2026 Volume: 02 Issue: 02 ISSN 2347-7008 Review Article

International Journal Pharmaceutical Medicinal Research

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# SILVER NANOPARTICLES' TOXICITY TO HUMAN HEALTH

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**Article Received: 24 December 2025**
**Article Revised: 13 January 2026**
**Published on: 02 February 2026**

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DOI: https://doi-doi.org/101555/ijpmr.3615

## ABSTRACT

Nanoparticles (NP) have received a lot of interest and study during the past decade. From current understanding in the field of nanotoxicology, it has become obvious that the most NPs, if not all are more toxic than bulk compounds. Concerns have developed as a result of fast progress and development over the probable dangers to human health and the environment linked with usage and application of neurotoxics. One of the most accessible and widely used nanomaterials in the world is silver nanoparticles (SNPs). Quantification and detection of SNPs in biotechnological systems must be undertaken in a variety of models, so that we can establish how human health may be influenced by these genes. This is important because it is difficult to test all nanomaterials and estimate their effects on human health due to the variety of uses they have. As a result, some scientists think that these adverse effects are tolerable. Nanotechnology has several uses, particularly in the biological sciences and medicine. Nanomaterials are utilised to coat or treat or diagnose.

**KEYWORDS:** Gastrointestinal Toxicity; Genotoxicity And Carcinogenicity; Immune System Toxicity; Kidney Toxicity; Liver Toxicity; Lung Toxicity; Muscle Toxicity.

## INTRODUCTION

The large and increasing use of silver nanoparticles (AgNPs) constitutes a major environmental issue. In fact, they are widely used in a number of areas, especially for pharmaceuticals and textile items from which they have been released into the environment. AgNPs are employed due to their antibacterial and biocidal characteristics. Organisms are known to be poisoned by silver. There has been an increasing number of studies focused on the toxicity of AgNPs in recent decades[1]. The antibacterial activity of SNPs is much stronger than that of its metal salt in certain applications[2]. The structure and architecture of molecules changes according on the synthesis technique, from an oval, triangular, hexane shape to a nanowire form SNP[3]. Traditional ways can synthesise SNPs, as well as an alternate method known as a biogenic or green NPs Synthesis[4]. Recently, a variety of bacterial species, fungus, algae, and plants have been employed to create clean, nontoxic, biocompatible, and ecologically friendly SNPs [5–9]. Curiously, there has been an increasing concern over potential hazardous effects coming from their use or inadvertent release into the environment as a result of an interest in nano materials' potential benefits and increased production[10]. So far, atmospheric pollution and respiratory effects in mammals or in vitro experiments with mammalian cells have been subject to a number of nanotoxicological investigations [11].

## NANOSILVER

For thousands of years, silver has been recognised as a favoured metal utilised by mankind. The advancement of silver nanoparticles has been propelled by recent progress in nanoscience, which involves the study and manipulation of chemical and biological materials with dimensions between 1 nanometre and 100 nanometres. The silver nanoparticle comprises several silver atoms or ions amalgamated to create a particle measuring up to 100 nm in size. These nanoparticles has the potential to infiltrate and eradicate bacteria and other microorganisms due to their diminutive size. Silver nanoparticles, or nanosilver, are extensively integrated into various consumer products, including textiles like socks, sportswear, pants and beds, as well as vacuums, washing machines, toys, sunscreens and numerous others (Figure-1).

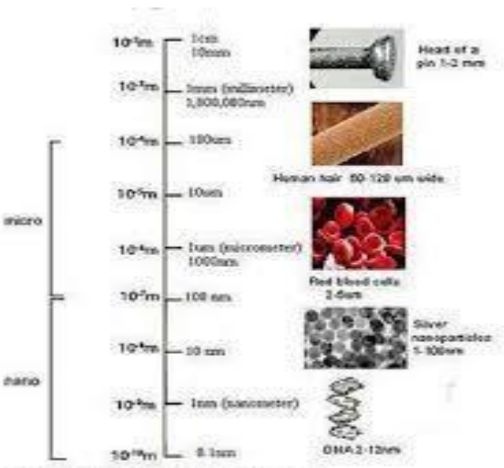


**Figure-1: Different sizes of nanoparticles.**

However, the chronic effects of this new technology on human health or the environment remain unknown. Recent research indicate that penetrated fabrics, when laundering, release silver nanoparticles into the wash cycle, thus entering wastewater systems and the environment. These nanoparticles endanger the bacteria essential for ecological processes in the environment. Certain studies have shown that nanoparticles can traverse the blood-brain barrier and infiltrate the brain.  nanosilver compositions mentioned earlier have been utilised by researchers and documented in patent literature, nevertheless they persist in the market for an extended duration. In the early 20th century, the commercial distribution of therapeutic nanoscale silver colloids, referred to by many trade names like Collargol, Argyrol, and Protargol commenced, and utilisation became prevalent over a span of 50 years.

