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ETHICAL CHALLENGES IN NANOMEDICINE AND THEIR IMPACT ON POPULATION ACCEPTANCE

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Abstract

New medical approaches are increasingly relying on the clinical implementation of nanotechnologies. The use of nanotechnologies promises to expand and improve the possibilities for medical intervention. However, due to the interdisciplinary complexity of these approaches in clinical practice, new ethical issues arise that cannot be addressed based on already existing paradigms in bioethics. Another problem facing their clinical implementation is the lack of clear ethical guidelines and a well-formulated legislative framework. This context, which could also be characterized by the lack of good communication within the interdisciplinary team, has the potential to generate numerous oppositions among the population. The present study aims to conduct a systematic literature review, focused on the analysis of data from the field studies with the purpose of developing a philosophical discourse on the attitude and ethical concerns of the population towards the implementation of nanotechnology. Through this study, we try to observe significant indicators that characterize the attitude and behaviour of the population, highlighted by studies conducted so far at the international level. The impact of refractory behaviour on the implementation of new therapies can be seen by analysing the attitude of the Romanian population in the context of the recommendation of the anti-Covid 19 vaccination, which was strongly influenced by conspiracy theories stating the existence of microscopic chips in the mRNA vaccine. Therefore, in the final part of the paper, we will reflect, based on the analysed literature, on the possible actions performed by the authorities that may reduce population reluctance and unfounded ethical concerns.

Keywords: nanoethics, nanomedicine, population acceptance, public debate, public engagement.

Introduction

The use of nanotechnology in the clinical space is seen by specialists in the field as very promising by bringing numerous improvements and expanding the possibilities of medical intervention – for example, when surgery is not possible – and decreasing overall toxicity. However, some uncertainties remain about the effects on the body, as long as especially the long-term risks are not fully known, which generates several ethical issues that are aggravated by the complexity of medical procedures based on nanotechnology (Miah, 2017, p. 144).

Our focus is on the nanotechnology products of the second development generation, referring to „active nanostructures, which change their behaviour according to their environment” (Kermisch, 2012, p. 30). In this category, the author mentions, as an example, therapies based on nanodevices used for targeted delivery in oncology. However, a major

impediment to the implementation of these therapies in the clinical space is due to the high costs of the implementation of the nanomedicine which could not be managed without the support of the population. Therefore, the acceptability of the population – representing the extent to which beneficiaries would be willing to undergo to those procedures if they were available – is a decisive factor in how the development and implementation of these therapies will evolve.

Therefore, we propose a systematic literature review on the attitude and ethical concerns of the population towards the implementation of nanotechnology because in the literature it is stated that very little is known about the population's perception of risks: „Not much more is known about public perception of the risks of nanotechnology than is known about nanotechnology risks themselves” (Kahan et al., 2008, p. 167) But why should we care about population perception? (Siegrist M, 2010, p.838) The attitude of the population towards a particular technology will have a significant impact on its development and implementation: “First, public opinion is crucial to the success and integration of new technologies. If the public turns against a technology, its likelihood of success (however defined) is greatly reduced.” (Sylvester, Abbott & Marchant, 2009, p. 168) The first studies of population perceptions were conducted to prevent public negative responses by improving the tools involved in the analysis of public perception. (Bensaude-Vincent, 2021, p.198) In addition, knowledge of public perceptions concerning the use of nanotechnology in the medical field may improve dialogue with the population and acceptability. Afterwards, the dialogue with the population on new technologies will have a major contribution to the informed decision-making process, ensuring cooperation from the target audience free from unethical actions specific to control and manipulation. Therefore, knowing the perception of risks among the public is essential in building a risk governance framework and governance board. (Murphy et al., 2022, p. 11022)

Theoretical framework

The first stage in developing the proposed topic demands to answer the question – what does nanotechnology refer to and what sets nanomedicine as a particular field? Nanotechnology is a major interdisciplinary research initiative of the 21st century, whose research relates to the development and study of nanoscale technological products. The term "nanomedicine" is formed from the noun "medicine" with the prefix "nano-" referring to the sizes of this type of product. (Cormick, 2009, p. 170) Unlike traditional medicine, nanomedicine is a field with an interdisciplinary approach aimed at a wide range of procedures to be implemented through the use of biotechnological possibilities. In addition to the nanoscale sizes of the technologies used, it aims “personalised and regenerative medicine (...), allowing the planning of a specific therapy for specific individuals”. (Allon et al., 2016, p. 1) In a few words, nanomedicine refers to the following aspects: nanoparticles used in diagnostics and therapy; surfaces on implants; materials embedded in smart devices; and scaffolds for cellular and tissue engineering.

