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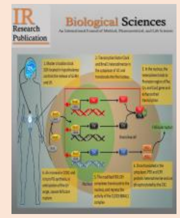

Implementation of nanotechnology in healthcare: immense challenges and opportunities

Ayush Chandra Mishra[1]*, Ratnesh Chaubey[1], Shobhit Prakash Srivastava[1]

[1]*Dr. M.C. Saxena College of Pharmacy, IIM Road, Lucknow*

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ABSTRACT

Healthcare, being a fundamental human right, has frequently been the focus of technological innovation. Technological advancements have aided in the delivery of high-quality, on-time, acceptable, and cheap healthcare. A new generation of nanostructures has emerged as a result of advances in nanoscience. Each one has its own set of characteristics that account for its amazing applicability. Nanotechnology has had a continual impact on healthcare since its birth and has had a significant impact on its evolution, contributing to better outcomes. Nanotechnology's application in healthcare is pushing the life sciences sector to new heights. Nanotechnology has the potential to improve many parts of medical care, including diagnostics, disease monitoring, surgical equipment, regenerative medicine, vaccine development, and medication delivery, thanks to its capacity to alter matter at the atomic level. Advanced research tools that can be used for drug discovery are also opening doors to better treatment options for various diseases. Nanotechnology has made strides toward omnipresence over the previous two decades, and this trend has been hastened by substantial studies in several healthcare industries. Nanomedicine is the application of nanotechnology and its associated nanocarriers/nanosystems to medicine, a field that has yielded several improvements in illness prevention, diagnosis, and therapy. In comparison to traditional nanosystems, some nanosystems have been discovered to be better prospects for theragnostic applications. This review paper will discuss medically significant nanosystems, as well as their applications and limits in fields like gene therapy, targeted medication delivery, and cancer and genetic disease treatment.

**Address for correspondence*
Dr MC Saxena College of Pharmacy, IIM Road, Lucknow, Uttar Pradesh India.
Email: ayushmishraofficial7@gmail.com

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Introduction

Nanotechnologies are emerging fields of study that aim to influence matter at the atomic and molecular levels. Nanomedicine has become one of the most important disciplines of nanotechnological study since it is undeniably beneficial to current medicine. It is now concentrating on the development of novel

Abbreviations: *NPs- Nanoparticles; CNTs- Carbon Nanotubes; PAN I- Polyaniline-1; BMIM BF4- 1-Butyl-3-methylimidazolium tetrafluoroborate; SPIO- Superparamagnetic Iron Oxide; TNP-470- O-(chloroacetylcarbamoyl) fumagillol; GBM- Glomerular Basement Membrane; GEC; Glomerular Epithelial Cell; SERM NP System- Surface-enhanced Raman spectroscopy NanaPartticle*

technologies for preventing, diagnosing, and treating a variety of ailments. Nanomaterials have shown to be particularly effective in killing tumor cells and are currently being tested in clinical studies. The findings are so intriguing that nanoparticles may become a suitable alternative cancer therapy, owing to their ability to target cancer cells directly and provide thorough visualization of tissue, rendering treatment planning much easier [1]. Nanoscience may also be a supply of the required breakthrough within the fight against atherosclerosis since nanostructures could also be utilized in each preventing and increasing the steadiness of arterial sclerosis lesions. One space of interest is making nanomaterials that aren't solely efficient, but also well tolerated by the human body. different potential applications of applied science in drugs include nano adjuvants with immunomodulatory properties accustomed deliver immunizing agent antigens; the nano-knife, a nearly non-invasive technique of destroying cancer cells with high voltage electricity; and carbon nanotubes, which are already a preferred means of repairing broken tissues and could be used to regenerate nerves within the future [2]. The terminology "nanobiotechnology" was developed lately to describe the mixing of cell genetics with nanotechnology. It is a scientific discipline concerned with nanoscale structures or biomaterials that are created using both physiochemical approaches. Nanotechnology has been a critical field of research over the last thirty years, thanks to nanomaterials' unique chemical, electrical, optical, biological, and magnetic capabilities [3]. Nanotech has attracted a lot of interest since it is well known that when nanoparticles and biotechnology come together, they create a platform with enormous potential and relevance following the planned diversification. Healthcare scanning, diagnostic tests, biochemical sensors, and dentistry are all examples of medical imaging. Among the applications include sterilization of medical equipment surfaces, skin care products, beauty products, exercise equipment, fabrics, environmental remediation, and gene inactivation [4].

