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Article

University community attitudes to the use of genetic editing

Atitudes da comunidade universitária em relação ao uso da edição de genes

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Abstract: Genetic editing has many applications in all areas of society but it can also have unpredictable consequences. The objective of this research was to study the attitudes of the university community to the use of genetic editing in agricultural, environment, health and improvement of the human species. Students completed an online questionnaire written in three languages such as English, Spanish and Portuguese, which was made available in nine countries. Knowledge of words associated with the genetic editing technique increases with the level of education of the students. Doctoral students showed greater support for genetic editing in humans. There is a high degree of acceptance for genome modification techniques for purposes such as consumption, industry or health (~70%). While it had a great rejection (78%) to the genetic intervention for the improvement of physical or cognitive characteristics. Most student's express that the government should regulate and invest in research on genetic editing. Most students are optimistic or slightly optimistic about advances in this technology, especially for the benefit of health and the agricultural sector. This research provides an overview of students' opinion of the genetic editing and serves as a basis for future studies.

Keywords: Eugenics; Designer babies; Gene therapy; Mutation.

Resumo: A edição gênica oferece diversas aplicações em todas as áreas da sociedade, mas também pode causar impactos negativos imprevisíveis. O objetivo desta pesquisa foi estudar as atitudes da comunidade universitária em relação ao uso da edição de genes na agricultura, o meio ambiente, a saúde e inclusive o melhoramento genético da espécie humana. Os universitários responderam a um questionário online escrito em três idiomas, incluindo inglês, espanhol e português. O questionário foi disponibilizado em 9 países. O nível de escolaridade dos alunos refletiu seu conhecimento de técnicas de edição de genes. Estudantes de doutorado demonstraram maior apoio à edição do genoma humano. Um grupo predominante aceita o uso de técnicas de intervenção genética para fins industriais, agrícolas e de saúde (~ 70%). Enquanto um grupo predominante (78%) rejeitou a modificação genética para a melhoria das características cognitivas ou físicas do homem. A maioria dos estudantes afirma que o governo deve regulamentar e investir em pesquisas sobre edição de genes. A maioria dos alunos está otimista ou significativamente otimista sobre os avanços dessa tecnologia, especialmente para o benefício do setor de saúde e agricultura. Esta pesquisa fornece um panorama geral da opinião dos alunos sobre o uso da edição de genética e serve como base para estudos futuros.

Palavras-chave: Eugenia; Design de Bebês; Terapia gênica; Mutação.

Introduction

Scientist have developed techniques to modify the DNA of any living beings and the scope will be unlimited. Engineering genetic tools bring many benefits in several areas but they also generate ethics and social concerns Genetic editing has the potential to provide several benefits. The Application resulting from genetic editing cover all sectors such as agriculture, the environment, medicine, among others. The literature shows several success examples of plants genome modification using editing genetic tools. For instance, Ricroch (2019) assures that genetic editing could contribute to new crop development to resist plagues and diseases adapting to adverse conditions due climate changing. The effects from the increase in carbon dioxide in the coming decades in crops are unknown (Velasquez-Vasconez et al., 2014; Velasquez-Vasconez et al., 2021). Genetics intervention techniques in living beings could contribute improving food production necessary to supply the demand of 10 billion people for 2050 (Gerten et al., 2020).

On the other hand, genetic editing techniques are beginning a new era of eugenics. The possibility of human genetic improvement has never been closer. In 2019 a Chinese scientist made an announcement about genetic editing with twin sisters. He Jiankui crossed for the first time in the history, the limits of ethics and science to create a pair of AIDS immune twins. The CCR5 genes that are necessary for the virus to penetrate the lymphocytes would have been edited to prevent the AIDS virus from attacking. The controversial experiment gave rise to terrifying scenarios. The twins genetically modified design could be the emergence of a new human race, the super-human. In this scenario, the Federal Court of Accounts (TCU, 2018a) highlighted that risk management seeks to achieve objectives established from analyzing the environment, either via strong management practices or through internal control measures that assist in identifying the potential risks of maintaining such risk at levels compatible with the management of the business.

