



NANOTECHNOLOGY AND HUMAN HEALTH: BIOETHICAL CHALLENGES WITHIN THE NIGERIAN CONTEXT

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Abstract:

The contemporary world is witnessing a broad spectrum of research interests and innovations in the fields of nanoscience and nanotechnology. This broad spectrum of research interests and innovations has extended to the area of human health. A careful examination of the Nigerian context clearly reveals that the appropriation and the application of nanoscience and nanotechnology continue to develop exponentially and have garnered much interest, leading to innovations, especially in the area of human health. However, it is also important to indicate that the legislative structures in the country have not developed efficiently vis-à-vis the demands and the challenges raised in the appropriation and application of nanoscience and nanotechnology in the area of human health. Medical research involving the use of nanoparticles has been documented in the country. It is important to point out that medical research that is neither scientifically correct nor ethically good cannot work towards securing the fundamental goals which are at the heart of medical practice and health care, namely, beneficence, the good of the patient and the flourishing of human life. Innovations in nanoscience and nanotechnology, especially in the context of human health, present before us significant challenges. These challenges demand a methodology that is interdisciplinary. The interdisciplinary approach in bioethics and health care, in the creative interaction that takes into consideration the insights from science, technology, medicine, health care, sociology and ethics, would bring about greater promotion of human well-being and human flourishing. Research, investments, and innovations in the fields of nanoscience and nanotechnology continue to develop at a very rapid pace. There is a need to take into account the achievements, the prospects and the challenges in the application of nanoscience and nanotechnology to human health. The core issue is to pay attention to the scientific concerns, the technological concerns in the application of nanotechnology, the environmental concerns, the health concerns and the ethical concerns. The examination of the challenges within the Nigerian context indicates that there is a need for further research and innovations in the areas of nanoscience, nanotechnology and human health. It is important that such research be carried out in a scientifically correct

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and morally responsible manner for the promotion of the good of human persons, human health, human society, the environment and the ecosystem.

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1. Introduction and Literature Review

Contemporary interest and research in the field of nanoscience and nanotechnology indicates that magnificent innovations have already been achieved, and the future points towards greater innovations and achievements. The core concern in this work is to examine the question of nanoscience and nanotechnology and the application and appropriation of nanotechnology in the area of human health and the life sciences, together with the bioethical challenges presented in such application and appropriation of nanoscience and nanotechnology, especially in the context of a developing country like Nigeria. In this context of Nigeria as a developing nation, the country is already experiencing innovations and challenges emerging from the field of nanoscience and nanotechnology. A very significant case could be seen in the claims made by a Nigerian scientist with regard to Antivirt® an experimental medicine appropriating nanoparticles towards curing HIV/AIDS. In another publication in 2020, there were also claims by the same scientist and his team with regard to Antivirt®, the use of nanoparticles and the therapeutic efficiency of Antivirt® in dealing with the health challenges presented by the SARSCOV2 and COVID-19. It is important to note that scientific knowledge and the technological application of the knowledge acquired in the field of nanoscience and nanotechnology have grown exponentially especially in the fields of Physics, Chemistry, Engineering, Information communication technology, Biotechnology, Neuroscience, Medicine, Healthcare, Energy, and Electronics just to mention these few. This growth in scientific knowledge and technology is very important but there is also a growing awareness of significant bioethical challenges, especially in relation to human wellbeing, human health, human flourishing and the protection of the environment. In this work, it would be pertinent to pay attention to the question of nanoscience, nanoscale and nanotechnology, the question of nanoscience, nanotechnology and human health, and the challenges within the Nigerian context.

2. The Question of Nanoscience, Nanoscale and Nanotechnology

The significant prefix “nano” in nanoscience and nanotechnology can trace the distinctive origin of its derivation to the Greek Language and culture. The word nano is derived from the Greek word *νάνος*, meaning “dwarf”, indicating that it is extraordinarily small in size and character. Nanotechnology involves the research, development and manipulation of materials, devices and systems that exhibit physical, chemical and biological properties at the nanoscale. The American Physicist and Nobel laureate

Richard P. Feynman, gave original insights into the contemporary development of nanoscience and nanotechnology, in his work entitled: “There’s Plenty of Room at the Bottom” published in the journal, *Engineering and Science*. This was fundamentally at the heart of the lecture he delivered at the meeting of the American Physical Society on the 29th of December, 1959, at the California Institute of Technology (22-36).

