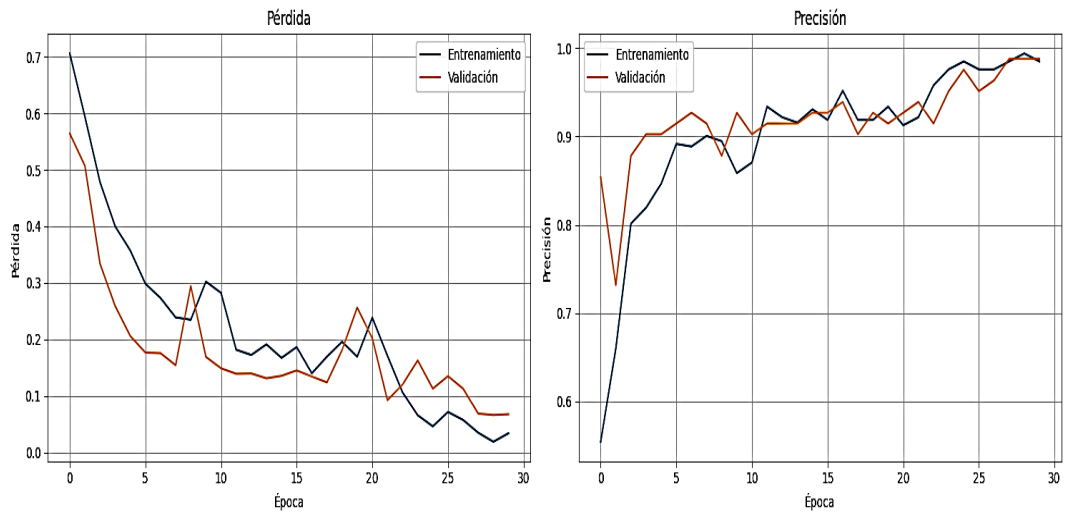
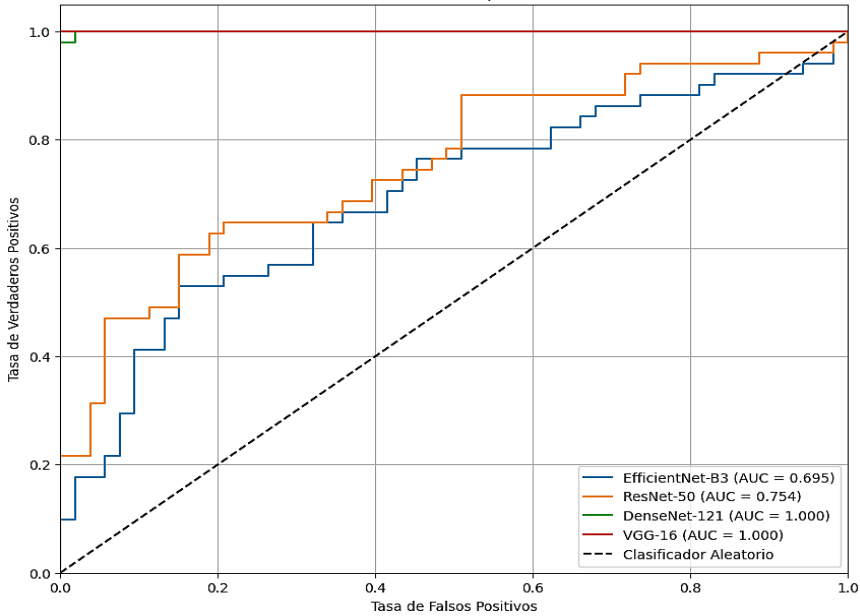


Figure 4*Comparative ROC curves***Error and Performance Analysis by Class**

Confusion matrices provide a detailed analysis of correct and incorrect predictions. The confusion matrices for DenseNet-121 and VGG-16 are nearly perfect (Table 2), with a minimum number of false negatives and false positives. In contrast, the EfficientNet-B3 confusion matrix reveals that the model misclassified most images in one class as belonging to the other, which explains its 49% accuracy. The ResNet-50 confusion matrix shows that it completely failed to predict one of the classes, assigning all instances to the opposite class.

Table 2*Confusion matrices of the CNN architectures*

Architecture	VP	FN	VN	FP
EfficientNet-B3	0	0	51	53
ResNet-50	53	51	0	0
DenseNet-121	53	1	50	0
VGG-16	53	1	50	0

Note. TP = True positives, FN = False negatives, TN = True negatives, FP = False positives. Data obtained from the test set after training with Python 3.12 and the scikit-learn library.

Statistical analysis

The ANOVA confirmed statistically significant differences among the four architectures ($F = 9742.32$, $p < .001$). The Tukey HSD post-hoc test revealed that there is no significant difference between DenseNet-121 and VGG-16 ($p = 1.00$), but both are significantly superior to EfficientNet-B3 and ResNet-50 ($p < .001$).

Table 3

Analysis of variance for comparing architectures

ANOVA:
F-statistic: 9742.3247
p-value: 0.0000

Note. One-way ANOVA ($\alpha = 0.05$). Values calculated using `scipy.stats.f\_oneway` based on the accuracy values in Table 1.

Table 4

Multiple comparison of means-Tukey HSD

Group 1	Group 2	Mean diff.	p-adj	lower	upper	Rejection
DenseNet-121	EfficientNet-B3	-0.5014	0.00	-0.5123	-0.4905	Verdad
DenseNet-121	ResNet-50	-0.4781	0.00	-0.4890	-0.4672	Verdad
DenseNet-121	VGG-16	-0.0002	1.00	-0.0111	0.0107	Falso
EfficientNet-B3	ResNet-50	0.0233	0.00	0.0124	0.0342	Verdad
EfficientNet-B3	VGG-16	0.5012	0.00	0.4903	0.5121	Verdad
ResNet-50	VGG-16	0.4779	0.00	0.4670	0.4888	Verdad

Note. Tukey HSD post hoc test ($\alpha = 0.05$). Mean diff = difference in means (accuracy). adj. p-value = adjusted p-value. Reject = True if adj. p-value < 0.05 . Calculations performed using Python/statsmodels.

3.2 Discussion

The results demonstrate that DenseNet-121 and VGG-16 achieve exceptional performance (99% accuracy, 99% F1 score, and 1.00 AUC-ROC) in classifying the Andean weevil. This success is attributed, in DenseNet-121, to its dense connections, which improve gradient flow and feature reuse (Huang et al., 2017); and in VGG-16, to its deep and uniform design, enhanced by transfer learning and regularization (Simonyan & Zisserman, 2014).

Conversely, EfficientNet-B3 (49% accuracy) and ResNet-50 (0% accuracy in one class) performed poorly and unexpectedly, contrasting with previous studies (Mishra et al., 2023; Chauhan, 2025). Probable causes include a suboptimal hyperparameter configuration, convergence problems, or poor adaptation of its residual blocks to the specific characteristics of the Andean weevil.

The stability of the learning curves for DenseNet-121 and VGG-16 demonstrates excellent generalizability, achieved through data augmentation, two-phase transfer learning, and regularization (Dropout, L2). This approach is crucial in agricultural domains with a scarcity of labeled data, consistent with the findings of Yun et al. (2024).

Statistical analysis (ANOVA and Tukey HSD) confirms that there are no significant differences between DenseNet-121 and VGG-16 ($p = 1.00$), but both clearly outperform EfficientNet-B3 and ResNet-50 ($p < 0.001$). This provides flexibility in choosing between computational efficiency (DenseNet-121, 6179 s) or architectural simplicity (VGG-16).

These findings align with previous Peruvian studies (Avalos et al., 2021; Huarote et al., 2023) that achieved over 99% accuracy in detecting potato pests. Ultimately, it is concluded that the most modern architecture is not always the best; in niche applications like this, proven effectiveness based on real-world data and a robust methodology are more valuable than technological innovation.

4. CONCLUSIONS

- DenseNet-121 and VGG-16 are the best architectures, with statistically similar performance ($p = 1.00$), 99% accuracy, a 99% F1-score, and an AUC-ROC of 1.00, allowing a choice between computational efficiency (DenseNet-121) or architectural simplicity (VGG-16). In contrast, EfficientNet-B3 (49% accuracy) and ResNet-50 (0% accuracy on one class) are not viable for this task.
- The implemented methodology (data augmentation, two-phase transfer learning, and regularization) proved effective for building robust classifiers from an initial limited dataset of 410 images, thereby fulfilling the objective of developing an optimized model.
- In niche applications such as Andean weevil classification, proven effectiveness with real-world data and a well-designed methodology are more valuable than the mere novelty of the architecture.

5. ACKNOWLEDGMENTS

I would like to express my sincere gratitude to the National University of the Altiplano (UNAP) for its institutional support, and to the university's Language Center, as well as its instructor, for reviewing and editing the manuscript. I also thank the Entomology Laboratory at UNSAAC for providing the images, and especially the entomologists and technicians who participated in the collection, identification, and validation of the Andean weevil specimens.

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LSTM-TRANSFORMER HYBRID MODELS FOR FORECASTING VISITOR NUMBERS AT THE HISTORIC SITE OF MACHU PICCHU

Walter Chunga Lovon

walter.chunga@unsaac.edu.pe

ORCID: 0000-0003-1355-3774

National University of the Altiplano - Puno



ABSTRACT

The Historic Sanctuary of Machu Picchu faces growing tourist pressure that threatens the heritage and environmental sustainability of the destination, highlighting the limitations of traditional approaches in predicting scenarios of high tourist variability. In this context, the objective of this study was to evaluate the predictive performance of hybrid LSTM-Transformer models applied to monthly visitor forecasts for the period 2010 to 2024. The research was conducted using a quantitative approach with a predictive scope and a non-experimental longitudinal design, utilizing a time series consisting of 180 monthly observations drawn from official records of the Peruvian tourism sector. To this end, bidirectional LSTM, adapted Transformer, and hybrid sequential LSTM-Transformer architectures were implemented, incorporating temporal cross-validation and inferential tests to compare the predictive accuracy of the evaluated models. The results revealed statistically significant differences among the analyzed architectures. The hybrid LSTM-Transformer model achieved the best predictive performance, recording an MAPE of 6.9%, an RMSE of 6.845, and a coefficient of determination R^2 of 0.927, consistently outperforming the individual architectures and the ARIMA model used as a benchmark. Furthermore, the temporal attention analysis identified seasonal patterns associated with 6- and 12-month lags. It is concluded that the hybrid model constitutes a robust tool for strengthening sustainable planning and carrying capacity management in heritage destinations with high tourist demand.

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1. INTRODUCTION

The Historic Sanctuary of Machu Picchu, designated a UNESCO World Heritage Site in 1983, is currently facing growing tourist pressure that threatens both the conservation of its archaeological heritage and the environmental sustainability of the surrounding Andean ecosystem. Between 2010 and 2024, visitor numbers recorded a cumulative increase of 115.5%, repeatedly exceeding the official operational capacity set at 5,040 visitors per day (UNESCO, 1983; UNWTO, 2023). This trend has intensified the risks associated with the physical deterioration of the monument, infrastructure overload, and the disruption of local ecosystems, highlighting the need to implement advanced predictive tools to strengthen the sustainable planning and management of the tourist destination.

In this context, the research problem lies in the persistent mismatch between growing tourism demand and limited institutional management capacity at Machu Picchu, where traditional time-series forecasting approaches, such as ARIMA and SARIMA, have shown significant limitations in modeling nonlinear behavior, multiple seasonality, and structural breaks caused by extreme events such as the COVID-19 pandemic (Wu et al., 2021). Recent research has shown that Long Short-Term Memory (LSTM) networks improve predictive accuracy by 23% to 30% compared to conventional statistical models; however, they face limitations in capturing long-range temporal dependencies and abrupt variations in highly dynamic time series (Hochreiter & Schmidhuber, 1997). For their part, Transformer architectures based on attention mechanisms have achieved MAPE reductions of between 18% and 22% compared to LSTM models, due to their ability to identify complex temporal relationships and global patterns in large data sequences (Vaswani et al., 2017; Yi et al., 2021). However, the available scientific evidence suggests that none of these architectures, when evaluated in isolation, is fully effective at addressing tourism time series characterized by high seasonality, structural volatility, and sudden crisis scenarios.

The scientific and practical significance of this research lies in the need to provide heritage managers with a predictive model that is robust, interpretable, and adaptable to uncertain contexts. Having a tool capable of forecasting tourist flows three to six months in advance would allow for the optimization of visitor capacity management strategies, the implementation of smart reservation systems, and the design of differentiated regulatory policies based on seasonal demand, thereby contributing to the sustainable conservation of Machu Picchu and establishing a methodological framework that can be applied to other UNESCO-recognized heritage sites.

Accordingly, this study aims to determine the extent to which a hybrid LSTM-Transformer sequential model statistically outperforms bidirectional LSTM architectures, an adapted Transformer, and the SARIMA model in predicting

monthly visitor numbers to the Historic Sanctuary of Machu Picchu, both under normal conditions and in critical scenarios associated with COVID-19. The overall objective is to evaluate the predictive performance of hybrid LSTM-Transformer models applied to tourism time series for the period between 2010 and 2024. The study designed, trained, and validated three deep learning architectures –bidirectional LSTM, adapted Transformer, and hybrid sequential LSTM-Transformer– comparing their predictive accuracy using RMSE, MAE, MAPE, and R^2 under temporal cross-validation with an expanding window to ensure the robustness of the estimates against structural disturbances. Additionally, the underlying temporal dependencies were characterized by interpreting the attention weights, and the predictive superiority of the hybrid model was statistically verified using the Diebold-Mariano, paired Wilcoxon, and Friedman tests.

Finally, the research hypothesis posits that the LSTM-Transformer hybrid model will achieve significantly superior predictive performance compared to individual architectures and the SARIMA model, yielding an RMSE of less than 7.5% under normal conditions and less than 10% during periods of crisis, with statistically significant differences ($p < 0.01$), thus validating its potential as a strategic tool for the predictive and sustainable management of heritage destinations with high tourist demand (Diebold & Mariano, 1995; Hochreiter & Schmidhuber, 1997).

2. METHODS

The research was conducted in the city of Cusco at the facilities of the Department of Mathematics at the National University of San Antonio Abad, and focused on the Historic Sanctuary of Machu Picchu, located in the district of Machu Picchu, province of Urubamba, department of Cusco, Peru. The sanctuary's geographic coordinates are 13°9'47"S, 72°32'44" W, at an elevation of 2,430 meters above sea level.

The study population consisted of all visitors officially registered at the Machu Picchu Historic Sanctuary during the period from January 2010 to December 2024. The data were provided by the Peruvian Ministry of Culture and the Cusco Regional Office of Culture. This population was divided into two categories: domestic visitors (Peruvians) and foreign visitors (non-Peruvians).

The analysis was based on a sample of $n = 180$ monthly records, covering the period from January 2010 to December 2024. This sample included three key time periods: the pre-pandemic period (2010–2019), the impact of COVID-19 (2020–2021), and the post-pandemic recovery phase (2022–2024).

All data processing and modeling was implemented entirely in Python 3.10. TensorFlow 2.13 with Keras was used as the primary framework for building and training the LSTM, Transformer, and hybrid models. Data processing was performed

using NumPy 1.24 and Pandas 2.0, while preprocessing—including Min-Max scaling, cyclic encoding, and temporal division—was carried out using Scikit-learn 1.3. Temporal cross-validation was implemented manually using Scikit-learn, and statistical tests (Diebold-Mariano, Wilcoxon, Ljung-Box, Shapiro-Wilk, Friedman) were run using SciPy and statsmodels. The hardware used was an Intel Core i7-12700H with an NVIDIA RTX 3060 GPU (6GB VRAM) and 16GB of RAM.

The preprocessing included nine sequential steps: seasonal imputation of missing values, logarithmic transformation $Y=\log(X+1)$, seasonal differencing with a lag of order 12, and Min-Max normalization to the range [0, 1]. Feature engineering incorporated cyclic encoding of the month using sine and cosine functions, high- and low-season dummy variables, and time lags of order 1, 6, and 12. The chronological partition strictly followed the time order, assigning the data to the training set for the 2010–2022 period with 156 observations, to the validation set for the year 2023 with 12 observations, and to the test set for the year 2024 with 12 observations. Three deep learning architectures were implemented: a bidirectional LSTM model, an adapted Transformer, and a hybrid sequential LSTM-Transformer model. Evaluation was performed using temporal cross-validation with an expansive window of five partitions corresponding to the years 2017, 2018, 2019, the critical period 2020–2021, and the recovery period 2022–2024. Predictive performance was quantified using standard error metrics such as RMSE, MAE, MAPE, and R^2 , supplemented with multiple comparison inference tests, including the Diebold-Mariano, Wilcoxon, and Friedman tests.

The study followed a quantitative methodological design of a comparative-predictive nature. Three deep learning architectures were implemented; their main characteristics and key hyperparameters are presented in Table 2. The first architecture was a bidirectional LSTM consisting of 2 layers with 64 and 32 units, respectively, 20% dropout to prevent overfitting, a 12-month lookback, a learning rate of 0.001, a batch size of 32, and early stopping with a patience of 50. The second was an adapted Transformer, configured with 4 attention heads, 3 encoder layers, a representation size of $d_{\text{model}}=128$, 10% dropout, sinusoidal positional encoding, and masked causal attention. The third was a hybrid sequential LSTM-Transformer model, arranged in a cascade where the output of the LSTM layer directly feeds the input of the Transformer, combining dropouts of 20% (LSTM) and 10% (Transformer). Table 1 summarizes these configurations.

Table 1*Implemented Model Architectures*

Model	Main Characteristics	Key Hyperparameters
Bidirectional LSTM	2 LSTM layers (64 and 32 units), 20% dropout, 12-month lookback	LR = 0.001, batch size = 32, early stopping patience = 50
Adapted Transformer	4 attention heads, 3 encoder layers, d_model = 128, 10% dropout	Sinusoidal positional encoding, masked causal attention
Sequential Hybrid LSTM-Transformer	Cascade architecture: LSTM output → Transformer input	20% dropout (LSTM) + 10% dropout (Transformer)

Note. This analysis is based on Hochreiter and Schmidhuber (1997), Vaswani et al. (2017), and Lim et al. (2019).

To ensure robustness and prevent the leakage of future information, strict temporal cross-validation was implemented using a 5-fold expanding window. Each fold used all data prior to a specific test year for training. The folds were distributed as follows: Fold 1 trained on 2010–2016 and tested on 2017; Fold 2 trained on 2010–2017 and tested on 2018; Fold 3 trained on 2010–2018 and tested on 2019; Fold 4 used 2010–2019 for training and tested on 2020–2021 (the COVID-19 period); and Fold 5 used 2010–2021 for training and tested on 2022–2024. This design allowed us to evaluate the models’ performance under both normal conditions and during the health crisis.

Four error and goodness-of-fit metrics were used to evaluate and compare the models: RMSE (root mean square error), MAE (mean absolute error), MAPE (mean absolute percentage error), and R^2 (coefficient of determination). Differences between models were evaluated using three statistical significance tests: Diebold-Mariano to compare predictive accuracy between two models, the paired Wilcoxon test to compare error medians, and Friedman to determine whether all models have the same performance ranking. Additionally, diagnostic tests were applied to the residuals of the optimal model: the Ljung-Box test to verify the absence of autocorrelation, the Shapiro-Wilk test to check for normality, and the ADF test to confirm the stationarity of the residuals. Table 2 summarizes each test, its null hypothesis, and the decision criterion adopted, following the thresholds established in the reference literature (Diebold & Mariano, 1995; Wilcoxon, 1945; Friedman, 1937; Ljung & Box, 1978; Shapiro & Wilk, 1965).

Table 2*Applied Statistical Significance Tests*

Test	Null Hypothesis (H_0)	Decision Criterion
Diebold–Mariano	Equal predictive accuracy between two models	$DM < -1.96$ or $r > 1.96$ ($p < 0.05$)
Paired Wilcoxon	Equal error medians	Small W value with $p < 0.05$
Friedman	All models have the same ranking	$\chi^2 > \text{critical value}$ ($p < 0.05$)
Ljung–Box	Residuals are free of autocorrelation	$p > 0.05$
Shapiro–Wilk	Residuals follow a normal distribution	$p > 0.05$
ADF	Residuals contain a unit root (non-stationary)	$p < 0.05$

Note. Prepared by the authors based on Francis X. Diebold and Roberto S. Mariano (1995), Frank Wilcoxon (1945), Milton Friedman (1937), Greta M. Ljung and George E. P. Box (1978), Samuel Sanford Shapiro and Martin Wilk (1965), and David Dickey and Wayne Fuller (1979).

3. RESULTS AND DISCUSSION**3.1 Results**

The results showed consistent superiority of the LSTM-Transformer hybrid model compared to the individual architectures and the ARIMA model used as a reference. The hybrid model achieved the lowest predictive error (MAPE = 6.9%; RMSE = 6.845) and the highest coefficient of determination ($R^2 = 0.927$), outperforming the bidirectional LSTM (MAPE = 8.7%; RMSE = 8.457; $R^2 = 0.891$), the adapted Transformer (MAPE = 8.2%; RMSE = 7.891; $R^2 = 0.903$), and the ARIMA model (MAPE = 12.4%; RMSE = 11.234; $R^2 = 0.821$).

Table 3*Predictive Performance of the Evaluated Models*

Model	MAPE (%)	RMSE	R^2
ARIMA	12.4	11.234	0.821
Bidirectional LSTM	8.7	8.457	0.891
Adapted Transformer	8.2	7.891	0.903
Hybrid LSTM-Transformer	6.9	6.845	0.927

Note. Prepared using data from the Peruvian Ministry of Culture—MINCETUR (2024). ARIMA baseline according to Box et al. (2015).

The Temporal cross-validation with an expanding five-fold window showed that the hybrid model maintained an average MAPE of 7.00% (SD = 0.19%) under normal

conditions. During the critical period associated with the COVID-19 pandemic (Fold 4: 2020–2021), the hybrid model achieved a MAPE of 9.3%, while the bidirectional LSTM reached a MAPE of 11.8% and the adapted Transformer 11.2%. In the recovery period of 2022–2024 (Fold 5), the hybrid model achieved a MAPE of 6.8%, maintaining the greatest inter-fold stability (MAPE range: 6.5%–9.3%) compared to the individual architectures (ranges: LSTM 8.1%–11.8%; Transformer 7.9%–11.2%).

The temporal attention analysis applied to the hybrid model identified that 12-month delays had the greatest predictive importance (weight = 0.34), followed by the monthly seasonal index (weight = 0.28) and 6-month delays (weight = 0.22). Delays of 1 month and 3 months had weights lower than 0.10.

From an inferential standpoint, the significance tests yielded the following results:

Diebold-Mariano: Hybrid vs. LSTM comparison: MD = -3.47 ($p < 0.001$); Hybrid vs. Transformer: MD = -2.81 ($p < 0.01$); Hybrid vs. ARIMA: MD = -4.56 ($p < 0.001$).

Paired Wilcoxon: significant differences between the hybrid model and each of the other models ($p < 0.01$ in all cases).

Friedman: $\chi^2(2) = 15.43$ ($p < 0.001$), with an average ranking of 1.00 for the hybrid model, 2.00 for the Transformer model, and 3.00 for the LSTM model.

The diagnoses on the residuals of the hybrid model confirmed: absence of autocorrelation (Ljung-Box: $p = 0.82$), normality (Shapiro-Wilk: $p = 0.34$) and stationarity (ADF: $p < 0.001$).

3.2 Discussion

The findings demonstrate that the cascaded integration of sequential memory mechanisms (LSTM) and global temporal attention (Transformer) allowed for a more accurate modeling of the nonlinear and seasonal dynamics of tourist flow at Machu Picchu. This superiority of the hybrid model coincides with the findings reported by Hochreiter and Schmidhuber (1997) and Vaswani et al. (2017), who respectively highlighted the capacity of LSTMs to retain long-term temporal dependencies and the capacity of Transformers to capture global relationships through attention. Furthermore, the results support the proposal by Lim et al. (2019) regarding the advantages of hybrid architectures in series with multiple seasonalities.

The greater predictive robustness of the hybrid model during the COVID-19 period (MAPE = 9.3% vs. $>11\%$ in individual models) confirms the findings of Wu et al. (2021) and Yi et al. (2021), who argue that hybrid models exhibit greater adaptive capacity in tourism contexts affected by extreme events. The lower inter-fold

variability observed in the hybrid model demonstrates superior structural stability in the face of external disturbances, a critical aspect for heritage management in crisis scenarios.

The identified pattern of temporal attention—dominated by annual (34%) and semi-annual (22%) lags—confirms the presence of strong seasonal cycles in tourism demand for Machu Picchu, coinciding with the findings of Zheng and Zhang (2023), who demonstrated that hybrid attention-based architectures allow for the detection of complex temporal relationships that conventional statistical approaches fail to identify. This finding is also consistent with the results of Lu et al. (2020), who reported similar seasonal patterns in tourist flows to Asian heritage sites.

The inferential tests (Diebold-Mariano, Wilcoxon, and Friedman) confirmed statistically significant differences between the evaluated architectures, validating the proposed hypothesis. The perfect average ranking (1.00) assigned by the Friedman test to the hybrid model reinforces the consistency of its predictive superiority, supporting the methodological approach proposed by Diebold and Mariano (1995) for the rigorous comparison of predictive accuracy in time series.

Taken together, these findings demonstrate that the LSTM-Transformer hybrid model is a robust, interpretable, and statistically validated tool for strengthening sustainable planning and anticipating tourism saturation scenarios in high-demand heritage destinations such as the Historic Sanctuary of Machu Picchu. The interpretability derived from the attention weights provides heritage managers with objective evidence for designing seasonally differentiated regulatory policies, while the methodological framework is transferable to other UNESCO sites facing similar carrying capacity management challenges.

4. Conclusions

- The sequential LSTM-Transformer hybrid model proved to be the highest-performing predictive architecture for estimating monthly visitors to the Historic Sanctuary of Machu Picchu during the period 2010–2024, achieving a MAPE of 6.9%, an RMSE of 6.845, and an R^2 of 0.927. These values significantly outperform the bidirectional LSTM (MAPE = 8.7%), the adapted Transformer (MAPE = 8.2%), and the reference ARIMA model (MAPE = 12.4%), demonstrating that the cascaded integration of sequential memory and global temporal attention mechanisms synergistically enhances modeling capacity for highly seasonal and nonlinear tourism series.
- Temporal cross-validation with an expanding five-fold window confirmed the robustness of the hybrid model under both normal conditions (average MAPE = 7.00%; SD = 0.19%) and under the severe structural disturbance of the COVID-19 pandemic, during which it maintained a MAPE of 9.3% compared to errors

exceeding 11% recorded by the individual architectures. Residual diagnostics corroborated the statistical validity of the model, confirming the absence of autocorrelation [Ljung-Box: $p = 0.82$], normality [Shapiro-Wilk: $p = 0.34$], and stationarity [ADF: $p < 0.001$].

- The analysis of the temporal attention weights identified the 12-month lag (weight = 0.34) and the monthly seasonal index (weight = 0.28) as the structural factors with the greatest predictive influence, followed by the 6-month semi-annual lag (weight = 0.22), confirming the existence of annual and semi-annual cycles as dominant determinants of tourist demand in Machu Picchu. This interpretability component provides heritage managers with objective evidence to anticipate saturation scenarios and design differentiated regulatory policies for each season.
- Finally, the Diebold-Mariano tests [DM = -3.47, $p < 0.001$ vs. LSTM; DM = -2.81, $p < 0.01$ vs. Transformers], paired Wilcoxon [$p < 0.01$] and Friedman [$\chi^2(2) = 15.43$, $p < 0.001$], with a perfect average ranking of 1.00 for the hybrid model, statistically validated its predictive superiority and consolidated its potential as a rigorous, replicable and transferable methodological framework to other UNESCO heritage sites facing similar sustainable management and carrying capacity challenges.

5. ACKNOWLEDGMENTS

I express my special gratitude to the English course professor for her motivation and valuable academic support throughout the development of this research. I also thank the faculty of the National University of the Altiplano for their methodological guidance, academic training, and scientific contributions, which significantly contributed to the completion of this study.

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CRIMES AGAINST PUBLIC ADMINISTRATION AND THEIR IMPACT ON THE MANAGEMENT OF THE PROVINCIAL GOVERNMENTS IN THE NORTHERN ZONE OF THE PUNO REGION

Richard Edilberto Díaz Laura

richarddiazabogados@gmail.com

ORCID: <https://orcid.org/0009-0005-4921-2279>

National University of the Altiplano - Puno



ABSTRACT

This study analyzes the impact of crimes against public administration on the management of the provincial governments in the northern zone of the Puno region during the 2023–2024 period. The objective was to determine the degree of impact of the crimes of nepotism and collusion on the public management of provincial mayors. The research adopted a quantitative approach, descriptive in nature, with a non-experimental and cross-sectional design. The study focused on the statistical report of the Attorney General's Office regarding corruption by officials of the provincial municipalities in the northern zone of Puno: Azángaro, Carabaya, Huancané, Lampa, Melgar, Moho, San Antonio de Putina, San Román, and Sandía. The data collection technique for the first variable was documentary analysis and for the second, a survey-type questionnaire directed at the population of the aforementioned provinces. Data processing was carried out using EViews 12.0 software, and simple linear regression was used to test the hypothesis. The results show that crimes against public administration have a negative impact of 6.7% on the management of provincial governments, reflecting a significant, although moderate, effect on institutional performance. It is concluded that these illicit practices deteriorate the quality of public management and limit institutional development, making it necessary to implement control, prevention, and ethical strengthening measures in public administration.

Keywords: collusion, corruption, public crimes, management, nepotism.

1. INTRODUCTION

Public administration constitutes the set of processes, regulations, and actions aimed at ensuring the functioning of the State and the satisfaction of collective needs. In this sense, the management of provincial governments represents a strategic level within the decentralization process, as it has the direct responsibility of implementing public policies, managing resources, and promoting territorial development. Its importance lies in the fact that it is the level of government closest to citizens, so its efficiency directly impacts the quality of life of the population (Montoya, 2018). However, this management is affected by the presence of crimes against public administration, particularly nepotism and collusion, which constitute specific forms of corruption that distort institutional functioning (Office of the Comptroller General of the Republic, 2023).

On the other hand, nepotism involves the undue favoritism of relatives or close associates in the hiring or appointment of public positions, violating fundamental principles such as meritocracy, equal opportunities, and transparency. This crime weakens the technical capacity of institutions, as it prioritizes personal relationships over professional competencies, generating administrative inefficiency (Ochoa, 2014). Likewise, collusion occurs when a public official conspires with third parties in contracting processes to obtain undue benefits, harming the State. This crime has a direct impact on the execution of works and services, generating cost overruns, poor project quality, and loss of public resources (Ramos, 2019).

Furthermore, in the management of provincial governments, these conditions often arise due to institutional weaknesses, which facilitate the emergence of illicit practices. These not only affect legality, but also directly impact the efficiency, legitimacy, and outcomes of public management, compromising local development. The crimes under study have a negative impact that hinders the efficient development of public administration (Huaynates, 2017).

From a theoretical perspective, the relationship between both variables can be explained through Klitgaard's theory of corruption, which establishes that corruption arises when there is monopoly of power, discretion, and absence of accountability.

At the international level, studies highlight that corruption limits the implementation of public policies due to factors such as institutional resistance, lack of capacities, and weak citizen participation. These approaches emphasize the need for modernization of the State and strengthening of governance. At the national level, research shows that crimes such as collusion and embezzlement directly affect the performance of municipalities, generating economic losses and deficiencies in project execution. Likewise, it has been identified that current sanctions are not always effective in deterring these crimes. In Puno Region – Northern Zone,

previous studies show a more critical reality, where corruption occurs recurrently and has direct impacts on regional development. It is highlighted that control mechanisms are insufficient and that there is a permissive institutional culture toward these practices. Provincial governments face limitations in transparency, control, and efficiency, which are aggravated by the presence of crimes such as nepotism and collusion. These crimes generate a negative impact on public management, manifested in low levels of budget execution, unfinished projects, deficient services, and loss of citizen trust. In addition, they cause institutional instability, since judicial proceedings against authorities imply changes in the leadership of entities, affecting the continuity of public policies.

Previous studies on this topic emphasize structural and governance solutions, while national and local studies reveal concrete management and control problems, which reinforces the need for specific studies such as the present one, focused on particular contexts such as the Puno region. The purpose of this research is to generate knowledge that allows for understanding the impact of crimes against public administration on the management of provincial governments. This will make it possible to:

- Identify how these practices affect the efficiency and outcomes of public management.
- Provide relevant information to strengthen control and oversight mechanisms.
- Contribute to the design of public policies aimed at transparency and the fight against corruption.
- Promote a culture of ethics and integrity in public administration.

For all the reasons mentioned above, the purpose of this research was to determine the impact of crimes against public administration on the management of the provincial governments in the northern zone of the Puno region, since corruption-related crimes negatively affect the management of governments.

2. METHODS

The research was carried out in Puno department, specifically in the provinces of the northern zone of the region, considering their strategic geographical location and their interaction with other regions of the country and with the Plurinational State of Bolivia. The study population consisted of all provincial municipalities in that area, including Azángaro, Carabaya, Huancané, Lampa, Melgar, Moho, San Antonio de Putina, San Román, and Sandia. No sampling was applied, as the total population was used, with the purpose of reducing bias and obtaining results that were more representative of reality.

To fulfill the objectives, econometric models based on Simple Linear Regression (SLR) were proposed, where the dependent variable was the management of provincial governments (MPG), and the independent variables included crimes against public administration (CAPA), the crime of nepotism (CN), and the crime of collusion (CC). These models made it possible to measure the impact of each type of crime on public management. The information was previously coded and organized into data matrices, facilitating its statistical analysis.

Regarding data collection techniques, documentary analysis was used through the review of secondary sources, mainly reports issued by the Office of the Comptroller General of the Republic. The documentary analysis sheet was used as an instrument, which made it possible to systematize the relevant information for the study. Data processing was carried out using tools such as Microsoft Excel for tabulation and the STATA statistical software for econometric estimation, which is suitable for cross-sectional data analysis.

Finally, various materials and resources were used, such as computer equipment, internet connection, and office supplies, which facilitated the development of the research. The application of simple linear regression made it possible to understand the relationship between the variables, evaluate the degree of impact of crimes on public management, and generate useful evidence for decision-making in the field of public administration.

Table 1

Impact of the Crime of Nepotism on the Management of Provincial Governments.

Source	SS	df	MS	N° Observations	46
Model	.939130435	1	.939130435	F (1,140)	4.70
				Prob > F	0.0271
Residual	8.8	44	.2	R-squared	0.0813
				Adj R-Squared	0.0759
Total	9.73913043	45	.216425121	Root MSE	.44721
Management of Provincial Governments	Coefficient	Standard Error	T	P> t 	[95% Confidence Interval]
Crimes of Nepotism	-.054	.1384437	-2.17	0.015	-.579015 -.020985
Constant	1.1	.1979057	5.56	0.000	.7011473 1.498853

Note: Data obtained from Stata 18.5 software.

Table 2**Impact of the Crime of Collusion on the Management of Provincial Governments.**

Source	SS	df	MS	N° observaciones	46
Model	.939130435	1	.939130435	F (1,140) Prob > F	4.70 0.0157
Residual	8.8	44	.2	R-squared Adj R-Squared	0.0664 0.0759
Total	9.73913043	45	.216425121	Root MSE	.44721
Management of Provincial Governments	Coefficien	Standard Error	T	P> t 	[95% Confidence Interval]
Crimes of Nepotism	-.08	.1384437	-2.17	0.012	-.579015 -.020985
Constant	1.1	.1979057	5.56	0.000	.7011473 1.498853

Note: Data obtained from Stata 18.5 software.

3. RESULTS AND DISCUSSION**3.1. Results**

The descriptive analysis of control reports related to the crimes of nepotism and collusion in the municipalities of the northern zone of the Puno region during the years 2023 and 2024 reveals the existence of multiple irregularities that directly affect the proper functioning of public administration. In the case of nepotism, various situations were identified in which municipal authorities and officials favored the hiring of relatives in different degrees of consanguinity and affinity. These acts were mainly recorded in municipalities such as Azángaro, San José, Ollachea, Quilcapuncu, Vilquechico, Samán, and San Román, showing a recurring pattern of violation of the principles of meritocracy, equal opportunities, and transparency in access to public service.

In particular, the reports show that nepotism occurs through the direct or indirect hiring of relatives of mayors, council members, and officials, including first, second, third, and even fourth degrees of consanguinity. These practices not only violate current regulations, but also affect institutional efficiency by allowing the entry of personnel who do not necessarily meet the required profiles. Likewise, it is observed that in some cases these hires are carried out within the framework of specific programs or execution agreements, which aggravates the situation by compromising public resources allocated to development projects.

On the other hand, the analysis of collusion-related crimes reveals irregularities in public procurement processes, including works, services, and the acquisition of goods. Cases were identified in which selection committees favored certain bidders, even when they did not meet the established requirements, or when there were more favorable offers for the entity. The hiring of companies prohibited from contracting with the State was also identified, as well as the approval of deficient services that generated economic losses. These practices reflect a clear manipulation of selection processes and a direct negative impact on the proper administration of public resources.

