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ORIGINAL ARTICLE

Elective course on genetic variability and drug response for medical students

Curso electivo sobre variabilidad genética y respuesta a fármacos para estudiantes de medicina

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ABSTRACT

Introduction: individual genetic variability significantly influences drug response, impacting treatment efficacy and safety.
Objective: to design an elective course for medical students, with the purpose of providing them with a solid foundation on genetic variability and drug response.
Methods: a curriculum development study focused on structuring an elective course on genetic variability and drug response for medical students was carried out. The curriculum development process is based on a systematic approach that includes the following stages: needs analysis, definition of objectives, content selection, content organization, teaching-learning strategies and learning evaluation. The course is aimed at medical students in the last years of their degree, who have already acquired basic knowledge in pharmacology, genetics and internal medicine. It will be implemented as an elective within the curriculum of the Baracoa Medical Sciences Branch.
Results: the course program includes its objective, target audience, duration in hours and rationale. It is structured in four topics with their respective contents to be dealt with. It incorporates the methodology to be followed to teach the content, as well as the evaluation system and the resources and literature to be used.
Conclusions: the elective course will provide medical students with a solid understanding of genetic variability and its impact on drug response and will enable them to acquire the knowledge and skills necessary to apply them in clinical practice.

Keywords: Drugs; Pharmacogenetics; Pharmacogenomics.

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RESUMEN

Introducción: la variabilidad genética individual influye significativamente en la respuesta a los fármacos, impactando la eficacia y seguridad del tratamiento.
Objetivo: diseñar un curso electivo para estudiantes de medicina, con el propósito de brindarles una base sólida sobre variabilidad genética y respuesta a fármacos.
Métodos: se realizó un estudio de desarrollo curricular enfocado en la estructuración de un curso electivo sobre variabilidad genética y respuesta a fármacos para estudiantes de medicina. El proceso de desarrollo curricular se basa en un enfoque sistemático que incluye las siguientes etapas: análisis de necesidades, definición de objetivos, selección de contenidos, organización de contenidos, estrategias de enseñanza-aprendizaje y evaluación del aprendizaje. El curso está dirigido a estudiantes de medicina de los últimos años de la carrera, que ya han adquirido conocimientos básicos en farmacología, genética y medicina interna. Se implementará como un electivo dentro del plan de estudios de la Filial de Ciencias Médicas Baracoa.
Resultados: el programa del curso cuenta con su objetivo, a quien va dirigido, duración en horas y su fundamentación. Está estructurado en cuatro temas con sus respectivos contenidos a tratar. Incorpora la metodología a seguir para impartir el contenido, así como el sistema de evaluación y los recursos y literaturas a utilizar.
Conclusiones: el curso electivo brindará a los estudiantes de medicina una comprensión sólida de la variabilidad genética y su impacto en la respuesta a los fármacos, permitirá que adquieran los conocimientos y habilidades necesarios para aplicarlos en la práctica clínica.

Palabras clave: Fármacos; Farmacogenética; Farmacogenómica.

INTRODUCTION

Modern medicine is in an exciting transition towards personalization of treatment, seeking to adapt therapeutic strategies to the unique characteristics of each patient. In this context, individual variability in drug response has become a significant clinical challenge.[1] Factors such as age, sex, liver and kidney function, and drug interactions can influence how an individual responds to a specific drug. However, one of the most relevant, and often underestimated, factors is genetic variability.[2]

Pharmacogenetics and pharmacogenomics study the interaction between genes and drugs. Pharmacogenetics focuses on how individual genetic variations affect drug response, while pharmacogenomics encompasses a broader approach, including the study of the entire genome and its influence on drug response. These disciplines have revolutionized our understanding of why some patients respond favorably to a treatment while others experience adverse effects or lack of efficacy.[3]

Genetic variations, such as single nucleotide polymorphisms (SNPs), can affect various aspects of a drug's pharmacokinetics and pharmacodynamics. For example, they can influence the activity of drug-metabolizing enzymes, the function of transporters that carry drugs into cells, or the affinity of drug receptors. These genetic differences can result in significant variations in the concentration of the drug in the body, the duration of its action, and its therapeutic effect.[4]

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Understanding the genetic basis of drug response opens the door to personalized medicine, allowing physicians to predict a patient's response to a specific drug, individualize drug dosage, choose the most appropriate drug, and prevent adverse drug reactions.

