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*RESEARCH ARTICLE*

# Worldwide Nanotoxicology Research Productivity and Contribution of Turkey

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***Worldwide Nanotoxicology Research Productivity and Contribution of Turkey***

***SUMMARY***

*Bibliometric analysis is increasingly used to investigate the quantity and quality of scientific publications in many research fields worldwide. The aim of this study was to evaluate the worldwide research productivity and the status of Turkey in the field of nanotoxicology by bibliometric analysis and to bring an insight into the nanotoxicology research. The Web of Science database was searched to identify nanotoxicology articles published between 1945 and 2018 (all years). Publication count, average citation, h-index and number of publications per million population (PmP) were investigated to determine the contributions of countries. Also, ULAKBIM National Database was searched to identify nanotoxicology research productivity in ULAKBIM indexed journals between 1963 and 2018 (all years). A total of 18,297 articles were identified in the Web of Science database. World nanotoxicology publications were increased significantly between this time period ($p<0.05$). The United States of America (USA) was the most productive country with 4827 articles (26.3% of total) followed by China with 4730 articles (25.8% of total) and India with 1268 articles (6.9 % of total). Turkey was ranked 21st with 266 articles (1.4 %). According to average citations per item and h-index, USA was also in the first place. There were 8 articles relating to nanotoxicology in the ULAKBIM National Databases but only 3 of them were research articles. The number of articles in nanotoxicology research area significantly increase from 1945 to 2018 ($p<0.05$). It was found that nanotoxicology publications were positively affected by gross domestic product (GDP) per capita and research foundation both qualitatively and quantitatively.*

***Key Words:*** *Anthranoids, phytoestrogen, docking, drug discovery, natural compound, estrogen*

***Dünyada Nanotoksikoloji Araştırma Üretkenliği ve Türkiye'nin Katkısı***

***ÖZ***

*Bibliyometri, dünya çapında pekçok araştırma alanında bilimsel çalışmaların nitelik ve niceliksel olarak incelenmesi için giderek artan bir şekilde kullanılmaktadır. Bu çalışma, bibliyometrik yöntemleri kullanarak, nanotoksikoloji alanında dünya çapında araştırma üretkenliğini ve Türkiye'nin katkısını değerlendirmeyi ve nanotoksikoloji araştırmalarına ışık tutmayı amaçlamaktadır. Web of Scince veri tabanında, 1945-2018 yılları (tüm yıllar) arasında nanotoksikoloji alanındaki çalışmalar araştırılmıştır. Ülkelerin katkısı, yayın sayısı, ortalama atıf sayısı, h-index ve bir milyon nüfus başına yayın sayısı kriterlerine göre değerlendirilmiştir. Ayrıca ULAKBİM Ulusal Veritabanı da 1963-2018 yıllarını (tüm yıllar) kapsayacak şekilde araştırılmıştır. Web of Scince veri tabanında, toplam 18297 makale tespit edilmiştir. Dünyadaki nanotoksikoloji çalışmaları yıllar geçtikte anlamlı olarak artmaktadır ($p<0.05$). Amerika Birleşik Devletleri (ABD), 4827 makale (% 26,3) ile en üretken ülke olup, onu Çin 4730 makale (% 25,8) ve Hindistan 1268 makale ile (% 6,9) takip etmektedir. Türkiye 266 makale (% 1,4) ile 21.sıradadır. Ortalama atıf sayısında ve h-index sıralamasında ABD yine birinci sıradadır. ULAKBİM Ulusal Veritabanı'nda nanotoksikoloji ile ilgili 8 yayın tespit edilmiş olup bunlardan yalnızca 3 tanesi araştırma makalesidir. 1945 ila 2018 yılları arasında makale sayısı bakımından nanotoksikoloji alanında hızlı bir yükseliş söz konusudur ($p<0.05$). Nanotoksikoloji alanındaki araştırmaları, kişi başına düşen gayri safi milli hasıla ve araştırma destekleri, hem nicelik hem de nitelik yönünden pozitif yönde etkilemektedir.*

***Anahtar Kelimeler:*** *Antranoitler, fitoöstrojen, docking, ilaç keşfi, doğal bileşik, östrojen.*

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## INTRODUCTION

Nanotechnologies are widely recognized recently all over the world and the effect of their use in social and economic spheres must be significant due to its practical potential (Litvinova & Posylkina, 2016). Also, recent developments in nanotechnology have advanced the direction of biomedical applications and the optimization of therapies (Öner, 1983).

