Chapter 5

Importance of training for the generation and appropriation of culture in Research Ethics, Bioethics and Scientific Integrity

Biomedical sciences and engineering

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Abstract

The following chapter presents the theoretical framework of the importance of training for the generation and appropriation of culture in research ethics, bioethics and the scientific apparatus, as it is for the Biomedical and Engineering areas, from the identification of cognitive biases, understood as that pattern of conduct in the exercise and what to do investigative. Therefore, the central objective of this chapter was the analysis of research from the evidence-based scientific literature, describing the cognitive biases, attitudes and behaviors related to ethical, bioethical elements and scientific apparatus in the two previously mentioned areas of knowledge. and raising the need for training in the change of attitudes and behaviors that counteract everything that opposes the ethics of research, bioethics, and scientific apparatus —EIBIC—.

Keywords: Training, Bias, Biomedical, Engineering, Research, Education.

Resumen

En el siguiente capítulo se presenta el marco teórico de la importancia de la formación para la generación y apropiación de la cultura en Ética de la Investigación, Bioética e Integridad Científica en las áreas biomédicas e ingenierías, desde la identificación de sesgos cognitivos, entendidos como patrón de conducta en el ejercicio y quehacer investigativo. Por lo anterior, el objetivo central de este capítulo fue el análisis de investigaciones, desde la literatura científica basada en la evidencia; primero, describiendo los sesgos cognitivos, actitudes y comportamientos relacionados con elementos éticos, bioéticos y de integridad científica en las dos áreas del conocimiento anteriormente mencionadas; y, luego, planteando la necesidad de la formación en el cambio de actitudes y comportamientos que contrarrestan todo lo que se opone a la Ética de la Investigación, Bioética e Integridad Científica —EIBIC—.

Palabras clave: Formación, Sesgos, Biomédicas, Ingenierías, Investigación, Educación.

Resumo

O capítulo seguinte apresenta o referencial teórico da importância da formação para a geração e apropriação de cultura em ética em pesquisa, bioética e integridade científica, como é para as áreas Biomédica e de Engenharia, a partir da identificação de vieses cognitivos. conduta no exercício e o que fazer investigativo. Portanto, o objetivo central deste capítulo foi a análise de autores da literatura científica baseada em evidências, descrevendo os vieses cognitivos, atitudes e comportamentos relacionados aos elementos éticos, bioéticos e de integridade científica nas duas áreas do conhecimento mencionadas anteriormente e levantando as questões necessidade de formação na mudança de atitudes e comportamentos que contrariem tudo o que se opõe à ética da pesquisa, à bioética e à integridade científica—EIBIC—.

Palavras-chave: Treinamento, Viés, Biomedicina, Engenharia, Pesquisa, Educação

5.1 Introduction

The increasing globalization of commerce, education and research has resulted in greater collaboration between institutions and countries, at the academic level, with an increase in scientific projects and publications, both in the biomedical and engineering areas. Consequently, in the last decades, the number of scientific articles published in journals monitored by platforms such as SCOPUS increased from around 1.1 million to almost 2.2 million publications. Similarly, during this same period, researchers from low- and middle-income countries increased their percentage of scientific and technical knowledge, with an increase in their publications from around 9.5% to 13.7%. This led to an analysis against the process of the method and scientific rigor of research, identifying possible biases arising from it (National Science Foundation [NSF], 2016).

Similarly, in the last 30 years, the co-authorship of authors from more than one country increased from 8% to 19%, in relation to countries such as the United States and China;

and researchers have increased their scientific production in health sciences by about 18.8% and in engineering by 18.2% (Balz, 2022). With this increase in publications, there have been more and more reports of irregularities in scientific conduct, both at the formative and strict research level. This is why, currently, attention has been focused on how institutions monitor the conduct of tutors or mentors in relation to research misconduct at all levels of training. Role models have been provided through training in responsible research, both at the educational and strict research levels. This, with the objective of reducing cognitive biases, as well as misconduct, both among trainees and research tutors, especially in institutions that have limitations in infrastructure and software technologies to detect, investigate or penalize research misconduct (Altman & Broad, 2005).

Therefore, the objective of this paper was to review the literature based on scientific evidence currently published, to identify cognitive biases, attitudes and behaviors related to ethical, bioethical and scientific integrity elements in the area of biomedical sciences and engineering, in relation to the generation and contribution to knowledge from science, technology and innovation. When analyzing the results of this process, the need for training in the change of attitudes and behaviors that threaten ethics, bioethics and scientific integrity -EIBIC- in Colombia and in the practice of research arises.

