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Journal of Physiotherapy

Definition of Research Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Medicine and Health Sciences, in Subdisciplines of surgery, physical exercise, physiotherapeutic treatment, thermotherapy, muscular physiology program, ultrasound, rehabilitation, augmented reality, articulated prosthesis.

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Encourage the interlocution of the International Scientific Community with other Study Centers in Mexico and abroad and promote a wide incorporation of academics, specialists and researchers to the publication in Science Structures of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S & T Councils - CONACYT Research Centers.

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Journal of Physiotherapy is a Research Journal edited by ECORFAN-Mexico S.C in its Holding with repository in Taiwan, is a scientific publication arbitrated and indexed with semester periods. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around subjects related to the theory and practice of surgery, physical exercise, physiotherapeutic treatment, thermotherapy, muscular physiology program, ultrasound, rehabilitation, augmented reality, articulated prosthesis with diverse approaches and perspectives , that contribute to the diffusion of the development of Science Technology and Innovation that allow the arguments related to the decision making and influence in the formulation of international policies in the Field of Medicine and Health Sciences. The editorial horizon of ECORFAN-Mexico® extends beyond the academy and integrates other segments of research and analysis outside the scope, as long as they meet the requirements of rigorous argumentative and scientific, as well as addressing issues of general and current interest of the International Scientific Society.

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Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to topics of surgery, physical exercise, physiotherapeutic treatment, thermotherapy, muscular physiology program, ultrasound, rehabilitation, augmented reality, articulated prosthesis and other topics related to Medicine and Health Sciences.

Presentation of the content

In the first article we present, *Genomic instability in a former high-performance athlete* by Castañeda-Aguirre, Víctor Elías, Rangel-Colmenero, Blanca Rocío, García-Vielma, Catalina and Cortes-Gutiérrez, Elva Irene, with adscription in Universidad Autónoma de Nuevo León and Instituto Mexicano del Seguro Social, the next article we present, *Design and development of universal leg prostheses with size adjustment using polylactic acid (PLA)* by Murillo-Rendón, Pablo Antonio, Cuate-Gómez, Diego Hernán, Garzón-Román, Abel and Lugo-Quintal, Jesús Manuel with adscription in Universidad Interamericana A. C., Instituto Tecnológico Superior Progreso and Benemérita Universidad Autónoma de Puebla, the next article we present, *Implementation of an gel dispenser with LED traffic light for early fever detection in public spaces* by González-Galindo, Edgar Alfredo, Fernández-Acosta, Luis Eduardo, Juárez-Gutiérrez, José de Jesús and Domínguez-Romero, Francisco Javier, with adscription in Universidad Nacional Autónoma de México, the last article we present, *An overview occupational encroachment in the health sciences. Based on teachers' perceptions in Mexico* by Ramírez-Jimenez, Alida, Salinas-Sánchez, Igor, Lara-Aguilar, Susana and Xolalpa-González, Juan Azael, with adscription in Universidad Nacional Autónoma de México and Tecnológico de Monterrey.

Content

Journal of Physiotherapy and Medical Technology 8[19]1-5: e1819105
Article

Genomic instability in a former high-performance athlete

Inestabilidad genómica en un exatleta de alto rendimiento

Castañeda-Aguirre, Víctor Elías [a], Rangel-Colmenero, Blanca Rocío* [b], García-Vielma, Catalina [c] and Cortes-Gutiérrez, Elva Irene [d]

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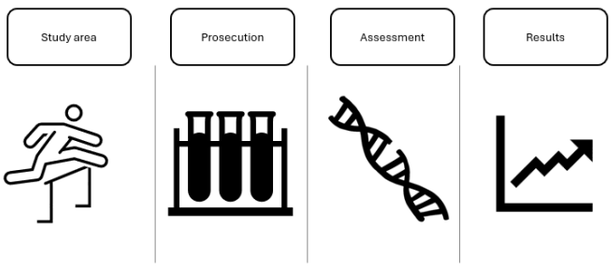
Abstract

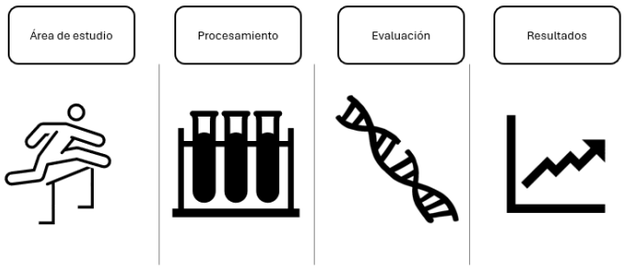
This study investigated the impact of high-intensity exercise on DNA damage. A former high-performance athlete was compared with individuals who performed moderate exercise, evaluating genetic damage using the comet single-cell gel electrophoresis assay in blood samples. The results indicated greater DNA damage in the former athlete, suggesting a possible relationship between exercise intensity and genetic damage. However, due to the limited sample size, larger studies are required to confirm these findings and determine whether factors such as type of sport or other variables could influence the results.



Quality of life, Sports, Health

Resumen

Este estudio investigó el impacto del ejercicio de alta intensidad en el daño al ADN. Se comparó a un exatleta de alto rendimiento con individuos que realizaban ejercicio moderado, evaluando el daño genético mediante el ensayo cometa en muestras de sangre. Los resultados indicaron un mayor daño al ADN en el exatleta, sugiriendo una posible relación entre la intensidad del ejercicio y el daño genético. Sin embargo, debido al tamaño limitado de la muestra, se requieren estudios más amplios para confirmar estos hallazgos y determinar si factores como el tipo de deporte u otros variables podrían influir en los resultados.



Calidad de vida, Deporte, Salud

Citation: Castañeda-Aguirre, Víctor Elías, Rangel-Colmenero, Blanca Rocío, García-Vielma, Catalina and Cortes-Gutiérrez, Elva Irene. [2024]. Genomic instability in a former high-performance athlete. Journal of Physiotherapy and Medical Technology. 8[19]1-5: e1819105.

Introduction

Deoxyribonucleic acid (DNA) damage can be the product of agents internal or external to the cell. It can be observed in specific gene sequences, in labile regions called fragile sites, or can itself in specific chromosomal alterations, sometimes related to certain diseases and cancer (Feng & Chakraborty, 2017).

Exercise, despite its positive health effects, induces an increase in the production of reactive oxygen species (ROS), a type of molecule that is harmful to cells. This increase is a physiological response of the body to training and is necessary for the muscles to adapt and strengthen (Santovito et al., 2023).

In other research it has been shown that a moderate physical activity workload exerts positive effects in terms of reducing DNA damage (Soares et al., 2015). On the other hand, it is specified that high-performance sport can generate a negative physiological response for the health of athletes (Medrano Plana et al., 2019).

As athletes advance in their career, intense training places greater demands on their bodies, requiring not only good general health (Jalalova, 2024). However, to our knowledge, there are no reports of studies that quantify DNA damage in high-performance athletes.

There are various techniques to evaluate and quantify DNA damage, the comet assay being one of the most widely used due to its ability to provide detailed information on the degree of damage to the genetic material of individual cells.

With this methodology, single-strand damage is quantified in alkaline labile sites in the DNA and is interpreted by the length of the cauda, that is, the longer the cauda of the comet, the greater the damage to the DNA. These measurements can be subjective or quantified with image analysis software.

The main objective of the present study is to report a high-performance athlete in whom high values of DNA damage were found using the comet technique compared with two normal controls who only performed moderate aerobic exercise.

Methodology

Below is a detailed description of the participants included in the study:

Study subject: 29-year-old male, body mass index (BMI) 22.1, no medical history, denies smoking, alcohol intake, recent COVID, drug use, exposure to mutagenic agents at work and home, as well as radiotherapy and chemotherapies. Dedicated to the sport of high-performance Karate, practiced for eight years training 10 h per week, having presence in state, regional, national, and international competitions.

Control 1: 25-year-old male, BMI 23.5, no pathological history, denies smoking, medication intake, recent COVID, drug use, exposure to mutagenic agents at work and home, excessive alcoholism, radiotherapies, and chemotherapies. Moderate impact athlete in long-distance and middle-distance swimming events.

Control 2: 26-year-old male with a BMI of 20.5, no medical history, denies smoking, medication intake, recent COVID, drug use, exposure to mutagenic agents at work and home, excessive alcoholism, radiotherapies, and chemotherapies. Moderate impact athlete in middle distance swimming events.

Surveys were applied to the study subject and controls to know some anthropometric data such as weight, height, with which the BMI was calculated, using the Quetelet formula: weight of a person in kilograms divided by the square of the height in meters, we used the International Medical Corps (lMC) classification proposed by the World Health Organization (WHO).

The athletes were also asked about their medical history of chronic degenerative diseases such as cancer, hypertension, diabetes, and occupational or household exposure to known teratogens, radiotherapies, or chemotherapies. If they recently had COVID and if they took any medication daily. Intake of tobacco, alcohol, drugs, or any other product that could damage DNA stability was asked.

Subsequently, the comet assay was performed on the subject and controls, using lymphocytes from a peripheral venous blood sample anticoagulated with EDTA.

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Castañeda-Aguirre, Víctor Elías, Rangel-Colmenero, Blanca Rocío, García-Vielma, Catalina and Cortes-Gutiérrez, Elva Irene. [2024]. Genomic instability in a former high-performance athlete. Journal of Physiotherapy and Medical Technology. 8[19]1-5: e1819105.
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Written informed consent was signed by all participants and the study is approved by the ethics and research committee of the Mexican Institute of Social Security (IMSS) with registration number R-2024-785-024. The methodology proposed by Cortés-Gutiérrez and collaborators (2012) was used.

The leukocytes were embedded in previously prepared agarose slides. The slides were immersed in different solutions to lyse the cells and expose the DNA. Subsequently, they underwent electrophoresis, at 23 V, where the DNA fragments form a cauda. The slides were fixed in a sequence of alcohols and allowed to air-dry for 24 h, protected from dust and light.

They were then stained with propidium iodide (PI) at a concentration of 1:1 and observed under a fluorescence microscope with a Texas red filter, specific for the light spectrum of the dye used. Photographs of the comets were taken on an Axio Scope Zeiss® microscope, equipped with a high-resolution camera.

These photographs were analyzed with image analysis software Image J version 1.4.3.6.76. The measurements were made taking as a starting point the center of the cell nucleus and up to the last fragment of the comet's cauda and were expressed in microns (µm). One hundred cells per study subject and controls were analyzed and average values were calculated in Microsoft Excel.

Results

The average of the study subject's measurements was 141 ± 16 µm (Figure 1).

Box 1

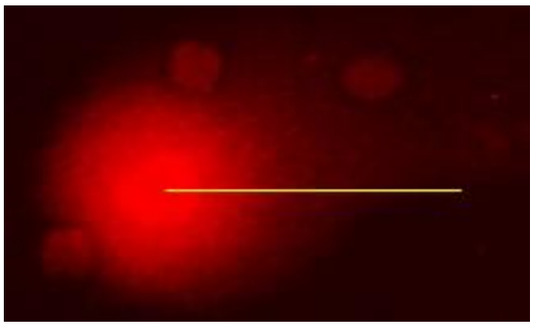

Figure 1

Alkaline comet from peripheral blood leukocytes of the study subject, a former high-performance athlete, stained with PI. Comet with a length of 363 µm.

Source: Own elaboration

The average of comet measurements in control 1 was 21 ± 5 µm. (Figure 2).

Box 2

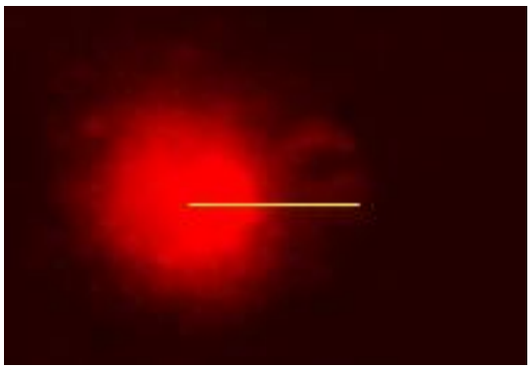

Figure 2

Alkaline comet of peripheral blood leukocytes from control subject 1, stained with PI. Comet with a length of 30 µm.

And finally, the average comet measurements from control 2 were 30 ± 6 µm (Figure 3).

Box 3

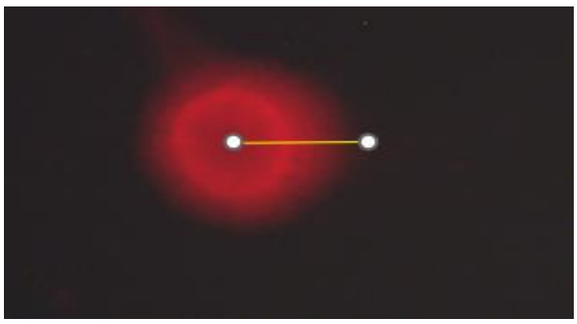

Figure 3

Alkaline comet from peripheral blood leukocytes stained with PI from control subject 2. Comet with a length of 23 µm.

Source: Own elaboration

Discussion of Results

Analysis of the comets revealed significantly higher average DNA damage in the former high-performance athlete compared to controls. The absence of other known risk factors suggests that high-performance physical exercise, practiced over a prolonged period, could have contributed substantially to the induction of this genomic damage, possibly through mechanisms associated with oxidative stress and inflammation.

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Castañeda-Aguirre, Víctor Elías, Rangel-Colmenero, Blanca Rocío, García-Vielma, Catalina and Cortes-Gutiérrez, Elva Irene. [2024]. Genomic instability in a former high-performance athlete. Journal of Physiotherapy and Medical Technology. 8[19]1-5: e1819105.
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Similar results were found by Kim and collaborators (2018), in which these authors established that high-intensity and prolonged aerobic exercise generates DNA damage due to the duration and intensity of the exercise in athletes who practice triathlon.

This may be because exhaustive exercise can generate muscle injuries that imply an oxidative increase in immune cells, which leads to a rapid formation of free radicals and subsequently generates oxidative damage, which produces muscle fatigue and weakness, lipid peroxidation, mitochondria dysfunction, and DNA mutations (Steinbacher & Eckl, 2015).

However, authors such as Cash and collaborators (2014) refer to that the practice of activity experiences a marked increase in DNA damage immediately after performing acute aerobic exercise, and that this increase remains significant in the future, over the course of 2 h and during the first day after physical activity; however, the maintenance of DNA damage is not observed during the period from 5-28 days after exercise.

This pattern suggests a unique temporal response of the genetic material in the face of stress induced by exercise. These findings obtained are consistent with the idea that inadequate and non-individualized training planning may have generated excessive stress in the body, favoring DNA damage.

The absence of previous studies in similar populations limits the ability to establish a definitive causal relationship; however, the data obtained suggest that high-intensity and prolonged physical exercise, when not properly controlled, could represent a risk factor for health, long-term effects on athletes, determining DNA damage.

There are studies in which the potential of microRNA as biomarkers to evaluate sports performance and understand the molecular mechanisms behind training adaptation is evaluated (Paulucio et al., 2024).

This study constitutes a basis for future research in athletes and former high-performance athletes, since it will allow us to more precisely visualize how the body responds at a cellular level to various training stimuli, considering variables such as intensity, density, volume, frequency, and type of training.

Likewise, it will be essential to establish rigorous control groups and control external factors such as nutrition, to isolate the effect of exercise on DNA damage.

