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# Nanoparticles based Cancer Therapeutics: Recent Practices

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## Abstract

Despite of the advancements in treating cancer, it is yet one of the dominant causes of death worldwide. The current therapies are either incapable against certain cancers or impeding to the patients, which diminishes their personal satisfaction. The utilization of nanoparticles in cancer treatment might possibly increment patient endurance, decrease secondary effects and diminish death rates. The fundamental constraint of current therapeutics is an absence of explicitness in conveyance as they target normal cells too. The advancement of nanoscale carriers can possibly defeat both fundamental and growth hindrances as well as give explicit, designated conveyance. This study also aims to focus on the therapeutic strategies in which different types of nanoparticles have been discussed comprehensively. Moreover, cancer nanomedicines have also been addressed in the end to highlight some more possible therapeutic measures.

## Keywords
Nanoparticles, Cancer, Therapeutics, Nanomedicine, Nanoscale carriers.

## Introduction

According to the World Health Organization; after cardiovascular diseases, cancer is the subsequent driving reason for death all over the world. By the year 2030 the death rate due to cancer will increase up to 13.1 million [1]. Regardless of the attempts to alleviate risk factors in the past many years, the pervasiveness of cancer is proceeding to increment [2]. The quiet killer which we know by the name of cancer, whenever distinguished at the beginning phase can prompt a fix by the therapeutic medication with extreme possibilities [3].

Cancer in the more extensive sense has 277 different kinds known till now [4]. Cancer is basically a malignant growth that results from the uncontrolled division of abnormal cells and some kinds of cancers are avoidable by changing the undesirable life habits [5]. Nanomedicines are broadly utilized in cancer treatment because they have minimum side effects [6]. Existing cancer therapies have restricted clinical advantages since caner antigens are not frequently conveyed to the immune cells therefore the constraints of cancer immunotherapy includes nanoparticles based therapeutics [7].

Nanoparticles allude to the particles with a measurement of around 10 to 1000nm and are considered a promising contender for cancer therapy [8]. Nanoparticles can be utilized to treat cancer due to the particular benefits including reduced harmful effects, enhanced permeability, high stability, biocompatibility, maintenance impact and exact targeting [9]. Nanoparticles are preferred not only because they increase designated aggregation at tumor sites but decrease the biodistribution in other cells too [10]. Nanoparticles work on the improvement of the anticancer treatment in living creatures overwhelmingly contrasted with customary chemotherapy [11]. Nanoparticles based drug delivery systems show numerous benefits in disease treatments like pharmacokinetics, exact targeting of cancer cells, decreasing secondary effects as well as medication opposition [12].

Nanoparticles have been used to lengthen blood dissemination times as well as improve the cancer take-up of chemotherapeutics by means of the improved penetrability and maintenance impact [13]. Organic and inorganic nanoparticles are widely used as cancer therapeutics. Contrasted with organic nanoparticles, inorganic nanoparticles have one of a kind electric, optical and magnetic qualities causing a more optimistic practice in cancer detection as well as treatment [14]. In this article, the nanoparticles-based cancer therapeutics and the recent practices on them are described in detail.

P.N. Navya 2019 et al. reported that the progress in material science and nanotechnology have brought medications to treat life threatening diseases like cancer. At this stage, we can envision that the further development and coming age of Nanomedicine could offer even better techniques for cancer. Moreover, the literature present in this review recommended that nanotechnology will give cutting edge stages to cancer growth and anticancer therapy. Hence the scope of nanoparticles and their physiochemical properties in cancer have been employed [2].

In another article, Roy van der Meel 2019 et al. described that tests for patient hierarchy are earnestly required in cancer nanomedicine to distinguish people reasonable for consideration in analytical preliminaries. Moreover, nanomedicines work in harmony with pharmaceutical and actual co-medicines, as well as ought to be progressively coordinated in treatment plans using a variety of modality. While most of the nanomedicine strategies are created for intravenous approach, it could be worthwhile to investigate more administration courses, these alternative routes, which have up to this point got moderately little thought in nanomedicine's case, may give critical benefits including applicability, cost, viability and toxicity [6].

Wooram Park 2018 et al. reported all the advance opportunities for nanoparticles in cancer immunotherapy as well as the methodologies for controlling the impediments of cancer immunotherapy which include nanoparticles in light of biomaterials. All the important headings in this article illustrated that the approaches for utilizing nanoparticles in cancer treatment have been improved with time. The improvements of nanoparticles-based vaccines is supposed to turn into a standard treatment fit for broadening life expectancy and working on personal satisfaction in cancer patients [7].

Shreelaxmi Gava 2021 et al. reported in the article that with the expanding research, a few kinds of nanoparticles like polymeric nanoparticles, metallic nanoparticles and others have shown better viability of medication delivery. However, several restrictions including inadequacy of cell culture models that accurately copy in vivo phase; long-lasting effects associated with it and neurotoxicity. This emerging area and with the development of proteomics analysis on the "mechanism of cancer origin", other nanoparticles-based medications can be taken advantage of. Change in clinical interpretation for nanoparticles-based cancer growth treatment will be achieved by nanotechnology as well as cancer treatment improvements [9].