That is why, from the Training Roundtable Discussion, the conceptual development group has worked in recent years on documents that provide SNCTI actors, at a transversal basis, with information on the development of a framework of ethics, bioethics and scientific integrity with standards for the conduct of research practices and activities. This is especially relevant in the multidisciplinary sphere, where it is essential to ensure that research results are reliable, that the training of future researchers is carried out ethically and that research improves our understanding of the world and its inhabitants, in an integral manner, respecting and protecting the subjects of study (both humans and animals), in biomedical science research, used to contribute to or generate new knowledge.

Likewise, the responsible conduct of research is based on the ethical behavior of the researchers towards the processes and subjects of the research, as well as their conduct with their collaborators or co-researchers. Therefore, it is essential to generate a culture related to the activities of supervision of scientific integrity at the level of the institutions or entities that conduct research, so that they include in their process of self-evaluation and quality of science, technology and innovation activities the supervision of each of the stages of development of the research process; As well as training in identification and implementation of activation of routes to control or minimize cognitive biases, bad practices or attitudes of researchers with impact on the reliability of the processes or results of research in the biomedical and engineering areas. The U.S. National Academy of Sciences, Engineering, and Medicine, in its report Advancing Research Integrity, states, “Practicing research integrity means planning, proposing, conducting, reporting, and reviewing research in accordance with the following values: objectivity, honesty, openness, accountability, fairness, stewardship” (Committee on Responsible Science et al., 2017).

On the same way, it is important for the practice of research integrity to provide a route or structure through which misconduct, praxis or bias in scientific activities can be identified, reported and addressed, both formatively and strictly, in any discipline or area of knowledge. Therefore, the International Academic Council, a multinational organization of academic science, states: “Academic institutions are necessary to effectively denounce irresponsible procedures in research and their efforts should be oriented to reduce the number of irresponsible behaviors and practices by researchers and their collaborators” (InterAcademy Council [IAC] & The Global Network of Science Academies [IAP], 2012).

According to the above, when conducting research there are many ways to undermine the integrity of the research process or generate biases in science, technology and innovation activities. Some of these practices involve activities in terms of behaviors that undermine the quality and reliability of the data or results of the studies and even affect the health and life of populations and other living beings, as well as air quality, among many other variables in biomedical sciences or engineering. These activities or behaviors include, for example, making data for studies (Kornfeld, 2012), as well as performing experiments with protocols that are not standardized or approved by the corresponding entities on humans or animals, without informed consent (Dubois et al., 2013). Although these types of behaviors may be uncommon - as they could lead to actions such as dismissal, withdrawal of investigators or even withdrawal of research funding - there is another subset of more frequent behaviors that, although they include less serious actions related to biases in the research development process, can cause significant problems for researchers, institutions and human participants or animal study subjects, because they compromise the integrity of the experimental data.

Such behaviors include, but are not limited to:

- Failure to adequately develop the informed consent process for the performance of research practices.
- Misuse or omission of research protocols.
- Neglecting to monitor processes within the training process (therefore, may increase the risk of falsification of data).

Such behaviors may reflect bias and lack of rigor, rather than an intention to commit irregularities within the research process or phases; however, they may lead to serious disciplinary actions by the regulators of the integrity of the research process within the institutions that conduct or finance the projects. In this regard, among the penalties that can be implemented in relation to malpractice or behavior by researchers, scientific literature reports their suspension, which can be temporary or definitive, depending on the seriousness of the action. Therefore, the institutions seek that this type of behavior is not repeated in the scientific and research community.

In its initial part, the following text presents -from a bibliographic review- a conceptual development on the importance of training for a change in the EIBIC culture. As a second element, it addresses the cognitive biases that can impact the accuracy or veracity of a phenomenon under study, as well as influence attitudes and behaviors in the EIBIC. Finally, the need for training on attitudes and behaviors that counteract anything that goes against EIBIC in both biomedical and environmental areas is proposed.

From historical perspectives, the World Medical Association developed the Declaration of Helsinki, adopted by its assembly in Helsinki in 1964 (World Medical Association, 2013). This guidance was intended specifically for physicians, regarding the participation of their patients in research. Subsequently (in 1982), the Council for International Organizations of Medical Sciences, using the Declaration of Helsinki as a reference, provided guidelines for conducting biomedical research on human subjects.