Because there is, to the best of our knowledge, no history of serious illnesses, ingestion of medications, or radio- or chemotherapies, etc., we rule out that DNA damage could derive from external physical factors and be due to training.

It is necessary to increase the number of participants of former high-performance athletes to corroborate the results obtained in the present study and to carry out appropriate statistical studies to demonstrate an association.

Conclusion

While the results suggest a relationship between high-performance exercise and DNA damage, it is important to emphasize that a definitive causal relationship cannot be established with the current data; the number of subjects needs to be increased.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no known competing financial interests or personal relationships that could have influenced the article reported in this article.

Authors' contribution

The contribution of each researcher in each of the points developed in this research was defined based on:

Castañeda-Aguirre, Víctor Elías: Generation of the research idea and data collection.

Rangel-Colmenero, Blanca Rocío: Mentoring and supervision of data collection.

García-Vielma, Catalina: Mentoring and supervision of data collection.

Cortes-Gutiérrez, Elva Irene: Standardization of the Kite online educational assessment test and advice.

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Availability of data and materials

The material resources that were used for the development of this research were those provided by the Human Performance Laboratory of the Faculty of Sports Organization, UANL, and the Cytogenetics Laboratory of the Northeast Biomedical Research Center, IMSS.

Funding

The research did not receive any funding.
Abreviaciones

Abbreviations

µm	Microliters
BMI	Body mass index
DNA	Deoxyribonucleic acid

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Basic concepts

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Journal of Physiotherapy and Medical Technology 8[19]1-9: e2819109
Article

Design and development of universal leg prostheses with size adjustment using polylactic acid (PLA)

Diseño y desarrollo de prótesis de pierna universal con ajuste en tamaños utilizando ácido poliláctico (PLA)

Murillo-Rendón, Pablo Antonio *[a], Cuate-Gómez, Diego Hernán [b], Garzón-Román, Abel [c] and Lugo-Quintal, Jesús Manuel [d]

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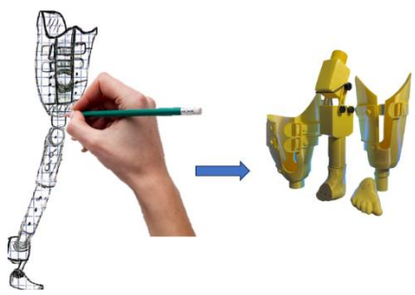
Abstract

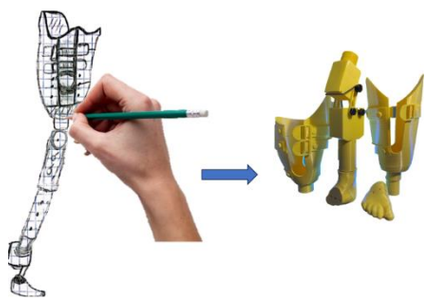
The history of leg prosthetics is a journey of continuous innovation and progress. In Mexico, according to INEGI (2015), there are 780,000 people with amputations; of the 75,000 amputees, only 10% have a prosthesis, and 7% do not know how to use it. The leading cause is Type 2 diabetes. Current prosthetics vary in cost and technology, ranging from hundreds to hundreds of thousands of dollars. Losing a limb affects mobility and psychological, social, and physical well-being. Unlike the rudimentary ones of the past, modern prosthetics are more advanced and functional. This study, with 50 participants, analyzes various anthropometric measurements to design an adjustable universal prosthesis, improving the quality of life for amputees through an interdisciplinary approach combining biomechanical analysis, material evaluation, and types of prosthetics. The results highlight the importance of considering gender for an optimal fit.



Analysis, Biomechanical, Functional, Participants

Resumen

La historia de las prótesis de pierna es un recorrido de innovación y progreso continuo. En México, según INEGI (2015), hay 780,000 personas con amputaciones; de 75,000 amputados, solo el 10% tiene una prótesis y el 7% no sabe usarla. La causa principal es la diabetes tipo 2. Las prótesis actuales varían en costo y tecnología, desde cientos hasta cientos de miles de dólares. La pérdida de una extremidad afecta la movilidad y el bienestar psicológico, social y físico. Las prótesis modernas, a diferencia de las rudimentarias del pasado, son más avanzadas y funcionales. Este estudio, con 50 participantes, analiza diversas medidas antropométricas para diseñar una prótesis universal ajustable, mejorando la calidad de vida de los amputados mediante un enfoque interdisciplinario que combina análisis biomecánico, evaluación de materiales y tipos de prótesis. Los resultados destacan la importancia de considerar el género para un ajuste óptimo.



Análisis, Biomecánico, Funcional, Participantes

Citation: Murillo-Rendón, Pablo Antonio, Cuate-Gómez, Diego Hernán, Garzón-Román, Abel and Lugo-Quintal, Jesús Manuel. [2024]. Design and development of universal leg prostheses with size adjustment using polylactic acid (PLA). Journal of Physiotherapy and Medical Technology. 8[19]1-9: e2819109.

Introduction

Leg prosthetics have come a long way since the earliest recorded attempts to create a functional replacement for a missing limb (Grimmer & Seyfarth, 2014). The hi story of leg prosthetics is a story of innovation, creativity, and continuous progress (Raschke, 2022).

The evolution of this technology has been driven by the constant pursuit of improving the quality of life for amputees (Sinha et al., 2011). Technological advancements have converged centuries to address significant leg prosthetics challenges (Nizamis et al., 2021).

In Mexico, there are 780,000 people with amputations, according to INEGI in 2015, and out of 75,000 amputees, only 7,500 have a prosthesis (10%), of which 5,250 (7%) do not know how to use it. The leading cause of amputation is Type 2 Diabetes Mellitus. Today, a wide range of prosthetics is available on the market, with costs ranging from a few hundred dollars to several hundred thousand, depending on the type of prosthesis, the materials used, and the incorporated technology (Instituto Nacional de Desarrollo Social, 2017).

Losing a lower limb is a life-changing event that can have profound physical and emotional effects on a person (Rees et al., 2019). It can affect their mobility and psychological, social, and physical well-being. The loss of a limb can be caused by a variety of factors, including genetic conditions, congenital malformations, automobile, sports, or work accidents, and diseases such as diabetes, gangrene, or cancer, among others (Pasquina et al., 2014).

In the past, the only option for amputees was to use rudimentary prosthetics, which were often uncomfortable and cumbersome and did not provide adequate support or functionality (Murray, 2009). However, prosthetics have become more advanced, comfortable, and functional with advancements in science and technology. Modern prosthetics are designed to provide amputees with a better quality of life by enabling them to perform daily activities and participate in sports and other physical activities (Keszler et al., 2019).

The development of prosthetics technology has been driven by a desire to create more advanced, more sophisticated devices that mimic a natural limb's movements. The earliest prosthetics were made from wood, metal, and leather and were designed to provide essential support and stability (Finch, 2011).

Over time, prosthetics have become more advanced, incorporating carbon fiber, titanium, and silicone to provide a more natural feel and better functionality (Cruz et al., 2020).

Today, several types of prosthetics are available on the market, from the most basic to the most advanced (Barrios-Muriel et al., 2020). The type of prosthesis a person chooses depends on their individual needs, the level of amputation, and their budget. (Laferrier & Gailey, 2010).

The cost of a prosthetic can vary widely depending on the type of prosthesis, the materials used, and the incorporated technology (Andrysek, 2010). A leg prosthesis can range from a few hundred dollars to several hundred thousand. This cost is often a barrier to many amputees who cannot afford the high prices of modern prosthetics. Therefore, solutions are being sought to reduce costs while maintaining the quality of materials, resistance, adaptability to any stump, and intuitive maintenance ("do it yourself").

The history of leg prosthetics is a fascinating narrative of innovation and continuous progress. Today, technological advancements are converging to address significant challenges in the field of leg prosthetics.

This research encompasses various topics related to the causes, materials, and solutions for implementing a universal leg prosthesis with size adjustments. The aim is to improve the quality of life of amputees through a universal leg prosthesis with size adjustments for individuals aged 15 to 60. The documentary research focuses on an interdisciplinary analysis combining biomechanical analysis, materials evaluation, and types of prostheses, injuries, and therapies.

This study aims to advance the design, creation, and implementation of a new leg prosthesis that surpasses the limitations of conventional designs, which often do not meet the needs or expectations of the user.

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Methodology

This study was conducted on a sample of 50 individuals, evenly divided between males (M) and females (W) (25 M and 25 W), to collect detailed data on various anthropometric measurements of the lower limbs. These data included age, weight, height, measurement from the stump to the knee, measurement from the knee to the foot, measurement of the stump above the knee (circumference near the groin), measurement of the stump above the knee (circumference near the knee joint), measurement of the stump below the knee (Calf circumference close to the knee), measurement of the stump below the knee (Ankle circumference close to the foot), Heel width measurement, and measurement along the foot.

Graph 1a shows the age distribution of the participants, with a minimum age of 15 years for both M and W and a maximum age of 60 years for W to 69 years for M. The average age in our sample was 31 years in W and 32 years in M. Regarding weight, there was wide variability in both groups, as shown in graph 1b. The minimum weights were 40 kg in W and 42 kg in M, while the maximum weights were 100 kg in W and 120 kg in M.

The average weight in the sample was 68.4 kg in W and 80.16 kg in M. It is important to note that the standard deviation of the population's weight was 15.81 kg in W and 19.69 kg in M. Graph 1c presents the height data, with minimum heights of 1.5 m in W and 1.6 m in M, and maximum heights of 1.74 m to 1.9 m in W and M, respectively. The average height was 1.6 m in W and 1.72 m in M.

The standard deviation of the population's height was 0.05 m in W, and 0.08 m in M. Graph 1d shows the measurement from the knee to the stump, with minimum measurements of 26 cm in W and 22 cm in M and maximum measurements of 49 cm in W and 40 cm in M.

The averages of these measurements were 35.88 cm in W and 27.76 cm in M, with standard deviations of 5.68 cm in W and 3.89 cm in M.

Box 1

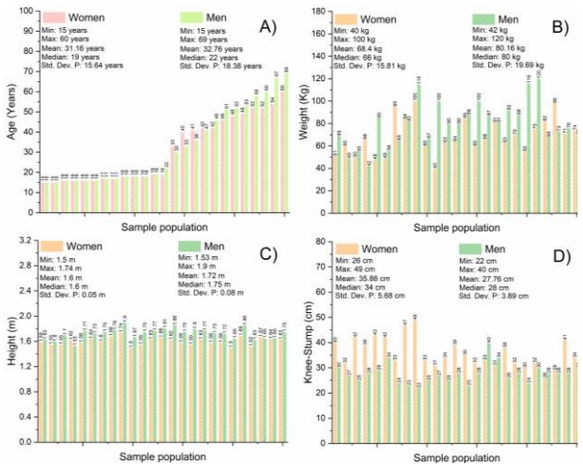

Figure 1

Population data on A) Age, B) Weight, C) Height, and D) Measurement along the stump to the knee

In figure 2a, we have the measurement along the knee to the foot, with minimum measurements of 46 cm in W and 43 cm in M and maximum measurements of 53 cm in W and 59 cm in M.

The averages of these measurements were 49.16 cm in W and 53.32 cm in M, with standard deviations of 2.2 cm in W and 4.03 cm in M. In figure 2b, we can observe the measurement of the circumference near the groin, with minimum measurements of 47 cm in W and 38 cm in M and maximum measurements of 75 cm in W and 83 cm in M.

The averages of these measurements were 59.68 cm in W and 53.12 cm in M, with standard deviations of cm in W and 10.67 cm in M. In figure 2c, we can observe the measurement of the circumference near the knee joint, with minimum measurements of 35 cm in W and 34 cm in M, and maximum measurements of 58 cm in W and 61 cm in M.

The averages of these measurements were 46.48 cm in W and 44.44 cm in M, with standard deviations of 6.67 cm in W and 7.19 cm in M. Now, in figure 2d, we can observe the measurement of the calf circumference close to the knee, with minimum measurements of 31 cm in W and M, and maximum measurements of 47 cm in W and 49 cm in M. The averages of these measurements were 36.84 cm in W and 39.56 cm in M, with standard deviations of 3.82 cm in W and 7.19 cm in M.

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Box 2

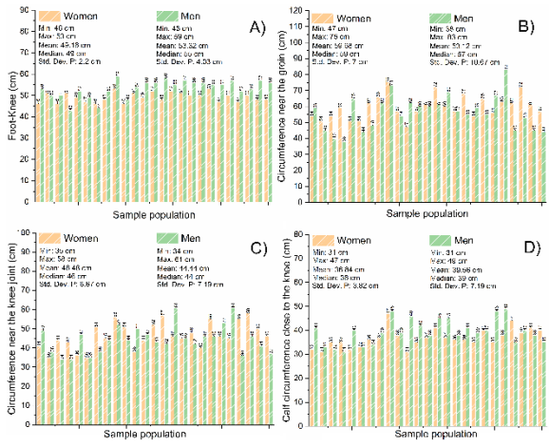

Figure 2

Population measurement data of A) foot to knee, B) stump above the knee circumference touching the groin, C) stump above knee circumference at knee level, and D) stump below the knee (calf) circumference hugging knee

In figure 3a, we can observe the measurement of the ankle circumference close to the foot, with minimum measurements of 20 cm in W and M, and maximum measurements of 27 cm in W and 30 cm in M. The averages of these measurements were 23.76 cm in W and 25.24 cm in M, with standard deviations of 2 cm in W and 2.81 cm in M. In figure 3b, we can observe the measurement of the heel width, with minimum measurements of 5 cm in W and M and maximum measurements of 9 cm in W and M.

The averages of these measurements were 6.96 cm in W and 7 cm in M, with standard deviations of 1.03 cm in W and 0.89 cm in M. In figure 3c, the measurement along the foot, with minimum measurements of 23 cm in W and 24.5 cm in M, and maximum measurements of 27.5 cm in W and 30 cm in M.

The averages of these measurements were 25.02 cm in W and 27.54 cm in M, with standard deviations of 1.04 cm in W and 1.17 cm in M. These data are essential for the design and development of universal leg prostheses with adjustable sizes that adapt correctly to the lower extremities of men and women in an individualized manner.

The results highlight the importance of considering gender when designing leg prostheses to ensure optimal fit and improve users' quality of life.

Box 3

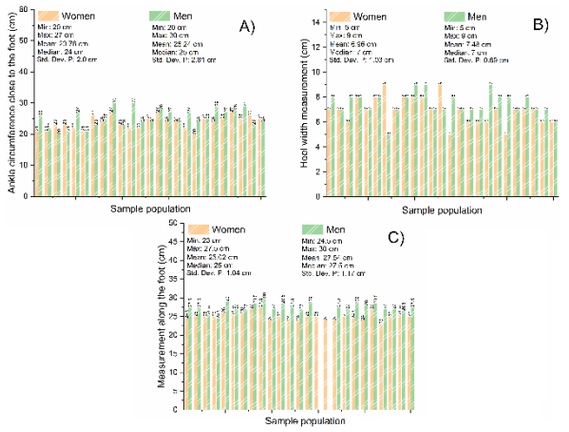

Figure 3

Population measurement data of A) the Stump below the knee (calf) circumference hugging the foot, B) the width of the heel, and C) the length of the heel

The software used was UltiMaker Cura 5.7.1, and the filament was Kardenal brand, with a diameter of 1.75 mm, extruded at a temperature of 190°C to 220°C, using a 0.4 mm nozzle for both printers.