Nafis Haider 2020 et al. demonstrated that perhaps among the most basic aspects in cancer therapy is its initial stage diagnosis prior the cancer cells spread. Moreover, cancer diagnosis timing is identically important because it will affect the visualization of cancer growth in patient. Moreover, apart from the huge significance of nanomedicines in cancer therapy, its toxic consequences for normal cells are likewise a main issue, particularly after persistent treatment. The nanoparticles of a tiny aspect might be taken advantage as sub-atomic analysis for extravascular objectives and cancer nanomedicines have alongside reduce renal clearance to accomplish great amassing of nanomedicines at infection site [1].

Jiaping Wang 2022 et al. reported in the article that CRISPR genome editing has been done utilizing nanomedicine platform and nanocarrier diminished the quantity of myelogenous leukemia cells (K562) in blood as well as bone marrow and expanded endurance rates in mice, furthermore changed declaration of favorable and hostile to apoptotic qualities and proteins. Barely any pre-clinical tests provide quantitative information on elements that might be significant in forming plan standards towards nanomedicines. Inferior exploratory plan and range of the trial settings additionally contribute for field's deferred progression and the absence of restorative impact. Liposome nanoparticle with a transcriptional activator and an advertiser enhancer has made huge commitments to the discipline of cancer treatment [11].

In another article, Yu Dang 2020 et al. reported that nanoparticle-based drug delivery mechanism is significantly superior to traditional drug delivery system due to increased half-life of weak medications as well as proteins, working on dissolvability of the hydrophobic medications as well as permitting controlled and designated arrival of the medications at the diseased site. This article has also focused on the three types of nanoparticles i.e. chitosan nanoparticles here chitosan is a natural carbohydrate polymer acquired from deacetylation of chitin. The other type is the silica nanoparticles which include the nanoparticles produced using inorganic materials and the third type is the Polylactide-co-glycolic acid also known as PLGA, produced by using the engineered polymeric material [8].

Javad Sharifi-Rad 2021 et al. reported that the cancer problems are quite possibly the most significant issue worldwide and proposed the logical examinations focus completely on late progress in the Chitosan Nano-delivery for cancer therapy. Moreover, these nanomaterials with oncological medication like the lactoferrin, doxorubicin, docetaxel, tamoxifen, 5-fluorouracil as well as others were contemplated. It was uncovered that the utilization of these nanomaterial in medications utilized in oncological therapy have shown upgrade of medication conveyance to the growths and further developing cytotoxicity impact on cancerous cell lines. Also, research on utilization of these nanomaterials in blend alongside the plant-determined optional metabolites has given promising outcomes. The most recent benefits of these nanoparticles practices in the nanomedicine are upheld likewise by clinical as well as pre-clinical examinations [5].

In another article, Yihan Yao 2020 et al. reported that the targeting of cancer cells explicitly is an imperative quality of the nanocarriers for drug conveyance, as it improves the restorative viability while safeguarding the ordinary cells from cytotoxicity. Drug opposition is as yet a significant issue in cancer therapy, instead of the way that the strategies for cancer therapy are expanding. Moreover, the multidrug obstruction prompts a disappointment of different kinds of cancer therapies, prompting disease movement and the poor diagnosis. Also, the improvement of immunotherapy has brought cancer treatment into another age. Nanoparticle not just assumes a significant part in conveyance chemotherapy yet has likewise shown extraordinary potential for applications in immunotherapy. Nanotechnology applied to cancer treatment has prompted another age of cancer treatment. It is important that nanoparticles size, composition, shape and surface are variables which influence connections of nanoparticles with immune system. Hence the security and resistance of these new methodologies should be additionally examined [12].

Mundekkad and Cho, 2022 demonstrated in the article that the origin of cancer therapeutics proposed a change in outlook from regular treatment to accurate medication. The advance restorative modalities achieved from the characteristics of nanoparticles have broadened their degree in cancer treatment past regular medication conveyance. Nanoparticles can be diverted in the disease treatment to typify the dynamic drug fixings and convey them to tumor site in a more productive way. It has been reported that a Google scholar search with the catchphrases i.e. Nano-formulations, cancer cure turned near 3000 hits in 0.08s; more than 18,000 publications are depended on the nanomedicines. Moreover, the absence of appropriate comprehension of mechanism of action of nanoparticles with biomolecules is the preeminent obstacle element. Many other promising procedures were also proposed such as the nanorobotics and the sub-atomic Nano-frameworks that can make fake organs and framework in order to control the future of Nano-chemotherapy [15].

