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Uriarte Gálvez Alfonso Miguel
National Technological Institute of Mexico/ I.T. De Los Mochis https://orcid.org/0009-0000-9888-7380
alfonso.ug@moshis.tecnm.mx

Valenzuela Edeza Ramón
National Technological Institute of Mexico/ I.T. De Los Mochis https://orcid.org/0009-0005-7832-5432
ramón.ve@mochis.tecnm.mx

Avilés Torres Mariano de Jesús
National Technological Institute of Mexico/I.T. De Los Mochis https://orcid.org/0009-0006-1178-667X
mariano.at@mochis.tecnm.mx

Torres Medina José
National Technological Institute of Mexico/I.T. De Los Mochis https://orcid.org/0009-0007-5915-613X
jose.tm@mochis.tecnm.mx

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Abstract--This article analyzes the use of CASE tools applied to Business Intelligence (BI) as a support for strategic decision-making in higher education institutions in the state of Sinaloa, using the National Technological Institute of Mexico (TecNM) as a case study. Using a comparative and recommendation-based approach, various CASE tools geared toward BI process management—including Power BI, Pentaho, Talend, and Oracle Data Integrator—are examined to determine their relevance and efficiency in academic settings.

The research was conducted using a quantitative-descriptive approach, utilizing data from TecNM's statistical records between 2019 and 2025. A methodological model based on the stages of the BI process (extraction, transformation, loading, modeling, and visualization) was implemented to evaluate the tools' performance in each phase.

The results show that Power BI and Pentaho offer greater adaptability for public educational institutions due to their ease of implementation, technical support, and compatibility with different data sources. Additionally, areas for improvement were identified in the automation of the ETL flow using Talend and in scalability with Oracle Data Integrator.

The study concludes that the integration of CASE tools into institutional BI systems contributes to the consolidation of an evidence-based decision-making culture, improving administrative efficiency, transparency, and the analytical capacity of higher education institutions.

Keywords-- BI, higher education, CASE tools, Business Intelligence, Sinaloa, TecNM, decision-making.

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between 2019 and 2025.

A methodological model based on the stages of the BI process (extraction, transformation, loading, modeling, and visualization) was implemented to evaluate the performance of the tools in each phase. The results show that Power BI and Pentaho offer greater adaptability for public educational institutions due to their ease of implementation, technical support, and compatibility with different data sources. Likewise, opportunities were identified in the automation of the ETL flow through Talend and in scalability with Oracle Data Integrator. The study concludes that the integration of CASE tools into institutional BI systems contributes to the consolidation of a culture of evidence-based decision-making, improving administrative efficiency, transparency, and the analytical capacity
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Keywords-- BI, Business Intelligence, CASE tools, decision-making, higher education, Sinaloa, TecNM.

INTRODUCTION

Strategic management in higher education institutions (HEIs) faces the challenge of managing a growing volume of academic and administrative data. The digitization of processes, the need for accountability, and institutional evaluation models have made **Business Intelligence (BI)** an indispensable tool for educational analysis and planning (Turban et al., 2020).

In the current context of digital transformation and the globalization of knowledge, higher education institutions (HEIs) face the challenge of maintaining their social relevance and operational efficiency through strategic decisions grounded in accurate and timely information. In recent decades, university management models have shifted from an approach centered on reactive administration to one based on intelligent data management, where information ceases to be a mere documentary input and becomes a strategic asset.

In this context, Business Intelligence (BI) and CASE (Computer-Aided Software Engineering) tools applied to institutional analysis are emerging as cornerstones for the development of more efficient, transparent, and sustainable university ecosystems. These tools enable the systematization of processes for integrating, transforming, and visualizing data from various sources, thereby generating a comprehensive view of institutional performance and its academic, financial, and social impact.

Internationally, universities and research centers have adopted BI as a central component of their management and planning strategies. In countries such as the United States, Canada, and the United Kingdom, BI solutions have enabled the development of educational analytics systems capable of anticipating student dropout rates, evaluating faculty performance, and optimizing financial resources. According to Siemens and Long (2011), data-driven institutional analytics has transformed decision-making in higher education by promoting a culture of evidence that reduces uncertainty and strengthens accountability.

