

# REVISTA **CIE**



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**Transformación de la Educación y la Práctica Médica en la Era de la Inteligencia Artificial y la Salud Pública**

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## Transformation of Education and Medical Practice in the Era of Artificial Intelligence and Public Health

We are pleased to present the third issue of the CIE Journal of Educational Research of the Faculty of Medicine of Tampico “Dr. Alberto Romo Caballero” at the Autonomous University of Tamaulipas. This volume reaffirms the journal’s mission as an academic forum dedicated to the dissemination of relevant scientific research in the field of education, through the publication of studies and scholarly reflections that address contemporary challenges arising from technological integration, competency-based training, and the health needs of the population.

Contemporary medicine is undergoing a process of structural transformation driven by the convergence of technological innovation, the evolution of educational models, and the imperative to strengthen public health through preventive and evidence-based approaches. Within this context, the contributions included in this issue examine how artificial intelligence and emerging pedagogical frameworks are redefining medical practice.

One of the central themes identified is the critical review of traditional models of medical education. The analysis of self-perceived competencies in mechanical ventilation reveals significant gaps between theoretical knowledge and practical capability, underscoring the need to strengthen educational strategies focused on the development of clinical competencies.

The incorporation of methodologies based on simulation, experiential learning, and objective assessment is presented as a viable alternative to enhance patient safety and the quality of medical care.

These strategies align with international standards and promote training that is consistent with the real demands of healthcare systems.

In parallel, artificial intelligence emerges as a disruptive factor in diagnosis, prediction, and clinical decision-making. The studies included demonstrate its potential to improve diagnostic accuracy and optimize risk stratification, while simultaneously emphasizing the need for ethical integration and rigorous methodological validation.

In the field of public health, findings related to community understanding of cervical cancer reveal limitations in exclusively biomedical strategies. The persistence of knowledge gaps reinforces the importance of contextualized educational interventions and effective health communication.

Likewise, the clinical reviews featured provide a comprehensive understanding of the health–disease process. The analysis of chronic kidney disease associated with hepatitis C highlights its pathophysiological complexity and the need for multidisciplinary, evidence-based approaches.

Finally, digital applications aimed at promoting healthy lifestyles illustrate the potential of technology as a tool for population-level intervention. Taken together, this volume reflects a transition toward an integrative medical paradigm that brings together education, technology, and social responsibility in support of global health.

Sincerely  
**Dra. Miriam Janet Cervantes López**  
Editor in Chief

# Self-perceived knowledge and skills in mechanical ventilation among undergraduate medical interns: a cross-sectional study

## Autopercepción del conocimiento y las habilidades en ventilación mecánica en médicos internos de pregrado: estudio transversal

Ricardo Humberto Colmenares Díaz, Amaranta Reyes Álvarez, Ahilton Eugenio Verdines Hernández, Alejandra Flores Reyes\*

### Abstract

Mechanical ventilation is an essential life-support tool whose proper application requires theoretical knowledge and practical skills that should be developed during undergraduate medical training; however, education in this area remains limited in many academic settings. The aim of this study was to assess the self-perceived level of knowledge, practical skills, prior experience, and satisfaction with mechanical ventilation training among undergraduate medical interns. A descriptive cross-sectional study was conducted involving 114 medical interns from a medical school in Mexico, using a 34-item questionnaire previously validated through the Delphi technique. The instrument evaluated four domains: theoretical knowledge, practical skills, prior clinical experience, and satisfaction with the training received. Results showed that only 39.38% of participants reported adequate theoretical knowledge, while 66.96% indicated insufficient practical skills to manage mechanical ventilators. Additionally, only 26.32% reported prior clinical experience with mechanical ventilation, and 86% expressed dissatisfaction with their current level of knowledge. These findings highlight the need to strengthen theoretical and practical mechanical ventilation training during undergraduate medical education.

**Keywords:** mechanical ventilation; medical education; undergraduate medical interns; self-perceived competencies; clinical simulation

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### Resumen

La ventilación mecánica es una herramienta esencial de soporte vital cuya correcta aplicación requiere conocimientos teóricos y habilidades prácticas que deberían adquirirse durante la formación médica de pregrado; sin embargo, la enseñanza en esta área presenta limitaciones en diversos contextos académicos. El objetivo de este estudio fue evaluar la autopercepción del nivel de conocimientos, habilidades prácticas, experiencia previa y satisfacción con la enseñanza de la ventilación mecánica en médicos internos de pregrado. Se realizó un estudio transversal descriptivo en 114 médicos internos de una facultad de medicina en México, mediante un cuestionario de 34 ítems previamente validado por técnica Delphi, que exploró cuatro dimensiones: conocimiento teórico, habilidad práctica, experiencia clínica previa y satisfacción con la enseñanza recibida. Los resultados mostraron que solo el 39.38% de los participantes reportó contar con conocimientos teóricos adecuados y el 66.96% refirió carecer de habilidades prácticas suficientes para el manejo del ventilador mecánico. Asimismo, únicamente el 26.32% señaló haber tenido experiencia clínica previa y el 86% manifestó insatisfacción con sus conocimientos actuales. Estos hallazgos evidencian la necesidad de fortalecer la formación teórica-práctica en ventilación mecánica durante el pregrado médico.

**Palabras clave:** ventilación mecánica; educación médica; médicos internos de pregrado; autopercepción de competencias; simulación clínica



### INTRODUCTION

Mechanical ventilation represents one of the most complex and, at the same time, most decisive therapeutic interventions in the management of critically ill patients, as it involves a dynamic interaction between the ventilator, respiratory physiology, and the patient's individual clinical response. From a theoretical standpoint, this intervention cannot be reduced to the mere application of technical parameters; rather, it requires an advanced cognitive process that integrates pathophysiological knowledge, procedural skills, interpretation of graphical signals, and clinical decision-making in frequently uncertain scenarios. Recent literature consistently reports that appropriate mechanical ventilation management is directly associated with relevant clinical outcomes, including mortality, duration of ventilation, ventilator-associated complications, and patient safety (Walter, 2021; Coldewey et al., 2021).

Within this context, contemporary patient safety models have emphasized that a considerable proportion of adverse events related to mechanical ventilation do not stem exclusively from technological failures, but from human errors attributable to gaps in training, experience, and clinical competence. Systematic studies have identified configuration errors, inadequate alarm interpretation, and limited understanding of patient-ventilator interaction as frequent causes of preventable events that negatively affect clinical outcomes (Coldewey et al., 2021). These observations

reinforce the need to conceptualize mechanical ventilation not merely as a technical act, but as a complex clinical competency whose development requires deliberate and structured educational strategies.

Traditionally, the acquisition of competencies in mechanical ventilation has been considered part of training in specialties related to critical care medicine. However, this approach is insufficient when considering that, in real-world practice, initiation of ventilatory support frequently occurs in emergency departments, general hospital wards, or settings with limited specialist availability. Multicenter studies have documented that general practitioners, undergraduate medical interns, and residents often face the need to initiate or manage mechanical ventilation without having achieved an adequate level of formal preparation, thereby increasing the risk of clinical insecurity and management errors (Hayashi et al., 2022; Wiedermann & Lederer, 2023).

From an educational theory perspective, training in mechanical ventilation faces a structural challenge: the discrepancy between declarative knowledge acquired in academic settings and the ability to execute safe clinical decisions in real scenarios. This phenomenon has been widely described in medical education literature as the gap between “knowing” and “doing,” particularly relevant in competencies involving high cognitive and technical complexity. Recent studies have shown that even when students and residents achieve acceptable performance on theoretical assessments, they encounter significant

difficulties when confronted with simulated or clinical scenarios requiring the simultaneous integration of multiple ventilatory variables (Hayashi et al., 2022; Schroedl & Vitale, 2022).

In this framework, the construct of self-perceived competence acquires theoretical and methodological relevance. Self-perception is defined as the subjective assessment individuals make regarding their level of knowledge, skills, and confidence to perform a specific clinical task. Although this construct does not necessarily equate to actual performance, its analysis is fundamental from an educational standpoint, as it influences decision-making, clinical behavior, and willingness to seek supervision or support. Recent studies have shown that low self-perceived competence is associated with increased clinical insecurity, whereas inflated self-perception not supported by actual competence may increase the risk of errors by generating a false sense of mastery (Takeda et al., 2023).

Available evidence suggests that, in the field of mechanical ventilation, medical students and trainees often report low levels of confidence and perceived competence, particularly in critical domains such as selection of ventilatory modes, adjustment of lung-protective parameters, and identification of patient-ventilator asynchronies. Studies conducted in diverse educational contexts have documented that these deficiencies persist even at the end of undergraduate training and during the early years of postgraduate education, reflecting structural

limitations in traditional teaching models (Takeda et al., 2023; Wiedermann & Lederer, 2023).

In response to these limitations, contemporary educational theory has promoted the use of simulation-based approaches grounded in experiential and deliberate learning models. Simulation enables the recreation of complex clinical scenarios in controlled environments, facilitating cognitive integration, immediate feedback, and progressive competency development. Recent literature shows that mechanical ventilation training programs based on in-person or virtual simulation achieve significant short-term improvements in knowledge, confidence, and performance, particularly when aligned with competency-based objectives and structured assessments (Mireles-Cabodevila & Chatburn, 2023; Macedo et al., 2025).

Nevertheless, a critical analysis of this evidence reveals that most studies have focused on resident or postgraduate trainee populations, while the undergraduate level remains insufficiently explored. Moreover, although increases in knowledge and self-confidence following specific educational interventions have been documented, questions persist regarding the baseline level of preparation with which undergraduate medical interns enter real clinical settings. This gap is particularly relevant in middle-income countries, where opportunities for structured mechanical ventilation training are limited and heterogeneous.

From an integrative theoretical perspective, analyzing self-perceived knowledge and skills in mechanical ventilation allows the linkage of three fundamental dimensions of the educational process: theoretical knowledge, practical skills, and subjective perception of competence. The interaction among these dimensions is critical, as it influences future clinical behavior, self-regulated learning, and patient safety. The absence of systematic studies evaluating these dimensions jointly in undergraduate medical interns constitutes a relevant knowledge gap that scientifically justifies the present study.

Accordingly, contemporary theoretical frameworks suggest that mechanical ventilation represents a high-complexity clinical competency whose learning cannot rely solely on theoretical exposure or incidental clinical experience. The combination of training gaps, limited self-perceived competence, and the absence of homogeneous undergraduate curricular standards underscores the need for studies that rigorously characterize the level of preparation of medical interns. Generating such evidence is essential to guide the design of competency-based educational strategies aligned with patient safety principles and the real demands of contemporary clinical practice.

### **METHODS, TECHNIQUES AND INSTRUMENTS**

This study was conducted using an observational, cross-sectional, and descriptive design, with the aim of evaluating self-perceived levels of knowledge and

skills in mechanical ventilation among undergraduate medical interns. This methodological approach was considered appropriate for exploring, at a specific point in time, the subjective perception of competencies acquired during medical training, without seeking to establish causal relationships or intervention effects.

The target population consisted of undergraduate medical interns affiliated with the Faculty of Medicine of Tampico “Dr. Alberto Romo Caballero” at the Autonomous University of Tamaulipas, Mexico. A non-probabilistic convenience sampling method was used, including those interns who voluntarily agreed to participate during the data collection period. This type of sampling is commonly employed in exploratory studies of perception and medical education, particularly when evaluating defined and accessible academic populations.

Data were collected using a self-administered questionnaire implemented through the Google Forms platform. The instrument was based on a questionnaire previously developed and validated by Tallo et al. (2017) using the Delphi technique, which was translated and adapted into Spanish following methodological guidelines for assessing self-perceived competencies in educational contexts. The questionnaire comprised 34 items distributed across four conceptual dimensions: theoretical knowledge of mechanical ventilation, practical skills in ventilator management, prior experience with mechanical ventilators, and satisfaction with the

training received during undergraduate medical education.

The instrument began with an informed consent section, followed by basic sociodemographic variables, including age, sex, and academic status, with response options corresponding to undergraduate medical intern (UMI) and social service medical trainee (SSMT). Subsequently, items were primarily formulated in a dichotomous format (“yes/no” or “true/false”), with the exception of one polytomous item designed to assess decision-making in a clinical scenario related to mechanical ventilation. This structure enabled direct capture of participants’ self-perceptions regarding specific competencies.

To strengthen content validity within the local context, the questionnaire underwent review by intensive care specialists. Additionally, a pilot test was conducted in a sample of 12 social service medical trainees, allowing assessment of clarity, comprehension, and functionality of the instrument. As no relevant inconsistencies or difficulties were identified during this phase, no further modifications were required prior to application to the final sample. Data collection was carried out by distributing the questionnaire via social media platforms, using an electronic link and a QR code specifically targeted to the undergraduate medical interns included in the study. Participation was voluntary and anonymous, and confidentiality of the information provided was guaranteed. The data collection period lasted two weeks, at the end of which responses from 114 undergraduate medical interns were obtained.

Data analysis was performed using Microsoft Excel and SPSS statistical software version 26. A descriptive analysis of the sample’s sociodemographic variables was conducted, as well as performance across each of the four domains evaluated by the questionnaire. Results were reported using frequencies, percentages, and 95% confidence intervals, with the aim of providing a precise estimate of response variability and facilitating analytical interpretation within the study context.

From an ethical standpoint, the study was reviewed and approved by the Research Ethics Committee of the Faculty of Medicine of Tampico “Dr. Alberto Romo Caballero” at the Autonomous University of Tamaulipas. All participants provided electronic informed consent prior to completing the questionnaire, in accordance with ethical principles for research involving human subjects and current regulatory provisions regarding confidentiality and voluntariness.