In another review, Stefan Morarasu 2022 et al. reported about the targeted cancer treatment by means of the pH functionalized nanoparticles, which were displayed to further develop drug conveyance and upgrade the antitumor impacts in different exploratory threatening cell lines. The pH nanoparticles, paying little mind to being polymeric or metallic, were displayed to have great growth entrance in many trial dangerous cell lines in vivo. Also, it was concluded that no matter whatever the sort and construction of pH functionalized nanoparticles is pH-responsive nanoparticles can increment the tumor regression rates contrasted with the controls. Drug conveyance, is consequently reliant upon the openness of nanoparticles to the acidic pH [16].

David Kovacs 2022 et al. has reported in the article that the metal nanoparticles particularly silver nanoparticles confine perfect expect in cancer biology. Therapeutic potential of nanoparticulated silver depends on its extraordinary way to actuate cell demise in the mammalian cells. This extraordinary capability of the silver nanoparticles as the anti-cancer agents, in any case they also highlighted that the poisonous behavior of nanomaterials renders them fairly like the chemotherapy medications. Aside from the immediate anti-cancer activity, silver nanoparticles could act as the delivery mechanisms of the cytotoxic drugs or improve counter disease execution of the combinational accomplices upon chemotherapy or radiotherapy [17].

## Materials and Methods

For methodology, the world-renowned journals were searched to select the related articles published recently. The inclusion criteria of this section include the key words, time duration, journals and others. Moreover, a systematic research was performed on PubMed, Springer, Wiley online library and Nature with the keywords including nanoparticles, cancer, therapeutics and nanoscale carriers; in order to identify studies and reported the outcomes on cancer patients were determined from the year 2020 to till date. The keywords were searched in these big publishing bodies and the duplicates were removed in order to get most relevant articles. Some of the titles inserted in the table were short-listed after they met the inclusion criteria mainly of the year and keywords. The objective of this analysis is to get recent therapeutic techniques related to cancer. Moreover, the systematic reviews and meta-analysis were considered as a priority in the inclusion criteria.

Table 1: Recently published related articles from the world-renowned journals

| | PubMed | Springer | Wiley | Nature |
|---|---|---|---|---|
| 1. | Association of germline TYK2 variation with lung cancer and non-Hodgkin lymphoma risk [18] | Anti-angiogenesis in cancer therapeutics: the magic bullet [19] | Role of cancer-associated fibroblast subpopulations in immune infiltration, as a new means of treatment in cancer [20] | Targeting drugs to tumours using cell membrane-coated nanoparticles [21] |
| 2. | The Risk for Prostate Cancer With Calcium Channel Blockers: A Systematic Review, Meta-Analysis, and Meta-Regression [22] | Enhancing cellular uptake and membrane permeability of gallic acid for breast cancer therapy via folate-tagged PEGylated iron oxide nanoparticles has theronastic agent [23] | Resistance to DNA repair inhibitors in cancer [24] | Enhancing cancer immunotherapy with nanomedicine [25] |
| 3. | Return to work in patients with head and neck cancer: Systematic review and meta-analysis [26] | Membrane-wrapped nanoparticles for photothermal cancer therapy [27] | Annual report to the nation on the status of cancer, part I: National cancer statistics [28] | Natural killer cells in antitumour adoptive cell immunotherapy [29] |
| 4. | Liposomal Drug Delivery Systems for Cancer Therapy: The Rotterdam Experience [30] | PLGA-based nanoparticles for the treatment of cancer: current strategies and perspectives [31] | Poly-aneuploid cancer cells promote evolvability, generating lethal cancer [32] | Metabolic glycan labelling for cancer-targeted therapy [33] |
| 5. | Updates on Responsive Drug Delivery Based on Liposome Vehicles for Cancer Treatment [34] | Smart nanomaterials for cancer diagnosis and treatment [35] | Ageing and cancer: a research gap to fill [36] | Macrophages as tools and targets in cancer therapy [37] |
| 6. | Correlation between radiologic and pathologic extranodal extension in HPV-associated oropharyngeal cancer: Systematic review [38] | Radiolabeled nanomaterials for biomedical applications: radiopharmacy in the era of nanotechnology [39] | American Cancer Society's report on the status of cancer disparities in the United States, 2021 [40] | Drugging p53 in cancer: one protein, many targets [41] |
| 7. | Engineered tumor cell-derived vaccines against cancer: The art of combating poison with poison [42] | Nanostructured lipid carriers: a promising drug carrier for targeting brain tumors [43] | Tieing together loose ends: telomere instability in cancer and aging [44] | Multifunctional biomolecule nanostructures for cancer therapy [45] |