Positive characteristics such as improved intelligence, better physical or social skills, could be incorporate into your children before birth. The controversial experiment gave rise concern questions for instance: How far will genetic improvement in humans be allowed? Or who will have access to the technique? However, not everything is worrying, with the advances in this technology, it will be possible to treat almost all human diseases. Researchers have shown that it is possible to induce mutation with high precision, including the modification of region as small as a base in the DNA (Komor et al., 2016). These studies are very encouraging for the patient's clinical treatment with accurate mutation.

It all started with machinery of genome two microorganism. A group of scientists has discovered how the system that uses batteries to control virus attacks works. One of the components is called CRISPR, acronym clustered regularly interspaced shot palindromic repeats that is part of the adaptive immune system that prokaryotes use to combat numerous infections of viruses or plasmids (Bhaya, Davison and Barrangou, 2011). This immune system mechanism is divided into three phases. Initially, the exogenous DNA sequences of invading organisms are identified and incorporated into the CRISPR locus. This process is catalyzed by the Cas1 and Cas2 proteins that are present in all organisms that have this system (Mcdonald et al., 2016). In a second infection event, the CRISPR locus is capable of transcribing a RNA CRISPR (pre-crRNA), which is processed into short crRNAs that contain the CRISPR spacer and repetitions (Schaefer et al., 2017). Then crRNAs can form a ribonucleoprotein complex with Cas protein resulting in cleavage of invading DNA or RNA (Cong et al., 2013). This system has been adapted for most genetic engineering applications. The most widely used is the CRISPR Cas type II system, which has the advantage that it uses only a single protein known as Cas9 and a gRNA (guide RNA) that is formed by the fusion of two RNAs (crRNA and tracrRNA) (Schaefer et al., 2017). In this way incorporating or expressing these two components inside the cell, scientist are able to accurately edit the genome of an organism (Huang et al., 2018; Mcdonald et al., 2016).

In the same way that in text editing we are able to delete, copy and paste letters, phrases or passages of entire text, genetic editing has the potential to rewrite the genome of any type of living organism (Bhaya et al., 2011; Pinello et al., 2016). This tool will be very useful in all sectors of society in the near future. The most worrying aspect is to define the extent to which the use of these tools will be allowed and what the biological, ethical and social consequences will be, mainly with the manipulation of the human genome. With the purpose of identifying the student's opinion on the subject, this work aims to

evaluate the university community's attitudes to the use of genetic editing in different organisms.

Material and Methods

In order to know the student's opinion on the subject. A descriptive study was carried out on university students from different countries such as Colombia, Peru, Norway, Venezuela, Chile and Brazil to describe the opinions, a series of questions was prepared that were associated with genetic editing techniques. The questionnaire was divided into two parts. The first part, the questions were adapted to collect data from students, such as age nationality, type of university to which they belong and education level. We also asked a series of questions on the subject to estimate the level of knowledge of students using genetic editing. In the next part the multiple-choice questions were designed to establish student's opinions regarding ethical and social issues related to use of genetic editing. In this way, the concern of university students regarding the use of genetic improvement of human were identified. The survey was conducted in September 2019.

To estimate the level of knowledge of the interviewed students a numerical scale was elaborated. The level of education was rated on scale of 1 to 4, with 1 being the value assigned to undergraduate students and 4 being the value assigned to graduate student. Likewise, the level of knowledge associated with CRISPR technique was rates on a scale of 1 to 5, with 1 being the value assigned to "nothing" and 5 being the value assigned to "many". The previous one was carried out with the purpose of estimating the relationship between the level of education and the level of education and the level of knowledge of CRISPR technique, using the principal component analysis (PCA). Subsequently, statistical analyzes were done for non-parametric data including multivariate test.

Results and Discussion

136 students that participated in the survey. The average age of university students was 28 years old and, who belong to seven countries, with Norwegians being the only students interviewed in the American continent. More than half of the participants were Brazilian, while only one Venezuelan student (Figure 1).