## **RESULTS AND DISCUSSION**

A total of 114 undergraduate medical interns participated in the study. Of the analyzed population, 57.9% were female and 42.1% male, with a mean age of 24 years. These data reflect the typical composition of the medical intern cohort within the institutional context evaluated.

Regarding theoretical knowledge, the results revealed relevant deficiencies in fundamental concepts of mechanical ventilation. The majority of participants (81.6%  $\pm$  7.2%) reported lacking knowledge of

technical regulations associated with the use of medicinal gases, although 56.1% ( $\pm 9.1\%$ ) stated that they could identify the main graphical resources provided by mechanical ventilators. Nevertheless, essential respiratory mechanics concepts were largely unknown: 60.5% ( $\pm 9.0\%$ ) did not identify the concept of respiratory system resistance, 58.8% ( $\pm 9.1\%$ ) were unfamiliar with compliance, and 61.4% ( $\pm 9.0\%$ ) did not recognize the concept of time constant. Furthermore, more than half of the interns were unfamiliar with basic principles of mechanical ventilation in patients with chronic obstructive pulmonary disease, and this proportion increased significantly in the case of acute respiratory distress syndrome, where 71.9% ( $\pm 8.3\%$ ) reported lack of knowledge. Similarly, 70.2% ( $\pm 8.4\%$ ) were unfamiliar with the principles of positive end-expiratory pressure, and fewer than half of the participants reported knowing the principles of ventilator weaning.

With respect to practical skills, the results showed a limited perception of competence in performing basic tasks related to ventilator management. More than half of the interns (57.9%  $\pm 9.2\%$ ) indicated that they would have difficulty turning on a mechanical ventilator, while 70.2% ( $\pm 8.4\%$ ) expressed concern for patient safety if advanced airway management were required under their care. Ventilator configuration in pressure-controlled and volume-controlled modes was perceived as unsafe by 77.2% ( $\pm 7.7\%$ ) and 76.3% ( $\pm 7.8\%$ ) of participants, respectively. Additionally, 74.6% ( $\pm 8.1\%$ ) reported being unable to establish adequate sedation in

mechanically ventilated patients, and 70.2% ( $\pm 8.4\%$ ) had not used specific pain assessment scales in this context. Indicators related to advanced monitoring showed the greatest limitations: fewer than 25% of participants considered themselves capable of calculating static or dynamic compliance of the respiratory system, measuring plateau pressure, or identifying auto-PEEP, reflecting limited familiarity with critical ventilatory safety parameters.

Analysis of prior clinical experience revealed very limited exposure to mechanically ventilated patients. Fewer than half of participants reported having observed mechanical ventilator use in real clinical contexts, and a large majority stated that they were unable to interpret basic clinical scenarios related to respiratory failure. This lack of practical exposure appears to be directly reflected in perceived insecurity and in the limitations observed across knowledge and skill domains.

Regarding teaching received during medical training, most interns considered the information provided in their academic program to be insufficient. Although a relevant proportion acknowledged the presence of qualified instructors, dissatisfaction with the level of knowledge acquired and the perceived urgent need for educational reinforcement predominated.

Consistently, the vast majority agreed that learning mechanical ventilation should not be omitted during undergraduate training, even when other professionals may assume this role in the clinical environment (Figure 1).

When responses were grouped according to the four evaluated pillars—knowledge, practical skills, prior experience, and satisfaction with training—a global profile characterized by a low level of perceived preparation emerged (Figure 2).

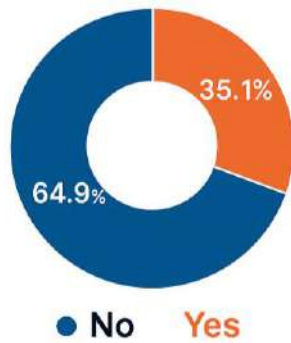


Figure 1. Self-perceived adequacy of mechanical ventilation training

Less than half of participants reported adequate theoretical knowledge, approximately two-thirds acknowledged insufficient practical skills, prior clinical experience was the most deficient component, and although satisfaction with training showed relatively higher values, it remained below desirable levels for a critical clinical competency such as mechanical ventilation.



Figure 2. Distribution of the level of self-perceived preparedness in mechanical

The findings of this study demonstrate substantial deficiencies in self-perceived theoretical knowledge, practical skills, and clinical experience in mechanical ventilation among undergraduate medical interns, consistent with recent international literature on medical education and critical care training (Hayashi et al., 2022; Wiedermann & Lederer, 2023). The high proportion of participants reporting lack of knowledge of fundamental respiratory mechanics concepts aligns with studies showing low baseline competence in mechanical ventilation even among advanced trainees when education relies predominantly on theoretical content without structured practical integration (Hayashi et al., 2022; Schroedl & Vitale, 2022).

The lack of understanding of ventilatory principles applied to specific clinical conditions, particularly acute respiratory distress syndrome, is especially relevant, given that these conditions constitute frequent indications for mechanical ventilation in hospital settings. Previous studies have indicated that limited understanding of these principles is associated with difficulty selecting lung-protective ventilatory strategies and increased clinical insecurity during decision-making (Takeda et al., 2023; Walter, 2021). In this sense, the results reinforce the notion that fragmented theoretical knowledge does not automatically translate into functional clinical competence.

Regarding practical skills, the study demonstrates a marked gap between declared knowledge and perceived ability to perform essential operational

tasks, such as configuring ventilatory modes, adjusting alarms, and performing advanced patient monitoring. This observation is consistent with research documenting similar limitations among residents and early-career physicians, particularly in contexts lacking formal competency-based programs and standardized practical assessments (Schroedl & Vitale, 2022; Coldewey et al., 2021). The low self-perceived competence in advanced monitoring, including plateau pressure and auto-PEEP measurement, is particularly concerning due to its direct implications for patient safety and prevention of ventilator-induced lung injury (Coldewey et al., 2021; Walter, 2021).

The limited prior clinical experience reported by the evaluated interns is consistent with findings from studies conducted across diverse educational systems, where exposure to mechanically ventilated patients during undergraduate training is restricted and predominantly observational (Hayashi et al., 2022; Macedo et al., 2025). This lack of early exposure to real or simulated ventilatory scenarios contributes to delayed acquisition of critical competencies and reinforces perceived insecurity when confronting complex clinical situations, a phenomenon widely described in studies on the transition from undergraduate to postgraduate training (Macedo et al., 2025).

A relevant finding of the present study is the high level of dissatisfaction with the training received, despite recognition of qualified teaching staff. This

apparent contradiction suggests that the issue lies not solely in available human resources, but in the pedagogical model employed. According to recent literature, programs lacking deliberate strategies to integrate theory, supervised practice, and structured feedback tend to generate negative perceptions of self-efficacy and clinical preparedness, even when academic content is formally included in the curriculum (Wiedermann & Lederer, 2023; Takeda et al., 2023).

Multiple studies have demonstrated that implementation of simulation-based educational strategies, both in-person and virtual, significantly improves knowledge, confidence, and performance in mechanical ventilation among populations with limited experience (Mireles-Cabodevila & Chatburn, 2023; Ippolito et al., 2023). Additionally, programs based on virtual reality, online simulators, and competency-structured curricula have proven to be effective and scalable alternatives for developing complex clinical skills, even in resource-limited settings (Lee & Han, 2022; Kim & Yoo, 2025; Al Kahf et al., 2026). These findings contrast with the situation observed in the present study, where training appears to rely primarily on conventional theoretical strategies.

Overall, comparison of the present results with available evidence confirms that low perceived preparation in mechanical ventilation among undergraduate medical interns is not an isolated phenomenon, but rather a local manifestation of a

widely documented educational problem at the international level. The concordance between the study findings and prior reports reinforces their relevance and underscores the need to strengthen mechanical ventilation training from early stages of medical curricula through pedagogical approaches oriented toward progressive clinical competency development and patient safety improvement.

## CONCLUSIONS

The results of this study reveal a relevant discordance between the competency demands inherent to contemporary clinical practice and the preparation perceived by undergraduate medical interns at the completion of their basic training. This finding suggests that undergraduate medical education does not guarantee the comprehensive development of the theoretical and practical competencies required to safely and effectively manage clinical scenarios involving mechanical ventilation.

Limited acquisition of essential theoretical foundations, together with low self-perceived ability to perform key operational tasks, highlights insufficient integration between conceptual learning and practical application. Additionally, reduced exposure to real or simulated clinical situations during undergraduate training appears to contribute significantly to perceived insecurity among medical interns, which may negatively affect early professional performance and quality of care. This scenario is particularly relevant given that mechanical ventilation is a high-risk intervention requiring

well-consolidated clinical competencies from the earliest years of medical practice.

From an academic and methodological perspective, the findings support the need for a critical review of undergraduate medical curricula, with particular emphasis on high-complexity clinical competencies. Incorporation of structured educational strategies that promote integration of theoretical knowledge with supervised clinical practice, as well as progressive skill development through active learning methods, emerges as a necessary pathway to address the identified gaps. In this regard, assessment of interns' perceived preparedness provides valuable information for planning and prioritizing educational interventions aimed at strengthening fundamental clinical competencies.

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## Medical diagnosis with neural networks

### Diagnóstico médico con redes neuronales

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#### Abstract

Artificial intelligence, through the use of artificial neural networks, has become a relevant tool in the transformation of diagnostic and predictive processes in contemporary medicine. This study analyzes the application of artificial neural networks for disease prediction and diagnostic support, as well as their integration with telemedicine platforms. Using a structured methodology that includes data collection, preprocessing and feature selection, neural model design and training, validation, and continuous monitoring, significant improvements were identified in the early detection of complex diseases and in clinical risk stratification. The results demonstrate a reduction in errors associated with human factors, improved personalization of treatments, and optimization of healthcare resource utilization. In addition, the developed systems showed potential for continuous patient monitoring and dynamic adaptation of clinical recommendations. Nevertheless, the study highlights the need for ongoing validation and ethical, responsible integration to ensure clinical effectiveness and safety

**Keywords:** artificial intelligence; artificial neural networks; medical diagnosis; telemedicine; disease prediction

#### Resumen

La inteligencia artificial, mediante el uso de redes neuronales artificiales, se ha consolidado como una herramienta relevante en la transformación de los procesos diagnósticos y predictivos en la medicina contemporánea. El presente estudio analiza la aplicación de redes neuronales artificiales para la predicción y el apoyo al diagnóstico médico, así como su integración con plataformas de telemedicina. A través de una metodología estructurada que abarca la recopilación, preprocesamiento y selección de datos, el diseño y entrenamiento de modelos neuronales, su validación y monitoreo continuo, se identificaron mejoras significativas en la detección temprana de enfermedades complejas y en la estratificación del riesgo clínico. Los resultados evidencian una reducción de errores asociados a factores humanos, una mayor personalización de los tratamientos y una optimización en el uso de recursos sanitarios. Asimismo, los sistemas desarrollados mostraron potencial para el seguimiento continuo de pacientes y la adaptación dinámica de las recomendaciones clínicas. No obstante, se destaca la necesidad de validación permanente y una integración ética y responsable para garantizar su efectividad y seguridad clínica.

**Palabras clave:** inteligencia artificial; redes neuronales artificiales; diagnóstico médico; telemedicina; predicción de enfermedades

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### INTRODUCTION

The accelerated development of artificial intelligence (AI) has driven profound transformations across multiple scientific domains, with a particularly notable impact on contemporary medicine. The increasing digitalization of healthcare systems, together with the exponential growth in the volume and complexity of available clinical data, has created a favorable environment for the adoption of advanced computational models capable of supporting diagnostic, prognostic, and therapeutic decision-making. Within this context, artificial neural networks (ANNs) have emerged as one of the most influential approaches in deep learning, owing to their ability to model complex nonlinear relationships and extract clinically meaningful patterns from heterogeneous data sources (Esteva et al., 2021; Topol, 2021).

Medical diagnosis represents one of the areas in which the application of ANNs has demonstrated the greatest potential, particularly in scenarios characterized by high information density, the need for timely decisions, and substantial interindividual variability. Numerous studies have shown that deep learning–based models can match or even surpass human performance in specific diagnostic tasks, especially in the analysis of medical images, biomedical signals, and multimodal data, thereby improving diagnostic accuracy and reducing variability associated with individual clinical judgment (Rajpurkar et al., 2021; Shen et al., 2021). This progress is especially relevant given that diagnostic errors remain a significant cause of adverse

events in current healthcare systems (Rajkomar et al., 2022).

In particular, ANNs have demonstrated high effectiveness in the automated analysis of medical images using convolutional architectures, as well as in the interpretation of clinical time series through recurrent neural networks, enabling early detection of cardiovascular, oncological, and neurological conditions (Attia et al., 2022; Yao et al., 2021). These developments have contributed substantially to the advancement of precision medicine by facilitating earlier and more personalized diagnoses based on large-scale clinical and biological data (Kather et al., 2021).

In parallel, the integration of neural networks with telemedicine platforms has expanded the reach of AI-assisted diagnosis beyond traditional hospital settings. The incorporation of intelligent systems into remote healthcare delivery has improved access to specialized diagnostic services, particularly in regions with limited healthcare infrastructure and shortages of trained medical personnel. In such contexts, the convergence of AI and telemedicine is emerging as a key strategy to reduce disparities in healthcare access and optimize the allocation of clinical resources (Bestsenny et al., 2022; Ting et al., 2022).