The vision of Feynman gave impetus and originating insight in relation to the scientific and technological inventive capacity towards manipulating and controlling things on an infinitely small scale. Research and innovations in nanotechnology have contributed immensely to technological and industrial developments in various areas of human endeavour, especially in the fields of Biotechnology, Engineering, Electronics, Medicine, Health care and the environment. Nanotechnology continues to expand human knowledge and proficiency in the contribution towards unlocking huge potentials at the nanoscale. Nanotechnological innovations in the appropriation of scientific knowledge in dealing with natural structures, artificial structures, materials and systems at the level of the nanoscale, have contributed greatly towards human development. Within the context of human health and health care, innovations in the field of nanotechnology continues to make great contributions especially in relation to disease prevention, diagnoses, medical technology, regenerative medicine, development of vaccines, therapy, and targeted medication delivery, just to mention these few. In the original Greek language and culture, as already noted, “nano” typically refers to a dwarf in size and character. But paradoxically, the great efficiency of nanotechnology lies precisely in this infinitesimal degree of minuteness in size. The reality of the smallness of size is an important factor in nanotechnology. This then characteristically points to the question of the nanoscale:

Nanoscale pertains to the size of one-billionth or 10^{-9} m of a material. A new scientific field of science in the form of nanotechnology was created because it was observed that materials, products and devices developed from nanoscale particles almost always exhibit properties different from those of large-scale bulk materials. This follows the basic principles of physics and chemistry that as the state of matter is composed of atoms, any changes in atomic size, shape and arrangement directly affect the material properties (Shiza Malik, Khalid Muhammad and Yasir Waheed, 2023).

The question of nanoscience is closely related to the question of the nanoscale due to the fact that nanoscience is fundamentally concerned with the scientific knowledge involved with the manipulation of matter at the level of the nanoscale. At the level of the nanoscale, matter exhibits unique characteristics that can contribute towards innovative applications in various areas, including human health and the environment. The field of nanoscience embraces the scientific expertise needed in designing, synthesizing, and describing materials and devices at the level of atoms, molecules and supramolecular structures based on the unique properties and phenomena of matter at the size of the nanoscale. Health care and medical research are appropriating the knowledge derived from nanoscience in the development of nanodevices, especially as diagnostics, sensors

and therapeutic delivery systems. (German, J. B., Smilowitz, J. T., Zivkovic, A. M., 171-183).

The appropriation of nanoscience and nanotechnology in the field of human health continues to make a profound impact in the contemporary world, generating both positive and adverse reactions. This impact as well as reactions, could also be felt in the Nigerian context.

3. Nanoscience, Nanotechnology and Human Health

Developments in nanoscience and nanotechnology have contributed immensely to human progress in multiple fields of human endeavour, especially in the areas of Biotechnology, Physics, Chemistry, Computer Science, and Engineering. The contemporary world has seen the appropriation and application of nanoscience and nanotechnology to human health with promising results. Nanoscience involves the study of matter at the nanoscale – dimensions between approximately 1 and 100 nanometers or 1,000 times smaller than the width of a human hair. At these incredibly small scales, materials have unique phenomena that point towards new applications and innovations in various fields of human endeavour ([US Department of Energy, Office of Science](#)) Nanoscience points towards the convergence of scientific disciplines including physics, chemistry, materials science and biology, just to mention these few. Nanoscience deals with manipulation of materials at atomic and molecular scales, nanotechnology, on the other hand, deals with the ability to observe, measure, fabricate, assemble, control, restructure and manipulate matter at the nanometer scale (Bayda, Samer, 2020).