It was reported that nano-based products increased 30-fold between 2011 and 2015 and its estimated global market over $1 trillion in 2015 (Vance et al., 2015). Therefore, human and environmental exposure to nanomaterials is already occurring and increase dramatically. This growth in nanotechnology cause concerns regarding their potential adverse effects (Toensmeier, 2004).

Nanotoxicology is interested in the assessment of the toxicological properties of nanoparticles (NPs) with the intention of determining whether (and to what extent) they may pose an environmental or societal threat. In recent years, increasing data demonstrated that NPs could induce toxicity and genotoxicity via different exposure routes. NPs can cause an induction of reactive oxygen species (ROS) which can induce oxidative stress and may lead to cytotoxicity, DNA damage, and other effects. Although nanotoxicology researches have grown dramatically over the past decade, studies investigating the environmental fate, transport, and toxicity of a variety of nanomaterials are still lacking (Bacanlı & Basaran, 2014; Walters, Pool, & Somerset, 2016). It has been emphasized that nanomedicine and nanotoxicology are two sides of the same coin. Intentional enhancement with therapeutic and diagnostic goals (theranostic nanomedicine) or unintentional (toxicology) toxicity of nanomaterials may exploit the same mechanisms and affect identical metabolic pathways (Shvedova, Pietroiusti, & Kagan, 2016).

The word "bibliometrics" has been derived from the Latin and Greek words "biblio" and "metrics" which refer to the application of mathematics to the study of bibliography. Bibliometric analysis is useful in the evaluation of the quantity and also the quality of research in interested field. This type of research can help to provide an insight into the dynamics of the field such as quality and productivity in a country or region and provide useful indicators of scientific productivity. Besides, it shows the most productive authors, institutions, and locations. The scientific papers promote knowledge sharing but the quality and quantity of research contributions vary different countries because of the different developmental status, healthcare systems and research organizations (Langer, Díaz-Olavarrieta, Berdichevsky, & Villar, 2004). The number of articles published by a country is an indicator of its contributions to literature, and bibliometric analysis is often used to assessment of publications both qualitatively and quantitively. There are a number of studies which analyse the contributions of different countries in different fields of medicine (Çatal, Akman, Şükür, & Azboy, 2018; Hauptman, Chow, Martin, & Itagaki, 2011; Michalopoulos & Falagas, 2005; Vergidis, Karavasiou, Paraschakis, Bliziotis, & Falagas, 2005). But to the best of our knowledge, no previous studies that investigated global scientific productivity and contribution of Turkey in the field of nanotoxicity. This study aimed to analyze the quantity and quality of worldwide publications and the contribution of Turkey between 1945 and 2018 to determine the current status of global scientific productivity in the nanotoxicology area.

## MATERIALS AND METHODS

Science Citation Index Expanded (SCI-E) and Emerging Sources Citation Index (E-SCI) databases accessed through Web of Science (WoS) (Thomson Reuters, Philadelphia, PA, USA) were used for this study. The WoS is the world's leading database for citation and other academic impact information and it widely used in the studies on scientific productivity (Li, Rollins, & Yan, 2018). A computerized literature search was carried out using this database on March 27, 2019. Following search terms: "nanotoxicology" or ''nanomedicine" or ''nanotoxicity" in all fields was used and 1945-2018 (all years) was selected as time span.

24,999 articles were reviewed to analyze research volume and productivity in the field of nanotoxicology between 1945 and 2018. Of those, 6,702 articles were excluded for the publication type i.e. review, meeting abstract, editorial material, news item, proceedings paper, correction, book chapter, letter, retracted publication, retraction, biographical item. Finally, 18,297 articles were included in this study.