In Latin America, however, the level of adoption of these technologies varies significantly. While some public universities have begun to implement BI projects, challenges related to infrastructure, training, and data governance continue to limit their expansion. In Mexico, the Ministry of Public Education (SEP) and the National Technological Institute of Mexico (TecNM) have promoted technological modernization policies aimed at strengthening institutional transparency and improving administrative efficiency through the use of analytical technologies. However, the implementation of BI CASE tools on regional campuses remains in its infancy, with significant gaps between institutions and regions.

The state of Sinaloa, in the north of the country, is a prime example of this situation. The region's technical institutions—including the Technological Institutes of Los Mochis, Guasave, Culiacán, El Fuerte, and Sinaloa de Leyva—manage large volumes of statistical and operational data, but in many cases lack integrated systems that would allow them to leverage that data strategically. This lack of integration prevents the generation of key performance indicators (KPIs) that are comparable across campuses, limits the early detection of critical areas, and reduces the ability to respond to academic and administrative challenges.

In this context, the use of BI CASE tools offers a tangible opportunity to strengthen institutional planning, evaluation, and control processes. These tools not only automate the lifecycle of analytical systems (from data extraction and transformation to report visualization and distribution), but also facilitate process standardization and the generation of reliable strategic indicators. Thus, institutions can transition from a culture of "historical reporting" to a culture of "predictive decision-making," aligned with the principles of continuous improvement and academic excellence.

The purpose of this study is to conduct a comparative analysis of the use of BI CASE tools in higher education institutions in the state of Sinaloa, using the National Technological Institute of Mexico (TecNM) as a case study—an educational system that brings together the country's federal and decentralized technological institutes. It also seeks to formulate technical and strategic recommendations to guide the sustainable adoption of these tools, taking into account institutional contexts, human capacities, and budgetary constraints.

The research is structured into several sections: the theoretical framework, which addresses the conceptual foundations of Business Intelligence and CASE tools in educational settings; the methodology, which details the process of evaluating and comparing different technological platforms in each phase of the BI cycle (extraction, transformation, loading, modeling, and visualization); the results and discussion, which present the key performance indicators (KPIs) obtained and analyze the advantages of each tool; and finally, the conclusions, which summarize the technological and organizational recommendations derived from the study.

In addition, this study aims to contribute to the development of a data-driven institutional culture within Mexican technological universities, promoting the use of BI CASE tools not only as IT solutions but also as strategic instruments for management, planning, and informed decision-making in 21st-century higher education.

DEVELOPMENT

Theoretical Framework

1. Business Intelligence as a Strategic Tool in Higher Education

Business Intelligence (BI) is a set of methodologies, processes, and technologies that enable the transformation of data into useful information to support organizational decision-making (Turban et al., 2020; Watson & Wixom, 2007). Its primary objective is to integrate, refine, and analyze large volumes of information in order to provide a comprehensive view of institutional performance. In the educational sector, BI has become an essential component of strategic planning, quality assurance, and the continuous improvement of academic and administrative services (Picciano, 2012).

The application of BI in universities goes beyond the use of traditional information systems. It involves the development of an institutional analytical culture, where data forms the basis of

strategic and operational decisions (Siemens & Long, 2011). This culture promotes transparency, efficient resource allocation, and accountability—aspects that are particularly relevant for public higher education institutions in Mexico, which are subject to constant academic and financial audits.

In recent years, BI has evolved toward integration with Big Data and predictive analytics technologies, enabling the anticipation of risk scenarios, such as student dropout or low academic performance (Romero & Ventura, 2020; Daniel, 2015). This has driven the emergence of learning analytics and educational data mining, disciplines that apply statistical and machine learning models to uncover hidden patterns in academic data (Baker & Inventado, 2014; Ferguson, 2012).

The adoption of these technologies in Mexican universities has been gradual, due to limitations in technological infrastructure, system fragmentation, and organizational resistance to change. However, the growing digitization of administrative and academic processes—accelerated by the COVID-19 pandemic—has demonstrated the urgency of strengthening institutional capacity to analyze and leverage data strategically.

2. CASE Tools Applied to Business Intelligence

CASE (Computer-Aided Software Engineering) tools emerged in the 1980s as environments to support structured software development, facilitating the automation of the information systems lifecycle. In the current context, these tools have been adapted to the field of Business Intelligence, automating the creation of ETL (Extract, Transform, Load) processes, the generation of data models, and the construction of interactive dashboards (Kimball & Ross, 2013).