Likewise, irregularities were detected in the hiring of personnel under the CAS regime, where applicants who did not meet the minimum requirements for education, experience, or evaluation were declared winners. This situation highlights deficiencies in control and supervision mechanisms, as well as possible acts of undue favoritism. In other cases, improper payments were recorded, such as the granting of economic benefits without legal basis, which also causes harm to the State and weakens citizens' trust in public institutions.

Regarding the impact analysis, the statistical results show that crimes against public administration have a negative impact on the management of provincial governments. In general terms, it was determined that these crimes negatively affect management by 6.7%, which implies that the greater the presence of illicit acts, the lower the level of efficiency and fulfillment of institutional objectives. This result is statistically significant, which validates the relationship between both variables and confirms that administrative crimes constitute a determining factor in the deterioration of public management.

Specifically, the crime of nepotism presents a negative impact of 5.4% on the management of provincial governments, indicating that these practices affect the quality of public service and the proper administration of human resources. Likewise, the crime of collusion shows an even greater impact, reaching 8%, which demonstrates that irregularities in procurement processes have a more significant effect on institutional management, due to the handling of economic resources and the execution of public investment projects.

The negative coefficients obtained in the econometric models confirm that there is an inverse relationship between the occurrence of these crimes and the efficiency of public management. In addition, the statistical significance values ($p < 0.05$) indicate that the results are reliable and that the analyzed variables validly explain the behavior of the management of provincial governments, although with moderate levels of explanation, reflected in the R-squared values.

Finally, based on the findings obtained, guidelines are proposed aimed at reducing the impact of crimes in public administration. Among these, the strengthening of internal and external control mechanisms, the promotion of transparency and accountability, training in public ethics, regulatory strengthening, the implementation of technological tools, and the application of effective sanctions stand out. These measures seek to improve institutional integrity, prevent acts of corruption, and contribute to a more efficient, transparent, and citizen-oriented public management.

3.2. Discussion

The results of the linear regression model show that crimes against public administration have a negative impact of 6.7% on the management of provincial governments in the northern zone of Puno. This means that the greater the presence of irregularities or acts of corruption, the lower the efficiency, transparency, and legitimacy of public management. This finding is consistent with Zavaleta (2023), who points out that corruption weakens meritocratic culture and deteriorates institutional development, as well as with Candiotty (2023), who identifies that administrative crimes affect the proper application of regulations and public management processes. Taken together, it is confirmed that corruption not only generates economic losses, but also a crisis of institutional legitimacy and citizen distrust (Zavaleta, 2023).

Regarding nepotism, the results show a negative impact of 5.4% on public management, evidencing its presence in various provincial municipalities through the hiring of relatives in public positions, violating current regulations. This result is related to García (2018), who argues that selection processes in public administration are vulnerable to favoritism and political clientelism. Likewise, Huaynates (2017) states that nepotism reduces administrative efficiency and that current sanctions are not sufficient to eradicate it. In this sense, it is reaffirmed that nepotism directly affects meritocracy, equal opportunities, and institutional ethics.

Regarding the crime of collusion, a negative impact of 8% was identified, making it the crime with the greatest effect on the management of provincial governments. The reports of the Office of the Comptroller General reveal practices such as irregular contract awards and collusion with suppliers, which directly affects the execution of public works. This result is consistent with López (2021), who points out that collusion generates deficiencies in project execution and loss of State resources. Similarly, Marín (2022) explains that this crime involves the breach of the functional duty of public servants, who act for their own benefit or that of third parties. In addition, Pezo (2022) warns that the perception of impunity regarding these crimes aggravates their persistence in the public sector.

Likewise, the results show that the persistence of nepotism and collusion is linked to the weakness of internal control bodies and limited citizen participation, which is consistent with Silva (2024), who highlights the importance of constant audits to prevent corruption. Monserrate (2023) also points out that the lack of training and institutional resistance hinder the implementation of transparency policies, a situation reflected in the analyzed provincial governments.

Finally, it is concluded that it is necessary to strengthen control mechanisms, transparency, and public ethics in order to reduce the impact of these crimes. This aligns with Rodríguez (2015), who argues that public administration must guarantee the proper functioning of the State, and with Tuesta (2020), who highlights the importance of citizen trust in government legitimacy. Consequently, the results support the need to implement stricter control policies, greater citizen participation, and ethical training for public officials.

4. CONCLUSIONS

- The crime of nepotism has a negative impact of 5.4% on the management of provincial governments in the northern zone of the Puno region during 2023–2024, as shown in Table No. 1. It is concluded that nepotism has a negative and significant impact on provincial public management, affecting merit-based access to public service, institutional efficiency, and transparency in decision-making. Control reports demonstrate multiple cases of the hiring of relatives of mayors and council members, confirming repeated violations of Law No. 26771 and of the principles of equality and administrative integrity.
- The crime of collusion has a negative incidence of 8% on the management of the provincial governments in the northern zone of the Puno region during 2023–2024, as shown in Table No. 2. It is concluded that collusion constitutes the crime with the greatest negative incidence in local public management, since it directly compromises the proper administration of public resources, procurement processes, and the execution of municipal works. The reports of the Comptroller's Office show recurrent practices of collusion between public officials and suppliers.

5. ACKNOWLEDGMENTS

I express my sincerest gratitude to the Graduate School of the National University of the Altiplano, the language program, and the English course.

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PREVENTIVE TAX AUDIT AND REDUCTION OF TAX CONTINGENCIES IN INTERPROVINCIAL TRANSPORT COMPANIES OF MOQUEGUA

Magali Fátima Falcon Centeno

m.fatimafalcon@gmail.com.

<https://orcid.org/0009-0003-3936-8662>

National University of the Altiplano of Puno



ABSTRACT

The present research aimed to determine the influence of preventive tax auditing on the reduction of tax contingencies in interprovincial passenger transportation companies in the Moquegua region during the year 2025. The study follows a quantitative approach, correlational type, and non-experimental cross-sectional design. The population consisted of 156 formal interprovincial passenger transportation companies, from which a probabilistic sample of 50 companies was selected. For data collection, the survey technique was used and the instrument was a structured Likert-type questionnaire composed of 23 items. Data processing was carried out using IBM SPSS software version 26, employing descriptive and inferential statistics. The results showed that there is a positive and significant relationship between preventive tax auditing and the reduction of tax contingencies, obtaining a Pearson correlation coefficient of 0.971 with a two-tailed significance of 0.01. It is concluded that preventive tax auditing constitutes a fundamental tool to strengthen compliance with formal and substantial tax obligations, reducing tax risks, economic sanctions, and tax contingencies in interprovincial transport companies in the Moquegua region.

Keywords: tax auditing, tax contingencies, tax obligations, tax prevention, interprovincial transport.

1. INTRODUCTION

Preventive tax auditing constitutes a control tool aimed at proactively evaluating an organization's compliance with tax obligations, with the purpose of detecting errors, preventing tax contingencies, and strengthening the company's financial and tax management. (Callohuanca, 2020) and (Flores, 2012) tax auditing constitutes a technical and specialized examination aimed at verifying the proper compliance with the tax obligations established by the current tax regulations.

For his part, (Benavides, 2019) maintains that preventive tax auditing is a strategic tool that allows anticipating and detecting tax risks before an inspection. Likewise, (Hidalgo, 2022) states that this type of audit involves the implementation of internal control procedures focused on the ongoing analysis of formal and substantive tax obligations.

According to (SUNAT, 2022), it states that the timely compliance with tax obligations allows organizations to reduce fiscal risks and avoid sanctions resulting from regulatory non-compliance. According to (Flores, 2012), tax contingencies refer to the potential fiscal risks faced by an organization when there is non-compliance, errors, or omissions in the application of current tax regulations. Likewise, (Moreno & Ríos, 2020) point out that these risks increase due to the absence of preventive controls and tax audits, generating economic and legal impacts on business management.

The Peruvian tax environment presents constant regulatory changes that make tax compliance difficult for companies, especially in interprovincial passenger transportation. This sector carries out permanent accounting and tax operations related to receipts, declarations, and taxes. Likewise, SUNAT has strengthened its control and supervision mechanisms through technological tools. Consequently, companies without adequate tax controls face higher risks of penalties, adjustments, fines, and late payment interest. (SUNAT, 2022).

2. METHODS

The present research was carried out in the provinces of Mariscal Nieto, Ilo, and General Sánchez Cerro, jurisdictions that make up the Moquegua region, located in the southern area of Peru. The study was conducted during the year 2025, considering as the unit of analysis the formal companies dedicated to interprovincial passenger transportation registered in this region.

The research was framed within the quantitative approach, since it allowed for the objective measurement of the study variables and the statistical analysis of the relationship between preventive tax auditing and the reduction of tax contingencies. According to Hernández (2014), the quantitative approach uses the collection and

analysis of numerical data to test hypotheses and establish behavioral patterns among variables.

The research design was non-experimental and cross-sectional. (Creswell, 2014) He notes that in non-experimental designs, variables are observed and analyzed in their natural context, without the researcher intervening or deliberately manipulating the facts or study conditions.

The population consisted of 156 formal interprovincial passenger transport companies registered in the Moquegua region, distributed among the provinces of Mariscal Nieto, Ilo, and General Sánchez Cerro. Stratified probabilistic sampling was used for participant selection. This procedure allowed for proportional representativeness according to the distribution of companies by province, reducing selection biases and ensuring greater statistical accuracy.

The sample consisted of 50 formally registered and operational interprovincial transport companies during the year 2025.

The technique used was the survey, considered suitable for collecting quantifiable information on perceptions and business tax practices. A structured questionnaire was used as an instrument, consisting of 23 items formulated using a five-point Likert scale with the following response categories: always, almost always, sometimes, almost never, and never.

The questionnaire was designed considering two main variables:

Independent variable: preventive tax audit with the following dimensions:

- Compliance with formal tax obligations
- Compliance with substantive tax obligations
- Preventive tax control and review

Dependent variable: reduction of tax contingencies with the following dimensions:

- Tax risks
- Tax penalties
- Tax inspection and adjustments

The items were written in technical language and adapted to the operational context of interprovincial transport companies.

The validity of the questionnaire was carried out through expert judgment, a procedure that allowed the evaluation of relevance, clarity, and coherence of the

items in relation to the research objectives. Specialists in auditing, taxation, and research methodology participated, reviewing the instrument and making observations aimed at optimizing its content and conceptual consistency. Subsequently, the reliability test was conducted using Cronbach's Alpha coefficient with IBM SPSS version 26.

The analysis obtained a value of $\alpha = 0.90$, an indicator considered to be of high reliability. According to Hernández et al. (2014), values above 0.80 demonstrate adequate internal consistency of the instrument, confirming that the items show stability and precision to measure the proposed variables.

The development of the research was carried out through a systematic process organized in various methodological stages.

First stage: documentary review and problem delimitation

Initially, a bibliographic and documentary review related to preventive tax auditing, tax obligations, and fiscal contingencies was carried out. For this purpose, specialized books, scientific articles, theses, current tax regulations, and institutional documentation issued by SUNAT were consulted.

Second stage: design and development of the instrument

Based on the theoretical review and scientific background, a structured questionnaire of 23 items was designed.

In this phase, variables, dimensions, and indicators were defined, ensuring that each question was directly related to the research objectives and allowed obtaining measurable and verifiable information.

Subsequently, the instrument was submitted for validation by specialists and adjusted according to the observations made.

Third stage: coordination and access to companies

During this stage, the academic purpose of the research was explained and authorization was requested for the application of surveys, guaranteeing confidentiality and strictly scientific use of the information collected.

Fourth stage: survey application and fieldwork

The fieldwork was carried out during the year 2025 through scheduled visits to the selected companies. Data collection was carried out respecting ethical principles of voluntariness, anonymity, and confidentiality.

Fifth stage: coding and statistical processing

Once the information collection was completed, the questionnaires were reviewed to verify the integrity and consistency of the responses.

Subsequently, the data were coded and recorded in a statistical matrix developed in IBM SPSS version 26.

The processing included data cleaning and the creation of frequency tables and percentages through descriptive statistics.

Sixth stage: inferential analysis and hypothesis testing

To evaluate the relationship between variables, the Pearson correlation statistical test was used.

This procedure allowed determining the intensity, direction, and statistical significance of the association between preventive tax auditing and the reduction of tax contingencies.

Hypothesis testing was carried out considering significance levels of 0.01 and 0.05, allowing for statistical rigor in the interpretation of results.

Ethical considerations

The research respected ethical principles of scientific integrity, confidentiality, and informed consent. The information collected was used solely for academic purposes, ensuring the confidentiality of the identity and sensitive tax data of the companies.

3. RESULTS AND DISCUSSION

3.1. Results

The results obtained allowed for the analysis of the behavior of preventive tax audits and their relationship with the reduction of tax contingencies in interprovincial transport companies in the Moquegua region. To this end, descriptive and inferential statistics were used through IBM SPSS version 26 software, considering frequencies, percentages, and Pearson correlations.

The findings are presented based on the dimensions studied and directly respond to the general research objective.

Application of preventive tax audits

First, the frequency with which companies carry out preventive tax audits as an internal control mechanism was evaluated.

Table 1

Frequency of application of preventive tax audits by province

Province	Always	Almost always	Sometimes
Mariscal Nieto	15%	75%	10%
Ilo	12%	33%	55%
Sánchez Cerro	8%	25%	55%

Note. Survey results applied to interprovincial transport companies of Moquegua.

The results show differences in the implementation of preventive tax audits in Moquegua, highlighting Mariscal Nieto with a higher frequency of application, while Ilo and Sánchez Cerro present a more limited preventive management, increasing the risk of tax contingencies. Likewise, a high positive relationship was found between the compliance with formal tax obligations ($r=0.814$) and the reduction of contingencies, as well as a very strong relationship regarding substantial obligations ($r=0.984$), demonstrating that proper document control, correct determination, and timely payment of taxes reduce fines, penalties, and tax inspections. These findings are consistent with (Benavides, 2019), (Ríos, 2020), and (Hidalgo, 2022) who highlight preventive tax auditing as a key strategy to strengthen compliance and reduce fiscal risks.

General relationship between preventive tax auditing and reduction of tax contingencies

In order to respond to the general objective of the research, the Pearson correlation test was applied between preventive tax auditing and reduction of tax contingencies.

Table 2

Correlation between study variables.

Variables	person coefficient	significance
Formal obligations and contingencies	0.814	0.01
Substantial obligations and contingencies	0.984	0.05
Preventive audit and contingencies	0.971	0.01

Note. Results processed using IBM SPSS version 26.

The results evidenced a very strong and significant positive relationship between preventive tax auditing and the reduction of tax contingencies ($r=0.971$; $p=0.01$), demonstrating that companies with ongoing tax reviews present lower risks of penalties and non-compliance with SUNAT. These findings coincide with (Benavides, 2019), (Hidalgo, 2022), and (Moreno & Ríos, 2020). Consequently, it is

confirmed that preventive tax auditing significantly influences the reduction of tax contingencies in interprovincial transportation companies in Moquegua.

3.2. Discussion

It is confirmed that preventive tax audits have a positive and statistically significant impact on reducing tax liabilities for interprovincial transportation companies in the Moquegua region. The results obtained showed a very strong correlation ($r=0.971$), demonstrating that companies that implement preventive tax controls face a lower risk of penalties, objections, and tax observations. These findings are consistent with those of Benavides Orillo, J. A. (2019), who concludes that preventive tax auditing is an effective tool for anticipating errors and reducing tax liabilities during tax audit processes.

With regard to the results obtained, it can be noted that compliance with formal tax obligations significantly influences the reduction of tax contingencies, with a positive correlation of 0.814. This demonstrates that the proper issuance of payment receipts, the timely filing of tax returns, and the adequate maintenance of accounting records reduce the risk of fines and administrative penalties. These results corroborate the assertion by Flores Soria, J. (2012), who argues that tax contingencies arise primarily from regulatory non-compliance and deficiencies in tax controls. Likewise, this aligns with the observations of the National Superintendency of Customs and Tax Administration (SUNAT, 2022), which emphasizes that timely compliance with tax obligations reduces fiscal risks and strengthens business management.

regarding compliance with substantial tax obligations and the implementation of ongoing preventive controls, yielding a very strong correlation of 0.984. These results are consistent with those reported by Hidalgo Valenzuela, L. Y. (2022), whose study demonstrated that the implementation of preventive audits significantly reduces tax penalties and strengthens legal certainty for businesses. Similarly, the findings support the argument put forward by Moreno & Ríos (2020), who assert that the absence of internal controls increases exposure to tax contingencies and tax audits. In summary, the evidence from this study demonstrates that preventive tax auditing is not only a tax control mechanism but also a strategic tool that strengthens internal control, improves financial sustainability, and optimizes decision-making in interprovincial transportation companies.

4. CONCLUSIONS

- It is concluded that interprovincial transportation companies in the Moquegua region vary in their frequency of conducting preventive tax audits, with the frequency ranging from “always” to “almost always” in some provinces, such as Mariscal Nieto. This indicates that such audits are recognized as an important

internal control mechanism, although their implementation is not consistent across all the companies evaluated.

- The inferential results, particularly the Pearson correlation analysis, suggest that there is a significant relationship between the implementation of preventive tax audits and the reduction of tax liabilities. This indicates that the more frequently and systematically these audits are conducted, the lower the probability of incurring tax risks.
- The use of statistical tools such as IBM SPSS version 26 made it possible to objectively validate the results obtained, demonstrating that descriptive and inferential analysis is essential for informing tax-related decision-making. This underscores the importance of incorporating quantitative methodologies into business management to improve tax control and planning.

5. ACKNOWLEDGMENTS

Special thanks are expressed to the Graduate School of the National University of the Altiplano of Puno and to the professors of the Master's in Accounting and Management for the academic and methodological support provided during the development of this research.

Likewise, thanks are given to the interprovincial passenger transportation companies in the Moquegua region for providing the necessary information and voluntarily collaborating in the data collection process, allowing the execution of the study and the achievement of its scientific objectives.

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PREVENTIVE OBSERVATIONS AS A STRATEGY FOR REDUCING SAFETY INDICES: A LOOK AT THE SANTANDER MINING UNIT

Christian Giancarlo Flores Ticona

floresticona98@gmail.com

<https://orcid.org/0009-0005-2918-5226>

Universidad Nacional del Altiplano – Puno



ABSTRACT

Preventive observations aim to analyze the causes and consequences of occupational accidents. The objective of this research was to verify safety indices where reports of hazardous incidents were quantified, in order to implement the preventive observations format in the Santander Mining Unit. This is a study aligned with a quantitative approach, experimental type, and pre-experimental design. A non-probabilistic sample of 116 mining employees was used, who were subjected to preventive observations, and based on these observations, corrective and preventive measures were proposed. For data collection, the preventive observations format was used, which was structured in 3 parts. For data processing, the Minitab 18 statistical program was used, supported by Microsoft Excel 365 and the SPSS statistical program version 27. The comparison of safety indices before and after was performed using Student's t-test. The results showed that the behavior of mining workers in the area of safety is due to non-compliance with safety regulations, where 41.88% neglect their work area, and 39.0% do not comply with hazard identification. It is concluded that preventive observations as a strategy significantly reduced safety indices; from a frequency index of 143.68 to zero, from a severity index of 1508.62 to zero, and from an accidentability index of 216.76 to zero in the Santander Mining Unit.

Keywords: Accidentability, Preventive observations, Safety, Severity.

1. INTRODUCTION

Preventive observations are a procedure used in recent years in many companies, known as "Behavior-Based Safety," as a fundamental strategy for detecting and measuring unsafe acts that increase the probability of personal or industrial accidents

occurring in such environments, as well as for designing intervention strategies for their prevention and control (Martínez, 2015). However, the use of this technique in natural environments requires great rigor, both in the design of the observation and in the preparation of records or checklists of behaviors, and in its application by properly trained observers (Ramos O. C., 2010).

In Peru, the Ministry of Energy and Mines publishes a preliminary report prepared by the Technical Mining Directorate regarding fatal accidents reported in the Peruvian mining sector (MINEM, 2023). The report contains situational information and statistical graphs from the year 2000 to 2023. According to this report, in 2023 there were 50 fatal accidents in the mining sector, representing an increase of 163% compared to 2020, when there were 19 fatal accidents. On the other hand, Statista is a platform that offers statistics and information on various topics, including mining, metals, and minerals. According to Statista, in 2021 there were 1,190 mining accidents that left people seriously injured or incapacitated, and another 3,371 minor accidents. In addition, Statista confirms that there were 50 fatal mining accidents in 2021, the highest figure since 2013 (Statista, 2023). Therefore, institutional platforms safeguarding the health of mining workers, as well as the induction to adequate work performance by employers, mitigate work accidents in mining units. As demonstrated by several studies, such as Zuñiga (2021), who determined in the Las Bambas mine during 2019 that workshops on awareness of protection during work are effective.

Therefore, the purpose of the research is to apply preventive observations in the Santander mining unit, through corrective and preventive measures, verifying compliance with safety regulations and worker behavior to demonstrate the reduction of safety indices that will be carried out on the workers.

2. METHODS AND MATERIALS

The research was conducted in the Santander mining unit, located in the district of Santa Cruz de Andamarca, province of Huaral, region of Lima. The mine elevation ranges between 4,550 and 4,750 meters above sea level.

The respective instruments were field notebooks, checklists, data collection sheets, and safety records were also used. It was divided into four stages, the first being data collection, which had a time span of 6 months. This is based on the planning, execution, and evaluation stages, with the identification of preventive observations to then carry out the respective planning. The indicators in this stage were the safety index in preventive observations and the identification of factors.

Stage two was based on the implementation of the strategy, designed from preventive observations and deviations by focused groups, where documentary control of corrective and preventive measures was carried out, which encompasses the safety culture of workers.

Stage three of the research was based on evaluating the cost-benefit of compliance with safety perception, which was based on deadlines, reports, and feedback based on a safety management system.

As the final stage of the research, the results were analyzed using Student's t-test for related samples to reach the conclusions and recommendations of the research.

Independent variable: Preventive observations

- Worker behavior Strategies
- Corrective measures
- Preventive measures

Dependent variable: Safety Indices

- Frequency, severity, and accidentability index.

3. RESULTS AND DISCUSSION

3.1. Results

Below is the number of workers in the Santander mining unit to whom the preventive observations strategy was applied during the process.

Tabla 1

Number of workers over 6 months

Month	Start	End	Observations
January	116	116	First evaluation; workers remain
February	116	115	Second month of evaluation; one worker dismissed
March	115	110	Design and implementation month; 5 workers resign
April	110	90	Second month of implementation and start of evaluation; 20 workers dismissed
May	105	100	At the beginning of the month a new call is made; 15 workers added, of which 100 remain
June	100	100	Workers remain

Note: Data obtained from the HR labor registry - Santander

Design for the preventive observations format

It was designed in 3 sections, each fulfilling its respective function of collecting information and proposing corrective measures. The first section of the format records the date the deviation occurred, the shift, the name of the observer, and the name of the observed person(s) committing the deviations. The second section is completed in the safety department once the worker's record is obtained with the identified DNI, referring the person who performed said behavior and put it at risk, and the worker's explanation of why they did it is taken in order to then propose a solution. In the third section, the members of the safety committee were the first to fill out these behavioral observations.

Corrective measures according to focus groups

Once the focused groups are assembled with several people, they undergo corrective measures, the first being personnel training in compliance with procedures and consequence management. This measure is the first step after capturing the worker with their deviation form filled out. If this does not correct the worker or the actions taken are serious, work is done on the aspect of feedback to personnel in the psychology department.

Preventive measures according to focus groups

Prevention activities are those that seek to identify, evaluate, and control the hazards and risks associated with an organization's processes and operations, in order to guarantee the safety and health of workers and compliance with current regulations. Among these activities are IPERC and supervision of IPERC completion.

Implementation time

The implementation time was focused on 6 months, in which the first two months were of strict evaluation before application. The third month was based on the design of the preventive observations strategy. The fourth month involved the implementation of strategies based on training and instructions that must comply with the safety management system. In the fifth month, feedback and evaluation of the training are carried out, and in the last month, follow-up on the correct completion of the preventive observations format is performed.

Table 2

Comparison of deviations before and after application of observations

Focus Group	Deviation N	Before		After	
			%	N	%
3	Handled moving/energized/pressurized equipment	29	7.59%	0	0.00%
3	Operated equipment at unsafe speed	31	8.12%	2	1.92%
5	Did not evaluate SSO management tools before starting work	7	1.83%	6	5.77%
3	Exposed to the line of fire	4	1.05%	6	5.77%
2	Inappropriate use of equipment or tools	1	0.26%	1	0.96%
5	Operated equipment without authorization	20	5.24%	1	0.96%
4	Did not use/inspect safety or emergency devices	6	1.57%	8	7.69%
4	Did not provide necessary management tools to perform activity	3	0.79%	1	0.96%
1	Did not use/improper use/did not wear PPE	9	2.36%	5	4.81%
3	Improperly handled load during loading, unloading, or storage	36	9.42%	0	0.00%
3	Took unsafe positions/postures/did not use three points of contact	0	0.00%	0	0.00%
5	Performed work without authorization	43	11.26%	0	0.00%
6	Lack of attention/playing/joking at work	39	10.21%	1	0.96%
6	Acted under the influence of alcohol and drugs	22	5.76%	0	0.00%
5	Did not comply with established procedures or methods (standard, instruction, internal regulations, Continuous IPERC, ATS)	31	8.12%	58	55.77%
4	Did not verify application of control	1	0.26%	3	2.88%
5	Performed work without necessary training	79	20.68%	0	0.00%
3	Did not pay attention to warnings/signs/prevention signals	0	0.00%	2	1.92%
2	Poor evaluation of SSO management tools	11	2.88%	1	0.96%
4	Did not delimit/block work area	3	0.79%	9	8.65%
	Other	7	1.83%	0	0.00%
	TOTAL	382	100%	104	100%

Note: Safety department, Santander Mining Unit

Results of observation strategies using Student's t-test

The demonstration of the reduction in deviations before and after application is statistically supported by Student's t-test shown in Table 3.

Table 3*Analysis of deviations before and after using the T-test*

Description	Values
Difference	13.238
t (Observed value)	2.632
t (Critical value)	2.086
GL	20
valor-p (two-tailed)	0.016
alpha	0.05

* The number of degrees of freedom is approximated by the Welch-Satterthwaite formula

In Table 3, the difference in the average deviations for each of the focus groups is evidenced, totaling 13.238. Based on hypothesis testing, the observed t-value is 2.632, which is greater than 2.086. This statistically means there is a significant reduction, as the observed t-value is greater than the critical t-value, and the second condition is that the two-tailed p-value is less than 0.05, which is shown to be 0.016. For more details, the t-test is shown in Figure 1 based on the deviation report before and after the application of preventive observation strategies.

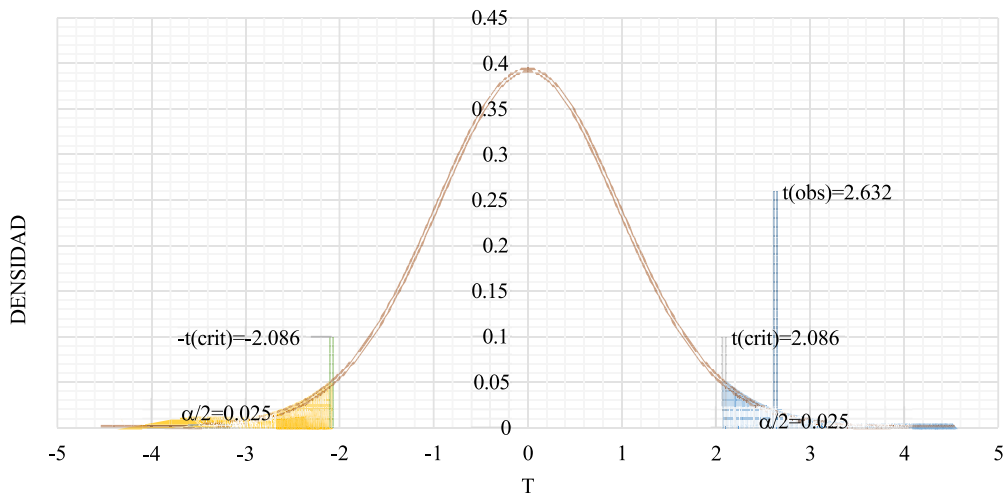
**Figure 1.** T-test for related data / deviation report

Figure 1 shows the t-test for related data where clearly the observed t-value of 2.632 is in the rejection region of the null hypothesis, thus confirming the significant reduction of deviations before and after.

Comparison of safety indices before and after application of preventive observations

Safety index reports operation in Santander Mining Unit

Safety Index	Jan	Feb	Mar	Apr	May	Jun
Disabling accidents (AI)	3	4	2	1	0	0
Fatal accidents (AF)	0	0	0	0	0	0
Total accidents (TA)	3	4	2	1	0	0
Man-hours worked (HHW)	27840	27840	27000	24000	24600	24000
Days lost (DC)	35	42	18	9	0	0
Man-hours trained	4350	3622.5	3905	3550	3727.5	3550

Note: Safety department, Santander Mining Unit

4. DISCUSSION

According to Ticona and Aguila (2019), they concluded that accidentability indices are associated with psychosocial risk determinants. Statistically, it was demonstrated that the variables have a high positive correlation, and the results of this research show that accident indices are associated with constant worker training to obtain positive results in the Santander mining unit. However, training is not constantly carried out in other mining units, nor is it evaluated to see how to improve.

According to Huachin (2023), in his research article “Preventive Observations,” he reached results where workers with deficiencies who assume risky behaviors affecting underground mine operations are gathered. We reached a result according to the focus of workers into groups based on preventive observations that the majority of accidents... therefore, standardization of underground mine work is important to avoid actions not contemplated in the standards.

5. CONCLUSIONS

- Preventive observations as a strategy significantly reduced safety indices; from a frequency index of 143.68 to zero, from a severity index of 1508.62 to zero, and from an accidentability index of 216.76 to zero in the Santander Mining Unit.
- The behavior of mining workers in the area of safety is due to non-compliance with safety regulations, where 41.88% neglect their work area, and 39.0% do not comply with hazard identification, which leads to a high safety index in the Santander Mining Unit.
- A preventive observations format was designed which focuses workers into groups according to preventive observations. These groups underwent a

rehabilitation and feedback process with corrective and preventive measures based on psychological aspects.

6. ACKNOWLEDGMENTS

Thanks to the doctoral program of the Graduate School of the National University of Altiplano, especially the language program and the English course.

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LEVEL OF LOGICAL-MATHEMATICAL INTELLIGENCE IN HIGH SCHOOL STUDENTS IN PUNO

Ricardo Javier Garambel Pérez

pergarambel1@gmail.com

ORCID: 0009-0000-5177-6827

National University of the Altiplano of Puno



ABSTRACT

Logical-mathematical intelligence constitutes an essential capacity for reasoning, problem solving, and mathematical learning. The objective of the research was to determine the level of logical-mathematical intelligence in first-year secondary school students at the Commercial Secondary School No. 45 "Emilio Romero Padilla" in Puno during the 2013 school year. A quantitative, non-experimental, descriptive design was used. The population consisted of 490 students. For data collection, a 20-item questionnaire adapted from Barraza Macías (2003) was applied. Data processing was carried out using SPSS version 18 software. Frequencies, percentages, means, and standard deviations were calculated. The results showed that, on average, the students scored 9.40 points out of a maximum of 20. 51% of the students were at the low level, 49% at the medium level, and no student reached the high level. In the analysis by dimensions, everyday problem solving ($M = 10.96$) and generation of new problems ($M = 10.31$) were at the medium level, while creation of new cognitive proposals ($M = 6.70$) was at the low level. It is concluded that students predominantly exhibit low to medium levels of logical-mathematical intelligence, with greater deficits in the creative dimension.

Keywords: secondary education; logical-mathematical intelligence; logical thinking; Puno; problem-solving.

1. INTRODUCTION

The development of logical and mathematical thinking constitutes a fundamental competence for the comprehensive education of students. Gardner's theory of multiple intelligences (1994) posits that human intelligence is not a unitary capacity, but rather a set of relatively autonomous abilities. Among them, logical-mathematical intelligence stands out, defined as the ability to reason

deductively and inductively, formulate hypotheses, and solve problems through analytical processes (Antunes, 2001). Recent research has corroborated the validity of this approach. Reyes-Vélez (2017) points out that this intelligence develops through the child's interaction with their environment, while Shirawia et al. (2023) and Gonzalez-Nucamendi et al. (2022) demonstrated its positive impact on learning and academic performance. Yavich and Rotnitsky (2020) found that 80.9% of students in excellent classes exhibited this intelligence as dominant, and Maharani, Marsigit, and Wijaya (2020) confirmed that students with logical-mathematical intelligence achieve better results in mathematics. In Latin America, Hernández, Prada, and Rincón (2019) found that this intelligence scored the highest average among basic education students.

The results of PISA 2018 show that Peru scored 400 points in Mathematics, ranking 64th out of 77 countries (OECD, 2019). At the national level, the ONEM 2018 showed exceptional achievements in regions such as Arequipa and Junín. In Puno, although there are outstanding students in the COREMAT and ECE 2018 (MINEDU, 2018), the majority present low or medium levels. Studies attribute this issue to methodologies focused on memorization (Flores, 2008) and the lack of stimulation of creative thinking (Oñate et al., 2011). In Puno, there are few studies that evaluate this intelligence, which justifies the present research.

The general objective was to determine the level of logical-mathematical intelligence in first-year secondary students of the Commercial Secondary Educational Institution No. 45 "Emilio Romero Padilla" in Puno during 2013. The specific objectives were: (a) to establish the level in everyday problem solving, (b) in the generation of new problems, (c) in the creation of new cognitive proposals, (d) to identify the dimension with the greatest presence, and (e) to describe the predominant characteristics.

2. METHODS

The research was conducted at the Secondary Commercial Educational Institution No. 45 "Emilio Romero Padilla," located in the city of Puno, Peru, during the first academic bimester of 2013. The population consisted of 490 first-year secondary school students, with whom a census sampling was conducted, including all the students, to ensure the representativeness of the data. For data collection, a structured questionnaire of 20 items was administered, adapted from the instrument designed by Barraza Macías (2003) and previously used in similar contexts by Montelongo Astorga (2007). The questionnaire evaluates three specific dimensions: everyday problem solving, which includes 8 items; the generation of new problems, with 6 items; and the creation of new cognitive proposals, also with 6 items. Each item is scored dichotomously, assigning one point for a correct answer and zero points for an incorrect answer, so the total score per student can range from 0 to 20 points.

The instrument was subjected to a content validity process through the judgment of three experts in education and psychology, obtaining an Aiken's V coefficient of .85, which demonstrates adequate validity. Likewise, its reliability was estimated through Cronbach's Alpha coefficient, reaching a value of .79 for the global scale, considered acceptable for educational research. To interpret the results, a scale based on the percentage of correct answers was established, considering that the maximum possible score is 20 points. Thus, the low level was defined as 0 to 9 points, the medium level as 10 to 15 points, and the high level as 16 to 20 points. The cutoff point for the medium level was set at 10 points, equivalent to 50% correct answers, following standard psychometric criteria that consider a mastery of 50% or more to indicate an acceptable development of the assessed skill.

The procedure was carried out in three sequential stages. In the first stage, authorization was requested by the educational institution's administration, and the project was presented to the institutional ethics committee, obtaining approval with the code CEI-UNA-2013-027. Subsequently, a meeting was held with the parents to explain the objectives of the research, the procedures to be followed, and the exclusive academic use of the data, after which written informed consent was obtained. In the second stage, the questionnaire was administered in a controlled manner in 45-minute sessions per classroom, with the presence of the researcher to resolve any doubts. Finally, in the third stage, the data collected were systematized and organized for subsequent analysis.

The processing and analysis of the data were carried out using IBM SPSS Statistics version 18 software. A descriptive analysis was conducted, which included the calculation of absolute and relative frequencies (percentages), as well as the calculation of arithmetic means (M), standard deviations (SD), minimum and maximum values for the total questionnaire score and for each of the three evaluated dimensions.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1

Distribution of students according to logical-mathematical intelligence level (n = 490)

Level	Range	f	%
Low	0 – 9	250	51
Medium	10 – 15	240	49
High	16 – 20	0	0

Note. Levels were assigned according to the scale: low (0-9 points), medium (10-15 points), high (16-20 points).

51% of the students are at a low level and 49% at a medium level, while no student reached a high level. This finding indicates an insufficient development of logical-mathematical intelligence in the evaluated population and suggests that the educational system is not adequately stimulating this cognitive ability.

Table 2

Scores in everyday problem-solving (n = 490)

Indicator	M	DE	Nivel
Resolution of everyday problems	10.96	2.72	Medio

Note. M = arithmetic mean; SD = standard deviation. Level was assigned according to the scale: low (0-9), medium (10-15), high (16-20).

The students achieved an average of 10.96 points (medium level), indicating basic skills for solving routine problems. However, this level suggests that they haven't yet achieved a solid mastery to tackle more complex or novel problems in real-world contexts.

Table 3

Scores in Generation of New Problems (n = 490)

Indicator	M	SD	Level
Generation of new problems	10.31	2.72	Medium

Note. M = arithmetic mean; SD = standard deviation. Level was assigned according to the scale: low (0-9), medium (10-15), high (16-20).