By the 1980s, few institutions had adopted institutional reviews to evaluate and monitor conduct and practices in human or animal research in response to concerns about scientific misconduct; instead, independent monitoring and regulation of scientific activities had been adopted. During the same period, cases of scientific misconduct began to be reported, resulting in international institutional standards to reduce scientific misconduct (Steneck, 1994). In 1989, to ensure that attention was focused on scientific integrity in the conduct of research, institutional training grants began to be offered at the international level, with the aim of demanding the implementation of a program on principles of scientific integrity that would be an integral part of the proposals made to strengthen research in all its stages (National Institutes of Health [NIH], 1989). Since these proposals, updates of guidelines for good research practices have been implemented; but experts suggest that, despite these guidelines, transgressions to scientific integrity continue to occur and there is still a lack of consensus on how to teach the importance of training for the generation of a culture of Research Ethics, Bioethics and Scientific Integrity.

In accordance with the above and considering the duties of caring for a good practice in research, given the need to promote and observe scientific integrity as a standard of conduct, the ethical and deontological principles that inspire and guarantee a rigorous and responsible praxis are necessary. For this purpose, the Low Countries Code of Conduct for Research Integrity specifies 61 standards for conducting good research. A unique feature of the code is that it also contains a chapter on duties of institutions conducting research, with the aim of enhancing and reinforcing good practice around the practice of research, and researchers to steer away from malpractice. This is articulated in the following words: "Research institutions should create and maintain conditions that promote integrity through education, clear policies and reasonable standards for the progress of research, while fostering a working environment that embraces integrity" (Singapore Declaration, 2010).

In that sense, implementing strategies to promote research integrity across institutions will contribute to good research practices. The plan should cover a set of mandatory topics and normally describe a combination of educational programs, codes, manuals, policy measures, regulations, facilities, auditing schemes and support systems to have the necessary tools for quality procedures articulated with guidelines that can help research institutions formulate their research integrity promotion. Therefore, the initiative of global research institutions and other interested parties - from the academic component or systems interested in improving research quality, such as the continuous process of quality assurance and research integrity - is a responsibility of all interested parties.

One of the factors that can generate biases in research is the variable related to economic incentives. It could be argued that one of the most important things that research institutions must do is to avoid implementing harmful incentives in the evaluation of researchers for career advancement. Currently, the prevailing focus on bibliometric indicators derived from publication and citation counts send a strong message that only these things really matter when doing research (Núñez, 2022). In recent years research in the biomedical sciences has increased significantly both in practice and in publication, therefore, there have been recurrent calls to improve the rigor and quality in research both formatively and strictly, each of the members of the academic community sharing the responsibility to ensure the rigor of the research processes, either as researchers in the design and implementation of research processes, as manuscript reviewers who evaluate the results of scientific activity. The process of generating or contributing to knowledge must be solid, rigorous and transparent at all stages of design, execution and reporting in order for knowledge to benefit research and society. Thus, evaluations of researchers rarely include considerations related to the reliability, rigor and transparency of the process. Therefore, the Hong Kong Principles (HKP) were developed as part of the 6th World Conference on Research Integrity with a specific focus on the need to foster research improvement by ensuring that researchers are explicitly recognized and rewarded for behaviors that strengthen research integrity. The five principles are introduced: responsible research practices; transparent reporting; open science (open research); valuing a diversity of research types; and recognizing all contributions to research and scholarly activity (Moher, 2020).

The Hong Kong principles are chosen with a view towards explicitly recognizing and rewarding researchers for behavior that leads to reliable research, so as to avoid malpractice in research. The principles have been developed with the belief that their implementation could help define how researchers and career advancement are evaluated, with a focus on behaviors that strengthen research integrity. Five principles were identified:

1. Evaluate research practices and responsible parties.
2. Assess the submission of complete research reports.
3. Reward open science practice.
4. Recognize a wide range of research activities.
5. Recognize other essential tasks, such as peer review and mentoring.

Research institutions should make their research integrity policies based on scientific evidence, to the extent possible, to avoid bias. Evaluation of research processes is a focal point of decisions regarding the hiring, promotion, and tenure of research process leaders, to build, write, present, evaluate, prioritize, and select curriculum vitae. Institutions must make decisions in a constrained environment (e.g., limited time and budgets) (Moher, 2018). However, even for easily measurable aspects, the criteria used for assessment and decisions vary across settings and institutions and are not necessarily applied consistently, even within the same institution (Meursinge Reynders, 2022). For example, there is a large literature related to the impact factor of the journal to evaluate the scope of bibliographic citations, in that sense some institutions use to evaluate the literature published by their professors as well as the monetary rewards of the publication process (Tijdink, 2016).

