Colombian Journal of Anesthesiology

OPEN

Received: 4 February, 2025 ▸ Accepted: 5 February, 2025 ▸ Online first: 4 March, 2025

DOI: https://doi.org/10.5554/22562087.e1139

The pulse of paradigms: A journey towards change in medical science

El pulso de los paradigmas: un viaje hacia el cambio en la ciencia médica

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How to cite this article: Delgado-Noguera M. The pulse of paradigms: A journey towards change in medical science. Colombian Journal of Anesthesiology. 2025;53:e1139.

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Abstract

The history of medicine is a continuum of ideas and practices, characterised by progress, error rectification, and paradigm shifts. Drawing on Thomas Kuhn's concept of "paradigm shifts," this article examines the transition in medicine from a traditional paradigm, centred on clinical expertise and authority, to the Evidence-Based Medicine (EBM) and Clinical Epidemiology (CE) model.

Before the rise of EBM, medicine functioned as "normal science," relying on pathophysiological reasoning and academic authority. However, by the mid-20th century, anomalies such as diagnostic and treatment variability exposed the limitations of the traditional paradigm. EBM introduced an evidence-based approach, emphasising objectivity, reproducibility, and risk quantification in clinical decision-making.

Despite its advancements, this new paradigm faces significant criticisms. The proliferation of low-quality studies, scientific fraud, and a perceived detachment from the human aspects of medicine represent contemporary challenges. Nonetheless, EBM has redefined clinical practice, integrating rigorous scientific methodology with patient care. It has also transformed the doctor-patient relationship, enabling personalised treatment based on probabilistic risk assessments and patient preferences.

This article highlights the need to view clinical medicine as a journey marked by challenges in clinical practice, research, and scientific evidence in the ongoing pursuit of improving healthcare.

Key words

Paradigm shifts; Evidence-based medicine; Clinical epidemiology; Science; Medicine.

Resumen

La historia de la medicina refleja un continuo de ideas y prácticas marcado por el avance, la rectificación de errores y el cuestionamiento de paradigmas establecidos. Inspirado en el concepto de “cambio paradigmático” de Thomas Kuhn, este artículo analiza cómo la medicina ha transitado de un paradigma tradicional, basado en la experiencia clínica y la autoridad, hacia el modelo de la Medicina Basada en la Evidencia (MBE) y la Epidemiología Clínica (EC).

Antes del auge de la MBE, la medicina funcionaba como una “ciencia normal”, con un enfoque en el razonamiento fisiopatológico y la autoridad académica. Sin embargo, en la segunda mitad del siglo XX, surgieron anomalías en forma de variabilidad en diagnósticos y tratamientos, lo que evidenció las limitaciones del paradigma tradicional. La MBE introdujo un enfoque basado en pruebas científicas rigurosas, promoviendo la objetividad, la reproducibilidad y la cuantificación del riesgo en la toma de decisiones clínicas.

No obstante, este nuevo paradigma también enfrenta críticas. La proliferación de estudios de calidad variable, el fraude científico y la desconexión con los aspectos humanos de la medicina son desafíos actuales. A pesar de sus limitaciones, la MBE ha transformado la práctica clínica, marcando un cambio significativo en la relación entre médicos y pacientes, al integrar la ciencia con el arte de la medicina. Este artículo subraya la necesidad de ver la medicina clínica como un viaje que presenta desafíos en la práctica clínica, la investigación y la evidencia científica en la búsqueda continua de mejorar la atención médica.

Palabras clave

Cambio paradigmático; Medicina basada en la evidencia; Epidemiología clínica; Ciencia; Medicina.

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INTRODUCTION

The history of medicine has been, over time, a vast ocean of ideas, beliefs, and practices; a tapestry of knowledge woven with the threads of trials to alleviate human suffering, glimpse hope, rectify error, and persevere in progress. Amid this sea of changing knowledge, movements arise that dare to question certainties, swinging between critical thinking and adherence to a framework, a "paradigm" in Thomas Kuhn's terms (1). In his work "The Structure of Scientific Revolutions," Kuhn posited that science does not advance linearly but flows in episodes, in waves of paradigmatic change.

For clinical medicine, a field shaped by practice and repetition, these waves have been considered akin to revolutions, shaking the foundations, the way doctors conceive health, disease, and ultimately, life itself.

Normal science and medicine of yesteryear

Before the advent of EBM and CE, medicine—though with a scientific attitude primarily based on advances and experiments in basic sciences, on the advances of Pasteur, Virchow, on Koch's postulates, and Flexner's recommendations for medical schools (2)—was built around a paradigm of inherited wisdom, where personal experience and the authority of masters set the pace (3). Flexner advocated, among other reforms, that medical schools should base their training on natural sciences, be affiliated with a university to earn respectability, and be endowed with adequate scientific means. He also advised students to complete at least two years of university studies before starting medical practice and dedicate themselves to full-time study, and advocated that the number of medical schools should be reduced (3).