The mean was 10.31 points (medium level), showing that students can pose basic problems but have limitations in formulating novel situations. This difficulty could

be associated with methodologies that favor repetition over inquiry and divergent thinking.

Table 4

Scores on the creation of new cognitive proposals (n = 490)

Indicator	M	SD	Level
Creation of new cognitive proposals	6.70	4.75	Low

Note. M = arithmetic mean; SD = standard deviation. Level was assigned according to the scale: low (0-9), medium (10-15), high (16-20).

This dimension obtained the lowest meaning (6.70 points, low level), with high heterogeneity ($SD = 4.75$). The main difficulty lies in the inclination toward careers linked to mathematical reasoning and creativity, making it the most deficient area.

Table 5

Comparison of mean scores between dimensions (n = 490)

Dimension	M	SD	Level
Everyday problem solving	10.96	2.72	Medium
Generation of new problems	10.31	2.72	Medium
Creation of new cognitive proposals	6.70	4.75	Low

Note. The level was assigned according to the established scale: low (0-9 points), medium (10-15 points), high (16-20 points).

The dimension with the greatest presence is everyday problem solving (10.96 points), followed by generation of new problems (10.31 points). The creation of new cognitive proposals is the lowest, with a difference of more than 4 points, confirming that creative thinking is the most deficient area.

Table 6

Predominant characteristics of logical-mathematical intelligence

Characteristic	Nivel alcanzado
Everyday problem solving	Medium (M = 10.96)
Generation of new problems	Medium (M = 10.31)
Creation of new cognitive proposals	Low (M = 6.70)
Presence of high level	0%
Variability in creative dimension	SD = 4.75

Note. M = arithmetic mean; SD = standard deviation. Levels were assigned according to the scale: low (0-9 points), medium (10-15 points), high (16-20 points).

The predominant characteristics include a basic development in procedural dimensions, a marked weakness in the creative dimension, absence of high level, and high variability in the latter ($SD = 4.75$). This reflects individual differences associated with diverse learning experiences.

3.2. Discussion

The results of this research show that the level of logical-mathematical intelligence in the 490 students evaluated is predominantly low (51%) or medium (49%), with a total absence of students at the high level, reflecting an insufficient development of this cognitive ability in the studied population. In relation to the general objective, more than half of the students are at the lowest level, while the rest barely reach a medium level, coinciding with what was reported by Caljaro Tarqui (2001), who identified deficiencies in cognitive abilities in students from the Puno region, showing that difficulties persist over time. In the dimension of everyday problem solving, students obtained an average of 10.96 points (medium level), indicating that they possess basic skills to solve routine problems and apply mathematical procedures in everyday contexts, although without achieving a solid mastery that would allow them to face more complex or novel problems, as pointed out by Flores (2008). Regarding the dimension of generation of new problems, they reached a mean of 10.31 points (medium level), showing that they can pose basic questions and problems, but with limitations in formulating complex or novel problem situations that require a higher level of abstraction, which could be associated with teaching methodologies that favor repetition over inquiry (Barnett & García, 2008).

Regarding the dimension of creation of new cognitive proposals, it obtained the lowest means (6.70 points), placing it at the low level, with a high standard deviation (4.75) reflecting great heterogeneity in student performance. The main difficulty does not lie in executing procedures, but in the inclination toward careers linked to mathematical reasoning and creativity. The difference of more than 4 points with respect to the other dimensions confirms that this is the most deficient area, coinciding with Oñate, Saavedra, and Spolmann (2011), who also found that the dimension associated with professional interests is the most lagging. The dimension with the greatest presence was everyday problem solving ($M = 10.96$), followed by generation of new problems ($M = 10.31$), while creation of new cognitive proposals turned out to be the most deficient, confirming that professional interests linked to mathematics are the weakest areas. The predominant characteristics of logical-mathematical intelligence in the studied population include a basic development in procedural dimensions, a marked weakness in the creative dimension, total absence of students at the high level, and high variability in this last dimension ($SD = 4.75$), reflecting significant individual differences probably associated with diverse previous learning experiences. The study presents limitations: the sample was limited to a single educational institution, so the results cannot be generalized; the

cross-sectional design prevents establishing causal relationships; and the instrument, although reliable ($\alpha = .79$), was self-made and would require additional validation. Based on these limitations, future lines of research are suggested: to develop comparative studies in multiple educational institutions in the region, to apply longitudinal designs to analyze the evolution of this intelligence throughout schooling, to carry out qualitative research exploring the perceptions of teachers and students about difficulties in the creative dimension, to implement quasi-experimental designs to evaluate pedagogical intervention programs aimed at strengthening professional interests toward mathematical careers, and to validate the instrument used in broader populations.

4. CONCLUSIONS

- The level of logical-mathematical intelligence in the 490 students evaluated is predominantly low (51%) or medium (49%), with an overall mean of 9.40 points out of 20 and a total absence of students at the high level, which confirms an insufficient development of this cognitive ability in the studied population and suggests that the educational system has not adequately stimulated logical and mathematical reasoning from early stages.
- In the dimension of everyday problem solving, students reached a medium level ($M = 10.96$, $SD = 2.72$), indicating that they possess basic skills to solve routine problems, although without achieving a solid mastery to face more complex problems.
- In the dimension of generation of new problems, they also reached a medium level ($M = 10.31$, $SD = 2.72$), showing significant limitations in formulating novel problematic situations that require a higher level of abstraction.
- In contrast, the dimension of creation of new cognitive proposals obtained the lowest level ($M = 6.70$, $SD = 4.75$), with a difference of more than 4 points compared to the other dimensions. The high standard deviation reflects great heterogeneity in student performance, making this the most deficient area.
- It is recommended to implement pedagogical strategies aimed at strengthening professional interests toward mathematical careers, as well as early and personalized interventions to reduce heterogeneity in student performance.
- Everyday problem solving showed the highest presence ($M = 10.96$), while creation of new cognitive proposals was the lowest ($M = 6.70$), indicating that the educational system has prioritized procedural teaching over fostering professional interests in scientific careers, with high variability ($SD = 4.75$) and no students reaching the high level.

ACKNOWLEDGMENTS

To Professor Dra. Diana Vargas Velásquez for her guidance in the English course for the preparation of this article.

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OPERATIONAL AUDIT OF THE EFFECTIVENESS OF ADMINISTRATIVE MANAGEMENT AT THE AGENCIES OF THE NATION BANK

Karin Zenaida Huamantuma Fernandez

karin.hf18@gmail.com

ORCID: 0009-0006-1367-9632

Universidad Nacional del Altiplano Puno



ABSTRACT

Service managers in financial institutions are essential for customer service and meeting performance indicators; however, they do not always achieve operational objectives, revealing a gap between auditing and administrative management. In this context, the study aimed to determine the impact of operational auditing on the effectiveness of administrative management at Nation bank branches in the Puno region during the 2024 period. The study was conducted using a quantitative, non experimental approach with a correlational design and cross sectional scope. A probabilistic sample of 38 service managers from 8 Nation bank branches in the Puno region (Acora, Desaguadero, Ilave, Yunguyo, Juli, UNA, Transportes, Puno) was used. A structured survey questionnaire consisting of 20 items was used for data collection, and the data were processed using IBM SPSS Statistics Version 25. Descriptive and inferential statistics were used to test the hypothesis. The variables met the assumption of normality (Shapiro Wilk, $p > 0.05$). The results showed a positive and significant relationship between operational auditing and administrative management, with a Pearson coefficient of determination of 0.833 and a statistically significant regression model ($F = 180, 103; p < 0.001$), indicating that 83.3% of the variability in administrative management is explained by operational auditing. Likewise, the regression coefficient ($\beta=0.965$) confirms a strong impact of operational auditing on administrative efficiency. It is concluded that operational auditing significantly influences the effectiveness of administrative management, promoting the achievement of institutional goals.

Keywords: Performance audit, administrative management, efficiency.

1. INTRODUCTION

In the field of public and financial management in Peru, performance auditing is defined as a systematic and objective evaluation of organizational processes, aimed at measuring the economy, efficiency, and effectiveness in the use of resources for the achievement of institutional objectives (Ochoa, 2022). This approach goes beyond traditional audits by analyzing internal controls, strategic alignment, and operational performance, enabling the identification of opportunities for improvement in non-financial processes (Chavez et al., 2020; Coello & Guaranda, 2019). In public entities such as Nation bank, its application is key to optimizing resources, reducing operational risks, and strengthening internal control in complex regional contexts (La Cruz & Rojas, 2024).

For its part, the effectiveness of administrative management involves the ability to optimize human, material, and technological resources to achieve institutional objectives, integrating planning, organization, and control functions (Hurtado, 2008). This concept is measured through performance indicators that ensure efficient processes, reduced processing times, and continuous improvement, especially in public organizations (Fernández, 2020). In this regard, performance auditing has a positive impact on administrative management by identifying inefficiencies and proposing corrective actions, contributing to more efficient, proactive, and results-oriented management (Huamán, 2020).

In Puno region, Nation bank branches operate in a context characterized by geographical dispersion, limitations in technological infrastructure, and high demand for financial services in rural areas, which requires efficient administrative management to ensure financial inclusion (Triana, 2010). However, the absence of periodic operational audits leads to inefficiencies in key processes such as customer service and inventory control, compromising the achievement of institutional goals (CGRP, 2011).

The problem manifests itself in procedural delays, duplication of functions, and underutilization of human resources, increasing operational risks such as fraud and non compliance (Huamán, 2020). These deficiencies lead to reactive management, affecting institutional competitiveness and public trust in peripheral regions (Vera, 2024).

Various studies have demonstrated the relationship between performance auditing and administrative management. Meza (2019) showed that performance auditing is significantly correlated with improvements in administrative processes. Similarly, Ramos & Zegarra (2020) concluded that auditing allows for the identification of inefficiencies and the optimization of institutional performance. Mamani (2020)

found a near-perfect correlation between comprehensive auditing and administrative effectiveness, highlighting the role of control in service quality.

On the other hand, Quispe (2020) demonstrated that the low implementation of recommendations limits administrative effectiveness, emphasizing that auditing alone is not enough; rather, it is necessary to implement improvements. Likewise, Angulo & Arias (2024) confirmed that auditing based on internal control and continuous evaluation positively influences management. Overall, the literature agrees that performance auditing improves administrative management; however, it differs in that some emphasize evaluation, while others highlight the implementation of recommendations as a key factor in the impact.

The purpose of the research was to determine the impact of performance auditing on the effectiveness of administrative management at Nation bank branches in the Puno region during the 2024 period, as there is a low incidence of performance auditing on administrative management effectiveness at Nation bank branches in the Puno region, which leads to operational inefficiencies, failure to meet targets, and institutional risks. Likewise, the study seeks to propose improvements aimed at optimizing administrative management, strengthening internal control, and improving the quality of financial services in regional contexts.

2. METHODS

The research was conducted in the Peruvian highlands, specifically in Titicaca Lake basin on the Peruvian side, an area characterized by unique high-altitude climatic conditions (Minam, 2013). Nation bank plays a fundamental role in financial inclusion and the implementation of public policies through its territorial presence in Peru via branches and operational staff (MEF, 2023). The research lasted one semester in 2024. A census sample of 38 service managers from Nation bank in the Puno Region was used, drawn from the 8 Nation bank branches in the Puno Region (Acora, Desaguadero, Ilave, Yunguyo, Juli, UNA, Transportes, Puno). IBM SPSS Statistics version 25 was used for data processing. The data collection method was a survey, through which information was obtained on operational auditing and the effectiveness of administrative management. The instrument used was a structured questionnaire with 20 items, using a 1-to-5 Likert scale. Table 1 shows that the independent variable, operational audit, was measured across four dimensions: planning, execution, evaluation of findings, and communication and follow up. Similarly, the dependent variable administrative management effectiveness was operationalized through the dimensions of goal achievement, operational efficiency, service quality, and decision making.

Table 1*Variable Operationalization Matrix*

VARIABLE	DIMENSION	FREQUENCY SCALE
OPERATIONAL AUDIT (VI)	Planning	Never Almost never Sometimes Almost always Always
	Execution	Never Almost never Sometimes Almost always Always
	Assessment of findings	Never Almost never Sometimes Almost always Always
	Communication and follow-up	Never Almost never Sometimes Almost always Always
EFFECTIVENESS OF ADMINISTRATIVE MANAGEMENT (VD)	Goal Achievement	Never Almost never Sometimes Almost always Always
	Operational efficiency	Never Almost never Sometimes Almost always Always
	Quality of service	Never Almost never Sometimes Almost always Always
	Decision-making	Never Almost never Sometimes Almost always Always

Note: instrument adapted from Huaman (2020).

3. RESULTS AND DISCUSSION

3.1. Results

Table 2

Descriptive analysis of the effectiveness of the operational audit.

PERCEPTION LEVEL	FREQUENCY (%)	INTERPRETATION
High	68.4%	- Managers consider that operational audit processes are carried out appropriately and efficiently.
Medium	23.7%	- Compliance with operational audit processes is perceived as moderate.
Low	7.9%	- There is limited confidence in the proper conduct of operational audits.
TOTAL	100%	

Note: Data obtained from IBM SPSS

Table 2 shows service managers' level of perception regarding operational auditing, which was favorable. Of the total respondents, 68.4% indicated a high level of compliance with operational audit processes, while 23.7% reported a moderate level, and only 7.9% indicated a low level. These results reflect that activities related to planning, execution, evaluation of findings, and follow-up on recommendations are carried out appropriately in the Nation bank branches in the Puno region.

Table 3

Descriptive analysis of the effectiveness of administrative management

PERCEPTION LEVEL	FREQUENCY (%)	INTERPRETATION
High	73.7%	- Managers perceive adequate levels of administrative management.
Medium	18.4%	- There is a moderate perception of administrative effectiveness.
Low	7.9%	- Limitations are evident in some administrative processes.
TOTAL	100%	

Note: Data obtained from IBM SPSS

Table 3 presents a descriptive analysis of the effectiveness of administrative management: 73.7% of service managers perceived a high level, 18.4% a medium

level, and 7.9% a low level. These results indicate that Nation bank branches demonstrate adequate levels of goal achievement, operational efficiency, service quality, and administrative decision making.

TABLE 4

Correlation between operational audit and administrative management effectiveness

Variables	Operational audit	Administrative management effectiveness
Operational audit	1	0.833
Effectiveness of administrative management	0.833	1

Note: Data obtained from IBM SPSS

Table 4 showed a very high and statistically significant positive correlation between operational auditing and the effectiveness of administrative management ($r=0.833$; $p<0.001$). This indicates that the proper implementation of operational auditing contributes significantly to strengthening administrative management in Nation bank branches in the Puno region. Furthermore, it demonstrates that increased levels of planning, execution, evaluation, and follow-up of audits are associated with improved goal achievement, operational efficiency, service quality, and institutional decision-making.

TABLE 5

Normality Tests

	Statistic	Shapiro Wilk	
		gl	Sig.
V1 Aud.Oper.	,960	38	,197
V2 Adm. Manag.	,963	38	,245

Note: data obtained from IBM SPSS

In Table 5, both variables satisfy the assumptions of normality: Shapiro Wilk (V1: 0.960, $p=0.197$; V2: 0.963, $p=0.245$). This validates the use of parametric techniques such as linear regression for robust inferences. In the context of operational auditing, normality implies that efficiency scores follow predictable patterns. The Shapiro Wilk test was used in this study because the sample size is less than 50.

3.2. Discussion

The results obtained show that operational auditing is viewed favorably at Nation bank branches in the Puno region, as 68.4% of service managers rated the level of compliance with operational audit processes as high. Likewise, the effectiveness of

administrative management was perceived as high by 73.7% of respondents. These findings suggest that activities related to the planning, execution, evaluation, and monitoring of audits are carried out appropriately and have a positive impact on institutional administrative performance.

Similarly, the very high positive correlation found between operational auditing and the effectiveness of administrative management ($r=0.833$; $p<0.001$) demonstrates that strengthening auditing mechanisms significantly influences the improvement of administrative processes. In this regard, the results align with the findings of Guillin et al. (2018), who argue that performance auditing constitutes a systematic process aimed at evaluating the efficiency, effectiveness, and economy of institutional operations, thereby enabling the optimization of administrative management and resource utilization.

Likewise, the findings are consistent with the research conducted by Hernández (2024), who concluded that performance auditing contributes significantly to institutional strengthening and improved administrative performance in public entities in the Puno region. Similarly, Vera (2024) determined that the proper application of operational audits and internal controls improves operational efficiency and the reliability of information in financial organizations and cooperatives. Consequently, the results obtained in the Nation bank branches demonstrate that the operational audit is establishing itself as a strategic tool for strengthening administrative management and promoting an administration oriented toward the fulfillment of institutional objectives.

On the other hand, the high levels of perception regarding goal achievement, operational efficiency, and service quality reflect that the evaluated branches maintain relatively organized and coordinated administrative processes. This aligns with Schilder et al. (2002), who argue that operational auditing in banking institutions should evaluate the quality of systems, procedures, and organizational structures to ensure adequate risk management and efficient use of institutional resources. In this context, the results suggest that Nation bank's branches have been progressively strengthening their administrative oversight and control mechanisms.

Similarly, Delgado et al. (2021) state that identifying deficiencies and following up on audit recommendations generate sustainable improvements in operational efficiency. This position is consistent with the findings, as the dimensions related to audit follow up and the implementation of recommendations showed significant associations with work organization, coordination between departments, and the achievement of administrative goals. Therefore, it can be noted that the comprehensive operational audit cycle constitutes a determining factor in strengthening administrative effectiveness in the banking sector.

Finally, the results are also consistent with the performance audit approaches proposed by the OAS (2009), which emphasize that the systematic evaluation of institutional performance contributes to improving the efficiency, effectiveness, and control of administrative processes. In this vein, the present study confirms that an adequate operational audit facilitates decision-making, strengthens organizational coordination, and improves the achievement of institutional goals in the Nation bank branches in the Puno region.

4. CONCLUSIONS

- It was determined that operational auditing significantly impacts the effectiveness of administrative management at Nation bank branches in the Puno region during the 2024 period. The statistical results showed a very high positive correlation between the two variables ($r=0.833$; $p<0.001$), demonstrating that the proper application of operational audit processes contributes to strengthening goal achievement, operational efficiency, service quality, and administrative decision-making in the evaluated branches.
- It was established that operational auditing is at favorable levels in the Nation bank agencies in the Puno region, as 68.4% of service managers perceived a high level of development in operational audit processes. These results allow us to conclude that activities related to planning, execution, evaluation of findings, and follow-up on recommendations are carried out appropriately, generating positive effects on the effectiveness of institutional administrative management.
- It is concluded that strengthening operational auditing, especially in the follow up phase, is key to achieving efficient and results-oriented administrative management. However, opportunities for improvement were identified in the evaluation of processes and in the clarity of staff roles; therefore, it is recommended to reinforce the audit methodology, review the organizational structure, and promote continuous training to ensure sustainable changes.

5. ACKNOWLEDGMENTS

I express my deep appreciation and sincere gratitude to the Graduate School of the National University of the Altiplano in Puno for providing the advanced academic platform that ensured the rigor of this research.

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CLOUD COMPUTING FOR CRITICAL DATA AT THE CHALLAPALCA SPECIAL HIGH-SECURITY PRISON

Ricardo Segundo Huertas Gonzales

ricardohuertasgonzales@gmail.com

Orcid: 0009-0009-9851-4328

National University of the Altiplano - Puno



ABSTRACT

A data storage system is the technological infrastructure used to retain, organize, and protect digital information in order to ensure efficiency and user satisfaction. The objective of this study was to evaluate the impact of implementing a cloud-based data storage system on the management of critical information at the Challapalca Special High-Security Prison. The study employed a quantitative, experimental approach with a pre-experimental design and a longitudinal scope. The sample consisted of 108 administrative and security staff members. The data collection instrument was a questionnaire administered via a survey regarding the cloud storage system, which had been previously evaluated using system usability criteria based on the ISO 9126 standard. Subsequently, the data were processed using IBM SPSS version 25, and hypothesis testing was performed using the standard Z-test for normal distribution, with a significance level of $\alpha = 0.05$. The results showed an acceptance level of 97.2% and a Z_c value of 2.610, which is higher than the critical Z_t value of 1.96, allowing the null hypothesis to be rejected. It is concluded that the implementation of the cloud-based system significantly improves the management of critical information, enhancing access, security, availability, and efficiency of document storage at the EPRCE Challapalca.

Keywords: cloud computing, data storage, critical information, ISO 9126, web system.

1. INTRODUCTION

Currently, managing critical information in public institutions poses a challenge, especially in contexts where data security, availability, and continuity are essential. In this scenario, management efficiency depends on the technologies used for data storage and processing. In this regard, software development plays a key role in

optimizing data management and ensuring its security and availability in critical environments (ISO/IEC 27034, 2018).

In correctional facilities, information is typically managed through local storage, such as hard drives or physical documents, which increases the risk of data loss, unauthorized access, and limitations on information availability (Khan et al., 2020; Wu y Zhao, 2022). Furthermore, evidence from the correctional sector shows that, in crisis situations such as riots or internal conflicts, institutional infrastructure and resources can be compromised.

In countries such as Colombia, projects to digitize records and implement electronic document management have been launched with the aim of reducing the deterioration of physical documents and improving access to information. These initiatives highlight the need to transition to digital systems and centralized storage, thereby optimizing data management in institutional settings. In response, cloud computing has emerged as a technological alternative that allows for the centralization of information, improves its accessibility, and ensures more robust security mechanisms. This technology, considered a key factor in improving information systems, offers advantages such as scalability, 24/7 availability, and resource optimization, allowing organizations to access their data from any location with an internet connection (Zhou et al., 2021; Li y Wang, 2022). Likewise, various studies highlight that cloud-based solutions contribute significantly to strengthening data management and protection in institutional settings (Ahmed y Hussain, 2023; Zhang et al., 2023).

Currently, Peru's prison system, which is responsible for enforcing prison security and administrative regulations, demonstrates a need to strengthen its technological mechanisms and information management systems. A significant incident occurred in 2012, when a riot broke out at the Challapalca Special Maximum-Security Prison, where inmates took control of the facility and held staff hostage, highlighting the vulnerability of control and management systems in such environments. Such events jeopardize the integrity, availability, and security of critical information when it is stored on physical media or traditional storage systems.

In this context, the study aimed to evaluate the impact of implementing a cloud-based data storage system on the efficiency of critical information management. To this end, a web-based system with FTP access and file validation was developed and implemented, and it was evaluated using software quality criteria (ISO 9126) and user satisfaction metrics.

2. METHODS

The research was conducted at the Challapalca Special Maximum-Security Prison, located in the Tacna region of Peru at an altitude of approximately 4,600 meters

above sea level. This prison falls under the jurisdiction of the Puno Altiplano Regional Office and is considered one of the highest-altitude prisons in the country. This facility was established to house highly dangerous inmates, operating under extreme geographical and climatic conditions that require strict mechanisms for the control and management of critical information.

The research lasted six months, during which time the necessary arrangements were made with the Regional Directorate of the Altiplano Puno Regional Office of the National Penitentiary Institute (INPE) in order to obtain the necessary authorizations for conducting the research and implementing the cloud-based data storage system.

The implementation process began with the identification of issues related to the use of traditional storage methods, such as local drives, external storage devices, and physical documentation, which had limitations regarding the security, availability, and backup of institutional data. Subsequently, a web-based system was developed and implemented to optimize the management of critical data through features for storing, uploading, accessing, and managing digital files.

To digitize the information, the physical documents were first scanned and converted to digital format, allowing them to be subsequently stored centrally in a cloud environment. It should be noted that during the software implementation process, various difficulties arose related to the geographical location of the Challapalca Special Maximum-Security Prison, as extreme weather conditions, the facility's remote location, and connectivity limitations hindered timely access to technological resources and specialized technical support. Furthermore, the institution's available computer equipment was used to implement the system, enabling the digitization, uploading, and access of information.

The study population consisted of 150 administrative and security staff members with access to critical information within the correctional facility. From this population, a representative sample of 108 users was selected using simple random sampling, and these individuals participated in the evaluation of the implemented system.

The independent variable was a cloud-based data storage system, evaluated using system usability criteria based on the ISO 9126 standard, taking into account factors related to ease of use, interface quality, error handling, resource optimization, speed, and system performance. On the other hand, the dependent variable was represented by information management efficiency, measured using user satisfaction indicators related to interface, navigation, access, clarity of information, and system organization.

The data collection framework was based on the questionnaire method. A structured questionnaire consisting of 16 questions, designed using a Likert scale, was used as

the measurement tool. This questionnaire made it possible to assess users' perceptions regarding the functionality, usefulness, and satisfaction level of the implemented system.

Data processing and statistical analysis were performed using IBM SPSS version 25. In the descriptive analysis, frequency and percentage analyses were applied to assess the levels of acceptance and satisfaction with the implemented system. In the inferential analysis, the standard Z-test for normal distribution was used to test hypotheses, with a significance level of $\alpha = 0.05$, allowing for a statistical determination of the influence of the cloud-based system on the improvement of critical information management.

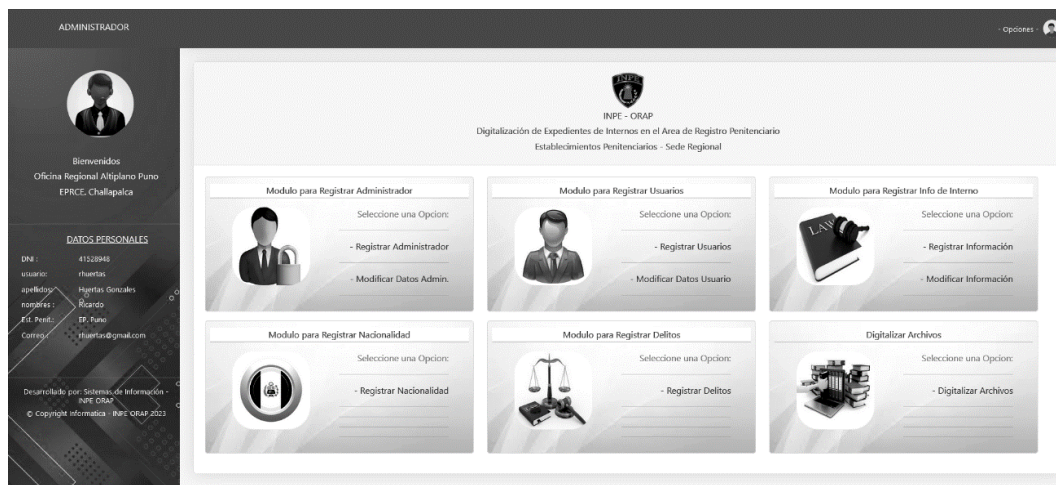
3. RESULTS AND DISCUSSION

3.1. Results

The results obtained following the implementation of the cloud-based data storage system demonstrate a significant improvement in the management of critical information at the Challapalca Special Maximum-Security Prison. The system was evaluated based on the quality criteria established in the ISO 9126 standard, as well as user feedback gathered through a satisfaction survey.

Figure 1

Interface of the cloud-based data storage system



Note: Work team.

Figure 1 shows the interface of the implemented system, which enables the secure and efficient management, storage, and sharing of files.

Table 1

System validation results according to ISO 9126

Ranking	Interval	Result
Unacceptable	[27 – 54>	
Barely acceptable	[54 – 81>	
Acceptable	[81 – 95>	
Meets the requirements	[95 – 122>	96.2
Exceeds the requirements	[122 – 135>	

Note: Data provided by EPRCE CHALLAPALCA staff.

With regard to software quality attributes, it can be concluded that the cloud-based virtual data storage system for administrative and security staff at the National Penitentiary Institute – Altiplano Puno Regional Office of the Challapalca Special Closed Regime Penitentiary—meets the requirements established in the ISO 9126 standard, obtaining a score of 96.2 within the range corresponding to the “Meets requirements” category, demonstrating an adequate level of performance, efficiency, and quality of the implemented system.

Table 2

User satisfaction level

Indicator	Result
System interface	Very good
System Navigation	Very good
System Access	Good
Information security	Very good
Clarity of information	Good
Storage and sharing processes	Very good
Error messages	Appropriate
Menu Organization	Very good
Overall satisfaction	97.20%

Note: Data provided by EPRCE CHALLAPALCA staff.

Based on the results of the satisfaction survey, it appears that administrative and security staff have a high level of acceptance of the implemented system, with a satisfaction rate of 97.2%. Users rated aspects related to the interface, navigation, access to information, menu organization, and file storage and sharing processes favorably, indicating a positive perception of the system’s functionality and usefulness.

Table 3

Hypothesis testing using the Z-test

Statistician	Value
Calculated Z (Zc)	2.61
Z-table (Zt)	1.96
Significance level	0.05
Decision	H ₀ is rejected

Note: Data obtained using SPSS software version 25.

With regard to hypothesis testing, it was determined that the calculated Z-statistic $Z_c = 2.610$ is greater than the critical value $Z_t = 1.96$ for a significance level of $\alpha = 0.05$, allowing us to reject the null hypothesis and accept the alternative hypothesis. Consequently, it is concluded that the implementation of the cloud-based data storage system significantly influences the improvement of critical information management at the Challapalca Special Maximum-Security Prison.

Overall, user satisfaction reached a 97.2% acceptance rate. Furthermore, the software quality assessment conducted in accordance with ISO 9126 achieved a score of 96.2, placing it at the “meets requirements” level. In the hypothesis testing, a Z_c value of 2.610 was obtained, which is greater than the critical value $Z_t = 1.96$ for a significance level of $\alpha = 0.05$, allowing the null hypothesis to be rejected and the alternative hypothesis to be accepted.

3.2. Discussion

The implementation of the cloud-based web system made it possible to optimize the management of critical information within the Challapalca Special Maximum-Security Prison. The use of centralized storage reduced the limitations associated with traditional media such as physical documents and local devices. These results are consistent with Zhou et al. (2021) and Ahmed and Hussain (2023), who argue that cloud technologies improve the availability, access, and security of institutional information.

Validation of the system according to the ISO 9126 standard yielded a score of 96.2, placing it in the “Meets Requirements” category. The results demonstrated adequate levels of functionality, efficiency, and usability of the implemented system. These findings are consistent with the observations of Zhang et al. (2023), who indicate that cloud-based solutions offer significant improvements in performance and optimization of technological resources.

In terms of user satisfaction, a 97.2% acceptance rate was achieved, indicating a favorable perception of the system’s interface, navigation, and data storage

processes. Likewise, the Z-test statistically confirmed that the system's implementation significantly improves the management of critical information. These results align with Li and Wang (2022), who assert that cloud platforms enhance administrative efficiency and information accessibility in public institutions.

4. CONCLUSIONS

- It is concluded that the implementation of a cloud-based data storage system significantly improves the management of critical information at the Challapalca Special Maximum-Security Prison. This is evidenced by hypothesis testing, where the Z_c value of 2.610 exceeds the critical Z_t value of 1.96, allowing us to reject the null hypothesis and accept the alternative hypothesis.
- It was determined that the implemented system meets the quality criteria established in the ISO 9126 standard, demonstrating adequate levels in areas such as usability, interface quality, error handling, resource optimization, speed, and system performance, thereby ensuring its efficiency and reliability.
- Users expressed a high level of satisfaction, with a 97.2% approval rating, reflecting a positive perception of the interface, navigation, access to information, clarity of data, menu organization, and file storage and sharing processes.
- It was found that the implementation of the system overcame the limitations of traditional storage methods, such as the use of local devices or external storage, thereby reducing the risk of data loss and improving the availability and security of institutional data.
- It is concluded that the use of cloud-based technologies is an effective alternative for managing critical data in public institutions, enabling the optimization of administrative processes, improving access to information, and strengthening control and security mechanisms.

5. ACKNOWLEDGMENTS

To my alma mater, the National University of the Altiplano—School of Statistical and Computer Engineering—for providing me with a quality education within its higher education institutions, and to the faculty for sharing their experiences and knowledge as part of my professional training. Thank you for your guidance.

To my family, for being the driving force that pushes me to achieve my goals and aspirations.

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WORK-RELATED STRESS AND PHYSICAL ILLNESSES AMONG WORKERS AT THE MANUEL NUÑEZ BUTRON REGIONAL HOSPITAL IN PUNO

Fredd Davison Maquera Ramos

45574154@epg.unap.edu.pe

<https://orcid.org/0009-0008-1098-1064>

National University of the Altiplano - Puno



ABSTRACT

Work-related stress is an occupational health problem that arises when the demands of work exceed the worker's resources, manifesting as emotional exhaustion, depersonalization, and a decrease in personal fulfillment, and is associated with various physical ailments. In a context where workload management is weak, this study was conducted to determine the degree of association between work-related stress and physical illnesses among workers at the "Manuel Núñez Butrón" Regional Hospital in Puno in 2019. A quantitative approach, non-experimental correlational design, and cross-sectional scope were employed. A probabilistic sample of 242 workers was used. The instruments used were the Maslach Burnout Inventory (MBI, 22 items) and a 30-item WHO questionnaire for common physical illnesses; both showed good internal consistency, with Cronbach's alpha = 0.89 and 0.95, respectively. Data were analyzed using IBM SPSS Statistics v25. To test the hypothesis, Pearson's chi-square test was applied; the overall analysis showed an association between high stress levels and the presence of physical illnesses ($\chi^2 = 56.25$), with an overall association index of 0.68. The findings reveal a predominance of emotional exhaustion and a higher frequency of digestive disorders, headaches, and musculoskeletal pain among those with high stress levels. It is concluded that work-related stress constitutes a significant risk factor for the physical health of outpatient clinic staff; it is recommended to implement institutional programs for prevention and stress management and to strengthen occupational health surveillance.

Keywords: work-related stress; burnout; physical illnesses; occupational health; outpatient clinic.

1. INTRODUCTION

Work-related stress among healthcare workers is a public health and occupational health issue that affects both individual health and the quality and continuity of the services provided. When the demands of the job exceed available resources, workers experience psychological and physiological reactions that result in a decline in well-being, reduced performance, and an increased risk of somatization. In hospital settings, clinical overload, pressure to achieve results, continuous exposure to emotionally demanding situations, and insufficient human and material resources create a context that is particularly vulnerable to the onset of burnout syndrome and its physical manifestations (Maslach & Jackson, 1981; Maslach, Schaufeli & Leiter, 2001; WHO, 2017).

The construct of burnout encompasses three central dimensions: emotional exhaustion, depersonalization, and reduced personal fulfillment, which allow for the characterization of professional burnout and its functional impact. The empirical literature has consistently shown that high levels of burnout are associated with frequent physical problems among healthcare workers, such as digestive disorders, headaches, musculoskeletal disorders, and cardiovascular disorders; these effects are explained by the interaction between cognitive processes (stress appraisal), job demands, and chronic physiological responses (Lazarus y Folkman, 1984; Karasek, 1979; psycho-neuro-immunological models). In summary, the evidence suggests that the psychosocial burden of work can result in sustained activation of the hypothalamic-pituitary-adrenal axis and inflammatory processes that promote the onset of somatic symptoms.

In Peru, concern over psychosocial factors in the workplace has driven regulatory frameworks and prevention policies, including Law 29783 and the 2017–2021 National Occupational Safety and Health Plan, aimed at promoting safer and healthier work environments. However, gaps persist in local diagnostic approaches that integrate standardized stress measurements and systematic records of physical illnesses in specific populations within the health sector. The “Manuel Núñez Butrón” Regional Hospital in Puno, as a regional referral center, handles a high volume of outpatient care, which increases its staff’s exposure to stressors and creates specific risks stemming from work organization and the region’s environmental conditions. In the words of the thesis that inspired this article: “Work-related stress is a set of reactions the body undergoes in response to multiple risk factors, including those arising from the physical environment, disruption of biological functions, work organization, and various psychosocial, work-related, and non-work-related components.” (Ramos, 2020).

Linking the study of burnout to the presence of physical illnesses addresses a theoretical and practical need. Theoretically, it allows for the integration of

explanatory frameworks (transactional, demand-control, psycho-neuro-immunological) to understand why the same workload produces different health effects depending on personal resources, social support, and coping strategies. Practically, it provides local evidence that facilitates the prioritization of occupational health interventions: identification of critical stressors, design of stress management programs (training, psychological support, workload reorganization), and establishment of protocols for monitoring and recording occupational morbidity. The original thesis documented significant levels of burnout and a high prevalence of physical illnesses among outpatient clinic workers, underscoring the urgency of having robust data for institutional decision-making (Ramos, 2020).

For all these reasons, the purpose of this research is to determine the existence and magnitude of the relationship between work-related stress and physical illnesses among outpatient clinic workers at the “Manuel Núñez Butrón” Regional Hospital in Puno during 2019, with the aim of generating evidence applicable to occupational health management in regional hospital settings and providing input for institutional policies that reduce the burden of work-related illness.

2. METHODS

The study was conducted at the “Manuel Núñez Butrón” Regional Hospital in the city of Puno, a leading regional institution located in the district and province of Puno, Puno Region, in southern Peru, at an altitude of approximately 3,827 meters above sea level. The region’s geographical and climatic context, characterized by low temperatures, high altitude, and high demand for healthcare services, creates a work environment that increases healthcare workers’ exposure to psychosocial and occupational risk factors related to work-related stress, burnout, and physical illnesses resulting from hospital working conditions.