According to the above, there are few evaluations of scientists that focus on the analysis of good or bad research practices, nor do the measures that are currently implemented tell us much about the contribution that researchers have to society, as is the final result of each process with impact on the population, which is the objective of most applied research. In the applied and life sciences, the replicability of findings by others or the productivity of a research finding is rarely systematically evaluated, despite documented problems with the published scientific record and its reproducibility across published domains (Kleinert, 2014).

That said, there is still much we do not know about research integrity in research institutions. Which is why institutions have made the decision to validate research and its results, for example, to rigorously examine the effects of a health intervention, trial participants (human or animal) are usually required to be randomized among the intervention being studied, which is why some researchers advocate protocol registration as a way to ensure transparency and reduce bias. This has in some percentage provided insights to research institutions to improve their policies and fulfill their duties of care in promoting research integrity (Al-Shahi Salman, 2014).

Similarly, it is important to keep in mind that there are many interested parties in fostering a responsibility in research integrity. First, researchers themselves are accountable for their behavior in every part of the research process. Researchers are a role model for students, in terms of behavior; therefore, ideally, they should be a good role model. Secondly, research institutions must generate the conditions for responsible behavior, among others, by training researchers to act in accordance with the highest standards of quality and social responsibility.

Also, funding agencies and scientific journals have a role within the system and a responsibility. But there is no magic pill or quick fix: the dilemmas and distractions facing researchers are real and universal. Therefore, we must as a society collaborate and do all we can to prevent malpractice and foster research integrity (Kretser, 2019)

5.2 Importance of training for culture in Research Ethics, Bioethics and Scientific Integrity

The results of the systematic search of the available literature related to the importance of training for the appropriation of a culture in Research Ethics, Bioethics and Scientific Integrity in biomedical sciences and engineering allowed the identification of studies in full text. These were independently selected by two reviewers, using the databases of health, biomedical and multidisciplinary sciences (including engineering), by combining the following keywords: Research Ethics, Bioethics, Bioethics and Scientific Integrity, biomedical and engineering. In the second evaluation stage, the articles were obtained in full text and evaluated by the two authors, who agreed by consensus on the final inclusion of the selected articles. The first reviewer extracted and sorted each full-text article by database, while the second reviewer independently verified the extracted data and resolved differences generated in this phase of the conceptual literature review.

The following lines present an analysis of results, from the theoretical and conceptual framework of the discussion on the importance of training in Research Ethics, Bioethics and Scientific Integrity: biomedical sciences and engineering.

As a result of the analysis of the documents selected in the theoretical framework, we have the book Bioethics, bridge to the future (Potter, 1971), in which the need for what the author calls the new science of survival is raised and justified, in these words: “We have a great need for an ethics of the earth, an ethics of wildlife, an ethics of population, an ethics of consumption, an urban ethics, an international ethics and the others”. Potter’s original idea was to create a new discipline that would bring together the realm of facts and the realm of values, the domain of the sciences and the humanities, in order to find ways out or, at least, road maps that could serve as a guide in the complex labyrinth formed by contemporary society, the product of the fusion between the scientific and industrial revolutions.

Similarly, Singer explains the importance of ethics by contextualizing that, if we observe carefully enough, we can discover that most decisions are related to ethics. Similarly, the beliefs and habits with which we were raised can exert a great influence on us; but, once we begin to reflect on them, we can decide to act in accordance with them or against them (Singer, 1994). On the other hand, Garrafa states in his research results that there is currently a growing visibility and enforceability of bioethics, not only in the scientific and educational fields (Garrafa, 2010), but in all activities involving science, technology and innovation. Similarly, for Adela Cortina, ethics must be understood as a unique fact irreducible to others, so that our human world is incomprehensible if we eliminate that dimension which we call moral. Therefore, ethics is applied when there is an effort to provide grounded answers to the moral problems that arise in the concrete fields of human action, not as far as eternal and predetermined principles are applied to particular disciplines (Cortina, 2000).