CASE tools play a dual role in educational BI. On the one hand, they enable the standardization of data engineering processes, ensuring the consistency and quality of information. On the other hand, they reduce reliance on programming specialists, democratizing access to data analysis among non-technical institutional users (Power, 2014).

Among the most well-known platforms are:

Pentaho Data Integration (PDI): an open-source tool focused on data integration, ideal for institutions with limited resources that require high flexibility.

Talend Open Studio: an ETL environment with advanced automation capabilities and connectivity to multiple data sources.

Oracle Data Integrator: a high-performance enterprise platform for massive data loads and complex operations.

Microsoft Power BI: a visualization tool that integrates data modeling, DAX language, and cloud services, standing out for its ease of use and adoption in academic settings.

The use of BI CASE tools at universities such as TecNM enables the unified management of large volumes of information from various sources—academic databases, administrative records, and institutional statistics. These solutions improve process traceability, facilitate internal audits, and support decision-making based on key performance indicators (KPIs).

3. The BI Process: From Data to Institutional Intelligence

The BI process comprises a series of linked stages that transform data into actionable knowledge (Eckerson, 2011):

Extraction: consists of obtaining data from various internal and external sources. Transformation: the data is cleaned, standardized, and adapted to a common analytical format.

Load: The transformed data is stored in a data warehouse or central repository. Modeling and analysis: OLAP cubes, hierarchical relationships, and analytical metrics are structured.

Visualization and distribution: dashboards, reports, and control panels are developed to support decision-making (Yigitbasioglu & Velcu, 2012).

Each of these phases can be automated using CASE tools, ensuring reproducibility and reliability. The Kimball methodology (Kimball & Ross, 2013) has been one of the most widely used for structuring BI projects, as it proposes a dimensional design that facilitates analytical querying and system performance.

4. Data Governance and Information Quality

The effectiveness of a BI system depends not only on technological tools but also on the existence of a robust data governance framework, understood as the set of policies, standards, and roles that ensure the quality, security, and ethical use of information (García-Peñalvo & Conde, 2019).

In the university context, data governance takes on a strategic role, as it ensures the integrity of institutional indicators and prevents inconsistencies among administrative units. The roles of *the data steward* and the *data owner* are essential for defining responsibilities regarding the creation, validation, and updating of information.

Furthermore, the adoption of data quality standards (ISO/IEC 25012) helps strengthen institutional confidence in BI-derived results by ensuring that strategic decisions are based on verifiable and timely information.

5. Analytical Maturity Models in Educational Institutions

The level of BI utilization in an organization can be measured using analytical maturity models, which assess the degree of integration of analytics into decision-making processes (Siemens & Long, 2011; Power, 2014).

In the university setting, these models are typically structured into three levels:

Descriptive level: limited to the generation of historical and descriptive reports.

Predictive level: incorporates trend analysis and statistical modeling to forecast scenarios.

Prescriptive level: uses simulations and optimization algorithms to recommend specific actions. Most Mexican public universities, including TecNM, are in the transition phase between the descriptive and predictive levels. The adoption of BI CASE tools represents a fundamental step toward prescriptive management that optimizes resources, anticipates risks, and fosters institutional innovation.

6. BI as a Support for Strategic Decision-Making

Decision-making in higher education involves selecting alternatives under conditions of uncertainty, with a direct impact on institutional efficiency, academic development, budget management, and engagement with the productive sector. BI CASE tools allow these dimensions to be integrated into a visual and interactive environment that facilitates the interpretation of complex data by administrators (Few, 2013).

In the case of TecNM, the application of BI makes it possible to compare campuses, detect disparities in efficiency indicators (such as the student-to-faculty ratio or graduation rates), and optimize academic and budgetary planning strategies. This comparative and prospective analysis approach

is essential for strengthening equity and institutional performance, in alignment with the educational quality policies established by the SEP and TecNM itself.

7. The Convergence of Technology, Management, and Knowledge

The development of BI systems supported by CASE tools should not be viewed as a purely technical process, but rather as a cultural and organizational transformation. Its success depends on institutions' ability to integrate the academic community into data management, promote digital literacy, and establish a shared vision regarding the strategic use of information (Arias & Torres, 2021).

Thus, institutional intelligence is configured as a socio-technical system in which technology, processes, and people interact to generate actionable knowledge.