The 3D printer used for printing the entire knee and foot part was the Creality Ender-3 V2, with dimensions of 475 x 470 x 620 mm, a bed size of 220 x 220 x 250 mm, and a weight of 8 kg. The total printing time was 67 hours and 32 minutes, with an infill speed of 40 mm/s and a wall speed of 20 mm/s, with a bed temperature of 60°C and a nozzle temperature of 220°C. The infill percentage for all parts was 20% in zigzag, with a retraction of 2 mm.

To print the sockets, the Creality Ender-3 V3 SE was also used. Its dimensions were 420 x 366 x 640 mm, the bed size was 220 x 220 x 250 mm, and it weighed 7.32 kg. The printing time was 47 hours and 34 minutes, with an infill speed of 180 mm/s and a wall speed of 90 mm/s, a bed temperature of 60°C, a nozzle temperature of 220°C, an infill percentage of 20% in zigzag, and a retraction of 2 mm.

Results

The construction of a universal prosthesis presents a series of obstacles. With the data presented in figures 1, 2, and 3, the necessary parameters are obtained to establish a range of measurements.

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For the ⇳ length measurement (stump - knee), an average of 35.88 cm for W and 27.76 cm for M is obtained; this indicates that the screw providing these measurements should be 8.12 cm, although to allow space for fasteners, a length of 9.5 cm is suggested. As for the length measurement ⇳ (knee-foot), the average for W was 49.16 cm and for M 53.32 cm.

Therefore, the screw for these measurements should be 4.16 cm, although a length of 5.5 cm is recommended to allow space for fastening.

For the ⇔ stump above knee (circumference near to groin), the average was 59.68 cm for W and 53.12 cm for M. Therefore, this part should be printed with a circumference of 56.4 cm, with a stretching and compression capacity of ± 2.66 cm.

For the ⇔ Stump above knee (Circumference near the knee joint), the average was 46.48 cm for W and 44.44 cm for M. Therefore, the piece should have a circumference of 45.46 cm, with a stretching and compression capacity of ± 1.02 cm. For the circumference of the ⇔ Stump below knee (Calf circumference close to knee), the average was 36.84 cm for W and 39.56 cm for M.

Therefore, this part should be printed with a circumference of 38.2 cm and a stretching and compression capacity of ± 2.72 cm. For the ⇔ Stump below knee (Ankle circumference close to the foot), the average was 23.76 cm for W and 25.24 cm for M. Therefore, the piece should have a circumference of 24.5 cm, with a stretching and compression capacity of ± 0.74 cm.

Regarding the ⇦⇨ heel width measurement, an average of 6.96 cm for W and 7.48 cm for M was obtained so that the size will be 7.22 cm. For the ⇖⇘ measurement along the foot, the average was 25.02 cm for W and 27.5 cm for M.

However, it was decided to use a minimum of 23 cm for women and a maximum of 30 cm for men because the variation in height in most measurements is not proportional. Therefore, the foot screws will have a length of 10 cm in order to allow anyone to adjust the foot size from 23 cm to 30 cm.

All this information is represented through the symbols in Figure 4.

Box 4

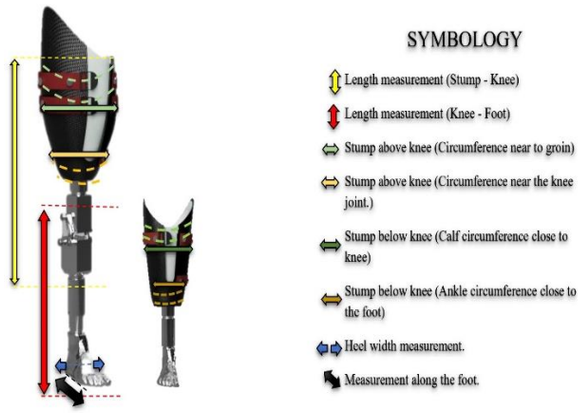

Figure 4
Symbology to measure the leg parts and design the universal prosthesis

With the provided information, the design of the leg prosthesis was initiated, taking into account all measurements.

The printing times were as follows: transfemoral socket (Figure 5A): 23 hours and 7 minutes, transtibial socket (Figure 5B): 24 hours and 27 minutes, two units of the first coupling (Figure 5C): 3 hours and 2 minutes, second coupling (Figure 5D): 1 hour and 17 minutes, first part of the knee (head) (Figure 5E): 6 hours and 17 minutes, second part of the knee (base) (Figure 5F): 7 hours and 53 minutes, two large anchors (Figure 5G): 51 minutes, small anchor (Figure 5H): 22 minutes, swivel nut with hat (Figure 5I): 23 minutes, third coupling (Figure 5J): 1 hour and 44 minutes, two units of the fourth coupling (Figure 5K): 8 hours and 26 minutes, two units of the fifth coupling (Figure 5L): 1 hour and 46 minutes, two units of the sixth coupling (Figure 5M): 2 hours and 52 minutes, seventh coupling (extension for the transtibial) (Figure 5N): 3 hours and 3 minutes, two forefeet (toes) (Figure 5O): 9 hours and 22 minutes, two hindfeet (heel) (Figure 5P): 14 hours and 40 minutes, six buckles (Figure 5Q): 2 hours and 12 minutes, six extension nuts for foot (Figure 5R): 3 hours and 18 minutes.

The total printing time to complete the prosthesis was 89 hours and 28 minutes.

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Box 5

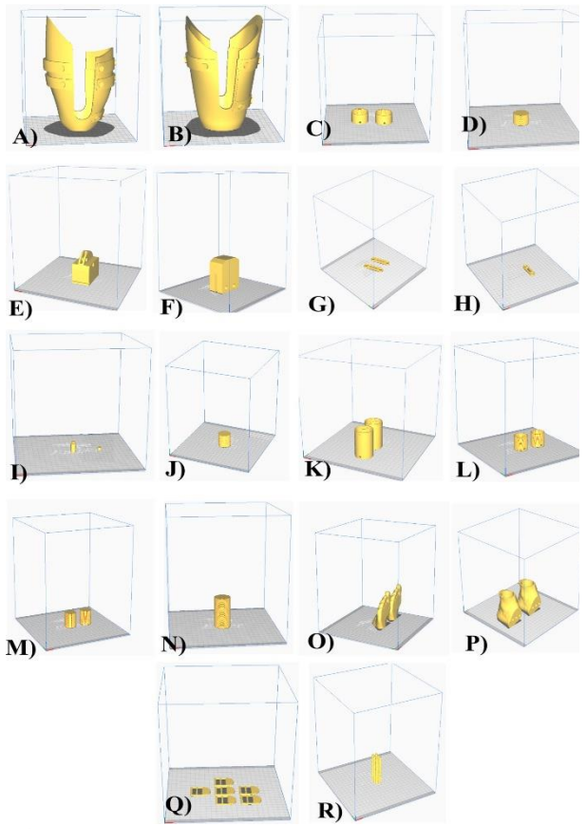

Figure 5

Printing time: A) Socket transfemoral, B) Socket transtibial, C) First coupling, D) Second coupling, E) First part of knee, F) Second part of knee, G) Large anchors, H) Small anchor, I) Swivel nut with hat, J) Third coupling, K) Fourth coupling, L) Fifth coupling, M) Sixth coupling, N) Seventh coupling, O) Forefoot (toes), P) Hindfoot (heel), Q) Buckles and R) Extension nuts

The total grams used for the prostheses, transfemoral and transtibial, were 586 g and 518 g respectively (see figure 6). The quantity of each printed part is shown in Table 1. With this documented information, it was determined that each gram of filament costs 0.29 pesos, calculated using the formula 298.99 pesos (filament price) divided by 1000 g, resulting in 0.29 pesos per gram.

Once the cost per gram was calculated and considering the total grams used in each prosthesis, the total filament cost for each was determined. The production cost of the transfemoral prosthesis was 169.94 pesos and that of the transtibial prosthesis was 150.22 pesos. These calculations were performed as follows:

For the transfemoral prosthesis:

$$(586gr)\left(0.29\frac{pesos}{gr}\right) = 169.94\,pesos$$

For the transtibial prosthesis:

$$(518gr)\left(0.29\frac{pesos}{gr}\right) = 150.22\,pesos$$

Box 6

Table 1

Quantity in grams of each piece of the leg prosthesis with adjustment in sizes

Quantities	Pieces	Grams
1	Socket transfemoral	263 gr
1	Socket transtibial	333 gr
2	First coupling	18 gr
1	Second coupling	11 gr
1	First part of knee	55 gr
1	Second part of knee	70 gr
2	Large anchors	5 gr
1	Small anchor	2gr
1	Swivel nut with hat	2 gr
1	Third coupling	15 gr
2	Fourth coupling	48 gr
2	Fifth coupling	12 gr
2	Sixth coupling	24 gr
1	Seventh coupling	26 gr
2	Forefoot (toes)	78 gr
2	Hindfoot (heel)	118 gr
6	Buckles	12 gr
6	Extension nuts	12 gr

The results shall be by section of the article.

Box 7

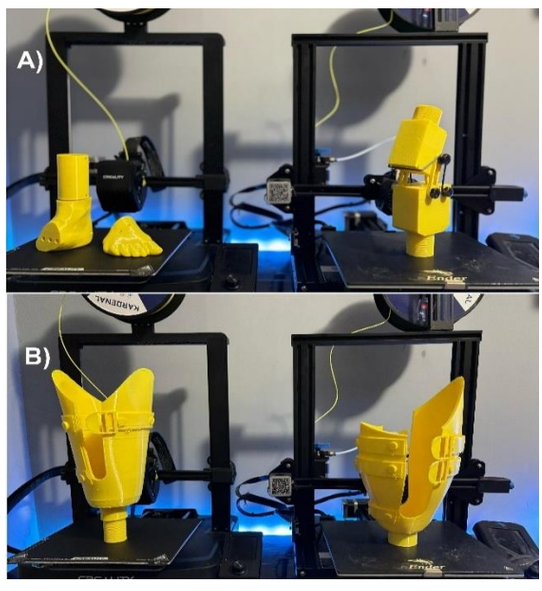

Figure 6

Leg prosthesis with adjustment in sizes A) Knee and foot, B) transfemoral and transtibial

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Several authors have conducted extensive research on the process parameter optimisation of the FDM process. Afrose et. al (2015) studied the fatigue behavior of polylactic acid (PLA) parts processed by fused deposition modelling (FDM) additive manufacturing process. The authors reported the effect of part build orientations on the tensile fatigue properties of PLA material.

A Cube 3D printer was used to print dog-bone test specimens in three (X, Y and 45°) different build orientations. Results show that the 45° build orientation components exhibit a longer fatigue life for the same proportion of applied static stresses than the parts in the X and Y construction orientations. Eryildiz (2021) studied the FDM 3D-printed PLA parts fabricated at different build orientations to examine the effects of build orientation on the tensile properties and build time of material.

The author reported that the tensile strength reaches a maximum for 0° orientation. Also, for upright (vertical) build orientation, 36% less tensile strength was obtained compared to flat orientation.

Syrlybayev et al. (2021) considered includes the influence of pre-processing of the printed part to improve the part strength and new research trends such as, vacuum-assisted FDM that has shown to improve the quality of the printing due to improved bonding between the layers. The authors reported that the layer thickness is the most critical factor among the studied ones. Furthermore, tensile strength decreases with increased layer thickness for both ABS and PLA filaments.

Algarni & Ghazali (2021) studied four FDM materials: polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polyether ether ketone (PEEK), and polyethylene terephthalate glycol (PETG). The authors reported a comparative study was conducted on four materials depicting that strength decreases for all materials with increased printing speed.

Conclusions

This study, conducted on a sample of 50 individuals evenly divided between males (25) and females (25), aimed to collect detailed anthropometric measurements of the lower limbs.

Data included age, weight, height, measurements from knee to stump and foot to knee, stump circumferences, heel width, and length. Graphs depict the distribution of these measurements by gender.

Key findings include:

- Age: The average age was 31 for W and 32 for M.
- Weight: Average weight was 68.4 kg for W and 80.16 kg for M.
- Height: Average height was 1.6 m for W and 1.72 m for M.
- Stump to Knee Measurement: Averages were 35.88 cm for W and 27.76 cm for M.
- Foot to Knee Measurement: Averages were 49.16 cm for W and 53.32 cm for M.
- Stump Circumferences: Averages for the stump above the knee were 59.68 cm (W) and 53.12 cm (M), and below the knee were 36.84 cm (W) and 39.56 cm (M).
- Heel Width: Average width was 6.96 cm for W and 7 cm for M.
- Heel Length: Average length was 25.02 cm for W and 27.54 cm for M.

These data are crucial for designing universal leg prostheses with adjustable sizes, ensuring a correct fit, and enhancing users' quality of life. Gender-specific considerations are vital in prosthesis design to achieve optimal fitting.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Authors´ contribution

Murillo-Rendón, Pablo-Antonio, and *Cuate-Gomez, Diego-Hernan:* Will conduct the development, experimentation, different measurements of people's legs, and article writing.

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Garzón-Román, Abel and *Lugo-Quintal, Jesús Manuel*: Helped with the correction of the manuscript.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, Murillo-Rendon, upon reasonable request.

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Abbreviations

ABS	Acrylonitrile butadiene styrene
FDM	Fused deposition modelling
INEGI	National Institute of Statistic and Geography
M	Male
PEEK	Polyether ether ketone
PETG	Polyethylene terephthalate glycol
PLA	Polylactic acid
W	Female

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Article

Implementation of an gel dispenser with LED traffic light for early fever detection in public spaces

Implementación de un despachador de gel con semáforo LED para la detección temprana de fiebre en espacios públicos

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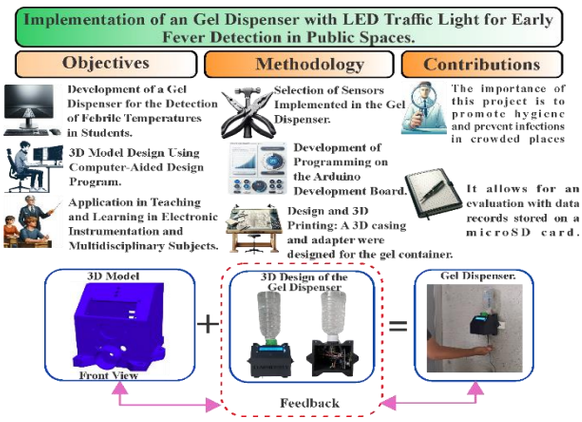
Abstract

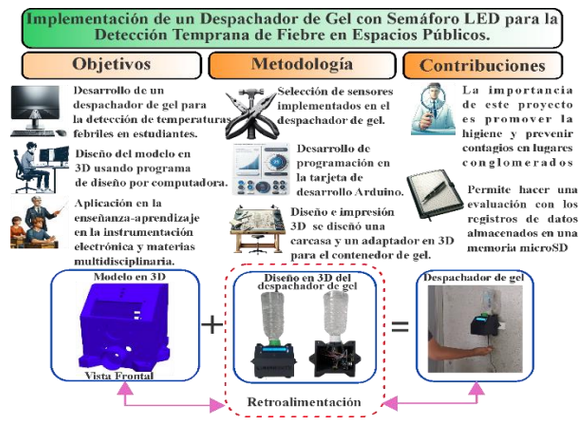
This project introduces a Gel Dispenser with LED Traffic Light for Early Fever Detection in Public Spaces. The LED traffic light changes color based on detected body temperature: red indicates fever, amber indicates elevated non-fever temperature, and green shows normal temperature. It utilizes an MLX90614 infrared temperature sensor, which, along with the FC-51 sensor, detects a hand, measures the temperature, and activates a pump to dispense antibacterial gel. Data are recorded on a MicroSD card and displayed on a screen. Designed during the late stages of COVID-19, it promotes hand hygiene by encouraging the use of antibacterial gel and reducing water consumption. Additionally, it offers a more comfortable temperature measurement by taking readings from the palm rather than the forehead. It has been effective in detecting febrile temperatures in students, proving to be a valuable solution for future pandemics.