State of the art innovations in nanoscience and nanotechnology have made it possible for nanoscience and nanotechnology to be applied in taking care of human health in a variety of perspectives which include medical diagnoses, therapeutic procedures, regenerative health care procedures, gene therapy, dentistry, oncology, drug delivery and cosmetic health care, medical devices, laboratory investigations, biomedical devices and materials, just to mention these few. The interest and innovations in nanotechnology with regard to human health and health care have grown exponentially and the prospects are enormous. *“Nanotechnology is a term used to define areas of science and engineering in which phenomena occurring at nanoscale dimensions are used in the design, characterization, manufacture and application of materials, structures, devices and systems”* (Abid Haleem, Mohd Javaid, Ravi Singh, Shanay Rab and Rajiv Suman, 70-77).

Nanotechnologies are being increasingly appropriated in the field of medicine and health care. Innovations in contemporary nanosystems have made significant contributions to health care especially in relation to diagnosis, imaging, and treatment of various health problems including cancer, cardiovascular diseases, ocular diseases, degenerative diseases, central nervous system related diseases, just to mention these few. It is important to note that nanomaterials integrate well into biomedical systems because most biological systems operate at the level of nanosize. In the field of drug delivery, nanosystems offer great benefits in the delivery of drugs to targeted tissues or organs

with greater precision and control efficiency compared to conventional techniques. Drug delivery to target tissues, good biocompatibility and the control of drug flow to the bloodstream are some of the most significant reasons for the use of nanosystems in drug delivery. (Anjum, S., et al., 2021).

In the context of the growing interests, innovations and investments in nanoscience and nanotechnology, the World Health Organization, WHO, indicates that: Nanotechnology is the science and application of materials with a size below 100 nanometres (a nanometre is 10^{-9} metres. Many substances at this scale acquire properties that can be different from those at other scales (atomic or molecular level as well as bulk). This has allowed fields, from medicine to consumer products, from the creation of new materials to food additives, whose benefits and returns have attracted considerable research and financial investments ([World Health Organization](#)).

The benefits of nanotechnology are well-known and well-documented. But the “love of wisdom” also demands that attention should be paid to the important challenges with regard to the impact on the environment, the ecosystem and human health. The person of Socrates brought about profound anthropological transformations in early Greek philosophy, and with profound philosophical insight, Socrates indicated that the unexamined life is not worth living (*Apology*, 38a). Building upon the philosophical insights of Socrates within the contemporary context, it could also be stated with philosophical insight and a marked sense of existential commitment that the unexamined technology is not worth developing. This affirmation includes nanotechnology.

The properties of nanomaterials and of engineered nanoparticles in particular, have raised concern about unwanted or unexpected interactions with biological systems, which could result in adverse consequences for human and ecosystem health ([World Health Organization](#)).

4. Challenges Within the Nigerian Context

The contemporary world is becoming more and more complex through an intermingling of social, economic, political, religious, scientific, technological and cultural factors, and within the world community, one cannot deny the reality of globalization and the processes of the incorporation of peoples into a complex world community through the network of personal, social, political, economic, scientific and technological phenomena. Nigeria as a country is fully alive to the reality and challenges of the contemporary world phenomenon of globalization. In the contemporary world characterized by the phenomenon of globalization, it is important to note that the utilization of nanoscience and nanotechnology in various fields of human endeavour is expanding and gaining momentum in Nigeria. “...nanotechnology has considerable impact on the collective areas of study in Nigeria, which include Health, Environment, Society and Speculative issues” Ejeta, K. O., Dolor, G. A., Ndubuka, G. I., et. al., 136-139).

Research in nanoscience and nanotechnology is generating a lot of interest in Nigeria, and it is equally important to pay attention to the challenges and the impact as

well as the bioethical implications emerging from the use of nanotechnology especially in the areas of health, environment and biosystems, just to mention these three.