Despite these advances, the implementation of ANNs in medical diagnosis faces important technical, clinical, and ethical challenges. Major obstacles include the reliance on large, high-quality labeled datasets, difficulties in ensuring model

generalizability across diverse populations, the opacity of algorithmic decision-making processes, and concerns related to data privacy and security (Kelly et al., 2022; Morley et al., 2021). These limitations have stimulated growing interest in the development of explainable artificial intelligence approaches aimed at increasing transparency and fostering clinical trust in ANN-based diagnostic support systems (Zhang et al., 2023).

Against this background, a systematic analysis of the role of artificial neural networks in medical diagnosis is scientifically warranted, taking into account both their conceptual foundations and their practical applications, benefits, and current limitations. Examining these technologies from an academic and methodological perspective allows for a deeper understanding of their transformative potential in diagnostic processes, while also identifying knowledge gaps related to their implementation in real-world clinical settings and their impact on the quality and equity of healthcare delivery (Lupton & Jutel, 2023). Consequently, the study of ANN-assisted medical diagnosis not only reflects an emerging technological trend but also constitutes a necessary step toward more accurate, accessible, and evidence-based models of care.

## **METHODS, TECHNIQUES, AND INSTRUMENTS**

The implementation of artificial neural networks in medical diagnosis requires a structured methodological approach to ensure the scientific validity of the developed models and their potential

clinical applicability. Although these architectures have demonstrated a strong capacity for analyzing complex data, their use entails relevant challenges, including the need for large volumes of properly labeled data, susceptibility to adversarial perturbations, and limited interpretability of decision-making processes—an essential aspect for building trust in clinical environments. Accordingly, the adopted methodology is conceived as a comprehensive process encompassing data management, model development, and continuous evaluation, following a systematic sequence of interdependent stages.

The initial phase involves data collection, which constitutes a central determinant of subsequent model performance. In the medical context, this stage entails the integration of information from multiple clinical sources, such as electronic health records, laboratory test results, demographic data, symptom questionnaires, and, when applicable, genomic and proteomic data. The integration of these sources enables the construction of multimodal datasets that more accurately reflect the biological and clinical complexity of patients, thereby laying the groundwork for a more precise and personalized diagnostic and predictive approach.

Once the data have been consolidated, preprocessing is performed to ensure data quality, consistency, and suitability for neural network training. This process includes record cleaning to correct errors, remove duplicates, and address missing values, as well as the transformation of categorical variables into numerical

representations compatible with learning algorithms. In addition, normalization and scaling procedures are applied to prevent imbalances in variable contributions during training, along with dimensionality reduction techniques when warranted by data complexity. Collectively, these actions enhance model stability, efficiency, and generalization capability.

Subsequently, feature selection is conducted to identify the most informative and relevant variables for the diagnostic or predictive task. This stage aims to reduce noise and redundancy in the data, promoting a more parsimonious and efficient model without compromising performance. Feature selection is guided by a combination of algorithmic criteria and clinical considerations, ensuring that retained variables possess both statistical relevance and medical significance, thereby strengthening model interpretability and clinical utility.

The design of the neural network architecture represents a core methodological component, as it determines the model's ability to capture complex patterns within medical data. Architectural choices are informed by the nature of the problem and the type of data analyzed, with convolutional neural networks employed for medical image processing and recurrent or long short-term memory networks used for sequential data such as biomedical signals or clinical time series. In all cases, the design seeks a balance between depth and complexity, incorporating regularization strategies to minimize overfitting and promote generalization to unseen

data—an essential requirement for deployment in real clinical settings.

Appropriate activation functions are selected to model complex nonlinear relationships and facilitate the learning process. These choices are made in accordance with task requirements and training stability, given their direct impact on model accuracy and clinical relevance. In parallel, an optimization scheme is defined to govern weight updates, selecting algorithms that ensure efficient and stable convergence during training.

Model training is performed by partitioning the dataset into training, validation, and test subsets to evaluate performance at different stages and prevent overfitting. During this process, the neural network iteratively adjusts its parameters to minimize a loss function that quantifies the discrepancy between predicted and actual values. This progressive learning across multiple iterations refines predictive capability and enhances overall model performance.

Model evaluation is conducted using metrics that provide a comprehensive assessment of diagnostic and predictive effectiveness, encompassing overall accuracy as well as the ability to correctly identify positive and negative cases. These metrics are essential for determining clinical viability and guiding methodological refinements. To strengthen robustness and generalizability, cross-validation is applied using multiple data partitions, reducing dependence on a single split and enabling assessment

of performance stability under varying input conditions.

Finally, once validated, the model may be implemented as a decision-support tool in clinical environments or healthcare platforms, either for real-time prediction or retrospective analysis. The methodology also incorporates continuous monitoring and updating processes aimed at maintaining accuracy in response to evolving disease patterns, the incorporation of new data, and changes in medical protocols. This continuous improvement framework is fundamental to ensuring the sustained utility of artificial neural networks in medical diagnosis and their responsible integration into healthcare systems.

## RESULTS AND DISCUSSION

The application of the artificial neural network–based methodology for disease prediction and diagnostic support resulted in a substantial improvement in early disease identification, particularly in contexts characterized by high clinical data complexity and heterogeneity. The developed models demonstrated a strong ability to detect subtle patterns and nonlinear relationships that are not always evident through conventional diagnostic approaches, enabling more precise and timely identification of conditions such as cardiovascular disease, diabetes, and various forms of cancer.

These findings are consistent with previous studies documenting the superiority of deep neural networks in processing multimodal clinical data and in the early

detection of pathological entities with nonspecific initial manifestations (Esteva et al., 2021; Rajpurkar et al., 2021). From a diagnostic standpoint, the capacity of neural networks to simultaneously integrate multiple sources of clinical, demographic, and biomolecular information reinforces their utility in scenarios where early disease progression is silent or exhibits high interindividual variability.

Recent research has emphasized that this integrative capability constitutes one of the principal contributions of AI to medical diagnosis, overcoming the limitations of rule-based models or univariate analyses (Rajkomar et al., 2022; Kather et al., 2021). In this regard, the present results support the relevance of ANNs as complementary tools for enhancing diagnostic accuracy in clinical practice.

Moreover, the incorporation of AI-based systems had a positive impact on reducing errors associated with human factors, such as fatigue, cognitive bias, and variability in clinician experience. The use of neural network models as decision-support tools reinforced diagnostic consistency by providing a secondary analytical layer without replacing professional clinical judgment. This outcome aligns with existing literature highlighting the value of AI as an adjunct system that enhances diagnostic reproducibility and reduces interobserver variability, particularly in high-workload care settings (Kelly et al., 2022; Topol, 2021).

With respect to risk prediction, the implemented models demonstrated adequate capability to identify

patient profiles with an increased likelihood of developing specific diseases through the combined analysis of clinical, demographic, and biomolecular variables. This predictive capacity enabled more precise risk stratification and the targeting of early, preventive interventions, representing a meaningful advance toward proactive healthcare approaches. Similar results have been reported in studies employing neural networks for longitudinal data analysis and clinical time series, especially in cardiovascular and metabolic domains (Attia et al., 2022; Yao et al., 2021).

Additionally, the findings indicate that the use of artificial neural networks promotes treatment personalization. The ability to process large volumes of data facilitated the generation of therapeutic recommendations tailored to individual patient profiles, potentially translating into greater clinical efficacy and reduced adverse effects associated with generalized treatment strategies. This observation is consistent with the principles of precision medicine, in which AI has been identified as a key enabler for adapting therapeutic strategies to patient-specific characteristics (Kather et al., 2021; Rajkomar et al., 2022).

From an operational perspective, model implementation yielded favorable effects on healthcare resource optimization. The capacity to prioritize cases based on estimated risk contributed to more efficient allocation of human and technological resources, a particularly relevant consideration in healthcare systems facing high

demand and structural constraints. Recent studies have shown that the combination of early prediction and risk stratification through AI can improve resource management and reduce pressure on specialized care services (Bestseny et al., 2022; Ting et al., 2022). Concurrently, improvements in early detection and disease prevention suggest a potential reduction in costs associated with prolonged hospitalizations, delayed treatments, and unnecessary repetition of diagnostic tests.

Finally, the results highlight the value of artificial neural networks for continuous patient monitoring and follow-up. The models' ability to incorporate updated health status data enabled dynamic adjustments to clinical recommendations, supporting the prevention of complications and improvement of long-term outcomes. This adaptive approach is particularly pertinent in the management of chronic diseases, where continuous surveillance and timely intervention are critical determinants of patient quality of life (Lupton & Jutel, 2023).

Nevertheless, interpretation of these findings must account for limitations documented in the literature, particularly those related to data quality and representativeness, model generalizability across different populations, and the limited explainability of deep neural network decision processes.

These challenges remain the focus of active research and underscore the need to integrate explainable AI approaches to enhance transparency and clinical trust in such systems (Morley et al., 2021; Zhang et al.,

2023). Overall, the results and their discussion confirm the potential of artificial neural networks to improve the accuracy, efficiency, and proactivity of medical diagnosis, provided that their implementation is responsible, continuously validated, and aligned with real-world clinical workflows.

## CONCLUSIONS

The findings of this study indicate that artificial neural networks constitute a robust methodological tool for the analysis of complex clinical data and the enhancement of diagnostic processes in contemporary medicine. The ability of these models to process large volumes of heterogeneous information and detect non-obvious patterns supports earlier disease identification and more precise diagnostic approaches, with direct implications for the quality and timeliness of medical care.

The integration of artificial neural networks into telemedicine environments emerges as a strategic component for expanding access to specialized diagnostic services, particularly in regions with limited infrastructure and healthcare workforce availability. This approach contributes to reducing disparities in care, optimizing resource management, and advancing toward more equitable models of healthcare delivery without compromising diagnostic quality.

Furthermore, the results demonstrate that the use of artificial neural networks supports preventive and

personalized healthcare by enabling risk stratification and the adaptation of therapeutic interventions to individual patient characteristics. This capability is especially relevant in the management of chronic and highly prevalent diseases, where early detection and continuous monitoring are critical for improving clinical outcomes and patient quality of life.

At the same time, the analysis underscores that the positive impact of these technologies is critically dependent on responsible implementation. The need for high-quality data, continuous validation processes, and mechanisms that enhance model interpretability represents a central requirement for ensuring clinical acceptance and safe use. Accordingly, the incorporation of artificial neural networks into healthcare systems should be viewed as a dynamic process subject to ongoing evaluation and improvement, rather than as a static technological solution.

In summary, the conclusions reinforce the notion that artificial neural networks have the potential to substantially transform medical practice by improving diagnostic precision, personalizing treatments, and expanding access to quality healthcare services. Realizing these benefits, however, requires an interdisciplinary approach that integrates clinical, technical, and ethical expertise, aimed at maximizing the value of artificial intelligence for the benefit of patients and healthcare systems as a whole.

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## Analysis of community understanding of the diagnosis of cervical cancer: A cohort study

### Análisis de la comprensión en la comunidad sobre el diagnóstico del cáncer cervical: Un estudio de cohorte

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#### Abstract

Cervical cancer continues to represent a significant public health problem, particularly in contexts where timely diagnosis and preventive strategies have limited coverage. The aim of this study was to analyze the level of understanding among the female community regarding the diagnosis, risk factors, and early detection strategies for cervical cancer. A prospective cohort study was conducted in a sample of 100 women over 18 years of age, residents of the municipalities of Tampico and Ciudad Madero, Tamaulipas, without formal training in health sciences. Data were collected through a structured online questionnaire that assessed general knowledge, risk factors, preventive practices, and personal medical history. The results revealed a moderate overall level of knowledge, with notable deficiencies in specific diagnostic aspects, particularly in the recognition of combined HPV testing and cytology. Relevant differences were identified according to age group, with higher levels of knowledge observed among young adult women and lower levels among women over 55 years of age. These findings highlight the need to strengthen community-based educational strategies aimed at promoting timely diagnosis, prevention, and effective communication between healthcare services and the population.

**Keywords:** cervical cancer; human papillomavirus; early diagnosis; screening; community knowledge

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#### Resumen

El cáncer cervical continúa representando un problema relevante de salud pública, particularmente en contextos donde el diagnóstico oportuno y las estrategias preventivas muestran una cobertura limitada. El presente estudio tuvo como finalidad analizar el nivel de comprensión en la comunidad femenina sobre el diagnóstico, los factores de riesgo y las estrategias de detección temprana del cáncer cervical. Se llevó a cabo un estudio de cohorte prospectivo en una muestra de 100 mujeres mayores de 18 años, residentes de los municipios de Tampico y Ciudad Madero, Tamaulipas, sin formación en ciencias de la salud. La recolección de datos se realizó mediante un cuestionario estructurado aplicado en línea, el cual evaluó conocimientos generales, factores de riesgo, prácticas preventivas y antecedentes personales. Los resultados evidenciaron un nivel de conocimiento global moderado, con deficiencias importantes en aspectos diagnósticos específicos, particularmente en el reconocimiento de la prueba conjunta para VPH y citología. Se identificaron diferencias relevantes según el grupo etario, observándose mayor conocimiento en mujeres adultas jóvenes y menor comprensión en mujeres mayores de 55 años. Los hallazgos resaltan la necesidad de fortalecer estrategias educativas comunitarias orientadas a la promoción del diagnóstico oportuno, la prevención y la comunicación efectiva entre los servicios de salud y la población.

