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1. Declara que en la confección de *Medicine today and tomorrow. Towards the digital transformation of health care*, se acogió a las buenas prácticas de calidad, privacidad y ética, teniendo como referencia el Código de Conducta y Buenas Prácticas que, para editores de revistas científicas define el Comité de Ética de Publicaciones (COPE) y de las revistas del CSIC (Consejo Superior de Investigaciones Científicas de España). Así mismo amplía estos criterios para alinearse y contribuir a los objetivos establecidos en la Declaración Mundial sobre la Educación Superior en el siglo XXI: Visión y Acción, particularmente con el artículo 2: Función ética, autonomía, responsabilidad y prospectiva.

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ABSTRACT / RESUMEN

Evolution of training in Medicine. Medical education seems to be in a perpetual state of unrest.
The troubled story of the clinical investigator. The future is knowledge translated into science and applied in clinical technology.
The paradoxical situation of health professionals. The term hyposkillia refer to the deficiency of clinical skill of physicians. Physicians who learn to request all kinds of tests and procedures, but who do not always know when to order them or how to interpret them. In addition, there is a numerical leadership – receive the largest number of users, in the fewest number of minutes, and spending as few euros as possible per patient: numberomics.
Perspectives. In a few years the digital world has grown in such a way that it has become crucial for the functioning of society. Medicine as a whole does not escape this. AI and ML coupled with rapid improvements in computer processing are already improving the accuracy and efficiency of diagnosis and treatments. A global convergence is presented as the engine of an accelerated evolution of health care.
From the laboratory to the clinic and back, and also to the company. Translation physiology or from molecules to public health, which also involves the pharmaceutical and technology companies.
Creative destruction. It would say that all of us actually think that probably a 50 or 60%, it not more, of visits to primary care physicians do not need to be face-to-face. Do we need more algorithms and fewer doctors?
Mistrust and hope. But what is the art of Medicine?

Evolución de la formación en Medicina. La educación médica parece estar en un perpetuo estado de inquietud.
La turbulenta historia del investigador clínico. El futuro es el conocimiento traducido en ciencia y aplicado en tecnología clínica.
La situación paradójica de los profesionales de la salud. El término hiposkillia se refiere a la deficiencia de habilidad clínica de los médicos. Médicos que aprenden a solicitar todo tipo de pruebas y procedimientos, pero que no siempre saben cuándo solicitarlos ni cómo interpretarlos. Además, existe un liderazgo numérico – recibir el mayor número posible de usuarios en el menor número de minutos y aquilatando el número de euros por paciente: numerómica.
Perspectivas. En pocos años el mundo digital ha crecido de tal forma que se ha convertido en algo decisivo para el funcionamiento de la sociedad. La medicina en su conjunto no escapa a ello. AI y ML, junto con las rápidas mejoras en el procesamiento informático, ya están mejorando la precisión y la eficiencia de los diagnósticos y tratamientos. Una convergencia global se presenta como el motor de una evolución acelerada del cuidado de la salud.
Del laboratorio a la clínica y viceversa, y también a la empresa. Fisiología traslacional o de la molécula a la Salud pública, que también involucra a las empresas farmacéuticas y tecnológicas.
Destrucción creativa. Diría que todos nosotros realmente pensamos que probablemente un 50 o 60%, o más, de las visitas a los médicos de atención primaria no necesitan ser cara a cara. ¿Necesitamos más algoritmos y menos médicos?
Desconfianza y esperanza. Pero, ¿qué es el arte de la Medicina?

MEDICINE TODAY AND TOMORROW.
TOWARDS THE DIGITAL TRANSFORMATION OF HEALTH CARE.

Evolution of training in Medicine

"Medical education seems to be in a perpetual state of unrest –these are the words with which Molly Cooke *et al*.[1] begin the article that opens the series on Medical Education in *The New England Journal of Medicine*, in September 2006–. From early 1900s to the present, more than a score of reports from foundations, educational bodies, and professional task forces have criticized medical education form emphasizing scientific knowledge over biological understanding, clinical reasoning, practical skill, and development of character, compassion, and integrity".

