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**NANOETHICS:  
COUNTRIES WITH  
NANOTECHNOLOGICAL  
DEVELOPMENT**

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**Abstract:** Nanotechnological development is evidenced in the creation of innovative products that provide comfort. However, any positive change will have its contrast that affects to society and that generates new problems that keep it busy. This social effect requires the participation of ethics in each of the branches of nanotechnology. Therefore, the objective of this work is to present a bibliometric investigation of the countries that consider ethics within their nanotech development. 303 articles were analyzed, of which 16 obtained in complementary journals to international magazine "Nanoethic" given in the EBSCO host database. Statistical analysis of this database helped to identify the countries most active in this area, their production per year (2005-2019) and the area to which the application of nanomaterials is directed. The results shown in the United States is the country that most reports the application of ethics in nanotechnology and the line of knowledge that most requires discussing this issue is the area of economics. This initial study leads to further increase the exhaustiveness of data collection, mainly to identify the responsible participation of research in nanoethics by several developed countries such as Russia, China and Japan; which have no contribution within the analyzed population data.

**Keywords:** Nanoethics, ethics, nanotechnology.

## INTRODUCTION

Nanotechnology is the ability to observe, measure, manipulate, and manufacture matter at the nano and atomic scales (Mongillo 2007). Nanotechnology leads to the creation of novel products with potential applications in different fields (Kulkarni 2014), from health sciences such as diagnosis and treatment of diseases to products that cover different types of needs. However, the

fact that nanomaterials is smaller than a cell, which can be absorbed by it and interact with each organic agent, such as DNA; It can cause a disease as serious as cancer. Furthermore, the uncontrolled use of nanotechnology can alter the environment. This effect gives off a social responsibility that focuses on the ethics applied by professionals who create and commercialize nanotechnological devices; study called Nanoethics (Arnaldi et al. 2014).

Under this idea, the objective of this work reflects a bibliometric summary to identify the application of ethics within nanotechnological development from two perspectives: the areas of knowledge where the subject is addressed and the countries that are most aware of this point. Furthermore, this study required the exhaustive compilation of the literature review whose key words were: nanoethics, nanotechnology and ethics. As an initial work, a search for documents is carried out in the Nanoethics magazine («NanoEthics: Springer Journal» s. f.) and in the host EBSCO Database («EBSCO Publishing Service Selection Page - Ehost2» s. f.); documents obtained under the license of the Autonomous University of Zacatecas. The number of articles collected was 303 in total, being 287 from the Journal Nanoethics that presents 13 volumes published from 2007 to 2019, with 3 issues published per volume.

## LITERATURE REVIEW

Currently, the word ethics is specifically heard accompanied by several prefixes and other words that complement it: bioethics, nanoethics, medical ethics, environmental ethics, narrative ethics, among others (Miah 2017). But what is ethical? Why this ease of application to generate a branch of research in any area of knowledge? There are several norms that characterize the word or ethical application, which focus attention on values (Campillo Vélez y Zuleta Salas 2014; Demir

2011). However, there are still debates due to the moral and philosophical controversy that the word represents, mainly, the technological framework (Arnaldi 2018; Baserer, Baserer, y Akcan 2016). Another possible description of this, so famous word, could be visualized from the awareness of man about his actions related to the damage that could be done by the nature of the planet where we find our short, medium or long term. Considering that part of nature also refers to human relationships. If one person harms another by means of a labor force, verify that the work ethic of the first actor is being violated. Within human development, there was a need to stop the discredited acts that a person carries out against some agent in his environment. Therefore, the word ethics, as Demir mentions it, is derived from the adjective 'ethikos' in Greek, whose origin is 'ethos', place where animals and humans begin to live, and the culture that surpasses the good or bad attitude begins of it (Demir 2011).

From the perspective of the fourth industrial revolution, the critical social strength has deepened in raising ethics for better social development (Adorno 2018). Some focus on biomedicine that despite fighting some specific diseases, generates new ones (Ateudjieu et al. 2019). Others are concerned that Artificial Intelligence will generate a more strategic and more damaging third world war (VV. AA. 2018). The decline in employment is not neglected (Naidoo, Abarantyne, y Rugimbana 2019). Consequences that are happening and that do not have a particular actor, but rather that development that reflects human capacity gives rise to one problem when trying to solve another, of course the pandemic that is taking place now and worldwide.