The study was conducted during the year 2019, with approximately five months allocated to the stages of planning, institutional coordination, instrument administration, statistical processing, and analysis and interpretation of results. The research was framed within a quantitative approach, with a non-experimental design, a descriptive-correlational level, and a cross-sectional design, as it aimed to determine the relationship between work-related stress and physical illnesses among administrative workers without deliberately manipulating the study variables (Hernández, Fernández & Baptista, 2014).

The sample consisted of 242 workers selected through non-probabilistic convenience sampling, considering criteria of accessibility, availability, and voluntary participation. The surveyed population included workers of both genders, with participation from both men and women belonging to different areas and professional profiles within the healthcare facility.

The surveys were administered directly to staff comprising physicians, nurses, midwives, nursing technicians, administrative staff, healthcare support staff, and other professionals involved in hospital care. The inclusion of different occupational profiles allowed for a comprehensive view of working conditions and factors associated with occupational stress present within the hospital environment. Additionally, the participation of workers with varying lengths of service and job responsibilities was considered, as prolonged exposure to care workload and organizational pressure can influence the onset of stress-related physical illnesses.

The data collection method used was a survey, and the instruments employed allowed for the assessment of both the level of work-related stress and the presence of physical illnesses related to the hospital work environment. The questionnaires were administered in person within the hospital facilities, following prior coordination with administrative departments and in accordance with ethical criteria regarding confidentiality and voluntary participation by the workers.

To measure the “work-related stress” variable, the Maslach Burnout Inventory (MBI) was used, an instrument developed by Maslach and Jackson (1981) and widely used in research on burnout and occupational health. The questionnaire consisted of 22 items distributed across three fundamental dimensions: emotional exhaustion, depersonalization, and personal accomplishment. Responses were measured using a five-point Likert scale: never, rarely, sometimes, often, and always. The interpretation of scores allowed for the classification of work-related stress levels as low, moderate, and high.

The emotional exhaustion dimension assessed indicators related to physical fatigue, psychological exhaustion, work-related tension, and emotional overload stemming from the demands of hospital work. The depersonalization dimension considered attitudes of indifference, irritability, emotional detachment, and interpersonal coldness toward patients and coworkers. Finally, the personal fulfillment dimension measured work motivation, professional satisfaction, perception of achievement, and assessment of individual performance.

For the “physical illnesses” variable, a questionnaire adapted according to World Health Organization (WHO) guidelines was administered, consisting of 30 items designed to identify physical illnesses and symptoms frequently associated with chronic work-related stress. Among the main conditions considered were digestive disorders, headaches, insomnia, high blood pressure, musculoskeletal pain, and chronic fatigue, as the scientific literature demonstrates a recurring association between occupational stress and deteriorating physical health in healthcare workers.

Table 1*Variables Analyzed in the Study*

Variable	Dimensions	Indicators
1. Work-related stress	1.1. Emotional exhaustion	Physical fatigue, mental exhaustion, emotional tension, psychological exhaustion, work overload
	1.2. Depersonalization	Irritability, indifference, interpersonal detachment, emotional coldness
	1.3. Personal fulfillment	Work motivation, job satisfaction, sense of accomplishment, work performance
2. Physical illnesses	2.1. Digestive disorders	Gastritis, gastrointestinal discomfort, abdominal pain
	2.2. Neurological disorders	Headaches, migraines, insomnia
	2.3. Musculoskeletal disorders	Muscle pain, neck stiffness, physical fatigue
	2.4. Cardiovascular disorders	High blood pressure, palpitations, elevated blood pressure

Note. Compiled based on the Maslach Burnout Inventory (MBI) by Maslach and Jackson and on questionnaires for assessing work-related physical illnesses adapted according to WHO guidelines.

Data processing and statistical analysis were performed using IBM SPSS Statistics version 25. Descriptive statistical procedures were used to determine frequencies, percentages, and the distribution of variables; inferential statistics were also applied to test the research hypothesis and determine the degree of association between the variables studied.

The Pearson chi-square test was used to test the hypothesis, as it allowed for the evaluation of the relationship between the level of work-related stress and the presence of physical illnesses among outpatient clinic workers.

3. RESULTS AND DISCUSSION

3.1 Results

Sociodemographic Characteristics

The sociodemographic results showed a predominance of female staff and healthcare workers in the outpatient clinics of the “Manuel Núñez Butrón” Regional Hospital in Puno. Additionally, a higher proportion of workers with 5 to 10 years of service

was observed, a situation that reflects ongoing exposure to stressors related to the patient care workload, work pressure, and hospital dynamics.

Table 2

Sociodemographic characteristics of the evaluated workers

Sociodemographic variables	Categories	Frequency (n=242)	Percentage (%)
Gender	Male	96	39.7
	Female	146	60.3
Occupational group	Physicians	48	19.8
	Nurses	72	29.8
	Obstetricians	26	10.7
	Nursing technicians	41	16.9
	Administrative staff	33	13.6
	Other healthcare professionals	22	9.1
Length of service	< 5 years	67	27.7
	5 – 10 years	103	42.6
	> 10 years	72	29.7
Employment status	Clinical	187	77.3
	Administrative	55	22.7

Note. Data obtained from a survey of workers.

Prevalence of physical illnesses

Regarding physical illnesses, the most common conditions were headaches, digestive disorders, and insomnia, with a higher prevalence observed among women and among healthcare workers with more than five years of service. These results are related to prolonged exposure to emotional stress and the work demands typical of the hospital environment.

Table 3*Prevalence of physical illnesses among workers*

Physical illnesses	Male n (%)	Female n (%)	Healthcare staff n (%)	Administrative staff n (%)	> 5 years of service n (%)	Total
Headaches	29 (12.0)	49 (20.2)	64 (26.4)	14 (5.8)	53 (21.9)	78 (32.2)
Gastritis and digestive disorders	20 (8.3)	35 (14.4)	43 (17.8)	12 (4.9)	39 (16.1)	55 (22.7)
Insomnia	18 (7.4)	31 (12.8)	38 (15.7)	11 (4.5)	36 (14.9)	49 (20.2)
High blood pressure	19 (7.9)	14 (5.7)	21 (8.7)	12 (4.9)	24 (9.9)	33 (13.6)
Musculoskeletal pain	10 (4.1)	17 (7.1)	21 (8.7)	6 (2.5)	19 (7.9)	27 (11.2)
TOTAL	96 (39.7)	146 (60.3)	187 (77.3)	55 (22.7)	171 (70.7)	242 (100.0)

Note. Percentages were calculated based on the total number of workers evaluated (n = 242).

Work-Related Stress Profile (MBI)

The work-related stress profile showed a predominance of moderate and high levels of burnout, primarily in the emotional exhaustion dimension. The highest stress levels were found among healthcare personnel, especially nurses and physicians, as well as among workers with longer tenure, confirming the influence of work overload and clinical pressure on occupational health.

Table 4*Work-related stress profile according to MBI dimensions*

Variables	Low n (%)	Medium n (%)	High n (%)	Total
Gender				
Male	28 (11.6)	47 (19.4)	21 (8.7)	96
Female	24 (9.9)	74 (30.6)	48 (19.8)	146
Occupational group				
Physicians	8 (3.3)	24 (9.9)	16 (6.6)	48
Nurses	11 (4.5)	37 (15.3)	24 (9.9)	72
Obstetricians	6 (2.5)	13 (5.4)	7 (2.9)	26
Nursing technicians	10 (4.1)	22 (9.1)	9 (3.7)	41
Administrative staff	12 (4.9)	17 (7.0)	4 (1.7)	33
Others	5 (2.1)	8 (3.3)	9 (3.7)	22
Length of service				
< 5 years	24 (9.9)	31 (12.8)	12 (4.9)	67
5 – 10 years	19 (7.9)	58 (24.0)	26 (10.7)	103
> 10 years	9 (3.7)	32 (13.2)	31 (12.8)	72

Note. Classification based on the Maslach Burnout Inventory (MBI) scales.

Table 5*Association between work-related stress and physical illnesses among workers*

Variables	Physical illnesses present n (%)	Physical illnesses absent n (%)	Total
Level of work-related stress			
Low	18 (7.4)	34 (14.0)	52
Medium	87 (36.0)	34 (14.0)	121
High	63 (26.0)	6 (2.5)	69
Gender			
Male	59 (24.4)	37 (15.3)	96
Female	109 (45.0)	37 (15.3)	146
Type of staff			
Clinical	142 (58.7)	45 (18.6)	187
Administrative	26 (10.7)	29 (12.0)	55
Length of service			
< 5 years	38 (15.7)	29 (12.0)	67
5 – 10 years	76 (31.4)	27 (11.2)	103
> 10 years	54 (22.3)	18 (7.4)	72
Total	168 (69.4)	74 (30.6)	242 (100%)

Note. Data obtained from the surveys.

Table 6*Pearson's chi-square test, association between work-related stress and physical illnesses*

Items	Value	df	Asymptotic significance (two-tailed)	Exact significance (two-tailed)	Exact significance (one-tailed)
Pearson's chi-square	56,250	2	,000		
Continuity correction	54,118	2	,000		
Likelihood ratio	58,437	2	,000		
Fisher's exact test				,000	,000
Linear-by-linear association	52,904	1	,000		
Number of valid cases	242				

Note. Results obtained using IBM SPSS Statistics v25.

A statistically significant relationship was found between work-related stress and physical illness ($\chi^2 = 56.25; p < 0.05$), leading to the rejection of the null hypothesis and the acceptance of the alternative hypothesis.

Reliability of the Instruments

It should be noted that both questionnaires have a reliability coefficient of 0.89 for the Maslach Burnout Inventory (MBI) and 0.95 for the physical illness questionnaire, demonstrating high reliability.

3.2. Discussion

The results obtained showed a statistically significant relationship between work-related stress and physical illnesses among outpatient clinic workers at the “Manuel Núñez Butrón” Regional Hospital in Puno, yielding a Pearson chi-square value of $\chi^2 = 56.25$ with a significance level of $p < 0.05$, confirming that workers with moderate and high levels of stress experience a higher frequency of physical ailments, particularly headaches, digestive disorders, insomnia, and musculoskeletal pain. Furthermore, the most affected dimension was emotional exhaustion, a finding that reflects psychological wear and tear associated with work overload and constant caregiving pressure.

These findings are consistent with national and international literature that identifies work-related stress as one of the main psychosocial risk factors among healthcare workers. Studies conducted by Maslach, Schaufeli, and Leiter (2001) indicate that emotional exhaustion is at the core of burnout syndrome and is directly linked to physical changes resulting from prolonged physiological arousal. Similarly, the World Health Organization (WHO, 2017) acknowledges that sustained work demands in the healthcare sector increase the likelihood of digestive, cardiovascular, and musculoskeletal disorders, particularly in hospital settings with high care demands.

Furthermore, the research demonstrates methodological and conceptual consistency. The transactional model by Lazarus and Folkman (1984), as well as Karasek's (1979) demand-control model, explain that when work demands exceed a worker's coping resources, chronic physiological and psychological responses are generated that ultimately affect physical health. In the present study, this relationship was evidenced by the high frequency of physical illnesses observed in workers with high levels of burnout, reinforcing the validity of the findings and their applicability in the regional hospital setting.

4. ACKNOWLEDGMENTS

This work was made possible thanks to the efforts of my mother, Lilia Ramos Pari, who holds a bachelor's degree in psychology. She conducted the foundational

research that enabled the development of this scientific article, and her academic contributions served as the primary foundation for this work. Likewise, I would like to acknowledge the Graduate School and the Academic English course for strengthening the research and scientific skills applied in the writing of this article. Finally, I would like to extend special thanks to Dr. Diana Vargas Velásquez for her guidance and high standards in the preparation of this scientific article.

5. CONCLUSIONS

- A statistically significant association was found between work-related stress and physical illnesses among workers at the “Manuel Núñez Butrón” Regional Hospital in Puno, as evidenced by Pearson’s chi-square test ($\chi^2 = 56.25; p < 0.05$). The results confirmed that workers with moderate and high levels of work-related stress exhibit a higher frequency of physical illnesses related to occupational burnout.
- The emotional exhaustion dimension was the predominant component of burnout syndrome, showing a higher prevalence compared to depersonalization and personal accomplishment. Furthermore, this dimension was more strongly associated with the presence of headaches, digestive disorders, insomnia, and musculoskeletal pain, highlighting the physiological impact of chronic work-related stress on the health of hospital staff.
- The most common physical illnesses identified in the study population were headaches (32.2%), gastritis and digestive disorders (22.7%), and insomnia (20.2%), results that reflect the influence of psychosocial conditions and work overload present in the outpatient hospital setting.
- The instruments used demonstrated adequate internal consistency and high statistical reliability. The Maslach Burnout Inventory (MBI) obtained a Cronbach’s alpha of 0.89, and the physical illness questionnaire achieved a Cronbach’s alpha of 0.95, demonstrating precision and stability in the measurement of the variables studied.
- The findings highlight the need to strengthen institutional strategies aimed at preventing and managing workplace stress through psychological support programs, active breaks, ongoing occupational health monitoring, redistribution of workloads, and the promotion of healthy work environments that help reduce the risk of work-related physical illnesses.
- Finally, it is recommended that future research be conducted using longitudinal designs and larger probabilistic samples, incorporating clinical indicators and biomarkers related to occupational stress, in order to deepen the causal analysis

and evaluate the impact of preventive interventions on the physical health and work performance of healthcare personnel.

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ARTIFICIAL INTELLIGENCE AND ADMINISTRATIVE EFFICIENCY IN THE PROVINCIAL MUNICIPALITIES OF THE PUNO REGION

Nardelina Ochochoque Laura

nardelinalaura@gmail.com

ORCID: 0009-0009-1971-0495

National University of the Altiplano – Puno



ABSTRACT

Digital transformation in the public sector has driven the adoption of technological tools aimed at improving administrative efficiency and enhancing the quality of public services. In this context, artificial intelligence represents a strategic alternative for optimizing administrative processes, reducing operational times, and strengthening institutional management in provincial governments. A quantitative, non-experimental approach with a correlational design was used. The study involved a sample of 120 administrative staff members from the provincial municipalities of the Department of Puno. Data collection utilized a survey-style questionnaire, employing a 64-item closed-ended Likert scale as the primary instrument. Statistical analysis was performed using SPSS version 25. Spearman's Rho coefficient was used to test the hypothesis. The results demonstrated a high positive correlation between artificial intelligence and administrative efficiency ($Rho = 0.684$). It is concluded that the implementation of artificial intelligence represents a necessary strategy to strengthen the modernization of public management and promote more efficient and results-oriented local governments.

Keywords: Administrative efficiency, public management, provincial governments, artificial intelligence.

1. INTRODUCTION

Technology adoption is key to optimizing services in modern governance. New Public Management argues that modernizing the administrative apparatus optimizes fiscal resources and increases citizen satisfaction (García 2023). Thus, implementing government processes with intelligent automation reduces bureaucratic bottlenecks and streamlines document flow.

Artificial intelligence consists of a set of algorithms and computational models capable of automating tasks, processing massive volumes of data, and predicting operational scenarios (Russell and Norvig 2022). In the public sector, this technology serves as operational support through three fundamental dimensions: the automation of repetitive processes, the deployment of intelligent assistance systems, and the consolidation of interconnected digital management.

On the other hand, administrative efficiency is the institutional capacity to maximize public outcomes while minimizing internal time and costs (Mendoza 2024). This governmental characteristic is reflected in the optimization of response times, increased staff productivity, and the quality of service perceived by the user. The success of this variable in local governments depends on coordinating adequate technological support with simplified processes.

The significance of the study lies in the fact that municipal automation speeds up citizen responses by 45% and optimizes administrative procedures by 35% (Sánchez and Benítez). However, the problem in Peru stems from disparities that concentrate technological resources in the central government (Torres 2025). In the Puno region, provincial municipalities face structural deficiencies due to their reliance on physical infrastructure and a slow digital transition in 2026. This needs to incorporate artificial intelligence clashes with technological, organizational, and economic barriers, such as outdated computer systems, a shortage of data science personnel, and limited budgets.

The purpose of this research is to determine how the implementation of artificial intelligence influences the administrative efficiency of provincial municipalities in the Puno region in 2026. To this end, the study evaluates the level of technology adoption and the state of municipal efficiency. Furthermore, the study establishes the relationship between these two variables and identifies the technological, organizational, and economic barriers that restrict their incorporation into municipal management.

2. METHODS

The study was conducted in the 13 provincial municipalities within the department of Puno, Peru. The geographic scope included institutional sites located along an altitudinal gradient ranging from 2,178 to 4,315 meters above sea level, covering various ecological zones in the region (Table 1).

Table 1

Geographical Characteristics of the Provincial Municipalities in the Department of Puno

Province	Average Elevation (Ft above sea level)	Geographic Coordinates
Azángaro	3,859 m	14°54' S, 70°12' O
Carabaya (Macusani)	4,315 m	14°04' S, 70°26' O
Chucuito (Juli)	3,888 m	16°13' S, 69°27' O
El Collao (Ilave)	3,850 m	16°05' S, 69°38' O
Huancané	3,841 m	15°12' S, 69°46' O
Lampa	3,873 m	15°22' S, 70°22' O
Melgar (Ayaviri)	3,918 m	14°53' S, 70°35' O
Moho	3,811 m	15°21' S, 69°30' O
Puno (San Carlos de Puno)	3,827 m	15°50' S, 70°02' O
Saint Anthony of Putina	3,878 m	14°55' S, 69°52' O
San Román (Juliaca)	3,825 m	15°29' S, 70°08' O
Sandia	2,178 m	14°20' S, 69°28' O
Yunguyo	3,826 m	16°15' S, 69°05' O

Note: Data obtained through digital georeferencing on the Google Maps platform (2026).

Data collection took place during the first half of 2026 in their natural setting, with the aim of assessing the characteristics of the variables and determining the degree of association between them. The census-type sample population included all employees in the administrative areas (N = 120). The participants, of both sexes, were between the ages of 18 and 70, according to the records validated by the human resources offices of the provincial municipalities analyzed.

A survey was used for each variable, employing a questionnaire with a five-point Likert scale: Strongly disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly agree (5). For the artificial intelligence variable, the dimensions of process automation, intelligent systems, and digital management were measured; while for administrative efficiency, time optimization, institutional productivity, and service quality were evaluated. Validity was determined by expert judgment and reliability by Cronbach's alpha, yielding a value greater than 0.70.

Data analysis was performed using SPSS version 25. Descriptive analysis utilized frequency tables and percentages, while hypothesis testing and the direction of

association were determined using Spearman's nonparametric Rho correlation coefficient.

3. RESULTS AND DISCUSSION

3.1. Results

Table 2

Frequency distribution and percentages by age of administrative staff.

Age Range	Frequency (f)	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
18 to 30 years (Youth / CAS)	32	26.7	26.7	26.7
31 to 45 years (Young adults)	46	38.3	38.3	65.0
46 to 60 years (Older adults)	28	23.3	23.3	88.3
61 to 70 years (Nearing retirement)	14	11.7	11.7	100.0
Total	120	100.0	100.0	

Note: Questionnaire administered to employees of the Provincial Municipalities of Puno (2026).

The demographic data indicate that the predominant age group is 31 to 45 years old, accounting for 38.3% (46 employees), followed by younger staff aged 18 to 30, accounting for 26.7% (32 employees). Overall, 65.0% of the sample consists of staff under the age of 45, indicating a predominantly young and middle-aged workforce.

Table 3

Levels of AI Implementation and Administrative Efficiency in the Sample.

Study Variable	Level	Frequency (f)	Percentage (%)	Valid Percentage (%)
Independent Variable: Implementation of Artificial Intelligence	Low	54	45.0	45.0
	Half	48	40.0	40.0
	Tall	18	15.0	15.0
	Total	120	100.0	100.0
Dependent variable: Administrative Efficiency	Low	22	18.3	18.3
	Half	68	56.7	56.7
	Tall	30	25.0	25.0
	Total	120	100.0	100.0

Note: Questionnaire administered to employees of the Provincial Municipalities of Puno (2026).

With regard to the first specific objective, 45.0% (54 employees) rate the adoption of AI as "Low," while only 15.0% perceive it as "High." For the second specific objective, 56.7% (68 civil servants) state that Administrative Efficiency is at a

medium level, while 18.3% perceive it as Low, demonstrating that public administration maintains average performance but with outdated technologies.

Table 4

Percentage distribution of the dimensions of the study variables.

Variable / Dimension	Low (f / %)	Half (f / %)	Tall (f / %)	Total (f / %)
V1: AI Implementation				
D1: Process automation	42 (35.0%)	62 (51.7%)	16 (13.3%)	120 (100%)
D2: Technology infrastructure	66 (55.0%)	40 (33.3%)	14 (11.7%)	120 (100%)
D3: Technology training	72 (60.0%)	34 (28.3%)	14 (11.7%)	120 (100%)
D4: Digital Management and the Use of AI	48 (40.0%)	56 (46.7%)	16 (13.3%)	120 (100%)
V2: Administrative Efficiency				
D1: Service time	38 (31.7%)	64 (53.3%)	18 (15.0%)	120 (100%)
D2: Institutional productivity	24 (20.0%)	70 (58.3%)	26 (21.7%)	120 (100%)
D3: Quality of service	18 (15.0%)	68 (56.7%)	34 (28.3%)	120 (100%)
D4: Resource Optimization	32 (26.7%)	62 (51.7%)	26 (21.7%)	120 (100%)

Note: Questionnaire administered to employees of the Provincial Municipalities of Puno (2026).

The dimensional breakdown of the third and fourth specific objectives shows that the main barriers limiting the adoption of AI are technological training (60.0%, low level) and technological infrastructure (55.0%, low level). In contrast, the dimensions related to optimization are concentrated at the medium level, where Process automation (51.7%) and Institutional productivity (58.3%) stand out. However, the Time taken to process citizen requests has the most unfavorable rate at the Low level, at 31.7%.

3.2. Discussion

The findings empirically confirm that the implementation of artificial intelligence has a significant and positive influence on administrative efficiency in provincial local governments in the Puno region ($p=0.684$, $p<0.01$). This finding confirms the principles of contemporary public management, in which digital transformation acts as a catalyst for improving the state, reducing traditional bureaucracy, and streamlining administrative procedures.

When assessing barriers to adoption, the results reveal a structural disconnect in the region. Although 65.0% of the sample consists of digitally literate human capital under the age of 45, technological training stands at a low level of 60.0% and infrastructure at 55.0%. These indicators explain why the overall adoption of

artificial intelligence remains stagnant at a low level (45.0%). This reality aligns with the findings of Alcaide-Muñoz et al. (2020), who argue that the integration of disruptive technologies in local governments fails not due to generational resistance, but rather due to the absence of digital literacy policies and budgets for specialized software. The municipalities of Puno operate under a reactive approach, acquiring isolated licenses without structuring an integrated digital ecosystem.

With regard to the impact on operational processes, process automation shows an average level (51.7%), in line with the average level of administrative efficiency (56.7%). However, the main bottleneck lies in response time, which 31.7% of public servants rated as low. This phenomenon is supported by Criado and Gil-Garcia (2019), who state that public organizations easily digitize their internal (back-office) processes but fail to optimize their front-office service windows. In the municipalities of Puno, San Román, and Chucuito, the absence of virtual agents or predictive systems to resolve citizen requests perpetuates long response times.

Finally, the correlation obtained validates the principles of smart government. The results are consistent with those of Valle-Cruz et al. (2021), who demonstrated in Latin American contexts that the use of algorithms for financial decision-making reduces operating costs and increases transparency. For municipalities in the Puno region, the high statistical significance obtained ($p=0.000$) is a clear indicator that, by overcoming connectivity gaps and institutionalizing artificial intelligence training programs, administrative efficiency will shift from the current average level toward highly competitive standards.

4. CONCLUSIONS

- It was determined that the implementation of artificial intelligence tools has a significant and positive impact on the administrative efficiency of the provincial municipalities in the Puno region in 2026. This finding is scientifically demonstrated through the application of Spearman's Rho correlation coefficient, which reported a value of $\rho = 0.684$ with a two-tailed significance level of $\text{Sig.} = 0.000$ (a value below the critical threshold of $\text{Alpha} = 0.05$). Statistically, this represents a moderate-to-high relationship, which allows us to reject the null hypothesis and affirm that a planned increase in the adoption of smart technologies directly raises the standards of optimization and performance in local public management.
- It was found that the level of implementation of artificial intelligence tools in the provincial municipalities of the Puno region is predominantly low (45.0%), followed by a medium level (40.0%) and an emerging high level (15.0%). These quantitative results show that the deployment and integration of algorithmic or automated solutions in Puno's municipalities is in an initial or embryonic phase,

characterized by isolated efforts and a clear absence of a unified technological ecosystem within the regional public administration.

- The assessment found that the level of administrative efficiency in the provincial municipalities of the Puno region is predominantly at a medium level (56.7%), while 25.0% is perceived as High and the remaining 18.3% as Low. It is concluded that, although local administrative management maintains an acceptable level of operational consistency in the performance of its routine functions, it suffers from bureaucratic stagnation that limits its transition toward a modern and competitive public management model.
- The analysis showed that institutional productivity (58.3%) and service quality (56.7%) are at intermediate levels due to initial progress in internal data automation. However, a critical shortfall was identified in response time to citizens, which registered a low level (31.7%). This indicates that the nascent automation is concentrated on internal processes (back-office), neglecting the front-office service counter for end users.
- The main structural barriers identified as drastically limiting the adoption of artificial intelligence in municipal management were technological training (60.0% at the “Low” level) and technological infrastructure (55.0% at the “Low” level). Despite having an administratively young and mid-level workforce (65.0% of civil servants are under 45 years of age), the lack of specialized digital literacy programs and the shortage of civil servants or adequate IT equipment negate the human capital’s readiness, becoming the most severe institutional barriers to modernization in the Puno region.

5. ACKNOWLEDGMENTS

I am deeply grateful to the Graduate School of the National University of the Altiplano for opening the doors to my research development and providing me with the tools necessary to achieve this academic goal. In particular.

I would like to express my gratitude to my professors for generously sharing their knowledge and valuable time, and for patiently guiding me through every stage of this work. I also extend this gratitude to our institution’s Language Program for the support provided during my education and for equipping me with the language skills necessary to access global scientific literature, which was essential for the development and completion of this research.

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ASSESSMENT OF LIGHTING COMFORT THROUGH CHROMATIC SYNERGY: A LOOK AT THE PASIRI HEALTH CLINIC IN PUNO

Leidy Estrella Olaguivel Zapana

<https://orcid.org/0000-0001-9711-2591>

leidyestrella1998@gmail.com

Universidad Nacional del Altiplano



ABSTRACT

Hospital lighting ensures conditions suitable for clinical activities through natural or artificial light in accordance with standards. Chromatic synergy combines color and lighting to improve perception and well-being. Lighting comfort enables visual activities with adequate and uniform levels of light and color. The purpose of this study was to evaluate the lighting comfort of the architectural environments at the Pasiri Health Center to determine the efficiency of the lighting and the chromatic properties of each architectural space. The research was conducted using a quantitative, non-experimental approach with a correlational, cross-sectional design, aimed at evaluating lighting comfort in the facility's environments. The primary instrument was a UNI-T UT383 digital lux meter to measure illuminance. Additionally, data sheets and comparative matrices were used to record data and assess regulatory compliance. Data processing was systematized in Excel using Student's t-test, and both variables were integrated to determine lighting comfort and chromatic synergy. The results reveal a lighting deficit: 62% do not comply with regulations, 23% comply, and 15% partially comply. Although light tones improve perception, they do not compensate for the insufficient lighting. Student's t-test confirms significant differences and low lighting comfort. In conclusion, there is a lighting deficit and low regulatory compliance. The color scheme used does not compensate for the insufficient lighting. The combination of these two factors results in poor lighting comfort, which affects users' functionality, safety, and well-being..

Keywords: Architectural Lighting, Color, Hospital Architecture, Lighting Comfort and Lux Meter.

1. INTRODUCTION

Architectural lighting in healthcare facilities is essential for ensuring spaces that are functional, safe, and suitable for clinical activities. Proper lighting improves the quality of care and the well-being of patients (WHO, 2009). Illuminance, measured in lux, must meet minimum values established by the Illuminating Engineering Society (IES, 2020), such as 300 lux in consultation areas and 500 lux in critical zones, as failure to do so can lead to eye strain and errors. Likewise, the International Commission on Illumination (CIE, 2018) notes that lighting quality depends on distribution, uniformity, glare control, and color rendering, so hospital design must appropriately integrate natural and artificial lighting.

Color theory in hospital architecture uses color strategically to influence users' perception, orientation, and well-being, serving aesthetic, functional, and psychological purposes. According to Ching (2015), light colors, such as whites and beiges, enhance the sense of spaciousness and brightness due to their high reflectance. In this vein, the CIE (2018) notes that light surfaces improve light distribution, while dark surfaces absorb light and reduce visual quality. Furthermore, appropriate use of color helps reduce stress, improve orientation, and promote patient recovery (Ulrich et al., 2008), so its design must be balanced and comprehensive.

The Pasiri Health Center, located in Juli, Chucuito - Puno, is a key facility for rural healthcare; however, it suffers from infrastructure limitations that affect lighting comfort. Specifically, deficiencies have been identified in the lighting and color scheme, with low luminance despite high-reflectance finishes, indicating inadequate integration of the lighting design. Furthermore, the windows do not comply with Technical Standard No. 113-MINSA, restricting natural light. This situation reflects a deficient architectural design, which negatively impacts functionality, healthcare performance, and user well-being.

The purpose of this study is to evaluate lighting comfort at the Pasiri Health Center using a comprehensive approach that integrates architectural lighting and color schemes across different spaces, as there is a need to improve the architectural lighting and its color design, since it does not meet regulatory standards.

2. METHODS

The study was conducted at the Pasiri Health Post, located in the district of Juli, province of Chucuito, Puno region, in southern Peru, at an elevation of 3,070 meters above sea level, at UTM coordinates North (N) 451 350 and East (E) 8 192 025. This facility belongs to the Chucuito Health Network and serves as a primary care center for the rural population of the area.

The study was conducted over a six-month period, from September 2025 to January 2026. A quantitative, non-experimental approach was adopted, using a correlational, cross-sectional design aimed at evaluating lighting comfort in the facility's environments.

First, data was collected in thirteen identified areas of the Pasiri Health Center (CRED, cold chain, storage room, waiting room, first-aid room, pharmacy, obstetrics, restrooms, sputum testing room, kitchen-dining room, residential restrooms, residence 1, and residence 2). To this end, on-site measurements of illuminance levels were taken using a UNI-T UT383 digital lux meter. The measurements were performed using the point method, placing the instrument at the center of each room, at heights of 1.60 m (standing position) and 0.90 m (seated position), in order to represent the actual conditions of use of the space. These measurements were supplemented by a lighting analysis and architectural observation of each room.

Next, a color analysis was conducted, taking into account the predominant color, the percentage of dominant white, and the color intensity of each environment, with the aim of evaluating their influence on light perception. This information was recorded using observation forms.

Subsequently, the data obtained were compared with the values established in current regulations for healthcare facilities (NTS No. 113, RNE A.010, WHO, International Commission on Illumination – CIE S 008/E:2018, and World Health Organization – Guidelines for Health-Care Facilities), by creating comparative tables in spreadsheets (Excel), which allowed us to determine the degree of regulatory compliance for each environment.

Finally, inferential statistical methods, such as Student's t-test for a single sample, were applied to assess the significance of the differences between the measured illuminance levels and the standard values. In addition, the results regarding illuminance and color rendering were combined to evaluate lighting comfort comprehensively, with the aim of drawing technical conclusions about the quality of hospital environments and their impact on user well-being.

Table 1*Variables, dimensions, and indicators of architectural lighting comfort*

Variable	Dimensions	Indicators	Unit of measurement	Instrument/Technique
Architectural lighting	Natural lighting	Illuminance level per room	Lux (lx)	Digital lux meter
		Regulatory compliance	Compliant / Partially compliant / Non-compliant	Regulatory comparison (NTS N°113 / technical standard)
		Difference between standard and actual lux	Lux (lx)	Calculation of the illuminance gap
	Color evaluation	Percentage of dominant white	%	Architectural color analysis
		Color intensity of the environment	Qualitative (Very low – High)	Observation + data sheet
		Predominant color type	Color (white, beige, blue, etc.)	Color survey
	Lighting comfort	Adjusted Light Comfort Index	Index (0–1 or standardized scale)	Combined statistical model
		Perceptual suitability of the environment	Low / Medium / High	Technical-architectural assessment
		The Importance of Lighting Comfort	Student's t-test	Statistical Inference

Note: Variables analyzed in the study, dimensions and indicators, unit of measurement, and the instrument/technique.

3. RESULTS AND DISCUSSION

Results

Table 2

Descriptive analysis of architectural lighting levels.

Environment	Recommended lux level according to regulations	Current lux level	Difference from regulatory minimum (lux)	Regulatory compliance
CRED	300 lux	280 lux	-20	Partial
Cold chain	200 lux	90 lux	-110	Does not meet
Storage room	200 lux	80 lux	-120	Does not meet
Waiting room	200 lux	210 lux	+10	Meets
First-aid room	500 lux	260 lux	-240	Does not meet
Pharmacy	500 lux	190 lux	-310	Does not meet
Obstetrics	300-500 lux	240 lux	-60	Partial
Social Services	100-200 lux	60 lux	-40	Does not meet
Sputum test	300 lux	70 lux	-230	Does not meet
Kitchen-dining room	300 lux	220 lux	-80	Does not meet
Social Services: Residential Care	300 lux	95 lux	-205	Does not meet
Residential Care 1	100 lux	110 lux	+10	Meets
Residential Care 2	100 lux	100 lux	+0	Meets

Note: Values determined through architectural assessment and measurement using a digital lux meter.

The descriptive analysis of the architectural lighting levels in the 13 spaces evaluated reveals widespread non-compliance with current regulations. According to the technical interpretation, only 3 spaces (23%) meet the required levels, 2 spaces (15%) partially meet them, and 8 spaces (62%) do not meet the established minimum values, reflecting a deficient condition in the evaluated infrastructure.

Among the areas in compliance with regulations are the waiting room, Residence 1, and Residence 2, all of which have adequate levels of simulated lighting in relation to their functional requirements. The CRED and the obstetrics area fall into the partially compliant group; although they approach regulatory values, they still have shortcomings that affect optimal visual performance. On the other hand, the areas with the highest level of non-compliance are the pharmacy, the sputum testing area, the topical treatment area, the restrooms, and service areas such as the cold chain and the warehouse, where the recorded lux levels are significantly below the required levels, indicating critical deficiencies in artificial lighting.

Consequently, the results show that the evaluated infrastructure has a significant deficiency in lighting levels, with values predominantly below current regulations, which directly impacts the functionality of healthcare spaces, increases risks in care processes, and reduces visual comfort for both users and healthcare staff.

Table 3

Percentage distribution of color use by room

Setting	Applied color	Pantone code	% other colors	% dominant white	% wood (doors)	Color intensity
CRED	Smoky white	Pantone 12-0704 TCX	22%	78%	100%	Low
Cold chain	Blue	Pantone 7541 C	18%	82%	100%	Very low
Warehouse	Beige	Pantone 9202 C	15%	85%	100%	Very low
Waiting room	Beige	Pantone 9202 C	30%	70%	100%	Lower-middle
First-aid room	Smoky white	Pantone 12-0704 TCX	32%	68%	100%	Middle
Pharmacy	Smoky white	Pantone 12-0704 TCX	28%	72%	100%	Lower-middle
Obstetrics	Smoky white	Pantone 12-0704 TCX	35%	65%	100%	Middle
Social Services	Smoky white	Pantone 12-0704 TCX	20%	80%	100%	Low
Sputum test	Smoky white	Pantone 12-0704 TCX	25%	75%	100%	Lower-middle
Kitchen-dining room	Beige	Pantone 9202 C	40%	60%	100%	Middle
Social Services: Residential Care	Smoky white	Pantone 12-0704 TCX	17%	83%	100%	Very low
Residential Care Facility 1	Beige	Pantone 9202 C	45%	55%	100%	Upper-middle
Residential Care Facility 2	Beige	Pantone 9202 C	45%	55%	100%	Upper-middle

Note: Data obtained through color analysis, architectural observation, and lighting simulation.

The project's color synergy analysis is based on a limited white-beige palette, in which white serves as the dominant color (70%) in all spaces, ensuring the sterility, order, and visual neutrality characteristic of a hospital environment, while beige is incorporated as a functional accent (30%) to provide warmth, orientation, and lighting comfort depending on the nature of the space. Technical and service areas such as the storage room, cold chain, and restrooms feature a greater predominance of white (82%) with minimal use of other colors, which are limited to hospital furniture (18%), reinforcing their operational and control-oriented nature. In contrast, care and intermediate-use areas such as waiting rooms, treatment rooms, obstetrics, medication dispensing, and sputum testing maintain an intermediate balance (70% white and 30% beige), promoting orientation and stress reduction. Finally, spaces for prolonged stays, such as patient rooms and the kitchen-dining area, increase the presence of beige (42%), creating greater warmth and a sense of livability, without losing the hygienic foundation of white (58%), thus achieving a functional color hierarchy consistent with hospital standards.

