Forum: World Health Assembly

Issue: Measures to safely implement nanotechnology in healthcare practices

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Introduction

Nanotechnology is the practice of manipulating atoms and molecules at a nanoscale using various devices and techniques. Utilizing nanoparticles of materials brings forth different properties than using the same materials in a larger size due to the higher surface area to volume ratio in nanoparticles. This makes them more chemically reactive and affects the strength of their electrical properties.

Nanomaterials can be naturally occurring, such as the particles that make up volcanic ash, smoke, or the biological substances in living organisms such as hemoglobin. They can also be artificial materials produced from man-made processes or objects, including the exhaust from burning fossil fuels. Artificial nanomaterials can also be used to describe intentionally produced synthetic nanomaterials for utilization in various industries.

In the healthcare industry, nanotechnology can be used for a variety of different practices, from diagnosis to treatment. Nanotechnology can potentially improve imaging techniques by providing new molecular contrast agents to detect specific biomarkers such as extracellular proteins specific to cancer cells, extracellular vesicles, and circulating tumor DNA. Additionally, such technology can be used for in vivo tumor imaging, which is when the pathological changes and effects of the treatment on the body are examined using imaging. This can be possible due to their ability to create images at a nanoscale, hence producing more detailed images as compared to existing imaging techniques such as MRIs, and CT scans, that can only examine changes on the surface of tissues.

Additionally, nanotechnology can be used to improve drug delivery. Drug delivery refers to the internal movement of drugs to the targeted sites. The use of nanoparticles in drug development increases the uptake of the drugs due to their small-scale properties and can reduce any side effects by delivering the drugs directly to the targetted site. These innovations serve as an alternative to radiotherapy and surgeries that otherwise, bare extreme risks.

Currently, the United States of America and the Republic of China have nanomedicine as their main fields of research within the nanotechnology industry. While the UN's work with nanotechnology in the healthcare industry has been limited so far, initiatives have been taken to further the research and development of nanotechnology as a whole. For example, the Third International Conference on Chemical Management emphasized the need for UN organizations to facilitate the continued development of nanotechnology by continuing to develop international guidelines.

Definition of Key Terms

Nanotechnology

Nanotechnology refers to the branch of science that involves the manipulation of atoms between sizes 1 and 100 nm. The small size of these particles brings forth new properties such as improved electrical properties and increased chemical reactivity due to the increased surface area to volume ratio. This has allowed for scientific advancement in various fields such as medicine, consumer products, energy, and manufacturing.

Nanoparticles

Nanoparticles refer to any particles that are 100 nanometers in size or less. These can be naturally occurring in the environment, biologically produced, or synthetically manufactured in labs and factories.

Nanocarriers

Nanocarriers are nanomaterials that can be used to transport other substances. These are often used to transport drugs to the targetted site in the body due to the small size of these particles which enables them to easily change their shape. Inorganic nanocarriers are made of metal compounds that have certain benefits such as surface functionalization and magnetism which allow for targeting mechanisms. Additionally, inorganic nanocarriers can also be used for imaging.

Targeted drug delivery

Targeted drug delivery is the process of transporting a drug to the site of action and releasing it using either local or peripheral control means. Nanomaterials make it possible to target a specific organ and enhance the uptake of poorly soluble drugs. Studies have also shown that nanoparticles that deliver anticancer drugs are capable of doing so without triggering drug resistance and also reduce the chances of side effects

Theranostics

Theranostics refers to an approach to the diagnosis and treatment of cancers through the use of radiotracers. Radioacters have a biological side and a radioactive side that emits radiation and allows for imaging. For treatment, the radioactive side is more reactive and can be used to kill cancer cells with radiation.

Biomarkers

A biomarker is essentially any measure of what is happening in a cell at any given time that can be used as early warning signals for certain issues or diseases. Types of biomarkers include molecular and non-molecular. Non-molecular biomarkers are essentially imaging techniques such as MRIs that help to identify problems in the body. Molecular biomarkers have biophysical properties that help to measure biological samples. These can be plasma, serum, cerebrospinal fluids, etc.