The ethical issues specific to the use of nanotechnology are studied by a discipline called *nanoethics* because, as the literature presents it, nanotechnology is a new, interdisciplinary and highly complex field. Its ethical issues are classified into the following categories: “legal and regulatory issues; research funding and priorities; equity; environmental, safety and health issues; privacy; medicine”. (Bacchini, 2013, p. 111), However, there is a wide dispute about how to report on ethical issues brought to attention by the advent of nanotechnology, and there are two approaches to nanoethics: either it raises ethical issues that are not raised by other types of technologies, or it raises ethical issues of another kind. (See: Van de Poel, 2008, pp. 31-34; See also: Bacchini, 2013; Schuurbiens et al., 2009; Swierstra & Rip, 2007; Alpert, 2008; Dupuy, 2007; Gordijn & Cutter, 2014) A

small part of the scientific work shows, however, that many of the questions and concerns of nanoethics are already known, but in the case of nanotechnology, these issues are intertwined. By the first approach, nanotechnology is considered not to give rise to any new type of ethical issue, but only to new cases of certain well-known types of ethical concerns. However, the main view supports the fact that nanotechnology raises a type of ethical question that requires new regulatory standards or analytical tools since some of the emerging ethical concerns in nanomedicine aim at the impact of human enhancement. This new series of questions raised in the field of bioethics (Van de Poel, 2008, pp. 30-33) supports the claim that nanoethics requires new ethical skills and new normative standards. The literature exposes that each type of nanomedicine application faces some specific ethical challenges that we briefly mention:

1. Surveillance: respect for privacy, respect for autonomy, respect for human dignity, respect for intellectual property. (Allon et al., 2016, p. 4)
2. Diagnosis: the patient's right to know or refuse information, questions related to confidentiality. (Ebbesen & Jensen, 2006, p. 7)
3. Targeted drug delivery: fairness and accessibility, assessment of risk-benefit balance, risk of loss of control, respect for autonomy, invasion of privacy and aspects concerning intellectual property. (Ebbesen & Jensen, 2006, p. 7)
4. Personalised medicine: changes in the doctor-patient relationship, the improvement of autonomy, the principle of justice, privacy issues, property rights and data control. (Allon et al., 2016, p. 6)
5. Nanosurgery: risk-benefit ratio, equity and affordability compared to other medical procedures. (Ebbesen & Jensen, 2006, p. 2)
6. Human enhancement: risks related to “playing God”, slippery slope risk, ethical issues of ageing and longevity, equity and human dignity issues, patenting of nanoproducts involving parts of human beings, ethical issues related to the concern to improve rather than cure. (Ebbesen, J, 2006, p. 4)

However, in the course of our paper we try to observe how ethical issues of nanomedicine are approached from the perspective of *common morality*, but what does common morality refer to? This represents the moral competence of common sense (Pleșu, 2017, p. 21), having a series of specific characteristics. Thus, in the absence of a sense of moral orientation, it is strongly influenced by personal and religious beliefs, moral routines that may vary from one community to another, being about routines and moral orders existing at the level of a community. The common morality is based on tacit knowledge and it aims at developing a "cold" discourse on the issues it concerns. This approach rather tries to answer the question – What should *I* do to behave morally? – and therefore it does not always resort to public opinion or appropriate regulation. Therefore, it moves away from concerns about what humanity, in general, should do on issues of personal choice and personal moral values, in the present context, about whether or not nanoproducts should be adopted into someone's life. Although common morality led to the development of the four principles of bioethics, there is friction between established moral routines and new technology, a well-known problem that goes as far as “a moral panic” about how science develops. (Van de Poel, 2008; Swierstra & Rip, 2007; Miah, 2017; Ebbesen & Jensen, 2006).