Nigeria can utilize nanotechnology as a springboard to solve challenges in water and sanitation, energy, foods and nutrition, security, healthcare, and environment to meet the expectations of SDGs (Lateef, A., Azeez., M., Badmus, S., Adigun, G., 20)

In relation to the question of nanotechnology and human health it is important to note that Maduiké Ezeibe and his team have made some significant claims. It is important to pay attention to those claims, especially in the Nigerian context and the ethical challenges that they present before the rational mind. According to Maduiké Ezeibe and his team:

“For a treatment to achieve permanent cure of HIV/AIDS, it should terminate the viral infection and improve CD4-lymphocytes counts of patients, to at least 1000/ml. So, the significant decrease ($P = 0.030$) in mean viral load and the significant increase ($P = 0.001$) in mean CD4-lymphocytes count after 8 weeks of this trial-treatment, indicate that the Antivirt® is potentially an effective antiretroviral medicine.” (Maduiké C. O. Ezeibe, Dahiru Aleeyu, Ijeoma J. Ogbonna, Ekenma Kalu).

Maduiké Ezeibe and his team maintain that the fact that Antivirt® is made of nanoparticles gives it the advantage of being capable of reaching HIV “hidden” in cells, crossing physiological barriers to target HIV as well as HIV-infected cells and mop out HIV through physical effects, there is greater success in therapeutic efficiency.

The reason termination of HIV infections is not achieved with existing antiretroviral therapies (ARTs) is that their molecules are too large to cross physiological barriers. For that limitation, they do not reach HIV infections “hidden” in some cells. So, even when viral loads become undetectable in the blood of treated patients, the infection may still remain “hidden”. Antivirt® is made of Nanoparticles. So, unlike the other ARTs, it crosses physiological barriers to reach HIV and HIV-infected cells in organs/tissues. And since it acts by a physical effect (mopping out HIV), the medicine is safe for prolonged treatment till termination of the infection is achieved (Maduiké C. O. Ezeibe, Dahiru Aleeyu, Ijeoma J. Ogbonna, Ekenma Kalu, doi: 10.4236/wja.2016.62005).

The claims published by Maduiké Ezeibe and his team have generated a lot of controversies within and outside the Nigerian context. The website of the Committee of Vice Chancellors of Nigerian Universities acknowledged the claims made by Maduiké Ezeibe and his team.

A research team at the Michael Opara University of Agriculture, Umudike (MOUAU), Abia State, led by Prof. Maduiké Ezeibe has been able to prove that Medicinal Synthetic Aluminium (sic)-magnesium Silicate (MSAMS), which it developed can cure HIV/AIDS. The result of the clinical trial of the antiretroviral efficacy of MSAMS in males and females was published in the British Journal of Medicine & Medical Research 18(11): 1-7, 2016.

From another perspective, it is important to point out that the claims made by Maduike Ezeibe and his team have been challenged vigorously by the Nigerian Council for the Control of AIDS, NACA, and the Nigeria Centre for Disease Control, NCDC. The Nigerian National Centre for the Control of AIDS, NACA, and the Nigeria Centre for Disease Control, NCDC, on the 7th of February, 2017, put forward a joint statement giving a vigorously robust confutation of the claims made by Maduike Ezeibe and his team. The Nigerian National Centre for the Control of AIDS, NACA, and the Nigeria Centre for Disease Control, NCD, in a joint statement entitled “Response to AIDS Cure Claims by Nigerian Scientist”, stated:

“Our attention has been drawn to a recent media statement by Maduike Ezeibe, a Professor of Veterinary Medicine and Clinical Virology at the Michael Okpara University of Agriculture, claiming to have discovered a new drug for the cure of HIV/AIDS. An editorial in the newspaper “Leadership” (<http://leadership.ng/opinions/569782/nigerian-scientist-conquers-hiv-aids>), quoted the professor as saying that the drug, produced with “Aluminium Magnesium Silicate” was tested on ten persons living with HIV. The newspaper reported a clinical outcome of an ability to “reach all cells” and making HIV “a conquered organism”. The claim for an HIV/AIDS cure is not new. It is also not new to find a scientist using ambiguous scientific methods and practices to buttress this claim and to find obscure journals increasingly prepared to publish these claims... To examine the facts, this study was published in two little-known journals and involved less than ten patients. In the “clinical trial” as reported, there was no evidence of the use of controls, which is the basis of all efficacy trials. Without controls, you can neither have randomisation nor blinding, two other critical factors in studying the effects of new medicines. Critically, the primary outcome measured in this study was based on plasma viral load levels that are known to fluctuate in patients, even in the absence of any intervention. It is also worth noting that virological suppression (viral load of less than 50 copies/ml) was not achieved in 6 of the patients. There appeared to be no medical doctor involved in the execution of this study, and there was no evidence of where or how the patients were treated or monitored during this study or their clinical and treatment status at the beginning or at the end of it....One critical issue is that there was no evidence from the publication that the authors obtained ethical clearance from an appropriate body in Nigeria to conduct this study, and only ambiguous evidence that informed consent was sought from the evidently vulnerable patients. As a result of the above issues with this process, there is really no basis for a claim to cure of AIDS in this study...” (Nigeria Centre for Disease Control, NCDC).

In spite of the challenges emerging from the robust confutation from the Nigerian Council for the Control of AIDS, NACA, and the Nigeria Centre for Disease Control, NCDC, in 2020, in another publication, Maduike Ezeibe and his team repeated much of the earlier claims already made in the article published in 2016. They did not end there.

They further expanded the therapeutic claims to include treatment for SARSCOV 2 and COVID-19.

Electrostatic attraction, which is antiviral-mechanism of the Antivirt® is a physical effect. So it does not have adverse effects on animal cells. Also, aluminum silicate and magnesium silicate, which were used for the reaction that produced the Antivirt®, are safe medicines that have already been approved for use by regulatory agencies in many countries (including by NAFDAC in Nigeria). Therefore, the new medicine is safe for prolonged medication, as confirmed by the result of the toxicological test by NIMR. Termination of HIV infection to produce cure of HIV/AIDS is only a matter of time if the treatment continues.... Since the Antivirt® has been able to reduce infection of HIV, an RNA virus (positively charged), by as much as 64.12% in five months, despite the severe immune deficiency associated with HIV-infections, the medicine may terminate infections of Covid-19 virus (another RNA virus which is not associated with severe immune-deficiency) in a much shorter treatment-duration (M. C. O. Ezeibe, B. L. Salako, F. I. O. Onyeachonam, A. David, O. O. Aina, E. Herbertson, M. E. Sanda, I. J. Ogbonna, E. Kalu, N. U. Njoku, M. I. Udobi, C. A. Akpan, doi: 10.4236/wja.2020.102012).

Antivirt® is an experimental medication that utilizes nanoparticles in the appropriation and application of the knowledge and technological expertise arising from the field of nanoscience and nanotechnology. HIV/AIDS is a challenging health condition that deserves serious attention from all persons of goodwill. The research efforts of scientists all over the world towards therapeutic breakthroughs in overcoming the challenges of HIV/AIDS should be highly appreciated and commended. Such research efforts must be carried out in a sound, ethical manner, paying attention to the guidelines offered by the World Medical Association in the Declaration of Helsinki with regard to Medical Research Involving Human Subjects. It is also good to note the importance of justified research protocol in each research study involving human subjects and the significance of the relevant ethics committee entrusted with the responsibility of guidance and oversight functions (World Medical Association, Articles, 22 - 23). In the light of the vigorously robust confutation from the Nigerian Council for the Control of AIDS, NACA, and the Nigeria Centre for Disease Control, NCDC, there are significant ethical issues which demand serious attention in the Nigerian context. The Constitution of the Federal Republic of Nigeria clearly indicates that the government's primary purpose shall be the people's security and welfare. (Federal Republic of Nigeria, The Constitution of the Federal Republic of Nigeria, 1999, Chapter, II, 14, 2b, <https://nigerianconstitution.com>). In challenging situations involving citizens' health and welfare, it is important for the relevant organs of government to provide supervisory oversight for the good of the people.