Without a doubt, we clearly see the technological development that will leave

its mark on each of the activities we carry out in daily life. This developed technology is called emerging technology (Raposo-Rivas y Martínez-Figueira 2019). This new social transformation goes hand in hand with emerging technologies, among them is nanotechnology (Payá et al. 2019) because it is a resource with disruptive potential that transforms processes already used and is also associated with digital as it is defined in the article by Sosa et al. (Sosa, Salinas, y De Benito 2019).

Today, although some are still in debate, the fourth industrial revolution is taking place; trying to supply or complement microelectronics as the third disruptive technology that marked the third industrial transformation (VV. AA. 2018). Human knowledge went beyond the transformation of matter with the micrometer size, its scalar vision delved 1000 times deeper into what was already tangible, nanomaterial. One of the beginnings of nanotechnology, considered in 1989 by scientists responsible for the laboratory of the International Business Machines Corporation (IBM) in Zurich. Those who managed to manipulate Xenon atoms through a tunnel effect microscope (Mongillo 2007), two decades after starting the third industrial revolution.

Hence, the concept of nanotechnology is summarized in that it is really surprising as the smallest matter with the most value of the function of the objects created by it, as Miguel García says, nanomateria is small but spicy (García 2016). That is, what facilitates the day to day of society. For example, it covers needs such as providing a missing part of the human body, what we call implants (Senn et al. 2017) some limitations remain. The bottleneck for optimal electrical stimulation with CI is caused by the anatomical gap between the electrode array and the auditory neurons in the inner ear. As a consequence, current

devices are limited through 1. Electronic devices the size of our hands are created that help interact with people who are anywhere on planet Earth (Li et al. 2012). However, there are always unfavorable consequences in the face of actions taken, from the production of some disease (Jayandran y Haneefa 2016) to the increase in insecurity due to the personal information that can be channeled (VV. AA. 2018) , among other risks (Beumer 2018). Thus, ethics in an emerging technology, such as nanotechnology, cannot be neglected from any perspective.

## **BIBLIOMETRIC PRODUCTION DENSITY**

The words ethics and nanotechnology are key in the XXI century to have a solid relevance in diverse subjects, individually and together. However, the fusion of both topics in terms of literature reports in prestigious international magazines has a relatively low bibliometric density. An average of 25 articles per year are published between 2005 and 2019, accumulating a total of 303 as shown in Figure 1. Precisely, as of 2007 the reports increase and are maintained in a linear manner, with a mean proportionality already mentioned. The year 2007 presents the maximum value (30 articles) and the minimum value, with 22, is reported for 2018. According to the magazine Nanoethics («NanoEthics: Springer Journal» s. f.), formal publications related to the ethical study applied in nanotechnology It has been presented since 2007 to date. This implies that the relativity of bibliometric production of the nanoethics application is limited to this journal. Therefore, it is debated for a second investigation to refute this low number of publications.

## **KNOWLEDGE DIVERSITY**

The importance of identifying ethical work at an international level in a multidisciplinary

and avant-garde area such as nanotechnology implies obtaining information on where and in what social responsibility is being applied in this topic that is part of a global change. This section covers the second point, in which areas of knowledge is nanoethics being applied? The idea is to consider those lines of research that raise awareness of the creation and use of nanotechnology on our planet from an ethical point of view. The database used is classified into 5 lines of research, according to the nanoethics approach. Social: those articles that report objectives of social responsibility and ethics; that give philosophical, anthropological, historical, art, and educational critiques of nanotechnological development. Biotechnology: these works raise awareness of synthetic biology; medicine, such as implants and nanomarkers that work for diagnosis or treatment; veterinarian or animal handling both for an in vivo study and the consequences of some nano-garbage contamination; Toxicology, reports that indicate the ethics applied in a laboratory to perform a biocompatibility analysis on new organic or inorganic nanomaterials that subsequently go through chemical processes for food or engineering applications. Public policies: those articles that value the organizational reforms in different governments or institutions that consider or not, in an ethical way, the application of nanotechnology in society. Sustainability: published works whose key words emphasize the application of ethics with the environment. Economy: publications that describe the ethical impact of nanotechnological development in the market. Knowledge areas mentioned in the order of highest to lowest contribution percentage, see Figure 2.