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| 8. | A perspective to weaponize microRNAs against lung cancer [46] | Nanoscale Drug Delivery Systems in Glioblastoma [47] | Moderators of the association between stigma and psychological and cancer-related symptoms in women with non-small cell lung cancer [48] | The evolving translational potential of small extracellular vesicles in cancer [49] |
| 9. | Advances in Nanotechnology for Cancer Immunoprevention and Immunotherapy: A Review [50] | The nanocomposites designs of phytomolecules from medicinal and aromatic plants: promising anticancer-antiviral applications [51] | Cognitive function prior to systemic therapy and subsequent well-being in older breast cancer survivors: Longitudinal findings from the Thinking and Living with Cancer Study [52] | The blood–tumour barrier in cancer biology and therapy [53] |
| 10. | Prostate Cancer Outcomes in Patients Living With HIV/AIDS Treated With Radiation Therapy: A Systematic Review [54] | A study on ER stress-induced apoptosis pathway in cervical cancer HeLa cells treated with biosynthesized gold nanoparticles [55] | A distinct repertoire of cancer-associated fibroblasts is enriched in cribriform prostate cancer [56] | Obstacles and opportunities in a forward vision for cancer nanomedicine [57] |
| 11. | A technical note on emerging combination approach involved in the onconanotherapeutics [58] | Multifunctional Gold Nanoparticles for Improved Diagnostic and Therapeutic Applications: A Review [59] | Cancer outcomes research—a European challenge: measures of the cancer burden [60] | 3D bioprinted cancer models: from basic biology to drug development [61] |
| 12. | Adding recombinant AAVs to the cancer therapeutics mix [62] | Gas-stabilizing nanoparticles for ultrasound imaging and therapy of cancer [63] | Uptake of cancer risk management strategies among women who undergo cascade genetic testing for breast cancer susceptibility genes [64] | Engineering microrobots for targeted cancer therapies from a medical perspective [65] |
| 13. | The emerging role of cancer nanotechnology in the panorama of sarcoma [66] | Tuning the Toxicity of Reactive Oxygen Species into Advanced Tumor Therapy [67] | Annual report to the nation on the status of cancer, part II: Progress toward Healthy People 2020 objectives for 4 common cancers [68] | Non-coding RNAs and ferroptosis: potential implications for cancer therapy [69] |

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| 14. | Functionalized Peptide-Based Nanoparticles for Targeted Cancer Nanotherapeutics: A State-of-the-Art Review [70] | Pharmacokinetics and biodistribution of a novel anticancer thyrointegrin αvβ3 antagonist: triazole modified tetraiodothyroacetic acid conjugated to polyethylene glycol (P-bi-TAT) [71] | Engineering nanostructured pure cancer cell membrane-derived vesicles as a novel therapeutic cancer vaccine [72] | Noncoding RNA therapeutics — challenges and potential solutions [73] |
| 15. | DNA methylation biomarkers in colorectal cancer: Clinical applications for precision medicine [74] | Nanoparticles: A New Approach to Upgrade Cancer Diagnosis and Treatment [75] | Validation of the 7-item Functional Assessment of Cancer Therapy-General (FACT-G7) as a short measure of quality of life in patients with advanced cancer [76] | Interleukins in cancer: from biology to therapy [77] |
| 16. | Broadening the Horizons of RNA Delivery Strategies in Cancer Therapy [78] | Nanotechnology in emerging liquid biopsy applications [79] | Characterizing cancer-associated myosteatosis: anatomic distribution and cancer-specific variability of low radiodensity muscle [80] | LncRNAs in breast cancer: a link to future approaches [81] |
| 17. | Design and applications of liposome-in-gel as carriers for cancer therapy [82] | Biocompatible Nanoparticles as a Platform for Enhancing Antitumor Efficacy of Cisplatin–Tetradrine Combination [83] | Targeting cellular senescence to combat cancer and ageing [84] | Signaling pathways in cancer-associated fibroblasts and targeted therapy for cancer [85] |
| 18. | Circadian clock as a possible control point in colorectal cancer progression (Review) [86] | Natural Products in Cancer Therapy: Past, Present and Future [87] | MASTL: A novel therapeutic target for Cancer Malignancy [88] | Clinical development and potential of photothermal and photodynamic therapies for cancer [89] |
| 19. | Nanotechnological approaches for diagnosis and treatment of ovarian cancer: a review of recent trends [90] | Nano drug delivery systems in upper gastrointestinal cancer therapy [91] | Clinical applications of mass spectrometry-based proteomics in cancer: Where are we? [92] | The current state of the art and future trends in RAS-targeted cancer therapies [93] |
| 20. | Signaling pathways in the regulation of cancer stem cells and associated targeted therapy [94] | Strategies to target long non-coding RNAs in cancer treatment: progress and challenges [95] | Family history of cancer in first degree relatives and risk of cancer of unknown primary [96] | Targeting non-coding RNAs to overcome cancer therapy resistance [97] |