The level of *knowledge* determines a major impact on ethical decisions that the one who reflects on ethical issues has: here we refer to the levels of knowledge that go from mere opinion to *scientific knowledge* (Carey & Smith, 1993). The paper of Carey and Smith (1993) talks about the stages of epistemological development of the individual and states that, in the first stage, it is assumed that knowledge comes from empirical experience. At a later stage, the individual will come to realize that there may be several interpretations for the same information and will begin to analyse the information based on logical arguments, as far as

his intellectual abilities allow it. In this context, the authors specify the impact that education has on the individual's ability to comprehend. With regard to the evolution of scientific knowledge, scientific communities tend to be conservative in accepting new information (Wray, 2007, p. 338) – “there seem to be some quite important scientific situations in which consensual acceptance alone is appropriate and belief would be wholly out of place” (Cohen, 1992, p. 90 In Wray, 2007, p. 341). However, once the scientific community validates some new information in the field, it is part of scientific knowledge. Thus, unlike common knowledge, scientific knowledge is based on the community's acceptance rather than conviction or belief. “Cohen defines knowledge as justified true belief or acceptance” (Wray, 2007, p. 341); Due to this approach followed by the scientific community to knowledge, there was born the so-called *Evidence-based medicine*. However, very often, how a piece of new information is validated by the scientific community remains for laypeople a reason for distrust, not understanding the arguments based on which some information that seems to be revolutionary is rejected, while other data that were vehemently supported previously can be invalidated by new studies in the field.

Methodology

In this study, we intend to conduct a systematic literature review through which to observe, by analysing the studies published on the topic at the international level so far, the determinants of the population's attitude towards the nanotechnologies of the second generation. We chose to conduct a systematic literature review because the purpose of the study is to develop an argument regarding the need for more research on the attitude and ethical concerns of the population and instruments based on dialogue for improving their acceptance. Therefore, the objectives of the study are to identify invariable (socio-demographic) and variable indicators that influence population acceptance and ethical concerns concerning the practice of nanomedicine. We have distinguished between variable and non-variable indicators because we are talking about aspects that are already given in generating a certain behaviour from the population, but also aspects on which there may be accidental or intentional (directed) changes by carrying out certain specific, ethical interventions.

For selecting papers to be included in the present study, we conducted a search in the PubMed platform and through the Google Scholar search engine for the following keywords: "nanoethics population" and "nanotechnology population attitude". Based on relevance to the proposed topic, we selected 37 papers published between 2004 and 2023 which fall, through the methodology approached, into the following categories: studies on population perception, literature reviews on the field and reports on the activity of certain organizations for observing the population's familiarity with nanotechnology. Studies on the perception of the analysed population are based on the following research methods: public opinion polls, focus groups and quasi-experimental models, such as consensus conferences. A large part of the empirical research papers is represented by the quantitative researches that present important data on the behaviour of the population, but, unfortunately, without sufficiently deepening the factors underlying their attitudes and decisions. (Berube et al., 2011, p. 3090)

Results

The population's attitude towards nanotechnology is determined by several invariable and variable indicators that will be described below. The predetermined indicators are represented by socio-demographic data that determine a particular individual such as gender, age, education, financial status or cultural background; the existence of well-clarified legislation in the field and the extent to which the nanotechnological product comes into contact with the body. Among the main variable indicators, we could list the following:

heuristic – concerning the degree of someone's objective information; how public communication is carried out; understanding the process of developing nanomedicine therapies and the implications associated with their implementation; religious views (degree of religiosity) and philosophical/moral views; beliefs in conspiracy theories and attitudes towards scientists, government authorities and technology development. (Cormick & Hunter, 2014, p. 13; Ganesh Pillai & Bezbaruah, 2017, p. 5; Frédéric Vandermoere et al., 2010, p. 377; Kamarulzaman et al., 2020, p. 7)

Observed indicators

Invariable indicators

Studies have shown that men seem to regard more to the benefits of nanotechnology; while women are more worried about the risks that could arise in the context of the clinical implementation of nanotechnology. (Capon et al., 2015, p. 4; Joubert et al., 2020, p. 8) Then, another indicator with a significant impact is age – as expected, older people show greater concern about the health risks of nanotechnology (Capon et al., 2015, p. 4) than young ones who are much more enthusiastic about the benefits, having a predominantly positive perception and better knowledge of the topic (Joubert et al., 2020, p. 3). Afterwards, the cultural origin (the worldview existing at the community level) and a person's standard of living also have their mark on the perception of nanotechnology and on the degree of exposure to information (determining the level of education) regarding these new technologies (Cormick & Hunter, 2014, p. 4; Ho, Scheufele, & Corley, 2011a, p. 190; Kahan et al., 2008, p. 89; Frédéric Vandermoere et al., 2010, p. 378) The social group to which the individual belongs has a major impact on the formation of his opinion on nanotechnology (Gehrke, 2018, pp. 28, 36; Kahan, 2009, p. 706). It has been observed that people with a higher level of education have a predominantly positive attitude towards it. (Smith et al., 2008, p. 469) Another socio-cultural determinant is the standard of living, which, the higher it is, the more the benefits of nanotechnology are perceived. (Frédéric Vandermoere et al., 2010, p. 377; Kamarulzaman et al., 2020, p. 7)