Thermometer, Dispenser, Hygiene

Resumen

Este proyecto presenta un Dispensador de Gel con Semáforo LED para la Detección Temprana de Fiebre en Espacios Públicos. El semáforo LED cambia de color basado en la temperatura corporal detectada: rojo indica fiebre, ámbar indica temperatura elevada sin fiebre y verde muestra temperatura normal. Utiliza un sensor de temperatura infrarrojo MLX90614 que, junto con el sensor FC-51, detecta una mano, mide la temperatura y activa una bomba para dispensar gel antibacterial. Los datos se registran en una tarjeta MicroSD y se muestran en una pantalla. Diseñado durante las etapas finales de COVID-19, promueve la higiene de manos al fomentar el uso de gel antibacterial y reducir el consumo de agua. Además, ofrece una medición de temperatura más cómoda al tomar lecturas desde la palma de la mano en lugar de la frente. Ha sido efectivo en detectar temperaturas febriles en estudiantes, demostrando ser una solución valiosa para futuras pandemias.



Termómetro, Dispensador, Higiene

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Introduction

Implementing technological solutions for early fever detection and hygiene promotion, utilizing infrared sensors and visual alert systems. Both devices offer practical and effective solutions for use in public spaces, contributing to the prevention of disease spread.

The device promotes hand hygiene, encourages the use of antibacterial gel, reduces water consumption, and provides a more comfortable temperature measurement from the palm of the hand. It has proven effective in detecting febrile temperatures in students, offering a valuable solution for future pandemics. Both projects share significant similarities in terms of their purpose and technological approach. Early disease detection is crucial and greatly benefits from rapid technological advancements.

Detailed studies provide replicable solutions, helping to establish methodologies and costs. For example, Scott et al., (2024) mention the implementation of infrared sensors for the rapid detection of respiratory infections, although they do not specify the exact type of sensor.

This work underscores the importance of sharing knowledge to respond quickly to events like the SARS-CoV-2 outbreak in late 2019. Another relevant study is by Zou et al., (2024), which describes the development of a dual-signal fluorescent immunosensor combined with a machine learning system to detect specific pathogen antigens.

These sensors are noted for their high precision and represent a cost-effective and efficient solution for the rapid detection of pathogens in clinical and public settings, significantly improving detection and response capabilities to infectious diseases, although it does not specify if it is low-cost. However, some studies, such as Tantely et al. (2024)., do not provide specific cost details but employ procedures that can be very expensive. This study uses specific sensors designed to detect pathogen biomarkers, capable of providing quick and accurate results by detecting changes in fluorescence or absorbance in the presence of pathogens.

Meanwhile, Kamel et al., (2024) developed a modified lateral flow test strip based on streptavidin-biotin, demonstrating a significant improvement in sensitivity and specificity for the detection of the SARS-CoV-2 S1 antigen in saliva samples.

The use of smaller quantities of nanobodies and ACE-2, as well as the elimination of the conjugate pad in the test design, contribute to cost reduction. Finally, **Jin** et al., (2024) highlight that colorimetric sensors are generally inexpensive due to the low cost of materials. Their study explores the application of colorimetric sensors in various translational contexts, from the use of colorants to detection mechanisms, demonstrating that they are effective for the precise detection of a wide range of analytes in practical applications.

They aim to develop devices that allow for contactless temperature measurement to prevent the spread of diseases such as COVID-19 (Inayah et al., 2022). The effectiveness of hand hygiene is relevant, as Gozdzielewska et al., (2022) states, in preventing the transmission or acquisition of coronavirus or influenza infections in the community.

Hand hygiene for the general public is a recommended measure to prevent these infections. This study systematically reviewed the effectiveness of interventions for preventing the transmission or acquisition of coronavirus or influenza infections in the community. Other relevant works have developed where the need to measure body temperature without contact and quickly during the COVID-19 pandemic is addressed.

This need has led to the widespread use of infrared thermometers, cameras, and thermal scanners as alternatives to traditional clinical thermometers.

These studies examine the issues and limitations of these non-contact temperature measurement devices from clinical and metrological perspectives, with the aim of improving the accuracy of body temperature measurements and estimating the uncertainty of these measurements in the field. Both traditional sources of instrumental uncertainty and clinical and medical variables related to the subjectivity of the measured object are analyzed**.**

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Studies have been conducted that focus on recent changes and challenges in hand hygiene according to Boyce (2023), especially in the context of the pandemic, which led to a temporary increase in hand hygiene compliance rates and a shortage of alcohol-based hand sanitizers. New recommendations from non-regulatory agencies have been issued, and guidelines have been revised in response to the pandemic.

These include periodic audits of alcohol dispensers to ensure adequate volume and effective rubbing times. Challenges in Hand Hygiene Technique: Proper alcohol rubbing technique, including duration (at least 15 seconds) and coverage of all hand surfaces, is crucial for antimicrobial efficacy. However, many healthcare professionals do not meet these standards.

Automated Monitoring Systems: The need for complementary strategies to improve compliance rates is evident. Hand sanitizers with at least 60% ethanol have been shown to be effective against various emerging pathogens, including SARS-CoV-2 and Candida auris. Proper placement of dispensers is essential to improve hand hygiene compliance rates.

Hand sanitizers during the COVID-19 pandemic highlight the importance of hand hygiene in preventing the transmission of infections. The use of hand sanitizers has seen a significant increase in global demand due to their effectiveness in reducing pathogenic microorganisms. According to Gloekler et al., (2022), alcohol-based sanitizers are notable for their mechanisms of action and effectiveness.

The study emphasizes the need to develop effective and safe sanitizer formulations to prevent future pandemic outbreaks. The implementation of technological strategies is highly relevant in places with crowds or high flows of people to avoid contact with objects that could cause the spread of viruses or bacteria, such as the system implemented by Venkataramanan et al., (2023) for an automatic door opening system with contactless temperature detection.

This system reduces the risk of COVID-19 infection by avoiding direct contact with traditional door handles and performing automated temperature control.

The system uses an MLX90614 infrared temperature sensor, a PIR sensor, an LCD screen, servomotors, and LEDs for motion detection, and an Arduino Uno microcontroller. It highlights the need for precautionary measures such as wearing masks, social distancing, and disinfecting hands and arms to prevent the spread of COVID-19.

The system has been tested in various scenarios, showing 100% accuracy in motion and temperature detection. Currently, the safety and efficacy of hand sanitizers marketed for children during the COVID-19 pandemic are being examined, according to Dell'Isola et al., (2021). Studies have been conducted addressing concerns about the safety and efficacy of alcohol-based hand sanitizers due to temporary FDA recommendations that modified the allowable impurity limits in these products.

A survey was conducted from January to April 2021 in physical and online stores to identify hand sanitizers appealing to children. Thirty-one selected products were analyzed to detect impurities and measure ethanol content. Impurities were evaluated using a gas chromatography-mass spectrometry method. Out of 139 identified products, 31 were analyzed for impurities. Impurities such as acetaldehyde, benzene, and acetal were found in some products, exceeding the FDA's recommended limits.

Handwashing is essential during pandemic times. According to Szczuka et al., (2021), in her work "The trajectory of COVID-19 pandemic and handwashing adherence: findings from 14 countries," the World Health Organization (WHO) guidelines were analyzed across 14 countries. The study observed 6,064 adults and analyzed how the total number of COVID-19 cases relates to deaths and handwashing frequency.

This work proposes a study that should conclude with a trajectory of how the pandemic significantly affects hygiene behaviors and suggests that future research should consider these indicators to better understand health prevention behaviors during a pandemic.

Applications have been developed such as the work on experimental data of push and pull forces using automatic liquid dispensers.

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These experiments are essential for design and data collection using sensors. In this project, three types of liquids (water, soap, and hand sanitizer) were used at three volume levels (50 ml, 150 ml, and 250 ml) and tested at six servo motor rotation angles (30°, 60°, 90°, 120°, 150°, and 180°).

During the experiment, push and pull force data on the automatic liquid dispenser were recorded and transmitted to cloud servers using internet networks. The collected data provide a valuable reference for industrial engineers in calculating electrical power requirements and predicting the recharge period of automatic liquid dispensers.

The dataset can be reused in future studies to design and develop new prototypes of automatic liquid dispensers, avoiding over-design or under-design and optimizing energy consumption (Sitorus et al., 2021). The work developed by Kumar (2021) describes the design and development of a compact, contactless infrared thermometer.

This device is intended to assess body temperature and maintain physical distancing in social environments. It uses infrared technology to measure temperature without physical contact, reducing the risk of spreading diseases such as COVID-19. Additionally, the device is designed to be portable and convenient, facilitating its use in various spaces such as schools, offices, and public hospitals.

The article also details the device's fabrication, including component selection, circuit design, and microcontroller programming. Test results showed that the contactless thermometer is accurate and reliable for fever detection, providing an effective tool for early symptom detection in community settings. Kumar mentions that the use of such devices can significantly contribute to the prevention of the spread of infectious diseases and the maintenance of public health.

The work developed by Vandika and Ranham (2020) presents a prototype based on the MLX90614 sensor and an Arduino development board for a system that measures body temperature using the infrared sensor, which has generally been used for health monitoring.

The device is designed for individuals with normal physical conditions but can also be useful for those with disabilities, such as blindness. The developed system measures temperature without contact and transmits the data to an Android application.

The sensor's accuracy, combined with the Arduino's capability to process and send data, allows for efficient and precise body temperature measurement, maintaining an error margin between 0.3°C and 0.6°C compared to analog thermometers. Additionally, the device includes additional sensors to monitor other vital signs such as blood pressure and pulse, providing a comprehensive health assessment.

The MLX90614 sensor can be adapted to various microprocessors or development boards, one of which is the STM32F107. This project, developed by Jin et al., (2015), was employed to identify security liquids in places such as subways, airports, and train stations, preventing contamination and injuries from corrosive or toxic liquids.

The hardware design, PCB creation, and programming were done using a software called Keil C, allowing the measurement of the temperature of liquids in bottles of various shapes, materials, sizes, and wall thicknesses at different distances. The project ensured high reliability, low cost, low power consumption, and real-time response. The project enabled the analysis of the effects of measurement distance, bottle material, and wall thickness on the accuracy of the measured temperature. The results showed that the measurement accuracy varies with distance and bottle material, highlighting that the optimal measurement distance is 5 mm to minimize errors.

Objetive

Develop and implement a gel dispenser with an integrated LED traffic light for early fever detection in public spaces, aimed at enhancing preventive measures against contagious diseases and promoting hygiene among the population.

Hypothesis

In Mexico, socioeconomic disparities significantly limit access to education and healthcare, a situation that became evident during the SARS CoV2 pandemic.

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Despite the efforts of the media and healthcare personnel, many people ignored recommendations to wash hands, wear face masks, and maintain social distancing. Additionally, the fear of forehead temperature checks, due to the erroneous belief that it could cause brain damage, contributed to the spread of the virus in crowded places.

If a user-friendly and easy-to-use gel dispenser is implemented, it could significantly reduce the transmission of infectious diseases in enclosed spaces by promoting hand hygiene and detecting fevers early. Placing these devices at strategic points such as schools, shopping centers, hospitals, and public and private transportation systems could establish effective control that prevents potentially ill individuals from entering, similar to measures observed during the pandemic, where guards at entrances checked temperatures and provided hand sanitizer, denying access to those showing symptoms of illness.

Methodology and development

The project was developed in the Measurement and Instrumentation Laboratory at the Technological Center of the Facultad de Estudios Superiores Aragón, with the objective of designing an LED traffic light system that changes color based on detected body temperature, using an MLX90614 infrared temperature sensor.

A proximity sensor was integrated to automatically activate the dispenser when a hand is detected. Additionally, a data storage system was implemented using a MicroSD card to record temperatures and the usage of the attached antibacterial gel. An LCD screen was integrated to display the current temperature and the device status.

The collected data allows the evaluation of the device's effectiveness in detecting febrile temperatures and its acceptance in public spaces such as schools, transportation centers, and other crowded places.

The Arduino module used in the project for temperature measurement was the GY-906, an infrared thermometer with an MLX90614 sensor from Melexis (2006).

Melexis has developed a whole family of these thermometers, but the AXX model was selected for its easy adaptability to a project with an Arduino UNO board, as it includes a voltage regulator from 5V to 3V. This sensor can operate at ambient temperatures from -40°C to 125°C (COMPONENTS101, 2020) and detects temperatures between -70°C and 380°C with a minimum accuracy of ±4%. However, its highest accuracy is between 0°C and 50°C of ambient temperature, detecting objects between 0°C and 60°C with a variation of ±0.5%. Additionally, it has a measurement resolution of 0.02°C (UNIT ELECTRONICS, 2023). The schematic diagram of the circuit designed for the Gel Dispenser XXI shows power supplied through a Jack power input providing 12V.

This voltage powers the system's motor, and in parallel, a regulator is used to convert the power to 5V, thereby energizing the Arduino UNO board and most of the system components, except for the MicroSD module which operates at 3.3V directly obtained from the Arduino. On the same side of the board, the analog inputs connect the SCL and SDA pins of the I2C adapter for the LCD screen and the MLX90614 temperature sensor. On the lower right side, where key processes are controlled, PWM outputs were used to send signals to the LEDs, buzzer, and IRF3205 transistor.

The PWM pin was also employed to read the output from the FC-51 Proximity Sensor, which activates the mentioned components. Finally, on the upper right side, the specific pins for the operation of the MicroSD module are configured according to the programmer's library specifications, ensuring correct functionality as illustrated in Figure 1.

Box 1

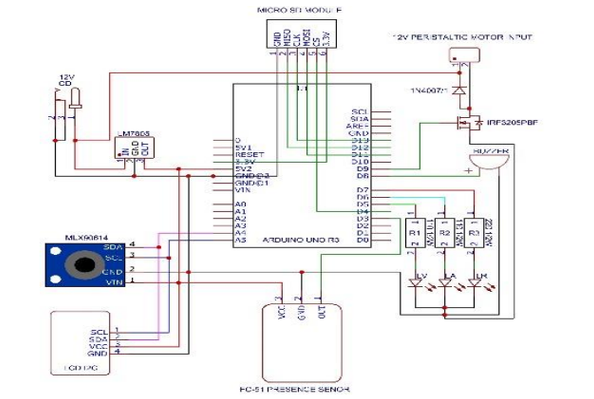

Figure 1

Schematic Diagram of the Electrical Circuit for the Dispenser XXI

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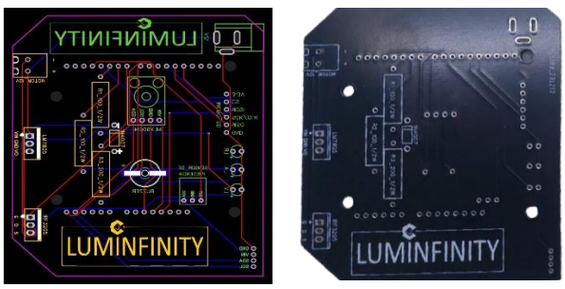
In Figure 2a, the traces of the printed circuit board (PCB) are shown in relation to the schematic diagram presented in Figure 1. This figure illustrates both layers of the PCB: the top layer is represented by blue and green colors, while the bottom layer is represented by red and yellow colors. On the other hand, Figure 2b presents a view of the physical PCB from its underside.