The *Report* prepared by Abraham Flexner[2] for the *Carnegie Foundation for the Advancement of Teaching*, at the request of the *American Medical Association*, in 1910, has been the guide for most of the curricula in the medical schools of the United States and Canada and, by extension, in much of the rest of the world. Robert H. Ebert[3] summarized the philosophy of the medical educational program in three points: "1. Learn by doing, consider the utility of what is being taught, do not make the educational process too long, treat college students as responsible adults, but provide reasonable curricular pathways, depending on the choice of a career, and finally, teach medicine as a scientific discipline at both the preclinical and the clinical levels. 2. The medical school should be an integral part of its parent university. 3. Each medical school should have a university hospital in which the staff constitute the teaching faculty, and, whether owned affiliated, all power appointment rests with the medical school and university. The faculty should be salaried".

The idea was pioneered at the Universities of Harvard, Michigan, and Pennsylvania in the 1880s, but the Flexner Program was most decisively implemented at Johns Hopkins University, with the full support of Dean William H. Welch. However, it was there that he encountered the greatest opposition; clinician William Osler rejected the primacy of the laboratory over the clinic and the inappropriateness of appointing scientists as clinical professors. W. Osler did not oppose the application of scientific objectivity to the practice of medicine, but he resisted the interposition of a scientific ethos between doctor and patient. Osler would end his professional life as *Regius Professor* of Medicine at Oxford. In any case, one of Flexner's contributions was to recognize that medical training must respond to, adapt to, and even anticipate the scientific, social, and economic changes that occur with each generational change. Flexner and freedom to change were an essential part of Flexner's message[4].

Ninety years later, in 1999, Michael ME Johns[5] wrote: "At the turn of the century, this school of medicine –Johns Hopkins University School of Medicine– created the first rigorous, science-based medical curriculum in the nation. The curriculum was emulated by most medical schools and became the standard for medical education in this century […] When I gave Dr. De Angelis and her committee its charge, I suggested that our basic philosophy of medical education must be directed not toward creating a neurosurgeon, a family practitioner, a cardiologist, or a general pediatrician but toward creating an undifferentiated physician 'stem cell' who is so well prepared that he or she

is fully capable of taking any career path after medical school. The new curriculum is preparing students for the demands and responsibilities of a new era of medicine, science and medical arts". The Flexner versus Osler dialogue has endured and, as Molly Cooke *et al*. noted, has spawned a long and rich series of trials. One of them –focused on clinical research– is collected in the *Journal of Clinical Investigation* published by the *American Society for Clinical Investigation*. Alfred E. Cohn[6] wrote in the dedication to the first volume of the magazine: "We have, as all those interested in the progress of medicine know, for some time been inquiring whether medicine is entitled to be called a science. To us the answer to this question is clear and unequivocal. It is clear because of the nature of the case. The phenomena of interest in medicine are the phenomena of disease as these are manifest in affected persons. They are phenomena which exist as concrete entities in nature, they are indivisible and they fall within the province of no other inquired. They constitute the proper concern of medicine". For Robert M. Glickman[7], Cohn defines the essential nature of clinical research as the phenomenon of disease, its understanding, which is why it escapes any discipline; In addition, by its nature, clinical research, in addition to being interdisciplinary, is applied.

The troubled story of the "clinical investigator"

In 1979, James B. Wyngaarden[8] published an adaptation of an inaugural lecture by the *Association of American Physicians*: "The clinical investigator as an endangered species". Clinical research includes a wide range of activities that range from epidemiology to the study of patients or laboratory analysis of different samples obtained from patients. Clinical research is carried out by medical researchers working in a clinical department of a university hospital. "The physician-scientist has a very special role both in posing relevant medical question and in applying new knowledge to the investigation of disease and the teaching of students. The future of clinical science depends on the quality and the numbers of new leaders in the field".