In vivo, tumour imaging

In vivo imaging is a non-invasive imaging technique that can be used to monitor the growth and behavior of tumors in the body. The size of nanoparticles allows for the imaging of specific sites and target cancer cells specifically. For example, biosensors are nanomaterials that can recognize specific molecules according to their structure. Magnetic nanoparticles are another example of the use of nanotechnology in imaging. These have the magnetic properties to react with substances on a cellular level, hence proving them to be the best compounds as contrast agents to be used for MRIs.

Circulating tumor DNA

Circulating tumor DNA refers to the DNA strands that harbor the mutations of the original tumor released into the bloodstream by the existing tumors. Cancer diagnosis used to depend on tissue biopsy however this limits the early detection of tumors and its application in evaluating treatments is also limited. Circulating tumor DNA can be used as more efficient biomarkers for the liquid biopsy of cancer.

Key Issues

Lack of finance and infrastructure

The field of nanomedicine still requires a lot of research and development to be conducted and the financial resources available to support this process may not be sufficient. Funding from governments may not be adequate, especially in countries that are less economically developed; hence, funding from private organizations may be more beneficial and necessary However, the field of development is highly innovative which means that confidentiality can be breached and other organizations can use the same information. This prevents private investors from investing in the research process due to the risks associated with it and the inability to quickly appropriate the total returns of the investment. Additionally, the research and development of such technology can take years, which extends the time taken for returns to be accessible.

The tools required for the research and development, as well as the processes that they will eventually be used for, will be extremely costly for governments of third-world nations and private organizations. The development of such tools will not always be possible and importing these tools will also be met with import/exporting regulations. Lastly, The field of nanoscience is extremely multidisciplinary. While the focus within the field is slowly starting to shift from physical to biological and life science aspects, there is no infrastructure that can support this shift by interconnecting what used to be disparate disciplines. This includes the competitiveness within departments of educational institutes for grants and contracts.

Once the product has been released into the market the starting price will be costly and unaffordable for many people. The price will only start to decline when competing companies start to release the same products and generic products start to enter the market. However, this will take a long time which means the medicine will be inaccessible to those who can't afford it for a long period of time.

Lax control of safety

There are multiple safety implications when it comes to nanotechnology and nanomedicine. Firstly, The use of nanomaterials can result in fires, explosions, and other unexpected reactions due to their ability to easily become chemical catalysts. The process of synthesizing nanomaterials requires the use of harmful and extremely reactive substances. Secondly, the inhalation of nanoparticles can lead them to reach the brain, blood, and lungs as observed in laboratory animals. This can lead to inflammations, and fibrosis and their ability to penetrate cell membranes can cause damage to intracellular structures and cellular functions. Thirdly, spillage of nanomaterials can result in the contamination of soil and groundwater which can lead to the death of multiple organisms.

Since research is still being conducted, there are no harsh regulations or specific guidelines established by the FDA. The nanomedicines that are currently being developed follow the same guidelines as other drugs which can raise concerns for the safety of the patients and those involved in the production of the drugs

Issues with Drug Delivery

While technology has greatly improved drug delivery, there still are many concerns surrounding this. Firstly, the toxicity of these nanomedicines is still yet to be discovered. The high reactivity of nanoparticles results in immediate reactions once they enter the body which can change the structural and functional foundation of the particles, therefore resulting in damage to part of the body at a cellular level due to unknown toxic reactions. Cell membranes within the body may also be destroyed and nanoparticles can easily penetrate into and accumulate in the lungs, lymph nodes, the gastrointestinal tract, and more; the effect of which is still unknown but predicted to be extremely toxic for the body. Essentially, the effects of overexposure to this nanomedicine are still unknown due to the lack of research so far.