Citation reports of the countries, average citations per item, the number of publications per million population (PmP), and h-index were determined. PmP was calculated by dividing the total number of publications by the population of each country. Gross domestic product (GDP) per capita of the countries were listed according to The World Bank data.

The number of articles from Turkey, the year of publication, the journal which the article was published in and publishing institutions were recorded. The

publishing institutions were determined according to the corresponding author. The articles were divided into two groups regarding two equal time periods (01.01.2000-31.05.2009) and (01.06.2009-31.12.2018), starting with the first nanotoxicology article which published in 2000, to investigate the increase of the number of published articles over time. At the same time, ULAKBIM National Databases (ULAKBİM TR DİZİN) was scanned to assess nanotoxicology researches in national journals between the years of 1963 and 2018 (all years). Same search terms with WoS analyze were used.

Analysis of data was performed using the computer program SPSS 23.0 for Windows (SPSS Inc, Chicago, IL, USA). This study included all published articles and not merely a representative sample. Therefore, the descriptive analysis was primarily used. The distribution of the data was checked for normality using the Kolmogorov–Smirnov test. The homogeneity of the variance was verified by the Levene test. The differences among the groups with normal distribution were evaluated by Student's t-test for two independent groups. The differences among the groups without a normal distribution were evaluated by Mann–Whitney U for two groups. The magnitude of the linear relationship was calculated by Pearson and Spearman correlation analysis. $p<0.05$ was considered statistically significant.

## RESULTS

18,297 nanotoxicology papers were published in SCI-E and E-SCI listed journals between 1945 and 2018 worldwide but there was no publication before 2000. There was a significant increase in the number of nanotoxicology publications worldwide as well as in Turkey. The number of articles on nanotoxicology increased from only 2 articles in 2000 to 3042 articles in 2018 ($p < 0.05$) (Figure 1).

There was an increase of 152,000 %, an average of 8,000 % per year in the number of articles. The highest growth in the number of articles was recorded in 2018 (n=3042). Whereas, the number of articles on nanotoxicology published in Turkey increased from 1 article in 2008 to 39 articles in 2018. Thus, there was an increase of 3,700 % an average of 370 % per year. The highest growth in the number of articles was recorded in 2016 (n=58), but after that publication number was decreased in Turkey (Figure 1).

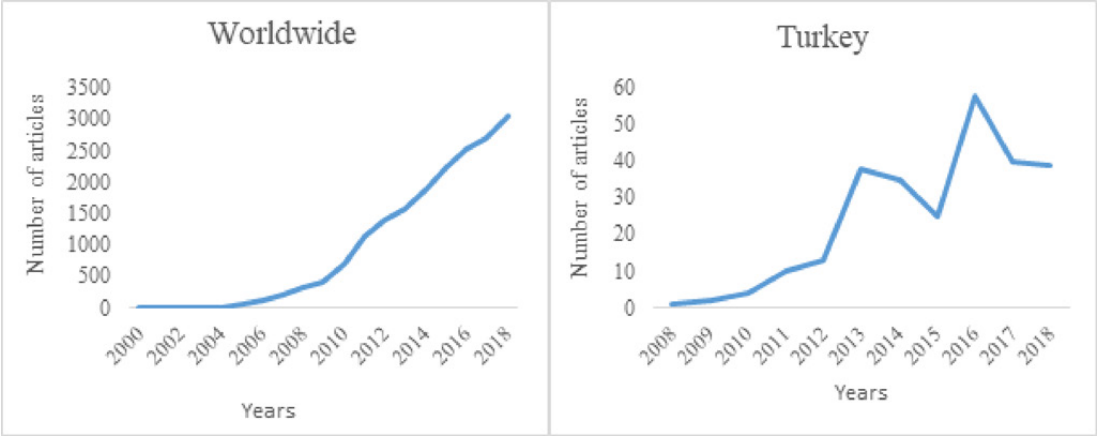


**Figure 1.** A total number of nanotoxicology articles and publication years

The United States of America (USA) was the most productive country with 4827 articles (26.3 %) followed by China with 4730 articles (25.8 %) and India with 1268 articles (6.9 %). Turkey was ranked 21st with 266 articles (1.4 %). The USA was also in the first place according to h-index with 157 points and average citations per item with 33.8. Whereas in the first place according to PmP was Singapore followed by Denmark and Switzerland. Turkey ranks last by the h-index and the average citations per item, and 22nd according to PmP (Table 1).