A few years later, James V. Warren[9] delivered the opening address at the annual meeting of the *Central Society for Clinical Research*: "I believe that there exists a problem in the subset of full-time academic physicians that we have traditionally called the clinical investigator. They are, in effect, an endangered species. We should not try to turn the clock back and expect to operate as we did earlier in the century. Rather we should change the mode of operation to meet the new conditions and yet obtain some of the same dividends […] We are living in a new world. Let us look at it as an exciting challenge for new directions in medical research and education". Problematic situation that Joseph L. Goldstein[10] called PAIDS (Paralyzed Academic Investigator's Disease Syndrome). Ten years later he published, with Michael S. Brown[11] "The clinical investigator: Bewitched, bothered, and bewildered – But still beloved", where they insisted on defining three types of medical research: basic, disease-oriented research (DOR: disease-oriented research) and patient-oriented (POR: patient-oriented research); the latter characterized by "The 4 P's of POR: Passion, Patients, Patience, and Poverty". More or less at the same time, Barbara Culliton[12] published "Clinical investigation: an endangered science", and Jay A. Berzofsky[13] titled his inaugural speech before the *American Society for Clinical Investigation* (ASCI): "Cross-fertilization among fields: A seminal event in the progress of biomedical research", and pointing out the path towards what in the first decade of our century was called "The Third Revolution". *The Convergence of the Life Sciences, Physical Sciences, and Engineering* was the title of an MIT report edited by Philip A. Sharp *et al*.[14]

“It is difficult to make predictions, especially about the future”, Mark Twain[15] is said to have commented (although it is often attributed to Niels Bohr, Robert S. Petersen…, although the origin seems to be a Danish proverb). Kansas City Royal pitcher Dan Quisensberry[16] was more specific: “I’ve seen the future and it’s just like the present, only longer.” He was wrong, notes Frank H.T. Rhodes[17]: “The future has always been different, and it becomes less and less like the present or the past”. Each generation assumes that it is experiencing a period of unprecedented change, in which the speed of transformation has never been experienced. The turn of the century, taken as a blurred red line, has introduced a complex variant. Until then, changes depended, for the most part, on non-renewable natural resources and were confined by geopolitical borders. No longer. The future is knowledge translated into science and applied in technology, global and in real time.

The paradoxical situation of health professionals

The longing for the clinical researcher was accompanied by disenchantment with clinical medicine as a whole. Far from what John C. Burnham[18] called the “golden age” –1930-1960– and the ”triple-threats” –clinical-researcher-teacher– of Ronald A. Arky[19], the medical profession today faces several problems. It is disoriented in a bureaucratic labyrinth; it has lost its autonomy; his prestige is in a downward spiral, and his professionalism has sunk. But the problems do not end here. A serious medical illness lurks in the shadows of it all. A disease for which only medicine itself is responsible and which threatens the public it is meant to serve. It begins in the Faculty, where it practically does not receive any attention. After incubation, it blooms during the period of specialization in the Residence years. Then he becomes chronic. Therapeutic and above all preventive measures are ignored, and in the best of cases are inadequate. We are faced with a typical picture of “clinical insolvency”.

Herbert L. Fred[20] coined the term hyposkillia to refer to the deficiency of clinical skills of physicians; a pathology due to the fact that his interests are focused on the disease and on the technique, which relegates direct contact with the patient to the background. A situation that is reflected in a new slogan that Pedro García-Barreno[21] coined as "high-tech low-touch medicine", and which is exemplified in the prevailing "hospitalocentrism". Physicians who learn to request all kinds of tests and procedures, but who do not always know when to order them or how to interpret them; Physicians unable to do a thorough history or physical examination. In addition, an arrogant management aimed at receiving —not attending to— the largest number of users, in the fewest number of minutes, and spending as few euros as possible per patient: numberomics[22]. Numerical leadership that could well give rise to a new area of knowledge in medical sciences, today molecular medicine together with genomics, proteomics or cellomics, numberomics.

Is there a cure for technological tyranny? Teachers are needed who know and teach pathophysiology, propaedeutics and clinical pathology; that apply high-touch. Teachers who know the basics of the different techniques and who know when to request them and how to interpret them, and who use high-tech to verify more than to formulate their clinical impressions. Francisco J. Ayala *et al*.[23] published an article in which they approach clinic and technology; refers to the role of information technology in solving “three long [long registration and queue times; long waiting times; long dispensary and payment queue times], one short [short physician visit times]”, problems

of large urban hospitals in China. An approach similar to the aforementioned numberomics. The problem is that professionals are not trained for the routine use of Information and Communication Technology (ICT).