In this scenario, the training of future health professionals in pharmacogenetics and pharmacogenomics becomes crucial. Medical students must acquire a solid understanding of these concepts and their clinical applications in order to offer more personalized and safe medical care to their patients.

According to Wong Ruiz and his collaborators,[5] the elective course promotes the fusion of knowledge acquired by students and the acquisition of skills and principles that must be applied in their professional career, in addition to being an excellent opportunity to deepen the understanding of certain fields of knowledge.

Elective courses are chosen by students according to their preferences and aptitudes, giving them the opportunity to delve deeper into topics that they are passionate about or that spark their curiosity. By having the freedom to select these courses, students can personalize their educational experience and develop specific skills that will be useful to them in the future. In this way, elective courses not only enrich the educational process, but also contribute to the comprehensive development of students by allowing them to explore different perspectives and approaches within a stimulating and enriching academic environment.[6]

Therefore, the purpose of this article is to present the structure of an elective course designed for medical students, with the purpose of providing them with a solid foundation on genetic variability and response to drugs, preparing them for the practice of personalized medicine and improving patient care.

METHODS

A curriculum development study was conducted focused on the structuring of an elective course on genetic variability and drug response for medical students. The curriculum development process is based on a systematic approach that includes the following stages:

- Needs analysis: A review of the scientific literature and recommendations of international organizations was conducted to identify essential competencies in pharmacogenetics and pharmacogenomics for medical students.
- Definition of objectives: Specific learning objectives were established for the course, considering the knowledge, skills and attitudes necessary for the practice of personalized medicine.
- Content selection: relevant content was selected to achieve the objectives, including basic concepts, clinical examples, practical applications, and ethical and social aspects.
- Content organization: the course was structured into thematic modules, ensuring a logical and coherent sequence.
- Teaching-learning strategies: various methodological strategies were defined to promote active and meaningful learning, including theoretical classes, discussion of clinical cases, simulations, teamwork and research.
- Learning assessment: Assessment instruments were designed to measure the achievement of learning objectives, including written and oral exams, class participation, research work, and evaluation of the management of simulated clinical cases.

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The course is aimed at fourth and fifth year medical students, who have already acquired basic knowledge in Cellular and Molecular Biology, Pharmacology, Genetics and Internal Medicine. It will be implemented as an elective within the curriculum of the Baracoa Medical Sciences Branch. The duration of the course will be one academic semester, with a total workload of 16 hours.

Various teaching resources will be used to facilitate learning, including:

- Course-specific teaching materials: presentations, scientific articles, clinical cases, clinical practice guides.
- Online learning platforms (virtual health classroom and WhatsApp): for course management, communication with students and access to digital resources.
- Simulation software: for practicing pharmacogenetic test interpretation and personalized drug dosing.

The results of the learning assessments will be analyzed to measure the effectiveness of the course in achieving the proposed objectives. In addition, student feedback will be collected to identify areas for improvement and optimize the design of the course in future editions.

RESULTS

School Year: genetic variability and response to drugs
Aim: understand the influence of genetic variability on individual response to drugs and its implications for clinical practice.
Addressed to: fourth and fifth year medical students.
Duration: adaptable to the needs of the academic program.

Course rationale:

Importance of the topic:
Modern medicine faces the challenge of individual variability in drug response. This variability can lead to:

- Lack of therapeutic efficacy: Some patients do not respond to treatment as expected, which may result in disease progression or lack of symptom relief.
- Adverse drug reactions (ADRs): Some patients experience serious and even life-threatening side effects due to genetic variability that affects the metabolism or action of drugs.