The healer-patient relationship was the ground for practicing the art of medicine, where physicians expected each medical encounter to be a crucible of knowledge and empathy between intuition and experience. Pathophysiological reasoning was the mainstay of diagnosis, etiology, and prognosis. This paradigmatic structure allowed medical science to follow a cumulative and progressive path, in a sort of "normal science" where doctors, driven by the inertia of the paradigm, solved problems and strengthened their knowledge within a supposedly stable and shared framework, supported by significant advances in basic sciences such as physiology, pharmacology, and biochemistry. In Colombia, the shift from the so-called French school to the American one in the 1960s and 1970s did not face much resistance, perhaps because many of the faculty had trained in the United States, and some medical schools were recipients of funding from the Alliance for Progress and various American agencies (4).

However, as Kuhn points out, a latent paradox lies behind this state of normal science: when cracks in knowledge emerge, when anomalies destabilize the status quo, a divide in time opens, creating a space for critical reflection and crisis in which, slowly but inexorably, a possible paradigm shift unfolds (1). In the clinical field, this transformation came with the advent of EBM and CE starting in the 1990s, though earlier in the northern latitude. This became a turning point, as the idea that knowledge and tools from biostatistics and public health were needed to scientifically apply clinical medicine gradually took hold. In my view, in line with McIntyre (2), it was accompanied by the right kind of attitude needed to challenge established patterns and to adopt a new way of understanding clinical knowledge. On the other hand, with EBM came the recognition of a significant component of uncertainty in medical practice, which had been minimized, stifled, or disregarded.

Anomalies and the emergence of inevitable change

By the mid-20th century, the traditional clinical paradigm began to show its limits. In an era where variability in medical practice was the norm, unsettling questions arose: how was it possible that different practitioners, faced with the same clinical picture, offered such disparate solutions? The answer lay in the very structure of medicine, anchored in experience and fragmented observation that, while undoubtedly valuable, did not offer the uniformity or replicability characteristic of empirical science. The specter of subjective and individual judgment-dependent practice hang over medicine, paving the way for the emergence of a paradigm crisis (5,6).

In Kuhn's terms, these "anomalies" began to erode the foundation of the existing medical paradigm. The disparity in diagnoses and treatments revealed the lack of an objective measurement and evaluation system. Clinical practices disregarded or lacked solid statistical methods, and physicians, in their quest to do good, were trapped in a web of unverifiable treatments and varying imprecise recommendations coming from the so-called "schools" of medicine. This problem became more evident as medical knowledge advanced, creating the urgency to find an alternative that offered a more rigorous scientific basis, less influenced by subjective interpretation (5,7).

Evidence-based medicine: a revolution under way

The emergence of EBM and CE represented, indeed, a possible paradigm shift. I use the term "possible" because the assertion that EBM represents a paradigm shift is still open for debate; it was criticized at the beginning (8) and more recently as well (9). Thus, I consider it a hypothesis that must be analyzed and criticized and, to delve into

that controversy, elements taken from the philosophy of science are presented here.

This new vision proposed a model according to which clinical decisions should be based on scientifically rigorous studies and not on the accumulation of individual experiences. Through Kuhn's lens, this change not only reconfigured medical knowledge but also redefined what it meant to be a doctor at the patient's bedside, transforming clinical practice into a discipline that required both technical competence in evaluating evidence and the ability to apply these principles to individual care (1).

This paradigm introduced a hierarchy of evidence, a new order in which evidence from randomized clinical trials and systematic reviews rose to the pinnacle of clinical knowledge. Unlike previous practice, where experience and observation reigned undisputed, the new paradigm promoted, in addition to recognizing uncertainty, a structured evaluation system that strived for transparency, where objectivity, methodological rigor, and reproducibility became core values. Doctors were no longer isolated in their clinical judgment; they were, instead, integrated into a network of shared and ever-expanding knowledge (3).

Personalization of treatments and risk quantification

The EBM and CE approach also transformed the doctor-patient relationship. By incorporating risk quantification and probability into decision-making, the possible new paradigm offered doctors a powerful tool to individualize treatments, taking into account both data from previous clinical studies as well as each patient's specific needs and characteristics. Instead of relying solely on their intuition and experience, physicians began to understand and use probabilistic estimates which allowed them to offer more reliable options, tailored to the needs of each clinical case and the preferences of each individual patient (2,6).