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| 21. | Long non-coding RNAs and microRNAs as regulators of stress in cancer (Review) [98] | Imaging diagnosis of metastatic breast cancer [99] | Identification of a serum biomarker signature associated with metastatic prostate cancer [100] | CRISPR in cancer biology and therapy [101] |
| 22. | Gold-Nanoparticle Hybrid Nanostructures for Multimodal Cancer Therapy [102] | Designing Aptamer-Gold Nanoparticle-Loaded pH-Sensitive Liposomes Encapsulate Morin for Treating Cancer [103] | Nanoparticle-based applications for cervical cancer treatment in drug delivery, gene editing, and therapeutic cancer vaccines [104] | A common goal to CARE: Cancer Advocates, Researchers, and Clinicians Explore current treatments and clinical trials for breast cancer brain metastases [105] |
| 23. | Recent Advances in Zinc Oxide Nanoparticles (ZnO NPs) for Cancer Diagnosis, Target Drug Delivery, and Treatment [106] | CD59 receptor targeted delivery of miRNA-1284 and cisplatin-loaded liposomes for effective therapeutic efficacy against cervical cancer cells [107] | Surface-functionalised hybrid nanoparticles for targeted treatment of cancer [108] | Toll-like receptor 9 agonists and combination therapies: strategies to modulate the tumour immune microenvironment for systemic anti-tumour immunity [109] |
| 24. | Nanoscale Formulations: Incorporating Curcumin into Combination Strategies for the Treatment of Lung Cancer [110] | Antiproliferative effects on tumor cells of the synthesized gold nanoparticles against Hep2 liver cancer cell line [111] | Molecularly Imprinted Polymer Nanoparticles: An Emerging Versatile Platform for Cancer Therapy [112] | Emerging nanomedical strategies for direct targeting of pediatric and adult diffuse gliomas [113] |

Some other review articles have been searched from the world-renowned journals and for this section, criteria of selection included keywords i.e. nanoparticles, cancer, therapeutics and nanoscale carriers and the articles from the year 2020 to till date were finalized to be a part of this section.

A systematic research was performed on world-renowned journals and following titles were finalized for this section. Moreover, the author's names along with the publication years are mentioned in this section and the table for this section is as follows:
related technique as in the list; Vienna (n=7), Utrecht (n=1) and interstitial (n=4) which totalled to 11 patients The patients are ranged from 41 to 84 years old.

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Table 2: Most relevant articles titles along with the author's names, publication year, theme and mapping of keywords

| **Title** | **Authors** | **Publication year** | **Theme** | **Keywords** | | | |
|---|---|---|---|---|---|---|---|
| | | | | nanoparticles | cancer | therapeutics | nanoscale carriers |
| 1. Association of germline TYK2 variation with lung cancer and non-Hodgkin lymphoma risk [18] | Yarmolinsky et al,2022 | 2022 | Deucravacitinib is under review at the Food and Drug Administration and EMA recently for treatment of moderate-to-severe plaque psoriasis. | X | ✓ | ✓ | X |
| 2. The Risk for Prostate Cancer With Calcium Channel Blockers: A Systematic Review, Meta-Analysis, and Meta-Regression [22] | Rotshild et al.,2023 | 2023 | Calcium Channel blockers are an important modality in treating hypertension. | ✓ | ✓ | X | X |
| 3. Return to work in patients with head and neck cancer: Systematic review and meta-analysis [26] | Justin Yu et al., 2022 | 2022 | Get back to work is a significant clinical result which should be viewed as in the survivorship care of patients with Head and Neck Cancer. | X | ✓ | ✓ | X |
| 4. Liposomal Drug Delivery Systems for Cancer Therapy: The Rotterdam Experience [30] | Amin et al.,2022 | 2022 | Liposomes modifications with phospholipids proved enhanced drug release. | ✓ | ✓ | ✓ | X |

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| 5. Updates on Responsive Drug Delivery Based on Liposome Vehicles for Cancer Treatment [34] | Nikolova et al., 2022 | 2022 | Liposomal drug delivery systems are better for cancer treatment than conventional treatments. | ✓ | ✓ | ✓ | ✓ |
| 6. Correlation between radiologic and pathologic extranodal extension in HPV-associated oropharyngeal cancer: Systematic review [38] | Morey et al.,2022 | 2022 | Pretreatment determination of extranodal extension has significant clinical implications in human papillomavirus positive oropharyngeal squamous cell carcinoma. | X | ✓ | ✓ | X |
| 7. Engineered tumor cell-derived vaccines against cancer: The art of combating poison with poison [42] | Zhang et al.,2023 | 2023 | Tumor immunization is a promising methodology for growth immunotherapy since it presents high particularity and not many secondary effects. | ✓ | ✓ | ✓ | X |
| 8. A perspective to weaponize microRNAs against lung cancer [46] | Murugan and Rangasamy et al.,2023 | 2023 | MicroRNAs are regulatory RNAs that silence specific mRNA by binding to it, inducing translational repression. | ✓ | ✓ | ✓ | X |