Pharmacogenetics and pharmacogenomics offer an explanation for this individual variability by studying the influence of genes on drug response. Knowledge of the genetic basis of drug response allows:

- Personalize treatment: select the most appropriate drug and dose for each patient based on their genetic profile, improving efficacy and minimizing the risk of ADRs.
- Prevent ADRs: Identify patients at higher risk of side effects and take preventive measures, such as adjusting the dose or choosing an alternative drug.
- Developing new drugs: designing safer and more effective drugs taking into account the genetic variability of the population.

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Justification for medical students:
Pharmacogenetics and pharmacogenomics are rapidly growing fields with significant implications for clinical practice. Medical students should be familiar with these concepts in order to:

- Understanding the genetic basis of individual variability in drug response.
- Interpret pharmacogenetic tests and use the information to make informed clinical decisions.
- Communicate the importance of pharmacogenetics to patients.
- Stay up to date on developments in this ever-evolving field.

This course will provide medical students with a solid foundation in pharmacogenetics and pharmacogenomics, preparing them for the practice of personalized medicine and improving patient care.

Contents:
Module 1: Introduction to Pharmacogenetics

- Definition and basic concepts of pharmacogenetics and pharmacogenomics.
- Genetic variability: polymorphisms, mutations and their impact on gene expression.
- Drug metabolizing enzymes (e.g. CYP450) and transporters (e.g. ABCB1).
- Implications of genetic variability in pharmacokinetics and pharmacodynamics.

Module 2: Clinical Examples of Genetic Variability and Drug Response

- Warfarin: polymorphisms in CYP2C9 and VKORC1 and their influence on dosing.
- Clopidogrel: polymorphisms in CYP2C19 and antiplatelet response.
- Isoniazid: acetylation polymorphism and treatment efficacy in tuberculosis.
- Tamoxifen: polymorphisms in CYP2D6 and treatment efficacy in breast cancer.
- Other examples: statins, antidepressants, antipsychotics, etc.

Module 3: Clinical Applications of Pharmacogenetics

- Pharmacogenetic tests: types, interpretation and clinical utility.
- Personalized drug dosage based on genetic profile.
- Prevention of adverse drug reactions.
- Implementation of pharmacogenetics in clinical practice: challenges and opportunities.

Module 4: Ethical and Social Aspects of Pharmacogenetics

- Privacy and confidentiality of genetic information.
- Genetic discrimination and access to medicines.
- Social and economic implications of pharmacogenetics.

Methodology:
The course combines theoretical classes with practical activities, including:

- Theoretical classes: presentation of content with the support of slides, videos and other multimedia resources.
- Discussion of clinical cases: analysis of real cases that illustrate the importance of genetic variability in the response to drugs.
- Practical activities: simulations of interpretation of pharmacogenetic tests and personalized drug dosing.
- Teamwork: research and presentation of topics related to pharmacogenetics.

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Assessment:

- Written and oral exams.
- Class participation and discussions of clinical cases.
- Teamwork presentations.
- Assessment of learning through simulated clinical cases.

Resources:

- Guidelines and recommendations from scientific societies: Clinical Pharmacogenetics Implementation Consortium (CPIC), Dutch Pharmacogenetics Working Group (DPWG), etc.
- Pharmacogenetic databases: pharmgkb, the human cytochrome p450 allele nomenclature database, etc.
- Pharmacogenetic test interpretation software.
- Scientific articles and literature reviews.

DISCUSSION

Pharmacogenetics and pharmacogenomics are transforming medical practice, offering the possibility of individualizing treatment and improving patient outcomes. The structuring of the course presented in this article seeks to respond to the growing need to train future health professionals in these fields, equipping them with the necessary tools for the era of personalized medicine.

The course design is based on pedagogical principles that promote active and meaningful learning. The combination of theoretical lectures with practical activities, such as discussion of clinical cases, simulations and teamwork, allows students to apply the knowledge acquired to real clinical situations. This encourages the development of critical thinking, decision-making and problem-solving skills, essential for effective medical practice.