The progress of nanoscience has provided us with a few astonishing devices that enable us to demarcate operations to levels previously considered to be impossible to achieve [5]. Traditional techniques have significant constraints, including high raw materials costs, drug waste, chemical and physical incompatibilities, clinical medication interactions, and the incidence of dose-related adverse effects. Liposomes, for example, are nanosystems that can be several micrometers in size. As this subject progresses day and night, the definition and categorization of NPs are constantly changing based on research and experimental knowledge on nanoparticles and nanotechnology from the US National Nanotechnology Initiative and the European Commission, the authors indicate it is vital to emphasize that the maximum size limit of NPs cannot be confined to 100 nm [7].

To exploit their characteristics, many types of nanoparticles (NPs) have been created, including metal, metal oxide, semiconductor, organic, and inorganic NPs. They can be created using a variety of methods, including traditional chemical manufacture and green synthesis. Chemically generated NPs are problematic because of their toxicity, expense, and efficiency. Bio-inspired NPs have an advantage over conventionally generated NPs due to their simplicity of manufacture, low cost, and low toxicity [6].

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In reality, certain commercial nanomedicine products, such as Abraxane (130 nm) and Myocet, are larger than 100 nm (180 nm). As a result, we can only limit or specify the spectrum of nanomaterials based on their diameters. Because of their incredibly small sizes, NPs and nanodevices can have unique properties and functions. It's also worth noting that NPs' small size gives them another, maybe more critical, advantage: they have a very high surface-area-to-volume ratio. This may seem little, but it makes them more reliable and reproducible [8].

Invitation activity, chemical inertness, heat transmission, and nonlinear absorption efficiency have seemed to be increased. Various NPs may be made into nanosystems by changing their shape, surface properties, and size, allowing them to be utilized for critical disease imaging, diagnosis, and therapy. By delivering drugs to specific areas or tissues, these functionalized nanoparticles can provide controlled-release therapy. To improve and promote tissue and cell interaction, several characteristics, such as energy, size and shape, the pattern of nanoscale medicinal compounds, and form, must be managed and explored [9].

The creation of novel nanomaterials for the detection, monitoring, and therapy of a wide variety of ailments, including cancer, cardiac, ophthalmology, and central nervous system ailments, has been made possible by nanotechnology goods.

Advantages of nanotechnology in the healthcare system in the recent scenario

The dependence of different pathophysiological conditions and anatomical changes occurred due to the diseased or inflamed tissue, which ultimately leads to develop a new approach toward the nanotechnology targeted products. This modern approach to the drug has the following advantages in the modern scenario-

- Targeting of the drug at distinct pathophysiological features of diseased tissue can be achieved with the help of nanotechnological techniques.
- The drug delivery is more convenient and is more amount than traditional drug delivery.
- Improve the efficacy of medications on tumor cells or inflammatory tissues through improved transmission and drug retention by using nanotechnology to promote vascular permeability in combination with reduced lymphatic outflow in tumor cells [10].

Nanosystems are used in a variety of healthcare fields

Nowadays medicines can be encapsulated in nanoparticles. Because nanoparticles can accurately locate damaged cells and deliver medicine to them, they are useful for drug delivery—the transfer of medicine to the body at targeted specific sites. This indicates that a lower dosage will suffice, resulting in fewer negative effects. Furthermore, nanoscience and nanotechnological technologies are accelerating the creation of more advanced instruments for the early detection and treatment of illnesses such as cancer and atherosclerosis, as well as neurosurgery. Nanotechnology's applications in illness diagnosis are fast evolving. Because of their distinctive physical size features, these elements are exceptional and essential in a wide range of human activities [11].

