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Bioethical Issues of Nanotechnology at a Glance

M Aala[1], B Larijani [1, 2], *F Zahedi[1]

[1]Endocrinology and Metabolism Research Center, Medical Sciences/University of Tehran, Iran
[2]Medical Ethics and History of Medicine Research Center, Medical Sciences/University of Tehran, Iran

Abstract

Nanotechnology is considered as an industrial revolution of the third millennium. Advances have a remarkable impact on different fields such as medicine, engineering, economy and even politics. However, a wide range of ethical issues has been raised by this innovative science. Many authorities believe that these advancements could lead to irreversible disasters if not limited by ethical guidelines. Involvement of developing countries in new fields of science could be associated with substantial advantages. In this paper, we intend to review main ethical issues of nanotechnology, taking into account the surge of interests in this field and the ever-increasing advances of nanotechnology in Iran. The issue of safety, considering environmental and ecological impacts of nanoparticles (smart dust), and standards of customer awareness are important debates. The 'Grey-goo' scenario and the concerns about 'post-humanism' are also discussed by bioethicists. There are further concerns about justice, intellectual property rights, accountability, and the probability of military and security misuse.

Keywords: *Nanotechnology, Nanoethics, Bioethics, Iran*

Introduction

Nanotechnology, also called *molecular manufacturing*, as an emerging field of science, has paved the way for an industrial revolution in the current century. In 1986, a researcher named Eric Drexler in his book, *Engines of Creation*, called this rapidly expanding branch of knowledge "nanotechnology" (1). The goal of nanotechnology is to build nanocomputers and nanomachines no bigger than bacteria, which like robots work at the atomic level of any physical or biological objects. This may be sound like science fiction, but ever-increasing evidence shows that these nanorobots could be used in near future. For instance, in the field of medicine, some of its more prominent benefits would be pharmaceutical creation, disease treatment, and nanomachine-assisted surgery (2). With nanomachines, we could better design and synthesize pharmaceuticals; we could directly treat diseased cells like cancer; we could better monitor the life signs of a patient; or we could use nanomachines to make microscopic repairs in hard-to-operate-on areas of the body (2-4). According to an interesting phrase, the benefits and hazards of nanotechnology could be "from utopian dreams and apocalyptic nightmares (5)".

Public and private expenditure on research in this innovative field has dramatically increased in recent years (6). This branch of science has focused on the creation of functional materials, devices, and systems through the control of matter on the nanometer scale, and the exploitation of novel phenomena and properties (physical, chemical, biological, mechanical, electrical, etc) at that length scale (7). Undoubtedly, advances will have a tremendous impact on fields such as materials, electronics, and medicine (6). Many developing countries are active participants in the field of innovative sciences. It is obvious that involvement of developing countries in new fields of science would have advantages; for instance, it could provide appropriate and more affordable solutions to the particular local health needs.

However, rapid advances in biomedical sciences have been associated with debates about ethical aspects of the new knowledge in different societies. The ethical issues and the possible benefits and harms about nanotechnology are increasingly discussed, as well as its implications for

***Corresponding author:** Tel: +98 21 88026902-3, Fax: +98 21 88029399, E-mail: fzahedi@sina.tums.ac.ir

international relations in science and technology policies. Special efforts should be made to address the related issues.

In current paper, we will review the main ethical issues of nanotechnology in brief. For compiling of the article, we have searched related sources through the databases of PubMed, Ovid and Google Scholar, using keywords of ethics and nanotechnology. We also searched some Iranian sites of nanotechnology, which have had ever-increasing numbers of visitors in recent decade.

Main Ethical Issues

Due to the far-ranging claims that have been made about potential applications of nanotechnology, a number of concerns have been raised about the effects of nanotechnology on the society and what action, if any, is appropriate to mitigate these risks (8). Some peculiarities of nanotechnologies rise to specific ethical concerns, including: invisibility, rapid development, military and security use, global impact, and risk of "nano-divide" (9). The invisibility of nanotechnologies after application makes it difficult to control and trace their effects (9).

While benefits of nanotechnology are widely publicized, the discussion of the potential effects of their widespread use in the consumer and industrial products is just beginning to emerge (10, 11). Short-term issues include the effects of widespread use of nano-materials on human health and the environment. Little experimental data about unintended and adverse effects of nano-particles exists (12) and this is the main ethical issue which have examined related to human health concern. Scientists are primarily concerned with toxicity, characterization and exposure pathways. Other than the obvious potential risks to patients, there are other toxicological risks associated with nanomedicine (12, 13). Like natural and residual nanoparticles, synthetic nanoparticles may have undesirable effects on health. The people most likely to be affected are those who produce, handle, use, or dispose of nanoparticles. Health impacts of nanoparticles currently under investigation include risks of lung and heart diseases from inhaled nanoparticles, accumulation of non-biodegradable nanoparticles in the liver and uptake into the brain. Nanoparticles may also enter the food chain (14).

Regulating or managing emerging technologies is particularly complex, especially when there is very little only insignificant data on their possible effects on human health and environment. Majority of the ethical issues that are most often brought up in relation to nanotechnologies are issues that have arisen in relation to other environmental promises and threats. Specters such as the threat of biological harm, the creation of radically new kinds of materials, and the threat to the meaning of being human are all familiar worries raised by technological developments such as nuclear power, genetically modified organisms, ecosystem restoration, and human genetic therapies (15). According to the safety concerns, accountability of scientists and researchers is an essential principle.