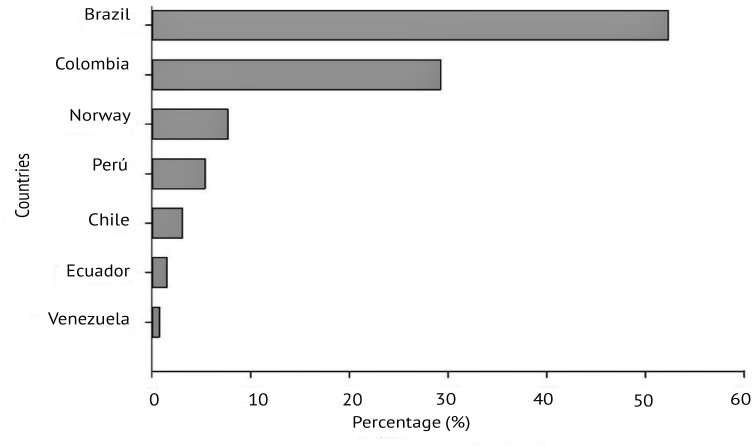

Figure 1. Percentage of student's survey according to their nationality

About 76 % of interviewees are taking masters or doctorate courses while undergrade students represent a smaller proportion. Meanwhile just one Post-Doctoral student participated in the interview. The PCA allowed explaining that 95.5% of the variance contained in the studied variance. The education levels of interviewees were positively associated with the level of knowledge about genetic editing keywords. Thus, doctoral students say they own more technician vocabulary such as crRNA, genetic editing, modified plants and CRISPR. On the opposite side, undergrade students own less knowledge about same words (Figure 2).

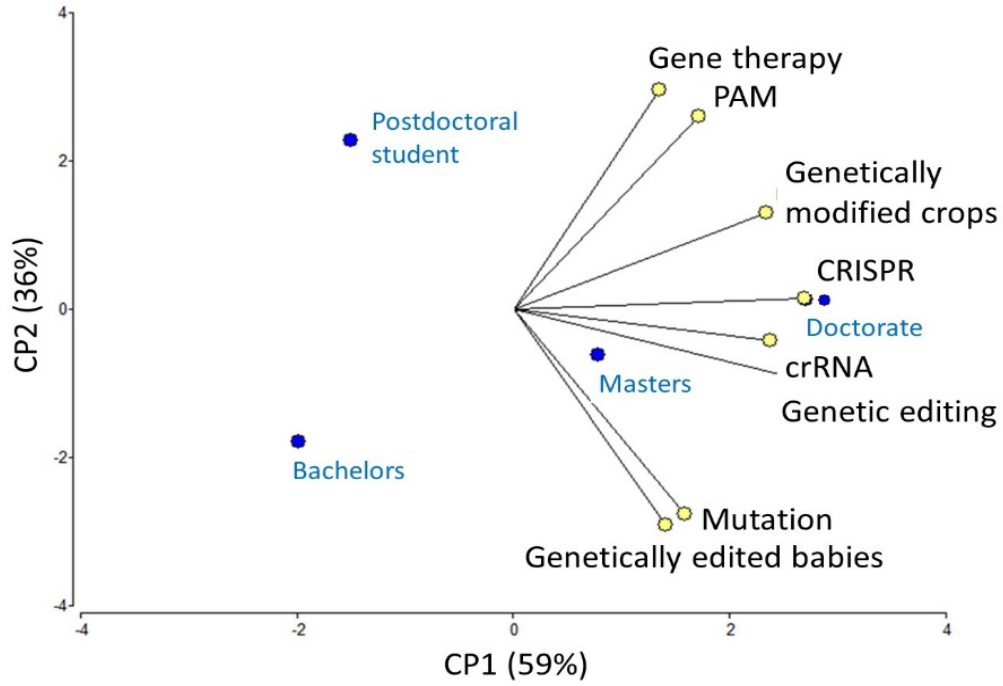

Figure 2. Analysis of the main components (PCA) of the eight associated variables with knowledge of the CRISPR technique and the four levels of education of the students interviewed