Perspectives

Based on discoveries in biology that have occurred in recent decades, mathematicians and biologists have accepted complexity as a technical subject; what Sir Paul M. Nurse[24] claims as an emerging topic in the future of the life sciences. The old philosophical theories regarding the bases of emergent properties and the conflicts between reductionism and holism as frames of reference have been reexamined in the light of the new theories of complex systems. The concepts of equilibrium, multi-stability or stochastic behavior –concepts familiar to physicists and chemists– are frequently used to understand certain problems intrinsic to living systems such as adaptation, feedback or emergent behaviour. And ideas like pattern formation that are at the heart of condensed matter physics help to understand the self-assembly and development of biological systems. If the crossbreeding between areas of knowledge, until recently ignored among them, is the way to understand the complexity of the living, little effort should be invested in justifying the convergent strategy of the so-called biomedical sciences in a broader environment[25].

In a few years the digital world has grown in such a way that it has become crucial for the functioning of society. Digitization is generally seen as a positive force. However, emerging technologies such as artificial intelligence are sometimes greeted with fear. Anyway, an increasing amount of our culture exists only in digital form[26].

The new paradigm "digital medicine" is built on the tripod "clinical, medical imaging, and molecular medicine", with three other tools used "artificial intelligence, big data, and telehealth". Teleheath has emerged as an unexpected silver lining of the COOVID-19 pandemic, improving access to care and facilitating a transition toward digital medicine[27]. The second gadget is big data. Large-scale multi-modal information on patient's health is ever increasing, providing an opportunity to use big data for taking individualized-precision medicine to a global scale[28]. In recent years, novel methods from artificial intelligence (AI) and machine learning (ML) commonly referred to as data science (DS) enabled many advances in data-driven medical fields including radiology[29], molecular medicine[30], and clinical medicine[31], that are already improving the accuracy and efficiency of diagnosis and treatment across various specializations. These suggestions raise the question of whether AI-based systems will eventually replace physicians in some specializations or will augment the role of physicians without actually replacing them and are unlikely to replace the traditional physician-patient relationship.

In the biomedical sciences, morphology, development and function converge and integrate –"multiomics"– the extended "omics" advances in what Eric J. Topol[32] calls a global panorama –"panoroma"– or "human geographic information system" (Human GIS) consisting of the integration of multiscalar data, and formed by a set of superimposed data layers such as street maps, traffic or satellite view, on a Google map. For a person, such layers include demographic and social graphs, phenome or appearance (basic physical data such as height, weight, hair color...).

Physiome built from physiological data provided by wearable technology, morpho-functional anatomy from different medical imaging techniques, a biological map built from the now classic «omes» –genome, transcriptome, epigenome, proteome, metabolome or microbiome– and environmental exposure or exposome data. This GIS is nothing but a chain of increasing complexity –systems biology or integrated physiology, in the sense of Sydney Brenner[33]–. This in an attempt to understand, beyond data analysis and partial interactions, the organism as a whole as an individual and its social interactions at a micro scale –microbiome or commensal flora– and macro –anthropogenics and epidemiology-. All this as a bridge between the laboratory and the clinic. But knowledge goes beyond the self-sufficient individual himself, it begins in the pre-conceptual period: it uses genetic knowledge to "plan a baby" and scrutinizes the implantation, embryonic, fetal and neonatal phases, with the aim of preventing and, in failing that, predict possible pathologies[34].

Biomedical Sciences contemplate the translation of knowledge –from the laboratory to the patient– and its feedback –reverse translation–, in the context of different pathologies –clinical medicine–, of a particular patient –personalized and precision medicine– and in the context from public health –translational physiology or from molecules to public health. Also, the transfer of this knowledge in added value –procedures and products−, oriented from domestic aspects –design of tools or accessibility for people with some type of disability–, urban planning –pathology of megacities–, environmental –xenobiotics–, styles of life –drugs, tobacco, alcoholism, sedentary lifestyle– or food –basic agricultural aspects.