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|---|---|---|---|---|---|---|---|
| 9. Advances in Nanotechnology for Cancer Immunoprevention and Immunotherapy: A Review [50] | Koyande et al.,2022 | 2022 | Cancer vaccines are most common method in Immunoprevention | ✓ | ✓ | ✓ | X |
| 10. Prostate Cancer Outcomes in Patients Living With HIV/AIDS Treated With Radiation Therapy: A Systematic Review [54] | Vaziri et al.,2023 | 2023 | Radiation Therapy is efficacious and well tolerated in PLWHA as supported by the comparable biochemical control, clinical outcome, and mortality to the general population as well as by the mild reports of radiotoxicity. | X | ✓ | ✓ | X |
| 11. Anti-angiogenesis in cancer therapeutics: the magic bullet [19] | Oguntade et al.,2021 | 2021 | Anti-angiogenesis is a promising methodology for growth immunotherapy since it presents high particularity and not many secondary effects. | ✓ | ✓ | ✓ | ✓ |
| 12. Enhancing cellular uptake and membrane permeability of gallic acid for breast cancer therapy via folate-tagged PEGylated iron oxide nanoparticles has theronastic agent [23] | Sandhiya & Ubaidulla, 2022 | 2022 | Organic action upgrade after heightening the cell take-up reaction through ligand and transporter based by means of nanoframework gallic corrosive was decided to be figured out into PLGA-based polymeric nanoparticles with iron oxide as theranostic specialist. | ✓ | ✓ | ✓ | ✓ |

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| 13. Membrane-wrapped nanoparticles for photothermal cancer therapy [27] | Aboeleneen et al.,2022 | 2022 | Nanoparticle-mediated photothermal therapy is a minimally invasive treatment for solid-tumor cancers that has immense promise as a standalone therapy. | ✓ | ✓ | ✓ | X |
| 14. PLGA-based nanoparticles for the treatment of cancer: current strategies and perspectives [31] | Alvi et al.,2022 | 2022 | Poly (lactic-co-glycolic acid) (PLGA) is FDA-approved synthetic polymer which can be used to formulate NPs that can be targeted to a specific site for the safe and effective delivery of drugs. | ✓ | ✓ | ✓ | X |
| 15. Multifunctional Gold Nanoparticles for Improved Diagnostic and Therapeutic Applications: A Review [59] | Sibuyi et al.,2021 | 2021 | Gold nanoparticles are among the FDA-approved metallic nanoparticles and have shown great promise in a variety of roles in medicine. | ✓ | ✓ | ✓ | X |
| 16. Radiolabeled nanomaterials for biomedical applications: radiopharmacy in the era of nanotechnology [39] | Pijeria et al.,2022 | 2022 | Cancer nano-theranostics have the potential to lead the way to more specific and individualized cancer treatment. | ✓ | ✓ | ✓ | X |
| 17. Nanostructured lipid carriers: a promising drug carrier for | Garg et al.,2022 | 2022 | Nanostructured Lipid Carriers are employed as an important | ✓ | ✓ | ✓ | ✓ |

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| targeting brain tumors [43] | | | carrier for the delivery of food, cosmetics, and medicines and recently have been used in brain targeting, cancer, and gene therapy. | | | | |
| 18. Nanoscale Drug Delivery Systems in Glioblastoma [47] | Liu et al.,2022 | 2022 | The standard therapy for GBM is maximal safe resection followed by adjuvant radiation and oral temolozomide which extends patients life expectancy. | ✓ | ✓ | ✓ | ✓ |
| 19. The nanocomposites designs of phytomolecules from medicinal and aromatic plants: promising anticancer-antiviral applications [51] | Kaplan, 2022 | 2022 | The evaluation of active compounds with plant origin may help in the remedy of human illnesses. | ✓ | ✓ | ✓ | X |

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| 20. A study on ER stress-induced apoptosis pathway in cervical cancer HeLa cells treated with biosynthesized gold nanoparticles [55] | Kamala Priya & Iyer et al.,2021 | 2021 | All these proteins have crucial role in the regulation of apoptosis through mitochondrial degradation, DNA damage, nuclear condensation and eventually cell death of the cancerous cells. | ✓ | ✓ | X | X |
| 21. Role of cancer-associated fibroblast subpopulations in immune infiltration, as a new means of treatment in cancer [20] | Mhaidly & Mechta-Grigoriou, 2021 | 2021 | Cancer-associated fibroblasts have multiple tumor-promoting functions and play key roles in drug resistance, through multiple mechanisms, including extracellular matrix remodeling, production of growth factors, cytokines and angiogenesis as well. | X | ✓ | ✓ | X |
| 22. Resistance to DNA repair inhibitors in cancer [24] | Baxter et al.,2022 | 2022 | DNA damage response represents a complex network of proteins which detect and repair DNA damage. | X | ✓ | ✓ | X |
| 23. Annual report to the nation on the status of cancer, part I: National cancer statistics [28] | Henley et al.,2020 | 2020 | Data on new cancer diagnosis was reported. | X | ✓ | ✓ | X |