**Table 1.** Top 25 countries according to the number of nanotoxicology publications

| Countries | Records | % of 18297 | h-index | Average citations per item | Population | GDP per capita (US $) | Number of publications per million ($\times 10^6$) |
|---|---|---|---|---|---|---|---|
| USA | 4827 | 26.381% | 157 | 33.84 | 329,093,110 | 62,517.5 | 14.6 |
| China | 4730 | 25.851% | 108 | 18.79 | 1,420,062,022 | 9,633.1 | 3.3 |
| India | 1268 | 6.930% | 73 | 20.12 | 1,368,737,513 | 2,016.2 | 0.9 |
| Italy | 1065 | 5.821% | 64 | 21.18 | 59,216,525 | 34,349.2 | 17.9 |
| Germany | 929 | 5.077% | 74 | 27.64 | 82,438,639 | 48,669.6 | 11.2 |
| Spain | 889 | 4.859% | 53 | 18.01 | 46,441,049 | 31,059.5 | 19.1 |
| South Korea | 813 | 4.443% | 55 | 23.6 | 51,339,238 | 32,046.0 | 15.8 |
| Iran | 769 | 4.203% | 45 | 12.18 | 82,820,766 | 5,222.0 | 9.2 |
| England | 760 | 4.154% | 66 | 27.24 | 66,860,948 | 42,260.9 | 11.3 |
| France | 722 | 3.946% | 62 | 22.4 | 65,480,710 | 42,930.8 | 11.0 |
| Japan | 675 | 3.689% | 53 | 21.26 | 126,854,745 | 40,105.8 | 5.3 |
| Canada | 586 | 3.203% | 59 | 31.73 | 37,279,811 | 46,733.0 | 15.7 |
| Taiwan | 458 | 2.503% | 44 | 17.96 | 23,758,247 | 25,534.3 | 19.2 |
| Brazil | 435 | 2.377% | 32 | 12.96 | 212,392,717 | 9,126.9 | 2 |
| Singapore | 395 | 2.159% | 58 | 29.26 | 5,868,104 | 61,230.2 | 67.3 |
| Australia | 382 | 2.088% | 42 | 20.44 | 25,088,636 | 56,698.1 | 15.2 |
| Denmark | 331 | 1.809% | 46 | 24.27 | 5,775,224 | 61,227.0 | 57.3 |
| Netherlands | 328 | 1.793% | 47 | 26.63 | 17,132,908 | 52,931.2 | 19.1 |
| Saudi Arabia | 328 | 1.793% | 37 | 17.96 | 34,140,662 | 23,186.7 | 9.6 |
| Switzerland | 304 | 1.661% | 46 | 27.68 | 8,608,259 | 83,583.0 | 35.3 |
| Turkey | 266 | 1.454% | 22 | 9.43 | 82,961,805 | 8,715.5 | 3.2 |
| Egypt | 234 | 1.279% | 27 | 11.29 | 101,168,745 | 2,572.4 | 2.3 |
| Poland | 229 | 1.252% | 29 | 17.43 | 38,028,278 | 14,468.8 | 6 |
| Portugal | 223 | 1.219% | 33 | 18.81 | 10,254,666 | 23,175.8 | 21.7 |
| Belgium | 209 | 1.142% | 36 | 22.65 | 11,562,784 | 46,978.7 | 18 |

Average citations per item were also strongly correlated with GDP per capita, PmP, and h-index ($p<0.01$). GDP per capita was strongly correlated with PmP ($p< 0.01$).