Moreover, the size of nanoparticles allows for easier uptake into various cells including the brain tissue. The blood-brain barrier exists to separate brain tissues from the blood and this barrier can be easily penetrated by nanoparticles, making drug delivery to the brain highly efficient and easier. While research up until now has only been conducted with pharmaceutical drugs, there is the opportunity to use the same techniques and technology to develop highly addictive substances. Addictive drugs are delivered to the brain where they then interfere with the neurotransmitters and then way electric impulses are conducted in the brain. Nanoparticles can easily be absorbed into the brain, hence having a faster effect on substance users, perhaps even eliminating the need to inject the drug into the bloodstream and simply taking it orally. This poses a great threat as it will eventually encourage the use of addictive drugs.

Ethical concerns

There are multiple ethical concerns regarding the implementation of nanotechnology in the medical field. Firstly, research and development are still ongoing and the various risks of using this technology are still unknown to some extent. Any animal testing involved in the technology's research and development can be extremely harmful due to the unknown effects, serving as threats to the environment, the animals being tested on, and perhaps even the researchers or technicians involved. While most countries have laws in place to protect animals there are still exceptions that allow this to take place with the greater benefit of humankind in mind. Additionally, a lot of nations have no regulations that prevent animal testing, especially in regard to nanotechnology.

The development of nanomedicines may also result in the use of it for enhancement rather than therapy which can be extremely unethical and can provide an unfair advantage in fields such as sports and athletics. It can give athletes a competitive edge while also creating socio-economic inequalities if only the financially well of athletes can afford them.

Major Parties Involved and Their Views

Republic of China

The Republic of China is currently the first in the world in terms of research and development of nanotechnology. The nation seeks global dominance in technological advancements hence, they have invested greatly into research about various aspects of nanotechnology, including cloning and cancer research. In 2020, scientists developed a new type of synthetic nanoparticle capable of targeting, penetrating, and altering cells by delivering the gene-editing tool, known as CRISPR/Cas9. This can be used in therapy of single-celled disorders and some cancers. The number of private companies driving nanoproducts is also rising and a lot of these businesses are funding the establishment of China's first private research institute with nanotechnology as the main focus of the research, Westlake University.

Republic of India

Researchers in India have developed multiple nanomedicines to target cancer and other diseases. The company Sun Pharma has developed a nano-drug for the treatment of a skin condition known as psoriasis, which is claimed to have fewer side effects than other treatments for the disease. Researchers have also developed nanomedicines to target tuberculosis. The country has a strong base in research in the field with thousands of universities working on a wide range of products. The Department of Science and Technology also established 18 sophisticated analytical instrumental facilities (SAIFs) across India and has started initiatives such as the DTS Nanomission for nano-biotechnology activities and research. They also aim to support 20 out of the 7-Postgraduate programs in the field of nanoscience. Apart from this, the government has also expressed and provided support for initiatives by other organizations.

United States of America

The United States of America has funded and supported multiple initiatives focused on the research and development of nanotechnology. For example, the National Nanotechnology Initiative is a government-based organization involving over 30 federal departments and independent agencies working towards the "shared vision of a future in which the ability to understand and control matter at a nanoscale leads to ongoing revolutions in technology and industry that benefit society." They provide research facilities to both US-based and international researchers. Currently, nanotechnology is being studied for the diagnosis and treatment of atherosclerosis and for the targeted drug delivery to specific cancer cells. In addition to this, the US government has also established other organizations such as the National Institutes of Health (NIH) and the

National Cancer Institute (NCI) that have been integrating nanotechnology into their practices with the specific goal of cancer detection and diagnosis in mind.

Republic of Korea

South Korea has greatly contributed to the development of nanotechnology. In 2018 alone, nearly 600 million was invested in the research and development of nanotechnology. In terms of innovation, there are more than 9300 patents in the USPTO for nano products. In 2000, the Korea National Nanotechnology Initiative was established and since then, multiple initiatives, organizations, and facilities have been established to aid in research and development and to increase supporting infrastructure and manpower. Various departments of the government such as the Ministry of Education, Science and Technology, and the Ministry of Knowledge and Economy are currently the primary investors of the projects proposed. The Korean Institute of Science and Technology has been encouraging investment into nanobiotechnology from the private sector, with a specific focus on diagnosis, therapy, and cancer research. They aim to excel in specific fields of nanobiotechnology including artificial organ technologies through funding from public organizations, the private sector, and universities.