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| 24. Poly-aneuploid cancer cells promote evolvability, generating lethal cancer [32] | Pienta et al.,2020 | 2020 | Poly-aneuploid cancer cells may serve as efficient sources of heritable variation that allows cancer cells to evolve rapidly and most critically for patient outcome and survival, permit evolutionary, therapy and metastasis. | X | ✓ | ✓ | X |
| 25. Ageing and cancer: a research gap to fill [36] | Solary et al.,2022 | 2022 | Cancer is one of the diseases promoted by tissue ageing. | X | ✓ | ✓ | X |
| 26. American Cancer Society's report on the status of cancer disparities in the United States, 2021 [40] | Islami et al.,2022 | 2022 | Comprehensive and up-to-date US data on disparities in cancer occurrence, major risk factors and access to screening by sociodemographic characteristics. | X | ✓ | ✓ | X |
| 27. Tieing together loose ends: telomere instability in cancer and aging [44] | Borges et al.,2022 | 2022 | Telomere maintenance is essential for maintaining genome. integrity in both normal and cancer cells. | X | ✓ | ✓ | X |

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| 28. Moderators of the association between stigma and psychological and cancer-related symptoms in women with non-small cell lung cancer [48] | Snyder et al.,2022 | 2022 | Lung cancer patients, particularly women, are vulnerable to experience disease-related stigma, which is linked to greater psychological distress and worse treatment outcomes. | X | ✓ | ✓ | X |
| 29. Cognitive function prior to systemic therapy and subsequent well-being in older breast cancer survivors: Longitudinal findings from the Thinking and Living with Cancer Study [52] | Kobayashi et al.,2020 | 2020 | Among older breast cancer survivors, self-reported, but not objective cognitive impairments, were associated with lower global well-being over the first 2 years of survivorship. | X | ✓ | ✓ | X |
| 30. A distinct repertoire of cancer-associated fibroblasts is enriched in cribriform prostate cancer [56] | Hesterberg et al.,2021 | 2021 | Localized prostate cancer is heterogeneous for disease aggressiveness that ranges from indolent cancers not needing treatment to highly aggressive cancers requiring multimodal therapies. | X | ✓ | ✓ | X |

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| 31. Targeting drugs to tumours using cell membrane-coated nanoparticles [21] | Fang et al.,2022 | 2022 | Cell membrane-coated nanoparticles are an emerging class of nanocarriers that have shown considerable promise for biomedical applications. | ✓ | ✓ | ✓ | ✓ |
| 32. Enhancing cancer immunotherapy with nanomedicine [25] | Irvine & Dane,2020 | 2020 | Nanomedicines therapeutics made out of or planned in transporter materials were initially evolved to build take-up of chemotherapy specialists by growths and to diminish their off-target harmfulness. | ✓ | ✓ | ✓ | ✓ |
| 33. Natural killer cells in antitumour adoptive cell immunotherapy [29] | Laskowski et al.,2022 | 2022 | Supportive cell treatment utilizing designed insusceptible effectors is a promising new way to deal with treat hematological and strong malignancies for which treatment choices are restricted. | X | ✓ | ✓ | X |

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| 34. Metabolic glycan labelling for cancer-targeted therapy [33] | H. Wang & Mooney 2020 | 2020 | Metabolic glycoengineering gives an integral asset to name cell layers with synthetic labels for resulting designated formation of sub-atomic freights through proficient sciences. | X | ✓ | ✓ | X |
| 35. Macrophages as tools and targets in cancer therapy [37] | Mantovani et al.,2022 | 2022 | Macrophages can mediate phagocytosis of cancer cells and engage in effective bidirectional interactions with components of the innate and adaptive immune system. | X | ✓ | ✓ | X |
| 36. Drugging p53 in cancer: one protein, many targets [41] | Hassin & Oren,2022 | 2022 | Small molecules that can either protect p53 from its negative regulators or restore functionality of mutant p53 proteins are gaining interest, and drugs tailored to specific types of p53 mutants are emerging. | X | ✓ | ✓ | X |

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| 37. Multifunctional biomolecule nanostructures for cancer therapy [45] | Jing Wang et al.,2021 | 2021 | Biomolecule-based nanostructures are inherently multifunctional and harbor diverse biological activities, which can be explored for cancer nanomedicine. | X | ✓ | ✓ | X |
| 38. The evolving translational potential of small extracellular vesicles in cancer [49] | Möller & Lobb, 2020 | 2020 | Cancer-derived extracellular vesicles are regarded as having promising potential to be used as therapeutics and disease biomarkers. | X | ✓ | ✓ | X |
| 39. The blood–tumour barrier in cancer biology and therapy [53] | Steeg, 2021 | 2021 | The protective blood–brain barrier has a major role in ensuring normal brain function by severely limiting and controlling the ingress of substances into the brain from the circulation. | X | ✓ | ✓ | X |
| 40. Obstacles and opportunities in a forward vision for cancer nanomedicine [57] | de Lázaro & Mooney, 2021 | 2021 | Cancer nanomedicines were at first imagined as enchantment slugs, making a trip through the flow to target cancers while saving sound tissues the harmfulness of exemplary chemotherapy. | X | ✓ | ✓ | X |