Nanotechnology revolves around the few common nanostructures, regardless of the subject or application. Nanoparticles, carbon nanotubes, dendrimers, nanoprobes, quantum dots, nano-diamonds, and nanowires are just a few examples. Nanoparticles have special properties, and their incredibly tiny size allows them to readily pass-through minuscule holes and membranes. Metal, lipid, ceramic, polymeric, and semi-conductor nanoparticles are among the five types of nanoparticles. Metal precursors are used to create metal NPs. These, in particular, exhibit special optoelectrical characteristics [12].

Carbon nanotubes (CNTs) are nanoscale tubes constructed of seamless graphite sheets. They have fullerene caps that seal the open terminal sections, they possess the greatest wear resistance of any natural substances. They are excellent magnetic irradiation absorbents, as well as having good heat conduction and catalyzed properties. Their qualities are influenced by their homogeneity, size and distribution, unique interfacial area, and carbon nanofibers. Carbon nanotubes are cylindrical-shaped fullerene nanotubes that belong to the heterocyclic nanotube family. Carbon nanotubes are also used to make buckyballs, which are circular and elongated. CNTs are widely employed in today's healthcare systems because they can overcome previously insurmountable challenges [13]. CNTs may easily permeate partly permeable cell membranes, according to an unknown mechanism. They can transport tiny organic medicines, proteins, peptides, nucleic acids, antibiotics, and other substances to specific sites. With these small molecules, CNTs can be chemically attached, trapped, or enclosed. They may transport proteins with molecular weights less than 80 kDa that is conjugated or quasi-bound. Endocytosis is the process by which cells absorb these substances. CNTs can also be used in X-ray imaging [14].

Green synthesis of CNTs

The synthesized CNTs were distributed in an aqueous acidic media with the oxidant, KPS after the aniline monomer was dissolved in [bmim] [BF4]. A water/IL interface was formed by carefully spreading the water layer across an equivalent amount of IL. Green PANI developed at the contact after about 1 minute and eventually moved to the aqueous phase. Finally, the whole water phase was filled with a dark-green CNT/PAN I composite, whereas the IL phase was red-orange in hue, probably due to aniline oligomer production. The mixture was gathered and cleansed [15].

Dendrimers are new polymeric structures that have specified topologies, are versatile in drug administration, and have high functionality. Their features are similar to those of biomolecules. These nanomaterial molecules have shown their potential abilities in encasing and/or conjugating large molecules of water-loving compounds through host contacts and covalent bonding (prodrug technique). Furthermore, because of the high surface group to molecular volume ratio, Nanoparticles are a potential gene delivery artificial carrier. Dendrimers have attracted researchers in the creation of novel drug carriers due to their features, and they have been implicated in a variety of medicinal and biological applications. Considering their wide range of uses, their usage in biological systems is restricted due to toxicity concerns. Therefore, the current review has focused on different strategies of synthesis, drug delivery and targeting, gene delivery and other biomedical applications, and the interactions involved in the formation of complexes and other biomedical applications. drug-drug combinations, as well as the characterization techniques used to evaluate, their toxicity issues, and related approaches to minimizing their inherent toxicity [16].

Liposomes are circular vesicles with one or more lipid bilayers sandwiched between them and an aqueous compartment They come in various breadths, ascending from little as a few nautical miles and going up to many micrometers. They may entrap a variety of compounds, including hydrophilic and lipophilic molecules. As a result, they are also regarded as the most effective medication delivery mechanism. The different rationale of these particles is that their constituting particle is remarkably identical to that of the human phospholipid layer (membrane), which aids drug transport in vitro. Their huge size also allows them to transport a large number of medicines [17].