Accordingly, in the study conducted by García and others, the training processes in the ethics area describe the achievements and repercussions of training in research ethics, as well as the didactic strategies that serve as stimulus, motivation and orientation for courses in the discipline. Garcia, in his article, concludes that:

> The training in research ethics provided by the CIEB (Interdisciplinary Center for Studies on Bioethics) under the auspices of the Fogarty International Center, was an experience of incorporation of knowledge and skills that can be applied in a practical way in teaching and institutional settings, as well as in the ethics committee and in research in this discipline. The training received had its expression in the various aspects outlined above, but above all in the ethical and bioethical view that gives a new way of situating oneself personally and professionally. (García Rupaya, 2012, p. 80)

According to the above, the main reasons for the bioethical training of health professionals lie in the ethical problems raised by the progress of science, technology and innovation; the context transformations; the changes in health systems; the ethical crisis of students during their training; the responsibility to safeguard the welfare and quality of life of patients; the need to strengthen the principles and values related to professionalism; and other competencies, such as the identification of moral issues, moral reasoning, decision making and moral activity.

Consequently, universities have a leading role in society, since their duty is to educate citizens; that is, people, not only with a solid professional education, but also civic, cultural, social, environmental and ethical. Therefore, it is necessary for these institutions to have policies that translate into a social and ethical commitment to development. As universities demonstrate that the ethical education of their students is a priority, faculties will be able to implement strategies to achieve this goal, both from the official curriculum as well as from the hidden curriculum. In the particular case of the training of engineers in multidisciplinary subjects, this is a complex task, since it requires the development of competencies from several well-established disciplines; this is the case of electromechanical, mechatronic and biomedical engineering, in which it is necessary to work on integrating subjects in order to achieve the training objectives (Pannucci, 2010).

In particular, engineering faculties in Colombia need to provide their students with an ethical education that allows them to understand that they should not only be prepared to apply the latest in technoscience, but also to apply ethics to their professional performance (Estrada, 2008). In this way, they will be able to assume the challenges that engineering - as a profession of high social risk - presents them and decide between the good and bad of their decisions. Likewise, they will be trained and motivated to contribute to the equitable development of the country and will avoid corruption or irresponsibility, among others. This education is required from the official curriculum with at least one subject that deals with specific topics of ethics for engineers and the code of ethics of engineering. Additionally, professors in their subjects should set an example of ethical behavior for their students. From the hidden curriculum, faculties can implement a series of strategies to overcome the resistance of some professors and students to the ethical discourse in the exercise of research, both formative and strict, thus allowing the strengthening in the areas of ethics, bioethics and Scientific Integrity.

To cite a case, we have the ethics of technology, which should be included within the new values. This dimension, which is conceived as a process or a capacity to transform or combine something already existing to build something new, cannot be done without a principle of shared responsibility. Research has shown that the exponential growth of data and information in the world of the system, as an interpretation of the world of life, poses an important challenge to the disciplinary view: it establishes the need to establish connections with other knowledge that will allow it to define points of reference and curatorship to face the current times of crisis of knowledge. Part of this effort is related, but not limited, to the incursion into the interdisciplinary (Henao, 2017).

Transdisciplinarity provides holistic schemes that subordinate disciplines, inquiring into the dynamics of systems in contexts and planes of reality; it seeks an opening of disciplines towards other objects of study. From the perspective and interests of knowledge, it is related to the threefold intersection between the technical interest, the practical interest and the emancipatory interest since it contemplates the possibility of subjectivity in relation to the interpretation of the world of life and its interconnections with the world of the system. For this reason, this text addresses the influence of the transdisciplinary approach in the research processes of the faculty.

Given the interdisciplinary nature of bioethics, it implies the need to integrate a set of diverse disciplinary and professional fields, bringing together anthropological, philosophical and technical knowledge from different branches (including engineering) for decision making. Santilli (2010) states that technology is the one that highlights such interdisciplinary character; hence they expose technology as the "central node". Unfortunately, current bioethics education is still highly focused and biased towards the training of health-related professionals. For this reason, the main bioethics institutions are still located in medical schools. Consequently, there is a vacuum in the teaching of bioethics for professionals and students from other careers; from this it can be inferred that it is not only important, but necessary, to formulate bioethics training projects for students from other areas, such as engineering.

In this regard, Develaki (2008) states that the study of bioethics should be proposed as a bridge between science, technology and humanities. In addition, the new applications of engineering to biological systems require the incorporation of human sciences in the training of engineers, since they are developed within a framework governed by ethics (Castaño, 2007). Bioethics can be, then, the starting point to access an integral ethical training in future engineering professionals, centered on the notion of responsibility; it can also contribute so that this technological area considers principles and values, and so that the ethical-social is the reference that guides the development of the discipline.

