# LONGITUDINAL ANALYSIS OF PERSONAL, INSTITUTIONAL, AND FAMILY FACTORS ASSOCIATED WITH ACADEMIC PERFORMANCE IN ENGINEERING STUDENTS AT ITVY

# LONGITUDINAL ANALYSIS OF PERSONAL, INSTITUTIONAL, AND FAMILY FACTORS ASSOCIATED WITH ACADEMIC PERFORMANCE IN ENGINEERING STUDENTS AT ITVY

Machi García Abdul Sahib[1], Villicaña Botello Antonio[2], Mendoza Espinoza Aurelia[3] , Araiza Amado José Juan[4] , Vela Palomera Leticia[5]

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[1]Sonora Institute of Technology,abdul.machi@itson.edu.mx , https://orcid.org/0000-0001-9685-8594
[2]National Technological Institute of Mexico/Yaqui Valley Technological Institute,avillicana.botello@itvy.edu.mx , https://orcid.org/0009-0002-4282-2099
[3] National Technological Institute of Mexico/Yaqui Valley Technological Institute,aurelia.me@vyaqui.tecnm.mx , https://orcid.org/0009-0005-7296-046X
[4] National Technological Institute of Mexico/Yaqui Valley Technological Institute,jaraiza.amado@itvy.edu.mx , https://orcid.org/0009-0007-5877-5852
[5] National Technological Institute of Mexico/Yaqui Valley Technological Institute,lvela.palomera@itvy.edu.mx , https://orcid.org/0000-0002-0549-8667

***Abstract*** – The study analyzes the factors associated with the academic performance of new students at the Yaqui Valley Institute of Technology during the period 2020-2025. Using a descriptive longitudinal design, the complete institutional records of 846 students were examined, using the results of three standardized questionnaires administered upon admission: Verbal Reasoning (CRV, α=0.87), Mathematical Reasoning (CRM, α=0.91), and Indirect Writing (CRI, α=0.83).

The results show a statistically significant downward trend, with a cumulative decrease of 30.1% in overall average performance. This decline was differentiated by skill, showing a greater impact in the area of mathematical reasoning (46.6% decrease), followed by verbal reasoning (28.4%) and indirect writing (15.7%). The Kruskal-Wallis test confirmed significant differences between the annual cohorts (H=45.32, p<0.001), and positive and significant correlations were identified between the three skills assessed. Multiple regression analysis revealed that personal factors (study hours, motivation), institutional factors (support programs, teacher preparation), and family factors (parental support) significantly explain variations in performance. The findings allow for the design of targeted institutional strategies, particularly math remediation programs, and offer a replicable methodological framework for other technological institutes in the context of Mexican higher education.

***Keywords*** – Longitudinal analysis, Technological education, Educational assessment, Associated factors, Academic performance.

***Abstract*** – This study analyzes the factors associated with the academic performance of new students at the Instituto Tecnológico del Valle del Yaqui from 2020 to 2025. Using a descriptive longitudinal design, complete institutional records of 846 students were examined based on the results of three standardized diagnostic tests: Verbal Reasoning (CRV, α=0.87), Mathematical Reasoning (CRM, α=0.91), and Indirect Writing (CRI, α=0.83).

The results show a statistically significant declining trend, with a cumulative decrease of 30.1% in the overall performance average. This impact varied by competency, showing a greater effect on mathematical reasoning (46.6% decrease), followed by verbal reasoning (28.4%) and indirect writing (15.7%). The Kruskal-Wallis test confirmed significant differences between annual cohorts (H=45.32, p<0.001), and positive, significant correlations were identified among the three competencies assessed. Multiple regression analysis revealed that personal (study hours, motivation), institutional (support programs, teacher preparation), and familial (parental support) factors significantly explain variations in academic performance. The findings allow for the design of targeted institutional strategies, particularly mathematics leveling programs, and provide a replicable methodological framework for other technological institutes within the context of Mexican higher education.

***Key words*** – Academic performance, Associated factors, Educational assessment, Longitudinal analysis, Technological education.

## INTRODUCTION

The Yaqui Valley Institute of Technology (ITVY) stands on land of profound global historical and scientific significance. Its origins are linked to the experimental station where, beginning in 1945, Dr. Norman Borlaug—later awarded the Nobel Peace Prize in 1970—conducted his pioneering research. Working alongside Mexican scientists in the vast Yaqui Valley, Borlaug developed high-yield dwarf wheat varieties that fueled the "Green Revolution," a feat that transformed global food security and, according to various accounts, saved billions of people from starvation [2].