Table 4

Student's t-test for a sample of lighting comfort (illumination + color evaluation)

Parameter	Result
Variable analyzed	Architectural lighting comfort (lux + chromatic support)
Number of environments (n)	13
Mean of differences (d)	-0.85 (adjusted comfort index)
Standard deviation (s)	0.74
Standard error (s/ $\sqrt{n}$)	0.20
Calculated t-statistic	-4.23
Degrees of freedom (df)	12
Critical t-value ($\alpha = 0.05$, two-tailed)	± 2.179
Statistical decision	H_0 is rejected
Statistical interpretation	There are significant differences in adjusted lighting comfort
Architectural interpretation	Chromatic support does not compensate for the lighting deficit in critical environments
Technical conclusion	Significantly deficient overall lighting comfort is evident, even with chromatic support

Note: Student's t-test for a single sample, taking into account expanded visual comfort (illumination + color evaluation as a perceptual support factor).

The results of the Student's t-test applied to integrated architectural lighting comfort (lighting and color rendering) show a statistically significant difference from the theoretical reference values. An average difference of -0.85 was obtained in the adjusted comfort index, with a t-statistic of -4.23 and 12 degrees of freedom, a value that exceeds the critical threshold of ± 2.179 ($\alpha = 0.05$), and therefore the null hypothesis is rejected. This result confirms that the overall lighting comfort of the evaluated architectural complex presents a significant deficit, where the contribution of color—although based on a predominance of light tones—fails to compensate for the insufficient lighting levels in the analyzed environments. Consequently, there is evidence of a structurally deficient lighting comfort condition, especially in clinical and care spaces, where visual demands are most critical.

3.1. Discussion

According to the Illuminating Engineering Society (IES, 2020), architectural lighting for specific environments must meet appropriate illuminance levels, as proper lighting design ensures visual accuracy and operational efficiency in hospital settings; likewise, the World Health Organization (2009) notes that adequate lighting improves the quality of care and reduces clinical risks, while the International Commission on Illumination (2018) emphasizes the importance of uniformity and glare control. However, it was found that at the Pasiri Health Center, 62% of the rooms do not comply with regulations, indicating widespread under-illumination. This situation aligns with previous reports of deficiencies in primary care facilities, where lighting design does not meet comprehensive technical criteria, leading to visual fatigue, reduced work performance, and a higher likelihood of errors in patient care.

According to Francis D. K. Ching (2015), color schemes should be based on the use of light colors, as they enhance the perception of space and brightness; likewise, the International Commission on Illumination (2018) maintains that light surfaces optimize light distribution, while studies such as those by Hildegard E. Peponis highlight that color influences spatial orientation and understanding. In this context, it was found that the Pasiri Health Center features an appropriate and functional white-beige color palette; however, this strategy does not compensate for the existing under-illumination, demonstrating that color acts as a complementary rather than a corrective element within the lighting system.

According to Roger S. Ulrich et al. (2008), lighting comfort must be adequate, as they found that proper lighting improves patient well-being, safety, and staff performance; similarly, research by Judith Heerwagen indicates that environmental quality directly influences patients' recovery and emotional state. However, Student's t-test revealed significant deviations from standard values at the Pasiri Health Center, confirming an overall deficit in lighting comfort. Consequently, it is

demonstrated that, although an adequate chromatic base exists, the inadequacy of the architectural lighting design results in poor environmental quality, affecting the functionality, safety, and well-being of users.

4. CONCLUSIONS

- It was found that architectural lighting in most spaces fails to meet current regulations, with only a minority of spaces complying with the established minimum illuminance levels, while the majority suffer from significant under-illumination. This condition is most critical in clinical care and diagnostic support settings, where recorded lux levels fall short of functional requirements, compromising adequate visibility and the proper performance of care activities.
- An analysis of the color scheme by space revealed a predominant strategy based on a white-beige palette, in which white serves as the dominant color due to its high reflectance and sterile qualities, while beige acts as a supporting element to provide warmth and spatial orientation. However, it became evident that, although the color scheme is technically appropriate and organized according to the use of the spaces, its ability to compensate for lighting deficiencies is limited given the existing lighting shortfalls.
- The assessment of lighting comfort through the synergy between lighting and color schemes revealed a significant overall deficit in the environmental quality of hospital spaces. The integration of both variables revealed that, despite having an appropriate color scheme based on light tones, this fails to compensate for the inadequacy of architectural lighting, a situation that was statistically corroborated using Student's t-test, confirming significant differences from the reference values. Consequently, it is concluded that the lighting comfort of the facility is structurally deficient, with a direct impact on the functionality, safety, and well-being of users.

5. ACKNOWLEDGMENTS

This project was successfully completed thanks to the faculty members at UNA – Puno. We would also like to thank the Graduate School of the National University of the Altiplano and the Language Program, and in particular Dr. Diana Vargas Velásquez for guiding the development of this scientific article.

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HUMAN TALENT MANAGEMENT AND TEACHER PERFORMANCE: A LOOK AT THE ARMY CAVALRY SCHOOL IN LIMA

Ángel Mauro Ortiz Cornejo

kennethcito06@gmail.com

<https://orcid.org/0000-0002-6703-9220>

National University of the Altiplano - Puno



ABSTRACT

Human talent management is a fundamental pillar of the military training sector, as effective management of this resource directly impacts educational quality and instructor performance. In this context, the objective of this study was to determine the relationship between human talent management and teaching performance at the Peruvian Army Cavalry School in Lima during the year 2025. The study employed a quantitative, non-experimental approach with a correlational design and a cross-sectional scope. It utilized a non-probabilistic, purposive sample of 50 officers who perform teaching and instructional duties. A survey-type questionnaire was used for data collection, employing two closed-ended Likert-scale questionnaires: one with 43 items to assess talent management and another with 40 items for teaching performance. Data processing was performed using SPSS statistical software, version 27. Spearman's Rho correlation coefficient was used to test the hypothesis. The results demonstrated a positive, moderate, and statistically significant relationship ($Rho = 0.579$). It is concluded that the adoption of effective human talent management policies has a direct impact on improving teaching performance at the institution.

Keywords: Human resources, military education, talent management, teacher performance.

1. INTRODUCTION

In today's global landscape, the strategic management of intellectual capital has emerged as a key driver of organizational effectiveness. Human talent management (HTM) is a fundamental pillar in the military sector, as it has a direct, sustained, and profound impact on operational performance, personnel occupational health, and, critically, on the training of future officers who will lead national security initiatives.

For its part, the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2024) warns that there is a structural crisis in the attraction and retention of teachers globally, emphasizing that the optimization of human resource management policies is the only viable strategy to ensure high-quality education. In this vein, Chiavenato (2020) defines HTM as a holistic and integrated set of policies and procedures designed to structure, enhance, and invigorate personnel-related components.

On the other hand, teaching performance in highly demanding environments, such as the Peruvian Army Cavalry School, is a key factor in ensuring the tactical, technical, and ethical training of cadets. According to Montenegro (2015) and Flores (2012), effective pedagogical practice requires instructors to possess superior adaptability, which manifests itself in the ability to plan learning, implement innovative training activities, and engage with the institutional community. Within the military organizational framework, the instructor (officer-instructor) faces the dual challenge of maintaining military orthodoxy and discipline while applying flexible teaching methodologies that stimulate critical thinking (Aucca et al., 2024). Therefore, teaching in this field is methodologically divided into four fundamental dimensions: preparation for learning, active classroom instruction, participation in school management, and the continuous development of professionalism and teaching identity (Peruvian Ministry of Education [MINEDU], 2022).

The importance of linking these two constructs—human talent management and teacher performance—has been confirmed by a wide range of recent research. Internationally, Chaparro (2015) and Sarmiento (2017) demonstrated qualitatively that neglecting staff members' psychosocial and training needs invariably leads to a decline in institutions' academic performance. In the Latin American context, Alarcón (2015) found that public educational efficiency suffers from administrative inefficiency due to archaic resource management models, showing a high positive correlation of 0.819. At the national level, research by Paredes (2017) and Espinoza (2017) established significant correlations of 0.768 between human capital management and institutional performance. More specifically, in military contexts analogous to that of this study, García and Yanarico (2025) identified a strong positive association of 0.805 at the Army Armored School. Conversely, Serrano and Gonzales (2016), in their analysis of the Cavalry School itself, warned that an inadequate organizational climate and a lack of workplace recognition had a corrosive effect on the efficiency of instructors. This dichotomy in the literature highlights a gap in empirical knowledge regarding the current impact of institutional guidelines on the daily practice of teaching officers.

From an axiological and teleological perspective, this research is justified theoretically, methodologically, socially, and practically. Theoretically, the study enriches the academic literature by interrelating Chiavenato's (2020) systemic model

with the MINEDU's (2022) performance rubrics in an atypical and largely unexplored setting such as a high-ranking military academy. Socially and practically, the findings provide a clinical, evidence-based diagnosis that will enable the Peruvian Army leadership to reformulate its recruitment, welfare, and promotion policies, eradicating obsolete practices and fostering a culture of high performance that will indirectly benefit national security through better-prepared officers. Methodologically, it provides rigorously validated measurement tools for future replication.

2. METHODS

This research was conducted at the Peruvian Army Cavalry School, a military institution located in the district of Chorrillos, in the province and region of Lima. Its geographical location is in a strategic area of the country's capital that is home to various military training institutions; the importance of this study site lies in the fact that it is an institution where multiple stakeholders converge: training officers, civilian and military instructors, administrative staff, and cadets in training. The request was submitted to the Peruvian Army Cavalry School, where the study was conducted during the first semester of 2025. The study employed a quantitative, non-experimental approach with a correlational design and a cross-sectional scope, utilizing a non-probabilistic, purposive sample of 50 officers who perform teaching and instructional duties.

The data collection framework was based on psychometric survey methodology. As measurement tools, two structured self-report questionnaires were designed, validated, and administered, based on a five-point Likert-type scale. The first instrument, designed to assess Human Talent Management, consisted of 43 items that examined the dimensions of personnel selection, training, evaluation, development, and compensation, based on the principles of Chiavenato (2020). The second instrument, focused on quantifying Teaching Performance, consisted of 40 items distributed symmetrically across the dimensions of lesson preparation, teaching delivery, institutional engagement, and professional ethics (MINEDU, 2022). Both instruments underwent rigorous content validity processes through expert review by specialists in military science and higher education, as well as statistical reliability tests for internal consistency.

Table 1

VARIABLE	DIMENSIONS	FREQUENCY SCALE
HUMAN TALENT MANAGEMENT	Staff Onboarding	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
	Staff Placement	
	Staff Compensation	
	Staff Development	
	Staff Retention	
	Staff Supervision	
TEACHER PERFORMANCE	Preparing students for learning	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
	Teaching to support student learning	
	Participation in coordinated school management	
	Development of professional competence and teacher identity	

Variables analyzed in the study

The research process proceeded in sequential phases: first, obtaining the necessary approvals from military authorities to ensure the protection and anonymity of the information in accordance with international bioethical protocols; second, the controlled administration of the questionnaires; and third, the systematization of the metrics. The analytical framework for the data was implemented using the Statistical Package for the Social Sciences (IBM SPSS) version 27. Analyses of absolute and relative frequencies were conducted for the descriptive phase. In the inferential phase, the Shapiro-Wilk goodness-of-fit test was first performed to assess the normality of the sample distribution; although the p-values indicated normality, the ordinal nature underlying the Likert scales dictated the use of Spearman's nonparametric Rho statistic, thereby maximizing the robustness and power of hypothesis testing.

3. RESULTS AND DISCUSSION

3.1. Results

The statistical analysis yielded substantial empirical findings that outline the organizational landscape of the military institution under study. At the level of categorical descriptive analysis, a highly interesting perceptual asymmetry emerged regarding how officers conceptualize institutional efforts versus their own teaching practices.

Table 2*Frequencies and percentages of the study variables*

Levels	HTM (f)	HTM (%)	Teacher performance (f)	Teacher performance (%)
High Level	49	98.0%	2	4.0%
Medium Level	1	2.0%	48	96.0%
Low Level	0	0.0%	0	0.0%
Total	50	100.0%	50	100.0%

Note. Data obtained from SPSS Software V° 27.

As shown in Table 2, the Human Talent Management variable exhibited an extraordinary and polarized concentration in the top quartile: 98.0% of the instructor officers (49 subjects) perceive the Cavalry School's recruitment, training, and incentive policies to be of excellent quality. The self-assessment and peer assessment of Teaching Performance showed a curve toward the central range: an overwhelming 96.0% (48 officers) reported a 'Medium' performance level, and only 2 officers (4.0%) achieved the 'High' performance rating. This telling contrast reveals that, while the military administrative structure is rated as optimal, there is a systemic barrier preventing that environment from translating into pedagogical excellence.

Table 3*Correlation - Human Talent Management vs. Learning Readiness*

Hypothesis	Variable 1	Variable 2	Rho	p-value	Result	Conclusion
H.E. 1	Human Talent Management	Preparing for Learning	0.362	0.00979	Sig. ✓	Accepted H1

Note. Data obtained from SPSS Software V° 27.

Table 3 shows that specific hypothesis 1 is accepted. There is a significant ($p = 0.0098$) and positive ($Rho = 0.362$) relationship between HTM and Learning Readiness. However, its moderate-to-weak magnitude suggests that lesson preparation is also determined by additional factors such as accumulated teaching experience, specific pedagogical training, and access to educational resources and materials.

Table 4*Correlation - Human Talent Management vs. Teaching for Learning*

Hypothesis	Variable 1	Variable 2	Rho	p-value	Result	Conclusion
H.E. 2	Human Talent Management	Teaching for Learning	0.475	0.00049	Sig. ✓	Accepted H2

Note. Data obtained from SPSS Software V° 27.

Table 4 shows that specific hypothesis 2 is accepted. There is a significant ($p = 0.00049$) and moderately positive ($Rho = 0.475$) relationship between Human Talent Management and Teaching for Learning. This is the most important finding of the study: human talent management has the greatest impact on the quality of teaching during classes.

Table 5*Correlation - Human Talent Management vs. Participation in Coordinated Management*

Hypothesis	Variable 1	Variable 2	Rho	p-value	Result	Conclusion
H.E. 3	Human Talent Management	Participation in Management	0.156	0.2796	No sig. X	Not accepted. H3

Note. Data obtained from SPSS Software V° 27.

Table 5 shows that specific hypothesis 3 is rejected. There is no significant relationship ($p = 0.2796$) between HTM and Participation in Community-Linked Management. The weak and non-significant correlation ($Rho = 0.156$) suggests that improving institutional participation requires specific interventions beyond individual talent management.

Table 6*Correlation – Human Talent Management vs. Professional Development*

Hypothesis	Variable 1	Variable 2	Rho	p-value	Result	Conclusion
H.E. 4	Human Talent Management	Professional Development	0.398	0.00419	Sig. ✓	Accept H4

Note. Data obtained from SPSS Software V° 27.

Table 6 shows that specific hypothesis 4 is accepted. There is a significant ($p = 0.0042$) and moderately positive ($Rho = 0.398$) relationship between HTM and the development of professional competence and teaching identity.

Table
Hypothesis Testing Matrix (Spearman's Rho Correlations)

Hypothesis Formulated (HTM vs)	Statistician (Rho)	Level Sig. (p)	Statistical Decision
Teaching Performance (Overall)	0.579	< 0.00001	Alternative Hypothesis Accepted
Dim 1: Lesson Preparation	0.362	0.00979	Alternative Hypothesis Accepted
Dime 2: Teaching for Learning	0.475	0.00049	Alternative Hypothesis Accepted
Dim 3: Participation in School Management	0.156	0.27960	Alternative Hypothesis Rejected
Dim 4: Professional Development	0.398	0.00419	Alternative Hypothesis Accepted

Note. Data obtained from SPSS Software V° 27.

Based on Table 7, the correlation coefficient for the general hypothesis was $Rho = 0.579$, heuristically categorized as a positive relationship of moderate magnitude. The probability test yielded a p-value < 0.00001 , far exceeding the alpha significance level of 0.05. Consequently, the null hypothesis was rejected, conclusively demonstrating that human talent management has a significant and influential relationship with the performance of training officers.

The interaction of the specific objectives revealed heterogeneous phenomena. The greatest formative impact of human talent policies unquestionably fell on the dimension of the “Teaching for Learning” practice within the classroom (0.475), demonstrating that military training equips teachers with methodological skills. However, the analytical climax emerged in the contrast of the third specific hypothesis: the correlation between HTM and ‘Participation in community-linked management’ yielded a meager 0.156, with a stochastic margin of error of 27.9%, leading to the resounding empirical rejection of this association. Finally, peripheral training dimensions such as curricular preparation (0.362) and professional identity construction (0.398) showed statistically valid and moderate correlations.

3.2. Discussion

The findings presented in this manuscript contribute to an in-depth scholarly dialogue with the existing literature and the theoretical framework of organizational management. The positive confirmation of the general hypothesis, quantified by a

Rho of 0.579, empirically validates the core axiom proposed by Chiavenato (2020), which holds that the synergies generated by optimal selection, motivation, and training of human resources act as driving forces for operational effectiveness. This level of association aligns qualitatively, albeit with quantitative nuances, with the metrics cited by García and Yanarico (2025), who recorded a considerably stronger correlation (0.805) at the Army Armored School. The discrepancy in the strength of the correlations between sister military academies strongly suggests that latent moderating variables, such as the specific leadership microclimate of the Cavalry unit or the institution's seniority, act as catalysts or inhibitors of the transfer of competencies toward actual teaching efficiency (Aucca et al., 2024).

Particularly revealing is the discrepancy observed at the descriptive level: the yawning chasm between the 98% of officers who applaud talent management and the stagnant 96% mired in the mediocrity of "average" performance. This systemic fracture finds a resounding echo in the critical postulates of Serrano and Gonzales (2016), who previously analyzed the Cavalry School in depth, concluding that inadequate management of the psychosocial ecosystem structurally stifled the educator's potential. Our data suggest a paradigm of 'blocked competence': the military institution recruits and trains elite talent, but the inflexibility of hierarchical orthodoxy does not provide the autonomy required for the instructor to elevate their practice to a higher degree of creativity.

The dimensional breakdown dramatically reinforces this theoretical assertion. While the benefits of HTM manage to seep into the classroom, effectively improving "teaching" methodologies (Rho = 0.475), they fail miserably when attempting to integrate the training officer into strategic decision-making. The total absence of statistical correlation (Rho = 0.156, $p > 0.05$) with participation in institutional management demonstrates that the Army operates inexorably under the traditional top-down model. An officer may possess formidable skills resulting from impeccable training, but the military chain of command inexorably restricts the spaces for cross-cutting dialogue and shared governance that characterize contemporary civilian educational spheres (UNESCO, 2024). In conclusion, the resources invested in human management optimize the teacher's algorithmic performance but do not empower them to take on roles of institutional innovation.

4. CONCLUSIONS

- There is a positive relationship between human talent management and teaching performance at the Peruvian Army Cavalry School during the 2025 period; this relationship is of moderate magnitude and highly statistically significant (Rho = 0.579, $p < 0.00001$). This means that talent attraction and development policies account for 33.5% of the variance in officers' teaching performance, demonstrating that institutional organizational maturity is an indispensable pillar

for ensuring military training of excellence, even when other environmental factors influence the remaining portion of effectiveness.

- With regard to readiness for learning, a statistically significant and direct correlation ($Rho = 0.362$, $p < 0.05$) was found between human capital management and readiness for learning. Although modest in scope, this correlation suggests that the methodological training provided fosters better structuring of the syllabus design, allocation of resources, and conceptualization of pedagogical objectives prior to the training activity.
- Between the level of human talent management and participation in community-oriented institutional management, the results indicate a lack of a statistically significant relationship ($Rho = 0.156$, $p = 0.279$). This corollary exposes a blind spot in the military cultural fabric: vertical hierarchical discipline regulations act as a restrictive barrier, preventing highly qualified and competent instructors from proactively engaging in the democratization and comprehensive structuring of their school's academic projects.
- With regard to the development of professional competence and teaching identity, it is evident that the mechanisms of extrinsic and intrinsic motivation employed by the Army have a positive influence on the ethos, critical self-reflection, and gradual assumption of the role of educator in an individual whose primary psyche was shaped by the archetype of the combatant.

5. ACKNOWLEDGEMENTS

I express my deep appreciation and sincere gratitude to the Graduate School of the National University of the Altiplano in Puno for providing the high-level academic platform that ensured the rigor of this research. My thanks also extend to the language program and the distinguished faculty of the research course. I offer a special tribute of honor and gratitude to the Cavalry School of the Peruvian Army, an institution that forges leaders and which, in strict adherence to its democratic and educational values, unconditionally provided the institutional and logistical support necessary for the empirical data collection of this research.

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FOLKLORIC DANCES AND THEIR IMPACT ON STRESS AMONG TRUCK DRIVERS

Sandra Alina Palli Quispe

sandrapalli7@gmail.com

Orcid 0009-0004-1252-2639

National University of the Altiplano - Puno



ABSTRACT

In today's workplace, stress negatively impacts emotional well-being and productivity, especially in sectors with high operational demands. The objective of this study was to determine the impact of practicing folk dances on reducing stress levels among trout farm workers at the company Piscifactorías de los Andes. The research was conducted using a quantitative, experimental approach with a quasi-experimental design, working with a sample of 40 employees randomly assigned to an experimental group and a control group. The data collection instrument was the Maslach Burnout Inventory, consisting of 22 items, administered via a pre-test and post-test before and after the intervention with Puno dances. Data processing and analysis were performed using SPSS Statistics v.25 software, employing the Student's t-test for parametric data and the Wilcoxon test for non-parametric data. The results showed a statistically significant and favorable difference for the experimental group ($p < .000$), while no significant variations were found in the control group ($p > .069$). Consequently, It is concluded that the regular practice of Puno dances has a positive impact on occupational mental health, effectively reducing stress levels among workers and establishing itself as a viable alternative for improving the emotional climate within the organization.

Keywords: Burnout syndrome, COVID-19, dance, stress, level.

1. INTRODUCTION

Dance is currently established as a therapeutic discipline aimed at channeling and releasing repressed emotions. In the organizational setting, it has been found that the implementation of movement and recreational dance programs generates positive and significant effects on employees' health, serving as an effective coping strategy for various daily stressors (Garcia, 2021). In this regard, evidence indicates that

rhythmic physical activity not only strengthens self-esteem but also acts as a protective factor against depression and anxiety (Cornejo, 2022).

Dance Movement Therapy (DMT) enriches interventions designed to prevent Burnout Syndrome or “professional burnout.” In this context, traditional local dances, characterized by their dynamism and distinct identity, possess high functional value that directly influences an individual’s behavior and psychosomatic balance (Noticias Andina, 2021), the viability of dance took on special urgency with the onset of the COVID-19 pandemic, a situation that drastically increased stress response levels in both the general population and the corporate sector (Palomino & Huarcaya, 2020). Against this backdrop of global crisis, psychosocial risk factors in the workplace intensified, increasing the vulnerability of work teams.

On the other hand, work-related stress arises from a sustained imbalance between perceived environmental demands and an individual’s coping resources, affecting both mental and physical health (Sotelo et al. 2020), safety measures such as lockdowns sought to safeguard people’s physical well-being but also exacerbated feelings of isolation, vulnerability, and loss during this period (Carbajal & Peñarrieta 2021). In Lozano’s research, (2020) indicate that up to 68.8% of workers in operational and service areas exhibited moderate to severe levels of stress. Given this critical situation, it is imperative to design and validate programs based on rhythmic physical exercise and traditional artistic expression, using them as timely intervention mechanisms to mitigate occupational burnout and strengthen mental health in the contemporary business environment.

Therefore, the purpose of this research is to determine the impact of Puno dances on the stress levels of trout farmers, as there is a need to seek therapeutic alternatives based on local dance practices to mitigate the psychological side effects of the pandemic.

2. METHODS

The research was conducted at the facilities of the company Piscifactorías de los Andes, located in the district of Salcedo, in the province and region of Puno. This geographic location is situated on the Collao Plateau, in southeastern Peru, at an altitude of 3,800 meters above sea level. The study was conducted during the first half of 2020 and focused on a population of workers (men and women) aged between 35 and 60, whose database was provided by the Human Resources department.

The data collection tool used was a survey based on the Maslach Burnout Inventory (MBI), consisting of 22 items, which measures the three aspects of burnout syndrome through the following subscales: first, the exhaustion or emotional exhaustion subscale assesses the experience of being emotionally drained by work demands, consisting of 9 questions (1, 2, 3, 6, 8, 13, 14, 16, and 20) with a maximum score of

54 points; second, the depersonalization subscale assesses the degree to which attitudes of coldness and detachment are recognized, consisting of 5 items (5, 10, 11, 15, and 22) with a maximum score of 30 points; and third, the personal fulfillment subscale assesses feelings of self-efficacy and fulfillment at work, consisting of 8 items (4, 7, 9, 12, 17, 18, 19, and 21) with a maximum score of 48 points. This was administered during the pretest and posttest phases.

The dance intervention program was carried out over a two-month period through alternating 45-minute sessions. The dances were selected based on staff preferences and are the most commonly danced in the Altiplano region. The administrative process began with obtaining permits from the company's management and the staff involved. After data collection, the data were organized into a digital database for tabulation and presentation in tables and figures using SPSS Statistics v.25 software. The program's implementation and data handling adhered to strict ethical considerations. Informed consent and the voluntary participation of members of both groups were ensured, guaranteeing the anonymity and confidentiality of the responses. Furthermore, the research was conducted according to a schedule of activities that complied with the organization's internal regulations, as well as the principles of responsibility and punctuality in each traditional dance session.

3. RESULTS AND DISCUSSION

3.1. Results

The following findings were derived from the statistical analysis.

Table 1 shows that the largest age group is between 31 and 40 years old (45%), followed by the 20–30 age group (35%). Regarding gender, there is a marked female predominance, accounting for 90% of the total sample; this demographic profile reveals a predominantly female population. Palomino and Huarcaya (2020) argue that women and older adults were more likely to develop intense stress responses during the COVID-19 health crisis. Along the same lines, Becerra et al. (2022) reinforce this position by noting that role overload and interpersonal demands exacerbated the psychological vulnerability of women during that period.

Table 1

Sample Distribution

		Count	% of N table
Age	De 20 a 30	14	35.00%
	31 a 40	18	45.00%
	41 a 64	8	20.00%
Gender	Male	4	10.00%
	Female	36	90.00%

Note: Data obtained from SPSS Statistics v.25 software.

Regarding the influence of folk dance and its impact on stress among trout farm workers at the company Piscifactorías de los Andes. Table 2 shows the differences observed for both the control group and the experimental group, demonstrating that there are indeed differences in stress levels in the experimental group ($p = .000 < .05$), whereas no differences were found for the control group ($p = .069 > .05$).

Table 2

Differences in burnout between the control and experimental groups

Measure		t	df	P-value (two-tailed)
Control	Pre_total - Post_total	1.944	17	.069
Experimental	Pre_total - Post_total	5.837	21	.000

Note: Data obtained from SPSS Statistics v.25 software.

Table 3 shows the stress levels among trout farmers before and after participating in the folk dance program. When assessing burnout levels prior to the intervention, it was found that the experimental group consisted of 3 individuals with low levels and 17 with moderate levels; similarly, the control group included 4 individuals with low levels and 16 with moderate levels. After the Puna dance program was implemented, the results showed significant changes only in the experimental group, where the low-level group increased to 8 people and the moderate-level group decreased to 12. In contrast, the control group remained stable, ending with 3 people in the low-level group and 17 in the moderate-level group.

Table 3

Levels of the Stress variable

	Pre-Burnout Level				Post-Burnout Level			
	Low		Medium		Low		Medium	
	f	%	f	%	f	%	f	%
Control	4	20.0%	16	80.0%	3	15.0%	17	85.0%
Experimental	3	15.0%	17	85.0%	8	40.0%	12	60.0%

Note: Data obtained from SPSS Statistics v.25 software.

To assess the impact of folk-dance practice on stress levels among trout farmers, Table 4 shows the differences in the three components obtained for both the control group and the experimental group, indicating that there are indeed differences in the emotional exhaustion component in the experimental group ($p = 0.000 < .05$), while no differences were found for the control group ($p = 0.058 > .05$).

Table 4

Differences in emotional exhaustion between the control and experimental groups.

status		t	gl	Sig. (bilateral)
Control	Pre-emotional	2.030	17	.058
	Post-emotional			
emotional exhaustion				
Experimental	Pre-emotional	4.881	21	.000
	Post-emotional			
emotional exhaustion				

Note: Data obtained from SPSS Statistics v.25 software.

The following results were obtained for the depersonalization component:

Table 5 shows the differences observed for both the control group and the experimental group, indicating that there are significant differences in depersonalization in the experimental group ($p = .001 < .05$), whereas no significant differences were found in the control group ($p = .293 > .05$).

Table 5

Differences in depersonalization between the control and experimental groups.

Status		Post-Depersonalization– Pre - Depersonalization
Control	Z	-1.052
	Asymptotic significance (two-tailed)	.293
Experimental	Z	-3.215
	Asymptotic significance (two-tailed)	.001

Note: Data obtained from SPSS Statistics v.25 software.

The Personal Fulfillment component yielded the following results:

Table 6 shows the differences observed for both the control group and the experimental group, confirming that there are indeed differences in stress levels and personal fulfillment in the experimental group ($p = .011 < .05$), whereas no differences were found in the control group ($p = .756 > .05$).

Table 6

Differences in personal fulfillment between the control and experimental groups.

Status		Post-Personal Fulfillment – Pre-Personal Fulfillment
Control	Z	-.311
	Asymptotic significance (two-tailed)	.756
Experimental	Z	-2.551
	Asymptotic significance (two-tailed)	.011

Note: Data obtained from SPSS Statistics v.25 software.

3.2 Discussion

The analysis of the findings regarding the overall objective confirms that the Puno dance program has a positive and statistically significant effect on reducing stress among trout farmers. Sotelo et al. (2020) concludes in their research that the dance program had a positive effect on the stress levels of the sample, as some teachers' scores decreased to lower levels in the post-test.

With regard to the first objective, the data obtained indicate that stress levels among workers are low for some and moderate for the majority, corroborating the findings of Palomino & Huarcaya (2020), who note that the current COVID-19 pandemic

presents certain characteristics that could increase stress response levels among both the general population and healthcare workers.

To evaluate the second specific objective, the three components of the burnout test were considered, namely the dimensions of emotional exhaustion in the group the experimental findings are consistent with those reported by Asian (2020), whose analysis revealed significant differences ($p < .05$) in favor of participants exposed to a program involving body expression and dance, thereby confirming the effectiveness of rhythmic stimuli in alleviating psychological exhaustion. Regarding depersonalization, the observed improvement supports the contributions of Velasco (2018), who defines dance as a fundamental method for restoring emotional balance through psychosomatic (body-mind) connection. This reconnection proved key to mitigating the effects of isolation and fear of contagion characteristic of the pandemic—factors that generated severe levels of stress in the economically active population, similar to the impact observed in high-pressure work environments reported by Carbajal & Peñarrieta (2021). Finally, the increase in personal fulfillment aligns with the findings of Vela (2021), who demonstrated that interventions based on movement and art therapy produce a significant decrease in perceived stress. As in the experience of Sotelo et al. (2020), Rhythmic training helped participants relieve accumulated tension and improve their self-perception of competence, enabling them to cope more effectively with the demands of the organizational environment compared to the control group. In summary, the findings of this study demonstrate that the traditional dances of Puno transcend their purely folkloric and cultural value. Instead, they have established themselves as an active strategy for psychophysiological management and a necessary intervention tool for contemporary occupational mental health.

4. CONCLUSIONS

- Practicing Puno dances has a positive and statistically significant effect on reducing work-related stress among workers at Piscifactorías de los Andes ($p = .0000$). While the control group showed no significant changes ($p > .0500$), the experimental group demonstrated a substantial decrease in exhaustion levels, validating the efficacy of traditional rhythmic activities as an effective intervention strategy in response to the critical demands generated by the COVID-19 pandemic.
- It was found that, prior to the intervention, the majority of workers—85%—exhibited moderate stress levels, driven by the predominantly female workforce and the psychosocial risk factors associated with the health crisis. However, following the implementation of the dance program, a favorable redistribution was achieved in the experimental group, doubling the proportion of participants in the low-stress category from 15% to 40% and reducing the prevalence of the

moderate-stress category, confirming an improvement in the emotional balance and occupational mental health of the evaluated staff.

- Dancing has a positive impact on the three dimensions of burnout: it significantly reduces emotional exhaustion ($p = .000$), alleviates feelings of depersonalization ($p = .001$), and enhances personal fulfillment ($p = .011$). By acting as a tool for reconnecting body and mind, this discipline allowed employees to channel tensions and increase their personal satisfaction, proving to be a superior resource to inactivity for restoring cognitive clarity and overall well-being in high-pressure work environments.

5. ACKNOWLEDGMENTS

Special thanks to the Graduate School and the Language Program for opening the door to mastering a new language. Thank you for understanding that language is not merely a technical tool, but a bridge to new cultures, knowledge, and global opportunities in an increasingly interconnected world. I would also like to express my gratitude to the course and to Dr. Diana Águeda Vargas Velásquez. Thank you for your patience, your teaching methodology, and for sharing your experience with such dedication. Your guidance has been essential in transforming linguistic challenges into solid skills.

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LEVEL OF KNOWLEDGE AND ATTITUDES TOWARD BIOSAFETY AMONG NURSING STUDENTS

Deysi Pinto Cama

deysi171331@gmail.com

orcid.org/0000-0002-1915-0258

National University of the Altiplano - Puno



ABSTRACT

Biosafety consists of protective measures implemented in institutions to safeguard health and reduce the risk of microorganism transmission, typically in hospital settings; this research was therefore conducted to determine the relationship between the level of knowledge and attitudes toward biosafety among eighth-semester nursing students at the National University of the Altiplano in 2022. The study employed a qualitative, non-experimental approach with a correlational design. A census sample of 52 students was used; the data collection instrument was a questionnaire on biosafety, and an attitude scale was applied for the second variable. Data were analyzed using SPSS version 25, and Pearson's chi-square test was used to test the hypothesis. The results showed a correlation of -0.326 between the two variables; furthermore, 67.3% of the students have a low level of knowledge regarding biosafety measures, and 86.5% have an appropriate attitude toward biosafety measures. In conclusion, there is a significant inverse relationship between the level of knowledge and attitude toward biosafety among eighth-semester students in the School of Nursing at the National University of the Altiplano.

Keywords: Attitudes, biosafety, knowledge, nursing, students.

1. INTRODUCTION

According to the World Health Organization (WHO), biosafety is a set of measures designed to protect personal health from biological, chemical, and physical hazards to which staff are exposed while performing their duties (1). The effectiveness of these measures depends on two critical dimensions among healthcare personnel: knowledge and attitude. Knowledge represents the ability to distinguish or make judgments about a situation, a theory, or both, regardless of whether the information is clear, specific, organized, unclear, or precise (2). Attitude is a multidimensional

construct that integrates cognitive, affective, and conative components, shaping an individual's predisposition and enduring behavior in response to a norm (3).

Biosafety measures currently serve as a line of defense in high-risk settings against various hazards posed by biological, physical, and chemical agents (4). This is why the primary tools used by healthcare workers to curb the spread of the pandemic—in addition to their unwavering dedication to service—are training on hygiene and the use of personal protective equipment (5). However, in Latin America, it has been shown that among the causes of workplace accidents, the risks posed by viral infections, needle sticks, and splashes of bodily fluids stand out (6,7). This highlights the importance of biosafety, with students demonstrating a level of knowledge ranging from moderate to low and mostly positive attitudes (8,10).

This is demonstrated by a study conducted by Contreras and Soto (11), which indicates that nursing students have been found to practice preventive measures—such as the use of personal protective equipment, handwashing, and healthy eating—to a greater extent in order to prevent the spread of infection.

Several studies found a moderately direct relationship between knowledge level and attitude with a p-value of 0.00, showing that 54.4% of nursing students have an average level of knowledge and 54.1% have a moderate attitude, suggesting that this knowledge should be reinforced and strengthened until an optimal level is reached—one characteristic of future healthcare professionals—to prevent hospital-acquired infections (12-13).

Furthermore, Quilca (14) identifies a significant correlation between knowledge and attitude, showing that 46% of nursing students have an average level of knowledge and 54% have an average level of attitude; the sample included nursing students from the National University of the Altiplano.

Due to the pandemic that began in 2022, the Ministry of Health (MINSA) emphasized the importance of understanding biosafety measures and properly using protective barriers to prevent the spread of infection. Despite this, a latent problem persists among nursing students about to begin their clinical rotations. The gap between theory and readiness for preventive practice poses a risk to patient safety and the students' own professional futures. Therefore, the purpose of this research is to determine the relationship between interns' knowledge and attitudes regarding biosafety in order to generate evidence that can strengthen academic training and prevent nosocomial infections.