Box 2



(a) (b)

Figure 2

a) Printed circuit board PCB. b) Printed circuit design

During the PCB soldering process, various tools were used, as shown in Figure 3. These tools include a board holder with a magnifying glass, solder wire, solder paste, an aluminum fiber for cleaning the soldering iron, a solder sucker, insulating tape, a soldering iron, a soldering iron stand, and a sponge with water.

Box 3

Figure 3

Materials Used for Soldering the Board

Figure 4 shows all the materials that make up the electronic system of the dispenser. These materials include the PCB, an Arduino Uno, red, yellow, and green LEDs, a MicroSD memory module with its corresponding MicroSD card, an IRF3205 MOSFET, an LM7805 voltage regulator, a buzzer, two 100Ω resistors and one 200Ω resistor, a connector, a 1N4007 rectifier diode, a Jack connector, a 16x2 LCD screen, an I2C adapter for the LCD, the MLX90614 infrared temperature sensor, the FC-51 proximity sensor, nuts and bolts for the components, and a 12V 3A AC-DC regulator with Jack output.

Additionally, extra tools such as screwdrivers and pliers were used for the assembly process.

Box 4

Figure 4

Electronic Components and Tools Used During Assembly

The selected switch for activating the peristaltic pump was the IRF3205 MOSFET, due to its great adaptability to low voltage and current electronic systems. According to the datasheet of this transistor from International Rectifier, its main characteristics are as follows: it is an N-channel MOSFET transistor of the IRF3205 series, with a TO-220AB package. It has three connection pins, which from left to right are arranged as Gate, Drain, and Source respectively for through-hole technology (THT) mounting.

The maximum drain-source voltage (VDS) it can withstand is 55VDC, the maximum gate-source voltage (VGS) is ±20V, and it supports up to a drain current (ID) of 110A. Additionally, it has a power dissipation (PD) of 200W, making it necessary to attach a heat sink.

Figure 5 illustrates the assembly and mounting process of the components on the PCB. In the background, the board holder can be seen, while the PCB is in the middle of the assembly process in the center.

At the front, the green LED is highlighted. On the board, the MOSFET and the LM7805 Voltage Regulator, resistors, rectifier diode, buzzer, green LED, MicroSD memory module, and the LCD screen cables with the I2C adapter are already soldered.

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Box 5

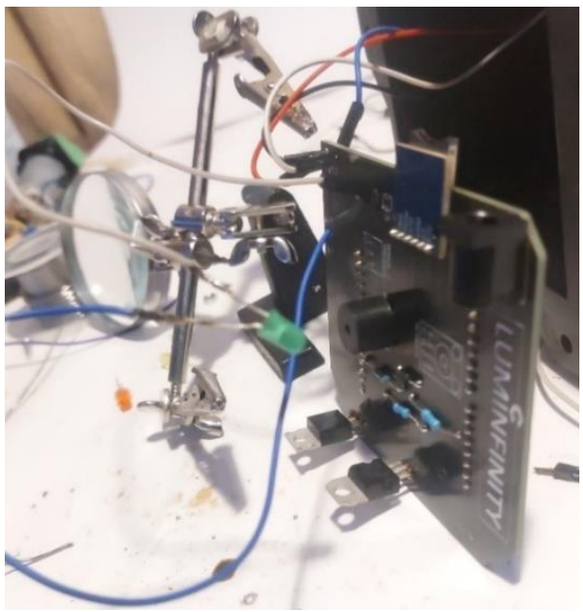

Figure 5

PCB of the Dispenser During the Soldering Process.

In Figure 6, most of the components are already soldered, allowing for a better view of how the I2C adapter is connected to the LCD screen and the distribution of components on the board. It also shows how the PCB is mounted on the Arduino UNO, achieving the connection through headers soldered to the PCB.

Box 6

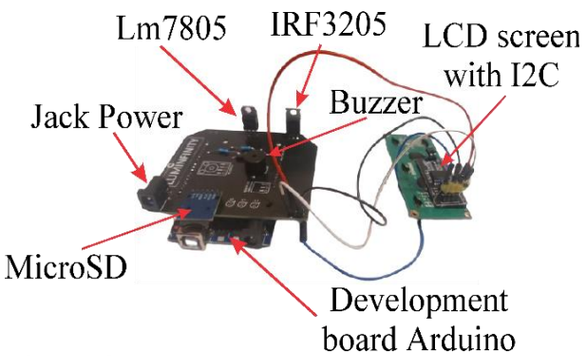

Figure 6

Components That Make Up the System's PCB and LCD Connection via I2C.

Figure 7 illustrates the internal operation of the peristaltic motor and its components. In the upper left part, the liquid inlet is connected to a plastic tube. Thanks to the rotation of the motor and the movement of the roller, a vacuum is generated in the tube that sucks the gel and transports it to the outlet located in the upper right part.

Box 7

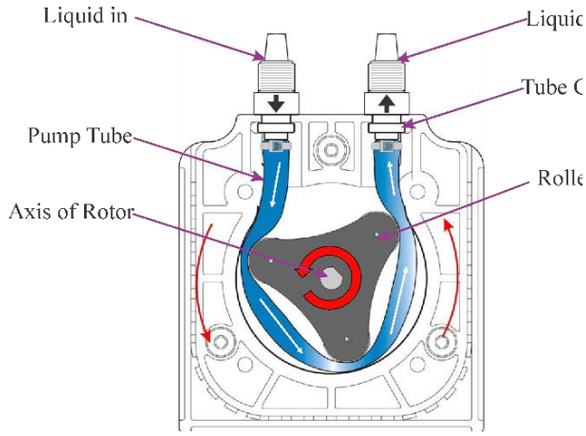

Figure 7

Internal Structure of the Peristaltic Motor

The following describes the external parts of the peristaltic motor. The power pins, the liquid inlet and outlet connected to a tube and an adapter, the metal housing of the motor, and the plastic housing of the peristaltic motor can be observed, as shown in Figure 8.

Box 8

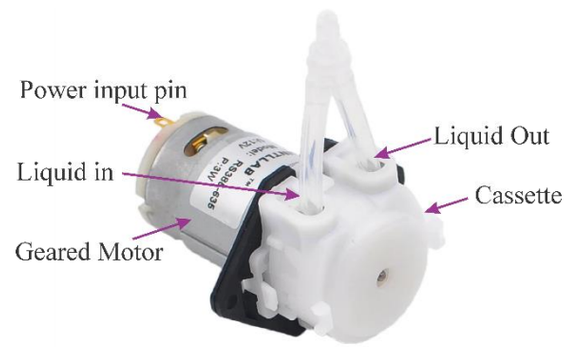

Figure 8

External Parts of the Peristaltic Motor

Results

The image shows the distribution of peripheral components related to temperature measurement and gel dispensing within the dispenser housing.

The design was based on the familiar use of commercial gel dispensers, where one typically places their hand underneath and waits for the presence sensors to detect and activate the system. However, by adding a third element, the temperature sensor, it was necessary to ensure that the sensor measured the warmest part of the hand, i.e., the palm. The sensor is positioned as shown in Figure 9.

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Box 9

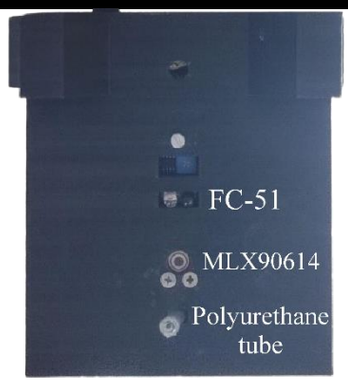

Figure 9
Bottom View of the Dispenser XXI Housing

Here, the 3D model of the housing is shown, designed in Fusion 360 with the license provided by UNAM, and the 3D printed model as seen in Figure 10.

The distribution of components within the housing is observed, including the spaces allocated for the LCD screen and the traffic light LEDs on the front. At the top, there is space for the peristaltic motor and the coupler for the gel bottle. On the sides, the "wings" with screw holes are highlighted, allowing the dispenser to be mounted on the wall.

Box 10

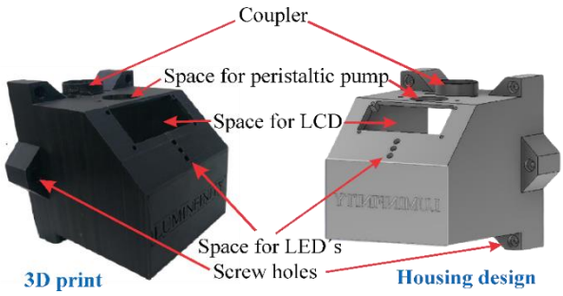

Figure 10
Parts of the Dispenser Housing

Figure 11 presents the flowchart designed for the coding in the Arduino Sketch for the so-called Dispenser XXI. The flowchart includes the declarations of the most important pins in the system.

Next, the conditions for reading and storing data on the SD card are shown. Subsequently, the conditions that determine the behavior of the dispenser based on the detected temperature are described, including the screens corresponding to each case and the activation of the motor to dispense gel. Finally, the system returns to the waiting welcome screen.

Box 11

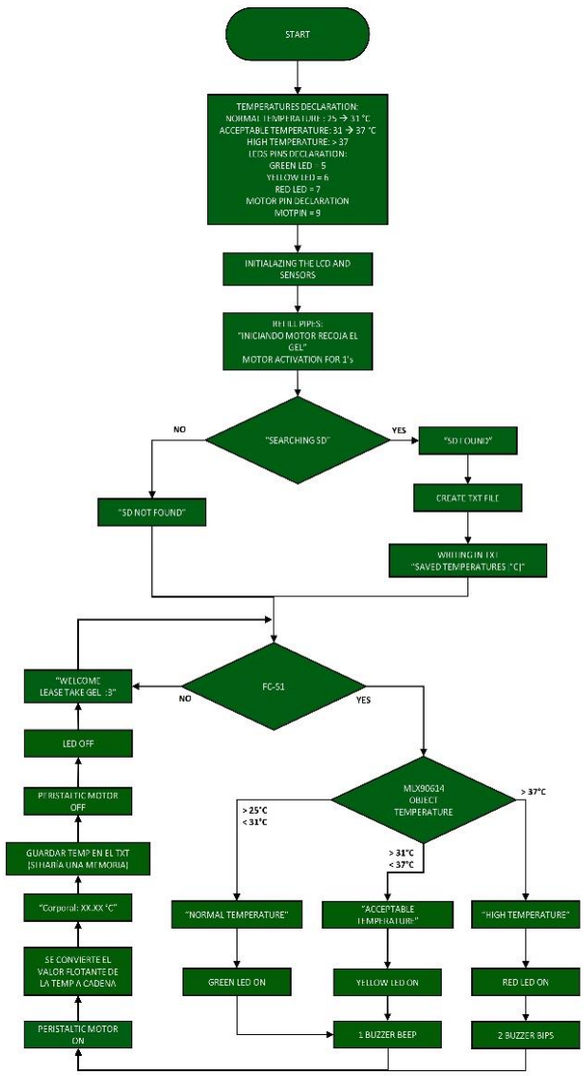

Figure 11
Flowchart of the XXI System Operation

Figure 12 provides a closer look at the distribution of components in the sampling area. The 16x2 LCD screen is secured to the housing using four screws and nuts that fit perfectly with the holes in its board. The green, yellow, and red LEDs, which indicate body temperature, are also present. Each LED is assigned to a specific temperature range and is activated according to the temperature detected by the sensor.

Utilizing the adapters for the peristaltic motor tube, an SMC brand polyurethane tube, model TU0604C, was used to transport the gel from the bottle to the motor and from the motor to the gel outlet for dispensing.

The tube gauge is 4 mm, and a total of 30 cm was used: 10 cm from the bottle to the motor and 20 cm from the motor to the outlet.

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Box 12

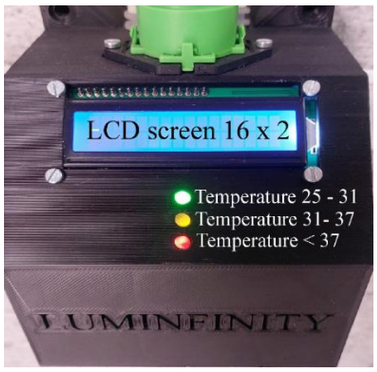

Figura 12

Sampling Area of the XXI Dispenser and Temperature Ranges Corresponding to Each LED

The antibacterial gel dispenser shown in Figure 13, equipped with a temperature measurement system, is installed at the entrance of the laboratory. As people enter the laboratory, the device automatically takes their temperature and dispenses antibacterial gel.

This system has been fundamental in maintaining strict hygiene control within the facilities, allowing for the early detection of students and visitors with symptoms of illness. Its use has been so significant that the gel container has required refilling over the past three months. During this period, approximately 1,200 people have used this system to record their temperature, demonstrating the effectiveness and high demand of the XXI dispenser in our work environment.

Box 13

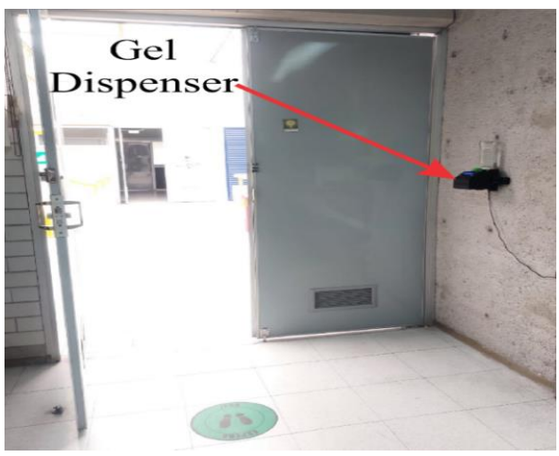

Figure 13

Dispenser XXI Installed and Operated in the Measurement and Instrumentation Laboratory of FES Aragón UNAM

The XXI Dispenser system includes a detailed organization of its parts, both internally and externally. In the front and rear views, it can be seen how the gel container is connected via a tube to the peristaltic pump, LCD screen, LED traffic light, housing, polyurethane tube, printed circuit board, Arduino UNO development board, MLX90614 infrared thermometer, and FC-51 proximity sensor, facilitating the continuous flow of gel to the dispensing mechanism. Additionally, the interconnection between the detection and gel dispensing system peripherals and the sampling area is observed.

This interaction is essential for the coordinated operation of the device and is managed through an electronic board linked to the Arduino UNO, as shown in Figure 13. This arrangement allows for the effective integration of all dispenser functions, ensuring precise and reliable operation.

Box 14

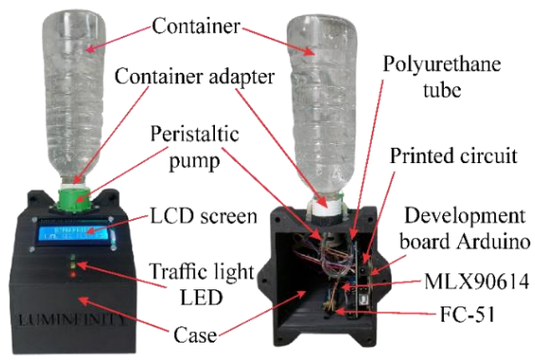

Figure 14

Front (Left) and Rear (Right) View of the Dispenser

Figure 15 presents images of users interacting with the XXI Dispenser in the Laboratory.