The most productive institution that published the highest number of articles worldwide is the Chinese Academy of Sciences with 575 articles (3.1%) between these time periods. Hacettepe University is the most productive institution in Turkey with 66 articles. The top 5 institutions that published the highest number of articles in this field are listed in Table 2.

**Table 2.** The distribution of articles by institutions

| World | | | Turkey | | |
|---|---|---|---|---|---|
| **Institutions** | **Record Count** | **% of 18,297** | **Organisation** | **Record Count** | **% of 266** |
| Chınese Acad Sci. | 575 | 3.143% | Hacettepe Univ. | 66 | 24.812% |
| Shanghai Jiao Tong Univ. | 304 | 1.661% | Gazi Univ. | 32 | 12.030% |
| Sichuan Univ. | 222 | 1.213% | Ege Univ. | 31 | 11.654% |
| Northeastern Univ. | 198 | 1.082% | Ankara Univ. | 27 | 10.150% |
| Fudan Univ. | 197 | 1.077% | Aksaray Univ. | 13 | 4.887% |
| Nanyang Technol Univ. | 193 | 1.055% | Kırıkkale Univ. | 12 | 4.511% |
| Univ Tehran Med. Scİ. | 190 | 1.038% | Ataturk Univ. | 9 | 3.383% |
| Zhejiang Univ | 189 | 1.033% | Adnan Menderes Univ. | 8 | 3.008% |
| Natl Unıv Singapore | 178 | 0.973% | Istanbul Univ. | 8 | 3.008% |
| Harvard Univ. | 177 | 0.967% | Middle East Tech. Univ. | 8 | 3.008% |

International Journal of Nanomedicine published the most nanotoxicology articles in this period while Artificial Cells Nanomedicine and Biotechnology published the most nanotoxicology articles originated from Turkey. Top 10 journals which published the most articles are listed in Table 3.

**Table 3.** The distribution of articles by journals

| WORLDWIDE | | | TURKEY | | |
|---|---|---|---|---|---|
| **Journal name** | **Record Count** | **% of 18,297** | **Journal name** | **Record Count** | **% of 266** |
| International journal of nanomedicine | 3.913 | 21.386% | Artificial cells nanomedicine and biotechnology | 140 | 52.632% |
| Nanomedicine nanotechnology biology and medicine | 1.593 | 8.706% | International journal of nanomedicine | 22 | 8.271% |
| Artificial cells nanomedicine and biotechnology | 1.129 | 6.170% | Journal of nanoparticle research | 12 | 4.511% |
| Nanomedicine | 1.055 | 5.766% | Nanomedicine | 10 | 3.759% |
| Nanotoxicology | 813 | 4.443% | Iet nanobiotechnology | 5 | 1.880% |
| Journal of nanoparticle research | 458 | 2.503% | Nanotoxicology | 5 | 1.880% |
| Acs nano | 365 | 1.995% | Nanomedicıne nanotechnology biology and medicine | 4 | 1.504% |
| Bıomaterials | 288 | 1.574% | Acs nano | 2 | 0.752% |
| Journal of controlled release | 225 | 1.230% | Biomacromolecules | 2 | 0.752% |
| Nanoscale | 212 | 1.159% | Bulletin of environmental contamination and toxicology | 2 | 0.752% |

The author with the greatest number of nanotoxicology publications was Zhang Y. (n=180) followed by Wang J. (n=159) and Wang Y. (n=155). In Turkey, Denizli A. (n=16) was the most productive author followed by Piskin E. (n=11) and Denkbas E.B. (n=8).