2. METHODS

The study was conducted at the School of Nursing at the National University of the Altiplano in Puno (UNAP), located at 1153 Floral Avenue in Puno, in southern Peru. The study lasted one semester.

To carry out the research, the necessary administrative steps were taken to request authorization from the authorities of the vocational school and its faculty. Once the required permissions were obtained, all materials were prepared to administer the research instruments, ensuring respect for each participant's autonomy, voluntary participation, the confidentiality of the information provided, and anonymity. Dates were coordinated with the faculty members on two separate occasions, during which the purpose of the research, the procedures to be followed, and the academic use of the information obtained were explained clearly and in detail.

Once all the information was gathered, the data was processed and analyzed using IBM SPSS Statistics version 25, and was coded and organized into a database. Descriptive statistics were employed and presented using single- and double-entry frequency tables and percentages, which facilitated the interpretation and visualization of the information. Regarding inferential statistics, Pearson's chi-square test was applied to examine the relationship between variables and verify the proposed hypothesis, presenting a contingency table that was created by cross-tabulating statistical data.

A census-type sampling method was used (15), resulting in a total of 52 enrolled students ready to begin their clinical internship. Data were collected using a survey technique involving a questionnaire and a rating scale, which allowed us to gather data as students completed both instruments.

The instrument used to measure the knowledge variable was the questionnaire titled "Level of Knowledge of Biosafety Measures," validated by Borja (16) in Peru. It consists of 27 items, and the instrument's measurement scale is as follows: Low (0–21), Medium (21–24), and High (24–27). The Spearman-Brown coefficient was used to determine its reliability, which was found to be 0.673, indicating that the instrument is reliable.

The attitude variable was measured using the scale: "Biological Risk Prevention Attitudes Instrument," developed and validated by Marreros (17) in Peru. It consists of 20 items, with a measurement range of: Inappropriate 0–37, Fair 38–65, and Appropriate 66–100. Likewise, Cronbach's alpha was used to determine its reliability, yielding a value of 0.820.

Table 1*Variables analyzed in the study*

VARIABLES	DIMENSIONS	UNIT OF MEASUREMENT
Knowledge	Basic Biosafety Principles.	1 = correct
	Protective Barriers.	0 = incorrect
Attitude	Attitude level	1 = Strongly disagree
		2 = Disagree
		3 = Undecided
		4 = Agree
		5 = Strongly agree

Note: “Level of Knowledge of Biosafety Measures” by Borja K and “Biological Risk Prevention Attitudes Questionnaire” by Marreros J.

3. RESULTS AND DISCUSSION

3.1. Results

Table 2*Relationship between Level of Knowledge and Attitude toward Biosafety*

			Attitude			Total
			Appropriate	Standard	Inappropriate	
Level of knowledge	High	Nº	0	0	0	0
		%	0.0	0.0	0.0	0.0
	Medium	Nº	12	5	0	17
		%	23.1	9.6	0.0	32.7
	Low	Nº	33	2	0	35
		%	63	3.8	0	67.3
	Total	Nº	45	7	0.	52
		%	86.5	13.5	0.0	100.0

Note: Knowledge assessment questionnaire and attitude scale.

Biosafety is essential in professional practice; therefore, an analysis of the relationship between variables revealed that 63.5% of eighth-year students about to begin their clinical rotations have a low level of knowledge but an appropriate attitude.

Table 3*Level of knowledge regarding biosafety*

	Frequency	Percentage
High	0	0,0
Medium	17	32,7
Low	35	67,3
Total	52	100,0

Note: Knowledge assessment questionnaire and attitude scale.

An analysis of students' knowledge levels revealed that 67.3% of students have a low level of knowledge. This highlights the need to take steps to improve their academic knowledge and ensure that this improvement is reflected in both their attitudes and practical skills.

Table 4*Students' attitudes toward biosafety*

	Frequency	Percentage
Appropriate	45	86,5
Standard	7	13,5
Inappropriate	0	0,0
Total	52	100,0

Note: Knowledge assessment questionnaire and attitude scale.

The results show that 86.5% of eighth-grade students demonstrate an appropriate attitude toward biosafety, indicating that most participants recognize the importance of implementing biosafety measures.

Table 5*Pearson's chi-square correlation test between variables*

	Value	Asymptotic significance (two-sided)
Pearson's chi-square	-,326	,018
Number of valid cases	52	

Note: Knowledge assessment questionnaire and attitude scale.

The inferential analysis using the chi-square test shows that the relationship between knowledge level and attitude is inverse, but a relationship does exist since the p-value is $0.018 < 0.05$, thus supporting the research hypothesis.

3.2. Discussion

The level of knowledge has a significant inverse relationship with attitudes toward biosafety among eighth-semester students in the School of Nursing at the National University of the Altiplano, with a p-value of 0.018. This indicates that as one variable increases, the other decreases, suggesting that despite having low or moderate levels of knowledge, students tend to have an appropriate attitude; that is, students have the attitude to properly implement biosafety measures, but due to their low level of knowledge, they will not be able to carry them out correctly as the biosafety measures describe. We can therefore understand that attitude is the predisposition we have to behave in a certain way in a given situation; this will depend on the experiences and knowledge we have regarding the situation we face (9).

These findings differ from those reported by Quilca (14), who found a direct correlation between the variables of knowledge and attitudes with a p-value of 0.006, indicating an average level among nursing interns in both knowledge and attitude. Similarly, Soto (18) found a direct relationship between knowledge and attitude with a p-value of 0.000. This indicates an average level of knowledge and attitude. In turn, Contreras and Soto (11) found a chi-square value of 0.022, revealing a relationship between the study variables. For their part, Tuñoque and Villoslada (19) found a moderately direct relationship between the level of knowledge and attitude ($p=0.00$) among students.

With regard to the level of knowledge about biosafety, it was found that students generally have a low level of understanding, which poses a risk because unintentional errors could lead to the spread of disease. Therefore, there is a need to take measures to improve academic knowledge and ensure that this knowledge is reflected in both attitudes and practical skills. Regarding basic aspects, students had little knowledge of universal precautions; they did not know the purpose of handwashing or the duration of clinical handwashing. In the area of protective barriers, students were unclear about what protective barriers are and did not know the purpose of wearing gloves. Regarding waste disposal, students were unclear about the classification of hospital waste and were unaware of the types of waste with potentially hazardous physical and chemical characteristics.

In line with the findings of Ríos, Rolón, and Espínola (7), who reported that knowledge of biosafety measures in the context of the pandemic is low, the students provided inaccurate answers regarding the procedures for removing a surgical mask and also gave incorrect answers regarding the proper use of the mask. This will be essential for developing strategies to promote biosafety among this group, as they are constantly exposed to all types of infections. On the other hand, there is a difference from Tapia (20), who notes that nursing interns have average knowledge

regarding biosafety measures, citing dimensions where they demonstrate an average level of proficiency in handwashing and the use of protective barriers.

The students' attitude toward biosafety is appropriate; this implies accepting or agreeing with the measures taken (21)—that is, each person is aware of and shows interest in the importance and proper application of biosafety when performing all procedures. This finding is consistent with that of Motta and Tapia (13), who found that respondents had a favorable attitude toward biosafety measures. Likewise, Fernández (8) found that students' attitudes were mostly positive.

4. CONCLUSIONS

- There is an inverse relationship between the level of knowledge and attitude toward biosafety among eighth-semester students in the School of Nursing at the National University of the Altiplano, with a p-value of 0.018 (less than 0.05), indicating that as one variable increases, the other decreases.
- The level of knowledge regarding biosafety measures was low among eighth-semester students in the School of Nursing at the National University of the Altiplano, which is a weakness since unintentional errors that spread disease may occur during patient care.
- Attitudes toward biosafety measures were appropriate among eighth-semester students in the School of Nursing at the National University of the Altiplano, demonstrating that they are interested in the correct practice and application of biosafety measures.

5. ACKNOWLEDGMENTS

To my alma mater, the National University of the Altiplano – Puno, for welcoming me and giving me the opportunity to develop professionally, preparing me for a competitive future and shaping us into good people.

To my prestigious School of Nursing, and to the faculty and students who participated in the study.

To the Graduate School of the National University of the Altiplano and the Language Program, especially Dr. Diana Vargas Velasquez for guiding this scientific article.

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APPROVAL OF INTERNAL TRANSFERS AND THE REASONABLENESS OF THE FINANCIAL STATEMENTS OF THE PROVINCIAL MUNICIPALITY OF LAMPA

Rocío Elizabeth Rivera Ruelas

Ro.lzbth15@gmail.com

Orcid: 0009-0004-1797-2575

National University of the Altiplano - Puno



ABSTRACT

The authorization of internal orders is a procedure through which funds are allocated to cover expenses, provided they comply with current regulations, and must be accounted for, as they affect the presentation of the financial statements. The objective of the research was to analyze internal authorization and its impact on the reasonableness of the financial statements of the Provincial Municipality of Lampa for the 2016 and 2017 periods. The study employed a quantitative, non-experimental approach with a descriptive design. Non-probabilistic sampling was used for convenience. The sample consisted of the statement of financial position and its respective notes, Simultaneous Action Report No. 001-2018-OCI/0461-AS, the construction balance sheet for the 2016 and 2017 periods, treasury directives, and internal directives. The data collection instrument was a log sheet. Data processing was performed using descriptive statistics through the calculation of percentages, with results presented in tables; the hypothesis was tested using the arithmetic mean. The results showed that internal orders pending as of 2016 represented 68.78% and those for 2017 represented 67.65% of the total authorized amount. In conclusion, the internal orders pending settlement increased current assets under the heading “services and other prepaid expenses,” resulting in an unreasonable statement of financial position, since these should have been recorded in the income statement under “expenses for goods and services”.

Keywords: Authorization, Internal Order, Financial Statements, Reasonableness.

1. INTRODUCTION

Public sector financial management encompasses the set of rules, principles, and procedures used by the Budget, Treasury, Debt, and Accounting System, and through them, by the entities and agencies involved in the process of planning, raising,

allocating, utilizing, safeguarding, recording, controlling, and evaluating public funds (Andía, 2009). In this context, procedures have been established for public entities regarding the allocation, use, and reporting of internal assignments to staff members to ensure timely coverage of expenses for goods and services required by users and to contribute to improving administrative management and user satisfaction levels in the execution of various activities; however, these are not accounted for within the timeframe established by Treasury Directive No. 001-2007-EF/77.15, which increases current assets under the category of prepaid services and other prepaid expenses, resulting in an unreasonable Statement of Financial Position. In light of the above, it is important to note that (Novoa, 2014) specifies that financial statements are systematic tables prepared in accordance with international accounting and financial reporting standards, as well as national accounting manuals and regulations, with the aim of presenting the company's financial and economic position in a reasonable and consistent manner. Furthermore, (Valdivia, 2012) noted that these reflect the effects of transactions and other events of a state entity, grouping them by categories according to their economic characteristics, which are called elements: in the case of the statement of financial position, the elements measured are assets, liabilities, and net equity; in the income statement: revenues and expenses.

In this regard, the Provincial Municipality of Lampa, under Directive No. 002-2017-MPL (2017), established procedures for the allocation, use, and accounting of funds; however, many of the authorized internal assignments have not been accounted for within the established timeframe. It should be noted that, according to (Calisaya, 2019), unreconciled internal orders included in the balances of accounting account 1205.0502 "Other Payables" unduly inflate the "services and other prepaid expenses" line item under current assets, presenting an unreasonable financial statement, since these funds have already been used to acquire goods and services. This aligns with (Huanacuni, 2017), who demonstrated that authorizations granted for maximum amounts result in unreasonable financial statements. On the other hand, (Alejo, 2016) demonstrated that compliance with the General Treasury Regulations in the District Municipality of Chucuito the average percentage of non-compliance for the 2014 period is 44.57% and for the 2015 period is 46.74%, which demonstrates that they partially comply with the standard, revealing deficiencies in its implementation.

Consequently, the purpose of this study is to determine the impact of internal order authorizations on the reasonableness of the financial statements of the Provincial Municipality of Lampa for the 2016–2017 period, and whether these authorizations comply with the entity's general and internal regulations.

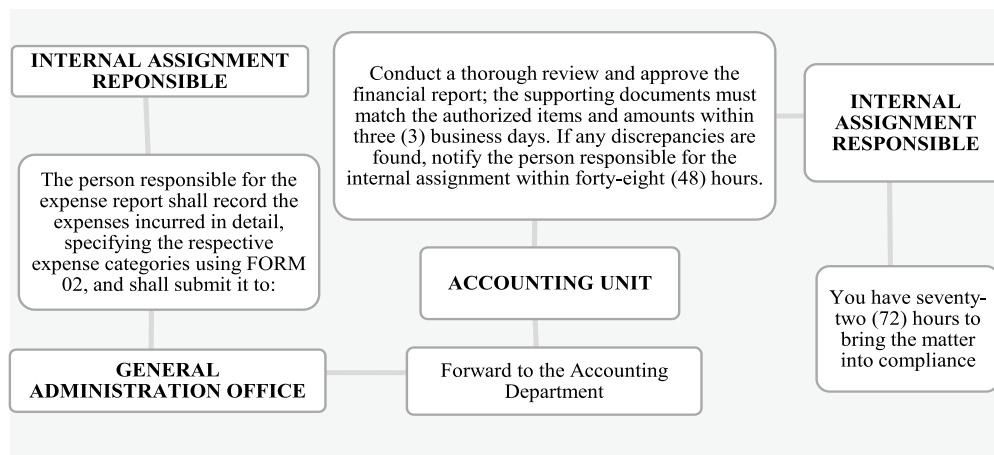
2. METHODS AND MATERIALS

The research was conducted at the Provincial Municipality of Lampa, located at Plaza de Armas No. 100, in the province of Lampa at 3,800 meters above sea level, in the central-western part of the department of Puno, over a period of one year and three months. The entity provided the financial statements and their respective notes for the 2016 and 2017 periods in digital format, using a quantitative approach, a non-experimental research design, and a descriptive methodology.

The study presents an analysis of outstanding balances awaiting settlement and their effect on the overstatement of current assets, particularly in the category of prepaid services and other prepaid expenses. The data collection technique used was documentary analysis, and a data collection form was used as the instrument. This form was used to compile the provisions of Directive No. 002-2017-MPL, from which a flowchart was developed to visualize the process and timeline for rendering accounts, as presented below:

Figure 1

Flowchart for processing internal orders



Note. Obtained from Directive No. 002-2017-MPL.

In addition, data collection forms were used to gather data on internal orders from Simultaneous Action Report No. 001-2018-OCI/0461-AS and compare them with the organization's internal regulations; the data was tabulated in tables, which are presented in detail in the results.

With regard to the Statement of Financial Position, a horizontal and vertical analysis was conducted based on the work of Ross et al. (2014), who note that vertical analysis aims to present the Statement of Financial Position in percentage terms

relative to total assets. On the other hand, “horizontal analysis, also known as trend analysis, emphasizes showing the consistency of the year under review relative to the figures of a base year”; thus, this method treats the total to be analyzed as 100% and then compares each of its components to determine the percentage it represents relative to the total and the relative importance of its components. This allows for the comparison of comparable figures from the financial statements for 2016 and 2017. In line with this, items showing changes were selected from the comparative balance sheet in order to determine the causes of the variations and draw the relevant conclusions. In this regard, data processing using descriptive statistics—specifically, the calculation of percentages—made it easier to identify unaccounted-for transactions and assess their impact on the reasonableness of the Statement of Financial Position.

Table 1

Variables analyzed in the study:

VARIABLE	DIMENSION	INDICATORS
1. Internal assignments (Independent Variable)	1.1. Completed assignments	Simultaneous Action Report No. 001-2018-OCI/0461-AS Construction balance sheet-Notes to the financial statements
	1.2. Uncompleted assignments	Simultaneous Action Report No. 001-2018-OCI/0461-AS Construction balance sheet-Notes to the financial statements
2. Financial Statements (Dependent Variable)	2.1. Accounting Information	Statement of Financial Position Accounting Records
	2.2. Notes to the Financial Statements	Accounts – Subaccounts – Transaction Details Construction Balance Sheet

3. RESULTS AND DISCUSSION

3.1. Results

In order to achieve the objectives of this research, an analysis was conducted of the financial statements and their notes, as well as the construction balance sheet, using tables and their interpretation, as detailed below:

Table 2

Authorizations for other payments to be accounted for in the 2016 and 2017 periods (in soles)

DETALLES	2016	%	2017	%
Submitted	590,152.46	31.22	578,983.69	32.35
Not yet submitted	1,300,028.20	68.78	1,210,748.96	67.65
Total, approved	1,890,180.66	100	1,789,732.65	100

Note. Data obtained from the 2016 Construction Balance Sheet and the 2017 Construction Balance Sheet.

Table 2 shows that the total amount of other disbursements subject to accountability in 2016 was S/ 1,890,180.66, representing 100%, of which only S/ 590,152.46, representing 31.22%, was accounted for; consequently, the outstanding amount amounts to S/ 1,300,028.20, representing 68.78% of the total authorized. Regarding the year 2017, the allocation for other disbursements subject to accountability totaled S/ 1,789,732.65, representing 100%, of which only S/ 578,983.69 (32.35%) was accounted for; consequently, the outstanding amount amounts to S/ 1,210,748.96, representing 67.65% of the total authorized. It follows that more than half of the authorized internal orders have not been accounted for, exceeding the deadline of three (3) business days and transgressing the following regulations:

Table 3

Rules transgressed in the deadline for submitting internal assignments

DIRECTIVE No.	ARTICLE	NUMERAL
001-2007-EF/77.15	Article 40.	40.2 The deadline for submitting a properly documented report, which must not exceed three (3) business days after the conclusion of the activity covered by the assignment. The person responsible for the internal assignment shall submit the documents to the General Administration Office, which will forward them to the Accounting Unit for a thorough review and approval of the financial report. The supporting documents must match the authorized items and amounts within a period not exceeding three (3) business days; if any discrepancies are found, the Accounting Unit will notify the person responsible for the internal assignment within forty-eight (48) hours. Upon receipt of the documentation, the person responsible for the internal assignment will have seventy-two (72) hours to rectify the issue.
002-2017-MPL	Article 7° Accountability	

Note. Extracted from Treasury Directive No. 001-2007-EF/77.15 and Directive No. 002-2017-MPL

Regarding Note 8: Prepaid Services and Other Expenses, the total for this item was S/ 1,590,793.26 for the 2016 period and S/ 1,481,179.63 for the 2017 period, as detailed below:

Table 4

Note 8: Prepaid services and other prepaid expenses

SUB-ACCOUNT	CONCEPT	BALANCE AS OF DECEMBER 31, 2017	%	BALANCE AS OF DECEMBER 31, 2016	%
1205.0402	Suppliers	19,475.44	1.31%	19,475.44	1.22%
1205.0501	Travel Expenses	193,500.62	13.06%	213,835.01	13.44%
1205.0502	Other Reimbursable Expenses	1,210,748.96	81.74%	1,300,028.20	81.72%
1205.98	Other	57,454.61	3.88%	57,454.61	3.61%
	TOTAL	1,481,179.63	100%	1,590,793.26	100%

Note: Obtained from the Notes to the Financial Statements – Note 8 for the years 2016 and 2017

Given that the largest balances are in the “Other Accounts Payable” account, amounting to S/1,300,028.20 and S/1,210,748.96, respectively, which represent 81.74% and 81.72% of the total for this category, which is reflected in Current Assets on the Statement of Financial Position even though they should no longer be included there, as shown in the following table:

Table 5*Statement of Financial Position (Current Assets) for the 2016–2017 Period*

STATEMENT OF FINANCIAL POSITION					
As of December 31, 2017 and 2016					
(IN SOLES)					
DEPARTAMENTO	: 21 PUNO				
PROVINCIA	: 07 LAMPA				
ENTIDAD	: 01 PROVINCIAL MUNICIPALITY OF LAMPA (301653)				
		2017	%	2016	%
ASSETS					
CURRENT ASSETS					
Cash and Cash Equivalents	Note 3	2,862,816.21	41.91	2,739,208.08	41.45
Marketable Securities	Note 4	-	0.00	-	0.00
Accounts Receivable (Net)	Note 5	4,433.12	0.06	4,433.12	0.07
Other Accounts Receivable (Net)	Note 6	144,088.49	2.11	144,088.49	2.18
Inventories (Net)	Note 7	1,407,506.25	20.60	1,681,244.32	25.44
Prepaid Services and Other Prepaid Expenses	Note 8	1,481,179.63	21.68	1,590,793.26	24.07
Other Asset Accounts	Note 9	931,623.18	13.64	448,459.05	6.79
TOTAL, CURRENT ASSETS		6,831,646.88	100	6,608,226.32	100

Note. Obtained from the 2016 and 2017 Statements of Financial Position

It was found that, for the 2016 period, current assets totaled S/ 6,608,226.32, and the “Prepaid Services and Other” account amounted to S/ 1,590,793.26, representing 24.07% of total current assets and ranking third for that year; and for the 2017 period, current assets totaled S/ 6,831,646.88, and the “Services and Other Prepaid Expenses” category amounted to S/ 1,481,179.63, representing 21.68% of total current assets and also ranking third. It was noted from the above that the outstanding internal orders for which no settlement has been made, recorded in the balances of account 1205. 0502 Other Accounts Payable, have a negative impact on the Statement of Financial Position, as they increase the item “Prepaid Services and Other Prepaid Expenses,” which is part of Current Assets, thereby rendering the Statement of Financial Position unreasonable. In addition, during 2016 and 2017, a total of 268 internal assignments were assigned to 108 employees, totaling S/ 1,018,038.55, as shown in the following table:

Table 6

Number of authorizations granted by type of internal request in 2016–2017

YEAR	APPROVAL OF INTERNAL ASSIGNMENTS S/	NUMBER OF INTERNAL ASSIGNMENTS	NUMBER OF EMPLOYEES
2016	604,587.10	158	62
2017	413,451.45	110	46
TOTAL	1,018,038.55	268	108

Note. Obtained from Simultaneous Action Report No. 001-2018-OCI/0461 (Appendix 1).

In that regard, since they were authorized and approved, they had to comply with the rules governing the handling of internal orders, as shown in the following tables:

Table 7

Summary of contract awards by activity for the 2016–2017 period

SUMMARY OF CONTRACTS AWARDED FOR ACTIVITIES CARRIED OUT DURING THE 2016–2017 PERIOD					
N°	ACTIVITY	2016		2017	
		N° OF ASSIGNMENT	N° OF EMPLOYEES	N° OF ASSIGNMENTS	N° OF EMPLOYEES
1	SAN SEBASTIÁN'S QASHWA CHILDREN'S CARNIVAL	1	1	1	1
2	PARTICIPATION IN THE MUNICIPAL OLYMPIC GAMES OF THE PUNO REGION	1	1	1	1
3	INTER-NEIGHBORHOOD AND SUBDIVISION WAPULULO CONTEST	2	2	3	2
4	ANNIVERSARY OF THE PROVINCE OF LAMPA	4	4	6	4
	TOTAL	8	8	11	8

Note. Obtained from Simultaneous Action Report No. 001-2018-OCI/0461-AS (Appendix 1).

The table above shows that the aforementioned activities took place in 2016 and 2017 and do not qualify as urgent and exceptional, even though Article 6 specifies that this funding mechanism is intended for events whose detailed expenses cannot be determined with precision or sufficient advance notice.

Table 8

Assignments granted for activities that were classified as non-fundable resources in 2016

ACTIVITIES CLASSIFIED AS NON-FUNDABLE RESOURCES IN 2016			
N°	C/P N°	Order Description	Amount
1	111	MANAGEMENT OF FUNDS UNDER THE INTERNAL ASSIGNMENT PROCEDURE FOR THE IMPLEMENTATION OF ACTIVITIES IN ACCORDANCE WITH THE WORK PLAN: "OFFICE SUPPLIES FOR THE MUNICIPAL MANAGEMENT OFFICE OF THE PROVINCIAL MUNICIPALITY OF LAMPA.	3,300.00
	3314	INTERNAL ASSIGNMENT IN ACCORDANCE WITH REGULATION No. 456-2016-MPL/GEMU, MEMORANDUM No. 561. REPORT No. 180-2016-MPL/OGA, SUPPLY REPORT No. 0314-2016-MPL/UABAS/CNY, REPORT No. 542-2016-MPL/OPP, REPORT No. 547-2016-MPL/UPER, FOR THE ACTIVITY OF THE PLAN ENTITLED: "FOOD FOR WORKERS OF THE PROVINCIAL MUNICIPALITY OF LAMPA"	13,696.00
2	3315	INTERNAL ASSIGNMENT PURSUANT TO REGULATION No. 456-2016-MPL/GEMU, MEMORANDUM No. 561. REPORT No. 180-2016-MPL/OGA, SUPPLY REPORT No. 0314-2016-MPL/UABAS/CNY, REPORT No. 542-2016-MPL/OPP, REPORT No. 547-2016-MPL/UPER, FOR THE ACTIVITIES OF THE PLAN ENTITLED: "FOOD FOR WORKERS OF THE PROVINCIAL MUNICIPALITY OF LAMPA"	12,304.00
3	3384	INTERNAL ASSIGNMENT PURSUANT TO REGULATION No. 465-2016-MPLGEMU. TO IMPLEMENT THE ACTIVITY PLAN "FOOD FOR THE FULL COUNCIL OF THE PROVINCIAL MUNICIPALITY OF LAMPA"	5,000.00

Note. Obtained from Simultaneous Action Report No. 001-2018-OCI/0461-AS (Appendix 1).

Table 8 showed that in 2016, internal orders totaling S/ 34,300.00 were authorized for activities classified as non-fundable resources under Article 6.2 of Directive No. 002-2017-MPL. Based on the analysis presented in the preceding paragraphs, it became clear that among the authorizations granted through internal requests in 2016 and 2017, there are authorizations that do not fall within the scope of Directive No. 002-2017-MPL; first, it is evident that they do not meet the criteria of urgency and exceptional circumstances, as specified in Article 6.1; and secondly, internal orders were authorized for activities classified as non-fundable resources, even though these were not permitted under Article 6.2 of the aforementioned directive; therefore, these should not have been authorized, affecting the balance of account 1205.0502, and, consequently, the Statement of Financial Position; and when the financial report is submitted, the Statement of Operations is affected.

3.2. Discussion

The relationship between the internal assignments of the Provincial Municipality of Lampa and the reasonableness of the Statement of Financial Position, it was found that the pending accounts for 2016 and 2017 increase the “Other Accounts Payable” category, consistent with (Calisaya, 2019), who verified that unreconciled internal orders included in the balances of accounting account 1205.0502 “Other Disbursements to Be Accounted For” negatively impact the Statement of Financial Position, unduly increasing the “services and other prepaid expenses” line item under current assets, resulting in an unreasonable Statement of Financial Position. Similarly, (Huanacuni, 2017) demonstrated that the authorizations granted for internal orders in 2014 with respect to 2015 increased to S/12,022,209.73, of which S/4,780,042.29 was reported, amounting to 39.76%; however, there remain authorizations granted for reporting purposes amounting to 60.24%, such that the financial statements show these authorizations granted for reporting purposes in maximum amounts, which renders the financial statements unreasonable. Regarding compliance with regulations governing internal assignments (Huayanay, 2017), he noted that the majority of employees—89%—submit their reports and financial statements to the Treasury Office more than 10 days after the assignment is completed. Likewise (Segura, 2017), it was determined that those on assignment must account for their expenses with proper documentation, but they fail to do so within ten business days. Based on the findings of Segura and Huayanay, we can observe that similarly, in the Provincial Municipality of Lampa, the majority of employees also fail to submit their financial reports within the established timeframe, thereby violating the regulations for the management of internal assignments. Finally, (Juárez, 2019) noted that: the lack of adequate prior oversight and the disinterest of those on assignment do influence the untimely submission of expense reports. As noted above, the investigation conducted at the Provincial Municipality of Lampa reveals that regulatory transgressions occur on an ongoing basis, as there is a lack of adequate prior oversight and follow-up.

4. CONCLUSIONS

- Approved internal orders totaled S/ 1,789,732.65 and S/ 1,890,180.66 for 2016 and 2017, respectively, of which S/ 1,300,028.20 remained unaccounted for in 2016, representing 68.78% of the total allocated; similarly, in 2017, S/ 1,210,748.96 remained pending settlement, representing 67.65% of the total allocated, increasing current assets under the heading of prepaid services and other prepaid expenses; revealing that the total for this category was S/ 1,481,179.63 in 2017 and S/ 1,590,793.26 in 2016, with the largest balance being that of account 1205.0502: Other Payables, with amounts of S/1,210,748.96 and S/1,300,028.20, respectively, representing 81.74% and 81.72%, which negatively impacts the reasonableness of the Statement of Financial Position,

rendering it unreasonable. This is because expenses were already incurred to carry out activities under internal assignment arrangements; since these remain pending settlement, they are carried forward to subsequent periods, even though the assignments have already been executed and should be recorded in the Statement of Operations under the expense category for goods and services for which they were granted.

- With regard to compliance with regulations governing the handling of internal orders, such as Treasury Directive No. 001-2007-EF/77.15 and internal directives of the Provincial Municipality of Lampa: Directive No. 004-2015-MPL and Directive No. 002-2017-MPL; it was found that these have been violated, as the authorizations were not granted within the framework of the procedure for the assignment, use, and accounting of internal assignments.
- To optimize the implementation of regulations governing the handling of internal assignments and accountability within the Provincial Municipality of Lampa, disciplinary measures must be implemented, internal guidelines must be amended, and a plan for monitoring and training staff must be developed.

5. ACKNOWLEDGMENTS

This project was successfully completed thanks to the faculty of the Graduate School at the National University of the Altiplano and the Language Program, with special thanks to Dr. Diana Vargas Velásquez for guiding the development of this scientific article.

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INFLUENCE OF THE ADDITION OF MINING TAILINGS ON THE PROPERTIES OF CONCRETE FOR TYPE II PAVERS

Danitson Walter Salluca Canaza

dsalluca@unsa.edu.pe

orcid.org/0009-0001-9318-3074

National University of San Agustín of Arequipa



ABSTRACT

Mining tailings represent one of the main environmental liabilities derived from mining activity due to their inadequate disposal and the contaminating impact they generate on soils and water resources, a problem that in Peru is intensified by the accumulation of mining waste without adequate technical utilization (MINAM, 2013). In response to this issue, the objective of the present research was to evaluate the influence of incorporating mining tailings as a partial replacement for fine aggregate on the properties of concrete for Type II paving blocks. The research was developed through the experimental method, under a quantitative approach, applied type, and experimental design. The study was carried out in the city of Arequipa, considering as the unit of analysis 150 Type II paving blocks manufactured through industrial vibrocompaction, including a control mixture and dosages with 5%, 10%, 25%, and 50% replacement of fine aggregate by mining tailings. The techniques employed included compressive strength, absorption, density, and dimensional variation tests according to NTP 399.611, using metallic molds, a digital balance, and a compression testing machine. Microsoft Excel and IBM SPSS were used for statistical data processing, applying arithmetic mean and comparative descriptive analysis. The results showed that mixtures with percentages lower than or equal to 10% presented adequate mechanical behavior and complied with regulatory requirements. Finally, the controlled incorporation of mining tailings represents a technically, economically, and environmentally viable alternative for the manufacture of Type II paving blocks (Wang et al., 2022).

Keywords: Concrete behavior, mining tailings addition, mechanical properties, unit costs, paving blocks.

1. INTRODUCTION

Currently, mining tailings represent one of the main environmental problems associated with mining activity due to the accumulation of waste generated during mineral extraction and processing operations. These materials, when not properly treated or disposed of, generate contamination in soils, water resources, and nearby ecosystems, also affecting populations located in mining influence areas. From the theoretical approach of the physical-mechanical behavior of concrete, several studies state that the partial incorporation of residual materials can modify properties such as strength, absorption, density, and compaction, depending on the granulometric characteristics and composition of the materials used (Agustiningtyas et al., 2022). Likewise, it has been reported that the reuse of industrial and mining waste in cementitious materials constitutes a sustainable alternative aimed at reducing environmental impacts and promoting the efficient use of resources within the construction sector (Wang et al., 2023).

In Peru, this problem becomes more relevant due to the constant growth of extractive activity in different regions of the country, which has caused the progressive accumulation of mining environmental liabilities that, in many cases, remain abandoned or under limited technical control (MINAM, 2013). Faced with this situation, the need arises to develop sustainable alternatives that allow the reuse of these residues and reduce the environmental impact they generate. In this context, the construction industry constitutes one of the activities with the greatest potential for incorporating alternative materials into its production processes due to the high consumption of inputs it requires and the possibility of reusing industrial and mining waste as part of concrete components (Raghavendra et al., 2024). Within this field, Type II paving blocks represent elements widely used in urban paving because of their strength, ease of installation, maintenance, and application in light-traffic roads; therefore, they must comply with technical requirements established in standards such as NTP 399.611 related to strength, absorption, density, and dimensional variation (Hussein & Al-Zwainy, 2022). The manufacture of paving blocks using mining tailings seeks not only to evaluate the physical-mechanical behavior of concrete under different percentages of fine aggregate replacement, but also to promote the use of mining waste within sustainable construction processes, contributing to reducing the accumulation of environmental liabilities and decreasing the consumption of natural aggregates. However, despite advances related to the use of waste in cementitious materials, there are still limited studies specifically focused on the incorporation of mining tailings into concrete paving blocks under different replacement dosages (Putra & Faza, 2023). In this sense, the objective of the present research was to evaluate the influence of incorporating mining tailings as a partial substitute for fine aggregate on the physical-mechanical properties of concrete for Type II paving blocks, considering as the independent variable the percentage of fine

aggregate replacement and as the dependent variable the compressive strength, absorption, density, and dimensional variation of the concrete. The research was developed using a quantitative approach, applied type, explanatory level, and experimental design, aimed at analyzing the behavior of concrete under different mining tailings dosages; likewise, Microsoft Excel and IBM SPSS were used for the statistical processing of the obtained information in order to organize and interpret the experimental results.

2. METHODS

The present research was carried out in the district of Yarabamba, Arequipa, using mining tailings obtained from the Santa Cecilia environmental liability site (MINAM, 2013), while the manufacture and evaluation of the experimental units were conducted at the facilities of Concretos Moldeados S.A.C. (COMOL S.A.C.) and the specialized laboratory ORPA S.A.C., institutions related to the production and quality control of prefabricated concrete elements. For the preparation of the mixtures, Type I Portland cement, potable water, coarse aggregate, fine aggregate, and mining tailings were used, the latter incorporated as a partial replacement for conventional fine aggregate (Wang et al., 2023). Prior to the preparation of the mixtures, the materials were subjected to physical characterization tests to determine granulometric properties, moisture content, absorption, and specific weight, verifying their suitability for the production of paving blocks. The research was developed under a quantitative approach, applied type, explanatory level, and experimental design, aimed at evaluating the variations generated in the physical-mechanical behavior of concrete under different percentages of mining tailings incorporation, considering as the independent variable the percentage of fine aggregate replacement and as the dependent variable the physical and mechanical properties of concrete, specifically compressive strength, absorption, density, and dimensional variation (Agustiningtyas et al., 2021). For the experimental development, five dosages corresponding to 0%, 5%, 10%, 25%, and 50% partial replacement of fine aggregate with mining tailings were established, maintaining constant the other proportions of the base mixture provided by COMOL S.A.C., with the 0% dosage considered as the control mixture for comparative purposes.

Metal molds for Type II paving blocks, a digital scale, drying oven, mixing containers, industrial vibrocompression equipment, and a compression testing machine were used as instruments and work equipment during the manufacturing and evaluation process of the samples. The production of the experimental units was carried out through industrial vibrocompression, obtaining a total of 150 Type II paving blocks equally distributed among the different experimental dosages. The manufacturing procedure included the stages of material dosing, mixing, placement of the mixture into molds, mechanical vibration, demolding, and storage of the manufactured units; subsequently, the paving blocks were subjected to a controlled

curing process under appropriate humidity and temperature conditions in order to guarantee the progressive development of the concrete's mechanical properties. Finally, the manufactured units were subjected to compressive strength tests at 7, 14, and 28 days of curing, in addition to absorption, density, and dimensional variation tests, considered as the main indicators for evaluating the physical-mechanical behavior of the paving blocks and verifying compliance with the technical requirements established in NTP 399.611 for concrete paving blocks intended for pavement applications (Hussein & Al-Zwainy, 2022). The obtained information was organized and processed through descriptive statistical analysis using tables, graphs, and measures of central tendency to interpret the behavior of each experimental dosage; Microsoft Excel and IBM SPSS were used for statistical data processing, tools that allowed the systematization, comparison, and interpretation of the obtained experimental results (Sovacool & Griffiths, 2020).

3. RESULTS AND DISCUSSION

3.1 Results

The obtained results demonstrate the influence of the percentage of fine aggregate replacement by mining tailings on the physical-mechanical behavior of Type II paving blocks. Table 1 presents the average compressive strength values at 7, 14, and 28 days of curing for the different evaluated dosages.

Table 1

Average Compressive Strength (kg/cm²)

<i>Tailings (%)</i>	7 days	14 days	28 days	Complies (≥380)
0%	355.70	391.84	392.81	Yes
5%	340.66	383.83	384.72	Yes
10%	334.39	377.08	381.45	Yes
25%	278.05	344.73	346.21	No
50%	235.92	273.34	286.71	No

Note: Average compressive strength results of Type II paving blocks evaluated at 7, 14, and 28 curing days. The minimum value of 380 kg/cm² established by the current technical standard was considered as the compliance criterion.