Another predetermined factor with a high impact on someone's perception regarding nanotechnology is determined by the type of application and the extent to which these products come into contact with the body (Reisch, Scholl & Bietz, 2011, p. 648; Simons et al., 2009, p. 1564). Thus, the use of nanotechnology in food, for example, is considered to pose the greatest risk, followed by cosmetics/sunscreens and their medical use. When it comes to nanomedicine applications, patients are much more reluctant to use therapies for human enhancement than those used in curative procedures. (Capon et al., 2015, p. 4; Cormick, 2009, p. 169; Gupta, Fischer & Frewer, 2015, pp. 93,94)

Variable indicators

In general, people believe that nanotechnology comes with both high risks and great benefits. (Lin, Lin & Wu, 2013, p. 555) However, people's attitudes towards the use of nanotechnology in medicine are generally positive, being confident in the promises of nanomedicine and putting their hope in the new possibilities for detecting and treating diseases, one of the most important benefits. (Joubert et al., 2020, p. 3; Simons et al., 2009, p. 1560) Knowledge is one of the critical factors influencing the perception of the risks and benefits of nanotechnology. (Kamarulzaman et al., 2020, p. 6) The literature highlights that public knowledge of nanotechnology and its applications in nanomedicine is relatively low. (Castellini et al., 2007, p. 185; Cobb & Macoubrie, 2004, p. 397; Cormick, 2010, p. 230; Macoubrie, 2006, p. 232; Joubert et al., 2020, p. 3; Simons et al., 2009, p. 1560; Frédéric Vandermoere et al., 2010, p. 376; Gupta, Fischer & Frewer, 2015, p. 102) Thus, about 50% of the population is not familiar with nanotechnology, and they are mostly unsure of the risks and benefits involved. (Berube et al., 2011, p. 3090; Besley, 2010, p. 2; Pidgeon, Harthorn &

Satterfield, 2011, p. 1695) The lack of real knowledge in this field is caused by the fact that the population gets information mainly from the media and rarely by reading scientific sources. (Ganesh Pillai & Bezbaruah, 2017, pp. 9-10; Scheufele & Lewenstein, 2005) People's perception of nanotechnology is therefore strongly influenced by the way it is presented in the media or novels (Castellini et al., 2007, p. 188), such as *Prey* or *Swarm* where some exaggerated dangers of nanotechnology implementation are exposed. (Cobb & Macoubrie, 2004, p. 400; Miah, 2017, p. 141) People's preference for media sources and novels or films makes them vulnerable to conspiracy theories. The perception of risks and the fear of unethical research or implementation of unethical lead therapies based on nanodevices is strongly influenced by the information in the media that spreads about incivility. (Anderson et al., 2014, p. 375)

Although, many papers highlight the positive attitude of the population towards nanotechnology, a few studies have found the existence of minor groups (but with great impact) that have a very negative outlook towards it. These people's discourse towards new technologies appears in antithesis with the experts' declarations and the official sources of information. Negative feelings towards nanotechnology are also generated by uncertainties and fear of the unknown. In addition, the literature highlights that those who have a negative attitude towards nanotechnology are less inclined to read informative, data-based, papers on this topic that could change their opinion. (Cobb & Macoubrie, 2004, p. 398; Joubert et al., 2020, p. 9) And, as a rule, they do not participate in ethical and well-balanced public debates on the topic of concern. (Cormick, 2010, p. 231) In contrast, people having rather a positive attitude towards nanotechnology, have, in general, better knowledge of the field (Besley, 2010, p. 3; Cacciatore, Scheufele & Corley, 2009, p. 394; Capon et al., 2015, p. 10; Cobb & Macoubrie, 2004, p. 398; Ganesh Pillai & Bezbaruah, 2017, p. 4; Lin, Lin & Wu, 2013, p. 556; Joubert et al., 2020, p. 3). At the same time, the last ones have a moderate or low level of religiosity, and, rather, a positive attitude towards scientists and nanotechnological development, having a better education overall. (Smith et al., 2008, p. 469)