This legacy is not just a historical fact; it constitutes the foundational DNA of the institution: a commitment to applying scientific and technological knowledge to generate high-impact solutions and contribute to community development [3]. In this context of excellence and social responsibility, the analysis of its students' academic performance takes on a particular dimension, aligned with the institutional mission of training professionals capable of facing current challenges with the same rigor and innovation that characterized their predecessors in these fields [4].

This study was conducted at the Yaqui Valley Institute of Technology, an institution that consistently strengthens its research and professional training capabilities in the context of higher technological education. This research contributes to the institutional academic ecosystem through a comprehensive analysis of factors associated with academic performance upon admission, with the potential for systematic replication in other technological and higher education institutes in the country. The Mexican educational environment has undergone significant transformations that require specific analysis by institution, and these changes will undoubtedly be consistent.

Higher technological education in Mexico faces significant challenges in ensuring educational quality and student academic performance [5, 6]. Previous studies at institutions of the National Technological Institute of Mexico have identified that personal, institutional, and family factors interact in complex ways, determining academic outcomes [7, 8]. Recent research in the post-pandemic context has revealed particularly serious effects in the area of mathematical reasoning, which undoubtedly requires focused educational interventions, well-directed to address this disadvantageous situation compared to previous decades [9, 10].

The main purpose of this study is to describe the temporal trends in the academic performance of new students at the Yaqui Valley Institute of Technology and to analyze the institutional, personal, and family factors associated with their variation during 2020-2025. To this end, the longitudinal methodological design allows not only for the implementation of strategies within the institution, but also for their extension to other technological institutes of a similar nature, facilitating comparative analyses and the development of consolidated strategies for educational improvement in the Mexican technological education system [11, 12].

### Factors associated with academic performance

The specialized literature consistently identifies four main categories of factors that influence academic performance in higher technological education. Personal factors include variables such as hours devoted to study, intrinsic motivation, and individual cognitive abilities, showing very strong positive correlations according to studies in Mexican universities in the post-pandemic context [13, 14]. Studies in Latin America have documented similar patterns of impact on academic performance during periods of crisis [15, 16].

Academic and institutional factors include teacher preparation, scholarship availability, the quality of the educational system, and institutional support programs, with significant positive correlations in university management analyses of the National Technological Institute of Mexico and, consequently, its various campuses [17, 18]. Family factors, such as direct family support, parental expectations, and family climate, also show significant positive correlations [19, 20]. Finally, sociodemographic and economic factors, including socioeconomic status and parental education, are fundamental variables that can operate as risk or protective factors [21, 22].

## DEVELOPMENT

This study considered some of the different situations that, from 2020 to 2025, have been occurring in different areas of society, profoundly impacting education systems at the global and national levels. The COVID-19 pandemic, the abrupt transition to distance learning, and the subsequent return to face-to-face learning created an unprecedented scenario for technological higher education [9, 15]. In this context, the Yaqui Valley Technological Institute (ITVY), an institution founded on a legacy of innovation and scientific rigor linked to the Green Revolution [1, 2], faced the challenge of maintaining the quality of its admission and initial training process. It was therefore crucial to systematically and rigorously address the performance of

performance on the diagnostic entrance exam of students admitted between 2020 and 2025. This analysis not only seeks to document a trend, but also to provide empirical evidence for the design of internal academic policies and offer a replicable methodological framework for other institutions in the national technological system [6, 12].

**Work methodology**

The research used a descriptive longitudinal design at the Yaqui Valley Institute of Technology, analyzing complete institutional records of 846 new students during the 2020-2025 school years. This methodological approach was selected for its suitability in identifying and describing changes, patterns, and trends in academic performance over time within the same institutional population [23]. The methodology implemented, detailed below, is designed with a focus on transparency and standardization that allows for its systematic replication at other campuses of the National Technological Institute of Mexico, thus facilitating future inter-institutional comparative studies and the strengthening of common strategies for educational improvement [3, 12].