Green Synthesis of Liposomes- The advanced system uses liposomes as nanoreactors, where the liposomes were prepared by recapitulating chloroauric acid and exploited the use of glycerol, incorporated within the lipid bilayer as well as in its hydrophilic core, as a reducing agent for the controlled medication of largely homogeneous populations of gold nanoparticles. The goods of temperature, the presence of a circumscribing agent, and the attention of glycerol on the size and unity of the nanoparticles formed were developed and compared with the result- grounded glycerol-intermediated nanoparticle conflation. Well-distributed gold nanoparticle populations in the range of 2 – 8 nm were prepared in the designed liposomal nanoreactor with clear dependence of the size on the attention of glycerol, the temperature, and the presence of a circumscribing agent whereas large, miscellaneous populations of nanoparticles with unformed shapes were attained in the absence of liposomes [18]

The solubility and stability of natural pharmaceutical compounds can be enhanced by niosomes (the nonionic surfactant vesicles), which are regarded as innovative drug delivery platforms. They were created to give natural medicinal substances with targeted and controlled release. Numerous variables, including the technique of manufacture, the kind and quantity of surfactant, drug entrapment, the temperature of lipid hydration, and the packing factor, might affect the creation of niosomes [19].

Quantum dots are nanostructures that range in size from 1.5 to 10 nanometers. They can carry electrons because of their semiconductor nature. When UV light travels across QDs, the particles become stimulated, and when they return to lower energy, they generate light. Depending on their size, QDs produce light of various hues. Heavy metal-based QDs, such as cadmium, are exceedingly dangerous and cytotoxic, hence they cannot be extensively used in the medical field. Graphene and carbon QDs, on either side, are extremely secure and reliable and have a broad spectrum of pharmacological applications [20, 21]. The uses of nanosystems in the different biomedical fields are illustrated in Figure 1.

Implementation of nanotechnology in the field of healthcare

Application of nanotechnology in gene therapy

Viral vectors and nucleic acids can both be complexed with nanoparticles. Before combining them with the magnetic particles, magnetic vector production involves the regular synthesis of the gene vectors. A combination of nanomaterials and a vector for biological applications must be built, according to the bulk of published studies. In the case of DNA, polymers can act as a bridge between particles and nucleic acid. SPIOs are iron oxide nanoparticles that have been bound to DNA and coated with transfection agents like polyethyleneimine (PEI). When the mix is performed in a permanent or pulsating magnetic field as opposed to usual conditions, immunoprecipitation capability increases 40-fold. This technique allows for enhanced Immunoprecipitation levels with a minimal quantity of DNA, offering up innovative, efficacious blend vector choices while avoiding the negative impacts of their integration [22]

In the case of viruses, several researchers have addressed the advantage of the powerful biotin-