## APPLICATION OF SILVER NANOPARTICLES

In the healthcare sector, silver nanoparticles (AgNPs) have been widely utilised as antibacterial agents in food preservation, textile coating, and various environmental applications. The evidence on silver toxicity remains ambiguous despite decades of utilisation. Several recognised organisations, including the US FDA, EPA, Japan's SIAA, Korea's Testing and Research Institute for Chemical Industry, and FITI testing and research institutes, were authorised to manufacture products utilising AgNPs. Furthermore, it promoted the utilisation of AgNPs in various textile materials by the textile sector. Silver nanocomposite fibres, featuring silver nanoparticles integrated into the fabric, have been developed in this context[15]. Nanoscale sensors exhibiting accelerated response times and reduced detection thresholds have been integrated with the electrochemical characteristics of AgNPs. Manno et al. electrodeposited silver nanoparticles onto alumina plates including gold micropatterned electrodes, demonstrating significant sensitivity to hydrogen peroxide. Nanoparticles have distinct catalytic behaviour compared to the chemical characteristics of larger materials. The optical characteristics of a metallic nanoparticle primarily rely on surface plasmon resonance, wherein free electron oscillations, denoted as Plasmon, transpire into the metal nanomaterial. The dimensions and morphology of the nanoparticle, the metallic species, and the surrounding medium are recognised to influence the Plasmon resonant peaks and linewidths. A novel form of optical data storage may utilise nanoclusters consisting of two to eight silver atoms. Moreover, biolabels and electroluminescent displays may utilise fluorescence emissions from clusters[17]. Nanotechnology is advancing swiftly by generating nanoproducts and nanoparticles (NPs) that exhibit unique and size-dependent physico-chemical properties, markedly distinct from those of bigger materials. The innovative features of these nanoparticles have been utilised in several applications, including pharmaceuticals, cosmetics, renewable energy, environmental remediation, and biomedical devices. Ag-NPs possess distinct physicochemical features, including strong electrical and thermal conductivity, enhanced surface Raman scattering, chemical stability, catalytic activity, and nonlinear optical behaviour. These attributes render them potentially valuable in inks, microelectronics, and medical imaging. Moreover, AgNPs have extensive bactericidal and fungicidal properties, rendering them highly sought after in numerous consumer products, including plastics, soaps, pastes, food, and textiles, hence enhancing their market value.

## ANTI-MICROBIAL USE OF SILVER NANOPARTICLES

Single nucleotide polymorphisms (SNPs) are extensively utilised in cosmetic and hygiene products due to their potent antibacterial effects [21,22]. Conversely, materials containing silver may be utilised for bacterial eradication. Despite their prevalent application, the mechanism of action of nanoNPs as bactericides in aqueous solutions and solid media remains poorly understood. The emission of silver ions from the nanostructured surface induces antibacterial activity. Silver nanoparticles (AgNPs) have demonstrated efficacy as a biocide against a wide range of bacteria, including both gram-negative and gram-positive species, many of which are highly hazardous. The capacity of NPs to modify cellular permeability and generate reactive oxygen species correlates with their antibacterial efficacy.[26,27]. The antibacterial efficacy of SNPs extends beyond bacteria and fungi, since they are also efficient against other species, including viruses. Silver fungicides can effectively dismantle fungal cell walls and membranes. Colloidal solutions of silver nanoparticles (SNPs) directly adhered to solid surfaces impede the proliferation of highly multidrug-resistant bacteria, including Staphylococcus aureus, Escherichia coli, Vibrio cholera, and Pseudomonas aeruginosa [33-36]. Research indicates that silver-doped titania nanoparticles are extremely efficacious against Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, and E. coli bacteria. The wound dressing SNP is commercially available and is generally considered safe for human health. The antibacterial efficacy of silver nanoparticles (SNPs) against the oral pathogen Streptococcus mutans was examined and the findings were juxtaposed with those of the dental disinfectant chlorhexidine. The results indicate that the SNPs are more efficacious than chlorhexidine[40].