Thanks to these sessions, it was possible to collect and store temperature data for subsequent analysis. These data allowed for the graphing and visualization of the recorded temperatures' behavior and the performance of statistical analyses.

From these analyses, average temperature values were determined and programmed into the device to establish appropriate temperature ranges. Additionally, a specific test was conducted to evaluate the sensor's accuracy at different distances.

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Placing the hand at a distance of seven centimeters where the sensor began to detect temperature, a variation of 1.39 °C was detected.

This result was compared with measurements obtained using a mercury thermometer to validate the accuracy of the MLX90614 sensor.

Box 15

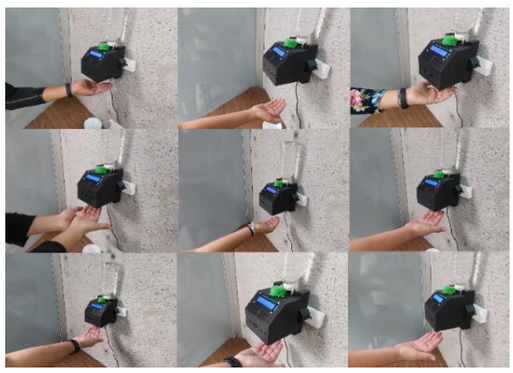

Figure 15

Students and Staff Who Have Used the Dispenser XXI in the Measurement and Instrumentation Laboratory of the Technological Center Aragón

In Table 1, the statistical data from the graph in Figure 16 is shown, which records the behavior of hand temperature measurement at distances between 0 cm and 10 cm. It was detected that at distances from 7.1 cm to 10 cm, the sensor fails to measure the hand's temperature.

To verify this behavior, several measurements were taken, of which three samples are presented, showing consistent behavior.

Box 17

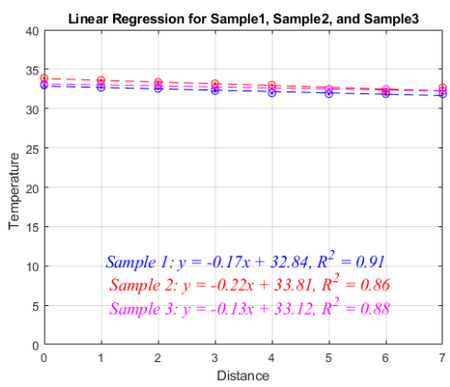

Figure 16

Behavior of the linear regression of the MLX90614 sensor measurements

The data was collected from students of both genders entering the laboratory. These data, shown in Graph 16, were recorded by the gel dispenser named Dispensador XXI. The microSD memory was extracted to visualize the data graphically.

The observed behavior indicates that the MLX90614 sensor shows a difference of at least three degrees Celsius, suggesting the need to adjust it to accurately detect febrile temperatures. This device also includes a buzzer that emits an audible alert if a high temperature is detected.

Box 16

Table 1

Statistical data of the MLX90614 sensor readings.

	Sample 1	Sample 2	Sample 3
mean	32.248	33.91	32.678
median	32.115	34.075	32.54
std	0.43236	0.75895	0.32884
var	0.18694	0.576	0.10814
range	1.12	2.21	0.84

Figure 16 shows the graph that visualizes temperature detection with the MLX90614 sensor. The data comes from students entering the laboratory. Before taking their temperature, they were asked to stay in the laboratory for at least 10 minutes to avoid measurement variations.

This precaution was taken because some students might have arrived after walking in the sun or carrying objects in their hands that could alter the measurements.

Box 18

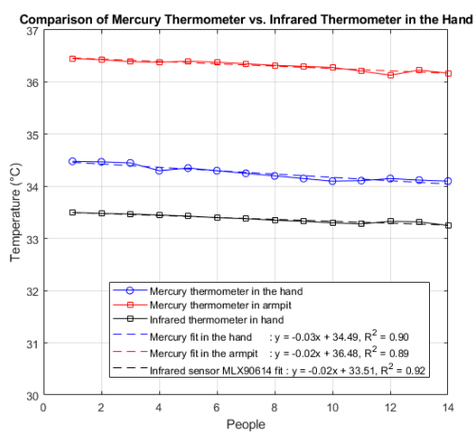

Figure 17

Behavior of the linear regression of the temperature measurements with the MLX90614 sensor for students entering the laboratory

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Conclusions

This study describes the development and implementation of a gel dispenser with an LED traffic light, specifically designed for early fever detection and to promote hand hygiene in public spaces.

Utilizing the MLX90614 infrared temperature sensor, the device has proven highly effective in identifying febrile temperatures. The functionality of the LED traffic light, which changes color based on the detected temperature, allows for direct and effective communication of health status to users, which is essential for controlling the spread of infectious diseases in crowded environments.

The automatic antibacterial gel dispenser not only promotes proper hand hygiene but also contributes to water conservation, offering a sustainable solution amid water scarcity exacerbated by high temperatures. This innovation has been successfully implemented in the Measurement and Instrumentation Laboratory at the Aragón Technological Center of the National Autonomous University of Mexico, where it has received positive feedback and shown significant impact in preventing disease transmission.

Initially designed in response to the COVID-19 pandemic, the dispenser highlights the importance of technological innovation in combating pandemics. Additionally, it stands out for its cost-effectiveness compared to other market options, offering an affordable approach to public health.

To expand the utility of this device, the integration of IoT technology is proposed, which would allow for remote monitoring of health statistics and dispenser usage, thereby broadening its applicability.

Furthermore, it is recommended to test and adapt the dispenser in a variety of public environments, such as shopping centers, hospitals, and transportation systems, to evaluate its effectiveness and acceptance in different contexts.

It is essential to conduct a longitudinal study to determine the actual impact of the device on the reduction of infectious disease transmission in the short and medium term.

The adoption of this type of technology could not only play a crucial role in preventing future pandemics but also promote continuous improvement of public health measures in crowded spaces.

Annexes

Code in C language for programming the development board of the Gel dispenser.

```
#include <Adafruit_MLX90614.h>
#include <LCDIC2.h>
#include <SD.h>
//////////////////////////////////////////////
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
LCDIC2 lcd(0x27, 16, 2);
File myFile;
//////////////////////////////////////////////
byte MOTPIN = 9; //false=0FF 9=ON(pin)
byte BZ = 8; //false=0FF 8=ON(pin)
byte LUZ = 1; //LOW(0) - HIGH(1)

const int TBAJ = 25; //°C
const int TMED = 31; //°C
const int TALT = 37; //°C
const int TMPRELL = 5000; //ms
const int TMSERV = 3000; //ms
const int TESP = 3000; //ms

byte sensorPin = 3;
byte AZ = 5;
byte AM = 6;
byte RJ = 7;
//////////////////////////////////////////////
String TEMPERATURAS(float, String);
String TEMP;
String
floatToString(float,int=8,int=2,boolean=true);
String TO;
void GUARDARTEMPS();
//////////////////////////////////////////////
void setup()
{
  Serial.begin(9600);
  //-------PANTALLAS DE PRESENTACIÓN
  MENSAJESDEINICIO();
  //-------LEDS Y BUZZER
  INICIALIZARINDICADORES();
  //-------MOTOR PARA RELLENAR EL TUBO DE GEL
(SE QUITARÁ O COMENTARÁ CON EL NUEVO
DISPENSADOR DEPENDIENDO LA VRSIÓN)
  RELLENARGEL();
  //-------SECCIÓN DONDE SE INICIA EL MLX90614
Y EL SENSOR DE OSTÁCULOS
  INICIARSENSORES();

  //-------SECCIÓN DONDE SE VE SI HAY O NO
MEMORIA SD
  INICIARSD();
}
void loop()
{
  float obj = mlx.readObjectTempC();

  String TO;
  String TEMP;
//////////////////////////////////////////////
  int value = digitalRead(sensorPin);
```

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```
  while (value == 1)
  {
    lcd.setCursor(3,0);
    lcd.print("BIENVENIDO");
    lcd.setCursor(0,1);
    lcd.print("TOME GEL PLIS :3");

    delay(1000);

    return;
  }
////////////////////////////////////////////
  //TEMPERATURA DEL OBJETO EN MONITOR SERIAL
  Serial.print(F("Temperatura:"));
  Serial.print(obj);
  Serial.println(F("°C"));

  //Regreso al While si la temperatura es
menor a TBAJ
  if (obj < TBAJ)
  {
    lcd.setCursor(3,0);
    lcd.print("BIENVENIDO");
    lcd.setCursor(0,1);
    lcd.print("TOME GEL PLIS :3");

    return;
  }

  //TIPO DE TEMPERATURA, LEDS Y BUZZER
  TEMP = lcd.print(TEMPERATURAS(obj,TEMP));

  //ENCENDER MOTOR
  digitalWrite(MOTPIN, 1);

  lcd.setCursor(4,1);
  //CONVERSIÓN DE TEMPERATURA FLOAT A CADENA
PARA EL LCD
  TO = lcd.print(floatToString(obj,0));
  lcd.print(0337);
  lcd.print("C");

  //-------GUARDADO DE TEMPERATURAS EN LA SD
  GUARDARTEMPS(float(obj));

  delay(TMSERV);
  lcd.clear();

  //APAGAR MOTOR
  digitalWrite(MOTPIN, 0);

  //INTERMEDIO
  lcd.setCursor(1,0);
  lcd.print("RETIRE LA MANO");
  delay(TESP);
  lcd.clear();
  lcd.setCursor(5,1);
  lcd.print("ESPERE");
  delay(TESP);
  lcd.clear();
}
////////////////////////////////////////////
//MENSAJES DE INICIO EN OBJETOS
void MENSAJESDEINICIO()
{
  lcd.begin();
  lcd.setBackLight(LUZ);
  lcd.clear();
  Serial.println(F("-------------------------
--------"));
  Serial.println(F(" "));
  Serial.println(F("UNIVERSIDAD NACIONAL
AUTÓNOMA DE MÉXICO"));
  Serial.println(F("FACULTAD DE ESTUDIOS
SUPERIORES ARAGÓN"));
  Serial.println(F("CENTRO TECNOLÓGICO
ARAGÓN"));
  Serial.println(F("LABORATORIO DE MEDICIÓN E
INSTRUMENTACIÓN"));
  Serial.println(F("LUMINFINITY BIOMEDICS"));
  Serial.println(F("LUIS (MILAN) EDUARDO
FERNANDEZ ACOSTA"));
  Serial.println(F("DISPENSADOR XXI"));
  Serial.println(F(" "));
  lcd.setCursor(6,0);
  lcd.print("UNAM");
  lcd.setCursor(3,1);
  lcd.print("FES ARAGON");
  delay(2500);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("CTEC ARAGON");
  lcd.setCursor(1,1);
  lcd.print("LAB MED E INST");
  delay(2500);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("LUMINFINITY");
  lcd.setCursor(3,1);
  lcd.print("BIOMEDICS");
  delay(2500);
  lcd.clear();
  lcd.setCursor(5,0);
  lcd.print("LEFDZA");
  lcd.setCursor(5,1);
  lcd.print("MILAN");
  delay(2500);
  lcd.clear();
  lcd.setCursor(2,0);
  lcd.print("DISPENSADOR");
  lcd.setCursor(6,1);
  lcd.print("XXI");
  delay(2500);
  lcd.clear();
}
////////////////////////////////////////////
//INICIALIZAR INDICADORES
void INICIALIZARINDICADORES()
{
  //-------LEDS
  for(uint8_t i=0; i<3; i++)
  {
    digitalWrite(AZ, 1);
    digitalWrite(AM, 1);
    digitalWrite(RJ, 1);
    delay(1000);
    digitalWrite(AZ, 0);
    digitalWrite(AM, 0);
    digitalWrite(RJ, 0);
    delay(500);
  }
  //-------BUZZER
  pinMode(BZ, OUTPUT);
  digitalWrite(BZ, 1);
  delay(250);
  digitalWrite(BZ, 0);
  delay(2500);
}
////////////////////////////////////////////
//RELLENAR TUBO DE GEL
void RELLENARGEL()
{
  //-------MOTOR
  pinMode(MOTPIN, OUTPUT);

  lcd.clear();
```

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```
  lcd.setCursor(0,0);
  lcd.print("INICIANDO  MOTOR");
  lcd.setCursor(1,1);
  lcd.print("RECOJA EL GEL");
  delay(2500);
  digitalWrite(MOTPIN, 1);
  delay(TMPRELL);
  digitalWrite(MOTPIN, 0);
  delay(2500);

  lcd.clear();
}
//////////////////////////////////////////
//INICIALIZAR SENSOR DE TEMP Y DE PRESENCIA
void INICIARSENSORES()
{
  //--------SENSOR DE PRESENCIA
  pinMode(sensorPin, INPUT);

  //-------SENSOR DE TEMPERATURA
  mlx.begin();
}
//////////////////////////////////////////
//INICIAR MEMORIA SD
void INICIARSD()
{
  //-------MEMORIA SD
  lcd.setCursor(2,0);
  lcd.print("BUSCANDO SD");

  delay(2500);
  lcd.clear();
  if(!SD.begin(4))//ver si hay una sd
conectada
  {
    lcd.setCursor(1,0);
    lcd.print("SIN MEMORIA SD");
    delay(2500);
    lcd.clear();
  }
  else
  {
    lcd.setCursor(2,1);
    lcd.print("SD DETECTADA");
    myFile =
SD.open("archivo.txt",FILE_WRITE);
    myFile.println("TEMPERATURAS GURADADAS
[°C]:");
    myFile.close();

    delay(2500);
    lcd.clear();
  }
}
//////////////////////////////////////////
//CONDICIONALES DE TEMPERATURAS
String TEMPERATURAS(float obj, String TEMPE)
{
  lcd.clear();

  if (obj > TBAJ && obj < TMED)
  {
    TEMP = "  TEMP NORMAL";
    digitalWrite(AZ, 1);
    delay(250);
    digitalWrite(AZ, 0);
  }
  else if (obj > TMED && obj < TALT)
  {
    TEMP = "TEMP ACEPTABLE";
    digitalWrite(AM, 1);
    delay(250);
    digitalWrite(AM, 0);
  }
  else if (obj > TALT)
  {
    TEMP = "   TEMP ALTA";
    digitalWrite(RJ, 1);
    delay(250);
    digitalWrite(RJ, 0);
  }
  digitalWrite(BZ, 1);
  delay(250);
  digitalWrite(BZ, 0);
  return TEMP;
}
//////////////////////////////////////////
//GURDAR TEMPERATURAS
void GUARDARTEMPS(float obj)
{
  myFile = SD.open("archivo.txt", FILE_WRITE);
//abrir el archivo
  Serial.println("GUARDANDO EN LA MEMORIA");
  Serial.println("  ");
  myFile.print(obj);
  myFile.println(" ");
  myFile.close();
}
//////////////////////////////////////////
//CONVERSIÓN DE LAS TEMPERATURAS
String floatToString(float obj, int l, int d2,
boolean z)
{
  d2 = 2; //Decimales
  char g[l+1]; //Numero entero mas el punto
  String p;
  dtostrf(obj,l,d2,g);
  TO = String(g);
  return TO;
}
```

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Declarations

Conflict of interest

The authors declare that they have no conflicts of interest.

They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

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Author contribution

González-Galindo Edgar Alfredo: Contributed to the main idea of the project and the implementation of the methodology for early fever detection using a gel dispenser with an LED traffic light. Supervised the development of the prototype and the integration of the MLX90614 temperature sensors and the FC-51 proximity sensor.

