

Ergonomic Challenges for Nanotechnology Safety and Health Practices

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Introduction

Nanotechnology has been broadly introduced to a wide range of industry fields such as aeronautics, agriculture, architectural design, bio-medical engineering, communication sciences, constructions, environmental science, food production, and information technology over the last decades [1-4]. Nanotechnology has the perspective to radically advance the efficiency of current industries and industrial products and considerable effects on the development of new products in all areas, ranging from disease diagnosis and treatment to environmental remediation. Now, nanotechnologies and nanomaterials are familiar terminologies and commonly applied to the field of industry designs.

Although nanotechnology-based and nanomaterial-based products are generally accepted at the precompetitive stage, an increasing number of products and materials are becoming commercially available. These include nanoscale powders, solutions, and suspensions of nanoscale materials as well as composite materials and devices having nanostructures [5]. Nanoscale products and materials are also increasingly applied to a number of areas such as optoelectronic, electronic, magnetic, medical imaging, drug delivery, cosmetic, catalytic, and materials applications.

Nanomaterials often show unique physical and chemical properties that impart specific characteristics to making engineered materials. But, little is known about what effects from such exclusive features may have on people's safety and health issues. The current literature has reported that the physicochemical characteristics of nanomaterials can influence their effects on biological systems [6]. These attributes include chemical properties, the degree of agglomeration, oxidant generation potential, particle size, shape, surface area, and solubility [7]. Until the results from research studies can fully clarify the characteristics of nanoparticles that may pose health and safety risks, precautionary measures are warranted.

Because of the wide range of possible applications of nanotechnology, continued assessment of the potential health and safety risks associated with exposure to nanomaterials is essential to safeguard their secure handling [8]. There is also an insufficient emphasis on application of nanomaterials in the domain of design ergonomics [9]. Therefore, ergonomists should make an effort to aware on applications of nanomaterials in the field of design ergonomics and safety and health implications of nanotechnologies in their operations.

Nanotechnology Safety and Ergonomic Concerns

Nanotechnology and its concerns

Nanotechnology is broadly defined by size. It mainly deals with particles of size less than 100 nm at least in one dimension [9,10].

These tiny-sized substances are known as nanomaterials and could be either natural or anthropogenic in their origins [9]. Nanotechnology involves the manipulation of matter on nanometer scales and offers the potential for unparalleled improvements in many different areas [11]. The capability to operate matters at the atomic or molecular level makes it possible to form new materials, structures, and devices that develop exclusive physical and chemical properties related to nanoscale structures.

Developments in the nanotechnology have been progressed quicker than comprehending on the conceivable significances of their side effects. Thus, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nanomaterials [12]. Workers within the nanotechnology-related industries have the potential to be exposed to exclusively engineered materials with nano-scale sizes and shapes and physicochemical properties. Minimal information is currently available on dominant exposure routes, potential exposure levels, and material toxicity of nanomaterials [13].

This fact indicates that our knowledge on the nanomaterial is not well understood and capability to prevent hazards from the nanotechnology is limited as well. Because of extremely small sizes and characteristics of the nanomaterial, the nanoparticles could translocate to the brain or other organs of the employee. Hence, effectual solutions for the exposure control should comprise a right hazard measurement of the pretentious work areas.

Safety and health issues of nanotechnology

Nanotechnologies and nanomaterials are rapidly emerging in many fields [9,14]. With large increases in demands, implications of nanomaterials on human health-related and safety-related issues need to be reviewed [15]. The recent literature reports that nanomaterials and nanoparticles have direct adverse health effects such as neuronal toxicity [16] and cardiopulmonary diseases [17]. Before applying nanomaterials, therefore, we should have thorough knowledge on nanoparticles-induced hazards and on how to handle them safely [15,16,18].

Because of their unique physicochemical properties, in many cases, it is difficult to assess toxic impacts of nanomaterials on biological systems [9]. However, workers may be constantly exposed to nanoparticles in different phases of working processes starting from manufacturing to packaging [9]. For instance, nanoparticles can enter into the human body through different routes [9] such as inhalation [19], ingestion [20], dermal route [21], and parenteral route [22]. Hence, prerequisite actions are necessary to create healthy and safe working environments. These arrangements should include supplying ventilation systems with fume hoods and high-efficiency air filtration,

personal protecting equipment, and product stewardship policies that workers and managers can understand [13].