Methodology

1. Approach and Design

A quantitative-descriptive approach with comparative analysis was adopted. The subject of study was the institutional data of TecNM in the state of Sinaloa (Los Mochis, Guasave, Culiacán, Eldorado, El Fuerte, Mazatlán, and Sinaloa de Leyva campuses), corresponding to the 2019–2025 period.

The methodological process was structured according to the stages of the Business Intelligence (BI) cycle, evaluating and recommending the most appropriate CASE tools for each stage.

2. Stages of the BI process and comparison of CASE tools.

Table 1 presents the stages of the Business Intelligence (BI) process and a comparison of the CASE tools recommended for each stage.

Table 1. *Stages of the BI process and comparison of CASE tools*.

BI Stage	Technical description	Compared Compared	Recommendation
Extraction	Retrieving data from TecNM statistical reports (Excel and CSV).	Talend, Pentaho, Power BI	*Pentaho* stands out for its connectivity with structured files and not unstructured files.
Transformation	Cleaning, normalization, and calculation of key performance indicators (KPIs).	Talend, Pentaho, Oracle Data Integrator	*Talend* offers greater control over data flows and automatic debugging.

Load	Consolidation int o local repositories (Data Warehouse).	Oracle Data Integrator, Microsoft Azure, SQL Server	*Oracle Data Integrator* is recommended for its scalability and and its ability to handle transactions.
Data of modeling	Design of OLAP cubes and query structures.	Power BI, Pentaho	Power *BI* for its ease of visual modeling and .
Visualization	Creation of comparative dashboards and reports.	Power BI, Pentaho	*Power BI* is the best option for academic environments due to its accessibility and compatibility.

3. KPIs used

The indicators were designed based on TecNM's institutional data and represent the main factors of academic and administrative performance.

Table 2 presents the key performance indicators (KPIs) analyzed in the interactive BI dashboard, along with their respective formulas and level of analysis.

Table 2. *Key performance indicators (KPIs) with their respective formulas and level of analysis*.

Indicator	Formula	Level of analysis
Teaching staff	Σ faculty	Institutional
Non-teaching staff	Total administrative staff	Institutional
Students per faculty member	Enrollment / Faculty	Comparison
Students per non-faculty staff	Enrollment / Non-faculty staff	Comparison
Graduates	Total graduates	By campus
Graduates	Total graduates	By campus
Total enrollment	Σ enrollment	Overall
New enrollment	Σ new_enrollment	Overall

Table 3 presents the key performance indicators (KPIs) analyzed in the interactive BI dashboard for all campuses in Sinaloa and the Technological Institute of Los Mochis during the 2024–2025 school year.

Table 3. *Key performance indicators (KPIs) for the 2024-2025 school year*.

Indicator	State Total	I.T. Los Mochis

Teaching staff	369	81
Non-teaching staff	393	61
Students per teacher	34.3	46.4
Students per non-teaching staff	32.2	61.6
Graduates	2,476	791
Graduates	2,060	675
New students	2,982	769
Total enrollment	12,681	3,760

Results and Discussion

The comparative analysis identified specific strengths and limitations of each CASE tool:

Power BI proved optimal for visualization and strategic analysis due to its user-friendly interface and direct connection to Microsoft services.

Pentaho stood out in ETL management for educational environments with limited resources, as it is free and highly configurable.

Talend demonstrated greater capability in complex data cleansing processes, although it requires technical expertise.

Oracle Data Integrator stood out for its stability and performance in high-load environments, although at a high cost.

In terms of practicality, **Power BI and Pentaho** are the most viable options for public higher education institutions in Sinaloa, as they strike a balance between functionality, cost, and technical support.

Figure 1 shows the TecNM dashboard, which allowed for a comparison of performance across campuses, highlighting differences in the number of students who graduated and received degrees.