Scientific-medical translation is the process of turning observations in the laboratory, clinic and community into actions that improve the health of individuals and society, from diagnosis and therapeutics to medical procedures and behavioral changes. Translational science is the field of research aimed at understanding the scientific and operational principles underlying each step of the process of translating knowledge into daily practice[35]. The tools are, like Biomedicine itself, complex: mathematics, physical-chemistry, biology, social sciences, agricultural sciences, urban planning or environment. Also eminently practical: different applications of computer and information sciences, laboratories, business or communication. The ultimate goal of biomedical sciences are the great challenges and threats to health. For this, it is necessary to have professionals capable, from the respective specializations, of building, from interdisciplinary, convergent dialogue, a global strategy from the genome to the environment of coexistence.

The foregoing from the fact that health care is undergoing a profound revolution as a result of three emerging forces: systems medicine, mega data and the involvement of people in their own health through social networks. For Leroy Hood *et al*.[36], this convergence leads to a medicine that is predictive, preventive, personalized and participatory; what he calls P4 (in a completely different sense than the ORP's distinctive 'Goldstein 4Ps'). The first 3 Ps - predictive, preventive, personalized - were established in the early 2000s, while the fourth P is much more recent.

For half a dozen years, Leroy Hood has insisted that, not beyond another dozen, each patient will have a cloud of billions of molecular, chemical-clinical, cellular, organic, phenotypic data, medical images or social networks, which they will demand a deal whereby such big data is reduced to simple

models that will serve as a guide in health in order to minimize disease. This requires facing two challenges: the noise inherent in big data and the integration of multi-scalar data in predictive models. On the other hand, each person's big data cloud will have to be integrated into a network of networks, which will be disturbed by the pathology of each personal data. Following Hood, the implementation of P4 medicine depends on the achievement of two main objectives. First, the technical aspects of systems medicine must be developed −strategies, technologies or analytical tools− that allow the generation and analysis of big data for each patient. Second, the ethical, legal, social, privacy, political, regulatory, and economic challenges of P4 must be addressed. Also, assuming the increasingly present role of autonomy, self-sufficiency and patient emancipation, P4 integrates patients and the rest of the actors in the health system: health personnel, companies, social security systems or private medical insurance, the public in general; All this requires a change in the general educational paradigm, while recognizing the leading role of advanced communication technologies: smart-Tech[37].

It should not be forgotten that along with the «convergence of knowledge» emerges a «business convergence» or formation of business platforms; the purpose is nothing more than a form of innovation insofar as the combination of the different products of each company separately breaks the pre-existing competition and the economic and regulatory barriers in order to offer greater value at lower cost and complexity. Convergence is more than size and scale, says Bill Copeland[38], it is an opportunity to build something of much greater value than the sum of its parts, which is but the general principle of all kinds of convergence. A "global convergence" is presented as the engine of an accelerated evolution of health care.

From the laboratory to the clinic and back, and also to the company

Biomedical Sciences refers, therefore, to the application of basic, experimental, logical and formal sciences, with the aim of increasing knowledge of Clinical Medicine and Public Health[39], in order to develop new strategies and improve existing ones for the prevention, diagnosis, treatment, monitoring and rehabilitation of diseases at personal and community levels and, with this, guarantee social welfare in the most efficient way possible. Certain Universities have created new Departments of Biomedical Sciences by merging classic Departments such as Anatomy, Physiology and Pathology in an effort to develop interdisciplinary integrative programs. But the Biomedical Sciences in their current development continue to broaden their horizon. From a perspective that looks to the future, molecular medicine and pedictive diagnosis are at the starting point of the current revolution, changing the scientific bases of prognosis, while at the same time entailing a change in the ethical dimensions of the relationship between patients. –"unpatients", in the sense of Albert R Jonsen *et al*.[40]–, his doctors and other professionals in the field of health.

Biomedical Sciences also emphasize the translational aspects of knowledge beyond the classic scheme "from the laboratory to the patient", emphasizing the importance of feedback "from the patient to the laboratory". The recovery of the figure of the «clinical researcher» –the one who serves as a bridge between the basic and the clinician– regains full validity. Biomedical Sciences provide applied knowledge. Francis S. Collins[41], director of the US National Institutes of Health (NIH), writes: "Despite dramatic advances in the molecular pathogenesis of disease, translation of basic