Most of the students agree with the use of genetic editing in all areas, except in the improvement of physical or cognitive characteristics. In general, around 59% of interviewees were disagree with the uses of genetic editing to esthetic benefit or intellectual in humans. Doctoral students showed a tendency to accept genetic editing in order to improve esthetic and cognitive traits (Figure 3). The level of higher education has not had a related with the levels of acceptance of genetic editing in the studied areas, also it was reported by (Scheufele et al., 2017). The same authors demostrated that high levels with religous orientation is asocciated with lower levels of support for genetic editing.

In this study, we do not question the religious profile of students althought some comments reflect concerns about theological aspects. For instance "assume the position of an omniscient God, capable of intervening to modify in his will, is the formula for catastrophe. The environmental and human crisis that we see today is a consequence of this mechanical mentality of nature". In the same way another student expresses his non conformity with the genetic edition, mentioining " who the human being is to decide to remake reality from his will? God? Could nature be decipherable by human logics? If so, then it its not nature,the human beaing would be an entity above nature. Believing this is a symptom of man's arrogance ", severals factors may be affecting the attitudes of interiewees to the genome modification, wich should be studied in greater depth.

More than 50 % of interviwees agreed with the use of genetic editing in microorganism, the agricultural sector or human disseases treatments (Figure 3). The consumption of genetically edited foods tends to be accepted by society despite the fear that it will have adverse effects on health or the environment (Ishii and Araki, 2016). Students were more doubtful when genetic intervation is used for the treatment of diseases. The results were similar to revealed in a global survey about population's atittudes to editing the human genome (Shew et al., 2018; McCaughey et al., 2016). According to the authors, 41 % of intervewees were disagree with the genetic treatment of patients with health problems. Although gene therapy could be used to save lives, universal acceptance today is far from being a reality. Around 70% of students would consume genetically edited products or accept the use of genetic editing for clinical purposes (Figure 4). In contrast, 78% of college students would reject the use of genetic editing to cognition or physical improvement of their children (Figure 4). Moreover, 12% of students agree to genetically improve their children's characteristics to make them more attractive and intelligent (Figure 4). Similarly, human genetic improvement received as support 11% according a study realized

in nine countries of Europe and North America (Bintu et al., 2012; Gaskell et al., 2017). The afirmation sugest the reject of genetic editing to esthetical or cognitive purposes is a global tendecy.

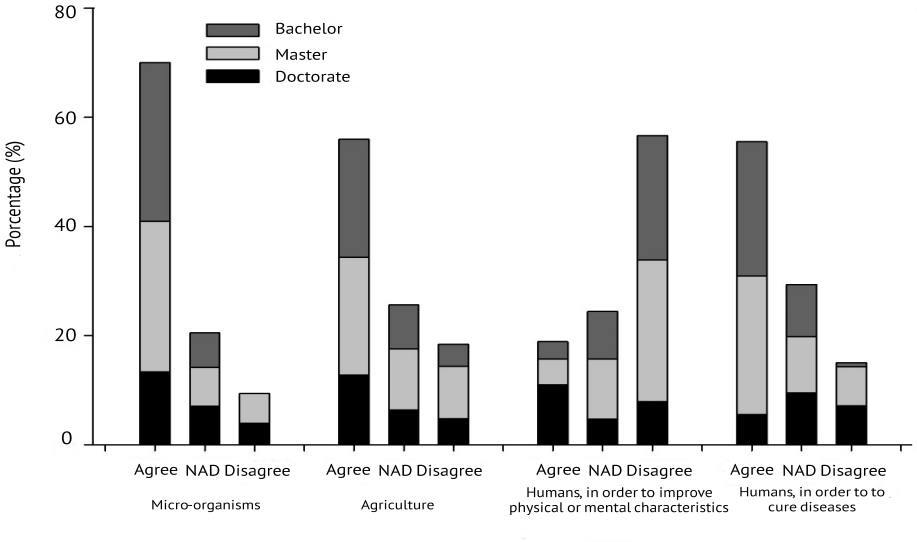

Figure 3. University community attitudes for the use of genetic editing in four society sectors, agree (A), Neither agree or disagree (NAD), disagree (DS)