Table 1 shows the behavior of the compressive strength of Type II paving blocks as a function of the percentage of fine aggregate replacement with mining tailings and curing time. It can be observed that all mixtures progressively increased their strength between 7, 14, and 28 days due to the cement hydration process and the gradual development of the concrete cementitious matrix (Wang et al., 2024). The control mixture reached the highest value at 28 days with 392.81 kg/cm², establishing itself as the comparative reference against the other evaluated dosages. Likewise, the

mixtures with 5% and 10% tailings obtained strengths of 384.72 kg/cm² and 381.45 kg/cm², respectively, complying with the minimum value of 380 kg/cm² required by NTP 399.611 for Type II paving blocks. However, the dosages with 25% and 50% presented strengths of 346.21 kg/cm² and 286.71 kg/cm², values below the regulatory limit, demonstrating that high percentages of tailings affect internal cohesion and reduce the mechanical efficiency of the concrete. These results demonstrate that the incorporation of mining tailings is viable only in moderate proportions in order to maintain adequate structural behavior in urban paving applications (Putra & Faza, 2023).

Table 2

Average Absorption (%)

<i>Tailings (%)</i>	<i>Absorption</i>	<i>Complies (≤7.5%)</i>
0%	4.09	Yes
5%	4.04	Yes
10%	4.02	Yes
25%	3.88	Yes
50%	3.82	Yes

Note: Average water absorption values in Type II paving blocks. The maximum permissible limit is 7.50%, according to the requirements established for concrete units intended for pavement applications.

The absorption results show that all evaluated dosages comply with the maximum permissible limit of 7.50% established by the current technical standard. Likewise, a slight decrease in absorption values is identified as the percentage of mining tailings incorporation increases, decreasing from 4.09% in the control mixture to 3.82% in the dosage with 50% replacement. This behavior demonstrates a progressive reduction in the porosity of the concrete, associated with the presence of fine tailings particles, which favor better internal compaction and lower permeability within the cementitious matrix of the material (Agustiningtyas et al., 2022; Wang et al., 2023).

Table 3

Average Dry Density (g/cm³)

<i>Tailings (%)</i>	<i>Density</i>
0%	2.124
5%	2.149
10%	2.192
25%	2.280
50%	2.270

Note: Average dry density obtained for the different Type II paving block dosages, expressed in g/cm³. The values reflect the degree of material compaction as a function of the mining tailings content.

Regarding the average dry density, an increasing trend is observed as the percentage of mining tailings incorporation rises, reaching the maximum value of 2.280 g/cm³ in the dosage with 25% replacement. This behavior demonstrates that the fine particles of the tailings favor better compaction and reduce internal voids within the concrete matrix (Agustiningtyas et al., 2023). Likewise, mixtures with mining tailings incorporation present values higher than the control mixture, indicating a positive influence on the physical properties of the material. However, high percentages do not guarantee proportional improvements in the mechanical behavior of the concrete (Wang et al., 2022).

Table 4

Dimensional Variation (mm)

<i>Tailings (%)</i>	<i>Width</i>	<i>Length</i>	<i>Height</i>	<i>Complies</i>
0%	1.10	1.40	1.13	Yes
5%	1.23	1.45	0.85	Yes
10%	0.92	1.35	0.95	Yes
25%	1.08	1.58	1.75	Yes
50%	0.85	1.57	0.90	Yes

Note: Dimensional variations recorded in the width, length, and height of Type II paving blocks. All dosages comply with the tolerance limits established by the corresponding technical standard.

The dimensional variation results demonstrate that all dosages manufactured with the incorporation of mining tailings comply with the tolerance limits established by the technical standard for Type II paving blocks, demonstrating adequate geometric stability during the manufacturing process (Hussein & Al-Zwainy, 2022). Regarding width, the recorded values ranged between 0.85 mm and 1.23 mm, while length variations fluctuated between 1.35 mm and 1.58 mm, remaining within the permissible ranges. Likewise, height values ranged from 0.85 mm to 1.75 mm, with the mixture containing 25% tailings presenting the greatest variation; however, no deformations affecting the functional performance of the paving blocks were observed. These results indicate that the incorporation of mining tailings does not generate significant alterations in the final dimensions of the material. Similarly, the observed dimensional uniformity reflects adequate behavior of the mixtures during the molding, vibrocompression, and curing processes, an important aspect to guarantee construction quality, ease of installation, and proper structural performance in urban paving applications (Putra & Faza, 2023).

Table 5**Cost Comparison (S/ per m²)**

Type	Cost
<i>Conventional</i>	26.09
<i>With tailings</i>	25.86

Note: Comparison of the unit cost per square meter between conventional paving blocks and paving blocks incorporating mining tailings, showing a 0.88% reduction in production cost.

The comparative cost analysis shows that the incorporation of mining tailings as a partial substitute for fine aggregate generates a reduction in the unit production cost of Type II paving blocks compared to the conventional mixture. The results indicate that the production cost of conventional paving blocks reached a value of S/ 26.09 per square meter, while the mixtures manufactured with the incorporation of mining tailings registered a cost of S/ 25.86 per square meter, representing an approximate reduction of 0.88% compared to the control mixture. Although the observed economic difference is not considerable in unit terms, it becomes relevant when projected to industrial production processes or large-scale manufacturing, where small cost reductions may represent significant savings in operational terms and material consumption. This economic behavior may be mainly attributed to the partial replacement of conventional fine aggregate with mining tailings, allowing a partial reduction in the use of natural materials commonly used in the manufacture of paving blocks. Likewise, the reuse of mining waste contributes to reducing costs associated with the supply and extraction of conventional aggregates, promoting better use of available resources (MINAM, 2013). From a technical and environmental perspective, the obtained economic results become more important considering that mixtures with moderate percentages of mining tailings maintained adequate physical-mechanical behavior and complied with the requirements established by the current technical standard. In this sense, the controlled incorporation of mining tailings not only represents an alternative aimed at reducing environmental impacts derived from the accumulation of mining liabilities, but also an economically favorable option for the production of Type II paving blocks within sustainable construction and circular economy processes (Sovacool & Griffiths, 2020).

Overall, the results presented in Tables 1 to 5 demonstrate that the incorporation of mining tailings generates a non-linear behavior in the properties of concrete, allowing the identification of an optimal replacement range in which the balance between mechanical performance, physical properties, and regulatory compliance is maintained. Although the increase in tailings content favors matrix densification and absorption reduction, this effect is not directly translated into an improvement in

strength, which highlights the complexity of the interaction between concrete components (Putra & Faza, 2023). Likewise, the dimensional stability observed in all dosages confirms that the use of tailings does not affect the geometry of the paving blocks, an aspect that is relevant from a construction standpoint. From an integral perspective, the results indicate that the controlled incorporation of mining tailings not only allows the optimization of material use, but also contributes to reducing production costs while maintaining the functionality of the final product. In this sense, it is evident that the use of tailings constitutes a viable alternative, provided that its application is limited to technically appropriate ranges that guarantee the balance between strength, durability, and sustainability (Raghavendra et al., 2024).

3.2. Discussion

The results obtained regarding the first specific objective demonstrate that the incorporation of mining tailings directly influences the compressive strength of concrete for Type II paving blocks, showing a progressive decrease as the percentage of fine aggregate replacement increases. The mixtures with 5% and 10% tailings reached values higher than the minimum required by NTP 399.611, while the dosages with 25% and 50% presented a significant reduction in resistant capacity. This behavior may be explained by the alteration of the bond between the cement paste and the tailings particles, affecting the internal cohesion of the concrete and reducing the mechanical efficiency of the cementitious matrix (Putra & Faza, 2023; Wang et al., 2022).

Regarding the second specific objective, related to the physical properties of concrete, the results demonstrated that the increase in mining tailings content favors the densification of the mixture and reduces the absorption values of the material. This behavior is related to the presence of fine tailings particles, which allow the reduction of internal voids and generate a more compact structure within the cementitious matrix. These results coincide with Agustiningtyas et al. (2025), who indicate that certain fine mineral residues improve compaction and reduce the permeability of concrete, favoring certain physical properties of the material (Raghavendra et al., 2021).

Regarding the third specific objective, the results show that mixtures with percentages lower than or equal to 10% comply with the requirements established by NTP 399.611 in terms of strength, absorption, and dimensional variation. Likewise, the dimensional tests demonstrated that all dosages maintained values within the permissible limits, indicating that the incorporation of mining tailings does not generate significant alterations in the geometry of the paving blocks nor affect their manufacturing conditions. According to Hussein and Al-Zwainy (2021), dimensional control constitutes a fundamental parameter in prefabricated elements

intended for pavement applications, guaranteeing structural stability and uniformity (Putra & Faza, 2023).

Finally, regarding the fourth specific objective, the results show that the partial incorporation of mining tailings allowed an approximate reduction of 0.88% in the production cost of the paving blocks. Likewise, the reuse of tailings contributes to reducing the accumulation of environmental liabilities and promoting circular economy strategies within the construction sector. This behavior demonstrates that the utilization of mining waste represents an environmentally sustainable alternative for materials intended for urban paving and sustainable construction processes (MINAM, 2013; Sovacool & Griffiths, 2020).

4. CONCLUSIONS

- The incorporation of mining tailings as a partial substitute for fine aggregate directly influences the mechanical behavior of concrete for Type II paving blocks, showing a progressive decrease in compressive strength as the replacement percentage increases. However, the mixtures with 5% and 10% tailings reached values of 384.72 kg/cm² and 381.45 kg/cm² at 28 curing days, complying with the minimum value established by NTP 399.611, which demonstrates that moderate incorporation percentages allow the preservation of adequate structural performance conditions in urban paving applications.
- Regarding the physical properties of concrete, the increase in mining tailings content favored the densification of the mixture and reduced the absorption levels of the material due to the presence of fine particles that contribute to reducing internal voids within the cementitious matrix. Likewise, the mixtures with tailings incorporation presented higher density values compared to the control mixture, demonstrating an improvement in the internal compaction of the concrete; however, high replacement percentages failed to compensate for the loss of mechanical strength observed in the dosages with 25% and 50% tailings.
- Regarding regulatory compliance, mixtures with percentages lower than or equal to 10% satisfactorily complied with the requirements established by NTP 399.611 in terms of strength, absorption, and dimensional variation. Likewise, the dimensional tests demonstrated that all dosages maintained values within the permissible limits, indicating that the incorporation of mining tailings does not generate significant alterations in the geometry of the paving blocks nor affect their manufacturing, molding, and vibrocompression conditions during the production process.
- Finally, from an economic and environmental perspective, the partial incorporation of mining tailings allowed an approximate reduction of 0.88% in the production cost of the paving blocks compared to the conventional mixture.

Likewise, the reuse of mining waste contributes to reducing the accumulation of environmental liabilities and promotes circular economy strategies within the construction sector, representing a sustainable and technically viable alternative for the manufacture of Type II paving blocks through processes aimed at the efficient use of resources and the reduction of environmental impact.

5. ACKNOWLEDGMENTS

This work was made possible thanks to the valuable support of the professors of the National University of the Altiplano – Puno, who, through their academic training and constant guidance, significantly contributed to the development of the competencies necessary for the preparation of this scientific article; likewise, special recognition is expressed to the Graduate School and the Language Program for providing the methodological and educational tools that strengthened the research process, allowing a rigorous approach in accordance with academic standards; in particular, special thanks are extended to Dr. Diana Vargas Velásquez for her guidance, support, and academic contribution, which were fundamental in directing and consolidating the present work.

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CONTINUING EDUCATION FOR DIRECTORS OF INITIAL EDUCATION INSTITUTIONS

Gardenia Lizbeth Tacanahui Quispe

gardenliz038@gmail.com

<https://orcid.org/0009-0007-6660-1596>

National University of the Altiplano – Puno



ABSTRACT

Continuing professional development for principals is a key factor in school management in early childhood education, as it is linked to planning, pedagogical leadership, resource management, and the institutional climate. The objective was to determine the relationship between continuing professional development and school management among principals of public early initial education institutions in the Puno Local Education Management Unit during 2024. The study adopted a quantitative approach with a descriptive-correlational scope and a non-experimental, cross-sectional design. The sample consisted of 58 principals, and data were collected using two validated questionnaires with Cronbach's alpha coefficients of 0.962 and 0.978, respectively. The data were analyzed using IBM SPSS Statistics version 25, applying Spearman's correlation. The results showed a positive and significant relationship between continuing education and school management ($r = 0.561$; $p = 0.000$). By dimension, participation showed a moderate correlation ($r = 0.448$; $p = 0.000$), perceived quality showed a moderate association ($r = 0.537$; $p = 0.000$), and applicability showed a strong positive relationship ($r = 0.869$; $p = 0.000$), indicating that transferring learning to institutional processes and routines is associated with more efficient and transparent management. The study concludes that relevant, context-specific, and practical training is linked to best practices in planning, instructional leadership, resource management, and school climate, providing evidence to guide policies and leadership training programs with a regional focus within the Puno Educational Management Unit.

Keywords: Principals, professional development, school management, leadership.

1. INTRODUCTION

Continuing professional development is a systematic, planned, and sustained process aimed at strengthening the professional competencies of teachers and school leaders throughout their careers. According to the Peruvian Ministry of Education (MINEDU, 2023), this process integrates both formal experiences—such as courses, workshops, certifications, and support programs and informal learning derived from reflection on practice, the exchange of experiences, and participation in professional communities. Through this integration, continuing professional development helps foster a culture of continuous improvement within educational institutions, strengthening their ability to respond to contemporary pedagogical and organizational challenges. The effective implementation of continuing education requires institutional management that ensures adequate resources, dedicated time, and professional recognition. In this regard, the Ministry of Education (2022) stipulates that training initiatives must meet criteria of territorial relevance, in-service support, and outcome evaluation, so that each training experience is linked to the real needs of the educational context, ensuring equitable access to professional development, especially in rural and hard-to-reach areas. The Regional Directorate of Education for Metropolitan Lima (DRELM, 2025) agrees that continuing education and knowledge management are pillars for the consolidation of reflective and collaborative educational communities, making training a structural process that involves leadership, planning, monitoring, and support. The relationship between professional development and school management has been extensively documented by empirical research. Cortez (2022), in public institutions in Ate, Lima, found a significant positive correlation ($r = 0.850$; $p = 0.000$) between continuing professional development and school management by administrators, demonstrating that continuing education programs have a positive impact on leadership capacity and institutional management. Bedia (2023) obtained a Spearman's correlation coefficient of $r = 0.778$ ($p < 0.05$) when analyzing the relationship between continuing education and pedagogical management in Cusco, concluding that training is a key component for strengthening leadership practice. Holguín (2020), in Ecuador, found that 82.4% of school leaders rated their professional training favorably and identified a significant correlation ($r = 0.605$) with pedagogical management. These findings are consistent with those of Chicoma (2020), who demonstrated that participation in collaborative professional development programs improves administrators' administrative and pedagogical skills, thereby increasing their motivation and institutional commitment. At the regional level, the jurisdiction of the Puno Local Education Management Unit faces conditions that exacerbate this problem. It rated educational management as deficient and 32.8% as fair, highlighting persistent shortcomings in institutional planning, leadership, and resource management.

Against this backdrop, the purpose of this study was to determine the relationship between professional development and school management among principals of public early initial education institutions within the Puno Local Education Management Unit during 2024, with the aim of generating empirical evidence to guide the design of policies and leadership training programs with a territorial focus. The study was structured around three dimensions of continuing education participation in training activities, perceived quality of training, and applicability of training and four dimensions of school management strategic planning, resource management, leadership and personnel management, and positive school climate in order to obtain a comprehensive and empirically grounded understanding of the relationship between these two variables in the Altiplano context.

The objective of the study was to determine the relationship between professional development and school management among principals of early initial education institutions in the Puno Local Education Management Unit, 2024. Specifically, the study sought to: (1) evaluate the relationship between participation in training activities and school management; (2) identify the relationship between the perceived quality of training and school management; and (3) analyze the relationship between the applicability of training and school management. In doing so, the study aims to contribute to scientific knowledge regarding the relationship between leadership training and the quality of school management in highland contexts, providing useful evidence for institutional decision-making and the design of improvement strategies relevant to the Puno region.

2. METHODS

The study was conducted in early initial education institutions affiliated with the Puno Local Education Management Unit, located in the district, province, and region of Puno, Peru, at 15°50'24.7" south latitude and 70°01'18.8" west longitude, at an elevation of 3,825 meters above sea level. The research adopted a quantitative approach with a non-experimental, cross-sectional design and a descriptive-correlational scope.

The study sample consisted of the 58 principals of public early initial education institutions belonging to the Puno Local Education Management Unit in 2024. Given the manageable size of the population, it was decided to include all principals as a census sample: 30 from urban areas (51.7%) and 28 from rural areas (48.3%). Principals who were in office during the research period were included, while acting principals or those on extended leave were excluded.

To measure the variable of continuing education, a 15-item questionnaire was used, organized into three dimensions of 5 items each: participation in training activities, perceived quality of training, and applicability of training, using a five-point Likert

scale. The established scales were: Low (15–35), Medium (36–55), High (56–75). To measure school management, a 20-item questionnaire was used, organized into four dimensions: strategic planning, resource management, leadership and personnel management, and positive school climate, with the following scales: Low (20–46), Medium (47–73), High (74–100).

Content validity was determined through the judgment of three experts with experience in educational management, yielding an Aiken’s V coefficient ranging from 0.87 to 0.96, which indicates high content validity. Reliability was assessed using Cronbach’s alpha, yielding values of 0.962 for the continuing education questionnaire and 0.978 for the school management questionnaire, indicating excellent internal consistency according to George and Mallery (2019). The instruments were administered online via Google Forms, following the reading and acceptance of the informed consent form.

For the normality analysis, the Kolmogorov-Smirnov tests were applied, yielding the following results: continuing education (K-S = 0.301; df = 58; p = 0.000) and school management (K-S = 0.284; df = 58; p = 0.000). Since $p < 0.05$ for both variables, a non-normal distribution was confirmed; therefore, Spearman’s correlation coefficient was applied to establish the relationship between variables, with a significance level of $\alpha = 0.05$ and 95% confidence. Data analysis was performed using IBM SPSS Statistics version 25.

3. RESULTS AND DISCUSSION

3.1. Results

The following section presents the results that address the research objectives.

Table 1

Relationship between levels of participation in training activities and school management levels among principals of early childhood education institutions in the Puno Local Education Management Unit, 2024

Participation in training activities	School Administration							
	Low		Medium		High		Total	
	N	%	N	%	N	%	N	%
Low	1	1,7	-	-	-	-	1	1,7
Medium	1	1,7	1	1,7	11	19,0	13	22,4
High	-	-	-	-	44	75,9	44	75,9
Total	2	3,4	1	1,7	55	94,8	58	100,0

Note: Compiled by the authors based on questionnaires administered to principals of early childhood education institutions in the Puno Local Education Management Unit (2024). **p < 0.01.

Table 1 shows that 75.9% of principals demonstrate a high level of participation in professional development activities and, at the same time, high levels of school leadership. This finding indicates that sustained engagement with the professional development processes promoted by MINEDU (2023) leads to more efficient, well-planned, and participatory institutional management. Only 1.7% reported low levels in both variables, reflecting limited participation and restricted leadership performance. These data confirm that the greater the involvement in training programs, the greater the principal's capacity to lead strategic planning processes, resource management, and the creation of a positive school climate. Vezub (2024) argues that the continuity and systematic nature of participation strengthen managerial professionalization and stimulate pedagogical innovation; in this regard, the findings of the Puno Local Education Management Unit are consistent with the OECD (2020), which demonstrates that diversified and sustained participation is directly associated with improved institutional management.

Table 2

Relationship between the perceived quality of training and school management levels among principals of early childhood education institutions in the Puno Local Education Management Unit, 2024

Perceived quality of training	School Administration							
	Low		Medium		High		Total	
	N	%	N	%	N	%	N	%
Low	2	3,4	-	-	-	-	2	3,4
Medium	-	-	1	1,7	8	13,8	9	15,5
High	-	-	-	-	47	81,0	47	81,0
Total	2	3,4	1	1,7	55	94,8	58	100,0

Note: Compiled by the author based on questionnaires administered to directors of early childhood education institutions in the Puno 2024 Local Education Management Unit. **p < 0.01.

Table 2 reveals that 81.0% of principals perceive high quality in professional development programs and, at the same time, demonstrate high levels of school management. This indicates that when programs are positively evaluated for their relevance, methodology, and depth, principals develop better practices in strategic planning, pedagogical leadership, and resource management. Only 3.4% reported low perceived quality and low levels of management, reflecting that dissatisfaction with the training received is associated with limitations in institutional leadership. Cuadrado (2024) notes that perceived quality is a decisive factor in the effectiveness of professional development, as contextualized and methodologically sound training increases motivation and commitment; these results are consistent with Foschi (2021), who found that positive perceptions of training are directly related to higher

levels of professional commitment, and with Noben et al. (2021), who demonstrated that competency-based programs strengthen self-efficacy and applied capacity.

To analyze the relationship between the applicability of training and school management among principals of early childhood education institutions in the Puno Local Education Management Unit, 2024.

Table 3

Summary of Spearman’s correlations by dimension and research objective

Continuing Education Component	Spearman's rho (r)	Sig. (bilateral)	N	Interpretation	Decision
Participation in training activities	0,448**	0,000	58	Moderate positive correlation	H ₀ is rejected
Perceived quality of training	0,537**	0,000	58	Moderate positive correlation	H ₀ is rejected
Practical Application of the Training	0,869**	0,000	58	Strong positive correlation	H ₀ is rejected
Continuing Education (General)	0,561**	0,000	58	Moderate positive correlation	H₀ is rejected

Note: Original analysis based on statistical analysis using Spearman’s rho correlation coefficient (IBM SPSS v25). N = 58 directors of early childhood education institutions, Puno Local Education Management Unit. **p < 0.01 (two-tailed).

Table 3 summarizes the results for the three specific objectives and the overall objective. The applicability of the training shows the highest correlation (r = 0.869), followed by perceived quality (r = 0.537) and participation (r = 0.448), all with a significance level of p = 0.000. This demonstrates that, while all dimensions of continuing education are positively associated with school management, the ability to transfer learning into institutional practice is the most decisive factor. Overall, the correlation r = 0.561 confirms that the comprehensive strengthening of continuing education—across its three dimensions—has a direct and significant impact on improving school management. This pattern is consistent with the findings of León and Cordero (2024), who argue that the effective transfer of learning into administrative practice strengthens institutional management, and with Nīmante et al. (2025), who identify follow-up support as a key factor in the sustainability of training outcomes.

Table 4

Relationship between levels of continuing education and school management levels among principals of early childhood education institutions in the Puno Local Education Management Unit, 2024

Continuing education	School Administration							
	Bajo		Medio		Alto		Total	
	N	%	N	%	N	%	N	%
Low	2	3,4	-	-	-	-	2	3,4
Medium	-	-	1	1,7	7	12,1	8	13,8
High	-	-	-	-	48	82,8	48	82,8
Total	2	3,4	1	1,7	55	94,8	58	100,0

Note: Compiled by the authors based on questionnaires administered to principals of early childhood education institutions in the Puno Local Education Management Unit (2024). Spearman's correlation coefficient: $r = 0.561$; $p = 0.000 < 0.05$. ** $p < 0.01$.

Table 4 shows that the majority of principals (82.8%) achieved a high level of professional development and, at the same time, high levels of school management. Thirteen point eight percent recorded moderate levels on both variables, while only 3.4% showed low levels. This distribution indicates that principals with higher levels of participation, perceived quality, and applicability of professional development are those who exercise more efficient, planned, and results-oriented management. Sims et al. (2023) argue that prolonged and contextualized professional development enables school leaders to develop competencies for the sustained improvement of their leadership practice; accordingly, MINEDU (2023) states that professional development constitutes a strategic pillar for strengthening school management and promoting collaborative educational communities.

3.2. Discussion

The results showed a significant positive correlation between continuing education and school management ($r = 0.561$; $p = 0.000$), confirming that greater professional development among principals is associated with more efficient, participatory, and results-oriented management. This finding is consistent with the study by Cortez (2022), who found a high correlation ($r = 0.850$; $p = 0.000$) between continuous professional development and school management among administrators in Lima, and with Bedia (2023), who reported a strong correlation ($r = 0.778$; $p < 0.05$) between continuing education and pedagogical management in Cusco. Internationally, Holguín (2020) identified a similar coefficient ($r = 0.605$; $p = 0.000$) among Ecuadorian teachers. These findings confirm that the professional development of school leaders is a key determinant of educational quality, theoretically supported by transformational leadership theory, which explains that

trained leaders foster commitment and innovation in their teams (Harris, 2023), and by organizational learning theory, which posits that institutions that learn collectively consolidate sustainable management processes (Bolívar, 2020).

With regard to participation in professional development activities, the moderate positive correlation found ($r = 0.448$; $p = 0.000$) is consistent with the study by Holguín (2020) and with the findings of Choque (2024), who found a strong relationship ($r = 0.764$; $p < 0.01$) between school management and executive leadership in Azángaro, where participation in training was a key predictor of effective leadership. From a theoretical perspective, transformational leadership theory explains that sustained participation in training processes develops the leader's inspirational influence and shared vision (Harris, 2023), while the professional development approach indicates that ongoing professional development improves planning and problem-solving skills (Vezub, 2024).

Regarding the perceived quality of training, the moderate correlation found ($r = 0.537$; $p = 0.000$) is consistent with Barba's (2021) study, which reported a significant association between pedagogical leadership and educational quality in schools in Quito. Likewise, Bedia (2023) found that 98.2% of teachers rated both their training and pedagogical management as high, confirming that training quality translates into administrative efficiency. Strategic management theory holds that institutions that implement quality training processes generate cycles of continuous improvement (Bryson and George, 2024).

With regard to the applicability of training, the strong positive correlation obtained ($r = 0.869$; $p = 0.000$) is the highest among all the dimensions analyzed, indicating that the ability to apply what has been learned has a direct impact on the effectiveness of school management. This result aligns with Cortez's (2022) findings and is consistent with Bernaola's (2023) report, who demonstrated that school management accounts for up to 90% of the development of continuing education. The theory of learning transfer holds that the effectiveness of training depends on its implementation in the real-world work context (León and Cordero, 2024), and the results-based management model explains that organizations that apply what they have learned achieve a tangible impact (Anand et al., 2023).

A limitation of the present study is the use of self-report instruments, which may be influenced by social desirability. Future studies should complement the assessment with direct observation or 360° feedback. Likewise, it is suggested to conduct longitudinal designs that allow for determining causality and analyzing the evolution of both variables over time, as well as extending the analysis to other educational levels.

4. CONCLUSIONS

- There is a positive and significant relationship between continuing professional development and school management among principals of early childhood education institutions in the Puno Local Education Management Unit (UGEL) ($r = 0.561$; $p = 0.000$), confirming that the professional development of school leaders is a determining factor in the development of efficient, participatory, and results-oriented management.
- Participation in training activities shows a moderate positive correlation with school management ($r = 0.448$; $p = 0.000$), demonstrating that the active and consistent involvement of principals in training programs leads to improved administrative and pedagogical performance, fostering more reflective and collaborative management.
- The perceived quality of training shows a moderate positive correlation with school management ($r = 0.537$; $p = 0.000$), demonstrating that when principals positively evaluate the relevance and depth of training programs, their institutional management improves significantly. This requires that training offerings be relevant, contextually appropriate, and consistent with the needs of bilingual rural settings.
- The applicability of training is the dimension with the greatest predictive power regarding school management, with a strong positive correlation ($r = 0.869$; $p = 0.000$). Principals who transfer the knowledge gained to their institutional practice develop more efficient, transparent, and sustainable management, making applicability the key indicator of training success.
- It is recommended that MINEDU and the Puno Local Education Management Unit implement contextualized continuing education programs using active methodologies and pedagogical support, incorporate transformational leadership modules adapted to the Altiplano environment, strengthen sustained participation through institutional incentives, and establish monitoring mechanisms to evaluate the applicability of the training in school leadership practice.

5. ACKNOWLEDGMENTS

The author would like to express her gratitude to the authorities of the Puno Local Education Management Unit for granting authorization to conduct this study, and to the 58 directors of early childhood education institutions who voluntarily participated in the research. Likewise, thanks are extended to the Graduate School of the National University of the Altiplano for the academic and institutional support provided during the course of this work.

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SUSTAINABLE ARCHITECTURAL DESIGN FOCUSED ON ENVIRONMENTAL MITIGATION IN READY-MIX CONCRETE

Cynthia Valeria Urviola Toledo

orcid.org/0009-0009-6325-9187

cynthiaurviola@est.unap.edu.pe

National University of the Altiplano



ABSTRACT

The ready-mix concrete industry plays a critical role in the climate crisis, accounting for approximately 36% of greenhouse gas emissions associated with the construction sector; however, industrial plants located in the Puno region are responsible for the highest levels of environmental pollution, which is causing harm to the local population. The objective of this research was to analyse the implementation of a sustainable and socially responsible industrial architectural design, based on the hierarchy of needs model. A quantitative, experimental approach with a pre-experimental design and longitudinal scope was employed, using field observation to evaluate the feasibility of the proposed model. The research focused on the ready-mix concrete plant located in the city of Caracoto, on the Juliaca-Puno Highway at km 8. The data collection instruments were field analysis and a questionnaire administered to the plant's workers, which had a reliability coefficient of 0.68 according to Cronbach's alpha. Excel spreadsheets were used for data processing, and the arithmetic mean was applied to test the hypothesis. Data processing was performed using Microsoft Excel software. The results showed that, prior to the implementation of the sustainable design, 83.33% of workers perceived pollution within the industrial environment; following the incorporation of green infrastructure, mitigation barriers, spatial optimization, and environmental control systems, this percentage decreased to 2.38%, resulting in an environmental improvement of 80.95%. It is concluded that sustainable architectural design has a positive influence on environmental mitigation and the functional improvement of industrial infrastructure.

Keywords: Architecture, Design, Industrial, Mitigation, Sustainability

1. INTRODUCTION

The growth of industrial infrastructure in the city of Juliaca has created significant environmental challenges related to air pollution, noise pollution, changes to the urban landscape, and the intensive consumption of natural resources, as evidenced in reports from the Ministry of the Environment (Minam). In this context, various studies argue that the expansion of industrial infrastructure in urban areas increases environmental pressure when there is no adequate land-use planning or sustainability criteria in its design (Newman P., 2021), (Kibert, 2016). Likewise, ready-mix concrete plants are strategic facilities for the development of the construction sector; however, their operational processes can generate significant environmental impacts when their architectural design does not incorporate sustainability criteria (Yeang, 1995).

From an architectural perspective, sustainable design has established itself as a strategy aimed at integrating industrial functionality, operational efficiency, and environmental protection. (Kibert, 2016) argues that sustainable architecture reduces environmental impact through the efficient use of resources, the optimization of spaces, and the incorporation of eco-efficient building solutions. Complementarily, (Yeang, 1995). argues that eco-industrial design must incorporate natural ventilation, green infrastructure, landscape barriers, and bioclimatic strategies that help reduce the polluting effects generated by productive activity. In line with this, the United Nations Environment Programme (Unep, 2020) notes that sustainable design is a key tool for reducing the environmental footprint of productive infrastructure

Likewise, (Newman P., 2021) notes that poor planning of industrial infrastructure can lead to environmental and urban imbalances, especially when such facilities are developed near populated areas or high-traffic road corridors. In this regard, the quality of industrial architectural design directly influences an infrastructure's ability to adapt to its surroundings and reduce its negative impacts through spatial, environmental, and functional strategies (Kibert, 2016) (Yeang, 1995).

At the national level, agencies such as the Ministry of the Environment (Minam), the National Water Authority (ANA), and the National Environmental Certification Service (Senace) for Sustainable Investments promote guidelines aimed at the development of sustainable industrial projects. However, various industrial infrastructures in the Puno region still face limitations related to environmental control, functional organization, and landscape integration, highlighting the need to implement sustainable architectural criteria in industrial design (Minam, 2021; Senace, 2021).

Specifically, at the ready-mix concrete plant located in the Caracoto district, architectural deficiencies were identified, including a lack of green infrastructure,

limited spatial organization, the dispersion of particulate matter, and the absence of environmental mitigation measures, all of which affect the plant's functional efficiency and its relationship with its immediate surroundings (Yeang, 1995). Various studies argue that the absence of sustainable criteria in industrial infrastructure increases environmental impacts and reduces the adaptability of buildings to their territorial context (Kibert, 2016)

Therefore, the purpose of this research is to evaluate the effect of sustainable architectural design on environmental mitigation at a ready-mix concrete plant. In this regard, the overall objective was to determine the influence of implementing sustainable architectural design strategies on reducing environmental impact and improving the functionality of the industrial infrastructure located in the Caracoto district.

2. METHODS

The research was conducted at a ready-mix concrete plant located in the district of Caracoto, specifically on the Juliaca–Puno highway at kilometre 8. The area has industrial and urban characteristics that made it possible to evaluate the interaction between the production infrastructure and the surrounding environment. The unit of analysis consisted of the physical infrastructure of the industrial plant, taking into account its spatial organization, construction conditions, and environmental mitigation measures. For the initial assessment, a census population of 84 workers involved in plant operations was used; these workers participated in identifying environmental conditions prior to the intervention. For the research, the following data collection techniques and instruments were used: a structured questionnaire with 5 items and dichotomous responses (Yes/No), designed to identify the initial perception of environmental pollution. The reliability of the questionnaire was evaluated using Cronbach's alpha coefficient, yielding a value of $\alpha = 0.68$, which is considered methodologically acceptable for experimental and exploratory research; technical observation forms and checklists; aimed at evaluating the architectural and functional conditions of the infrastructure. Field recording instruments to document the physical conditions prior to.

The methodological procedure was carried out in three stages. In the first stage, an initial assessment (pre-test) was conducted using surveys, direct observation, and a technical evaluation of the infrastructure, identifying deficiencies related to particulate matter dispersion, noise pollution, a limited presence of green infrastructure, and deficiencies in spatial organization.

In the second stage, a proposal for sustainable architectural improvement was designed and implemented, incorporating strategies such as vegetative barriers,

permeable pavements, dust control systems, natural ventilation, perimeter fencing, and functional reorganization of industrial spaces.

Finally, in the third stage, a follow-up assessment (post-test) was conducted, allowing for the analysis of changes generated by the intervention and the measurement of the reduction in the environmental pollution index within the plant.

Microsoft Excel software was used for data processing, through which data tabulation, table creation, and graphical representation of results were performed. For statistical analysis, absolute frequencies, percentages, and arithmetic means were used to compare the results obtained before and after the architectural intervention.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1

Initial assessment of perceptions of environmental pollution (Pretest)

Environmental condition	Frequency	Percentage (%)
Perceive pollution	60	83.33
Do not perceive pollution	24	16.67
Total	84	100.00

Note. Author's own compilation, initial assessment of environmental pollution perception (pretest)

The initial results showed that 60 of the 84 workers surveyed, equivalent to 83.33%, identified the presence of environmental pollution within the industrial setting, while 16.67% stated they did not perceive polluting conditions. These findings confirmed the existence of environmental deficiencies in the industrial infrastructure, primarily associated with the dispersion of dust particles, operational noise, and a limited presence of architectural mitigation elements. Furthermore, the results reflect the need to implement sustainable intervention strategies aimed at improving the environmental and functional quality of the production space.

Table 2

Types of pollution identified at the industrial plant

Type of pollution	Frequency	Percentage (%)
Environmental (particulate matter/dust)	60	71.43
Noise	48	57.14
Landscape or visual	36	42.86

Note. Prepared by the author; types of pollution identified at the industrial plant

The results showed that environmental pollution associated with the dispersion of particulate matter was the most frequently identified condition within

Table 3

Technical evaluation of the infrastructure before and after the architectural intervention

Architectural indicator	Before the intervention	After the intervention
Green spaces	Deficient	Implemented
Dust control	Deficient	Improved
Spatial organization	Fair	Optimal
Natural ventilation	Limited	Improved
Environmental barriers	Non-existent	Implemented

Note. Prepared by the authors, technical evaluation of the infrastructure before and after the architectural intervention

The results of the technical evaluation revealed significant changes in the main architectural indicators analysed following the implementation of the sustainable proposal. Before the intervention, the industrial plant exhibited deficiencies related to the absence of green areas, limited dust control, fair spatial organization, insufficient natural ventilation, and a lack of environmental barriers. Subsequently, the incorporation of sustainable architectural strategies allowed for a comprehensive improvement in the physical and functional conditions of the infrastructure, optimizing the relationship between the production process, the work environment, and the immediate surroundings. These improvements confirm that the architectural intervention generated a positive impact on the plant's environmental and operational performance

Table 4

Post-intervention assessment of environmental pollution perception (Post-test)

Environmental condition	Frequency	Percentage (%)
Perceive pollution	2	2.38
Do not perceive	82	97.62
Total	84	100.00

Note: Author's own analysis; post-intervention assessment of environmental pollution perception (post-test)

The results of the post-intervention assessment showed a significant improvement in workers' environmental perception, with only 2 of the 84 participants—equivalent to 2.38%—continuing to perceive any level of pollution within the industrial environment. In contrast, 97.62% reported not perceiving polluting conditions after

the architectural intervention. These findings demonstrate that the implementation of green infrastructure, natural ventilation systems, environmental barriers, and dust control mechanisms directly contributed to the reduction of polluting factors present in the industrial plant.