Data collection was governed by a standardized protocol that ensured the uniformity and reliability of the information. The three diagnostic instruments (CRV, CRM, CRI) were administered in person at the ITVY facilities using the institutional MOODLE platform, ensuring equitable conditions for all those evaluated. The design and validation of the items was carried out by the respective academies, ensuring the relevance and validity of the content for each disciplinary field evaluated [24]. This systematic process allowed for the construction of a robust longitudinal database suitable for statistical analysis. SPSS v.28 statistical software was used for data processing and analysis [25]. The analytical procedure included three main stages:

1) descriptive analysis (means, standard deviations, percentages) to characterize performance by year and competency;

2) nonparametric inferential analysis (Kruskal-Wallis H test) to compare differences in performance between the six annual cohorts; and

3) correlation analysis (Spearman's rho) and multiple linear regression to explore associations between competitions and identify the factors (personal, institutional, family) that best explain the variance in performance [23].

All analyses were performed with a 95% confidence level ($p < 0.05$).

**Study participants**

The study population comprised all first-year students at the Instituto Tecnológico del Valle del Yaqui during the period from 2020 to 2025 (N=846). This census inclusion criterion eliminates the error associated with sampling and provides a complete and representative view of the institution's intake performance during the period analyzed.

As shown in Table 1, the distribution by annual cohorts was as follows: 2020 (n=142), 2021 (n=158), 2022 (n=168), 2023 (n=172), 2024 (n=106), and
2025 (n=100). The variation in the size of each cohort reflects natural fluctuations in demand for admission to the institution.

**Table 1.** *Comparison of enrollment.*

| Cohort | n | % | Programs Evaluated |
|---|---|---|---|
| **2020** | 142 | 16.8 | 6 engineering programs |
| **2021** | 158 | 18.7 | 6 engineering programs |
| **2022** | 168 | 19.9 | 6 engineering programs |
| **2023** | 172 | 20.3 | 6 engineering programs |
| **2024** | 106 | 12.5 | 6 engineering degrees |
| **2025** | 100 | 11.8 | 6 engineering degrees |
| **Total** | **846** | **100** | **Systems, Industrial, Agronomy, ICT, Civil, Business Management** |

**Source:** *Own elaboration (2025).*

The sample included students from the six engineering programs offered by the institution: Computer Systems Engineering, Industrial Engineering, Agronomy Engineering, Information and Communications Technology Engineering, Civil Engineering, and Business Management Engineering.

The distribution by degree program was relatively balanced throughout the period, with Industrial Engineering and Systems Engineering accounting for the largest number of students. This diversity in the composition of the population allows the study's findings to be representative of the entire new student body at ITVY and to provide valuable *insights* for the various program coordinators.

**Instruments and procedures for data collection and analysis**

The standardized methodological process included the consistent application of three validated instruments (Table 2):

- Verbal Reasoning Questionnaire (CRV, $\alpha$=0.87)
- Mathematical Reasoning Questionnaire (MRQ, $\alpha$=0.91)
- Indirect Writing Questionnaire (CRI, $\alpha$=0.83).

This standardized assessment protocol allows for future comparability with other technological institutes [24].

**Table 2.** *Diagnostic assessment instruments applied.*

| Instrument | $\alpha$ | Items | Main Construct |
|---|---|---|---|
| **CRV** | 0.87 | 30 | Verbal Reasoning |
| **CRM** | 0.91 | 25 | Mathematical Reasoning |
| **CRI** | 0.83 | 2 | Indirect Writing |

**Source:** *Own elaboration (2025).*

**Procedure and data collection for qualitative analysis**

Primary information on performance was collected in a standardized manner through the institutional *MOODLE* platform. Diagnostic entrance exams were administered in person at the Institute's facilities, ensuring uniformity in assessment conditions.

The design of the test items for each subject area (Verbal Reasoning, Mathematical Reasoning, and Indirect Writing) was the responsibility of the corresponding academies, ensuring the validity of the content and its relevance to the fields of knowledge being assessed.

The raw scoring data, once obtained from the system, were processed and refined to construct the longitudinal database that enabled subsequent statistical analyses (Figure 1). This method guarantees the reliability and traceability of the information, complying with institutional ethical protocols for the use of academic data for research purposes.

