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Nanotechnology, Occupational Health and Safety Concerns

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Nanotechnology is the manipulation of matter on a near-atomic scale to produce new structures, materials and devices. Nanoparticles (NPs), the building blocks of nanotechnology, are the objects with at least one dimension smaller than 100 nanometer [1,2]. NPs find numerous applications in many fields, starting with electronics, throughout medicine, cosmetology, and ending with automotive and construction industries [3]. Nanotechnology, nanomedicine and nanotoxicology are complementary disciplines aimed at the improvement of human life. Nanomedicine will develop applications for novel and superior diagnostic, therapeutic and preventive measures. Nanotoxicity provides for the necessary safety assessment of nano-enabled products [4,5]. Exciting achievements based on nanotechnology and nanomedicine await us in the future; yet there are many challenges to get it right and recognize and avoid potential risks associated with these new developments where nanotoxicology will have a crucial role [6].

Concerns have been expressed about risks posed by engineered nanomaterials (ENMs), their potential to cause undesirable effects, contaminate the environment and adversely affect susceptible parts of the population [7,8]. Toxicity of NPs depends on many factors, for example: size, shape, chemical composition, solubility, surface area and surface charge. Risk assessment related to human health, should be integrated at all stages of the life cycle of the nanotechnology, starting at the point of conception and including research and development, manufacturing, distribution, use and disposal or recycling [3]. Fundamentally, risk assessment involves an estimation of the potential for exposure and characterization of hazard. Potential routes of NPs exposure include inhalation, dermal, oral, and in the case of biomedical applications, parenteral. Toxicity resulting from NPs exposure could occur at the various portals of entry, such as the lungs and skin, or at distant sites. Exposure to nanomaterials could occur during their development, manufacture, use, or following disposal [9].

NPs translocation and uptake by the body occurs after inhalation exposure (neuronal uptake, translocation across lung epithelium, and ingestion), oral exposure (ingestion), and dermal exposure depending on the characteristics of the NPs under investigation [9,10]. With the exception of airborne particles delivered to the lung, information on the biological fate of NPs including distribution, accumulation, metabolism, and organ specific toxicity is still minimal [2,11].

Nanosizing of some particulates, increases pathologic and physiologic responses, including inflammation, fibrosis, allergic responses, genotoxicity, and carcinogenicity, and may alter cardiovascular and lymphatic function [10,12-15]. Knowing how the size and physiochemical properties of NPs affect bioactivity is important in assuring that the exciting new products of nanotechnology are used safely [11,16].

A tragic case in point appears to be a recent report about worker exposure to heated polystyrene fumes and polyacrylate NPs in an unventilated confined space for several months, resulting in progressive pulmonary fibrosis, pleural effusions and granuloma formation with fatal outcome [17]. Regardless as to whether the NPs had caused the severe pathology – which is unclear, based on the information provided – holding on to extremely poor industrial hygiene conditions at the workplace was completely irresponsible. Preventing exposure is key, and that can readily be achieved today with appropriate engineering technology and personal protection equipment [6].

Even without being able to perform a quantitative risk assessment for ENMs, due to the lack of sufficient data on exposure, biokinetics and organ toxicity, until we know better it should be made mandatory to prevent exposure by appropriate precautionary measures/regulations and practicing best industrial hygiene to avoid future horror scenarios from environmental or occupational exposures. Similarly, safety assessment for medical applications as key contribution of nanotoxicology to nanomedicine relies heavily on nano-specific toxicological concepts and findings and on a multidisciplinary collaborative approach involving material scientists, physicians and toxicologists [6].

Occupational safety and health (OSH) concerns are receiving considerable attention in nanoscience and nanotechnology research and development. Policymakers and others have urged that research on nanotechnology's EHS implications be developed alongside scientific research in the nanotechnology domain rather than subsequent to applications [18]. Occupational physicians would thus be required to keep abreast and update themselves on toxicological and health and safety developments in this growing industry. There is also the need to look beyond the factory fence to consider safety and environmental impact of NPs containing products at all stages of the life cycle [8,10].

In conclusion, the current knowledge of OSH in nanotechnology includes the following: (i) NPs can be measured using standard measurement methods (respirable mass or number concentration), (ii) workplace exposures to NPs can be reduced using engineering controls and personal protective equipment, and (iii) current toxicity testing and risk assessment methods are applicable to NPs. Yet, to ensure protection of workers' health, research is still needed to develop (i) sensitive and quantitative measures of workers' exposure to NPs, (ii) validation methods for exposure controls, and (iii) standardized criteria to categorize hazard data, including better prediction of chronic effects [2].

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