Scientists who publish works from the point of view of the social sciences, not surprisingly, are the busiest and most concerned about

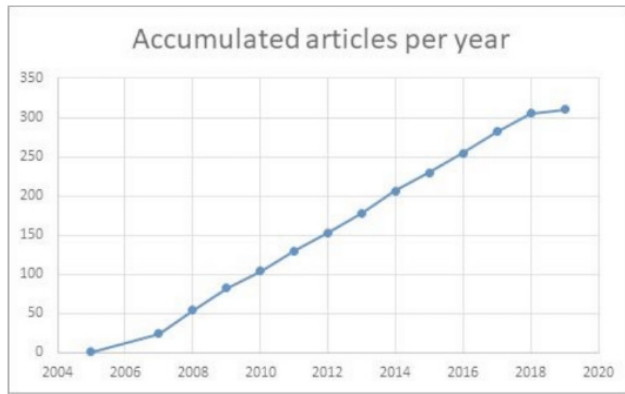


Figure 1. Articles on nanoethics related to the database studied.

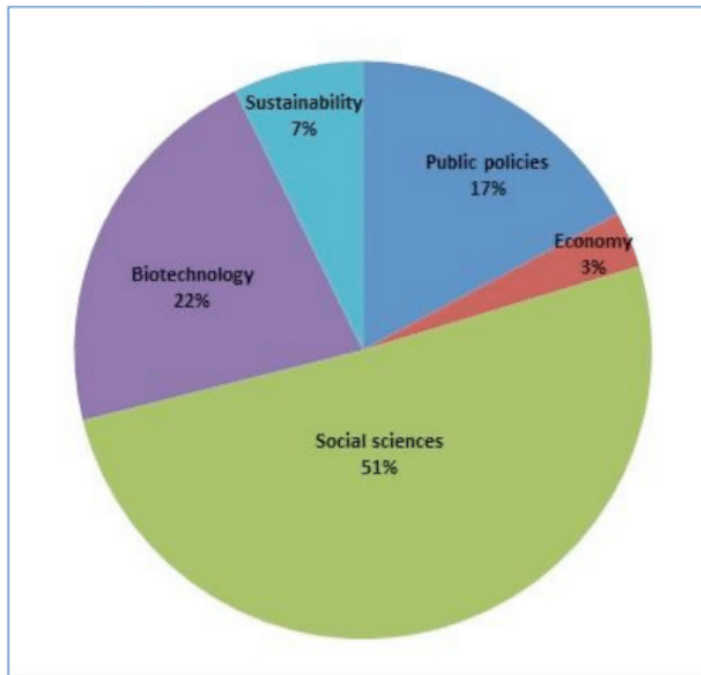


Figure 2. Percentage of contribution to the topic of nanoethics according to the area of knowledge.

managing social responsibility within nanotechnological development, backed by 51% of the works analyzed in this report. . Next, of the ethics applied to biotechnology with 22%; that it could not necessarily be said that these articles were published by biotechnological researchers who were aware of the ethics applied in their work. In addition, the application of ethics in public policies focuses on that lack of control and little regulation present in the use and application of nanotechnology in the world considering the organizational level of each country. This last line of research corresponds to 17% of the total reported. Next is the area of Sustainability (7%), an area that is extremely important today, and which until this moment begins to reflect nanoethical consideration in the dissemination of knowledge. Finally, as seen in Figure 2, ethical analysis in economic development is very scarce, worrying information due to the fact that the economy involves the distribution of nanotechnological objects in the market and therefore in the use and interaction with living beings.

These results indicate that there is a need to continue expanding the quality bibliographic contribution on this topic to raise awareness among the entire international community, the scientists who invent new nanomaterials, the producers they commercialize and the current governors. This implies that within those sustainable reforms that most of the national governments are discussing within their new public policies, the issue of nanoethics must be considered in all branches of knowledge. Therefore, the study presented in this work is essential in the development and strengthening of social responsibility worldwide.

## **INTERNATIONAL PARTICIPATION**

Nanoethics magazine is German with an impact factor of 2. EBSCO considers open

access articles, 16 of them contributed to this study, whose journals were: Science and Engineering Ethics, Journal of Business Ethics, American Society of Law, Medicine and Ethics, Business Ethics A European Review, and The American Journal of Bioethics. From 2005 to the beginning of 2019, the country that has contributed most to the objective of this paper is the United States (USA), with 70 articles analyzed.