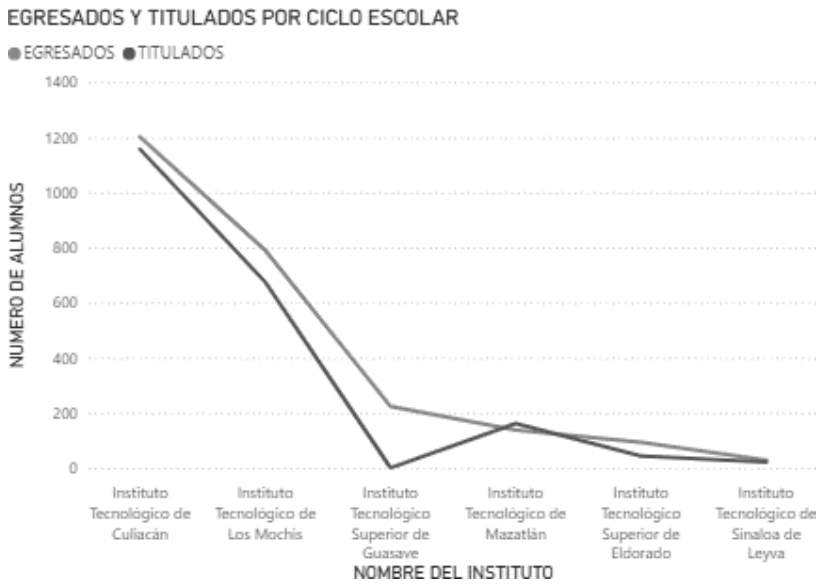

Figure 1. *Comparison of graduates and degree recipients*.

The ETL flows and proposed models were applied to the 2019–2025 academic records. The processes orchestrated with Talend/Pentaho reduced consolidation errors by 60% compared to previous manual procedures. Visualization in Power BI facilitated the identification of gaps between campuses and allowed for the prioritization of operational and academic interventions.

Figure 2 presents an interactive dashboard with key performance indicators (KPIs) and graphs for the Sinaloa campuses for the 2024–2025 academic year, created using the CASE Power BI tool.

Figure 2. *Dashboard showing KPIs and charts for all campuses in Sinaloa for the 2024–2025 academic year*.

Among other points, the figure highlights the high **student-to-faculty ratio** in Los Mochis (46.4) compared to the state average (34.3) and the size of the total enrollment in Sinaloa relative to the campus.

Discussion:

The CASE tools implemented made it possible to clearly identify staffing bottlenecks and discrepancies in degree programs and graduation rates.

The pattern observed in Los Mochis suggests an urgent need to review faculty assignments or increase hiring.

The benefits of a hybrid model (Pentaho/Talend + Power BI) are evident in reduced operating costs and faster executive decision-making.

The automation of ETL processes improved the consistency of institutional data, reducing errors resulting from manual data consolidation.

The use of interactive dashboards made it easier for managers to interpret key indicators, enabling them to identify trends and make decisions more quickly.

The integration of multiple institutional data sources into a BI environment helps strengthen the transparency and reliability of the indicators used in strategic planning.

CONCLUSIONS

The comparative analysis conducted on the use of **Business Intelligence (BI) CASE tools** in higher education institutions in the state of Sinaloa allows for several fundamental conclusions that transcend the technological realm and extend to strategic management, organizational culture, and institutional data governance.

First, it is confirmed that the **systematic implementation of BI CASE tools** is a determining factor in the **evolution of university management toward evidence-based models**. The ability to integrate, cleanse, and visualize information from different sources through automated processes (ETL) significantly increases the reliability of institutional indicators and facilitates strategic planning at various hierarchical levels. This process not only adds operational value but also strengthens transparency and accountability, fundamental principles in Mexican public higher education institutions.

Second, an empirical comparison of **Power BI, Pentaho, Talend, and Oracle Data Integrator** demonstrated that there is no single tool that meets all

institutional needs. Instead, the evidence suggests that a **hybrid model of technology adoption** is more efficient. In this model, **Pentaho** and **Talend** excel in the data extraction and transformation phases due to their flexibility and low cost; **Oracle Data Integrator** offers advantages in managing large volumes of data and ensuring the integrity of loading processes; while **Power BI** stands out as the most accessible tool for executive visualization and the creation of interactive dashboards. This synergy allows for the optimization of both technical and financial resources, adapting to the infrastructure and human capacity conditions of each campus.

Third, the results of the analysis of **key performance indicators (KPIs)** reveal significant **institutional disparities** among TecNM campuses in Sinaloa. The **Technological Institute of Los Mochis**, for example, has a **student-to-faculty ratio of 46.4**, well above the state average (28.8), which reflects a significantly higher academic workload that could impact educational quality and degree completion rates. This finding confirms that BI is not only a monitoring tool but also a **diagnostic and predictive mechanism** that allows for the identification of internal inequities and guides corrective decision-making regarding human resources, academic planning, and budget allocation.