biomedical research into safe and effective clinical application remains a slow, expensive, and failure-prone endeavor. To pursue opportunities for disruptive translational innovation, the U.S. National Institutes of Health (NIH) intends to establish a new entity, the National Center for Advancing Translational Sciences (NCATS). The mission of NCATS is to catalyze the generation of innovative methods and technologies that will enhance the development, testing, and implementation of diagnostics and therapeutics across a wide range of diseases and conditions […] The medical benefits of the current revolution in biology clearly cannot be achieved without vigorous and effective translation". Words that reinforce the value of Biomedical Sciences in that they guide research applied to the disease and/or the patient –DOR and POR–, which was already reinforced by the previous director of the NIH, Elias A. Zerhouni[42]. They also bear in mind the business aspect of transferring knowledge as an added value, learning about venture capital funds and the stock market, which requires specific preparation for it. All this under the protection of ethics and the law. Rescuing the physician-scientific workforce: the time for action is now, is the title of a recent article written by Dianna M. Milewicz *et al*.[43], attached not to "basic research" but to clinical departments of internal medicine, pediatrics, pathology, microbiology or immunology.

The curriculum must contemplate the analysis of the data that the clinic provides, so biostatistics, from the traditional clinical trial to the neonatal single-person clinical trial. Also, the understanding of big data or megadata essential for modern epidemiology and, also, in the field of medical records in the formats of written and digitized medical records. Digital environment that will dominate in the coming years; from telemedicine and ICT in the last mile to managing megacohorts. Without forgetting the presence of mathematics in the entire educational spectrum, from physiology to modelling.

The objective is to train professionals who, with initially reductionist knowledge but at the same time with an integrated vision of pathophysiological mechanisms, apply this knowledge to the study of relevant, essentially complex problems in the prevention, diagnosis and treatment of diseases. Also, cover the existing bridge between basic knowledge and its clinical and social application. On the other hand, health problems represent a key feedback factor in the search for and understanding of fundamental biological mechanisms. In addition, the Biomedical Sciences, even having their own entity, open the doors to the concurrence of the classic Medicine, Veterinary Medicine, Pharmacology or Biology. The intended training prepares, in a global way –from the molecules to the organism and its relationship in the biosphere; what Douglas R. Seals[44] calls "Translational physiology: From molecules to public health»– and eminently practical, to students to address complex problems through biomedical research in the sense «from the laboratory to the patient and from this to the laboratory", without neglecting the relationship with the global environment, the added technical-economic-labour value, the ethical and legal constraints or the dominant emerging technologies.

Creative destruction: digital medicine

According to Dr. Lawrence P. Casalino[45]: "I would say that I actually think that probably a good 50 or 60%, if not more, of visits to primary care physicians, face-to-face visits, don't need to be face-to-face". Vinod Khosla[46], a benchmark in venture capital wrote: "We need algorithms, not

doctors. The 80% of doctor will be replaced by technology". Eric Topol[47] concludes: "Consumers coming together to demand a new, individualized medicine will be the most powerful means of changing the future of health care". And MobiHealthNews[48] bombards you with "unique news" daily. However, as we enter the Second Machine Age, the question arises as to whether this digital landscape will not reset the need for healthcare professionals, says Erik Brynjolfsson[49].

Juhan Sonin[50], Director of Application Design at GoInvo and associate at the Massachusetts Institute of Technoloy (MIT) comments: "Humans don't want to think about health or healthcare in general. They don't. We're biologically switched to only think about it when we're hurting, and yet here we have one of the biggest industries in the US wanting us to think about it all the time. Machines and sensors and all this new tech and culture that we're grounding into now will be much more aimed at this idea of invisibleness, that robots, algorithms, and sensors will be taking much of the mundane, day-to-day aspects out of our lives - which is great, no one wants to think about that".

All of them are manifestations of a deep draft: they call into question the entire health care system. They indicate the need to address something much larger than change; what Eric Topol calls "*Homo digitus* and medicine Schumpetered"; the essence of creative destruction popularized by economist Joseph A. Schumpeter[51]. Everything is digitizable, connectable, controllable and applicable, through smart-technology. If so, today the medical schools are obsolete entities questioned by the completely insufficient offer of training in each and every one of the areas of digital medicine.