**Palabras clave:** cáncer cervical; virus del papiloma humano; diagnóstico oportuno; tamizaje; conocimiento comunitario



## INTRODUCTION

Cervical cancer remains one of the leading public health challenges worldwide, despite being a largely preventable disease and potentially curable when detected at early stages. According to recent estimates, it ranks as the fourth most common cancer among women globally, with a disproportionate burden in low- and middle-income countries, where the majority of incident cases and related deaths occur. This unequal distribution reflects profound disparities in access to human papillomavirus (HPV) vaccination programs, timely screening strategies, and adequate treatment services, as well as the influence of social and structural determinants that limit effective disease prevention (World Health Organization, 2025).

Scientific evidence has consistently established persistent infection with high-risk HPV as the primary cause of cervical cancer, particularly genotypes 16 and 18, which are responsible for most cases of squamous cell carcinoma and adenocarcinoma of the cervix. However, progression from viral infection to precursor lesions and invasive cancer is neither linear nor inevitable, but rather depends on the interaction of multiple biological, immunological, and behavioral factors. These include smoking, multiparity, early onset of sexual activity, multiple sexual partners, and low socioeconomic status, all of which have been associated with increased risk of viral persistence and malignant transformation (Perkins et al., 2023; Arip et al., 2022).

One of the major challenges in cervical cancer control lies in its typically asymptomatic early clinical course, which delays diagnosis until advanced stages in the absence of systematic screening programs. Numerous studies have demonstrated that the implementation of screening strategies, such as cervical cytology and HPV DNA testing, significantly reduces the incidence of invasive cancer and associated mortality. Nevertheless, the effectiveness of these strategies largely depends on population coverage and sustained adherence to screening programs, factors that are closely linked to the level of knowledge and understanding within the population regarding the disease and its diagnostic methods (Perkins et al., 2023; Terasawa et al., 2022).

In recent years, the World Health Organization has promoted a global strategy for the elimination of cervical cancer as a public health problem, establishing ambitious targets that include vaccinating 90 % of girls against HPV, screening 70 % of women at key ages, and providing timely treatment to 90 % of detected cases. Achieving these goals requires not only adequate healthcare infrastructure, but also an informed and empowered population that recognizes the importance of prevention and early diagnosis. Recent literature has consistently documented that knowledge levels regarding HPV, its relationship with cervical cancer, and screening tests vary significantly according to age, educational level, and sociocultural context, thereby influencing participation in screening

programs (Stephens et al., 2023; Khumalo et al., 2022).

Population-based studies conducted in different regions have shown that, even in contexts where screening programs are established, substantial deficiencies persist in the recognition of current diagnostic tests, particularly those integrating HPV detection as a primary or combined method. This lack of understanding not only limits the utilization of available tests, but also contributes to misperceptions of individual risk and the perceived need for preventive evaluations, especially among older women and groups with lower educational attainment (Tesfaw et al., 2021; Adewumi et al., 2022).

HPV vaccination represents a key intervention for the primary prevention of cervical cancer, with robust evidence demonstrating significant reductions in the incidence of precancerous lesions in vaccinated populations. Nevertheless, vaccine acceptance and coverage remain heterogeneous, influenced by information levels, cultural beliefs, and physician–patient communication. Recent research has highlighted that low awareness of the relationship between HPV and cervical cancer is associated with lower vaccination rates and, consequently, reduced long-term effectiveness of preventive programs (Stephens et al., 2023; CDC, 2025).

In this context, it is essential to analyze community understanding of cervical cancer diagnosis, using an approach that enables the identification of

knowledge gaps, generational differences, and priority areas for educational intervention. Assessing community knowledge not only provides valuable information for public health planning, but also constitutes a critical input for strengthening communication between healthcare services and the population, improving adherence to screening, and advancing toward the goal of eliminating cervical cancer as a preventable disease. Accordingly, the present study aims to systematically analyze the level of understanding regarding cervical cancer diagnosis within a community cohort, contributing local evidence to contextualize current challenges and opportunities in the prevention of this malignancy.

### **METHODS, TECHNIQUES AND INSTRUMENTS**

A prospective cohort study with an observational, descriptive–analytical approach was conducted to evaluate the level of understanding among women in the community regarding cervical cancer diagnosis, associated risk factors, and currently recommended early detection strategies. This methodological design was considered appropriate due to its capacity to systematically analyze the distribution of knowledge within a defined population and to explore potential differences associated with sociodemographic variables, particularly age, in line with evidence indicating marked heterogeneity in access to information and participation in screening programs across age groups and sociocultural contexts (Perkins et al., 2023; World Health Organization, 2025).

The study population consisted of women aged 18 years and older, residing in the municipalities of Tampico and Ciudad Madero, in the state of Tamaulipas, Mexico, with no professional or academic training in health-related fields. This delimitation was established to obtain a more accurate approximation of general community knowledge, excluding individuals whose information level might be influenced by professional training. The sample size was set at 100 participants, selected through simple random sampling, which helped reduce selection bias and improve representativeness within the local context.

Inclusion criteria comprised female sex, legal adulthood, permanent residence in the specified municipalities, and absence of a history of diagnosed active or previous gynecological disease. Exclusion criteria included women under 18 years of age, those with health-related training, prior diagnosis of relevant gynecological pathology, or cognitive limitations preventing adequate comprehension of the instrument. All participants provided informed consent prior to data collection, ensuring adherence to ethical principles of autonomy, confidentiality, and voluntariness, in accordance with international recommendations for observational public health research (World Health Organization, 2025).

Data collection was carried out using a structured questionnaire administered online via the Google Forms platform, selected for its accessibility and ability to ensure respondent anonymity. The instrument was designed to comprehensively assess

general knowledge of cervical cancer, its relationship with HPV infection, risk factors recognized in the literature, and early diagnostic strategies, including cervical cytology, HPV detection, and combined testing. Additionally, sociodemographic information and relevant personal medical history were collected to contextualize findings and explore potential associations. The questionnaire structure was based on approaches previously used and validated in community studies on knowledge and practices related to cervical cancer screening, adapted to the local context (Khumalo et al., 2022; Stephens et al., 2023).

For data analysis, participants were grouped into predefined age ranges, allowing comparison between young adult women and older adult women, given that recent literature has identified age as a key determinant of risk perception, HPV-related knowledge, and utilization of early detection services (Tesfaw et al., 2021; Perkins et al., 2023).

Results were analyzed using descriptive statistics, including frequencies, percentages, and measures of central tendency, to characterize overall knowledge levels and variations among the evaluated groups. This approach enabled the identification of specific informational deficits relevant to planning community-focused educational interventions.

The adopted methodology aligns with current recommendations for research in secondary prevention of cervical cancer, which emphasize the importance of generating local evidence on cognitive

and knowledge-related barriers to optimize screening implementation and advance toward global elimination goals (World Health Organization, 2025; Ong et al., 2023). Thus, the methodological approach not only described the current state of community knowledge, but also provided relevant inputs for the design of evidence-based health education policies.

### RESULTS AND DISCUSSION

Analysis of general knowledge assessments revealed a moderate overall level of understanding of cervical cancer, with a mean score of 5.0 on a scale from 0 to 10. This finding indicates that approximately half of the sample possessed basic knowledge, while the remainder demonstrated limited or no understanding of the topic. This pattern is consistent with international reports documenting persistent deficits in community knowledge regarding cervical cancer diagnosis, even in settings where screening programs are available (Khumalo et al., 2022; Stephens et al., 2023).

Heterogeneous performance across questionnaire items allowed identification of specific areas of strength and weakness. Items with the highest proportion of correct responses were related to general recognition of HPV, its mode of transmission, and the existence of preventive measures, including basic aspects of vaccination. In contrast, the greatest knowledge gaps were observed in questions related to timely diagnosis and current screening strategies, particularly those addressing specific diagnostic tests and their clinical indications.

These findings reflect a previously described trend whereby general awareness of HPV exceeds understanding of available diagnostic tools, thereby limiting informed participation in screening programs (Perkins et al., 2023).

Sociodemographic characterization of the cohort showed a balanced age distribution, as illustrated in Figure 1, minimizing bias associated with overrepresentation of a single age group. For comparative analysis, the sample was consolidated into two main groups: young adult women (18–30 years) and women older than 30 years.

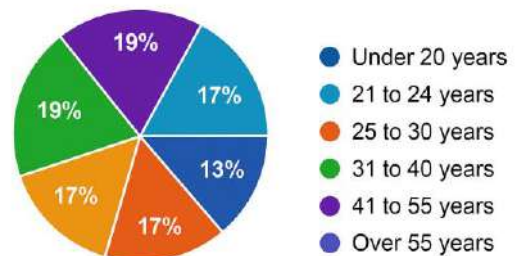
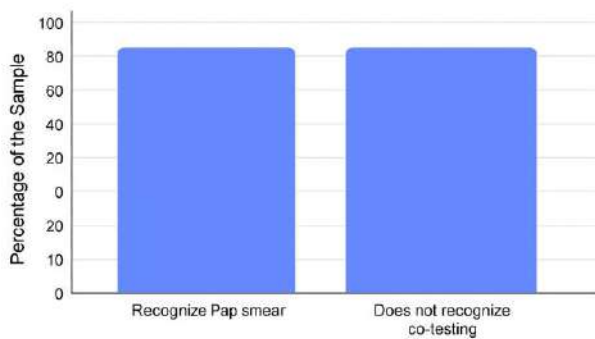


Figure 1. Distribution of the sample by age groups

This stratification revealed relevant differences in understanding of HPV and preventive measures, with approximately three quarters of participants demonstrating higher knowledge belonging to the young adult group. Conversely, lack of knowledge was more pronounced among women over 55 years of age, a finding consistent with studies documenting generational gaps in access to information and exposure to prevention campaigns (Tesfaw et al., 2021; Khumalo et al., 2022).

One of the most relevant findings concerned recognition of diagnostic tests. As shown in Figure 2, although a high proportion of participants identified the Papanicolaou test as a screening method, virtually all participants were unaware of combined cytology and HPV testing.



**Figure 2.** Recognition of diagnostic tests for cervical cancer

This result is particularly relevant from a public health perspective, as contemporary evidence supports primary HPV testing, alone or in combination with cytology, as the most sensitive strategy for early detection of high-grade cervical lesions (Terasawa et al., 2022; Perkins et al., 2023). The lack of association between this knowledge gap and age groups suggests that this informational deficit is widespread across the studied community.

Regarding risk factors and treatment of cervical cancer, a substantial knowledge deficit was observed. More than 70 % of participants failed to adequately identify disease-related risk factors, and over half were unaware of available therapeutic options. These findings are consistent with previous research indicating that etiological and therapeutic aspects are

often less well understood by the general population, thereby hindering individual risk perception and sustained adoption of preventive behaviors (Adewumi et al., 2022; Ong et al., 2023).

Analysis of personal data provided additional context. Sixty percent of participants reported having one or more children, predominantly among adult women, especially those aged 31–40 years. Additionally, a considerable proportion reported behavioral risk factors such as multiple sexual partners and a history of tobacco use.

Smoking was more frequently reported among young adult women, a pattern described in other studies as an emerging factor that may increase the risk of persistent HPV infection in younger cohorts (Perkins et al., 2023).

Regarding preventive practices, routine gynecological check-ups and Pap testing were more common among adult women, suggesting greater adherence to preventive care with increasing age. However, the fact that 71 % of participants reported not having received information about HPV from their family physician or gynecologist highlights a significant failure in physician–patient communication, identified in the literature as a major barrier to screening and vaccination (Khumalo et al., 2022; World Health Organization, 2025).

Finally, HPV vaccination coverage was low among most participants, with a higher proportion of

vaccinated women or recalled vaccination history observed among young adults. This finding aligns with international data showing a generational impact of vaccination policies, while also underscoring the need to strengthen information and follow-up strategies among women outside traditionally prioritized age groups (CDC, 2025; Ong et al., 2023).

### CONCLUSIONS

This study highlights that community understanding of timely cervical cancer diagnosis constitutes a critical component of effective secondary prevention strategies, beyond the mere availability of diagnostic tests and institutional programs. The generated evidence confirms that access to healthcare services alone does not guarantee adequate acquisition of the knowledge required for informed decision-making, posing a structural challenge for public health systems.

From a population perspective, the findings suggest that knowledge of cervical cancer and its diagnosis is not homogeneously distributed, but rather reflects complex generational, educational, and communicational dynamics. This heterogeneity implies that prevention strategies must move beyond generalized approaches and advance toward differentiated health education models capable of addressing the specific needs of each age and sociocultural group.

Furthermore, the study reveals that preventive practices, such as attendance at gynecological check-ups, are not always accompanied by a comprehensive

understanding of the diagnostic process, thereby limiting their potential impact. This dissociation between practice and knowledge reinforces the need to strengthen clinical communication as a central axis of prevention, positioning healthcare professionals not only as service providers, but also as active agents of education and informational support.

In terms of public health implications, the results underscore the importance of integrating community knowledge assessment as a key indicator within cervical cancer prevention programs. Early identification of informational gaps enables more efficient targeting of educational interventions and systematic evaluation of their impact, contributing to the achievement of global goals for reducing incidence and mortality from this malignancy.

Finally, this work provides local evidence reinforcing the need to address cervical cancer through an integrated perspective, in which biomedical prevention is articulated with sustained strategies of education, communication, and community participation. Strengthening these components is essential to advance toward effective early detection and the progressive elimination of cervical cancer as a priority public health problem.