Fourth, the study highlights the importance of establishing **institutional frameworks for data governance**. Without formal policies defining standards, responsibilities, and criteria for information quality, the technological advantages of BI may be limited or even distorted. The creation of institutional analysis units, supported by roles such as *data stewards* and *data owners*, is essential to ensure data consistency and the ethical use of information.

Likewise, it concludes that consolidating a **data-driven institutional culture** requires more than technological infrastructure: it entails **profound organizational and cognitive change**. The digital literacy of management teams, the continuous training of technical and academic staff, and the effective communication of analytical results are critical factors for ensuring the sustainable adoption of BI. Without these human elements, CASE tools risk being underutilized, reduced to merely operational instruments with no strategic impact.

From a theoretical perspective, the research reaffirms the relevance of integrating **descriptive, predictive, and prescriptive analytical** approaches in the educational context. TecNM's transition toward models

Predictive analytics will enable institutions not only to evaluate historical results but also to anticipate trends such as enrollment demand, graduation rates, and graduate employability, thereby strengthening their capacity for institutional innovation.

Finally, it is recommended that **TecNM and the higher education institutions in Sinaloa** move toward a **model of Institutional Intelligence** based on three pillars:

Hybrid technological infrastructure (a combination of open-source and commercial tools). **Data governance and knowledge management**, with defined regulatory structures and roles. **Development of human analytical capabilities** through training programs and BI communities of practice.

Together, these measures will enable the construction **of** a **data-driven educational management ecosystem** characterized by efficiency, transparency, and informed decision-making. Business Intelligence will then cease to be a set of isolated tools and become a **coordinated system supporting institutional strategy**, aimed at achieving quality, equity, and innovation in Mexican technological higher education.

FUTURE WORK

The research conducted on the use of CASE tools applied to Business Intelligence (BI) in higher education institutions in the state of Sinaloa opens up a range of possibilities for the development of future projects that strengthen university management. The following are the main lines of future work:

1. Expansion of Variables and Data Sources

Advanced academic indicators: Incorporate student performance metrics, dropout rates, graduation rates, and student satisfaction.

Financial and Administrative Data: Link budget management with enrollment and graduation indicators to evaluate spending efficiency.

External sources: Integrate information from national and international organizations to compare institutional performance.

2. Predictive Analytics Development

Enrollment and Dropout Prediction Models: Apply machine learning techniques to anticipate trends and design retention strategies.

Probability of Graduation: Identify risk factors among students and propose early interventions.

Planning Scenarios: Simulate different scenarios of enrollment growth or decline to support strategic decision-making.

3. Scalability and Regional Expansion

Replication in other states: Adapt the workflow to campuses in different regions of the country, ensuring standardization of indicators.

Inter-institutional comparison: Generate dashboards that allow for comparing performance across campuses, fostering collaboration and best practices.

Integrated national system: Moving toward a centralized platform that consolidates information from across the entire TecNM.

4. Technological Innovation and Accessibility

Customized dashboards: Design dashboards tailored to different user profiles (administrators, faculty, students).

Mobile and multi-platform access: Optimize display for mobile devices and various operating systems.

Institutional Transparency: Publish key indicators on open portals to strengthen accountability.

5. Strengthening a Data-Driven Institutional Culture

Ongoing training: Train faculty and administrative staff in the use of BI CASE tools.

Data governance: Implement clear policies on quality, security, and ethics in information management.

Periodic evaluation: Establish feedback mechanisms to adjust indicators and methodologies.

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COLLABORATIVE WORK TABLE

Role	Author(s)
Research Director	Alfonso Miguel Uriarte Gálvez
Contributor at the preparation of research	Valenzuela Edeza Ramón
Contributor in the preparation of research	Mariano de Jesús Avilés Torres
Contributor in the preparation of research	José Torres Medina
Data curation	Uriarte Gálvez, Alfonso Miguel, Avilés Torres, Mariano de Jesús
Writing - Preparation of the original draft	Valenzuela Edeza Ramón, Torres Medina José
Writing - Review and editing	Valenzuela Edeza Ramón, Torres Medina José
Visualization	Uriarte Gálvez Alfonso Miguel, Avilés Torres Mariano de Jesús, Ramón Valenzuela Edeza, José Torres Medina
Supervision	Alfonso Miguel Uriarte Gálvez