With such direct actions, identification of potential risks, development of novel approaches for risk assessment, and management to protect workers from any recognized adverse health and safety effects also should be preceded to protect workers working with nanomaterials. By implementing these solutions into safety and health management programs, the nanotechnology industry can accompany such inspiring new technologies to the marketplace whilst guard the workers, publics, and environments.

The safety of nanotechnology has been continuously tested. There has been some as yet unresolved debate on the potential toxicity of a specific type of nanomaterial which has been associated with tissue damage in animal studies [23]. However, the majority of available data indicate that there is nothing uniquely toxic about nanoparticles as a class of materials. Whether actual or perceived, the potential health and safety risks associated with the manufacture and use of nanomaterials must be carefully studied in order to advance our understanding of this field of science and to realize the significant benefits that nanotechnology has to offer society, such as for cancer research, diagnostics, and therapy [23].

Ergonomic affairs for nanotechnology

Ergonomics is a multidisciplinary science which deals with designing or arranging workplaces, products, equip or devices, and systems so that it can fit the people or workers, their movements and cognitive functions in relation to their work performance [9,24-28]. Ergonomics is actually a design-driven discipline so that improvements in all the domains of nanotechnologies and nanomaterials seem to be possible by the application of ergonomic design principles.

Nanotechnology may produce remarkable new types of materials with unique properties that can be harnessed by developing new concepts of support, adjustment, aesthetics, and comfort [9]. A recent study stated that nanotechnological revolution would profoundly affect not only our daily lives but also the science and practice of human factors/ergonomics [29]. Thus, nanotechnology and nanomaterials seem to be beneficial in the creation of both sustainable and ergonomic designs.

Moreover, workers and/or people who interact with nanomaterials and nanoparticles may expose to potential health and safety risks. This seems to be an emerging issue which can be an opportunity for ergonomists to take over those typical challenges because ergonomics, due to its interdisciplinary nature, can play a vital role to solve these difficulties associated with nanotechnological development [9].

To learn more about managing nanotechnology exposures in the workplace, as well as other important controls as handling or working with nanotechnologies and nanomaterials, ergonomic approaches would be effective to improve safety and health issues in the nanotechnology industry. Specifically, it can be expected that ergonomic applications and trials in the field of nanotechnology with special emphasis on occupational safety and health would be one of the future directions of research to ergonomists and ergonomic society.

Conclusion

The emergence of nanotechnology and nanomaterials is generally considered to be a major technological revolution in many fields [30].

As a result, nanotechnologies and nano-related techniques have been applied to a range of industries such as aerospace, agriculture, car manufacturing, communication and information engineering and technology, construction, environmental science, healthcare, medicine, sports, and textile industries [9].

Utilization of devices and/or gears of extremely small dimensions (nanoscale) seem to appear as a new challenge for the man-machine compatibility. Thus, ergonomic interventions become recognizable solutions for designing optimal interfaces in the nanotechnology [9]. To date, however, there have only been limited studies on risk management practices, neither in manufacturing nor in the handling of nanomaterials within industrial units [30].

Although most of the important operations of nanomaterials in diverse technology and industry fields are well known today, applications of nanotechnology in the field of design with the incorporation of ergonomic principles are less discussed [9]. Future research needs to explore new ideas on how to apply the knowledge of nanotechnology in the field of design with appropriate consideration of ergonomic values. For example, increasing work efficiency, performance, and productivity by regulating temperature and reducing cognitive impedance, ensuring occupational safety, and providing health hazards measures using nanomaterials may require in-depth investigations. Therefore, it can be expected that ergonomists take this opportunity to apply diverse ergonomic applications and trials in the field of nanotechnology and nanomaterials with special emphasis on safety and health to develop a safer and healthier society and workplace.