## EFFECTS OF SILVER NANOPARTICLES ON HUMAN

Air, water, and soil are reacting with nanoparticles released into the environment. This alters the surface features of particles, perhaps resulting in aggregation or modifications in particle charge and other surface attributes. To comprehend particle behaviour in the environment, these effects have been examined in aquatic ecosystems and soil, revealing that the study of nanoparticles and their environments is a complicated endeavour that requires exploration at all levels. To comprehend particle behaviour in the environment, these effects have been examined in aquatic ecosystems and soil, revealing that nanoparticles and their environments constitute a complex that must be investigated at all levels. The ongoing discussion is on the potential toxicity of nanomaterials, which may act as contaminants by hitching a ride on natural organic matter in environments such as soil or water. The degree of exposure for workers involved in nanomaterial manufacturing, certain demographic groups, or the general public must be delineated for nanoparticles manufactured on a wide scale. Several nanomaterials presently belong to this category: silicon dioxide, zinc oxide, silver, titanium dioxide, carbon nanotubes, and cerium dioxide. Research indicates that to comprehend and anticipate toxicological effects at the in vivo level, it is essential to focus on coating and surface features, in addition to the inherent nanotoxicological potential of the naked particle. To ascertain the entry pathways and susceptibility, research indicates that nanoparticles can infiltrate the body through the airways, dermal contact, or ingesting routes[45,46] (refer to Figure-2). The respiratory system serves as the principal pathway for airborne particulate matter to enter the body. Extensive data on ultrafine particles (such as dust, carbon black, and other pollutants) and their impact on the airways and lungs is accessible. Endocytosis of alveolar cells is the primary route for the transport of nanoparticles. From a neurotoxicological perspective, this might be potentially detrimental, as particles would get direct access to the central nervous system through this pathway. The skin is an additional potential pathway for human exposure. Titanium dioxide nanoparticles are commonly utilised in sunscreen formulations and may be absorbed by hair follicles or skin lesions. Given the rising utilisation of nanoparticles as food additives or in food production and packaging, there is apprehension regarding their potential entry into the bloodstream through gastrointestinal absorption. Research has demonstrated that nanoparticle absorption through the gastrointestinal tract is feasible and seems to depend on size. However, further research is essential to enhance understanding of the gastrointestinal absorption of nutrients. Nonetheless, the most concerning factor is that when nanoparticles infiltrate the body and enter the bloodstream, they may gain access to additional organs.