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# State of the art: Chronic kidney disease associated with the hepatitis C virus

## Estado del arte: Enfermedad renal crónica asociada al virus de la hepatitis C

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### Resumen

Chronic kidney disease associated with the hepatitis C virus (HCV) is a significant extrahepatic manifestation with substantial clinical, pathophysiological, and therapeutic implications. The objective of this narrative review was to comprehensively analyze the available scientific evidence on the mechanisms of kidney damage related to the hepatitis C virus, the main clinical scenarios described, and the impact of treatment with direct-acting antivirals (DAAs). A narrative review of scientific literature published between 2000 and 2024 was conducted, consulting specialized health sciences databases. The findings show that kidney damage associated with the hepatitis C virus occurs through immune-mediated mechanisms and direct damage, leading to various glomerular and tubulointerstitial entities, with clinical manifestations ranging from isolated proteinuria to advanced chronic kidney disease. Current evidence supports the notion that timely treatment with DAAs not only achieves viral eradication but also contributes to stabilizing or improving renal function and preventing the progression of damage. It is concluded that early recognition of these manifestations and timely implementation of antiviral therapies are fundamental to improving renal prognosis and reducing the burden of chronic kidney disease in patients with hepatitis C virus infection.

**Keywords:** hepatitis C virus; chronic kidney disease; hepatitis C-associated nephropathy; renal pathophysiology; direct-acting antivirals

### Abstract

La enfermedad renal crónica asociada al virus de la hepatitis C constituye una manifestación extrahepática relevante, con implicaciones clínicas, fisiopatológicas y terapéuticas significativas. El objetivo de esta revisión narrativa fue analizar de manera integral la evidencia científica disponible sobre los mecanismos de daño renal relacionados con el virus de la hepatitis C, los principales escenarios clínicos descritos y el impacto del tratamiento con antivirales de acción directa. Se realizó una revisión narrativa de literatura científica publicada entre 2000 y 2024, consultando bases de datos especializadas en ciencias de la salud. Los hallazgos muestran que el daño renal asociado al virus de la hepatitis C se produce mediante mecanismos inmunomediados y daño directo, dando lugar a diversas entidades glomerulares y tubulointersticiales, con manifestaciones clínicas que van desde proteinuria aislada hasta enfermedad renal crónica avanzada. La evidencia actual respalda que el tratamiento oportuno con antivirales de acción directa no solo logra la erradicación viral, sino que también contribuye a la estabilización o mejora de la función renal y a la prevención de la progresión del daño. Se concluye que el reconocimiento temprano de estas manifestaciones y la implementación oportuna de terapias antivirales son fundamentales para mejorar el pronóstico renal y reducir la carga de enfermedad renal crónica en pacientes con infección por virus de la hepatitis C.

**Palabras clave:** virus de la hepatitis C; enfermedad renal crónica; nefropatía asociada a hepatitis C; fisiopatología renal; antivirales de acción directa

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## INTRODUCTION

Chronic kidney disease (CKD) represents one of the major public health problems worldwide due to its high prevalence, insidious progression, and close association with a significant increase in morbidity, mortality, and healthcare costs. According to updated estimates from the Global Burden of Disease study, CKD affects approximately 10% of the global adult population and has become one of the leading causes of disability-adjusted life years, with sustained growth in low- and middle-income regions, where access to timely diagnosis and treatment is limited (Bikbov et al., 2020; Wang et al., 2025). Although diabetes mellitus and arterial hypertension represent the most frequent aetiologies, secondary glomerulopathies continue to play a relevant role in progression to advanced CKD.

Among secondary glomerulopathies, that associated with hepatitis C virus (HCV) infection has gained particular importance due to its systemic nature and the diversity of extrahepatic manifestations accompanying chronic infection. Beyond its impact on liver disease, HCV infection is independently associated with an increased risk of CKD development and progression, increased cardiovascular mortality, and a greater burden of comorbidity in patients with CKD and in those undergoing renal replacement therapy (Cacoub et al., 2016; Fabrizi et al., 2024).

At a global level, HCV infection continues to represent a significant health challenge. The World

Health Organization estimates that more than 50 million people live with chronic HCV infection and that, despite therapeutic advances, important gaps persist in diagnosis and access to treatment, particularly among vulnerable populations (World Health Organization, 2024; Martinello et al., 2023). In this context, HCV-associated CKD contributes substantially to the global disease burden by accelerating renal function decline and limiting therapeutic options, including kidney transplantation (Janczura et al., 2025).

From a pathophysiological perspective, HCV-induced renal injury is complex and multifactorial. Viral infection has been shown to cause renal damage through both immune-mediated mechanisms and direct cytopathic effects. The former include the formation and deposition of immune complexes, frequently associated with mixed cryoglobulinaemia, as well as complement activation and chronic inflammatory responses, ultimately leading to progressive glomerular injury (Sohal et al., 2024; Ferri et al., 2017). In parallel, recent studies have demonstrated the ability of HCV to infect renal cells, induce oxidative stress, and cause structural alterations in podocytes and renal tubules, thereby contributing to renal damage progression even in the absence of detectable cryoglobulins (Kaartinen et al., 2021; Yau et al., 2024).

The clinical expression of hepatitis C virus (HCV)-associated nephropathy is heterogeneous and ranges from isolated haematuria or proteinuria to nephritic

and nephrotic syndromes, membranoproliferative glomerulonephritis, focal segmental glomerulosclerosis, and, in advanced stages, irreversible chronic kidney failure. These manifestations are frequently associated with poorer renal and cardiovascular outcomes, as well as with a significant deterioration in quality of life (Fabrizi et al., 2018; Sohal et al., 2024). Clinical variability and the coexistence of metabolic risk factors complicate early diagnosis, thereby delaying timely and effective therapeutic intervention.

The advent of direct-acting antivirals (DAAs) has radically transformed the management of HCV infection and its extrahepatic manifestations. Over recent years, multiple studies have demonstrated that DAAs achieve sustained virological response rates exceeding 95%, even in patients with advanced chronic kidney disease or those undergoing dialysis, with a favourable safety profile (KDIGO, 2022; Martin et al., 2022). Moreover, viral eradication has been associated with stabilisation or improvement of renal function, reduction in proteinuria, and a decreased risk of progression to end-stage kidney disease (Pérez de José et al., 2021; Nevola et al., 2020).

The most recent international clinical guidelines recommend systematic screening for HCV infection in patients with chronic kidney disease, as well as periodic assessment of renal function in individuals with chronic HCV infection, underscoring the importance of an integrated approach between

nephrology and hepatology (KDIGO, 2022; Martin et al., 2023). Nevertheless, challenges persist regarding the early identification of renal involvement, optimisation of the timing of therapeutic intervention, and assessment of long-term renal outcomes following viral eradication. These limitations justify the need for integrative reviews that synthesise the current body of evidence.

In this context, the present narrative review aims to provide a critical and up-to-date analysis of the pathophysiology of HCV-associated renal injury, the main clinical scenarios described, and the role of direct-acting antivirals in the prevention and treatment of chronic kidney disease related to this infection. Integration of these aspects is essential to strengthen early diagnosis, optimise therapeutic strategies, and reduce the global burden of chronic kidney disease associated with HCV.

### **METHODS, TECHNIQUES AND INSTRUMENTS**

A narrative review of the scientific literature was conducted with the aim of synthesising and critically analysing the available evidence on the relationship between hepatitis C virus infection and chronic kidney disease, encompassing pathophysiological, clinical, and therapeutic aspects. This methodological approach was selected due to the complex and multifactorial nature of the phenomenon under investigation, as well as the heterogeneity of existing study designs, which makes a qualitative integration of evidence particularly appropriate.

The literature search was performed systematically using the PubMed, SciELO, and LILACS databases, which are considered relevant sources for research in nephrology, hepatology, and medical education. Controlled vocabulary terms and keywords in both Spanish and English were employed and combined using Boolean operators, including: hepatitis C virus, chronic kidney disease, HCV-associated nephropathy, glomerulonephritis, direct-acting antivirals, and renal manifestations.

Articles published between 2000 and 2024, written in either Spanish or English, that directly addressed chronic kidney disease related to hepatitis C virus infection, its pathophysiology, renal clinical manifestations, or the impact of antiviral treatment were included. Eligible publications comprised original research articles, narrative reviews, systematic reviews, meta-analyses, and international clinical practice guidelines. Editorials, letters to the editor, and publications that did not provide information relevant to the stated objectives were excluded.

The selection process was carried out in two stages: an initial screening of titles and abstracts, followed by full-text review of the selected articles. Extracted information was organised into thematic categories, including renal damage pathophysiology, associated clinical scenarios, therapeutic implications of direct-acting antivirals, and relevant clinical outcomes.

Integration and analysis of the reviewed material were conducted through narrative synthesis, allowing the identification of recurring patterns, areas of consensus, and existing gaps in knowledge.

## RESULTS AND DISCUSSION

Analysis of the scientific literature indicates that hepatitis C virus (HCV)–associated nephropathy manifests across a broad clinical spectrum, the heterogeneity of which reflects the complex interplay between immunological mechanisms, direct viral injury, and concomitant metabolic factors.

Initial clinical manifestations most commonly present as isolated proteinuria and/or haematuria, findings that are frequently associated with active viral replication and that, in a substantial proportion of cases, resolve following viral eradication with direct-acting antivirals (DAAs). This observation suggests a potentially reversible nature of renal injury during the early stages of disease (Pérez de José et al., 2021; Martin et al., 2022).

Nevertheless, progression to more complex glomerular syndromes represents a clinically relevant scenario. The reviewed literature indicates that a significant proportion of patients develop full-blown nephrotic syndrome, characterised by nephrotic-range proteinuria, hypoalbuminaemia, generalised oedema, and systemic haemodynamic disturbances.

These clinical presentations are closely associated with immune complex-mediated glomerulopathies, particularly within the context of mixed cryoglobulinaemic syndrome, an entity in which HCV seropositivity reaches up to 90% of reported cases (Cacoub et al., 2016; Sohal et al., 2024). In such settings, contemporary evidence consistently shows that immunosuppressive therapy initiated in the presence of active viral replication may exacerbate viral burden and accelerate renal deterioration. For this reason, international guidelines uniformly recommend prioritising antiviral therapy before any immunomodulatory intervention (KDIGO, 2022; Martin et al., 2023).

Isolated haematuria, although less frequent, should not be regarded as a benign finding. Several studies have documented its potential progression to full nephritic syndromes, accompanied by arterial hypertension, proteinuria, and a progressive decline in glomerular filtration rate. Despite its lower incidence, this clinical pattern is of considerable importance due to its potential to cause irreversible renal damage if not treated promptly. In this context, early initiation of DAAs, even prior to the use of calcineurin inhibitors, has demonstrated benefits in preserving renal function (Fabrizi et al., 2018; KDIGO, 2022).

In more advanced stages, HCV-associated chronic kidney disease is defined according to the Kidney Disease: Improving Global Outcomes criteria as a persistent reduction in estimated glomerular filtration

rate below 60 mL/min/1.73 m<sup>2</sup>, the presence of structural markers of renal damage, or both conditions for a minimum duration of three months. This scenario is more frequently observed in patients with long-standing chronic infection, typically involving decades of persistent viraemia, and in those with coexisting risk factors such as diabetes mellitus, arterial hypertension, and obesity (Wang et al., 2025; Janczura et al., 2025). Accumulated evidence indicates that viral eradication with DAAs is associated with a significant reduction in progression to chronic kidney disease and confers an additional benefit in terms of overall mortality (Nevola et al., 2020; Jiang et al., 2026).

From a pathophysiological perspective, HCV-induced renal injury involves both immune-mediated and direct cytopathic mechanisms. Deposition of immune complexes composed of cryoglobulins, IgG and IgM immunoglobulins, rheumatoid factor, and complement fractions represents the principal pathogenic mechanism underlying associated glomerulonephritides, particularly membranoproliferative forms (Ferri et al., 2017; Cacoub et al., 2016). In parallel, recent investigations have documented direct invasion of HCV into tubular epithelial cells, resulting in subclinical tubular injury and acute tubular syndrome, even in the absence of overt glomerulopathy. These findings expand the traditional understanding of virus-associated renal damage (Kaartinen et al., 2021; Yau et al., 2024).

Other less frequent histopathological variants, including fibrillary glomerulonephritis and focal segmental glomerulosclerosis, have also been described in association with HCV infection, particularly among patients with immunological comorbidities, HIV coinfection, or intravenous drug use. These entities are characterised by a more aggressive clinical course and accelerated progression to end-stage kidney disease, further underscoring the need for early aetiological intervention focused on viral eradication (Angeletti et al., 2019; Sohal et al., 2024).

The impact of direct-acting antivirals represents one of the most significant therapeutic advances in this setting. The studies reviewed report sustained virological response rates exceeding 95%, even among patients with advanced chronic kidney disease or those receiving dialysis, with a favourable safety profile (KDIGO, 2022; Martin et al., 2022).

Beyond virological cure, DAAs have been associated with improvements in proteinuria, stabilisation of glomerular filtration rate, partial recovery of tubular function, and a reduced risk of progression to end-stage kidney disease. These effects firmly position DAAs as the central therapeutic intervention in the management of HCV-associated nephropathy (Pérez de José et al., 2021; Nevola et al., 2020).

Finally, interpretation of these findings is particularly relevant in the context of cardiovascular risk. Chronic

kidney disease induced or accelerated by HCV infection is associated with chronic activation of the renin–angiotensin–aldosterone system, metabolic dysfunction, and persistent inflammation, thereby establishing a pathogenic cycle that increases the incidence of cardiovascular events and overall mortality (Rad et al., 2024; Martinello et al., 2023). Consequently, early viral eradication should be regarded not only as a nephrological or hepatological strategy, but also as an integrated intervention aimed at reducing systemic risk.