**Discussion**

Nanoparticles based cancer therapeutics has been applied by various scientists in various cancer associated researches because nanomedicines provide effective treatment with minimum or no adverse effects. Nafis Haider 2020 created a research that the lipid-based, polymeric as well as inorganic nanomedications which are specially formulated to convey various diagnostics and therapies to tumor cells either through enhanced permeability and retention or surface conjugated with particular targeting ligands in accordance with affinity for mostly translated proteins by specific tumors for effective targeting. Also the nanomedicines distinctive characteristics such as regulated particle size, broad surface area, ability to encapsulate numerous chemotherapeutic drugs as well as longer biological half-life, make them an outstanding response for the efficient cancer management [1].

But Mundekkad and Cho, 2022 demonstrated in the article that the origin of cancer therapeutics proposed a change in outlook from regular treatment to accurate medication, the absence of appropriate comprehension of mechanism of action of nanoparticles with biomolecules is the preeminent obstacle element. Many other promising procedures were also proposed such as the nanorobotics and the sub-atomic Nano-frameworks that can make fake organs and framework in order to control the future of Nano-chemotherapy and provide effective results too [15].

David Kovacs 2022 et al. has reported that the significant efforts have been made over the past ten years to bring nanoscale materials into the field of cancer therapy through basic and translational research. Because of this, numerous nanomaterial-based therapeutic modalities have been put into clinical trials to date in order to defeat cancer. Although most of these chemotherapeutic medications are the liposome-encapsulated, other nanomaterials, specifically metal-based nanostructures have become efficient therapeutic tools. Silver nanoparticles (AgNPs) are the most often used among them in several clinical applications because of their generally acknowledged anti-microbial properties.

Also, the silver-based nanoparticles are possibly useful in the therapy of tumors because of their particular cytotoxic abilities against mammalian cells and their anti-microbial properties. Despite there is a rapid growing body of scientific evidence which holds their potential use as anti-cancer agents, there are many difficulties that demand to be clarified prior silver nanoparticle-based treatments with high effectiveness and safety can be established [17]. Despite being anti-microbial, Abed Hassan Baraaj, 2021 reported the adverse effects caused by silver nanoparticles that due to their ability to resemble proteins and cellular components, they can get through the body's natural defense mechanism. They buildup and harm different elements like tissue, functional capacity and DNA of liver cells, the liver is one of the most targeted organs for nanoparticle damage.

To evaluate the damage produced by silver nanoparticles, 30 albino male rats were employed and split into three primary groups. A normal saline solution was administered to the first group, which served as the control. Another group received silver nanoparticles with a concentration of 2 mg/kg while the third group received silver nanoparticles with a concentration of 3 mg/kg of body weight. Each concentration was dissolved in 3 mL of ordinary saline and administered daily for 10 weeks via a feeding tube with a diameter of 0.6 cm to the experimental animal's stomach. The findings of the present investigation demonstrated histological changes in the liver tissue, including extensive granulomatous lesions accompanied by a rise in macrophage counts and necrotic hepatocytes with dilated sinusoids. Both concentrations of the parenchyma's architecture were deformed. The analysis of the liver's biochemical parameters revealed elevated levels of enzymes in correlation with AgNPs dosages. By using the comet assay, the damage in hepatocytes' DNA was discovered and the extent of the damage was shown by an increase in the frequency of DNA strand breaks and tailed nuclei. The formation of reactive oxygen species (ROS) was crucial in the occurrence of functional and structural liver abnormalities in the model animals. [114]

**Conclusion**

Cancer continues to rank among the world's leading causes of death despite of the improvements in cancer treatments. Despite of the efforts over the past few years to lower risk factors, the prevalence of cancer is still rising. Coventional treatments are either ineffective against some tumours or burdensome for the patient, therefore use of nanoparticles in cancer treatment may lessen side effects and reduce mortality rates too. Since they target normal cells as well, the main limitation of that therapeutics is their lack of explicitness in delivery. The development of nanoscale carriers may be able to overcome both basic and growth barriers and provide precise, targeted delivery. This study also attempts to concentrate on the therapeutic approaches in which various nanoparticles have been thoroughly examined and the discussion of cancer nanomedicines in the final section highlights new potential therapeutics.

**Conflicts of interest**

There were no conflicts of interest when writing this review. To ensure the study's integrity, I certify that no funding sources were involved in any stage of the analysis, no data had already been published or submitted for publication elsewhere and I had no personal motivation to withhold the results of the study. In other words, the findings of my inquiry will only be supported by the data I gathered.

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