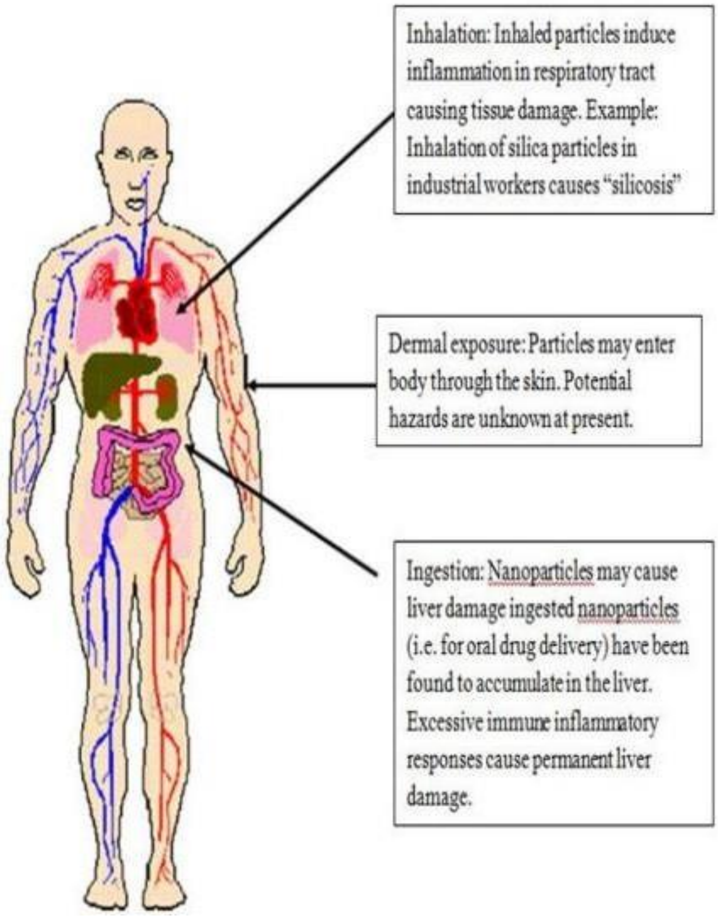


**Figure 2: Entry of Nanoparticles in to the body mainly via the airways, the skin or via ingestion.**

## TOXICITY OF SILVER NANOPARTICLES

Knowledge on the toxicity of these minute chemicals is limited, however their impacts are becoming evident. Certain nanoparticles have demonstrated toxicity within biological systems in multiple investigations. Consequently, it is imperative to undertake study in both the internal and external environments; external analyses may inform the inside investigations. Certain researchers have demonstrated that the majority of nanoparticles can emit reactive oxygen species, leading to oxidative stress and inflammation via the reticuloendothelial system (RES). Acute toxicity induced by nanoparticles has been examined in the oral cavities of rats. The findings indicate that nanoparticle toxicity is contingent upon their size, coating, and chemical composition. Moreover, various organs and tissues have demonstrated susceptibility to the structural effects of nanoparticles. Oxidative stress or preinflammatory cytotoxin activity in the lungs, liver, heart, and brain may correlate with impacts on inflammatory and immunological systems. Prethrombosis and paradoxical effects on cardiac activity may potentially influence the circulatory system. Nanoparticles may induce genotoxicity, carcinogenicity, and teratogenicity. Certain nanoparticles may penetrate the blood-brain barrier and induce neurotoxicity; further research is required. Occupational studies are quite few, and in a limited number of investigations, workers have been subjected to low concentrations of SNPs below the threshold limit values for brief durations[53-55]. Consequently, dependable epidemiological and ecotoxicological research is essential to address this information deficiency. Several physical parameters, like as size, chemical composition, surface area, reactivity, charge, and aggregation propensity, are linked to the toxicity of SNPCs. Smaller particles are recognised as more harmful than larger ones; however, particle size alone does not dictate nanoparticle toxicity. The presence of a substantial quantity of nanoparticles in circulation will enhance macromolecule absorption, facilitating their passage through the intestinal system. Lectin serves as an immunologic agent for coating, perhaps leading to immunosuppression, inflammatory responses, or digestive stimulation. Potential toxicity continues to be a worry with the application of Silver Nanoparticles in various clinical conditions. Hypersensitivity reactions have been seen in a minor percentage of burn victims treated with ionic silver. Silver nanoparticle wound dressings have been utilised in clinical settings for several years, with no reports of systemic toxicity reported from the FDA. The utilisation of silver nanoparticles at low concentrations seems to be safe.

## CONCLUSION

In recent years, nanotechnology has advanced significantly and permeated all scientific disciplines, including medicine. Among several types of nanoparticles, silver nanoparticles (Ag NPs) have garnered the most interest about their prospective applications. Silver nanoparticles (AgNPs) are among the most appealing nanomaterials for commercial uses. Antimicrobials, electrical, and medicinal devices have seen extensive utilisation. AgNPs are among the most appealing nanomaterials for commercial applications. This review offers a thorough examination of AgNPs, focusing on synthesis methods, antibacterial properties, and potential toxicological implications of an AgNP. Progress in nanotechnology has enabled the utilisation of particles measuring only nanometres. In vitro toxicity assessments involving particles sized between 1 and 100 nm are predominantly conducted for SNPs. Short-term research exist within the animal population. Nevertheless, there is limited study about the impact of single nucleotide polymorphisms on human health. Subchronic dermal exposure may result in substantial buildup of SNPs in the liver and lungs. Available animal findings indicate that SNPs induce histological abnormalities in the spleen, liver, and skin. The data unequivocally indicate that the target organs of SNP poisoning include muscles. In certain tissues, colloidal SNPs seem to elicit a harmful reaction that is contingent upon the dosage frequency. Ultimately, to more accurately assess the health risks associated with SNPs, there is a scarcity of rigorously controlled human research on their potential toxicity, necessitating further long-term investigations across a broad spectrum of dosages, ideally incorporating various particle sizes. It is strongly advised to ascertain the influence of shape and particle size in this context. The toxicity profile of the SNPs will be evaluated depending on various routes of administration in future research.

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