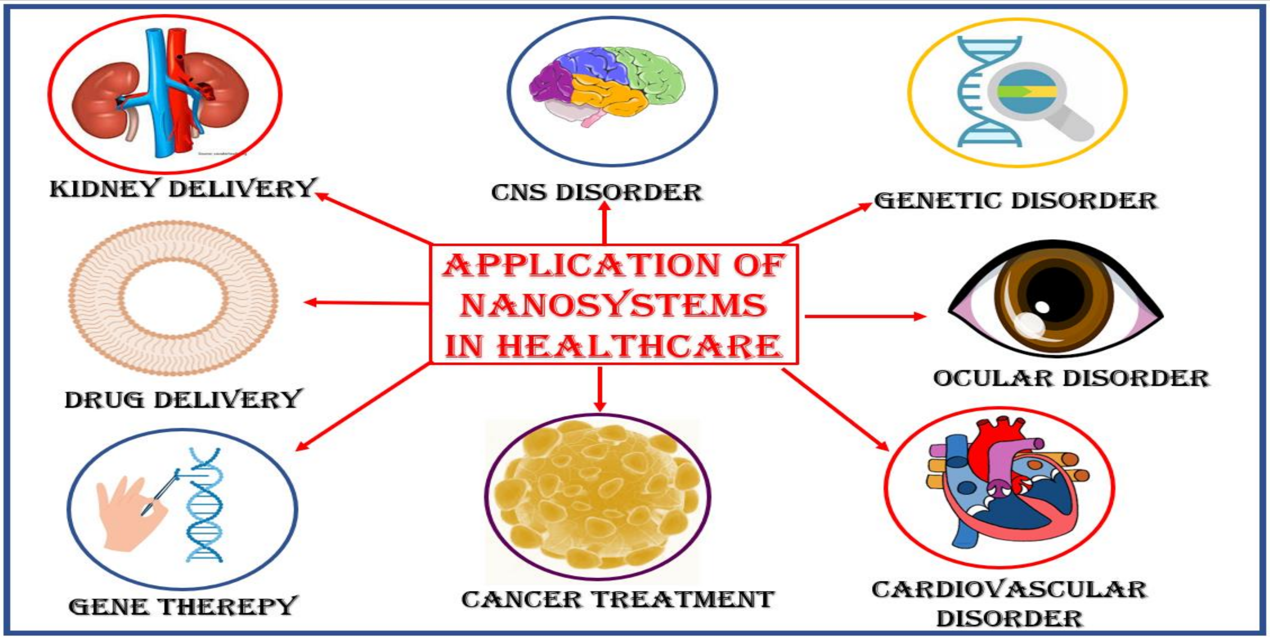

Figure 1. Applications of diverse nanosystems in allied healthcare fields are represented in the diagram.

streptavidin interaction. Retroviral and lentiviral carriers can be made using newly developed membrane protein with a biotin motif. When this novel protein is combined with streptavidin nanoparticles, a stable combination may be extracted. Magnetofection has been proven in several investigations to improve the transduction effectiveness of adenoviruses and retroviruses. In the existence of a magnetic field, the transmission of lentiviral vectors is particularly improved when mixed with magnetite nanoparticles [23]. Magnetic infection can increase the transmission efficiency of the measles virus, a paramyxovirus, by 30-70-fold in pleasant and terrible receptor cells. Both substances may have a direct relationship The combination of an adequate percentage of polyelectrolyte-coated magnetic nanoparticles and gene vectors in a salt-containing media might be enough to establish the connection via salt-induced colloid aggregation. The freshly created "magnetic vectors" are applied to the cells on magnetic culture plates after a brief incubation time. These plates are available commercially or may be constructed at the residence site using normal bacterial colony growth plates and powerful Nd-Fe-B magnets [24].

Application of nanotechnology-based nano vectors in drug delivery

Nano vectors have great potential for the targeted delivery of medicine to specific sites in the treatment of numerous diseases. Particularly if the solvents in the hydrophobic medications are dangerous, targeted drug administration is essential. If these solvents are ejected somewhere other than the target cell, they may contaminate the bloodstream or other body fluids. Drugs can be released under regulated conditions in time-released dosages because of nanostructures. Drug dosages are also reduced when drugs are administered in a targeted and localized manner. NPs are useful in boosting cancer therapy because of their small size, which allows them to penetrate deeply into tumor cells [25].

NPs used for drug delivery must have a nanoparticle center, an outer biodegradable insulating coating, and a linking molecule for better bioactivity. It connects the core of NPs to bioactive molecules due to the obvious responsive active compounds at both ends. Nano vectors are modified before drug delivery, including covering with compounds like proteins, folate, and monoclonal antibody [26]. Ligands are linked to NPs so that they may bind to particular locations, increasing specificity even further.