This transformation represented a significant step forward: medicine, traditionally a science with strong components of art and subjectivity, began to adopt a logic more in tune with that of exact sciences. It was, in Kuhn's words, a leap in understanding; a change that broke with the past to give way to a renewed and expansive vision of healthcare (1).

New crises and anomalies in the era of EBM

However, like any profound and possibly paradigmatic change, EBM has also shown its limitations. The great explosion of research in recent years has led to the proliferation of studies of variable quality, new and varied synthesis reviews that make it difficult to understand their classification and purposes, and, on the other hand, the presence of "predatory journals" and "ghost authors" fraud that has introduced a crisis of reliability in scientific literature (10). Fraud, according to McIntyre, is the intentional fabrication or falsification of evidence, aimed at leading someone to believe what we want them to believe (3). Thus, not only academic peers but also those called upon to review publications in universities or state agencies that are supposed to be the guardians of science and technology policies have believed and fallen prey to this fraud. On the other hand, excess focus on quantitative data has bred criticism of alleged disconnection from the more human aspects of medicine (8,11). And if that were not enough, the rise of pseudoscience and its influence on clinical decisions is another threat, as made evident during the SARS-CoV-2 pandemic (12).

As EBM and CE strove to find their rightful place, new anomalies emerged. The excess of evidence, repeated publications resulting from the response to calls to apply for public funding, and the complexity of interpreting a sea of data, created an information overload for practitioners, often exposed to contradictory studies and to the pressure to publish and remain abreast in a constantly changing environment. Even clinical practice guidelines, although evidence-based, often lack quality and face the problem of not being known, and therefore, used or applied in clinical settings (13). This situation poses a paradox: in its attempt at overcoming the limitations of the previous paradigm that was more akin to exact sciences, as previously noted, the new approach created its own problems, underscoring the need to strike a balance between the turbulent sea of scientific evidence and individual clinical judgment.

Medical science as a continuous journey

McIntyre (3) states that scientific thinking is a dynamic process that evolves through constant criticism and examination of theories. Consistent with the thinking of the author, this process can also be applied to clinical medicine, which has taken the path of methodological rigor, evidence, and falsifiability inherent to science but has become entangled in its own contradictions along the way. For McIntyre, science is characterized by openness to correction and to the possibility that existing beliefs or models may be wrong. This commitment to self-correction is what gives scientific thinking its distinctive character. In this sense, McIntyre revisits Karl Popper's principle of falsifiability but expands it by considering that the value of a theory not only depends on its ability to be refuted but also on the attitude or willingness of scientists to subject it to rigorous tests and accept its refutation should evidence so indicate. For the author, attitude is also crucial for distinguishing between science and pseudoscience.

External influences

It is important to remember that the EBM and CE movement gave rise to a scientific community that, while sharing principles and attitudes, was subject tp internal and

external tensions. As for external tensions, how clear is their role? The noise of the social and economic context surrounding these disciplinary communities cannot be turned down. What has been the role of the pharmaceutical industry and the so-called big pharma as major political, economic, and ideological drivers in the development of this movement? Have they served to foster its development or rather absorbed it? The EBM and CE movement has not remained isolated, immune to the buzz of external interests, as if scientific collectives could float in a vacuum free from the chains of the real world. But we know that isolation does not exist. Sciences breathe the sometimes pure and other times rarified air of context; and it is that air that can determine what flourishes and what withers in the fields of knowledge, even within distinct disciplinary boundaries.

Kuhn has been criticized for falling short in exploring how scientific revolutions clash, negotiate, and sometimes capitulate to external forces (14). In the case of EBM and CE, the analysis of external forces is yet unchartered ground.

Artificial intelligence and the horizon of a new paradigm

In this context, artificial intelligence (AI) emerges as a potential new paradigm shift. With its ability to analyze vast volumes of data and make predictions based on complex patterns, AI offers a tool that can help address the deficiencies of EBM while raising ethical and philosophical questions about the role of practitioners in an automated future. Will AI become the next step in the evolution of clinical medicine? Are we at the height of a new revolution, or are we facing a change that will require a profound reformulation of what we understand by "medical practice"?

Like any paradigm shift, the adoption of AI in medicine carries risks and resistance. However, the history of science has taught us that anomalies build up, and paradigm shifts are inevitable, and it is through these transitions—sometimes abrupt, like those of AI—that medicine, like knowledge as a whole, continues to advance.

The history of clinical medicine is ultimately a continuous journey, a constant ebb and flow of stability and change. Each human experience connects with something larger and initially intimidating, but paradigm shifts in medicine are a manifestation of the human quest to understand, alleviate, and ultimately transcend suffering.

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