5.3 Cognitive biases, attitudes and behaviors in science, technology and innovation.

Decision-making in the biomedical sciences and engineering is based on technical knowledge and evidence regarding the options to be considered in a defined scenario and in a given population. Thus, the success of any intervention is based on obtaining quality information about the problem to be addressed. This is usually acquired from previous experiences and studies conducted in more or less similar scenarios and populations, which may have been influenced, to a greater or lesser extent, by possible errors (Stenson, 2019).

Mistakes in research can originate randomly, by chance. Therefore, they can have an impact on a lower precision of the subsequent results (random errors); or, systematically, they can have an impact on the accuracy or veracity of the phenomenon under study. Such are known as biases, and their importance lies in the fact that they affect the internal validity of a study and, in some way, also invalidate the results of the research. Thus, biases can be represented as the difference between what is being assessed and what is believed to be assessed (Ayorinde, 2020). Therefore, unlike random error, systematized error is not compensated for by increasing the sample size of the study. However, although its importance is vital in the development of research, it is relevant to mention that none is exempt from them; therefore, it is essential to know them and, thus, try to avoid, minimize or correct them (Pollock, 2020).

Biases can occur at any stage of the research process, i.e., in the planning, conduct, analysis, presentation of results and their subsequent publication. The risk of bias is intrinsically related to clinical research, where its high frequency is assumed, since it involves variables with individual and population dimensions that are difficult to control. However, they also occur in basic sciences and engineering, contexts in which the experimental scenarios present conditions in which biases adopt peculiar characteristics that are less complex to minimize, since a series or a large part of the variables can be controlled.

The objective of this section is to identify the biases inherent to the biomedical and engineering sciences, which, when intervened, are expected to have an impact on the change of attitudes and behaviors in Research Ethics, Bioethics and Scientific Integrity. To achieve this objective, two processes have been carried out: first, the elaboration of a theoretical framework on the importance of training for the appropriation of culture in Research Ethics, Bioethics and Scientific Integrity in biomedical sciences and engineering; and second, the identification of cognitive biases, attitudes and behaviors related to ethical, bioethical and scientific integrity elements in biomedical sciences and engineering. Following the analysis of categories of cognitive biases in CTeI, three categories of biases were identified in biomedical sciences and engineering: availability bias, egocentric bias and intuition bias.

5.3.1 Introduction of research bias in biomedical sciences and engineering research

Bias is increasingly recognized as a serious problem in many areas of scientific research. Of particular concern are cases where research results appear to directly reflect the preferences and interests of certain stakeholders involved in the research process. Worrying examples of this have been identified, especially in privately funded research and in policy-related areas. Intuitively (and traditionally) it seems clear that the kind of bias suggested constitutes an outright epistemic failure. But philosophers of science have begun to identify that the ideal of pure, value-free science is, at best, just that: an ideal; and that all scientific practice involves all sorts of value judgments. While some philosophers have tried to distinguish acceptable from unacceptable value influences in science, efforts to draw this distinction in a principled manner have proved immensely difficult

Accordingly, in the theoretical framework analyzed, biases related to availability were found to impact science, technology, and innovation activities in the biomedical and engineering fields. These are listed below:

Frequency: Corresponds to variability in observation; that is, what is observed is not a pattern.

Measurement nature: Sometimes there may be difficulty in measuring the magnitude or value of a qualitative or quantitative variable. This situation may occur because the magnitude of the values is small, or due to the nature of the phenomenon under study.

Errors in the classification of certain events: They can be generated as a result of modifications in the nomenclature used, a fact that should be noticed by the researcher.

Selection bias: This type of bias, particularly common in case-control studies (events that occurred in the past may influence the probability of being selected in the study), occurs when there is a systematic error in the procedures used to select study subjects (Restrepo Sarmiento, Gómez-Restrepo, 2004). Therefore, this bias leads to an estimate of the effect different from that obtainable for the population under study.

Non-response bias: This occurs when the degree of motivation of a subject who voluntarily participates in an investigation may vary significantly in relation to other subjects, either by over- or under-reporting.

Membership bias: Occurs when among the subjects under study there are subgroups of individuals who share some particular attribute related positively or negatively to the variable under study.

Loss-to-follow-up bias: It can occur, especially in cohort studies, when the subjects of one of the cohorts in the study are totally or partially lost from the research, which generates that the pre-established follow-up cannot be completed and there is a relevant alteration in the results (Biele, 2019).

Egocentrics Biases

Due to neglect: The time factor is an important aspect, which affects different events in different ways.