It is necessary to connect more than one ligand because if just one ligand is attached, it may bind to receptors located in locations other than the targeted site. Furthermore, tumor cells frequently overexpress, meaning they contain many types of surface receptors. Because nano vectors have unique features and can undergo numerous alterations during drug loading, scientists are currently focusing on developing nanotechnology-based nanosystems for effective targeted drug delivery [27].

Table 1. Various nanocarrier with their application

Nanocarrier	**Application**	**Reference**
Carbon nanotubes	Used to deliver paclitaxel to the targeted site for treatment of tumors	[28]
	Used to target drug delivery of acetylcholine in Alzheimer's disease patients	[29]
Dendrimers	Used in oral therapy of hepatic colorectal cancer metastases	[30]
Liposomes	Used for treatment of cancer for targeted drug delivery	[31]
	Liposomes encapsulated idoxuridine used in the treatment of herpes simplex infected corneal lesions	[32]
	Delivery of aerosolized cisplatin drug to pulmonary circulation to prevent lung cancer	[33]
Niosomes	Oral administration of rh-insulin	[34]
	Beclomethasone dipropionate as niosomes-based polysorbate 20 was used for the treatment of prolonged obstructive pulmonary disease.	[35]
	Used in treatment of cancer	[36]
	Used in treatment of Parkinson's disease	[37]
Quantum Dots	Targeted doxorubicin drug delivery nanosystems for treatment of lung cancer	[38]
	Delivery of 5-fluorouracil for cancer treatment	[39]

Application of nanosystems in cardiovascular disease treatment

Liposomes are lipid vesicles with a cell-like structure generated by an organized phospholipid bilayer. As drug carriers, liposomes provide a lot of benefits, including non-toxicity, non-immunogenicity, prolonged medications, altering drug distribution in vivo, improving medication treatment index, minimizing drug side effects, and so on. Liposomes are easy to create and employ for enclosing polar and ionic chemicals, and they also work with nonpolar medicines [40]. Hydrophobic drugs may be enclosed in the bimolecular structure of phospholipids, whereas hydrophilic pharmaceuticals, especially those containing genes, can be attached to the hydrophilic region of liposomes. The size of the nanoparticles, their capacity, and surface chemistry may all be changed by modifying different lipid materials. Because electrostatic lipid bilayers are positively charged, they may elicit daily dosage cytotoxic and inflammatory reactions, but they may form a complex with negatively charged plasma protein. Two approaches to solving the difficulties include neutral lipids and pH-sensitive liposomes [41].

Hypertension is a condition that can cause a variety of issues, such as myocardial infarction, heart failure, stroke, high blood pressure, and damage to various bodily organs, such as the eyes, kidneys, and brain. Many antihypertensive medicines have been tried to treat this, but they have several disadvantages, along with a half-life, limited absorption, low aqueous solubility, unfavorable adverse effects, and much more [42]. To indicate such issues, targeted medicine delivery employing nanosystems has proven to be beneficial. Lipid carrier NPs, solid lipid NPs, polymeric NPs, liposomes, and nanoemulsions are a few of the nanomaterials that have been used to treat high blood pressure These are just a few examples, but nanotechnology-based nonviral stem cell therapies can heal a wide spectrum of cardiovascular diseases. Before nanovectors can be utilized effectively in people, more research into their effect on the cardiovascular system of a live animal is required. They are also used in the treatment of multiple sclerosis disease [43].

Application in treatment of ocular disease

Eye drops are the most accessible and frequent preparations for the treatment of numerous ophthalmic anterior problems such as corneal injury, keratitis, corneal scarring, conjunctivitis, and cataract. This route of administration, however, has restricted uptake because of the corneal barrier and pre-corneal factors. Eye drops have been found in both experimental and clinical studies to cause tear film instability, corneal surface degradation, and cornea and conjunctiva inflammation. On the other hand, significant effort is being put into extending medication retention duration on the ocular surface and enhancing drug penetration. Nanosystems are becoming an increasingly important aspect of this strategy. Some typical nanosystems for ocular anterior disease application have been created during the last few decades [44].