Table 5

Overall comparison of the pretest and posttest

Assessment	Pretest (%)	Post-test (%)	Reduction (%)
Perception of pollution	83.33	2.38	80.95

Note. Author's own work, overall comparison of pre-test and post-test

The comparison of the results obtained between the initial and final evaluations revealed an 80.95% reduction in the perception of environmental pollution within the industrial plant. Initially, 83.33% of workers identified unfavourable environmental conditions; however, after the implementation of the sustainable architectural proposal, this percentage decreased to 2.38%. These results demonstrate the effectiveness of the architectural strategies applied, which

3.2. Discussion

The results obtained in this study showed that the implementation of sustainable architectural design strategies led to a significant reduction in the perception of environmental pollution within the ready-mix concrete plant located in the Caracoto district. Initially, 83.33% of workers identified unfavourable environmental conditions associated primarily with the dispersion of particulate matter, noise pollution, and limited integration into the landscape; however, following the architectural intervention, this percentage decreased to 2.38%, representing an overall reduction of 80.95%.

These findings support the assertion that the incorporation of architectural sustainability criteria positively influences the environmental and functional performance of industrial infrastructure. (Kibert, 2016). The results obtained are consistent with the findings of (Kibert, 2016), who argues that sustainable architecture reduces environmental impacts through eco-efficient construction solutions, the integration of green infrastructure, and the functional optimization of industrial spaces.

In this study, the incorporation of vegetative barriers, natural ventilation, and dust control mechanisms significantly reduced the presence of environmental pollutants within the industrial plant, confirming the importance of sustainable design as a tool for environmental mitigation. Furthermore, the findings align with the principles of (Yeang, 1995)., who asserts that industrial ecological design must incorporate

bioclimatic strategies and natural elements capable of balancing the relationship between infrastructure and the surrounding environment.

In this regard, the implementation of green spaces and environmental barriers at the industrial plant improved landscape integration and visually reduced the negative impact generated by production activities, while also enhancing environmental comfort conditions within the industrial space. (Kibert, 2016) Similarly, the results are consistent with the observations of (Newman P., 2021), who argues that sustainable spatial planning helps reduce environmental impacts and improve the adaptation of industrial infrastructure to the urban environment.

In the research conducted, the functional reorganization of industrial spaces allowed for the optimization of internal circulation, improved operational conditions, and enhanced the environmental efficiency of the industrial plant. Particularly relevant is the fact that pollution associated with particulate matter was identified as the primary environmental issue within industrial infrastructure.

This finding demonstrates that ready-mix concrete plants require specialized architectural strategies aimed at controlling emissions and reducing air pollutants. In this context, the implementation of dust control systems, green infrastructure, and natural ventilation significantly reduced the environmental impact factors perceived by workers.

From an architectural and environmental perspective, the results demonstrate that sustainable design not only serves an aesthetic or landscape function but also constitutes a technical tool aimed at improving operational efficiency, reducing polluting impacts, and strengthening the relationship between industrial infrastructure and the urban environment. This highlights the need to incorporate sustainability criteria from the earliest stages of planning and design for industrial projects, especially for infrastructure located near urban areas and vulnerable populations.

Finally, the results obtained confirm that the implementation of sustainable architectural strategies constitutes a technically and environmentally viable alternative for mitigating environmental impacts at ready-mix concrete plants. Furthermore, the research provides evidence applicable to the context of the Puno region, where there is still limited research related to sustainable industrial architecture and environmental control in industrial infrastructure.

4. CONCLUSIONS

- The implementation of sustainable architectural design had a significant impact on environmental mitigation at the ready-mix concrete plant located in Caracoto,

reducing the perception of pollution from 83.33% to 2.38%, equivalent to an overall improvement of 80.95%.

- The initial assessment identified that the main environmental issues were related to the dispersion of particulate matter, noise pollution, and limited integration into the landscape, directly affecting the functionality and environmental quality of the infrastructure.
- The implementation of sustainable architectural strategies, such as green infrastructure, environmental barriers, natural ventilation, and spatial reorganization, significantly improved the operational and environmental conditions of the industrial plant.
- From an architectural perspective, incorporating sustainability criteria into industrial infrastructure not only helps reduce environmental impact but also enhances functional efficiency, the relationship with the urban environment, and public acceptance of the project.

5. ACKNOWLEDGMENTS

This work has been successfully completed thanks to the faculty at UNA – Puno. Additionally, we thank the Graduate School of the National University of the Altiplano and the Language Program, especially Dr. Diana Vargas Velásquez, for guiding this scientific article.

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DESIGN OF AN ETHERNET SYSTEM WITH MULTICAST TECHNOLOGY FOR TELEMEDICINE SERVICES

Luis Miguel Vargas Velásquez

lvargasv@cip.org.pe

ORCID: 0009-0009-1186-8415

National University of the Altiplano - Puno



ABSTRACT

The development of information technologies has allowed disciplines such as medicine to benefit from the real-time transmission of data, audio, image, and video. The objective of this research was to design and simulate an Ethernet network with Multicast technology to interconnect the Manuel Núñez Butrón Regional Hospital with other hospitals in the country, enabling telemedicine services. The research employs a quantitative approach, is experimental in nature, and uses a pre-experimental design. Data collection instruments included Multicast and Argus software. Data processing was performed in the CISCO laboratory at the National University of the Altiplano. To test the hypothesis, the arithmetic mean was applied. The results demonstrated zero data loss and minimal latency, confirming the viability of the Ethernet design with multicast technology for teleconsultation, teleassistance, and other applications. It is concluded that this design would improve the effectiveness of patient care provided by HMNB staff in collaboration with other hospitals.

Keywords: Multicast, Ethernet, Telemedicine, Data Networks

1. INTRODUCTION

Multicast architecture allows data to be transmitted from a single source to a specific group of destinations, optimizing resource usage in computer networks. Unlike unicast, which sends information to a single destination, and broadcast, which distributes it to all nodes, multicast reduces wasted bandwidth and transmission power. According to Deering and Cheriton (1990), multicast significantly improves the efficiency of information distribution in shared networks. Furthermore, 3GPP (2016) indicates that the MBMS service in LTE networks allows for optimized multimedia transmission through dynamic switching between unicast and multicast.

Furthermore, recent research highlights that multicast reduces bandwidth and power consumption in wireless environments (Tamayo, 2014). In this regard, Telecommunications Engineering maintains that SFN topologies increase network coverage and energy efficiency. Similarly, studies by Cisco Systems (2017) indicate that implementing multicast in Ethernet networks improves performance and avoids unnecessary data duplication. Finally, authors such as Stallings (2016) assert that multicast is a more efficient solution compared to the repetitive use of unicast connections in large-scale networks.

In the Peruvian context, the lack of specialized health centers in the regions motivates the implementation of hospital interconnection systems. The use of Ethernet with multicast technology allows for bandwidth optimization and ensures the simultaneous delivery of critical information, making it a strategic tool for remote healthcare. On the other hand, the need to improve healthcare in the Puno region, given the shortage of health centers and specialists, motivated the proposal to implement a telemedicine system at the Manuel Núñez Butrón Regional Hospital to provide remote medical services. To this end, an Ethernet network interconnection system based on Multicast technology was designed and simulated at the CISCO laboratories of the National University of the Altiplano in Puno.

The purpose of this experimental research was to design a healthcare Ethernet network interconnection system using multicast technology to optimize the transmission of medical information and enable the efficient application of telemedicine at the Manuel Núñez Butrón Regional Hospital. To achieve this, a simulated network architecture was developed using Cisco Packet Tracer, and traffic and monitoring tests were subsequently performed using Argus.

2. METHODS

The research was conducted in the Cisco laboratory of the School of Electronic Engineering at the National University of Asunción (UNA), using the Manuel Núñez Butrón Hospital in Puno, located in southeastern Peru, as a reference. The research lasted eight months in 2016 and employed an experimental approach, with tests performed in a physical laboratory.

- **Equipment used:** Cisco 2811 routers, Cisco 2960 switches, and a PowerEdge R620 server.
- **Software:** VLC Media Player for video transmission and Argus for traffic analysis.
- **Experimental System Design**

The interconnection system was structured under a hierarchical Ethernet topology composed of:

- A central distribution node.
- VLAN segments designated for: Teleconsultation, Remote Diagnosis, Hospital Administration, and Clinical Storage.
- Implementation of Multicast protocols for simultaneous distribution of video, audio, and medical data.
- Configuration of private IP addressing and internal dynamic routing.
- Prioritization of medical traffic using Quality of Service (QoS).

The design developed in Packet Tracer allowed for modeling the network's behavior before its physical implementation, verifying connectivity, response times, and transmission efficiency.

Tests performed: voice, data, and video transmission between multiple clients, packet flow measurement, and end-to-end latency analysis.

The methodology included the configuration of four interconnected routers, video transmission tests across multiple clients, and data quality analysis using ARGUS.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1

The stable behavior of the Multicast network in different traffic load scenarios through simulations performed.

EXPERIMENTAL SCENARIO	NUMBER OF NODES	GRAPH TYPE	TRANSMISSION STATUS
Basic Teleconsultation	10	Audio and video	Successful
Remote diagnosis	15	Medical imaging	Successful
Medical video conference	25	Streaming HD	Successful
Transfer of medical records	30	Clinical data	Successful
Comprehensive simultaneous traffic	40	Audio, video and data	Successful

Note: Data obtained using Packet Tracer.

During testing, it became clear that the Multicast protocol optimized bandwidth by avoiding redundant transmissions inherent in the Unicast model, achieving simultaneous and efficient distribution to multiple medical stations.

Furthermore, latency remained within acceptable parameters for telemedicine applications, remaining stable even during high-traffic scenarios.

Table 2

Network traffic behavior during experimental tests

EXPERIMENTAL TEST	TRANSMITTED PACKETS	LOST PACKAGES	PERCENTAGE OF LOSS
Package 1	12 450	0	0%
Package 2	18 320	0	0%
Package 3	24 875	0	0%
Package 4	31 640	0	0%
Package 5	45 210	0	0%

Note: Data obtained from ARGUS software.

The Argus software was used to capture, monitor, and analyze network traffic behavior during experimental tests. Performance indicators related to the following were evaluated:

- Packet loss.
- Transmission stability.
- Continuous data flow.
- Multicast traffic performance.
- Network congestion.

The results showed zero data loss in all experimental tests, achieving a 100% reliability index during the transmission of medical information. Similarly, Argus monitoring verified that:

- There were no connectivity interruptions.
- Multicast traffic remained stable.
- The transmission of medical videoconferences was performed without degradation.
- Packet flow exhibited uniform behavior.
- No bottlenecks were identified in the simulated network.
- Validation of the telemedicine system.

Furthermore, the experimental trials confirmed that the designed system meets the minimum requirements for implementing telemedicine services in a hospital setting. Among the validated functional applications are:

- Real-time medical teleconsultation.
- Clinical videoconferencing.
- Transfer of diagnostic images.
- Simultaneous sharing of medical records.
- Communication between healthcare areas.

Calculation of the arithmetic mean

The mean was calculated using:

$$\bar{x} = \frac{\sum x_i}{n}$$

Replacing:

$$\bar{x} = \frac{0 + 0 + 0 + 0 + 0}{5}$$

The average data loss is:

$$\bar{x} = 0.00\%$$

The average data loss is:

$$\bar{x} = 0.00\%$$

Hypothesis Testing

Given that:

- The mean data loss was 0.00%.
- The standard deviation was 0.00.
- There were no variations between the experimental tests.
- The multicast transmission exhibited complete stability.

In other words, the research hypothesis (H_1) is accepted and the null hypothesis (H_0) is rejected, concluding that the design of the Ethernet system with Multicast technology significantly improves network performance for telemedicine services at the Manuel Núñez Butrón Hospital.

3.2. Discussion

Based on the results of the research on the interconnection design of the Health Ethernet Network using Multicast, the packet flow analysis shows that the source IP address corresponds to the server 192.168.4.254, manually configured to control multicast transmission. The source port was dynamically assigned by Layer 4 of the server software. A key aspect was the configuration of the Time to Live (TTL) with a value of 12, which allowed multicast packets to traverse up to 12 routers. In previous tests, the TTL remained at 0 by default, limiting multicast to LANs and preventing routing between network segments.

Regarding the destination, the multicast address 239.255.0.1 was used for video transmission via VLC, configured on both the server and clients to allow multicast reception. This mechanism enabled multiple users to simultaneously share a single multicast session, significantly optimizing network resource usage. The configured destination port was 5004, corresponding to the Real-Time Transport Protocol (RTP), responsible for real-time data transmission; additionally, port 5005 was used for RTP control.

Similarly, the multicast addresses 239.255.0.2 and 239.255.0.3 were used to transmit two other independent videos, also configured on the server and clients via VLC. The results showed that, even when transmitting three multicast video streams to multiple clients, the maximum bandwidth consumption reached approximately 6 Mbps, equivalent to 6,834,026.91 bps. This is considerably low compared to the available network capacity, which was 1 Gbps between routers and 100 Mbps at the client devices. It is worth noting that the most significant result was that the data loss recorded during all tests was 0.00%, demonstrating 100% reliability in data transmission and confirming the efficiency of the multicast system implemented for telemedicine applications.

The results of this research align with the principles described by Cisco Press regarding multicast-enabled clinical networks. According to this technical literature, hospital environments require architectures capable of simultaneously supporting audio and video transmission, biomedical monitoring, and real-time clinical data exchange. Multicast is one of the most efficient technologies for reducing redundant traffic and optimizing bandwidth in complex hospital networks. The research conducted confirms these findings, as the simultaneous transmission of medical information to multiple nodes did not generate congestion or service degradation. Furthermore, these findings are consistent with national research aimed at improving the quality of service in institutional networks. The study conducted at the Ahuaycha District Municipality concluded that virtual and segmented networks significantly reduce packet loss and improve data network performance, demonstrating that proper logical segmentation optimizes the transmission of critical information.

Similarly, research on segmented IP telephony at the Lima Central Health Directorate showed significant improvements in latency, jitter, and packet loss, achieving over 75% optimization in the performance of the institutional network.

These results are also consistent with research on telemedicine in rural areas of Peru. The study by Mauricio et al. (2024) showed that the implementation of teleconsultation platforms reduced patient transfers to urban hospitals by 60%, significantly improving access to specialized services in regions with limited connectivity. This suggests that robust and stable network systems, such as the one proposed in this research, can significantly contribute to strengthening telemedicine in high Andean regions like Puno.

On the other hand, this research differs from some previous studies that reported congestion problems and high packet loss in multicast services and video calls. A recent study conducted at the National University of San Antonio Abad in Cusco revealed packet loss of approximately 69%, negatively impacting videoconferencing and multicast traffic. This difference can be attributed to the fact that the design proposed in this research incorporated appropriate traffic segmentation, a hierarchical Ethernet topology, and efficient data flow control through optimized multicast configuration.

From a theoretical perspective, the specialized literature maintains that multicast technologies minimize unnecessary retransmissions and significantly reduce the likelihood of congestion in simultaneous transmission networks. International studies on multicast transmission capacity indicate that this model improves performance when multiple receivers require the same information in real time, especially in sensitive applications such as video and telemedicine. Consequently, the experimental results obtained support the theoretical foundations regarding efficiency, stability, and network traffic optimization using multicast.

Finally, the results allow us to affirm that the proposed multicast Ethernet interconnection design represents a viable and efficient technological solution for hospital institutions that need to implement telemedicine services with high availability, stability, and reliability in the transmission of medical information. The complete absence of data loss during the experimental tests constitutes a relevant indicator of quality of service, especially in hospital settings where the integrity of clinical information is critical.

4. CONCLUSIONS

- The integration of Ethernet with Multicast technology demonstrated a significant improvement in bandwidth efficiency and the stability of hospital communications. The Health Ethernet Network using Multicast enabled the

application of telemedicine at the Manuel Núñez Butrón Regional Hospital in Puno.

- The stable behavior of the Multicast network under different traffic load scenarios, as demonstrated through simulations, showed that the Multicast protocol optimized bandwidth by avoiding redundant transmissions inherent in the Unicast model, achieving simultaneous and efficient distribution to multiple medical workstations.
- The Argus software was used to capture, monitor, and analyze network traffic behavior during the experimental tests. Data loss was zero in all the experimental tests performed, achieving a 100% reliability rate during the transmission of medical information.

5. ACKNOWLEDGMENTS

I extend my recognition and sincere gratitude to the Graduate School of the National University of the Altiplano of Puno, the Language Program, the representatives of the Manuel Núñez Butrón Hospital and the CISCO laboratory of the Professional School of Electronic Engineering of the National University of the Altiplano for the technical and logistical support provided.

6. CONCLUSIONS

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THE IMPACT OF READY MIX CONCRETE ON THE CARBON FOOTPRINT OF THE PERUVIAN ALTIPLANO

David Juan Arturo Villalva Ventura

djvillalvav@epgunheval.edu.pe

ORCID: 0000-0002-1223-5726

Hermilio Valdizán National University – Huanuco



ABSTRACT

The construction industry (CI) generated approximately 37% of carbon emissions (CE), contributing significantly to global warming; therefore, the research aimed to determine the influence of ready-mix concrete (RMC) on the carbon footprint (CF) in the CI in the Peruvian Altiplano (PA). To this end, a life cycle analysis was used, adopting a quantitative approach with an explanatory framework and experimental design. Twelve types of RMC were analyzed, with strengths ranging from 175 to 750 kg/cm², in relation to five quarries in the PA, yielding 2,750 samples. The data were subsequently processed using neural network techniques to model the relationship between variables, and finally, a multivariate analysis of variance (ANOVA) was applied using R software. In this process, experiments were conducted with different proportions of water, cement, and aggregates sourced from local quarries. As a result, a coefficient of determination (R^2) of 0.9448 was determined, with $HC = 0.2779 \text{ CPM} + 155.76 \text{ kgCO}_2/\text{m}^3$. It is concluded that there are three stages in the behavior of CPM in relation to the carbon footprint, whose values ranged between 262.61 kgCO₂e/m³ and 401.78 kgCO₂e/m³. Furthermore, 89% and 93% of the carbon footprint corresponds to the cement content.

Keywords: Concrete, construction, cement, carbon footprint, ready-mix

1. INTRODUCTION

The construction sector is one of the activities with the greatest environmental impact worldwide due to high energy consumption and carbon dioxide emissions generated in the manufacture of materials (Jiang et al., 2025; Miao et al., 2025). In particular, cement production accounts for nearly 7% of global industrial energy consumption and contributes significantly to climate change (Shao et al., 2025; Xi y Jia, 2025). Likewise, during a building's life cycle (Kastner et al., 2025; Liu et al., 2025), the

material production stage accounts for a considerable proportion of total emissions (Tetteh et al., 2025) .

In response to this issue, various studies propose technological strategies aimed at reducing the carbon footprint (Baz y Zhu, 2025; Han et al., 2025; Yasin et al., 2025) . Among these, energy efficiency, industrial innovation, and the replacement of polluting materials stand out (Cai et al., 2025; Liobikienė y Brizga, 2025) . Consequently, sustainability in construction has become an international priority (Liu et al., 2025; Wang et al., 2025) . Ready-mix concrete was one of the main variables of the study, as it is a material produced in a plant under controlled conditions that guarantee quality, strength, and uniformity (Ji et al., 2025; Lin et al., 2025) .

It is composed of cement, water, aggregates, and additives, the proportions of which determine its physical and mechanical properties (Jiang et al., 2025) . Its industrial production reduces human error associated with on-site mixing and improves the traceability of inputs (Miao et al., 2025) . However, when greater structural strength is required, cement consumption increases and, consequently, so do the associated emissions (Shao et al., 2025) . The second variable was the carbon footprint, defined as the indicator that quantifies greenhouse gas emissions expressed in CO₂ equivalent (Xi y Jia, 2025) . This variable allowed for measuring the environmental impact of the construction process (Kastner et al., 2025).

The overall objective of the research was to determine the influence of ready-mix concrete on the carbon footprint in the Peruvian highlands by analyzing strength levels, raw material consumption, and emissions generated during its production. The specific objectives were to determine the statistical relationship between both variables using regression models, evaluate the behavior of emissions at strengths ranging from 175 kg/cm² to 750 kg/cm², and identify the proportion of carbon incorporated in the raw materials. The results enabled the proposal of alternatives aimed at environmental reduction. Consequently, the study provided technical criteria to promote more efficient and sustainable construction in the regional context.

2. METHODS

The research was conducted in the Peruvian highlands, specifically in the Lake Titicaca basin on the Peruvian side, an area characterized by unique high-altitude climatic conditions (MINAM, 2013) . Average annual temperatures range from 7 °C to -10 °C, while precipitation reaches approximately 758 mm/year. These conditions directly influence construction processes and the performance of materials used in infrastructure (MINAM, 2015) .

The study was conducted using a quantitative approach (Zhang et al., 2025) , with an explanatory level and a basic applied research type (Liu y Li, 2025) . The objective was to analyze the relationship between ready-mix concrete and the carbon footprint in a demanding environmental context. To determine the carbon footprint of ready-mix concrete in m³, the life cycle methodology proposed by the Intergovernmental Panel on Climate Change (IPCC) was applied. The emissions calculation considered four main components: raw material production, raw material transport, ready-mix concrete manufacturing, and transport of the finished product. Specific equations were used to quantify factors such as material mass, energy consumption, fuel use, concrete density, and transport distances.

$$E = E_{PMP} + E_{TMP} + E_{FCPM} + E_{TCPM} \quad (1)$$

Where: E is the total emissions, E_{PMP} represents the embodied carbon emissions from raw material production, E_{TMP} are the emissions from raw material transport, E_{FCPM} are the emissions from ready-mix concrete manufacturing, E_{TCPM} are the emissions from ready-mix concrete transport. The four emissions were calculated using the following equations (Lin et al., 2025) :

$$E_{PMP} = \sum_i M_i * EF_i \quad (2)$$

$$E_{TMP} = \sum_i M_i * D_i * EF_{TMP} \quad (3)$$

$$E_{FCPM} = AD_f * EF_f + AD_e * EF_e \quad (4)$$

$$E_{TCPM} = \rho * D * EF_{TCPM} \quad (5)$$

Where: M_i is the mass of each raw material in kg/m³, EF_i is the carbon emission factor of each raw material in kgCO₂e/kg, D_i is the transport distance of each raw material in km, EF_{TMP} is the carbon emission factor for transport equipment in kgCO₂e/kg*km, AD_f represents fuel consumption during manufacturing in t/m³, EF_f is the carbon emission factor of the fuel in kgCO₂e/t, AD_e is the energy consumption during CPM manufacturing in kWh/m³, EF_e is the carbon emission factor for energy in kgCO₂e/kWh, ρ is the bulk density of CPM in kg/m³, D is the transport distance of CPM in km, EF_{TCPM} is the carbon emission factor for CPM transport equipment in kgCO₂e/kg*km (Lin et al., 2025) .

For the analysis of concrete properties, such as strength, workability, and durability. The study included an evaluation of three ready-mix concrete plants and a logistical analysis of distribution to seven cities in the highlands. Additionally, multilayer neural networks were applied to determine the influence between variables, enabling the modeling of complex and nonlinear relationships.

3. RESULTS AND DISCUSSION

3.1. Results

To conduct explanatory research on the relationship between ready-mix concrete (RMC) and the carbon footprint (CF), statistical procedures were applied to verify assumptions, measure association, model influence, and predict results using artificial intelligence. First, the normality of the data was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests.

Table 1

Test of normality of the variables

Variable Test	Test	Statistic	p-value	Decision
CPM resistance	Shapiro-Wilk	0.972	0.214	Normal
Workability	Shapiro-Wilk	0.955	0.041	Not normal
Durability	Shapiro-Wilk	0.968	0.118	Normal
Carbon Footprint	Shapiro-Wilk	0.981	0.463	Normal

Note The table shows that the variables CPM Resistance, Durability, and Carbon Footprint exhibited a normal distribution, with significance values greater than 0.05.

Table 2

Correlation between the variables

Variables	Coefficient	Value	p-value	Interpretation
Resistance vs. HC	Pearson	0.972	0.001	Very high positive
Workability vs. HC	Spearman	-0.541	0.012	Moderately negative
Durability vs. HC	Pearson	0.684	0.001	High positive

Note The table shows that Strength exhibited a very high and positive correlation with the carbon footprint ($r = 0.972$; $p < 0.05$), while Durability showed a high and positive relationship ($r = 0.684$; $p < 0.05$). In contrast, Workability showed a moderate and negative correlation ($r = -0.541$; $p < 0.05$), indicating that as this variable increased, the carbon footprint decreased.

Subsequently, the correlation between variables such as CPM strength, workability, durability, and HC was determined. When the data met the assumption of normality, Pearson's correlation coefficient (r) was used; when it did not, Spearman's correlation coefficient (Rho) was employed.

Table 2*Multiple Linear Regression*

Predictor variable	Beta	Est. Error	t	p-value
Constant	155.76	12.400	12.56	0.001
CPM resistance	0.2779	0.018	15.44	0.001
Workability	-1.842	0.721	-2.55	0.016
Durability	0.933	0.388	2.40	0.021

Note The table shows that CPM Strength was the variable with the greatest positive and significant influence on the carbon footprint ($\beta = 0.2779$; $p < 0.05$). Likewise, Workability had a significant negative effect, while Durability showed a significant positive influence in the multiple regression model.

Table 3*Artificial Neural Network Results*

Metric	Training	Validation	Test
RMSE	4.820	5.310	5.770
MAE	3.940	4.280	4.650
Correlation (R)	0.981	0.974	0.969

Note The table showed that the artificial neural network demonstrated high predictive capability, with low estimation errors during training, validation, and testing.

Figure 1 showed a positive linear relationship between the compressive strength of ready-mix concrete and the carbon footprint, indicating that higher strength levels were associated with increased CO₂ emissions per cubic meter produced. The regression model $Y = 0.2779x + 155.76$ with $R^2 = 0.9448$. Figure 2 shows a positive relationship between the strength of ready-mix concrete and the mass per cubic meter, indicating that as strength levels increased, the amount of materials used gradually increased. The regression models exhibited high coefficients of determination ($R^2 = 0.9767, 0.9922$, and 1.000). Figure 3 shows that the increase in the strength of ready-mix concrete was associated with a progressive increase in the total carbon footprint and that corresponding to cement consumption.

Figure 1

Relationship between the compressive strength of ready-mix concrete and carbon footprint

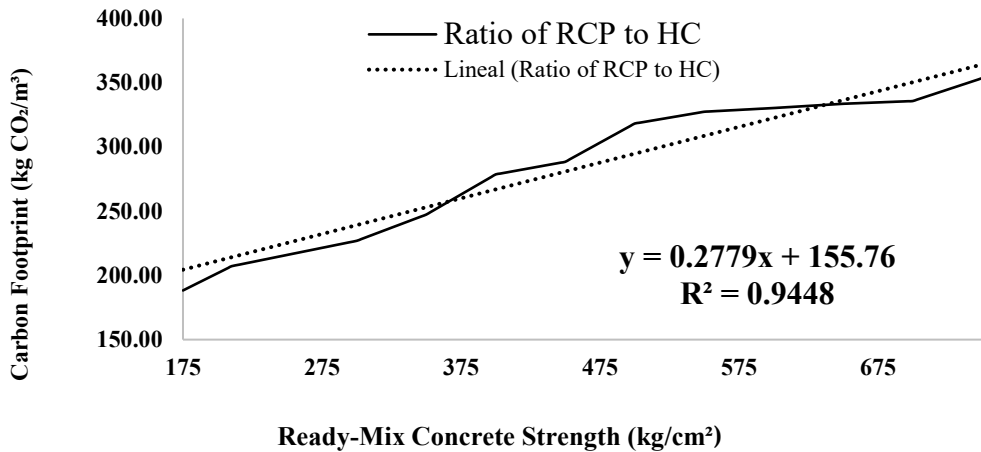


Figure 2

Influence of CPM mass on CPM type

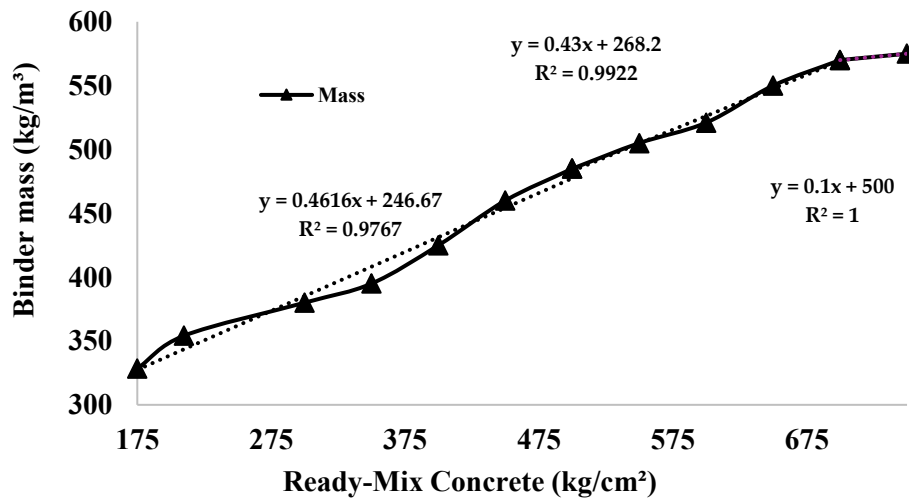
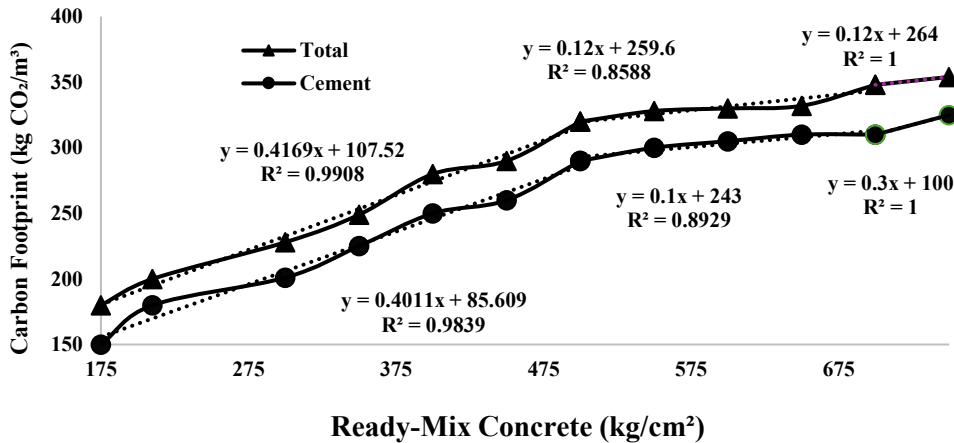


Figure 3

Influence of ready-mix concrete depending on the cement

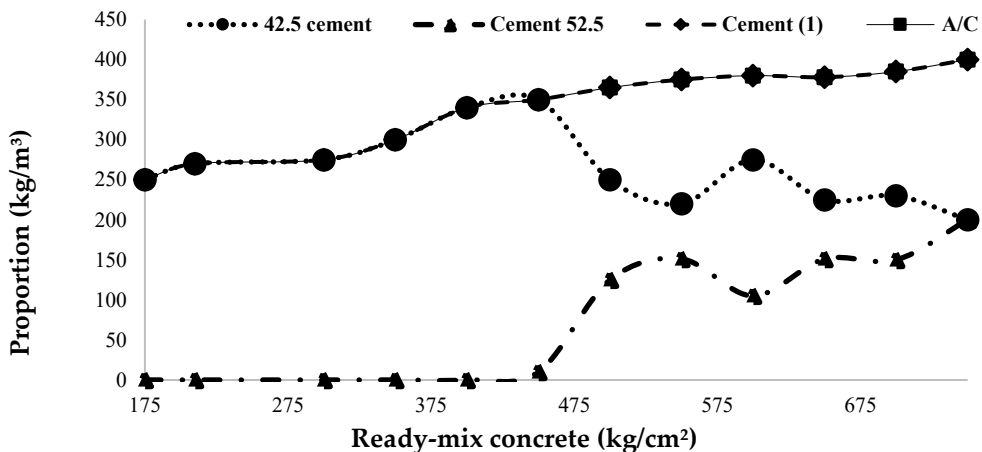


3.2. Discussion

Figure 4 showed that, as the strength of the ready-mix concrete increased, the composition of the materials used changed, with a progressive decrease in 42.5 cement and a greater proportion of 52.5 cement in high-strength mixtures.

Figure 4

Influence of CPM as a function of different materials and cement quantities



This behavior is consistent with the findings reported by Zhang et al.(2025) , Liu y Li(2025) , and Liu et al.(2025) , who noted that high-performance concretes require cements with better mechanical properties and a lower water-to-cement ratio, as well

as the findings of Lin et al.(2025) who indicated that lower water contents improve the strength and durability of concrete, similarly to Wang et al.(2025) .

Figure 5

Influence of CPM based on raw materials

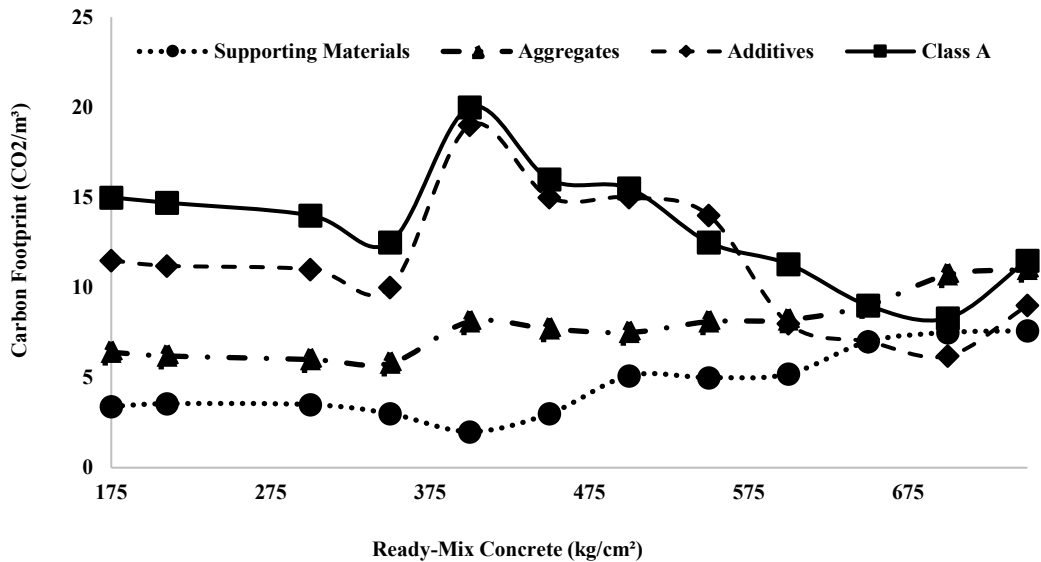


Figure 5 shows that traditional raw materials contributed most to the carbon footprint of ready-mix concrete, especially at intermediate and high strengths, which is consistent with the findings of Liu y Li(2025) , Liu et al.,(2025), and Zhang et al.,(2025) , who identified cement and traditional aggregates as the main sources of embodied emissions. Additives and aggregates maintained varying proportions depending on the strength level, similar to what was reported by Lin et al.(2025) , who indicated that dosage directly influences the environmental impact of concrete. This result is consistent with Wang et al.(2025) , who highlighted their potential to reduce emissions through partial cement substitution.

4. CONCLUSIONS

- It was concluded that there is a highly significant relationship between ready-mix concrete (RMC) and the carbon footprint (CF), evidenced by a coefficient of determination $R^2 = 0.9448$. This high correlation demonstrates that the behavior of the CF can be explained primarily by variations in the characteristics of the RMC. Likewise, the linear model $CF = 0.2779 RMC + 155.76 \text{ kgCO}_2/\text{m}^3$ confirms that an increase in concrete strength implies a proportional increase in carbon emissions.

- It was determined that the carbon emissions of CPM, in strength ranges from 175 kg/cm² to 750 kg/cm², ranged from 262.61 kgCO₂e/m³ to 401.78 kgCO₂e/m³. This behavior demonstrates that as structural demands increase, so does the consumption of inputs, especially cement, which directly impacts the increase in the carbon footprint. Therefore, the selection of strengths must consider both structural and environmental criteria.
- It was found that the embodied carbon from raw materials accounts for between 86.4% and 90.5% of the total emissions from ready-mix concrete. This indicates that most of the environmental impact does not stem from the construction process itself, but rather from the production of the materials used. Consequently, optimizing the selection and use of raw materials is a key factor in reducing the carbon footprint.

5. ACKNOWLEDGMENTS

We would like to thank the Doctoral Program in Civil Engineering at the Federico Villareal National University, as well as the Graduate School of the Altiplano National University, the language program, and the English course.

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