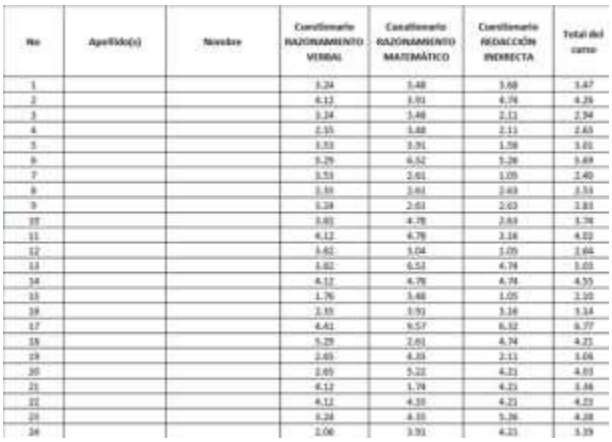

**Figure 1**. *Example of a data dump table (names removed)*
**Source:** *Prepared by the authors with data from the study (2025).*

**Data analysis and tests applied**

Table 3 presents the descriptive analyses performed, which are Kruskal-Wallis tests tests for differences between cohorts, Spearman's correlations between competencies, and multiple regression analysis to identify predictors of academic performance. All analyses were performed with a 95% confidence level using SPSS v28 software [25].

**Table 3.** *Outline of statistical analyses performed.*

| Objective | Test | Variables |
|---|---|---|
| **Trends** | Descriptive statistics | Scores by competency and year |
| **Compare cohorts** | Kruskal-Wallis (H) | Average Overall vs. Year (2020-2025) |
| **Associations** | Spearman (ρ) | Correlation CRV-CRM, CRV-CRI, CRM-CRI |
| Predictors | Multiple linear regression | Performance = f(Personal factors, institutional, family) |

**Source:** *Own elaboration (2025).*
**Note:** *All analyses were performed with a 95% confidence level using SPSS v28.*

**DISCUSSION AND ANALYSIS OF RESULTS**

The analyses carried out at the Yaqui Valley Institute of Technology show a statistically significant downward trend in overall academic performance averages, with a cumulative reduction of 30.1% between 2020 and 2025. These institution-specific findings provide a valuable comparative basis for other technological institutes with similar student characteristics [13, 18].

**Temporal trends by competency**

The pattern of decline differentiated by competency shows variable impact, with the greatest impact on mathematical reasoning (46.6% decline), followed by verbal reasoning (28.4%) and indirect writing (15.7%). This trend suggests lines of research applicable to other technological institutes facing equivalent academic challenges in their admission and leveling processes [10, 20].

**Statistical differences and correlations between variables**

The Kruskal-Wallis test revealed statistically significant differences between years of study ($H=45.32$, $p<0.001$), confirming the downward trend. Post-hoc analyses showed that the most significant differences occurred between the pre-pandemic period (2020) and subsequent years [15, 26].

Significant positive correlations were identified between the three competencies assessed: mathematical and verbal reasoning ($r=0.72$, $p<0.01$), mathematical reasoning and indirect writing ($r=0.58$, $p<0.01$), and verbal reasoning and indirect writing ($r=0.72$, $p<0.01$).

and verbal reasoning (r=0.72, p<0.01), mathematical reasoning and indirect writing (r=0.58, p<0.01), and verbal reasoning and indirect writing (r=0.65, p<0.01). These findings suggest that basic academic competencies develop in an interrelated manner in the ITVY student population [8, 13].

**Factors associated with applicant performance** Multiple regression analysis identified that personal factors (hours of study devoted, academic motivation) explain 38.2% of the variance in performance performance, the institutional factors institutional factors (teacher preparation, support programs) explain 25.7%, and family factors (parental support, family expectations) explain 18.3% of the total variance. These results underscore the potential of institutional educational interventions to mitigate the identified downward trends [18, 28].

**Comparison with studies in the TecNM system and Mexican universities**

The findings of this study are echoed and contrasted in research carried out at other institutions within the Mexican education system. A study at a public university in Mexico City identified that the use of digital platforms by teachers is a technological factor with a positive impact on performance, while entertainment with video games and full-time workloads had a negative influence [29]. This reinforces the importance of the institutional and personal factors identified in the ITVY and suggests that teacher technology integration strategies could be beneficial.

On the other hand, research at the National Technological Institute of Mexico (TecNM), entitled "Factors Associated with Academic Performance Management in Higher Education," directly addresses institutional performance management, providing a direct frame of reference for the TecNM context [30].

Similarly, studies on gender inequality in higher education, such as one conducted in Paraguay, reveal significant gaps in the perception of barriers to learning [31], where female students assume a greater domestic burden, although this does not always translate into statistical differences in the amount of time devoted to study. This calls for a more detailed analysis of gender variables in future replicas of this study.