In a rabbit surgical trauma model, flurbiprofen-loaded nanoparticles with a uniform size of around 100 nm suppressed the miotic response at a lower dosage than commercial eye drops. This activity was responsible for the increased release of medications from nanostructures and eventual absorption into the aqueous humor. The usefulness of colloidal nanocarriers in enhancing the pharmacokinetics of ocular drugs like flurbiprofen is demonstrated by this study [45].

Application of nanotechnology in cancer treatment

A variety of cancer-targeting ligands, including growth factors or folate, cytokines, and antibodies, have been utilized to facilitate the entry of vehicles into target cells. Caplostatin (TNP-470) was discovered to aggregate preferentially in tumor vasculature, as well as prevent the hyper-permeability of malignant blood arteries, due to its heightened permeability and retention properties. NP-conjugated chemotherapeutic drugs, such as angiogenic minute molecule inhibitor and doxorubicin, can penetrate cancer cells via the EPR effect, inducing growth suppression and vascular shutdown. Oligonucleotides are significant because they improve imaging and target cancer cells. In addition, linking them to metallic NPs, such as quantum dots and magnetic, ruby-eye doped, and gold nanoparticles, boosts their associated vasculature. A novel SERS NP system was recently created for the direct visualization of circulating tumor cells in blood [46].

Application of nanotechnology in cancer cell imaging

Nanoparticles, nanocantilevers, NP probes, and nanowire arrays are expected to eliminate barriers in initial cancer diagnosis. Without the use of radioactive labeling or extrinsic fluorescent dyes, micro-cantilevers were used to identify single nucleotide polymorphisms in a decamer DNA target oligo-nucleotide. Biomarkers linked with the tumor microenvironment, as well as the distribution, presence, and relative abundance of cancer signatures, have been discovered using probes with molecularly targeted recognition agents. The capacity of nanoprobe devices that rely on fluorophore to detect DNA modifications in tumor cells in clinical specimens, as well as DNA loss, has been demonstrated. In the early stages of cancer, carbon nanotubes have been developed to determine the activity of typical biological components [47].

Nanotechnology in CNS disorder treatment

Interestingly, NPs have also been utilized to treat other serious neurological traumas, including post-stroke neuroprotection and spinal cord injuries, as well as genetic and neurodegenerative diseases. Although these two fields appear to be highly complex, research has indicated that nanotechnology can help in the treatment of these major diseases over time. Another significant problem is the regeneration or repair of the central nervous system. Because injured axons cannot renew and regrow, this is a common issue. Extrinsic inhibitory molecules, as well as an age-related decrease in intrinsic regenerative ability, are among the reasons that prevent these axons from regenerating. Researchers are currently focusing their efforts on finding new strategies to block the function of substances that limit the development and regeneration of injured axons and brain cells [48]. Nanotechnology has been discovered to be a very effective perspective technique for treating central nervous system problems in this area. Traditional medications, which have grown unpopular owing to problems connected with them, are used to treat spinal cord injury. When these medications were given systematically, they were shown to be ineffective as they were swiftly assimilated and subsequently removed from the circulation before hitting the required The objective now is to fine-tune chemicals such that their bioavailability improves. For this, adenosine was combined with the lipid squalene to form nano-assemblies. The neurologic impairment score improved, and fine-motor restoration of the hind limbs was seen, showing the treatment's effectiveness [49].

Nanotechnology in Kidney disorder treatment

Targeted treatment in the renal system can improve therapeutic effectiveness while also reducing side effects. The glomerulus and tubules make up the nephron, which is the functional unit of the kidney. The glomerulus is made up of blood capillary tufts and is located in the kidney. The mesangium houses the glomerular filtration barrier compartments (glomerular filtration barrier compartments). Endothelial cells (GECs), glomerular basement membrane (GBM), and podocytes) are three types of cells that make up the glomerular basement membrane (GBM) The filamentous form of GECs prevents plasma components from entering the cell [50].