Another growing ethical concern related to nanotechnology is called 'Grey-goo' scenario (16). It is based on the fear that nanotechnological devices will either be programmed to self-replicate, or they will 'evolve' into devices capable of self- replicating, and if should they proceed to do so, they may destroy the natural world (16). This serious risk of nanotechnology, have been brought to the attention of the public by Bill Joy (17) by discussing about the research with regard to assemblers. The nanomachines will have the worrisome capacity of self-replication (5). Without this kind of assemblers it is hardly imaginable how molecular manufacturing could ever become practically feasible. This would involve grave dangers such as unbridled self-replication. In this case, since the newly produced assemblers would also start replicating themselves, the total number of assemblers would grow exponentially. If these uncontrolled assemblers used a wide variety of raw materials as resources for self-replication, they could devour the whole biosphere in an amazingly short while. The biosphere would, so to speak, be transformed into

gray goo (5, 17). Global ecophagy, "according to this catastrophic scenario imagined by certain nanotechnology specialists, the uncontrolled self-replication of nanorobots with the potential to destroy all of earth's ecosystems by transforming everything they find into goo" (18). It may destroy the natural world. Fears of global ecophagy and self-replicating nanorobots are closely tied and difficult to separate (16).

Human enhancement and its ethical aspects are discussed by authorities. Not only will it be possible to overcome contemporary diseases, pain and other unpleasant bodily symptoms. Over and above, nanotechnology will enable us to enhance all our human capabilities and properties (19). Among the applications of nanotechnology are enhancements to human memory, physical strength, and other features; in other words, 'post-humanism'. Such enhancements run the gamut from nanoscale sensors that might be added to the retina which improve sight to cochlear implants to improve hearing to performance enhancement technologies for athletes or to new forms of plastic surgery. Some believe that by defending post human dignity we promote a more inclusive human ethics, one that will embrace future technologically modified people as well as humans of the contemporary kind. We also remove a detective double standard from the field of our moral vision, to allow us perceiving more clearly the opportunities that exist for further human progress (20, 21).

Also, military and security misuse are other concerns about nanotechnologic advances. We can call nanoparicles "smart dust". Infinitesimally small surveillance devices such as nanoscale tracking devices, nanosensors, nanocameras and nanomicrophones could enable dictatorial observation and control of subjects in a way that is totally unprecedented (5). Nanotechnology could also become an instrument of terrorism (8). Nanotechnology research could be used to contribute to the creation of nefarious kinds of weapons by terrorists or by governments.

Intellectual property rights and patent management, particularly in the materialist world, could be considered as an important incentive for innovation and invention. On account of this fact, paying particular attention to the rights of pioneers is the subject of ethical notice. Some questions are also raised about public versus private control of intellectual property (22).

The risk of "nano-divide", as another worth noticing ethical issue, mentions potential deepening of inequalities between developing and developed countries (9). Nanotechnology has provided a special opportunity for developing countries to build their infrastructures more advanced and to reduce global health inequities. Consequently, there are also further concerns about justice and resource allocation. This issue is very different in developed and developing countries. Allocation of limited resources for such an innovative subject would be ethically challenging, considering the health care priorities in less developed societies. On the other hand, if developing countries do not play a significant role in innovative technologies like nanoscience, they must pay more expenses for providing the new products in the future. The mentioned facts highlight the issue of the global impacts of nanotechnoloy, and risk of "nano-divide". Decision-making about investment on the current researches is vital and needs special ethical assessment by policy-makers in developing countries.

Nanotechnology in Iran

The research on nanotechnology has been constantly rising recently. As a national future strategy in Islamic Republic of Iran, the Special Office for Nanotechnology Development has compiled a ten-yr strategy of nanotechnology development (2005-2014) (23). The Iranian site of Nanotechnology Initiative (www.nano.ir) (24) has been one of the most visited sites in this subject in the world. It seems that tendency toward nanotechnology is growing up in our country. Taken into account the rising number of published articles, containing 250 articles related to nanotechnology, Republic Islamic of Iran obtained the first position among Islamic

countries and the ranking of Iran in Nanotechnology in the world was 32 in 2006 (24).
An emphasis on ethics has been voiced by medical and religious professions in Iran in recent decade (25-27). According to the positive decrees (Fatwa) of religious scholars about challenging bioethical issues such as organ transplantation, abortion, assisted reproductive technologies, and stem cell research in Iran; the parliament has ratified some laws related to bioethics in recent years (28-31). Some guidelines in different fields of biomedical science are also compiled (26, 32). Providing basic standards and proper ethical guidelines in this field is needed.

Conclusion

Nanotechnology is showing promising developments in many areas and may benefit our health and welfare. However, we should be aware of possible unwanted side-effects. Nanotechnology means new materials and components, which can be included in many different existing products or enable new products (14). Despite potential benefits of nanotechnology, there are potential ethical issues, which need desirable solutions. According to the emphasis of the United Nations Educational, Scientific and Cultural Organization (UNESCO) on the nanoethics in recent years (8, 9), early assessment of ethical, legal and social implications of nanotechnologies will create opportunities to develop a normative framework in this field. Therefore, voluntary guidelines on science ethics and nanotechnologies as mentioned (particularly in regard to safety issues) could be elaborated in a consultative process and proposed as an indicative ethical framework for countries, corporations or scientific organizations. Such guidelines could also inspire national regulations. Therefore, setting standards of quality and safety and compiling appropriate culturally adapted guidelines and directives are recommended. Developing countries should seize opportunity in order to build capacity in new technologies and to meet local health needs; and thereby, reduce global health inequities. It should be mentioned that nanotechnology is an interdisciplinary enterprise, so the globe is confronted with challenges in different fields of ethics, law, economics, and politics. However, its ethical issues are not limited to those discussed in this brief overview.

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