5. Conclusion

The question of nanotechnology in relation to human health is an important question. In the Nigerian context it is evident that the appropriation and application of nanoscience

and nanotechnology is expanding in various fields. The utilization of nanoscience and nanotechnology is quite evident, especially in the field of human health and health care. Very outstanding cases are expressed in relation to the claims made by Maduiké Ezeibe and his team. The robust confutations emerging from the Nigerian Council for the Control of AIDS, NACA, and the Nigeria Centre for Disease Control, NCDC, also manifest serious challenges, including, but not limited to, the bioethical challenges that are clearly evident within the Nigerian context.

In light of the dignity of the human person, the value of human life and the importance of human health, it is essential to pay attention to these challenges. The global challenges presented by HIV/AIDS are well known and well documented. Consequently, it is of great relevance to pay attention to research carried out by Maduiké Ezeike and his team and the therapeutic claims that the team has made in various publications. It is important for the scientific community to subject such claims to worthwhile scientific investigation for the good of humanity and the good of science. The honest presentation of scientific facts and data should be given great attention. In light of the insight offered by philosophical studies, it would be important to pay attention to the methodological demands of the *Experimentum Crucis* in accordance with the observations offered by Francis Bacon in the *Novum Organum* (6). There is also the need to examine the methodological framework in relation to scientific claims, paying attention to the challenges of the inductive method the problems of verification and falsification and the insights offered by Karl Popper (32). From the point of view of bioethics and the philosophy of medicine, medical practice ought to be grounded in what, in modern parlance, is often referred to as “evidence-based medicine.” Furthermore, it is important to pay attention to the fact that if it is not scientifically correct medicine, it would be very difficult for it to become ethically correct medicine. The grandeur of medicine, the dignity of the human person and the importance of human health all demand that medical research and clinical practice should be carried out in a scientifically correct and ethically sound context. “Medical research is subject to ethical standards that promote and ensure respect for all human subjects and protect their health and rights” (World Medical Association, Article 7).

It is of utmost importance to pay attention to the ethical and scientific demands in research, medicine and clinical practice. In the light of the fact that the medical profession is not like other professions. This is not because other professions are not important but because of the grandeur of the integrity of life. Life is the foundation on which other achievements in human existence can be established. Medical research and clinical practice touch upon human life at critical moments and situations in which people could be healed, or people could be killed. Medical research and clinical practice touch upon human life in critical situations in human existence in which persons could be raised up or persons could be destroyed. In light of the grandeur of this responsibility, it is important for medical research and clinical practice to be scientifically correct and ethically sound. In light of the significance of human health and life, it is important to note that medical practice that is not scientifically correct, in accordance with the highest

existential standards of scientific knowledge, cannot claim to be ethically good. Unethical medical research that is morally bankrupt lacks the integrity to contribute towards the promotion of those goods that will lead to the advancement of human well-being and human flourishing in a meaningful way. *“Medical research involving human subjects must conform to generally accepted scientific principles, be based on a thorough knowledge of the scientific literature, other relevant sources of information, and adequate laboratory and, as appropriate, animal experimentation”* (World Medical Association, Article 21).

Medical research that is neither scientifically correct nor ethically good cannot work towards securing the fundamental goals at the heart of medical practice and health care, namely, the good of the patient and the flourishing of human life. In the balance of good over evil, good must always be done, and evil must be avoided. Beneficence ought to be at the heart of the medical establishment both in theoretical medicine and in clinical practice, and as such, should be the guiding moral principle in all dimensions of medical practice and health care. *“The Declaration of Geneva of the WMA binds the physician with the words, “The health of my patient will be my first consideration,” and the International Code of Medical Ethics Declare that, “A physician shall act in the patient’s best interest when providing medical care”* (World Medical Association, Article 3).