On the other hand, the population's attitude towards nanotechnology is also built on personal experience and previous knowledge (Miah, 2017, pp. 141-144) on aspects that can be taken as an analogy – such as the management of GMO products, as stated in several studies. (Ho, Scheufele & Corley, 2011b, p. 618; Macnaghten, 2010, p. 28; Murphy et al., 2022, p. 11022; Sylvester, Abbott & Marchant, 2009, pp. 167-168) The public is concerned about yet unknown issues in the management of nanotechnology, which are compared with other health, environmental and safety risks (Berube et al., 2011, p. 3096), aspects that they share and debate with their close ones. Even for people with limited knowledge, ambivalence can be observed in understanding societal benefits and potential risks. (Murphy et al., 2022, p. 11023) Although emotions are predominantly positive – negative feelings (worry, anger) are lower among the population – regarding the clinical use of nanotechnologies, the population sometimes perceives a higher level of risk than experts. (Berube et al., 2011, p. 3090; Satterfield et al., 2012, p. 754; Siegrist et al., 2007; Siegrist, 2010, p.840).

Then, studies show that a considerable influence is also brought by „value predispositions (i.e., religiosity and trust in scientists)” (Anderson et al., 2014, p. 374; see also Ho, Scheufele & Corley, 2010, p. 2709; See also Ho, Scheufele & Corley, 2011b, p. 619) Thus, „Religiosity, political ideology, and social trust are the dominant social factors influencing nanotechnology attitudes.” (Ganesh Pillai & Bezbaruah, 2017, p. 7) because these aspects underlie the construction of affect related to the introduction of nanotechnology into current clinical practice. (Bottini et al., 2011, p. 3475) Ethical and risk/benefit balance concerns issues on health, economy, environment or society. (Ganesh Pillai & Bezbaruah, 2017, p. 4) However, there are two major factors underlying current ethical concerns about deploying second-generation nanotechnologies. The first one states not being easy to predict

the behaviour of nanomaterials used in various therapies, as long as they have unpredictable behaviour maintaining a higher degree of uncertainty about future directions and possible consequences of research. In addition, the implementation of nanotechnology in the clinical space faces the lack of a specific legal framework and ethical guidelines. (Van de Poel, 2008).

The fact that the long-term consequences of nanotechnology use are still unknown, raises a few ethical issues regarding the introduction of unnecessary risks with a potentially significant impact on nature (Gupta, Fischer & Frewer, 2015, p. 105) and the lack of a specific legal framework and ethical guidelines (Van de Poel, 2008). This context causes the perception of the implementation of nanomedicine as “a rush to profit before risks are known.” (Macoubrie, 2006, p. 235; see also Sylvester, Abbott & Marchant, 2009, p. 175) considering to be used in the development and implementation of nanotechnology-based procedures in the clinical space funds that suppose be used in other areas of interest. This raises questions about the motivation for implementing nanotechnology, an aspect that is aggravated by the spread of fake news, fake science and fake research. In addition, equity in access to these products is one of the aspects with a strong emotional impact on the attitude of the population. (Gupta, Fischer & Frewer, 2015, p. 104). It is considered that the implementation of nanotechnology would have an undesirable impact on vulnerable groups and it may lead to a range of inequalities within society (Macnaghten, 2010, p. 27). Thus, the population justifies the importance of treating their development with greater responsibility and taking into account public opinion during the development of these new technologies, which is often neglected. (Cormick, 2009, p. 171; Patenaude et al., 2015, pp. 301-302) The implementation of nanotechnology in the clinical space can degenerate into control over matter, nature and the human body. Therefore, the development and implementation of second-generation nanotechnology may have a negative impact on the evolution of decision-making freedom, with the risk of losing privacy (Cobb & Macoubrie, 2004, p. 399) and reducing autonomy in the context of surveillance. Ethical issues threatening autonomy and the conduct of privacy by establishing some control procedures on the human body are closely related to the ethical question of "playing God", which would, probably, evolve into a slippery slope (Macnaghten, 2010, p. 31) as long as the nanomedicine would predominantly promote the human enhancement over treatment (Macnaghten, 2010, p. 33).