Endothelial cell membranes. Components such as collagen IV, nidogen, and others are found in the following layer. A tick connective tissue membrane is formed by laminin and proteoglycanFiltration slits are created by podocyte’s interdigitating processes. The most common techniques in kidney-targeted drug delivery systems have been prodrugs, macromolecular carriers, and nanoparticles. As a selective renal targeting mechanism, the action of renal enzymes leads to the release of the active form of prodrugs. As macromolecular carriers of kidney-targeted treatment, several peptides, proteins, viruses, and antibodies have been used. Furthermore, nanomaterials have shown tremendous promise in this regard [51].

Current scenario and trends in clinical translation of nanomedicine

Nanoparticle nanomedicines are often investigated to lessen localization in healthy non-target tissues and/or enhance therapeutic targeting to specific disease locations (i.e., site-specific drug delivery). The great majority of Nanoparticle nanomedicines are being developed for a range of malignancies and tumors, both in preclinical and clinical settings. In recent years, there has been a surge in the use of nanoparticle nanomedicine-based therapeutics for medication targeting non-cancer illnesses. By using the underlying biology of these illnesses, nanoparticle nanomedicines have been created in particular to address the therapeutic problem of effectively controlling inflammatory diseases. Rheumatoid arthritis, inflammatory bowel disease, asthma, multiple sclerosis, diabetes, and other non-cancerous inflammatory disorders have all been studied with nanoparticle nanomedicine treatment

Future perspective

The visions discussed in this article could seem improbable, ridiculous, or even heretical. However, theoretical and practical research to make them a reality is advancing quickly. More than several other innovations combined, nanotechnology will dramatically alter dentistry, healthcare, and human existence. Nanotechnology, like all other technologies, has a great potential for abuse and exploitation on size and scope that has never been seen before. However, they also have the potential to result in important advantages including greater health, better resource management, and decreased environmental pollution. The days of awe and miraculous are in fact upon us. The focus of current research is on recent advancements, particularly in the field of nanoparticles and nanotubes for the treatment of periodontal disease. Materials like hollow nanospheres, core-shell structures, nanocomposites, nanoporous materials, and nanomembranes will increasingly be used in the development of new dental materials.

The greatest desire of every healer, medicine man, and doctor throughout recorded history will finally come true once nanomechanics is available. Medical professionals will be able to perform curative and reconstructive surgeries in the human body at the cellular and molecular levels thanks to programmable and controlled microscale robots made of nanoscale components built to nanometer accuracy. Despite all other factors being equal, nanomedical doctors of the twenty-first century will continue to make effective use of the body's inherent healing abilities and homeostatic systems.

Conclusion

Despite biomedical nanotechnology's substantial contribution to healthcare management, major efforts are being made to tackle the obstacles of low repeatability, specificity, and effectiveness, as well as the regulatory environment connected with state-of-the-art biomedical nanotechnology. Experts recommend stepping up efforts to develop new systems that fulfill patient needs, keeping developments and possibilities in mind. Health organizations are looking for innovations that will make health care more accessible, inexpensive, and controllable. This might be accomplished by concentrating efforts on the design and development of intelligent and effective nano-enabled components that can raise diagnostics and treatments to the needed level of performance. These articles investigate the need for biomedical nanotechnology in the context of customized health and wellness, as well as its relevance, problems, and opportunities. We also urge specialists in the field to do their best to address and investigate difficulties in biomedical nanotechnology by performing cutting-edge research. The supportive and inspiring policies of government agencies are also highly crucial to assisting the research of companies, institutions, and universities. Overall, balanced research backed by public-private partnerships is recommended for developing and promoting biomedical nanotechnology for individualized health care management.

Contribution of authors

All authors have contributed equally, in planning, drafting, writing, and analyzing, the write–up.

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Conflict of interest

The author declares no conflict of interest, financial or otherwise.

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