Finally, recent research on structural barriers to access and quality in higher education in Mexico has pointed out that socioeconomic, geographic, and cultural factors can deepen inequalities despite the expansion of coverage [32]. Taken together, these studies underscore that academic outcomes are the product of a complex interaction between the individual, the institution, and the broader social context.

The marked decline in mathematical reasoning (46.6%) represents a particular warning sign for the technological education system, given the fundamental nature of these skills for success in engineering programs. This finding, which can be clearly seen in Table 4, suggests an urgent need for specific remedial programs in mathematics during the first year of educational programs [20, 33].

**Table 4.** *Percentage change in academic performance by skill (2020-2025).*

| Year | Math Ratio | Ver. Ratio | Indirect Writing | Overall Average |
|---|---|---|---|---|
| **2020** | 84.3 | 82.7 | 85.1 | 84.0 |
| **2021** | 78.5 | 79.2 | 83.4 | 80.4 |
| **2022** | 72.8 | 76.1 | 81.9 | 76.9 |
| **2023** | 65.4 | 72.8 | 79.3 | 72.5 |
| **2024** | 52.1 | 68.5 | 76.2 | 65.6 |
| **2025** | 45.1 | 59.2 | 71.7 | 58.7 |
| **%** | **-46.6** | **-28.4** | **-15.7** | **-30.1** |

**Source:** *Prepared internally using data from the study (2025).*

**Strengths and areas for improvement**

This study has methodological strengths that support the relevance of its findings, as well as limitations that outline opportunities for future research. The main strength lies in the longitudinal design that analyzed a complete census of 846 students over five years, generating a solid and representative database for the analysis of temporal trends and avoiding the biases associated with sampling [23]. The use of standardized and validated instruments (CRV, CRM, CRI) by institutional academies ensures the reliability and content validity of the measurements, allowing for consistent internal comparisons [24]. Likewise, the integration of multivariate statistical analyses (Kruskal-Wallis, Spearman, multiple regression) allows not only to describe the phenomenon, but also to explore associations and predictive factors with scientific rigor [23, 25].

Some of the areas for improvement or limitations identified are those that allow us to identify that the study is limited only to the analysis of quantitative performance data in standardized tests. Future research could enrich the understanding of the phenomenon through mixed methodologies, incorporating, for example, interviews or focus groups with students to explore perceptions, learning strategies, and subjective barriers behind the numerical results. Another limitation is the intra-institutional approach.

Although the methodology is replicable, the findings reflect the specific reality of ITVY. Extending this study to other TecNM campuses, as suggested in the conclusions, would allow us to discern whether the trends are local or systemic and to evaluate the impact of different institutional contexts and support policies [12, 28]. Finally, although the analysis identified general factors, it was unable to delve into specific contextual variables for each student, such as access to study technology, mental health, or type of school of origin. The systematic incorporation of these variables in future designs would allow for more accurate modeling of performance determinants and the design of more personalized and equitable interventions [21, 31]. Recognizing these limitations does not detract from the findings, but rather builds a bridge to a more comprehensive and in-depth research agenda, as clarified in the following table.

**Table 5.** *Strengths and Areas for Improvement*

| Strength/Improvement | Element | Description / Impact |
|---|---|---|
| **Strength** | **Longitudinal design** | Complete census analysis (N=846) over 5 years. Robust database for temporal trends, unbiased in. |
| | Standardized instruments | Use of validated tests (CRV, CRM, CRI) by institutional academies. Ensures reliability and validity for internal comparisons. |
| | Multivariate statistical analysis | Application of Kruskal-Wallis tests, correlation Spearman's and and multiple regression. It allows phenomena to be described and explore associations with rigor. |
| **Areas for improvement** | Quantitative data only | Based on test of tests. Future research could integrate qualitative qualitative (interviews, focus) to gain a deeper understanding into subjective. |
| | Intraocular institutional | Findings reflect the reality of ITVY. Replica on other campuses of the TecNM would allow discern si las trends are local or systemic. |
| | Variables contextual variables measures | No further details were provided in factors such as access to technology, mental health or school from origin. Its inclusion would allow interventions more personalized and equitable interventions. |

**Source**: *Own elaboration based on the study (2025).*

## CONCLUSIONS

This longitudinal study allows us to draw three fundamental conclusions that not only diagnose a specific institutional problem, but also chart a clear path for future action and research in the Mexican technological education system.