Wearable biosensors –lab-on-a-chip (LOC)–, a combination of microelectronics and microfluidic devices capable of analyzing dozens of parameters including DNA sequencing with <10 nl of sample; Connected to a smartphone capable of performing a high-resolution global ultrasound body scan, with the exception of the brain, and hyperconnected to a participatory global cloud, it will respond to most individual needs. The next step will be to replace the LOC with a lab-in-the-body (LIB). The patient, owner of their data, will contrast big data whose participatory analysis will eliminate the "tyranny of experts" –guides or protocols– that has been referred to as "eminence-based medicine" rather than "evidence-based medicine"[52]. There are about a dozen routine tests that have been in place for decades and are being questioned. This will have repercussions in the reduction of costs due to the individual control of unnecessary services, administrative costs or fraud.

Regarding hyperconnectivity, you only have to look at the statistics of social networks. Social and Hootsuite estimate the number of active users in the month of January 2018: 2,167 M Facebook, 1,500 M Youtube and 1,300 M WhatsApp. The importance of social networks in the "health care cloud" –before "medicine"– can be exemplified in Patients-Like-Me®; Jamie Heywood[53], co-founder and co-chairman, comments: "We started with the assumption that patients had knowledge we needed, rather than we had knowledge they needed. We didn't have the answers, but patients had the insights that could help us collectively find them". More than 600,000 people who suffer from more than 2,800 pathologies participate and whose mission is: "to put patients first". A challenge for the change or adaptation of the personalized or precision health of the future, as Francis S. Collins and Harold E. Varmus[54] presume.

This connectivity is but one ingredient of the Internet of Things (IoT) but, such is its impetus, that the term Internet of Medical Things (IoMT) is beginning to be used. For Deloitte[55], investing in exponential technologies reduces costs, increases accessibility and improves health care. While the global increase in health care grew at a rate of 1.3% in the period 2012-2014, an annual increase of 4.1% is projected for the five-year period 2017-2021, which will translate into spending of $8.7 trillion in 2020. The impactful technologies in this area are estimated to be: robotics, artificial intelligence, big data and analytics, synthetic biology, additive manufacturing especially 3D printing, wearable diagnostics, and biosensors and trackers. To which should be added a new-«born field: digital therapy, where virtual reality fits. The future is marked by emerging talent and technology. In 2015, within the framework of the Precision Medicine Initiative[56], the NIH Director's Advisory Committee launched the *Digital Health Data in a Million-Person Precision Medicine Initiative Cohort*, and two years later, the European Commission[57] launched the *Blueprint on Digital Transformation of Health and Care for Aging Society*.

Deloitte indicates 10 predictors for 2020s: “A/ External environment shaping predictions: 1. Health consumers (Informed and demanding patients are now partners in their own healthcare). 2. Healthcare delivery systems (The era of digitized medicine – new business models drive new ideas). 3. Werables and mHealth applications (Measuring quality of life not just clinical indicators). 4. Big data (Health data is pervasive – requiring new models and providers). 5. Regulatory compliance and patient safety (Regulations reflect the convergence of technology and science). B/ Internal industry performance shaping predictions: 6. Research and development (The networked laboratory – partnership and big data amidst new scrutiny). 7. The commercial pharmaceutical model (Local is important but with a shift from volume to value). 8. The pharmaceutical Enterprise configuration – the back office (Single, global organization responsible for insight enablement). 9. New business models in emerging markets (Still emerging, but full of creativity for the world). 10. Impact of behaviors on corporate reputation (A new dawn of trust)”.

Similar to the publications cited above on the possible extinction of clinical researchers, Dennis Bethel[58] writes: “In the face of rapidly changing industries, businesses must be ever vigilant to grow and evolve or they too will face extinction. We have all heard that 9 out of every 10 new businesses fail. However, unlike a tree that falls in the forest, when one of these bigger companies fail, the impact can be heard and felt worldwide. Investors are hurt, money is lost, and retirements are put on hold. Is medicine exempt from such a future? […] Ultimately, I think the final result with be something less than an apocalyptic collapse. However, many physicians may find the final result unrecognizable from the golden years of medicine. Many will welcome their status as a dinosaur and favor their extinction as opposed to the high stress, low job satisfaction, low wage, assembly-line approach of the Thunderdome”. And Kevin Kelly[59] points out: “The rotate tasks of any information-intensive job can be automated. It doesn't matter if you are a doctor, lawyer, architect, reporter, or even programmer: The robot takeover will be epic”. All of this seems to point to the paradox: “cars without drivers versus patients without doctors”. Hannah Waters[60] picked up the announcement of the prize (Tricorder Prize, $10 million) sponsored by the giant Qualcomm and the X Prize Foundation, to reward the inventor of a simple, portable, non-invasive device that can diagnose a series of pathologies with the same level of accuracy as a panel of physicians.