Due to subjectivity: Regardless of forgetfulness, we can obtain answers that do not correspond to reality when a question is limited to a period of time. If there are no records, or if they are of poor quality, we will obtain an approximate answer that may reflect more or less what happened in the period under study. Over-reporting and underestimation of events should also be considered.

Confusion and ignorance: Occurs when the role of certain variables, exposures or events of interest is confused. This phenomenon may occur due to ignorance or lack of foresight on the part of the researcher. However, they are sometimes unavoidable.

Dropout: This can occur in the course of longitudinal studies, either by abandoning the study (ceasing to participate or refusing to continue collaborating) or by the disappearance of the subject under study.

Errors in the measurement instrument: This is generated by the incorrect choice of the measurement instrument or by subjective estimates of the measurement.

Conceptual biases: This type of error is committed when certain variables that may function as confounding factors are not taken into consideration, or when the duration of the study is inadequate. In other words, conducting studies that are not in line with the problem statement.

Lack of knowledge: in operability due to confusion between the differences between scientific committee, research ethics committee and bioethics committees.

5.3.2 Intuition Biases

During the analysis stage: Once the data collected are available, they are analyzed. Systematic errors may occur at this stage due to incorrect transcription of information into the database (wrong coding or values not accepted by a database field).

Publication bias: This can be considered a type of selection bias that occurs when the researcher thinks that the published studies are all those actually performed. It is known that many studies are never published for various reasons, such as that they are not concluded, the author considers the results to be irrelevant, they are not accepted for publication, etc. On the other hand, there is duplicate publication of some studies.

Biases in the initial evaluation of the project: These are due to the use of erroneous information or to the deformation of the initial information, which orients it towards certain aspects. In short, it is the existence of prejudices or erroneous data that condition the research approach.

During data collection: These occur during the process of collecting information, either by obtaining incomplete or erroneous information, or by modifying the sample (or part of it) during the execution of the research.

Bias due to the respondent: The information provided by the respondent may be incorrect, due to forgetfulness, subjectivity, confusion, distrust, ignorance, misunderstanding or modification of the response by the survey itself, or incorrect measurement of parameters.

5.3.3 Bias control

As has been mentioned throughout this chapter, biases can appear at any time during a survey and can be prevented and controlled at the time of design or during analysis. Some ways to control biases are:

Randomization: The random assignment of patients to each group in clinical experiments allows them to be balanced by chance and thus to be comparable.

Blinding: This tool is very useful, especially in clinical experiments, to avoid the introduction of bias on the part of the patient or the observer. It can also be useful in case-control studies to avoid observer bias. This masking can be one of the research hypothesis.

Standardization: Standardization of the measurement procedure-as well as staff training with the instrument, with the interview, and with data collection-reduces the presence of measurement error.

Operational definitions: Having clear definitions of disease and non-disease or exposed and non-exposed persons reduces misclassification bias.

Define possible confusion variables: Possible confounding variables should be foreseen from the time of study design in order to establish adequate control of these variables. For example: by restriction (inclusion and exclusion criteria), stratification or matching (rarely used, because of the possibility of greater bias).

Losses: From the moment of the design, it should be anticipated what percentage of possible losses will be tolerated, so as not to affect the results, and this estimate should be included in the sample size calculation. Usually, 10% of the sample is overestimated.

Within the context of science and values, a phenomenon of preference bias is of particular interest. It occurs when a research result improperly reflects the researchers' preference for it over other possible outcomes. It should be noted that this is a special type of bias, as the term "bias" is also often applied to cases of systematic error, which need not relate to researchers' preferences for one outcome or another. A classic example is the type of bias in clinical trials introduced by randomization, which tends to reconfirm, if anything, the investigators' preconceived beliefs, rather than their preferences. An important warning is that preference bias must be distinguished from outright falsification or fabrication of results. Preference bias works in a more subtle way: by increasing the probability of the preferred outcome, rather than by bluntly fabricating it. Before turning to the task of giving a more precise idea and satisfactory characterization of preference bias, some examples of the phenomenon that has recently raised concern in biomedical literature are presented. They illustrate the variety of mechanisms by which investigator preferences can come to exert a kind of problematic influence on the outcome of research. In particular, cases of preference bias are almost always controversial.