**Table 4.** The distribution of articles by authors

| World | | | Turkey | | |
|---|---|---|---|---|---|
| Author | Record Count | % of 18,297 | Authors | Record Count | % of 266 |
| Zhang Y | 180 | 0.984 % | Denizli A | 16 | 6.015% |
| Wang J | 159 | 0.869 % | Piskin E | 11 | 4.135% |
| Wang Y | 155 | 0.847 % | Denkbas EB | 8 | 3.008% |
| Liu Y | 152 | 0.831 % | Turk M | 8 | 3.008% |
| Webster TJ | 142 | 0.776 % | Akgol S | 7 | 2.632% |
| Li Y | 135 | 0.738 % | Yılmaz H | 7 | 2.632% |
| Chen Y | 122 | 0.667 % | Baydemir G | 6 | 2.256% |
| Zhang L | 106 | 0.579 % | Kılıc E | 6 | 2.256% |
| Li J | 105 | 0.574 % | Elcin YM | 5 | 1.880% |
| Liu J | 97 | 0.530 % | Gencer N | 5 | 1.880% |

National Natural Science Foundation of China (12.98 %) was the first when funding agencies of the nanotoxicology studies were ranked. It was followed by the National Institutes of Health (NIH) with a different spelling (totally 5.85 %). In Turkey, Scientific and Technologıcal Research Council of Turkey (TUBITAK) with a different spelling (totally 17.29 %), was the first funding agency and followed by Gazi Unıversity Research Fund (Table 5).

**Table 5.** The distribution of articles by funding agencies

| World | | | Turkey | | |
|---|---|---|---|---|---|
| Funding Agencies | Record Count | % of 18,297 | Funding Agencies | Record Count | % of 266 |
| National Natural Science Foundation of China | 2.376 | 12.986% | Scientific and Technological Research Council of Turkey Tubitak | 19 | 7.143% |
| NIH | 641 | 3.503% | Scientific and Technological Research Council of Turkey | 11 | 4.135% |
| National Institutes of Health | 431 | 2.356% | Tubitak | 11 | 4.135% |
| National Science Foundation | 378 | 2.066% | Gazı University Research Fund | 7 | 2.632% |
| Fundamental Research Funds for the Central Universities | 279 | 1.525% | Turkısh Academy of Sciences | 6 | 2.256% |
| Nsf | 225 | 1.230% | Tubitak the Scientific and Technological Research Council of Turkey | 5 | 1.880% |
| National Basic Research Program of China | 204 | 1.115% | Turkish Academy of Sciences Tuba | 4 | 1.504% |
| National Basic Research Program of China 973 Program | 170 | 0.929% | Turkish Academy of Sciences Tuba Ankara Turkey | 4 | 1.504% |
| European Union | 157 | 0.858% | Ankara Unıversity Research Fund | 3 | 1.128% |
| China Postdoctoral Science Foundation | 154 | 0.842% | Ege University | 3 | 1.128% |

Table 6 presents a list of 10 most cited articles worldwide and in Turkey. The first article in the world ranking was published in 2007 and cited 2201 times. While the first article in the Turkey ranking was published in 2010 and cited 251 times.