## CONCLUSIONS

The evidence analysed confirms that chronic hepatitis C virus (HCV) infection represents a relevant determinant in the development and progression of multiple forms of renal injury through complex pathophysiological mechanisms that involve both immune-mediated processes and direct cytopathic effects. HCV-associated renal involvement manifests across a heterogeneous clinical spectrum, ranging from isolated urinary abnormalities to severe glomerulopathies and advanced chronic kidney disease, underscoring the need to understand this condition as a systemic manifestation rather than an exclusively hepatic disorder. The observed clinical variability is closely related to the duration of infection, the persistence of viral replication, and the coexistence of metabolic and cardiovascular risk factors.

The integrated findings of this review highlight that viral eradication through direct-acting antivirals constitutes the cornerstone of therapy in

HCV-associated nephropathy. Beyond their high virological efficacy, these agents have demonstrated a significant clinical impact on stabilisation or improvement of renal function, reduction of proteinuria, and decreased risk of progression to end-stage kidney disease, even among patients with advanced chronic kidney disease. In this regard, current therapeutic strategies prioritise early aetiological treatment, reserving the use of immunosuppressive therapies for specific clinical contexts and only after effective control of viral replication, in accordance with contemporary international guideline recommendations.

Finally, this review emphasises the importance of early detection strategies and multidisciplinary approaches integrating nephrology, hepatology, and primary care in order to optimise the diagnosis, treatment, and follow-up of patients with HCV infection and renal involvement. Early identification of the various renal clinical scenarios associated with HCV enables timely interventions with the potential to modify the natural course of the disease and reduce its systemic impact, particularly with respect to renal progression and cardiovascular risk.

There is a recognised need to strengthen future research through longitudinal studies evaluating long-term renal outcomes following viral eradication, as well as to develop preventive strategies targeting populations at high risk of progression to chronic kidney disease.

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## Virtual applications with artificial intelligence to promote healthy eating habits

### Aplicaciones virtuales con inteligencia artificial para promover hábitos alimenticios saludables

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#### Abstract

Virtual applications supported by artificial intelligence (AI) are transforming strategies for the promotion of healthy eating habits by enabling personalized, adaptive, and data-driven nutritional guidance. The purpose of this review was to analyze current virtual applications that incorporate AI to promote healthy dietary behaviors, identifying their main functionalities, benefits, limitations, and reported effectiveness in health promotion contexts. A documentary review was conducted using academic databases, including Scopus, PubMed, SciELO, Redalyc, and Google Scholar, focusing on studies published between 2019 and 2024. The analysis indicates that AI-based applications contribute to improved dietary awareness, personalization of nutritional recommendations, continuous user monitoring, and greater engagement in behavior change processes. However, limitations remain related to data privacy, unequal access to digital technologies, variability in scientific validation, and the need for professional supervision. Overall, the findings suggest that AI-driven virtual applications represent a promising complementary tool for nutrition education and health promotion, provided that their implementation is guided by ethical principles, scientific evidence, and educational integration.

**Keywords:** artificial intelligence; virtual applications; nutrition; healthy eating habits; health promotion

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#### Resumen

Las aplicaciones virtuales que emplean inteligencia artificial (IA) están revolucionando la forma en que las personas abordan la nutrición y la salud, estas herramientas innovadoras utilizan algoritmos avanzados para proporcionar recomendaciones dietéticas personalizadas, basadas en datos individuales como preferencias alimenticias, objetivos de salud y patrones de comportamiento. El propósito de este artículo fue explorar las aplicaciones digitales que incorporan la IA para fomentar hábitos alimenticios saludables, identificando las características y funcionalidades, ventajas, limitaciones, así como eficacia en la promoción de dichos hábitos. Para llevar a cabo esta revisión, se empleó un método de análisis documental, recopilando y examinando una amplia gama de estudios y fuentes académicas relevantes. Los hallazgos obtenidos a partir de este análisis demuestran de manera contundente los beneficios del uso de aplicaciones basadas en IA en el ámbito de la salud, encontrándose entre las ventajas más notables la capacidad de personalizar las recomendaciones dietéticas, el seguimiento continuo del progreso del usuario y el acceso a información nutricional precisa y actualizada. Se concluye que estas aplicaciones no solo facilitan la adopción de hábitos alimenticios más saludables, sino que también educan a los usuarios sobre la importancia de una nutrición balanceada y cómo mantenerla a lo largo del tiempo.

**Palabras clave:** inteligencia artificial; aplicaciones; nutrición; hábitos alimenticios; salud



### INTRODUCTION

In the current digital era, artificial intelligence (AI) is transforming a wide range of fields, and the promotion of healthy dietary habits is no exception. The growing prevalence of diet-related chronic diseases, such as type 2 diabetes mellitus, hypertension, and obesity, has underscored the urgent need for innovative strategies to improve public health. In this context, AI-supported mobile applications have emerged as key tools for reshaping how individuals approach nutrition and dietary behaviours (Almeida et al., 2023).

AI-based applications designed to promote healthy eating habits leverage advanced data-processing algorithms and machine-learning techniques to deliver personalised dietary recommendations. Unlike traditional approaches, which often rely on generic and non-individualised advice, these applications analyse personal data—including food preferences, nutritional requirements, and consumption patterns—to generate tailored dietary plans for each user. This level of personalisation not only enhances the relevance of recommendations but also improves adherence to nutritional goals, thereby facilitating sustainable changes in eating behaviours (Prado & Rodríguez, 2022).

Moreover, the ability of these applications to provide real-time feedback constitutes a distinctive feature that differentiates them from conventional methods. Users can receive immediate alerts and suggestions regarding their food choices, enabling them to

dynamically adjust their behaviour. This rapid and continuous responsiveness fosters greater awareness of daily dietary decisions and supports the development of healthier habits (De Jesús, 2024).

The use of AI within these applications also enables effective integration with other emerging technologies, such as augmented reality (AR) and virtual reality (VR). For example, some applications combine AI with AR to offer interactive nutritional education experiences, allowing users to visualise how different foods affect their health and wellbeing within a virtual environment. This immersive methodology not only makes nutrition education more engaging but also facilitates a deeper and more practical understanding of key concepts (Espinosa & Cartagena, 2021).

The impact of these technologies on the promotion of healthy dietary habits has been the subject of numerous studies highlighting their effectiveness. Research has shown that AI-driven applications not only improve the accuracy and relevance of dietary recommendations, but also play a crucial role in the management of chronic diseases and overall health improvement. Their capacity to integrate seamlessly into users' daily lives and provide continuous support represents a significant advancement in addressing diet-related health problems (González et al., 2020).

The incorporation of artificial intelligence into applications aimed at promoting healthy dietary habits represents a critical advance in health and wellbeing management. By offering personalised

recommendations, real-time feedback, and innovative educational experiences, these digital tools are redefining how nutrition is addressed and establishing a new standard in the promotion of healthy eating behaviours (Andrés, 2021).

The World Health Organization, through the Ottawa Charter, defines Health Promotion as a global political and social process encompassing actions aimed at strengthening the skills and capacities of individuals and communities, as well as modifying social, environmental, and economic conditions to generate a positive impact on individual and collective health (De la Guardia & Ruvalcaba, 2022).

A healthy lifestyle is defined as one that reduces the risk of serious illness or premature death and encompasses physical, mental, and emotional health, which have historically been considered key elements in health promotion, albeit to varying degrees (Valderrama, Castillo & Méndez, 2023).

Currently, up to 70% of primary care consultations in developed countries are related to lifestyle-derived diseases. Therefore, understanding the role of these factors is crucial for preventing the morbidity and mortality associated with multiple chronic non-communicable diseases, making them a primary focus of health promotion and prevention strategies worldwide. Moreover, interventions from this perspective have been shown to be cost-effective (Tala, Vásquez & Plaza, 2020).

Health education is fundamental to health promotion and is defined as a pedagogical process that, through the dialogue of knowledge, seeks to build or strengthen the capacity of individuals, families, communities, and organisations to promote health care, manage risks, and positively transform environments (Téllez, Miranda & Ortiz, 2018). In this context, it is essential for health systems to employ diverse resources in the design of policies and strategies that encourage healthy lifestyles through a comprehensive and systemic approach (Ballinas, 2021).

Information and Communication Technologies (ICTs) constitute valuable resources for providing information and education on physical activity, offering advice and techniques for specific exercises, establishing realistic goals, and developing personalised training plans. They also enable users to connect with personal trainers and other physical activity professionals online, facilitating the performance of physical activities from any location with internet access (Melo, 2023).

In Latin America, mobile device usage reaches approximately 73%, with the majority being smartphones. Among individuals who own these devices, each has an average of 18 applications installed, of which 59% are health-related, particularly nutrition applications (Murillo, 2021). These applications have a high capacity for data storage and continuous accessibility, making them highly available tools for nutritional interventions.

Four general categories have been identified: calorie counters, food scoring systems, diet plan generators, and healthy shopping lists, with some applications combining multiple functions (Novoa, 2023).

Artificial intelligence is a branch of computer science that encompasses concepts of logic and learning, simulating human intelligence processes such as learning, reasoning, and self-correction through the use of algorithms that enable machines to learn and make decisions. This allows for multiple forms of machine learning across computers, devices, robots, the internet, and mobile applications (Ruival et al., 2023). AI-based tools have also been adopted by health regulatory bodies; for instance, the Pan American Health Organization has developed a Virtual Campus (VCPH) that utilises AI to strengthen the capacities and competencies of health professionals (Listovsky et al., 2022).

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strengthen the capacities and competencies of health professionals (Listovsky et al., 2022).

This study aims to: (1) analyse the effectiveness of AI-based applications in promoting healthy dietary habits; (2) identify how these applications influence eating behaviours; (3) evaluate their effectiveness in improving health and preventing diet-related diseases; and (4) determine the advantages and disadvantages of this technology compared with other strategies for promoting healthy habits.

### **METHODS, TECHNIQUES AND INSTRUMENTS**

This section describes the methodology employed to fulfil the objectives of the study through documentary analysis. According to Bermeo et al. (2016), this method involves a series of specific processes, including the search, selection, organisation, and analysis of relevant documents. Tobón et al. (2015) emphasise that this process is oriented towards answering specific questions related to a particular topic. The primary aim of this methodological approach is to relate existing data on a given construct, thereby providing a comprehensive perspective that facilitates the formulation of appropriate solutions to the problem under investigation (Rivera et al., 2018).

This article examines key concepts related to virtual applications that employ artificial intelligence to promote healthy dietary habits. Their main characteristics, functionalities, advantages, and

limitations are identified, and an analysis is conducted of how these applications may influence the promotion of healthy eating behaviours and the management of specific nutritional conditions. To achieve these objectives, a rigorous selection of academic publications was carried out using databases such as Google Scholar, Redalyc, Dialnet, and SciELO, covering literature published between 2019 and 2024.

The initial search process was conducted using key terms such as artificial intelligence, applications, and healthy dietary habits. Filters and Boolean operators were applied to refine the results and ensure the relevance of the selected documents. The search yielded 3,140 results in Google Scholar, 1,687 in Redalyc, 8,777 in Dialnet, and 120 in SciELO. These records were subsequently subjected to a rigorous selection process to ensure that only the most relevant and up-to-date studies were included in the analysis.

Once the documents were collected, they were organised and analysed. The studies were classified according to their relevance and contribution to the topic under investigation, and various qualitative analysis techniques were employed to identify patterns and trends within the data. This process enabled an in-depth understanding of AI-based virtual applications and their impact on the promotion of healthy dietary habits.

Particular attention was given to studies addressing the effectiveness of these applications in modifying

eating behaviours, their capacity to personalise dietary recommendations, and their potential to improve nutritional health at both individual and population levels. In addition, advantages such as access to accurate nutritional information and continuous monitoring of user progress were assessed, as well as limitations, including the need for constant internet access and variability in the quality of recommendations.

The findings of this documentary review provided a solid informational basis for addressing the study objectives. Synthesis of the collected data made it possible to formulate well-supported conclusions regarding the use of artificial intelligence-based applications in the promotion of healthy dietary habits. This comprehensive approach not only offers an overview of the current state of technology in this field, but also highlights areas where improvements and future research efforts may be directed.

## **RESULTS AND DISCUSSION**

According to the bibliographic review conducted, it can be established that information and communication technologies (ICTs) have the potential to overcome temporal and geographical barriers that hinder collaboration among the various stakeholders involved in the process. This potential may be leveraged to promote healthy lifestyles and to facilitate family involvement in such processes.

In this context, the use of mobile phones is prioritised as a primary connectivity device, as they enable accessibility at any time and from any location,

thereby creating new opportunities for learning (Cristóbal, Cabrera & Aravena, 2023). Likewise, electronic media and web-based platforms for health education (e-learning) provide valuable resources for healthcare professionals, service users, and the general population.

Their main objective is to promote good practices in healthcare delivery and to encourage the adoption of healthy habits.

Additionally, these portals enable patients to access information related to their own health, thereby empowering them to participate actively in decision-making processes and to improve communication with other patients. This aspect is particularly relevant in the management of chronic diseases, where informed and engaged patients play a central role in achieving better health outcomes (Valenzuela, 2021). The following section presents a set of articles that report the main findings related to artificial intelligence and nutrition (Table 1).