Fernández-Acosta Luis Eduardo: Specialized in the design of the electronic circuit and the programming of the Arduino UNO, integrating the MLX90614 infrared temperature sensor and the FC-51 proximity sensor. Also developed the data storage system on the MicroSD card and configured the LCD screen to display fever temperature information.

Juárez-Gutiérrez, José de Jesús: Responsible for the physical assembly of the prototype, including the mounting of components and soldering on the PCB. Led the prototype testing process in different environments to validate its functionality and effectiveness, as well as the temperature data analysis. Additionally, contributed to the writing of the methodology and results sections of the article.

Domínguez-Romero Francisco Javier: In charge of the design and development of the test card system for power supply management of the device, including the management of the peristaltic motor. Also contributed to the schematic diagram of the circuit and the soldering of components on the PCB.

Availability of data and materials

The data for this research is available according to the sources consulted.

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Abbreviations

AC (Alternating Current)
DC (Direct Current)
PIR (Passive Infra Red)
PCB (Printed Circuit Board)
SD (Secure Digital)
SARS CoV2 (Severe Acute Respiratory Syndrome Coronavirus 2)
PWM (Pulse Width Modulated)
LCD (Liquid Cristal Display)
I2C (Inter-Integrated Circuit)
SCL (Serial Data)
SDA (Serial Clock)
MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor)
THT (Througth-Hole Tecnology)
VDS (Drain-Source Voltage)
VGS (Gate-Source Voltage)
ID (Drain Current)
PD (Power Disipation)

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Article

An overview occupational encroachment in the health sciences. Based on teachers' perceptions in Mexico

Una visión general del intrusismo laboral en las ciencias de la salud. Basado en las percepciones de los profesores en México

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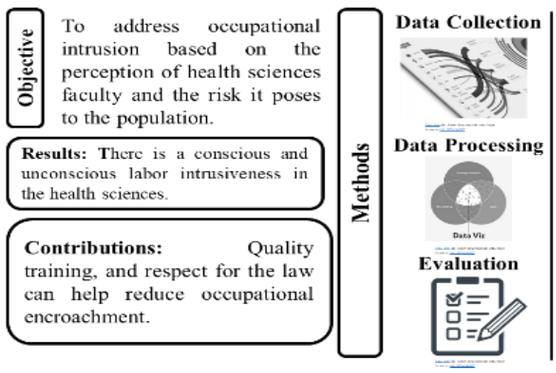
Abstract

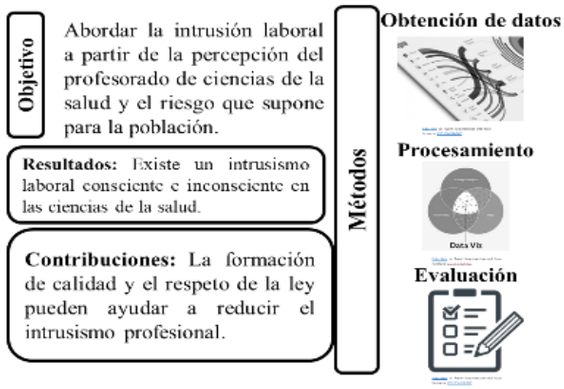
No one should be harmed while receiving health care, yet globally, at least five patients die every minute due to unsafe care. This study addresses the role of occupational encroachment based on the perception of health science faculty and the risk it poses to the population. It combines descriptive analysis with qualitative analysis of interpretative and semantic phenomenological observation. Involving 164 professionals in medicine, orthopaedics, psychology, and physiotherapy, the study argues that there is conscious and unconscious occupational encroachment in the health sciences. The characteristics most related to occupational encroachment were poor professional relationships (108 responses) and acts "outside the law" (84 responses). Professionals identify educational (68), professional (108), and social (60) factors as contributing to this issue. The study highlights that communication, quality training, and respect for the law can help reduce occupational encroachment, emphasizing the importance of ethical training in the health sciences to protect patient safety.



Education, Occupational encroachment, Ethics

Resumen

Nadie debería resultar perjudicado al recibir atención médica, pero globalmente, al menos cinco pacientes mueren cada minuto debido a cuidados inseguros. Este estudio analiza el intrusismo laboral en las ciencias de la salud según la percepción del profesorado y el riesgo que representa para la población. Combina análisis descriptivo y cualitativo de observación fenomenológica interpretativa y semántica, involucrando a 164 profesionales en medicina, ortopedia, psicología y fisioterapia. El estudio sostiene que hay intrusismo laboral consciente e inconsciente en las ciencias de la salud, relacionado con malas relaciones profesionales (108 respuestas) y actos "fuera de la ley" (84). Los profesionales identifican factores educativos (68), profesionales (108) y sociales (60) como contribuyentes a este problema. Destaca que la comunicación, la formación de calidad y el respeto por la ley pueden reducir el intrusismo laboral, subrayando la importancia de la formación ética para proteger la seguridad del paciente.



Educación, Intrusismo laboral, Ética

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Introduction

In May 2019, the 72nd World Health Assembly mandated that World Patient Safety Day be observed every September 17 (World Health Organization, 2019a), in response to the analysis of the millions of people who are affected each year by unsafe medical care around the world, causing 2.6 million deaths per year in developing countries alone. No one should be harmed while receiving health care, yet globally, at least five patients die every minute due to unsafe care (World Health Organization, 2019b) Among the causes, lack of care by professionals, incorrect medication or wrong doses are mentioned (World Health Organization, 2019a). However, we seem to lose sight of another, the recurrent intrusion of professionals who act in competencies that do not correspond to them and who, due to lack of preparation or knowledge, put people's health at risk.

It can be pointed out that there are already antecedents on the health risk caused by occupational encroachment, Ortiz J, Quintán J, and Armengol-Miró JR (Ortiz et al., 2006) describe it in their discussion on the health risk of occupational encroachment in sedation as acting among physicians.

(Falcón Romero & Luna Maldonado, 2006), also mention occupational encroachment as a danger in tourism areas, where it puts health at risk. In addition, Jiménez S.; García S.; Mingo M. and Ceballos L. (Jiménez et al., 2017) clearly mention the risks of intrusion in physical therapy, while Wuest, J; Ford-Gilboe, M; Merritt-Gray, M. and Berman, H. (Wuest et al., 2003) study the basic social problem of intrusion and the implications for the knowledge and practice of health promotion.

One thing is clear, they are not the only health professions impacted by such behavior; medicine (Araujo-Cuauro, 2022), forensic and legal (Checa, 2010), nutrition (González, 2003) and psychology (Solf, 2022), are among other professions that also suffer from it.

Checa M. (Checa, 2010) retakes in Art. 403 of the current Penal Code of Spain, which establishes that, whoever exercises acts proper of a profession without possessing the corresponding academic degree issued or recognized, will incur a penalty of six to twelve months.

If the professional activity carried out requires an official degree that accredits the necessary training and legally qualifies for its exercise, and if he/she does not have such a degree, a fine of three to five months will be imposed, establishing some sanction for such behaviour.

It should be noted that, beyond a culture of health care that has existed since the past (Guzmán-Gutiérrez et al., 2023; Tybjerg, 2022; Viniegra-Velázquez, 2020) including traditional medicine (Youn et al., 2023; Zafra et al., 2016) or medicine based on herbalism (Fu-Shuang & Jing-Ke, 2017; Husain & Wahidah, 2018), as well as the care of midwives (Lori et al., 2013; Sarmiento et al., 2021) or healers (Nortje et al., 2016), who by custom or out of necessity (Buranbaeva et al., 2013), have dedicated themselves to the provision of these services, transdisciplinary (Thompson, 2014) between empirical and modern medicine (Yuan et al., 2016), including the digital era (Cao et al., 2022), does not excuse the intervention of professionals who act with low ethical conduct in the care, diagnosis and prescription of health procedures outside their profession.

In this sense, Vincent K. Kopp, (2023) states it emphatically with the 16 duties of medical ethics of Rhodes R. (Rhodes, 2020, 2022) author who stands out for her work on this subject. It should be noted that from our perspective they are applicable to any health science.

Moreover, it is true that intrusion is not an occurrence on the part of professionals; countries such as Spain, Argentina, Chile, and Mexico (Corteggiano & González, 2019; Suárez-López, 2012), have been talking about this problem for more than a decade.

Therefore, it is important to reach a consensus on the definition of occupational encroachment, so that professionals from different countries and the different health sciences professions can understand the risk that this poses to the population, and to propose strategies for university education to prevent such behavior and to work on public policies that help to prevent health professionals from engaging in intrusive behavior.

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The objective of the study was to analyse the perception of professional teachers in health sciences in Mexico on occupational encroachment and the risk to the health of the population that it represents.

Materials and methods

A combination of quantitative descriptive analysis and a qualitative analysis of interpretative and semantic phenomenological observation was carried out to interpret the comments made by the health professionals who participated in the study.

For the development of the study, an instrument was established where health professionals were questioned about the professional competences of their area and their actions in different situations where they had to recognize the professional competences of their profession. Multiple-choice and open-ended questions were used.

The instrument was validated with Aiken V. (Aiken et al., 2008; Robles, 2018) as other authors have done, see equation 1, (Anculle-Arauco et al., 2022; Balaguer López et al., 2022)

$$V = \frac{\bar{X} - l}{k} \quad (1)$$

Where V is Aiken's coefficient, $\bar{X}$ average of all judges' scores, l is Minimum grade, and k is the subtraction of the maximum grade minus the minimum grade ratings for each item were organized and analysed using Aiken's V coefficient (Penfield & Giacobbi, 2004), the results of which are shown in Table 1.

In addition, the same calculation was performed for the overall satisfaction of the instrument, yielding an Aiken V for satisfaction of 0.95.

Box 1

Table 1

Instrument validation according to the score given by experts

Evaluated item	Evaluation indicator	Average	E.D.	Aiken´s V
1	Relevance	2,80	0,75	0,60
	Content	3,60	0,49	0,86
2	Relevance	4,00	0,00	1,00
	Content	4,00	0,00	1,00
3	Relevance	4,00	0,00	1,00
	Content	4,00	0,00	1,00
4	Relevance	3,80	0,40	0,93
	Content	3,80	0,40	0,93
5	Relevance	4,00	0,00	1,00
	Content	3,80	0,40	0,93
6	Relevance	4,00	0,00	1,00
	Content	4,00	0,00	1,00
7	Relevance	4,00	0,00	1,00
	Content	4,00	0,00	1,00
8	Relevance	4,00	0,00	1,00
	Content	4,00	0,00	1,00
9	Relevance	4,00	0,00	1,00
	Content	3,80	0,40	0,93
10	Relevance	4,00	0,00	1,00
	Content	3,60	0,49	0,86
11	Relevance	3,80	0,40	0,93
	Content	4,00	0,00	1,00
12	Relevance	4,00	0,00	1,00
	Content	3,60	0,80	0,86
Total, Scale	Relevance	4,00	0,00	1,00
	Content	4,00	0,00	1,00
	Satisfaction	4,80	0,40	0,95

Source: own elaboration

The instrument has been sent through four media social networks, institutional email contacts, WhatsApp, and Telegram from March 1 to 21, 2023. A total of 166 responses were obtained, however, two did not meet the inclusion criteria (Professionals in any area of Health) so they were eliminated leaving a sample of 164 participants with an average age of 32.8 years.

The criteria were:

- Inclusion.
- Professionals in any area of Health.
- Have completed the entire questionnaire.
- Perform health care practice.
- Exclusion.
- Any person who is not a health professional.
- Students or persons who have not graduated.
- Health professionals who do not practice their profession in clinical care.
- Elimination.
- Non-health care professionals.

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- Not having completed the questionnaire.
- Notification of desire to no longer participate in the research.

Figure 1 shows that the participation of health professionals' teachers´ is diversified, the personnel with the highest participation is 39 by medicine (24%), followed by 31 ortho-prosthetists (19%), 30 psychology (18%) and 28 physiotherapists (17%), these were followed by 6 other professions reflecting the interest and commitment of these professionals with the topic addressed.

Box 2

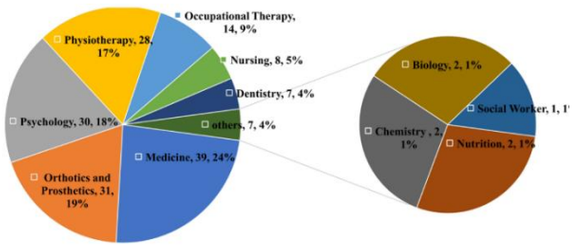

Figure 1
Professions Participants
Source: own elaboration

Results and discussion

According to the questions that were used through the instrument and after a descriptive analysis and content coding, the following information is presented.

Have you ever worked or collaborated with other health personnel outside your own profession? 96 of the participants collaborate interprofessional on a frequent basis, while 58 of them do so sometimes. 7%, equivalent to 10 people, commented that they have never worked interprofessional.

Do you consider the collaboration of other professionals necessary for the comprehensive care of your patients? 98% of them consider it necessary to maintain interprofessional collaboration, which indicates that most of them recognize the importance of bringing together the knowledge and skills of different professionals to provide more complete and effective care.

Only 2% of respondents believe that such collaboration is likely.

Three characteristics were presented as the most important in interprofessional work. Accordingly, 67 participants consider collaborative work to be the most important characteristic, 65 emphasize that communication is the most important, while the 32 participants consider that the most important thing is to respect professional roles.

Which competencies should be part of your professional performance?

Box 3

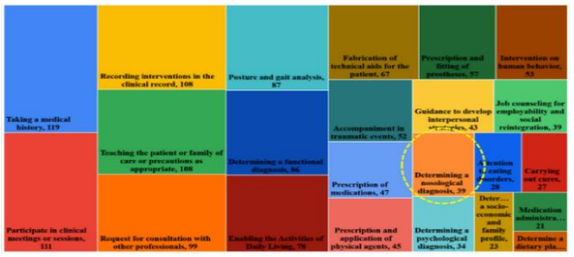

Figure 2
Competencies according to each profession
Source: own elaboration

Figure 2 shows the interaction that health professionals understand as part of their competencies. 72.5% of the participants recognize as part of their competencies the taking of a clinical history in accordance with their profession; 67.6% consider that they should participate in clinical sessions; 65.8% recognize that it is part of their profession to record their interventions in clinical notes and to teach patients; the fifth most recognized competency is that of requesting anticommutations from other professionals.

These competencies share the quality of being transversal, activities that all health professionals should perform, so they should be competencies recognized by 100% of the participants, however, this was not the case, another thing that was observed is that with the exception of one competency, all had a large number of occupational encroachment, for example, only two nutritionists participated in the survey, however, 11 participants recognized that "determining a food plan according to the needs" is part of their work. The only competency recognized and respected by the professional who must perform it is "Determining a nosologically diagnosis", which was respected by all professions related to medicine and indicated by the physicians who participated as shown in the yellow circle in the Figure.

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Two open-ended questions are presented below, for which the following strategy was used. Semantic and Interpretative Phenomenological. For the qualitative analysis, the MAXQDA Analytics software was used, which allows the creation of a content coding and provides a record that allows the testimonies to be converted into a citable reference by presenting them in the order of the following formula.

