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Review Article

Nanomedicine and Drug Delivery Systems: Roles, Advantages and Disadvantages

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Abstract

Nanotechnology is a new and rapidly evolving subject in the pharmacological and therapeutic professions. Nanoparticles have many advantages as medication delivery systems, including increased efficacy and fewer adverse drug reactions. This study investigated the roles of nanomedicine and drug delivery systems in the pharmaceutical industry, as well as the advantages and disadvantages of nanotechnology. The study used a qualitative research technique, with online survey questionnaires sent to medical professionals and experts in the field of nanomedicine. These surveys comprised open-ended questions that enabled respondents to record their responses in whatever way they deemed fit. The ten respondents were from a variety of medical and health institutes, as well as medical consulting firms. In terms of results, the research established that nanomedicine had been used in medical care for therapy and diagnostic purposes. They are being explored in clinical trials for several reasons. Nanoparticles are used to treat renal disease, Tuberculosis, skin problems, Alzheimer's disease, and various types of cancer and to create COVID-19 vaccines. Further information about the study findings may be found in the results and discussion chapter.

Keywords: *Citrus Limon*, Aurantium, Medica, Phytochemical, Tannins, Flavonoids

INTRODUCTION

Nanomedicine and Nanotechnology are the construction of diverse functional systems on a microscopic level. These systems have unique physical, electronic, and photonic properties that make them intriguing in a wide range of fields, from materials research to Biology. Among the most widely recognized areas of nanotechnology, the study is nanomedicine. It employs nanotechnology to provide highly tailored pharmaceutical treatments for disease diagnosis, prevention, and therapy. There has been a surge in nanomedicine research over the past several generations, which is now being translated into commercialization operations throughout the globe, resulting in the selling of various products. Drug delivery systems currently account for more than 75% of overall sales in nanomedicine. Nanoparticles range in size from 10 to 1000 nm. The active pharmaceutical ingredient (API) is encapsulated, encased, hydrolyzed, or connected to the nanoparticle matrix. By changing the manufacturing procedure, nanoparticles may be created. Nanoparticles are effective mucoadhesive

drug delivery vehicles. There are several applications for nanoparticulate drug delivery systems, such as gene therapy, treatment for cancer, AIDS treatments, and radiotherapy. It can also carry proteins, medicines, and vaccines and act as vesicles to pass the blood-brain barrier. The primary goals of nanoparticle development as a delivery system are to manage particle size, surface characteristics, drug transport, and API release such that site-targeted pharmacological activity is achieved at an acceptable therapeutic rate and dosage schedule. In this study, researchers will look at the benefits of nanoparticles as drug delivery systems and the associated drawbacks.

Research Question, Variables, and Hypothesis

- **RQ1:** What functions do nanomedicine and drug delivery systems play in the pharmaceutical sector?
- Independent variable: Nanomedicine.
- **Dependent variable:** Roles of nanomedicine and drug delivery systems.
- **RQ2:** What advantages and disadvantages does Nanotechnology have?
- **Independent Variable:** Advantages and disadvantages.

Dependent variable: nanotechnology

Research Aims and Objectives

The present research had two aims and objectives. The first was to identify the roles played by nanomedicine and drug delivery systems in the pharmaceutical industry. While the second was to identify the possible advantages and disadvantages that the application of nanotechnology may bring. This way, this research provides insights to future researchers, students, and professionals within the medical field with a reference document in matters of nanomedicine.

Literature Review

Kadhum et al. (2017) researched to develop techniques for creating and improving oral and topical LC compositions by assessing their absorption and distribution efficacy in vitro and in vivo. Liquid crystal (LC)-forming lipids are a kind of biocompatible amphiphile with applications in nutraceuticals, nutritional, and pharmacological sciences. As an LC-forming lipid, C17-Monoglycerol Ester (MGE) was employed. As drug models with distinct physiochemical characteristics, p-amino benzoic acid, ethyl PABA, methyl PABA, and sodium photosensitizer were chosen. Following changes in the LC forming lipid amounts in the compositions and encapsulated with diverse physiochemical characteristics of the medicines, several oral and topical LC combinations were produced. The research used small-angle X-ray scattering to examine the LC phase structures (SAXS). A porous hydrophobic approach was used to determine the drug-release characteristics of LC compositions. Wistar rats were used to test the oral bioavailability of LC preparations in vivo. In vitro, skin permeation tests were also performed to study the skin permeability of medicines from LC formulations.