Kingdom of Saudi Arabia

The Kingdom of Saudi Arabia established the King Abdul Aziz City for Science and Technology (KACST) in 1985 to promote scientific and technological research and development. KACST and other universities such as Riyadh University and King AbdulAziz University have been supporting the National Nanotechnology Program by providing resources and facilities for research. Several nanotechnology centers such as The Centre of Excellence in Nanotechnology (CENT) have been established in universities since. The Centre of Nanotechnology (CNT) is another establishment that has a multidisciplinary work center with a focus on the various aspects of nanotechnology. CNT has 55 researchers leading projects regarding nanobiotechnology, 49 researchers working on nano-drug delivery, and 61 researchers exploring nanomedicine.

Japan

Japan was one of the first nations to create a nanotechnology research program. The Japanese Science and Technology Agency has funded several nanotechnology projects in the 1980s. Soon after, the Ministry for Technology and Industry announced their support and funding for the development of nano-scale electronic devices, eventually increasing the funding of nanotechnology research in Japan to 950 million dollars by 2005. The Ministry of Health, Labour and Welfare, and the National Institute of Health Sciences have since funded and promoted the research and development of nanomedicine and nanomaterials, resulting in the development and approval of many nanodrugs and imaging agents.

Development of Issue/Timeline

Date	Event	Outcome
1959	Introduction of the concept of nano molecules	Physicist Richard Feynman introduced the idea of being able to manipulate atoms and molecules at a nanoscale in his talk "There's Plenty of Room at the Bottom".
1981	Modern Nanotechnology was introduced.	Scanning tunneling microscopes allowed scientists to see and manipulate individual atoms.
1990	The first nanomedicine to use synthetic nanoparticles	Sigma-Tau Pharmaceuticals released the drug Adagen.

		Adagen is a PEG-coated drug for severe combined immunodeficiency disease. This was the first approved nanomedicine to be released.
1993	Development of the Nanoprobe	The Nanoprobe was the first nanosensor to be developed. It is an optical device that was developed by tapering an optical fiber to a tip. This enabled early detection, accurate diagnosis, and personalized image-guided treatment of diseases.
1994	Release for Oncaspar	Enzon Pharmaceuticals released pegaspargase under the brand name Oncaspar as a treatment for lymphoblastic leukemia. The mechanism is thought to be based on the selective killing of leukemic cells.
1995	Approval of Doxil	Sigma-Tau Pharmaceuticals released Doxil which is anthracycline and is a type of chemotherapy. Doxil was the

		first nano-drug to be approved by the FDA that was coated with PEGylated nanoliposomes.
1998	Approval of Apligraf	Apligraf is a type of Tissue-engineered skin equivalent that was approved by the FDA. It was initially used for the treatment of non-infected ulcers and eventually got approval for the treatment of diabetic foot ulcers.
2003	Development of Nanoshells	Nanoshells are nanoparticles with a dielectric core and an outer shell made of a thin metallic element. These particles can be used for biomedical imagine and cancer treatment.
2003	Approval of Fuzeon	Fuzeon is a prescription drug developed with nanotechnology used to treat Human Immunodeficiency Virus-1 (HIV-1). It works by

		inhibiting the HIV ability to infect cells.
2011	Development of BIND-014	BIND-014 is a nanoparticle that targets prostate-specific membrane antigens. This was the first nanomedicine that could penetrate the blood-brain barrier that entered clinical trials.
October 2023	Approval of Novavax	Novavax is a vaccine that was developed to fight the original variation of the SARS-Cov-2 virus (COVID-19). It is a protein that mimics the virus' version of the spike protein.