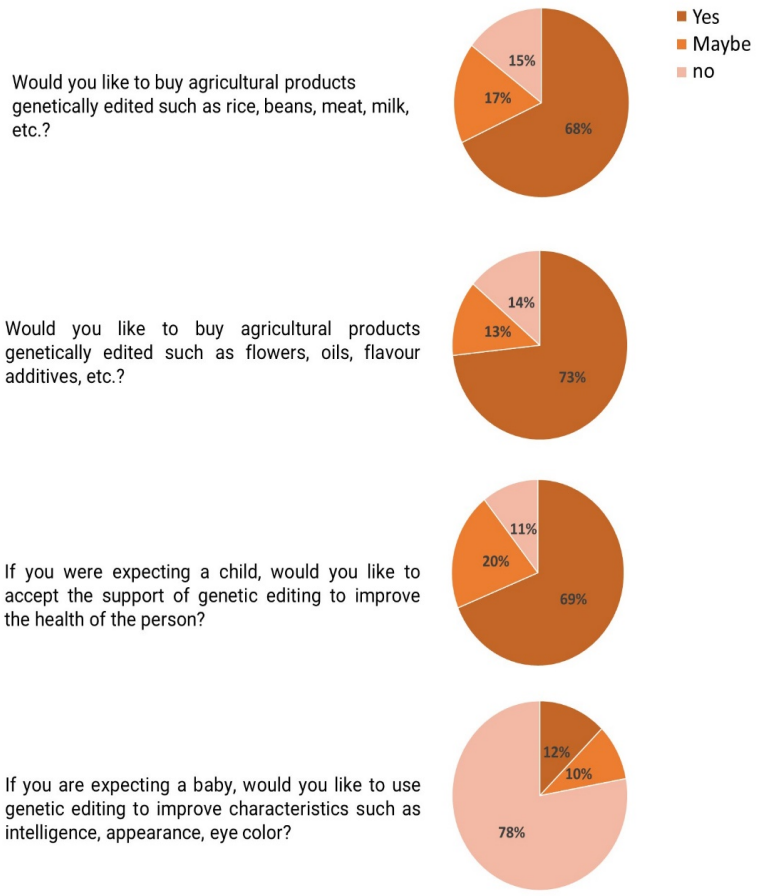

Figure 4. Consume genetically edited products or accept the use of genetic editing for clinical purposes according to students interviewed

The university community assures that DNA modification of living beings could have unexpected consequences. Every student said that genetic edition could have main impact in health and agricultural sector. Moreover, most doctoral students believe that DNA intervention in living being will not have negative consequences. However, most of interviewees believe that the action of genetic editing techniques could have both positive and negatives effects in all areas (Figure 5). The students comments were "Any progress in any society sector bring both positive and consequences, the importance of developing them take an action in application ethics such as social benefits, economics and environmental". Maybe these are the reason for some students support the idea of use of genetic modification techniques. In similar studies, the main comments of interviewees indicated genetic intervention generate risks and unknown consequences (Gaskell et al., 2017).

Area	Students	Negative	Positive and negative effects	Positive	I will not have effects
The enviroment	Bachelor	9	16	4	0
	Master	7	35	10	1
	Doctorate	2	26	14	1
Agriculture	Bachelor	8	16	5	0
	Master	2	29	23	0
	Doctorate	1	23	18	0
Health	Bachelor	4	14	11	0
	Master	5	27	22	0
	Doctorate	0	24	18	0
Society	Bachelor	5	17	4	3
	Master	5	36	10	2
	Doctorate	0	29	12	1

Figure 5. Effects of genetic editing on differents sector of society accoring interviweed students

Among 5 to 10% of students assure that government could not assume a prohivided attitude towards the use of genetic editing. Most university students (50 to 60 %) say that the government should regulate research on the modification of the genome of living beings (Figure 6). On the other hand, between 20 to 30% of students indicated that the government should invest in genetic editing programs, mainly in the agricultural sector and in health. While 30% of respondes believe that the government should approve projects that are associated with the development of this techology. These results differ from the attittudes of North American interviewees where 64% of the population indicates that the government should be responsible for the use of genetic editing for clinical treatments (Blendon, Gorski and Benson, 2016). The results that are associated with the government's role were the most divergent in this study, compared to similar surveys in other countries.