### 1. Main Findings: A Quantified Academic Alert

The longitudinal analyses carried out at the Yaqui Valley Institute of Technology confirm, in a conclusive manner, a statistically significant downward trend in academic performance upon entry during the period 2020-2025.

The Kruskal-Wallis test ($H=45.32$, $p<0.001$) validates that the differences observed between the six annual cohorts are not random but reflect a consistent pattern of decline [15]. The magnitude of this decrease—a cumulative reduction of 30.1% in the overall average in just five years—is in itself a priority alert for institutional management. This decline is not an isolated phenomenon, but a robust indicator of a substantial change in students' entrance abilities, probably influenced by the post-pandemic educational context and other structural factors [9, 16].

The most critical and worrying conclusion emerges when breaking down the data by diagnostic competency. Mathematical reasoning ability is revealed as the system's greatest vulnerability, with a catastrophic loss of 46.6% in average scores. This deterioration is much greater than that observed in verbal reasoning (-28.4%) and indirect writing (-15.7%), suggesting a differentiated and particularly severe impact on logical-quantitative competencies. This finding is extremely serious for a technological and engineering institution such as ITVY, where this competency is not only a subject but also the fundamental pillar and basic language for success in core subjects such as calculus, physics, statistics, and design [7, 33]. The gap identified directly threatens students' ability to keep up with the curriculum from the first semester, increasing the risks of failure and dropout [10, 20].

In addition to the negative trend, Spearman's correlation analyses revealed positive and significant associations between the three skills assessed (e.g., $r=0.72$ between mathematical and verbal reasoning, $p<0.01$). This indicates that the decline is not an isolated problem in one area, but rather reflects an interconnected impact on basic academic skills. However, the varying magnitude of the impact suggests that the resilience of these competencies to external factors differs.

Taken together, the results not only identify a trend, but also accurately quantify the depth and specificity of a multidimensional challenge that demands not a generic response, but immediate institutional intervention focused on mathematics and based on continuous diagnostics.

## 2. Practical Implications: From Evidence to Institutional Policy

The above conclusions transcend the descriptive to translate into high-value strategic inputs. First, they demand the urgent implementation of intensive math leveling programs, aimed at new students, as a structured academic policy and not as an isolated remedial action [20, 33].

Second, the study validates the longitudinal methodology and the use of standardized instruments as a robust tool for diagnosis and continuous monitoring. This methodology, which can be replicated at other TecNM campuses, allows for the establishment of comparative baselines at the national level and transforms the management of academic performance from an intuitive practice to one based on solid evidence [11, 28]. Therefore, the implications are twofold: a pedagogical intervention concrete and an evaluation model that strengthens institutional capacity for self-regulation.

## 3. Future Directions: Expanding the Scope of Research

To consolidate and expand the knowledge generated, two clear paths for future research are outlined. The first is to extend the study to a systemic scale, replicating this design in a representative sample of TecNM campuses. This would make it possible to discern whether the observed trend is a localized phenomenon or a widespread pattern, facilitating the design of more effective national policies [12].

The second path involves deepening the factorial analysis, systematically incorporating variables such as gender, family socioeconomic context, access to technology, and previous school trajectory [21, 31]. An analysis of this nature would enrich the understanding of the mechanisms underlying general trends and allow for the design of even more personalized and equitable interventions. In summary, this work concludes by establishing an accurate diagnosis, proposing direct actions, and defining a research agenda that can guide the efforts of the Yaqui Valley Institute of Technology and the TecNM system in the coming years.

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**Table of Contribution Roles**

| Role | Author(s) |
|---|---|
| Conceptualization | Abdul Sahib Machi García |
| Methodology | Antonio Villicaña Botello |

| | |
|---|---|
| Project management | Abdul Sahib Machi García |
| Resources | Antonio Villicaña Botello<br>Aurelia Mendoza Espinoza |
| Supervision | Abdul Sahib Machi Garcia |
| Validation | Abdul Sahib Machi García<br>Antonio Villicaña Botello |
| Visualization | Aurelia Mendoza Espinoza<br>José Juan Araiza Amado<br>Leticia Vela Palomera |
| Writing (original draft) | José Juan Araiza Amado<br>Aurelia Mendoza Espinoza |
| Writing (Revision and editing) | Abdul Sahib Machi García<br>Leticia Vela Palomera |