As a consequence, Kadhum et al. (2017) established that although variations in MGE percentage impacted the dissolution profile, variations in the physiochemical characteristics of the entrapped medicines altered it more strongly. The concentration of MGE significantly impacted drug absorption following oral and topical treatment of LC formulations. The concentration of LC-forming lipids and the physiochemical characteristics of entrapped medicines are critical factors in LC formulation efficacy in various pharmaceutical applications. The current findings may allow researchers to adjust LC formulation procedures to optimize medication oral bioavailability and skin penetration.

Sahu et al. (2021) examine the significance of nanoscience in other domains of medicine using various nanotechnology frameworks. In addition, researchers were looking at the potential applications of nanotechnology in people's health. They contend that nanotechnology or nanomedicine has emerged as the dominant and most professionally developed technology that aims to enhance the effectiveness of healthcare systems. Despite significant restrictions, numerous pharmaceutical and medical equipment businesses have already used therapeutic nanotechnology. Nanotechnology can improve the safety profile of medications with high hazardous potential, such as conventional cancer treatments. Living cells are microscopic virtual machines that participate in all biological operations, such as cell signaling, respiration, energy production, and nutrient delivery. As a result, Sahu et al. (2021) believe that nanotechnology is a promising candidate technology for dealing with biology and medicine for medicinal reasons.

Verma et al. (2022) focus on biological factors and process characteristics. Furthermore, the mechanism of absorption from the GI is explained in depth. Because of the tiny size and targeting characteristics of drug delivery vectors, nanomaterials have drawn researchers from all over the world. From a formulator's perspective, demand for self-nano-emulsifying drug delivery systems (SNEDDS) has increased exponentially. SNEDDS have shown broad usefulness in terms of regulated and targeted medication delivery. They are chemically composed of oil, detergents, and co-surfactants that reduce the emulsion size of the particles to 100 nm. Nonetheless, stability difficulties like medication precipitation during preservation and incompatibilities of constituents in shell limit their long-term utilization, as addressed in this research. SNEDDS have been used to treat various disorders, including cancer, hypertension, and ophthalmic and pulmonary ailments.

Methodology

This research applied the qualitative research design. It used online survey questionnaires shared with medical experts in nanomedicine and drug delivery systems. For this research, the questions were open-ended. Therefore the participants had the opportunity to type and share their responses in the way they deemed fit. The first question sought to answer the first research question concerning the role or application of nanomedicine and drug delivery systems in the pharmaceutical industry. The second question sought to identify nanotechnology's advantages and disadvantages. The findings were recorded, and discussions are discussed in the findings and discussion chapter.

Findings and Discussion

Application of Nanomedicine Pharmaceutical Industry

The first application was Nanomedicine's use in treating renal disorders. One participant noted that "nanoparticles are used to treat renal diseases in urology and nephrology." Ferumoxytol has been incorporated into nanoparticles for treating patients with renal impairment or end-stage kidney problems who lack erythropoietin. PEGylated gold nanoparticles may also address the mesangium—contractile lymphocytes that comprise the center stalk of the kidney's glomerulus—due to the development of various illnesses from this location. Rhein, naphthoquinone derivatives used to treat diabetic nephropathy, has shown a rise in dissemination and therapeutic effect due to nanoparticle nanotechnology. The second application was using Nanoparticles in the chemotherapeutic treatment of Tuberculosis. The enhanced effectiveness of anti-TB nanoparticles was attributed to their altered dependent variable after oral treatment.

The third use was the topical medication delivery of Nanoparticles for skin

disorders. PNPs are the most often employed nanoparticles for drug delivery via the skin. One of the participants noted that " PNPs derived from alginate and chitosan are employed to treat the symptoms, and they demonstrated better antibacterial activity against Propionibacterium acnes when contrasted to benzoyl peroxide only." Electro-spun fiber mats, in complement to polymeric nanoparticles, offer a high surface energy ratio, which aids in the efficient distribution of hydrophilic and hydrophobic drugs and makes them excellent for drug delivery. Nanoparticles are also employed in medicine targeting infectious disorders. Nanoparticles' physical and biological features are employed to treat several infectious diseases. Another participant noted that "the usage of a treatment carried on a nano-vector has increased the drug's effectiveness against infectious diseases." Because of its improved pharmacokinetic and toxic properties, polyethylene glycol-modified nanomaterials are the most often used non-viral delivery method. These are effective bioactive chemical carriers in the administration of certain medications for the treatment of infectious disorders.