However, the trust of the population is largely based on hope and fascination, being influenced emotionally (Cobb & Macoubrie, 2004, p. 399; Cormick & Hunter, 2014, p. 4; Ganesh Pillai & Bezbaruah, 2017, p. 6) or by the subjective perception of risks and benefits (Lin, Lin & Wu, 2013, p. 555). People would be willing to change their perspective on nanotechnology to a more positive one if the person who provides them with information on the subject is an expert in the field and has the same cultural background. Thus, trust is a particularly important ethical value in determining the positive perception of new technologies. (Cobb & Macoubrie, 2004, p. 400; Cormick, 2009, pp. 171-173; Ganesh Pillai & Bezbaruah, 2017, p. 8; Ho, Scheufele & Corley, 2011b, p. 615; Kamarulzaman et al., 2020, p. 7; Macoubrie, 2006, p. 233; Siegrist et al., 2007) The population is, therefore, strongly influenced by how politics and industry representants manage and create the framework for the use of nanotechnology and its applications. (Reisch, Scholl & Bietz, 2011, p. 651) Some studies have shown that people would rather trust scientists and the health department, and less the journalists, politicians, government, and industry. (Capon et al., 2015, p. 10; Lin, Lin & Wu, 2013, p. 555), proving high concerns about the ability of politicians to manage the risks of nanotechnology. (Bottini et al., 2011, p. 3482)

Considering the aspects brought to attention in the literature, we can say that even in the absence of fundamental knowledge, the population is preoccupied with the ethical aspects of nanotechnology implementation. (Gupta, Fischer & Frewer, 2015, p. 105) By analysing

the ethical concerns of the population, we can highlight an interest in the following ethical principles: autonomy, benefit, informed consent, non-maleficence, data protection and personal life, freedom in the decision-making process, justice or equity. At the same time, the population, by questioning the implementation of nanotechnology in the medical field, underlines the importance of the following values: safety, trust, responsibility, vulnerability and bodily integrity. (Cobb & Macoubrie, 2004, p. 400; Cormick, 2009, p. 171; Ganesh Pillai & Bezbaruah, 2017, p. 6; Macoubrie, 2006, p. 233; Gupta, Fischer & Frewer, 2015, p. 94). Values based on religion or political views also have a great impact on attitudes toward nanotechnology, determining the moral view on the topic. (Cacciatore, Scheufele & Corley, 2009, pp. 389,394; Ganesh Pillai & Bezbaruah, 2017, p. 7; Ho, Scheufele & Corley, 2010, p. 2709; Ho, Scheufele & Corley, 2011a, p. 190; Smith et al., 2008, p. 471; Frédéric Vandermoere et al., 2010, p. 379; Gupta, Fischer & Frewer, 2015, p. 94)

Discussions

The nature of the ethical concerns of the population

For an analysis of the ethical concerns of the population and to find ways to improve the population's engagement in the development of nanotechnology, it is necessary to ask ourselves the following questions: Is the population more concerned with current ethical issues regarding the development of nanotechnology or futuristic ones, with those concerning individualistic aspects or those with social impact? To what extent is this person willing to approach the implementation of nanomedicine from a utilitarian perspective or is he/she rather guided by its beliefs and value preferences?

Analysing those questions, it should be firstly mentioned that each individual's ethical concerns about the implementation of nanotechnology in the clinical space are generated by their socio-cultural background. (Ganesh Pillai & Bezbaruah, 2017, p. 6; Frédéric Vandermoere et al., 2010, p. 367), being influenced by the specific indicators mentioned in the previous pages. However, certain behavioural trends can be observed at the population level. Even if there is a deep interest in futuristic aspects, such as the consequences of trying to "play God", one of the main current ethical concerns of the population is risk management. However, the attitude of the potential beneficiary of these nanotechnologies is influenced by their worldview: individualistic and hierarchical or egalitarian and communal. (Kahan et al., 2008, pp.88-89) However, the population's concern regarding nanotechnology has been reoriented in recent years from the interest in the impact on humanity in general to the impact at an individual level of decisions. (Miah, 2017, p. 144) However, people are more concerned about social issues than about health or the environment. (Bottini et al., 2011, p. 3482)

As regards the second question, although utility is taken into account by the beneficiary, this is not the most important aspect in making a particular decision. In complex situations, the population tends to make decisions based on values and emotions rather than information. (Anderson et al., 2014, p. 374; Ganesh Pillai & Bezbaruah, 2017, p. 6). Therefore, if an option does not align with personal values, it is, most of the time, rejected. (Cormick, 2010, p. 231; Cormick & Hunter, 2014, p. 4). In addition, consumer attitudes towards nanotechnology are also influenced by their perspective on science, technology and nature. (Cormick & Hunter, 2014, p. 4)