Citation = Testimony (Colour of Code; Name of code; > subcode; Item or question of the instrument; Position of the comment; Date and time of the creation of the Code; area of belonging in the document; percentage weight of the testimony in the analysed document)

In the first question, "from your professional perspective, describe what occupational encroachment is", we found a frequency (*fi*) (number of testimonies, comments, or related words in each semantic field of the instrument) of 222 comments that could be coded in three semantic fields or cohesive chains and from each of these three sub-codes emerged according to figure 3.

Box 4

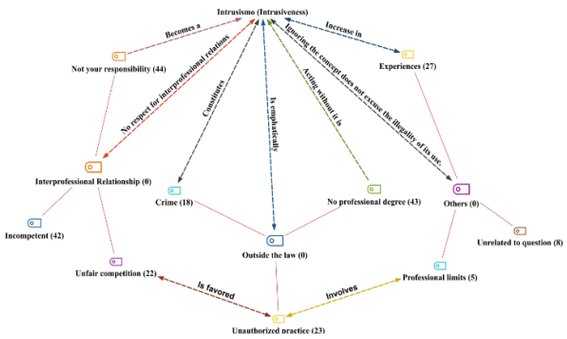

Figure 3

Semantic codes/fields

Source: own elaboration

Interprofessional relationship:

a. Not within your competence (professional education).
b. You are not competent/incompetent.
c. Unfair competition (competing).

Outside the law: Perceptions that consider occupational encroachment as a criminal activity.

a. Crime: When it is considered that it should have legal sanctions.
b. Practice without authorization. Refers to the performance of an activity without legal rights or the authorization.
c. Without professional title means to perform the activity without having the normative credentials.

Other

a. Professional limits. When it is considered that intrusion is not respecting the limits of the profession.
b. Experiences/experiences: These are testimonies about experiences that health professionals lived and considered it occupational encroachment.
c. Unrelated to the question: answers or comments that have no relation to the question or that reflected ignorance of the general topic of the study.

It should be noted that during the analysis of the study, existing relationships between the different semantic fields were revealed (Figure 3), that is to say it is clear that occupational encroachment, seen from different aspects, always converges and somehow disburses between activities that professionals consider inadequate in daily practice.

Among them, they considered that unauthorized practices favour unfair competition as well as implying that professional limits are not respected. Likewise, it was clearly revealed that acting in health areas without a professional title and license is part of occupational encroachment and that it becomes, in a reciprocal and emphatic manner, an activity outside the law, constituting a punishable offense.

Of the three codes organized in the study, Professional Relationship was the representation that obtained the highest *fi* of semantic links with 108, among them stand out interpretations such as covering a professional area that is NOT of my competence or training (Code: ● Interprofessional Relationship > Not of your competence; From your professional perspective; Position: 25 - 25; 26/06/2023 14:25:54; Area: 66; 0.46%).

In second place, "Outside the law" was found with a *fi* of 84 correlated comments, as an example: It is a person who without having a legal document accrediting the profession, practices it (Code: ● outside the law > Without professional title; 26/06/2023; 17:00:47; Area: 83; 0.56%).

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"Other", was the code that presented the least with a *f*i of 40 relations, in this one were identified comments such as Is a Person who profits professionally (Code: ● Other > Unrelated to the question; Position: 106 - 106; 26/06/2023; 16:41:11; Area: 41; 0.29%), some experiences for phenomenological analysis were It is something very risky in the habit of health because we put at risk the human being who is our core work (Code: ● Other > Experiences; Position: 4 - 4; 6/06/2023; 17:25:33; Area: 115; 0.81%). It can also be observed in (Figure 4), other examples about perceptions, as well as their frequencies represented with linking lines (the higher the *f*i the greater the linking thickness). According to this, not your competence with *f*i = 44, Not having a degree with *f*i = 43 and Incompetent or without knowledge with *f*i = 42 were the semantic fields that for the health professionals demonstrate the most what occupational encroachment is.

Box 5

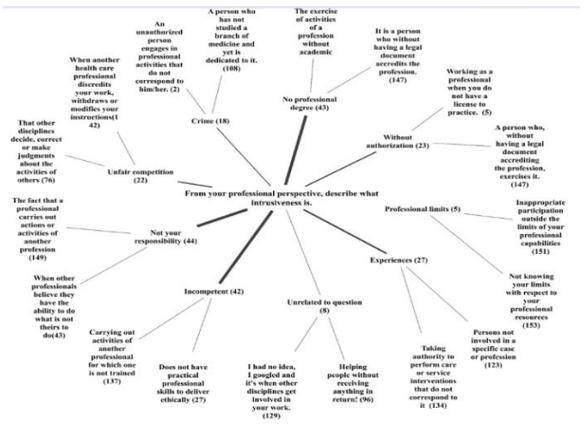

Figure 4

Case model: From your professional perspective, describe what occupational encroachment is.

Source: own elaboration

In your professional practice or workplace have you witnessed any type of occupational encroachment?

86 professionals have ever witnessed occupational encroachment in their areas, while 64 participants have frequently observed it, only 14 considered that they had never witnessed any type of occupational encroachment. For this reason, the question "Do you consider that in your profession there is professional occupational encroachment?" was asked. 99 participants considered that they frequently experience it, 61, only occasionally, and 5 participants considered that there has never been occupational encroachment in their profession.

What do you consider to be the main reason for professional occupational encroachment?

In this case, their results were varied, which induced the creation of six cohesive chains that illustrated the perceptions towards the main reasons for occupational encroachment, however, three of them, Table 2, were the ones that interacted most strongly and stood out as factors causing occupational encroachment.

Box 6

Table 2

Main factors leading to occupational encroachment, testimonials, and frequency. phenomenological analysis

Factors	Testimonial	*Frequency fi*	Reference code
	Educations		
Problem from the institutions	Universities, to have more students, offer preparation with a tendency towards the medical area.	20	Code: ● Educational > Problem from institutions; Position: 55 - 55; 27/06/2023 15:36:45; Area: 98; 0.769775%.
Lack of communication	Non-collaboration with other professionals	25	Code: ● Educational > Lack of communication; Position: 40 - 40; 27/06/2023; 15:15:29; Area: 42; 0.329903%.
Lack of preparation	Lack of knowledge and lack of education, inadequate education, professionalizatio n	23	Code: ● Educational > Lack of preparation; Position: 48 - 48; 27/06/2023 15:29:50; Area: 95; 0.74621%.
	Professionals		
Invasion of activities	Believing to have some minimal knowledge of another career, one would think that one could practice the same career.	29	Code: ● Professionals > Invasion of activities; Position: 113 - 113; 27/06/2023 16:13:04; Area: 100; 0.785484%.
Professional Profile	Lack of understanding of the scope of a discipline	16	Código: ● Professionals > Perfil Profesional; Position: 146 – 146; 27/06/2023 16:37:58; Area: 50; 0.392742%
Roles/Competence	Lack of delimitation of professional competences	20	Code: ● Professionals > Roles/Competence; Position: 26 - 26; 27/06/2023; 15:03:23; Area: 61; 0.479145%
	Social		
By Beliefs	Cultural context of the geographic areas and idiosyncrasies.	24	Code: ● Social > By Beliefs; Position: 19 - 19; 27/06/2023 14:36:22; Area: 58; 0.455581%.
By culture or customs		16	
Ethics	Lack of ethics and morals	20	Code: ● Social > Ethics; Position: 63 - 63; 27/06/2023; 15:43:29; Area: 22; 0.172807%.

Source: own elaboration

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Educational factors related to training and educational preparation, the problem from the institutions and the lack of communication between disciplines, are the characteristics that have caused the most intrusion.

After these, the factors dependent on the professional activity, the lack of knowledge of the professional profile and acting in competencies that are not of the profession cause occupational encroachment and in third place those related to social factors (beliefs, culture or customs of the population), in addition to the lack of ethics in the professional activity are the causes of occupational encroachment. According to this relationship where the frequencies of participation *f*i = 68, *f*i = 65 and *f*i = 60 shown respectively, these are the factors that produce occupational encroachment in the health sciences.

Economic factors such as necessity, cost competition or profit motives with a *f*i = 56, as well as laws and rules regulating the professions or sanctioning wrongdoing with a *f*i = 54. Other reasons such as easy access to training or information in health sciences that only professionals in the field should perform with a *f*i = 31 marks, were the three central factors that did not have such an important appearance.

What action do you consider most important to avoid occupational encroachment? According to the comments made by the participants, 59.1% of the respondents consider that knowing and respecting professional competencies and limits is the best way to combat occupational encroachment. 31.3% believe that creating awareness from professional training is the key to preventing intrusion. 9.6% of respondents highlight the importance of working collaboratively in patient care as a strategy to avoid occupational encroachment.

In general, it is observed that the participation of health professionals was balanced, however, it is important to note that physicians had the highest participation, followed by orthotists-prosthetists, psychologists, physiotherapists, and occupational therapists.

These data indicate that physicians had a greater interest and commitment to the topic addressed, which may be due to their central role in the health field. Orthotists-prosthetists also showed significant participation, reflecting the importance of their work in rehabilitation and the use of medical devices.

The participation of psychologists and physiotherapists was quite similar, as both groups have a strong interest in the topic and an understanding of its relevance in their respective areas of work.

This shows that multidisciplinary, as revealed by Nima Rezaei (Rezaei, 2022) in the work of the health sciences, is transcendental to reduce the risks of patient care that have led the WHO (World Health Organization, 2019a), even to determine one day a year for recognition, several authors demonstrate this in their works such as Kyu-Tae H. et. al. on the importance of multidisciplinary care in post stroke patients (Han et al., 2015).

The practice of medicine and other health professions requires specific technical and scientific knowledge, as well as adequate and certified training (Recognition of Official Validation of Studies (RVOE), 2015).

Lack of experience, knowledge, and skills necessary to perform certain medical procedures puts the health and safety of patients at risk. Health professionals through the study clearly express that occupational encroachment is an act that becomes a serious health risk, as Solft Zarate (Solf, 2022) shows with the intrusion of coaching in the professional work of psychology or Gonzalez L (González, 2003), in the field of nutrition mentions it, among other actions that will always be a health risk, as described by other authors (Jiménez et al., 2017) and has emphatically highlighted during the study.

In addition, the lack of knowledge in specific areas can lead to errors in the administration of medications, the performance of surgical interventions or the interpretation of diagnostic tests, among others.

It is essential that health professionals are properly trained and updated to ensure quality of care and patient safety.

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The concept of occupational encroachment (Daniel, 2004) according to health professionals in Mexico, converge in a very clear way. The study showed that the general perception is of acting in the professional field without a degree and license that evidences their specific training, it is also working without permission, an invasion in acting without being requested (without invitation), which also consents and encourages unfair competition and is a crime that should be punished and punished (Checa, 2010), for example, an individual who poses as a doctor and performs medical treatment without having the proper license. Because of this, its understanding, comprehension and avoid ability by all health professions is important and transcendental for the development of science and the best health care.

Accordingly, the need for equal and conceptually similar communication among health professionals, as demonstrated by several authors (Liu et al., 2021; Valdez et al., 2021; Walker & Sivell, 2022), leads to the need to create policies, spaces, guidelines, and models of multidisciplinary and interprofessional care that make clear what occupational encroachment is and its risks.

Studies such as the one developed by Wilkes M. and Kennedy R (Wilkes & Kennedy, 2017) integrate an important relationship between the reduction of occupational encroachment and an adequate university training, this through the strengthening of teaching with interprofessional actors, incorporating professionals from different areas so that students acquire a multidisciplinary vision.

University training provides the theoretical and practical knowledge necessary to perform adequately in a profession, while providing the acquisition of the necessary skills and competencies, which helps to reduce occupational encroachment, since those who have adequate university training have a greater chance of offering a quality and safe service.

On the other hand, the incorporation of professionals from different areas in university education provides students with a broader and more complete vision of their future profession. This allows them to understand the importance of working in a collaborative and interdisciplinary manner.

The study demonstrates the impact of the training provided by institutions of higher education, particularly in the health sciences, on occupational encroachment, the professionals surveyed, even with the age variability observed, which translates into periods of professional development.

In addition, references (Rhodes, 2020, 2022) are very emphatic in including within her ethical duties of medicine (Health Sciences), that "Overseeing the profession" and "Developing and maintaining professional competence", are two examples that, added to 14 other precepts, demonstrate that there are many professionals interested in the best health care and professional respect among the sciences involved in its delivery.

Each professional has a specific set of knowledge and skills that they bring to the healthcare team, and it is important to recognize and value these differences. According to the study, the best way to combat occupational encroachment is communication, this coincides in an outstanding way with studies such as the one carried out by Martin Padilla, E.; Sarmiento Medina, P. and Ramirez Jaramillo,

A (Martín Padilla et al., 2014), in their work on the incidence of interprofessional communication with the quality of care, besides knowing and respecting professional competences and limits, creating awareness from professional training and working in a collaborative and transdisciplinary way (Thompson, 2014) in patient care. These actions can contribute to quality and safety in health care.

Conclusions

The results obtained in this research are real phenomenological testimonies that allow us to see the dimensions of occupational encroachment, as well as its interaction in all the contexts of the daily life of the population and health professionals.

Interprofessional communication is transcendental for the reduction of occupational encroachment. Its correct application contributes to patient safety and guarantees the quality of care. Likewise, interprofessional communication and respect for professional boundaries are fundamental aspects of quality patient care.

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This study demonstrates the importance of ethical training in the health sciences and that the occupational encroachment competencies constitute a punishable action and represents a serious risk to the safety of the population.

Keywords: Occupational encroachment; Health risk; Health science; Patients; Ethics.

It is necessary that all the actors related to occupational encroachment: government, health and educational institutions, colleges, and professionals, work together to implement and establish policies and regulations on professional competencies, their limits, and sanctions for those who do not respect them.

Declarations

Conflict of interest

The authors declare no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Authors' contribution

Ramírez-Jiménez, Alida: I contribute to the idea of the project and the development of the research.

Salinas-Sánchez, Igor: I contribute to the idea of the project, the development of the research, data analysis, review an editing.

Lara-Aguilar, Susana: I contribute to the development of research, data analysis, review and editing.

Xolalpa-González, Juan-Azael: I contribute to the development of research, review and editing.

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Abbreviations

WHO	World Health Organization
RVOE	Recognition of Official Validation of Studies

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Background

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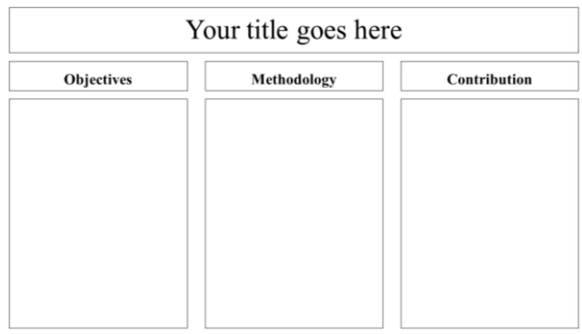

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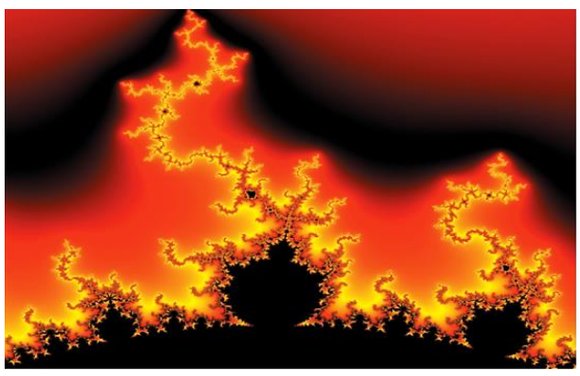

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