Support for genetic editing was drastically reduced when it was aimed at improving physical or cognitive characteristics, Where only 44% of the population agreed with government intervention in these types of projects. It suggests that perhaps the political conditions of each country may be influenced by student's attitudes to the role that the government should have in genetic editing control.

The possibility of changing the genome of living beings causes different attitudes in the university community. Concern is the common denominator of students (25-30%) in all sectors of society (Figure 6). It has not been studied in depth about the reasons that cause apprehension to the appearance of genetic editing. Although some comments revealed the technical concerns, "I consider the improvements resulting from the genetic improvement in several segments to be important, but I am afraid of the possible future adverse effects. Although the initial responses may prove to be slightly beneficial, in the medium to long term they may lead to unfavorable mutations/ predispositions. There is no way to predict in the short term". While other students revealed social concerns, "I am concerned that the world powers will use this for their own benefit, widening the social, economic and even genetic gaps with third world countries. At some point, one can speak of two different races, and it would be inevitable to return to the racism of the past".

Studies reveal that the population is mainly afraid of uncertainty about possible complications resulting from intervention in patients' DNA (Persaud et al., 2018). A smaller group felt pessimistic (5-10%) with genetic manipulation, mainly in the areas of society and the environment. In general, the university community felt

slightly optimistic about the possibility of changing the genome of living beings in all sectors studied (Figure 7).