On beliefs in conspiracy theories

The population has relatively limited knowledge about nanotechnology and, for this reason, potential beneficiaries are not capable of a real assessment of risks and benefits. They still have difficulty formulating key ethical issues. "Though risk awareness is low, fears can easily be triggered by news linking nanotechnology to concrete hazards or media reports of human suffering and harm. The lack of knowledge makes it very difficult for people to undertake a differentiated risk appraisal." (Simons et al., 2009, p. 1569) On the other hand,

social media offers patients opportunities for debate and criticism, but their awareness of the discrepancy between expert knowledge and ordinary people is diminished. (Murphy et al., 2022, p. 11028) During these debates, users of different social media platforms may be influenced by movements campaigning against the implementation of nanotechnology. Their promoters are considered to be knowledgeable in the field due to the way they present their arguments. For this reason, the decision-making process on new technologies is often unreflective (spontaneous). (Patenaude et al. 2015, p. 302). The population approaches nanotechnology, in fact, from a well-determined socio-cultural perspective, aligning, without any critical gaze, with the beliefs of the community to which they belong – by cultural background or by their adherence. (Cormick & Hunter, 2014, p. 2)

Therefore, the reaction of vulnerable groups to fake news on social media is often disproportionate and can have a decisive impact on the decisions they make about their own health. (Ganesh Pillai & Bezbaruah, 2017, p. 9) Potential beneficiaries question the positive future impact of implementing nanotechnology in the clinical context, as long as it involves, in their view, the acceptance of the obligation to undergo medical procedures. In addition, they are extremely concerned about the respect of ethical values such as transparency. They have suspicions about the reasons for implementing nanotechnology in the clinical space which, from the perspective of reluctant groups, can have wide military applicability through the possibility of controlling the population.

Since the success or failure of implementing a new technology depends to a large extent on how it is accepted by the population, serious ethical implications can arise regarding how *information, communication* and attempts to *engage the population* are carried out in debates on these topics. As recent events highlight, the development of innovative medical therapies may face opposition from individuals who are not properly informed and do not have a high level of trust in the authorities. Here we can recall the pandemic context in which much controversial information was evoked in the media, both by public figures and by some doctors. And this has had a major impact in undermining the cooperation of the population. In addition to other conspiracy theories that have circulated, there has been fear among the population of being a micro/nanochip in the mRNA vaccine against COVID-19 that can be controlled by 5G, impacting individual health and freedom. As a result, people have raised many concerns about the safety and ethics of introducing nanochips into the human body for medical purposes, although nanotechnology is positively portrayed in the media, highlighting the benefits that outweigh the risks. (Besley, 2010, p. 2, Cacciatore, Scheufele & Corley, 2009, p. 387; Cormick, 2009, pp. 170-171)

The legislative actions taken to encourage anti-COVID-19 vaccinations in Romania, in the pandemic context, have highlighted very well the impact that beliefs in conspiracy theories regarding the use of nanotechnologies for military purposes, without obtaining informed consent, can have. People have also expressed high concerns about the alleged existence of an electromagnetic field – generated by the introduction of nanochips in the vaccine – that would have the potential to influence thoughts and emotions. Following a Google search for the words “5G covid-19 vaccin cipul” (engl. “5G covid-19 vaccine chip”) numerous media publications were found sounding the alarm about the unfounded concerns of the population concerning the existence of nanochips in the anti-Covid vaccine. Although, in general, those who are impressed by conspiracy theories are too little open to information that refutes formed beliefs, many of these publications called on these people to study scientific sources and analyse the logic and foundations of the arguments made; aspects that would have made them notice the ridiculousness of these beliefs. Some of the titles of the papers found are the following: “The whole truth about the 5G-based VACCIN CHIP” (Mihail D, 2020), “The “infodemic” of COVID-19: vaccination, chips and 5G technology” (Răileanu, 2020), “Romanian doctor anti-Covid vaccination in England, abolished on

Facebook: "You inserted your chip, now you are being tracked with 5G" (Spiridon, 2020), "Father Doboş, message about the vaccine against Covid-19: „I am sending you to get the CIPs out of your head and CIP-CIRIPs”" (Mazilu, 2021), "Do the anti-COVID-19 vaccines contain 5G micro-chips?" (Vică, 2021), "Coronavirus vaccine comes with a 5G chip???" (Buhnici, 2020), "New revelations about vaccines. Do they contain microchips that connect to 5G or not? Now it's found out" (Popa, 2021), "The joke swallowed by conspiracists: "The chip in the vaccine consists of 4 processors and 4 transistors. The signal via the 5G network enters the left on INPUT. This is how they control you"” (Redacția, 2020), "Vaccine, nanochips and 5G technology. How the Metropolitanate of Moldova fed the society with false information regarding a possible vaccine against COVID-19: "These are things from the realm of fantasy and far from reality"” (Frunza, 2021). Due to controversies arising in this context, the vaccination rate in Romania, with at least one dose, reached only 42.55% (Coronavirus Resource Center, 2023), but the funds invested, actually wasted, in the purchase of vaccines could cover an incomparably higher rate of population. This behaviour of the Romanian population proves a weak trust in the scientific and governmental authorities.