**Table 1.** *Main studies on artificial intelligence and nutrition*

Author	Concept	Similarities
Ehis & Peabalo (2020)	That electronic devices, particularly smartphones, are vital today, are connected to current phenomena such as hybrid education and education records. This offers great opportunities for promoting health.	Tools, Promotion of health
Valencia Lozano & Bayona (2021)	The emergence of artificial vision allows collaborative values through its integral component across processes. Medicine and industries have addressed technological solutions and promoted implementation of Artificial Intelligence.	Data analysis
Jiménez. (2021)	The AI in the natural sector contributes to provide the emergence of evaluating its role about the training attention to health not on a good management of attention to health but also because it integrates.	Health sector, Management of health
Duarte-Sandoval & Ichazo (2022)	Present research from Colombia implementing a study using a study used in telemedicine, allowing patients to self-monitor data when receiving remote T3C treatment at a minimum risk level.	Tools, Health service
Gómez et al. (2022)	The example of research from research from Colombia implemented a study using its study using telemedicine, allowing the patient to self-monitor data when receiving remote T3C treatment at a minimum risk level.	Improvement of health
Goldman (2024)	An artificial intelligence (AI) is a precise technology able to process large amounts of data and obtain a way that all provider health and well-being for people.	Data processing
Ramírez et al. (2023)	Show the power of AI as transforming health by improving its quality of its citizens, by improving data management, and promoting equality in the healthcare service as access.	Data management, Health service
Zambambo & Mata (2024)	AI changes show tools could embody therapeutic education in diabetes.	Tools

In the field of health, Martínez, González, and García (2023) describe how new technologies promote healthy lifestyles by providing tools to inform and educate about the importance of physical activity and a healthy diet. There are numerous applications and online tools available for monitoring physical activity, offering real-time feedback. However, the responsible use of information and communication technologies (ICTs) is crucial to prevent sedentary behavior and other negative effects. International organizations such as the Pan American Health Organization (PAHO) have implemented programs such as the Information Systems for Health (IS4H), which manage interoperable systems with open data to generate strategic information for the benefit of public health (Díaz & Condori, 2024). Other studies, such as that of Vásquez (2021), highlight the advantages and disadvantages of virtual education, emphasizing its flexibility and accessibility, as well as challenges related to infrastructure and study habits.

Recent research on applications using artificial intelligence (AI) to promote healthy eating habits has shown promising results. A study conducted by Celuppi et al. (2020) demonstrated that the use of AI-based mobile applications can significantly improve adherence to healthy diets by personalizing dietary recommendations based on each user's profile and specific needs. Hoyos et al. (2023) employed fuzzy cognitive maps to support nutritional decision-making, enabling real-time adjustment of recommendations and improving adherence to dietary plans. Baquero et al. (2023) found that AI-powered mHealth applications allow continuous

monitoring and provide instant feedback, which is effective in reducing risk factors associated with chronic diseases such as diabetes and hypertension. These studies highlight the transformative potential of AI in promoting health and well-being through the improvement of dietary habits.

## CONCLUSIONS

Currently, the promotion of health and the prevention of diseases associated with unhealthy lifestyles have become fundamental priorities. In this context, health education plays a crucial role, and information and communication technologies (ICTs) offer significant potential to provide effective education on physical activity and nutrition. These technologies stand out for their ability to deliver real-time information, personalize content according to individual needs, and reach a broad audience quickly and efficiently.

The incorporation of new technologies, such as virtual reality (VR), augmented reality (AR), and educational platforms like Moodle, has proven to be highly effective in improving teaching, learning, and the promotion of healthy habits. Virtual and augmented reality, in particular, provide immersive experiences that facilitate a deeper and more practical understanding of health-related concepts. Moodle, meanwhile, offers a structured learning environment that supports continuing education and access to educational resources.

Furthermore, virtual applications that integrate artificial intelligence (AI) have demonstrated high

efficiency as tools for promoting healthy eating habits. These applications are characterized by high accuracy, sensitivity, and specificity, significantly contributing to the personalization of dietary recommendations and the continuous monitoring of eating behaviors. Their ability to provide instant feedback and real-time adjustments makes them valuable resources for health professionals, who can use them to optimize patient care and treatment processes. Consequently, ICTs and AI are transforming health education and healthcare delivery, enhancing the effectiveness of strategies for promoting healthy habits and optimizing population health.

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## Study variables in scientific research

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### INTRODUCTION

In scientific research, regardless of the field of knowledge, the so-called study variables represent one of the fundamental pillars of the research process. That is, they are elements that guide the methodological and statistical development of a project. Understanding this circumstance—knowing what variables imply and represent both conceptually and operationally, that is, how they will be measured or quantified—is crucial to ultimately being able to analyze and interpret results. Evidently, depending on the discipline, study variables will be specific. In other words, variables in Chemistry, Physics, or Agronomy have their own characteristics compared to those in the medical field.

Undoubtedly, in the latter field, variables include diseases, treatments, diagnoses, and all aspects related to the medical profession, as well as everything inherent to human beings in their personal, social, and family dimensions, which constitute elements of interest for medical practice. Research variables are the characteristics, conditions, or attributes of the elements that make up a given field of knowledge and that may change or vary within a study. Their distinctive feature is that they can be measured, observed, or manipulated to answer a research question or test a hypothesis.

Each variable plays a specific role in the research process, helping to describe, analyze, and understand the phenomena under study. Always guided by the principle of parsimony, a taxonomic organization of research variables is presented below. Different types were included in a single figure based on their nature, measurement scale, and participation in statistical processes.

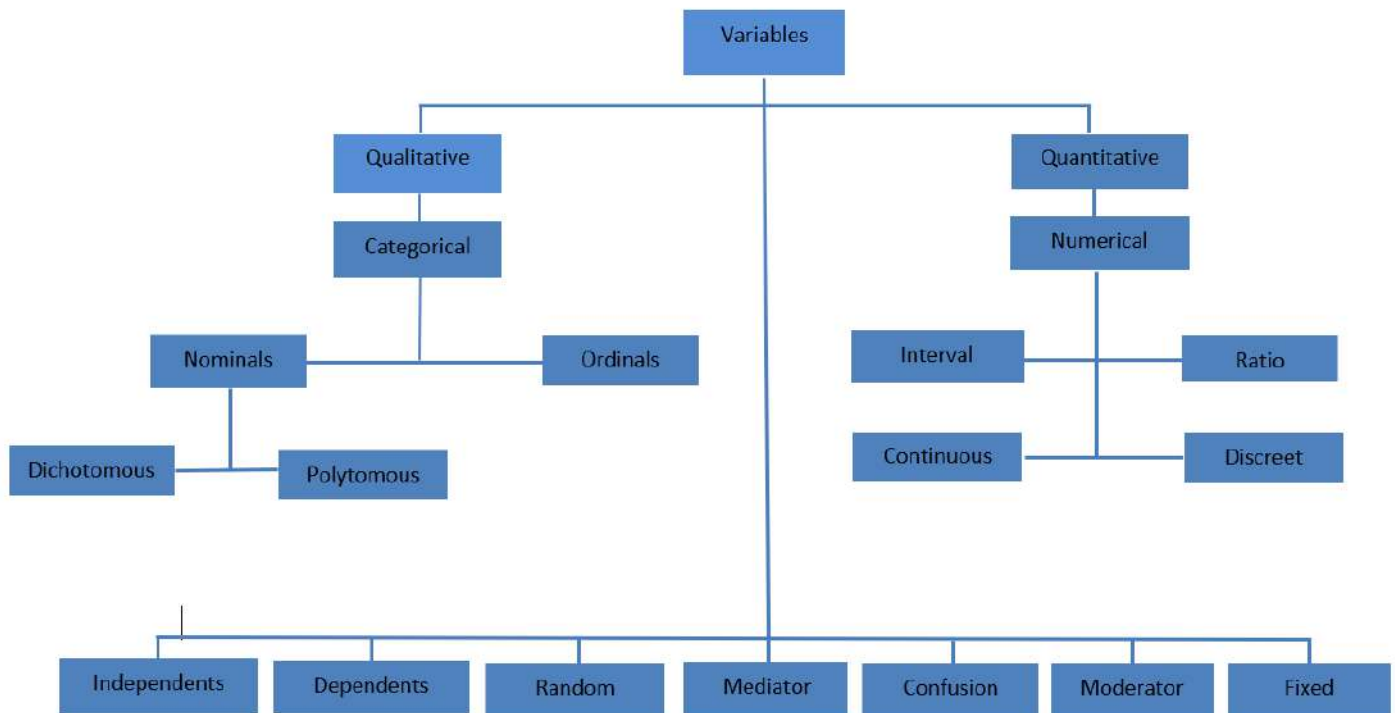


Figure 1. Variables in scientific research

Before addressing each element of this taxonomy, it is worth considering some preliminary aspects.

### OBJECTIVITY AND SUBJECTIVITY OF VARIABLES

First, it is important to understand that variables can be objective or subjective. But what are the differences?

Fundamentally, the difference lies in the way they are measured and in the nature of the data they represent. However, other aspects must also be considered, as shown in the following table.

Table 1. Differences between objective and subjective variables

<p><b>OBJECTIVES</b></p>	<ul style="list-style-type: none"> <li>• They are quantified directly, without interpretation, and are independent of the observer’s opinion.</li> <li>• They generally allow precise measurements.</li> </ul> <p><b>Example:</b></p> <ul style="list-style-type: none"> <li>• Body weight (kg), blood glucose level (mg/dL), height (cm).</li> <li>• The measurement procedure is standardized; therefore, different observers are expected to obtain the same results.</li> </ul>
<p><b>SUBJECTIVES</b></p>	<ul style="list-style-type: none"> <li>• They depend on the perception of the observer measuring them.</li> <li>• They cannot be quantified precisely.</li> <li>• They may be influenced by beliefs or incorrect interpretations.</li> </ul> <p><b>Example:</b></p> <ul style="list-style-type: none"> <li>• Perceived quality of medical care, quality of life perception, pain intensity, satisfaction level, degree of depression.</li> <li>• These variables are often measured through interviews or surveys.</li> </ul>

Dicho de otra manera, las variables objetivas se refieren a las que por la naturaleza de sus datos tienen propiedades medibles (ejemplo: glucosa en sangre, peso corporal), es decir, representan condiciones físicas. En el caso de las variables subjetivas, estas representan una idea o concepto (percepción de bienestar, depresión) que pueden tener diferentes enfoques, por lo que es fundamental desglosar el constructo en forma estructurada y racional, para conformar conceptos y dimensiones que puedan ser medibles y determinar si dicho constructo está presente o no en la evaluación.

**DIMENSIONALIDAD DE UNA VARIABLE**

In scientific research, the dimension of a variable refers to the nature or specific characteristic of the variable that is being measured or studied. We could preliminarily say, for example: If the variable body mass index is studied, the dimensions would be (weight and height). If the variable quality of life is studied, the dimensions could be (physical health, mental health, personal satisfaction, family relationships, for example).

By identifying the dimensionality of a variable, researchers can:

- Define precisely what is being studied
- Select appropriate measurement instruments
- Analyze and interpret data accurately
- Obtain more specific and relevant results

Objective variables are therefore composed of physical dimensions, and subjective variables of analytical dimensions, also called logical dimensions. Although the distinction is made (logical dimension–physical dimension), which is reasonable in essence, in practice the term dimensionality is used more generally, since although they are semantically different, in the context of scientific research, when talking about dimensionality it is understood that it can be logical or physical. We can also add that a variable may have one or several dimensions, and would therefore be described as unidimensional or multidimensional. Understanding the considerations of dimensionality, objectivity, or subjectivity, we can then establish the following considerations:

**Subjective, Logical, Multidimensional Variable:**

For example:

QUALITY OF LIFE. - It is composed of several dimensions: physical health, personal satisfaction, family relationships, and environment.

DEPRESSION. - Affective, motor, cognitive, and behavioral dimensions are integrated.

As can be observed, each of these dimensions captures a different aspect, which together make it possible to understand what each construct refers to. With this, we understand that it would be possible to speak of quality of life in terms of family relationships, but not necessarily physical health, or to consider depression in terms of affectivity, but not cognitive or motor aspects. It would be difficult to measure the variable quality of life or depression as something unidimensional; therefore, the need to break down the construct into different components is emphasized for better understanding and for more specific statistical calculations. Finally, it is worth reiterating that these are conditions that are not measured physically.

**Objective, Physical, Multidimensional Variable:**

They are composed of two or more dimensions, but their difference is physical; therefore, they are repeatable, reproducible, and have precise measurement.

For example:

BODY MASS INDEX. - Weight and Height.

BLOOD PRESSURE. - Systolic and Diastolic

RESPIRATION. - Inhalation and Exhalation

RESPUESTA INMUNE. - Cellular and Molecular

VELOCITY. - Distance and Time

DENSITY. - Mass and Volume

HEAT FLOW. - Temperature and Surface Area

On the other hand, if the variables present a single dimension and are likewise integrated by their objectivity or subjectivity, we would have:

**Objective, Physical, Unidimensional Variable:**

For example: Heart rate, respiratory rate, cardiac enzymes (Troponin, Creatine Kinase), body temperature, to name a few.

These are therefore individual physical conditions with a single measurement and dimension, which are quantified directly.

**Subjective, Logical, Unidimensional Variable:**

For example:

Pain Level.

Unidimensional subjective variables are not very common in research; likewise, as with multidimensional subjective variables, they hardly achieve stability under the criteria of repeatability and reproducibility. In other words, they involve a single dimension and measurement and depend on the evaluator's perception.