A careful examination of the Nigerian situation in the current context clearly reveals that the appropriation and the application of nanoscience and nanotechnology continue to develop exponentially and have garnered much interest, leading to innovations and investments. However, it is also important to indicate that the legislative framework is in abeyance. The legislative structures in the country have not developed efficiently vis-à-vis the demands and the challenges raised in the appropriation and application of nanoscience and nanotechnology, especially in the area of human health. There are great innovations in nanoscience and nanotechnology, and they continue to generate a lot of interest. In line with the current developments in nanoscience and nanotechnology, there is a need to promote authentic research for the good of human persons, human health, human society, the environment and the ecosystem. It is the affirmation of this work that in the current context of challenges in Nigeria with regard to the legislative framework, it would be appropriate to pay attention to the guidelines offered by the World Medical Association, WMA, especially with regard to research involving human subjects. The Declaration of Helsinki, by the World Medical Association, though addressed primarily to physicians, can also offer overarching ethical principles to guide others who are involved in medical research involving human subjects (World Medical Association, Article 2).

In the face of the innovations and challenges arising from the appropriation and application of nanoscience and nanotechnology to the field of human health, it is also the affirmation of this work that attention should be paid to the complex context of the contemporary world characterized by globalization and faced with multiple challenges. In this regard, it would be essential to pay attention to the demands of a more inclusive interdisciplinary methodology in research and practice, and it would be worthwhile to pay attention to the responsibilities arising from internationally acknowledged best

practices and the insights arising from the accumulated wealth of human knowledge and experience. There is also a need to pay attention to the insight offered by bioethics in relation to human life, human health, the life sciences, human wellbeing, human flourishing, the environment, and the ecosystem. There is a profound need to look at these challenges from the perspective of an inclusive, interdisciplinary methodology, paying attention to the demands arising from the dignity of the human person, beneficence in health care, justice in health care and the imperative of responsibility. The moral realm transcends the legislative realm because of the magnificence and the grandeur of moral freedom. Even in situations in which there may be legislative lacunae, the moral agent is still called upon to act in accordance with the imperative of moral responsibility, to do good and avoid evil. Again, even in situations in which laws have been enacted, it is still important to raise questions with regard to the moral validity of the laws, whether they are just laws, whether they are in accordance with the demands of right reason and whether they have been promulgated by the authority that is legitimate and whether they contribute towards the common good and the flourishing of justice (Aquinas, *Summa Theologica*, IaIIae, Q. 90, a 4). In the light of the grandeur of human freedom, the moral will and the rational intellect, the human person is called upon to act in accordance with the imperative of responsibility, in accordance with the right reason and the insights offered in the light of *phronesis*.

Innovations in nanoscience and nanotechnology, especially as applied in the context of human health and health care, also represent significant challenges before us. These challenges demand a methodology that is interdisciplinary. The interdisciplinary approach in bioethics and health care, in the creative interaction that takes into consideration the insights from science, technology, medicine, health care and ethics, would bring about greater promotion of human well-being and human flourishing. Research, investments, and innovations in the fields of nanoscience and nanotechnology continue to develop at a very rapid pace. There is a need to take into account the achievements, the prospects and the challenges in the application of nanoscience and nanotechnology to human health. The core issue would be to pay attention to the scientific concerns, the technological concerns in the application of nanotechnology, the environmental concerns, the health concerns and the ethical concerns. The examination of the challenges within the Nigerian context indicates that there is a need for further research and innovations in the areas of nanoscience, nanotechnology and human health. It is important that such research be carried out in a scientifically correct and morally responsible manner for the promotion of the good of human persons, human health, human society, the environment and the ecosystem.

Conflict of Interest Statement

The author declares no conflicts of interest.

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The author has a Doctorate in Moral Theology from the Accademia Alfonsiana, Lateran University, Rome and a PhD in Bioethics from the Catholic University of Sacred Heart, Faculty of Medicine and Surgery, Agostino Gemelli, Rome. Currently, he is an Associate Professor in the Department of Philosophy University of Uyo, Nigeria. His research interests include, Value Philosophy, Bioethics, Metaphysics Anthropology, Metaphilosophy, Logic and Philosophy of Science.

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