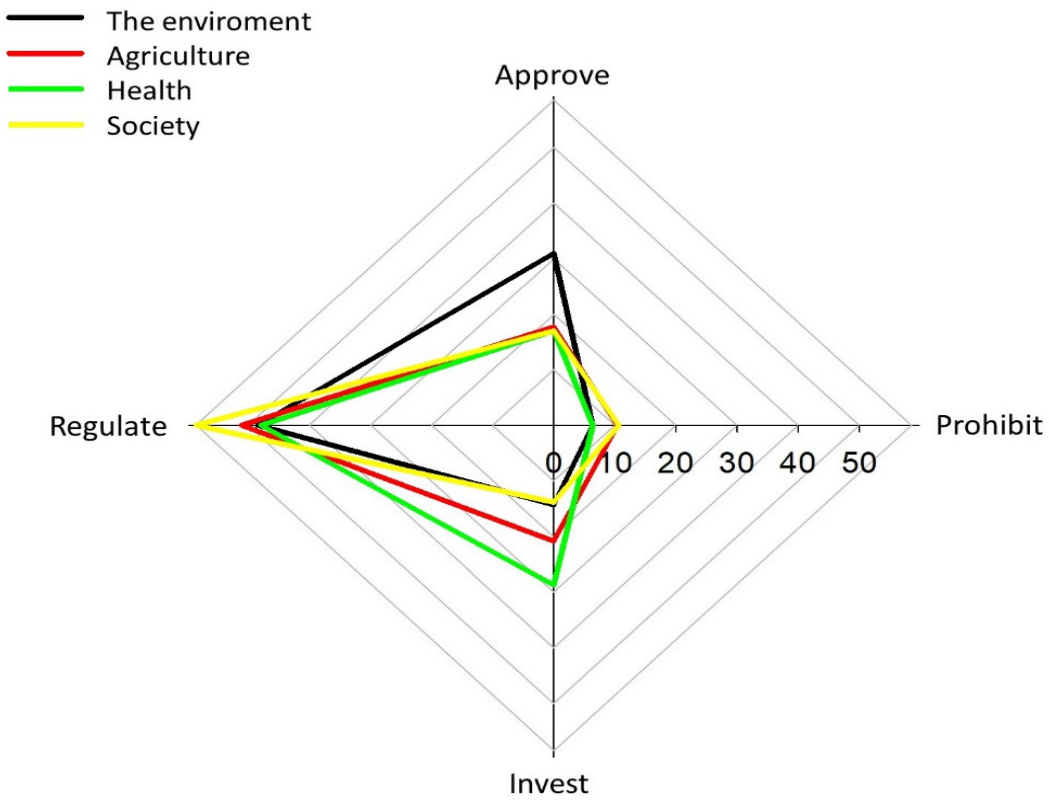

Figure 6. Role that the government should play in the use of genetic editing according to the students interviewed

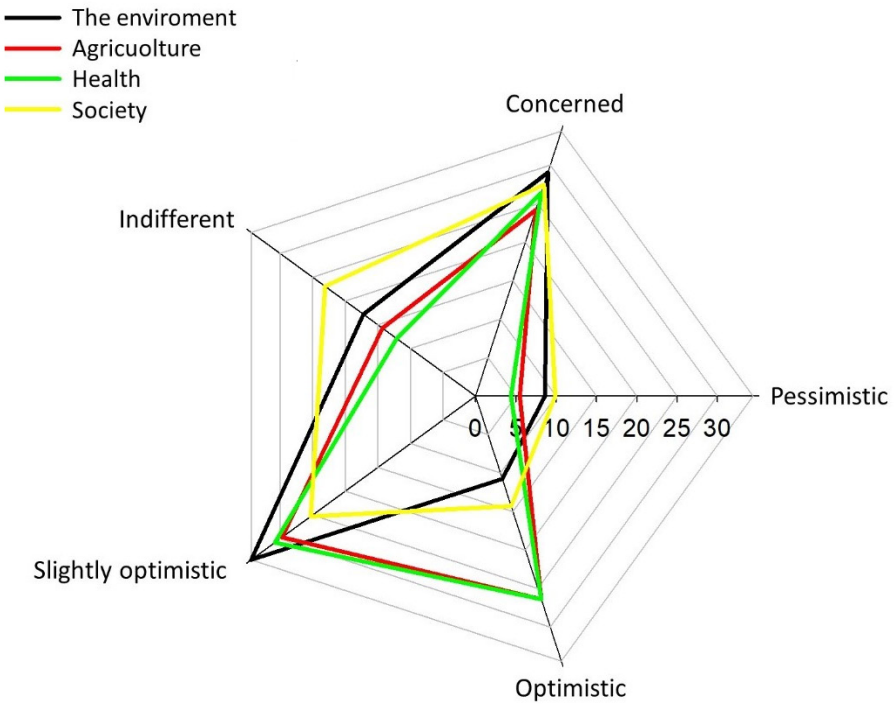

Figure 7. Scenario of the use of genetic editing in the sectors studied according to the students interviewed

Study limitations

The study was conducted through online forms without incentives and without monitoring, which may have influenced the strength of the attitudes in our results. The research was directed to professionals who were mainly in the area of natural sciences; therefore, students would already have prior knowledge on the subject. The number of participants from countries outside Latin America was not large enough to carry out an international comparison. The size of our study population (n=136) does not allow generalizing the attitudes of South American professionals, although it can serve as a basis for future research.

Conclusions

The research suggests that the acquisition of knowledge about genetic editing favors the acceptance of genome manipulation techniques. Most students are in favor of consuming genetically edited products and foods. Similarly, gene therapy for clinical use received support from students. On the other hand, most university students reject genetic editing in humans for the purpose of improving physical or cognitive characteristics. Although there are a number of students who support genetic editing in all areas, almost all respondents say that genetic editing will have unknown consequences. A large proportion of respondents are in favor of regulating and financing projects involved with genetic editing techniques. The attitude of students varies according to their goals, although most are optimistic about the advances in genetic editing in living beings.

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