Mistrust and hope. The art.

In the year of his death Franz J Ingelfinger reflected[61]: "Nothing express as effectively and as succinctly the course of American medicine since World War II as Aaron Wildavsky's provocative observation that we are 'Doing better and feeling worse'. The immense scientific and technological developments that have characterized medicine during 20th century account for our 'Doing better'. Paradoxically, the same developments also account for our 'feeling worse', and are related to technology's dominant influence in shaping the past, present, and future of medical care". Three years later, Charles, Prince of Wales[62], declared to the press: "I would suggest that the whole imposing edifice of modern medicine, for all its breath-taking success, is, like the celebrated tower of Pisa, slightly off balance". In October 1990 the *Economist* published the article "Doctors can damage your health"[63]. "The costly wonders of modern medicine have not had much effect on life expectancy or the incidence of sickness. Should the billions that rich countries spend on high-technology doctoring be spent on health instead?". And four years after, in the same section "New anatomy lesson, please"[64] you can read: "The medical world is in a sorry state. The business of medical care is under attack from all sides", and then read "New technologies are set to transform medicine, eradicate most diseases and hugely improve people's health". At and the end "What would Hippocrates have done? He would soon have found that, although many new technologies raise tricky medical, ethical and social problems, they can be managed with legislation and with the right regulatory constraints. It is hard to see why anyone should reject the opportunities that new medical technologies are likely to offer. The reward, after all, could be a guaranteed hale and hearty future for all".

In 1952, the British physician Robert Coope[65] published an anthology: *The Quiet Art*. The title, comments David Weatherall[66], is taken from Virgil's *Aeneid*[67]: "[...] he preferred to know the virtues of herbs and traces of cures and exercise without renown their arts of unspoken fame". The book includes a reference to a paper published in *The Practitioner*, an English journal for general practitioners, written by Sir Arthur Hall[68] in 1941: "Medicine however much it develops must always remain an 'applied science' and one differing from all the rest in that the application is to man himself. Where there are no sick persons there would be no need for Medicine, either the Science or the Art. So long as there are both, both will be necessary. The application of its Science, to be of value, must be made in such a way that it will produce the maximum of relief to the sick man. This calls for certain qualities in the practicing physician which differ entirely from anything required in the practice of the other applied sciences. Herein lies the Art of Medicine. The need for it is as great today as it ever was, or ever will be, so long as human sickness continues".

But who sets priorities? David Weatherall writes: "Sooner or later we will have to decide on our priorities. But who will set them? Doctors cannot do this; the whole ethos of medical practice is based on doing everything possible for an individual patient. So who will make the decisions? Will it be left to market forces or government committees? And on what criteria will their judgments be based? […] We cannot duck these issues for much longer". Barbara Culliton's view is gloomy: "An ideal patient is a patient who is never seen"[69].

And what is the art of Medicine? Wheatherall continues to write: ”Apart from clinical and pastoral skills, good doctoring requires an ability to cut through many of the unexplained manifestations of disease, to appreciate what is important and what can be disregarded, and hence to get to the core of the problem, knowing when scientific explanation has failed and simple kindness and empiricism must take over. This is the real art of clinical practice”. For his part, H David Crombie[70] after beginning his reflection on *The Surgeon's Art*,-“My subject is the art of surgery, its history and progression into the present high-tech age”- cites to the writer-surgeon William A Nolen[71]: “The transformation is a low process marked by a little more dexterity on one case, a slight improvement in judgment on another, a bit more confidence on a third. No big jumps, just small steps forward. But when it's all over and the new surgeon is turned loose to practice his art, somehow he's ready”.

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NOTE: Complementary translation – *Google translator.*