Strengths of the course design include:

- Student-centred approach: The course is tailored to the learning needs of medical students, providing a balance between theory and practice.
- Clinical relevance: Course content focuses on the clinical applications of pharmacogenetics and pharmacogenomics, providing concrete examples of how these disciplines impact patient care.
- Active methodology: the various teaching-learning strategies encourage active participation of students and the development of essential skills for medical practice.
- Comprehensive assessment: assessment instruments allow the achievement of learning objectives to be measured in a complete and objective manner.

Among the limitations and challenges are:

- Access to pharmacogenetic testing: The implementation of pharmacogenetics in clinical practice may face limitations due to the availability and cost of genetic testing.
- Infrastructure and resources: Course implementation may require investment in simulation software and online learning platforms.
- Constant updating: Pharmacogenetics is a constantly evolving field, which requires continuous updating of course content.

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The implementation of this course can contribute to:

- Improving the quality of patient care: Physicians with knowledge of pharmacogenetics and pharmacogenomics can make more informed, personalized and safe therapeutic decisions.
- Reduce healthcare costs: Preventing adverse drug reactions and optimizing treatment can reduce costs associated with hospitalization and management of complications.
- Promote research in pharmacogenetics: training professionals with knowledge in this field can boost research and the development of new clinical applications.

A course on pharmacogenetics and pharmacogenomics for medical students is a fundamental step in preparing future health professionals for the era of personalized medicine. The course design presented in this article offers an effective model that can be adapted to different educational contexts. The implementation of such courses in medical schools is recommended to promote the training of physicians capable of providing safer, more effective and personalized medical care.

Further studies are needed to assess the effectiveness of this course in improving medical students' knowledge, skills and attitudes regarding pharmacogenetics and pharmacogenomics. In addition, research is required to explore the barriers and facilitators to the implementation of pharmacogenetics in clinical practice and medical education.

Pharmacogenetics and pharmacogenomics represent the future of medicine, and education in these fields is essential for physicians to provide the best possible care to their patients.

One of the difficulties of this study is the lack of previous research focusing on elective subjects related to the topic addressed in this work, which makes it difficult to compare results with other studies. However, similar experiences have been found in the literature dealing with the creation of elective subjects, although focused on other topics.[7,8]

Blanco Balbeito and collaborators,[9] proposed to design an elective course focused on Research Methodology for medical students in the clinical stage, with the aim of enhancing their research skills.

On the other hand, Rodríguez Álvarez et al.,[10] suggest the implementation of an elective course for dentistry students focused on the prevention and treatment of common occupational diseases in the field of dentistry. The purpose is to educate students about the risks to which they could be exposed, in order to encourage the adoption of healthy habits from the beginning of their professional training.

Segura Sierra,[11] proposes the incorporation of an elective course that addresses the essential foundations of management and administration in the health field for medical students. Its objective is to promote, from the first years of the degree, the acquisition of knowledge, the strengthening of skills and the development of competencies necessary to lead in the health field.

On the other hand, Álvarez Hernández and his team,[12] propose the creation of an elective course focused on the history of the Federación Estudiantil Universitaria (FEU) in order to enrich the academic activities that contribute to the growth of this organization. This initiative seeks to increase the visibility and representation of the members of the FEU in all areas of work, as established in its main document: the "ABC" of the FEU.

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CONCLUSIONS

The elective course will provide medical students with a solid understanding of genetic variability and its impact on drug response, enabling them to acquire the knowledge and skills necessary to apply them in clinical practice.

Conflicts of interest
The authors declare that there is no conflict of interest.

Financing
There wasn't any.

Authors' contribution
YPO: participated in conceptualization, investigation, project administration, supervision, visualization, writing - original draft, writing - review and editing.
CMQL: participated in the Research, visualization, writing - original draft, writing - review and editing.
DML: participated in Research, visualization, writing - original draft, writing - review and editing.
RBMP: participated in the Research, writing - review and editing.
DYLP: participated in the Research, writing - review and editing.

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