Other countries that publish the most nanoethics are Germany, with 49; Netherlands, with 39; and Australia with 33. This journal does not present articles published by researchers from some countries considered to be First World; for example, Russia and Japan. Only one article by a Chinese researcher, presented a nanoethics paper in collaboration with the Netherlands (Timmermans, Zhao, y van den Hoven 2011). It seems that the countries with the greatest impact on the fourth industrial revolution from a nanotechnological perspective, and under the restriction of the database used, do not present attention to the ethics that this development implies; Or, researchers from prominent countries on the Asian continent are not interested in publishing in a German journal, which opens the possibility of looking for less widespread journals that reflect a contribution of nanoethics by these first world countries. Researcher Dalton Brown from England makes a comparison of the nanoethical environment that occurs in the USA and China (Dalton-Brown 2012). The author indicates that in that year, the USA faced the governmental problem of control regarding the labeling and marketing of nanoproducts; However, the Chinese government was more concerned with producing quantity of food with the help of nanomaterials without measuring consequences. The opposite was the case with European countries, says the author. Perhaps

at this time the ROC has better measures in its nanoproducts; But, it is true that from 2012 until now no Chinese scientist has been interested in publishing in Nanoethics.

Figure 3 corroborates the aforementioned, the numbers presented on the world map represent the number of articles published in the countries marked with the assigned color. In addition, he gives reason to what Dalton mentioned, a large number of European countries reflect social responsibility in nanotechnological development. In Latin America, there is participation: Colombia, Brazil and Mexico. These last two countries present greater nanotechnological development in Latin America, Mexico after Brazil (Guerrero 2016). Canada is not far behind in raising awareness of ethical enforcement today. In addition, Asian countries such as: Thailand, Taiwan, Iraq, Iran, India, and even South Korea. In 2016, from South Africa, Wynberg collaborates with a scientist from the USA to publish in the journal Nanoethics (Laird y Wynberg 2016), but it could practically be said that the African continent also has little contribution to the subject. Despite the fact that most countries contribute to the creation and development of nanomaterials, there is a slow incorporation of countries around the world in the participation of ethical application in nanotechnological development.

## CONCLUSIONS

Three decades after the discovery of nanomatter, the impact of nanoproduction has accelerated the start of the fourth industrial revolution. But this speed has brought as a consequence a greater social inclination towards the application of nanoproducts as a human need compared to the ethical application of the cost benefit that nanomaterials represent to nature that lives inside and outside of living beings.

This work presents little scientific participation at the international level with respect to the ethical study of nanotechnology. An average of 25 articles per year are published primarily in the journal Nanoethics, since 2007. Social science researchers are the most interested in raising awareness of responsibility and ethics that should not be neglected in nanotechnology development. Few are the countries that have a legal control that corresponds to the discovery and commercialization of nanoproducts. The direct participation of developed countries within this social responsibility is not yet reflected, which contradicts the hypothesis raised. Therefore, as a future line of research, it will be considered to expand the database to explore the behavior in the growth of publications within nanoethics.

It is worth mentioning that at this stage of the pandemic, COVID-19, social responsibility cannot be set aside in such a controversial issue as nanotechnology. The research carried out to generate new knowledge in this area and, worse still, the generation of patents that end up in direct interaction with our ecosystem, will undoubtedly present a future risk if the measures of security are not taken into account.

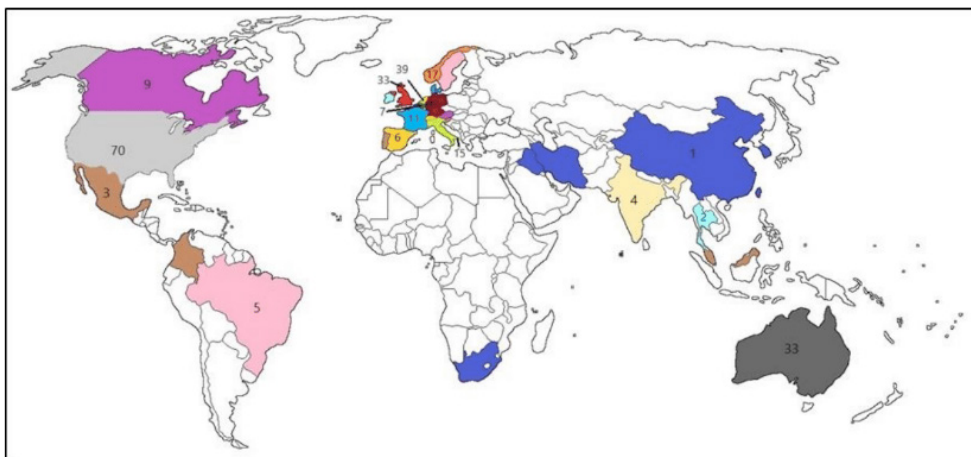


Figure 3. Number of articles published in the countries marked with the assigned color and number.

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