References

1. Michael FA, Paulo JF, Daniel LS (2009) Nanomaterials and Nanotechnologies: An Overview. *Nanomaterials*, In: *Nanotechnologies and design: an introduction for engineers and architects*. Butterworth-Heinemann 1: 1-16.
2. Arivalagan K, Ravichandran S, Rangasamy K, Karthikeyan E (2011) Nanomaterials and its potential applications. *Int J ChemTech Re* 3: 534-538.
3. Mehta MD (2011) Understanding advances in nanotechnology: minimizing risks and maximizing benefits with application of the appropriate governance framework. *Int J Nanotechnol Mol Comp* 3: 1-11.
4. Mousavi SR, Rezaei M (2011) Nanotechnology in agriculture and food production. *J Appl Environ Biol Sci* 1: 414-419.
5. Eastlake A, Hodson L, Geraci C, Crawford C (2012) A critical evaluation of material safety data sheets (MSDSs) for engineered nanomaterials. *Chem Health Saf* 19: 1-8.
6. Navya, PN, Daima HK (2016) Rational engineering of physicochemical properties of nanomaterials for biomedical applications with nanotoxicological perspectives. *Nano Convergence* 3:1.
7. National Institute for Occupational Safety and Health (2009) Approaches to safe nanotechnology managing the health and safety concerns associated with engineered nanomaterials. NIOSH 2009-125.
8. National Institute of Environmental Health Sciences (2016). *Nanomaterials*.
9. Chowdhury A, Sanjog J, Reddy SM, Karmakar S (2012) Nanomaterials in the field of design ergonomics: present status. *Ergon* 55: 1453-1462.
10. National Nanotechnology Initiative (2016) What is Nanotechnology.
11. Elnashaie S, Danafar F, Hashemipour H (2015) From Nanotechnology to Nanoengineering. In: *Nanotechnology for Chemical Engineers*. Springer Science Business Media Singapore. Chapter 2: 79-178.
12. Buzea C, Pacheco II, Robbie K (2007) Nanomaterials and nanoparticles: Sources and toxicity. *Biointerphases* 2: MR17-MR71.
13. National Institute for Occupational Safety and Health (2016) *Nanotechnology. Workplace Safety and Health Topics*, The National Institute for Occupational Safety and Health (NIOSH).

14. Caruthers SD, Winkline SA, Lanza GM (2007) Nanotechnological applications in medicine. *Curr Opin Biol* 18: 26-30.
15. Sequeira R, Genaidy A, Weckamn G, Shell R, Karwowski W, et al. (2008) Health effects of nanomaterials: a critical appraisal approach and research to practice. *Hum Factors Ergon Manuf* 18: 293-341.
16. Boyes WK, Chen R, Chen C, Yokel RA (2012) The neurotoxic potential of engineered nanomaterials. *Neurotoxicology* 33: 902-910.
17. Maudgalya T, Genaidy A, Weckamn G, Shell R, Karwowski W, et al. (2008) A critical appraisal of epidemiological studies investigating the effects of ultrafine particles on human health. *Hum Factors Ergon Manuf* 18: 358-373.
18. Green CJ, Ndegwa S (2011) Nanotechnology: a review of exposure, health risks and recent regulatory developments. National Collaborating Centre for Environmental Health.
19. Jaques PA, Kim CS (2000) Measurement of total lung deposition of inhaled ultrafine particles in healthy men and women. *Inhal Toxicol* 12: 715-731.
20. Hillyer JF (2001) Gastrointestinal persorption and tissue distribution of differently sized colloidal gold nanoparticles. *J Pharm Sci* 90: 1927-1936.
21. Rouse JG, Yang Y, Rasmussen JP, Barron AR, Riviere NA (2007) Effects of mechanical flexion on the penetration of fullerene amino acid-derivatized peptide nanoparticles through skin. *Nano Lett* 7: 155-160.
22. Murashov V, Howard J (2007) Biosafety, occupational health and nanotechnology. *Appl Biosaf* 12: 158-167.
23. National Cancer Institute (2016) Safety of Nanotechnology. National Institutes of Health, US Department of Health and Human Services. USA.
24. Kim IJ (2015) Knowledge Gaps and Research Challenges in the Contemporary Ergonomics. *J Ergon* 5: 2.
25. Kim IJ (2016) Safety and Health Practices in Food Industry and Ergonomic Interventions. *J Ergon* 6:1.
26. Kim IJ (2016) Accidents and Accident Prevention in the Agricultural Industry: Ergonomic Engagement. *J Ergon* 6: 3.
27. Kim IJ (2016) Ergonomic Involvement for Occupational Safety and Health Improvements in the Oil and Gas Industry. *J Ergon* 6: 3.
28. Kim IJ (2016) Cognitive Ergonomics and Its Role for Industry Safety Enhancements. *J Ergon* 6: 4.
29. Karwowski W (2006) From past to future: building a collective vision for HFES 2020+. *Hum Factor Ergon Soc Bul* 49: 1-2.
30. Catherine LAllain C, Caroly SS, Drais E (2014) Areas of discussion about work, resources for prevention of risks related to nanomaterials. International Conference on Safe production and use of nanomaterials, Nanosafe 2014, Session 11 Risk Management 18-20, Grenoble, France.