Taking into account the aspects highlighted by the media articles, we assume that the acceptance rate of nanodevices in the Romanian population would be at a level equivalent to the anti-COVID-19 vaccination. The population's concerns regarding the introduction of these new therapies in the clinical space could concern the following aspects:

1. Concerns about the safety/risk of the products they are exposed to.
2. Concerns about information on the procedure.
3. Concerns about the autonomy to continue or to interrupt the procedure.
4. Data Security Concerns.
5. Concerns about equal (fair) access to treatment.
6. Futuristic concerns about the social and global impact of the use of wireless-guided nanocarriers for targeted drug delivery.

Recommended actions aiming to reduce public reluctance and unfounded ethical concerns

Regulatory and risk assessment initiatives in the development and marketing of nanodevices are necessary to reduce possible negative effects and mistrust of the population. However, ethical and moral issues regarding the implementation of nanotechnology must also be the focus of authorities, developers and industry. Besides, education and information play a crucial role in improving the capacity of the population to assess the risks and benefits of nanotechnology (Cacciatore, Scheufele & Corley, 2009, p. 399; Simons et al., 2009, p. 1569; Sylvester, Abbott & Marchant, 2009, p. 177). “Enhancing the understanding of emerging technologies is crucial to enable social and political debates and to avoid public backlash.” (Joubert et al., 2020, p. 9) It is necessary to help the population make decisions about nanomedicine through a reflection process that includes the following steps (Patenaude et al. 2015, p. 302):

1. To Analyse the possible consequences of the action if it is carried out.
2. To make a value judgment (assessment) about consequences.
3. To weigh conflicting value judgments.
4. To respond to stakeholders justifying their decision.

In addition to hiring communication experts in information communications (Besley, 2010, p. 5; Ho, Scheufele & Corley, 2011a, p. 193), nanomedicine developers, industry and authorities should involve trusted institutions in risk communication before negative, unsubstantiated claims appear in the media. They have to anticipate the public fears and doubts about hiding information or using these procedures in an unethical way. Conversely, if some potentially negative information appears initially in alternative sources of information, it can shake the population’s confidence in politicians and different types of authorities. (Anderson et al., 2014, p. 375) The population is more concerned about whom to trust than

about the information itself that can be interpreted. (Ho, Scheufele & Corley, 2010, p. 2707) At the same time, a context should be created for involving the population in ethical debates on nanotechnology and its development, and a first step to this end would involve conducting studies to better understand the motivations behind the attitudes of the targeted population. Then, authorities should communicate in a way that arouses the consumers' interest in debates and even engage more reluctant segments of the population in debates (Cormick, 2010, p. 231; Cormick & Hunter, 2014, p. 13). Involving people in nanotechnology debates that do not overwhelm them with new concepts has the potential to lead to greater acceptance of new nanotechnologies implementation in clinical settings. (Castellini et al., 2007, p. 188)

Conclusions

Based on the data provided by this literature review, we can deduce that, although the predetermined traits of the individual which cannot be modified by interventions influence the person's attitude towards nanotechnology, the decisive impact is made by the knowledge, value predispositions and trust in scientists and authorities that will lead to the construction of a certain type of affect towards the clinical implementation of therapies based on second-generation nanotechnologies. The development of a certain type of affect will lead to different degrees of concern for information on alternative media sources and to a certain degree of vulnerability to conspiracy theories, as the case presented may reveal regarding the anti-Covid-19 vaccination campaign in Romania. Therefore, the authorities have the responsibility to find the appropriate ways to communicate data-based information on these new types of nanotechnologies with the public, answering their ethical concerns and assuring them of being responsible and transparent in the research and implementation of the specific therapies.

Based on the affect and information received from various sources, the person will acquire a certain perception of risks and benefits, as well as several ethical concerns. (Bottini et al., 2011, p. 3475) Therefore, the degree of support from the population for the implementation of nanotechnology in clinical settings can be ethically improved by: conducting studies on the targeted population to reveal the motivations underlying their attitudes and ethical concerns regarding the medical use of new technologies, communicating and educating the population and by taking into account public opinion in the development of new nanotechnology products and by developing regulations of their implementation.

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