**MEASUREMENT RESOURCES**

The instruments used to measure variables are diverse and depend on their nature, what is to be measured, and the researcher's selection. For a unidimensional objective variable, evidently only one instrument or resource will be required, often mechanical:

For example:

For body weight, a scale; for height, a stadiometer (also called a height meter); for body temperature, a thermometer, etc.

If the variable is objective and multidimensional:

For example:

For body mass index, the combination of dimensions will therefore be required and, consequently, of resources or instruments: (weight/height<sup>2</sup>) (scale and stadiometer). Other examples would include mass, density, immune response, etc.

In the case of unidimensional or multidimensional subjective logical or analytical variables:

The resources are called documentary, such as scales, questionnaires, or inventories (both unidimensional and multidimensional); that is, no physical devices are used.

In recent years, a wide variety of these instruments have been developed and validated for different purposes. Ideally, once the study variable has been decided, its dimensionality and the best resource for its measurement must be established. It is important to note that measuring a variable is only the beginning of a series of considerations that must be taken into account for the purposes of scientific research.

The following diagram illustrates what has been described.



- By measuring, we obtain data
- The final values of the data have properties
- The properties make it possible to determine the measurement scale to be used

\* Do not confuse measurement scale with measurement resource.

The final values of the data obtained from measuring the variable can generally be categorized as categorical or numerical (the former reflect categories or characteristics, while the latter come from counting or measuring). The

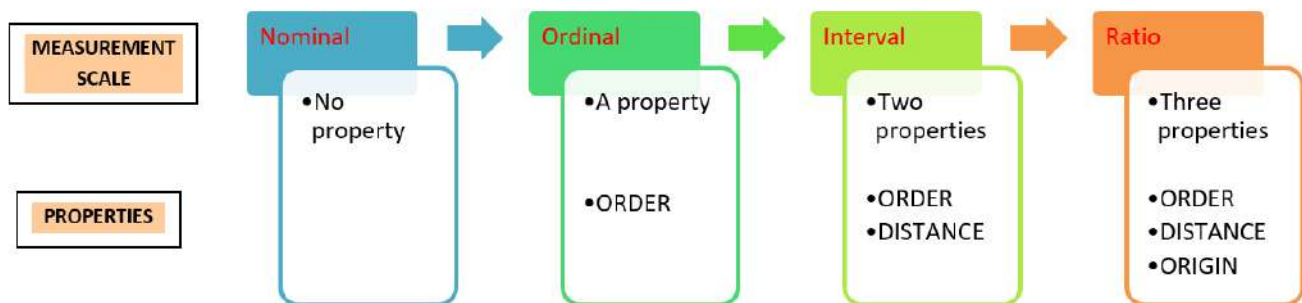
former are also known as qualitative and the latter as quantitative, although this terminology is infrequently used in this context because it leads to confusion.

The properties of the data can be classified according to the following conditions:

- Order
- Distance
- Origin

Consequently, depending on these properties, the measurement scales are configured (nominal, ordinal, interval, and ratio).

In this way, the following scheme is established:



Even though it is common to state, quoting literally, “nominal variable, interval variable, ordinal variable, etc.”, in a strict sense it should be stated as: “measurement scale of the ordinal variable, measurement scale of the interval variable, etc.” According to the taxonomy shown in Figure 1, qualitative variables are also designated as categorical based on their final value; these, in turn, encompass the nominal and ordinal measurement scales. Quantitative variables, for their part, correspond to the so-called numerical variables, which include the interval and ratio measurement scales, as well as the so-called discrete and continuous variables.

## CATEGORICAL VARIABLES

### NOMINAL SCALE

These are variables that correspond to categories; therefore, they do not include order, sequence, or hierarchy.

This type of variable can be grouped into two modalities:

**Dichotomous:** Refers to a division into two opposite and mutually exclusive parts.

For example:

Gender variable: male or female

Health status variable: healthy or ill

Diabetes variable: diabetes present or diabetes absent

**Polytomous:** Refers to something that is divided into many parts or elements, which allows a broader understanding of the variable under study.

For example:

Marital status variable: single, married, divorced, widowed, common-law

Religion variable: Catholic, Jewish, Muslim, Buddhist

### **ORDINAL SCALE**

In this case, the categories have an order or hierarchy, but there is no way to quantify distances, since they do not include this property as numerical variables do.

For example:

Educational level variable: primary, secondary, high school, bachelor's degree

Depression intensity variable: mild, moderate, severe, profound

## **NUMERICAL VARIABLES**

### **INTERVAL SCALE**

The expression is numerical, so its main property is to possess, in addition to hierarchy, a quantifiable distance; therefore, measurement is objective. However, in this case, the zero point is arbitrary, that is, it does not represent the nonexistence of the variable or the absence of what is being measured; it is merely a conventionally chosen reference point. This type of variable allows differences between values to be measured, since they are constant, but not proportional relationships, precisely because the zero is arbitrary.

For example:

If we say that the temperature in degrees Celsius is zero, this does not mean that there is a total absence of temperature; zero represents the freezing point of water. Furthermore, there are negative values, such as -1 degree, -2 degrees, etc.

In this case, if we said that 10 degrees Celsius is half of 20 degrees, we would be making an incorrect proportional relationship precisely because the zero is arbitrary.

### **RATIO SCALE**

This is the scale with the highest hierarchy, since in addition to order and distance, it includes the property of origin, and the intervals between values are constant. Any type of mathematical operation can be performed, as well as proportional comparisons. Thus, zero in this case can be considered absolute, that is, not arbitrary, which signifies the absence of the unit of study; therefore, it does not accept negative values.

For example:

In the case of weight or length, zero does indicate the total absence of the measured property, and proportional relationships are meaningful; for example, an object that weighs 10 kg weighs twice as much as one that weighs 5 kg, or an event that lasts 4 hours lasts twice as long as one that lasts 2 hours. On the other hand, no object or person can weigh zero kilograms.

It is important to note that within the category of numerical variables, in addition to those defined by the measurement scale, there are others that are not established from this perspective and depend on the values they can take and how they are obtained.

### **DISCRETE VARIABLES**

These are variables that take specific values derived from counting, generally whole numbers; that is, they do not admit fractions or intermediate values between one number and another. Less frequently, they are referred to as discontinuous. The values are finite and represent separate quantities.

For example:

Number of children in a family, number of patients, number of census beds in a hospital, number of deaths:  
(1, 2, 3, 4...)

### **CONTINUOUS VARIABLES**

They can take any value within an interval, including fractions and decimals. These variables are measured, not counted, and their possible values can be infinite.

For example:

A person's height: 1.80 meters

Drug concentration in blood: 0.8 mcg/ml

Body temperature: 36.5 degrees Celsius

In Figure 1, mention is made of another type of variables which, according to their configuration and positioning, are more closely related to the development of statistical processes.

### **INDEPENDENT VARIABLE**

This is a variable that is manipulated or selected to observe how it affects another variable called the dependent variable. That is, the first is the factor that influences the outcome of the second.

It has some characteristics:

- It is controlled and defined by the researcher, especially in experiments or clinical trials.
- It can be categorical or numerical.
- It is used to explain, predict, or influence the dependent variable.

### **DEPENDENT VARIABLE**

Also called response, outcome, or criterion variable, it is the variable that is measured to evaluate the effect of the independent variable.

Characteristics:

- It is the result of changes in the independent variable.
- It is measured by the researcher but not manipulated.
- It can be categorical or numerical.

In a study on the impact of insomnia on depression:

Independent variable: insomnia

Dependent variable: depression

It is important to note that it is the researcher's decision to determine which variable will be independent and which will be dependent, according to the line of research. It could therefore be the opposite, that is, the effect of depression on the development of insomnia:

Independent variable: depression

Dependent variable: insomnia

### **RANDOM VARIABLE**

This is a variable whose specific outcome is uncertain, but whose general behavior can be known, described, or predicted through a probability distribution. This means that this modality indicates how values are distributed and how likely each one is to occur.

Example:

If we roll a die, we do not know which number will appear, but each number has a probability of 1/6 of appearing. If we toss a coin, we do not know whether it will land heads or tails, but each side has a 50% probability of appearing.

### **FIXED VARIABLE**

This is a variable whose value does not change during an experiment or procedure. Unlike random variables, its values are constant or predefined and are not subject to chance or uncertainty. Main characteristics:

- Determinism: constant or defined value
- Control: used as a reference value
- Non-random: not influenced by uncertain factors

They provide a stable basis for interpreting results.

Example:

If the effect of diet on body mass index is studied, the number of calories assigned to each study group (2,000 calories, for example) would be the fixed variable.

There are other types of variables that, due to the function they fulfill in the analysis, are also important.

### **CONFOUNDING VARIABLE**

This is a variable that the researcher keeps constant or controls to prevent it from influencing the relationship between the independent and dependent variables. They are used to ensure that any change in the dependent variable is due exclusively to the manipulation of the independent variable.

Example:

In an experiment on the impact of sleep on academic performance, diet and the number of hours of study could be confounding variables to be controlled so that they do not affect the results.

### **INTERVENING OR MEDIATING VARIABLE**

This is a variable that lies between the independent and dependent variables and explains the relationship between them.

Example:

If the effect of stress on academic performance is investigated, motivation may be a mediating variable, since stress can reduce motivation, which in turn decreases performance.

### **MODERATING VARIABLE**

This is a variable that affects the direction or strength of the relationship between the independent and dependent variables.

Example:

If we examine the relationship between family support and well-being, participants' personality (extroverted/introverted) could be a moderating variable, since it could influence how strong the relationship is between family support and well-being.

Finally, let us imagine a project that investigates the impact of the number of hours of sleep (independent variable) on academic performance (dependent variable) in university students, taking into account motivation (mediating variable) and controlling confounding factors such as age and hours of study (control variables).

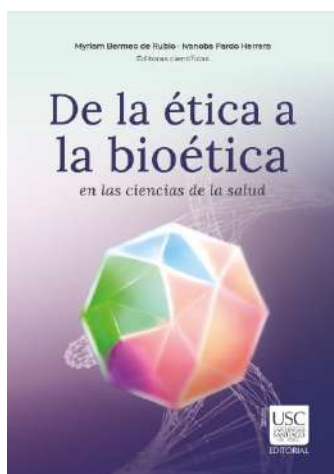
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## From ethics to bioethics in the health sciences

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The book *From Ethics to Bioethics in the Health Sciences* presents a comprehensive analysis of the evolution of ethical thought toward bioethics, highlighting its relevance across the various disciplines within the health sciences. The work emerges from interdisciplinary research aimed at reflecting on the importance of moral conduct, professional responsibility, and human dignity in the practice of health-related professions.

First, the text establishes a clear distinction between ethics and morality. Ethics is conceived as a philosophical discipline that examines human actions in relation to good and evil, whereas morality refers to the norms, values, and customs that guide individual behaviour within a given society. Ethics, therefore, analyses and reflects upon morality, allowing for the evaluation of whether actions are right or wrong. This distinction is fundamental for understanding the subsequent development of bioethics.

Bioethics is presented as an extension of ethics applied to the life and health sciences, particularly in response to scientific and technological advances that have generated new moral dilemmas. It is defined as a discipline that studies the ethical implications of medicine, biology, and healthcare practices, with the aim of protecting life and ensuring respect for human dignity. Unlike traditional ethics, bioethics adopts a more practical and interdisciplinary approach, as it integrates legal, social, cultural, and scientific dimensions.

The text emphasises that the professional practice of healthcare providers requires not only technical expertise but also a solid ethical foundation. From academic training to professional practice, ethics and bioethics should function as transversal pillars guiding decision-making processes. This is especially relevant in complex situations involving life, death, suffering, and patients' rights.

One of the key elements addressed in the work is the principle of autonomy, which recognises patients' right to make informed decisions about their health. This principle is closely linked to informed consent, understood not merely as a legal document but as a process of communication between the healthcare professional and the patient. Through this process, the aim is to ensure that patients are fully informed about the risks, benefits, and alternatives associated with medical procedures.

Likewise, the book highlights other fundamental principles of bioethics, such as beneficence (acting in the patient's best interest), non-maleficence (avoiding harm), and justice (the equitable distribution of healthcare resources and services). These principles serve as a guide for ethical professional conduct and contribute to improving the quality of healthcare delivery.

The work also addresses the issue of human error in healthcare services, noting that it is multifactorial and may be influenced by the complexity of healthcare systems, working conditions, and the use of technology. In this context, ethics and bioethics play a crucial role in error prevention and in promoting patient safety. The implementation of protocols and good clinical practices is presented as a key strategy to reduce risks and ensure safe care.

Another relevant aspect discussed is the need for deontological codes within each health discipline. These codes establish norms and principles that regulate professional behaviour, fostering responsibility, respect, and ethical commitment. However, the book reveals that not all disciplines possess well-structured or up-to-date codes, which represents a significant challenge for strengthening professional ethics.

Throughout the different chapters, the application of ethics and bioethics is analysed in fields such as medicine, nursing, dentistry, physiotherapy, psychology, among others. In each case, advances, limitations, and recommendations are identified in order to improve professional practice from an ethical perspective. The work concludes that bioethics must adapt to social and technological changes, while always maintaining human dignity as its central axis.

Finally, the book underscores that the current crisis of values in society makes ethical training for healthcare professionals more necessary than ever. Bioethics is presented as a fundamental tool for addressing contemporary challenges, promoting humanised, responsible, and patient-centred care. In this regard, the text calls for the strengthening of ethical education and the promotion of interdisciplinary dialogue as means to enhance quality of life and societal well-being.



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