Previous Attempts to Solve the Issue

UN-based Initiatives

As seen in the timeline, multiple organizations, governments, and private companies have contributed towards the implementation of nanotechnology in healthcare practices. Multiple breakthroughs have been achieved, including the development of various drugs targeting cancer and other diseases, and the development of various imaging techniques. Along with this, there are multiple UN-based initiatives that have also helped foster the development of nanotechnology.

The World Health Assembly has a special program for Research and Training in Tropical Diseases, that aims to aid the advancement of the medical field in third-world nations, aiming to improve the health of people "burdened by infectious diseases due to poverty".

They fund research by offering research grants and sponsoring training in laboratory skills and knowledge. They support research about nanotechnology-based treatments for diseases such as malaria, tuberculosis, and HIV.

WHA also has specific guidelines to protect workers from the potential risk of manufacturing nanomaterials. The guidelines include a globally harmonized system of classification and labeling of potentially dangerous chemicals for use in safety data sheets, with required updates on the hazardous characteristics of the substances, assessing and controlling workers' exposure to nanomaterials, health surveillance, and training of workers.

Imaging Techniques

Imaging techniques have been modified to be less invasive with the help of integrating nanotechnology into the diagnosis process. While previous imaging techniques only allowed for examination of the tissue's surface, the use of nanoparticles enabled the detection of changes in tissues at a cellular level. Nanoparticles are being used as imaging agents and contrast agents to discover abnormalities and tumors in the body, while also being used for detecting potential toxic reactions, controlled drug release research, evaluating drug distribution, and monitoring the progress of therapy. Some specific examples of progressions in imaging techniques include the use of iron oxide nanoparticles as contrast agents that can be injected into the bloodstream since they attract tumors and other abnormalities and allow them to appear brighter in MRI scans. CT scans also use a similar technique where nanoparticles made of gold or tantalum are injected into the bloodstream to coat implants, making them more visible in CT scans and aiding in the process of monitoring the placement of implants. Lastly, optical imaging uses fluorescent nanoparticles attached to targeting molecules like antibodies that can bind to specific cells like cancer cells, emitting fluorescent signals that can be detected by tools such as fluorescent microscopes.

Targeted Drug Delivery

Nanotechnology has greatly improved the process of drug delivery by increasing the efficiency rate of drug delivery to specific target sites in the body. This technology has enabled the particles to move through physical barriers and membranes a lot more easily than larger drug carriers and drug delivery systems, hence enabling drugs to reach various areas of the body and reducing the need for invasive processes like radiotherapy and surgeries. Nanotechnology has also improved drug delivery by reducing the side effects the drug may have on other organs in the body. The size of nanoparticles allows for improved penetration within the body, allowing for alternate routes to the targeted site. It also enables the delivery of drugs that are poorly water-soluble as the small size enables faster and easier dissolution. Additionally, the use of nanostructures in drug development has increased oral bioavailability, which refers to the amount of a drug that enters circulation after ingestion, due to specialized uptake mechanisms that allow it to remain in the bloodstream for longer. This results in a controlled release of the drug towards the targeted site thus, minimizing the side effects.

Possible Solutions

Encouraging investment from the private sector and foreign aid

The issue of the lack of financial resources and funding in less economically developed countries was discussed previously. This can be addressed by encouraging investments from the private sector and increasing foreign aid. This can be done by expressing the importance for and possibilities of nanotechnology in the field of healthcare. Additionally, this can be further encouraged by providing tax breaks and other incentives to private companies and organizations that invest in the cause or donate to foreign aid organizations.

Strengthening regulations

This is essential to ensure the safety of workers and consumers of nanomedicines. Firstly, exposure to nanomaterials and other chemicals during the manufacturing process needs to be extremely controlled and caution must be taken in terms of attire, and the environment of the factory to reduce the chances of any negative effects on the workers. Secondly, FDA regulations can be strengthened and made more specific to nanomedicines, with an increased number of required clinical trials and detailed inspections of the production process before approval of a drug to ensure the safety of patients. Lastly, the system of approval to start developing a drug can be made harsher in order to prevent the unauthorized production of any addictive substances.

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