Furthermore, nanoparticles are being used to treat Alzheimer's disease. One of the most recent techniques for enhancing CNS accessibility for detecting and treating neurological illnesses such as Alzheimer's disease is nanotechnology injections. As noted by one of the participants, " PNPs are some of the most promising nanoparticle applicants because, in addition to their capacity to access the barrier function of the Blood Brain Barrier by they efficaciously disguise the epithelial barrier restricting caricatures of the therapeutic agent, prolonging drug release, and defending drugs from enzyme hydrolysis. Furthermore, nanoparticles contain various anticancer drugs. Nano-oncology is a new branch of medicine that uses nanotechnology to treat cancer. The application of nanoparticles as medicine increases cancer cell selectivity and eliminates resistance mechanisms in malignant cells. Because of its biomedical applications and long-term drug release, PLGA is a frequently used polymer for manufacturing nanomaterials. It has been applied to manufacture drug-loaded nanoparticles for cancer treatment. Anticancer medicines such as doxorubicin, paclitaxel, 5-fluorouracil, and dexamethasone have been manufactured using PLGA.

The last use is the use of nanomedicine is in COVID-19 immunization. From 2020 until now, all researchers and experts have been focusing on developing treatments to counteract the global spread of the COVID-19 virus. The significance of nanoparticle technology in creating pharmaceutical formulations for diagnosing, managing, and enhancing considerable and growing immunity towards COVID-19 was emphasized in the year 2021. The Food and Drug Administration (FDA) authorized an excellent potential vaccine based on nanotechnology that demonstrated its significant importance in prophylaxis against COVID-19 virus with a significant proportion of 90% of the immunized inhabitants within and between various vaccines manufactured with good efficacy to combat and prevent the transmission of the COVID-19 disease outbreak around the globe.

Advantages and Disadvantages of Nanotechnology

While many believe that nanotechnology is the future of technology and that it will benefit everyone who uses it, nothing is ever flawless. There are going to be advantages and disadvantages to everything. The benefits and drawbacks of nanotechnology are readily stated, and here are a few of them:

Advantages of Nanotechnology

Nanotechnology is regarded favorably in the medical field since it may aid in

developing innovative medications. These help individuals get well quicker and with fewer adverse effects than standard medications. One of the participants noted that "nanotechnology development in medicine is now concentrating on topics like tissue repair, bone repair, immunology, and even treatments for diseases such as cancer, insulin, and other life-threatening disorders." Furthermore, nanotechnology has the potential to change a wide range of electronic goods, techniques, and purposes. Nano semiconductors, nano semiconductors, OLED, liquid crystal displays, supercomputers, and numerous other electrical goods benefited from the ongoing advancement of nanotechnology. The energy industry may also profit from nanotechnology. This technique creates more effective electricity, power generation, and energy-storage goods in smaller and more productive systems.

Disadvantages of Nanotechnology

The advancement of nanotechnology may cause the value of oil and gemstones to fall, owing to the prospect of creating alternative sources of electricity that are more economical and do not need the combustion of fossil fuels. This might also imply that since individuals can now build goods at the cellular scale, diamonds would lose value because they can now be manufactured overseas. Also, atomic weapons may be made more readily available, destructive, and devastating. Nanotechnology has the potential to make these more accessible. one of the participants established that "because these particles are so tiny, breathing them may cause issues, similar to how inhaling microscopic asbestos nanoparticles can cause real problems." Nanotechnology is now exceedingly expensive, and creating it may be pretty costly. It is also challenging to produce, partly because nanotechnology-based goods are more costly.

Conclusion

According to the conclusions of this study, nanomedicine and drug delivery systems play an essential role in the pharmaceutical sector. It may be used to treat renal issues, and it is also used in the current Covid-19 immunization treatments. The technique is also essential in the treatment of cancers and other disorders. However, there are potential risks linked with nanomedicine and nanotechnology in general. The advancement of nanotechnology may result in the value of gasoline and diamonds falling, owing to the prospect of creating alternative energy sources that are more effective and do not need the combustion of fossil fuels. Eventually, atomic weapons may become more readily available and more potent and devastating. Therefore, as much as nanomedicine, nanotechnology, and drug delivery system may be beneficial, great care is paramount to ensure that their application is for good purposes

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