Accordingly, preference bias consists of the infringement of standard conventional rights established by the respective research community, whether in the biomedical or engineering area. This analysis captures the intuition that bias of preference constitutes an epistemic deficiency, as the conventional norms themselves are adopted by the community in an effort to enable and preserve epistemic trust and to ensure the ability to fulfill their epistemological roles. It also explains why the diagnosis of preference bias is often not a clear-cut case, as the conventional standards in question come in varying degrees of both explicitness and universality.

Similarly, we should point out that an analysis of preference bias as an epistemic deficiency was only possible when considered from the perspective of social epistemology. The different frameworks of individual rationality considered were informative with respect to the connection between inductive risk and certain concepts of bias, but they did not offer any definitive and realistic definitions. These were constraints for the purpose of drawing a line between the inevitable burden of science value and unacceptable preference bias. The domain of standards is limited to certain procedures and aspects of the research process that are particularly susceptible to regulation by implicit rules.

But, as the examples discussed in this paper show, these limited aspects can sometimes be of vital importance. Although the critique of the traditional conception of value-free science has provided important insights, an image of science as an open playing field for individual value judgments may therefore be exaggerated.

5.4 Training aimed towards the appropriation of a culture of Research Ethics, Bioethics and Scientific Integrity.

In order to illustrate this third element, we present Derek Book's widely cited 1976 article, in which he defends the idea that university students, regardless of the careers they study, should receive ethics instruction throughout their professional training, since this has the important function of "helping students to develop a clearer and more consistent network of ethical principles that carefully accounts for the needs and interests of others" (Bok, 1976, p. 29). The teaching of ethics aids the moral development of the individual, because "students in these courses will be more aware of the reasons underlying moral principles and will be better equipped to reason adequately about the application of these principles to concrete cases" (Bok, 1976, p. 30). According to Derek, the transversal curriculum of ethics is necessary for students to have the minimum foundations that will help them to resolve with better chances of success the moral dilemmas that, as professionals, they will face in their future activities.

In this sense, Miller and collaborators suggest that integrity in research is linked to the moral identity of professionals (Miller, 1998). In this regard, Aldo Leopold -forest engineer, precursor of environmental ethics-, as early as 1887, suggested the extension of the moral frontier to grant nature the category of a subject of law. Leopold's writings at the University of Wisconsin involve ecosystem problems and environmental conflicts with human health issues. With this, he substantiates his idea of human belonging to an ecosystemic biotic community; that is, the need for an ethics-bioethics, not only in the field of human relations, but also in the field of engineering.

Because, although it is true that one of the purposes of biomedical and engineering studies is to obtain new generalizable knowledge about a given aspect, it cannot be ignored that such studies should not go against the condition of end in itself that the human being presents; that is, that only those that respect and serve the integral development of the person and his environment are ethically lawful, and this is achieved with a solid training of the researcher (Marañón Cardonne and León Robaina, 2015).

The health sciences researcher today knows that they have to reconcile two positions: on one side, they are aware that they must advance in the search for new knowledge to put it at the service of man; but, at the same time, they must be careful to defend that man who is not an object of research, but the end and the meaning of it, reaffirming the Kantian categorical imperative "work in such a way that you use humanity, both in your person and in the person of any other, always as an end at the same time and never only as a means" (Kant, 1995, pp. 44-45).

Training in ethics, bioethics and integrity in the biomedical and engineering areas will allow us to consider a minimum of ethical requirements for research. This will lead to reducing to the maximum the possibility of exploitation, in order to ensure that research subjects are not only used but treated with respect and responsibility while contributing to social good.

Conclusions

The effectiveness of research results can be affected by systematic error or random error. Such errors can appear at any time during the research. Therefore, both the researcher and the interested reader must be aware of their existence, in order to control and prevent them (in the case of the researcher) or to determine to what extent to believe in them (for the reader). Biases are the researcher's greatest disadvantage, and it must be clearly understood that they can appear at any time during the course of the research. It should be borne in mind that biases are committed in any study; our attitude towards them should be to try to minimize the degree of this type of behavior in the research process. The purpose of knowing them is, in a broad sense, to be able to determine whether they influence the results by excess or by defect; and, more specifically, to take them into account when interpreting them. Although the issue of breaching research integrity is still uncommon, either because the researcher may be suspended or have funding withdrawn upon detection, there is another subset of more frequent behaviors. These include less serious actions, such as those related to bias, which can cause significant problems for researchers, institutions and participants by compromising the integrity of the research process. The responsibility for safeguarding the integrity of the entire research process should be that of society in general; however, universities have a primordial role, since they should form, before being professionals, people with a solid ethical, cultural, social and environmental education.

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