**Table 6.** The most cited 10 nanotoxicology articles in the world and Turkey

| **World** | | |
|---|---|---|
| **Title** | **Times cited** | **Year** |
| Antimicrobial effects of silver nanoparticles | 2,201 | 2007 |
| Nanoparticle-mediated cellular response is size-dependent | 1,574 | 2008 |
| DNA targeting specificity of RNA-guided Cas9 nucleases | 1,566 | 2013 |
| Elucidating the mechanism of cellular uptake and removal of protein-coated gold nanoparticles of different sizes and shapes | 1,312 | 2007 |
| Comparison of the Mechanism of Toxicity of Zinc Oxide and Cerium Oxide Nanoparticles Based on Dissolution and Oxidative Stress Properties | 1,295 | 2008 |
| Nanoparticles in medicine: Therapeutic applications and developments | 1,262 | 2008 |
| Reconstituting Organ-Level Lung Functions on a Chip | 1,228 | 2010 |
| Principles of nanoparticle design for overcoming biological barriers to drug delivery | 1,169 | 2015 |
| Biocompatibility of gold nanoparticles and their endocytotic fate inside the cellular compartment: A microscopic overview | 973 | 2005 |
| Multifunctional polymeric micelles as cancer-targeted, MRI-ultrasensitive drug delivery systems | 917 | 2006 |
| **Turkey** | | |
| **Title** | **Times cited** | **Year** |
| Conjugated polymer nanoparticles | 251 | 2010 |
| Cellphone-Based Hand-Held Microplate Reader for Point-of-Care Testing of Enzyme-Linked Immunosorbent Assays | 133 | 2015 |
| In vivo biosensing via tissue-localizable near-infrared-fluorescent single-walled carbon nanotubes | 131 | 2013 |
| Resveratrol-loaded solid lipid nanoparticles versus nanostructured lipid carriers: evaluation of antioxidant potential for dermal applications | 116 | 2012 |
| Synthesis of magnetic core-shell Fe3O4-Au nanoparticle for biomolecule immobilization and detection | 114 | 2010 |
| A Nanomedicine Transports a Peptide Caspase-3 Inhibitor across the Blood-Brain Barrier and Provides Neuroprotection | 92 | 2009 |
| Antileishmanial effect of silver nanoparticles and their enhanced antiparasitic activity under ultraviolet light | 67 | 2011 |
| Genotoxic analysis of silver nanoparticles in Drosophila | 58 | 2011 |
| Preparation and characterization of poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBHHX) based nanoparticles for targeted cancer therapy | 41 | 2011 |
| RGDS-functionalized polyethylene glycol hydrogel-coated magnetic iron oxide nanoparticles enhance specific intracellular uptake by HeLa cells | 39 | 2012 |

There were 7 articles relating to nanotoxicology in the ULAKBIM National Databases between 1963 and 2018, and 5 of them were review articles and 3 of them were original research. These 3 articles were published in Turkish Journal of Biology, Afyon Kocatepe Üniversitesi Journal of Sciences and Engineering and Journal of the Faculty of Veterinary Medicine, Kafkas University. It should be stated that Turkish Journal of Biology and Journal of the Faculty of Veterinary Medicine, Kafkas University were indexed in also SCI-E. Total citation numbers of these articles were 5 (Table 7).

**Table 7.** Nanotoxicology articles in the ULAKBIM National Databases

| Title | Category | Times cited | Year |
|---|---|---|---|
| Nanomedicine, microarrays and their applications in clinical microbiology | Review | 5 | 2010 |
| Nanotechnology in the food industry and safety issue | Review | 0 | 2013 |
| Drug Delivery Systems and Nanotechnological Interaction | Review | 0 | 2013 |
| Nanotoxicology-New Research Area in Toxicology | Review | 0 | 2014 |
| Silver nanoparticles induced genotoxicity and oxidative stress in tomato plants | Original research | 0 | 2017 |
| In Vitro Cytotoxicity and Molecular Effects Related to Silicon Nanoparticles Exposures | Original research | 0 | 2017 |
| Evaluation of Genotoxic Effects of C60 Fullerene-γ-Fe2O3 and MultiWall Carbon Nanotubes-γ-Fe2O3 Nanoparticles | Original research | 0 | 2018 |
| Nanoparticle Applications in Mammalian Tumor and Normal Cell Lines | Review | 0 | 2018 |

## DISCUSSION

Nanoparticles are generally defined as a compounds having particles with at least one dimension of 1–100 nm in length. Their novel physical and chemical characteristics have made them useful in several applications; however, it can be potentially toxic. Although several studies have reported the toxicity of various NPs, much is still unknown (Moore, 2006; Oberdörster, Zhu, Blickley, McClellan-Green, & Haasch, 2006).

Nanotoxicology researches have shown important progress in recent years. This study also clearly demonstrated that there was a significant increase in the number of nanotoxicology publications worldwide and in Turkey ($p<0.05$).

The USA is the first country in the publication number ranking. When the top 25 countries according to the publication records were ordered based on the PmP which shows the scientific productivity of a community (Man, Weinkauf, Tsang, & Sin, 2004), Turkey ranked 22nd, India with a population of over 1 billion, was naturally at the end of this ranking. Singapore, Denmark, and Switzerland were the first three countries according to the PmP index.

Citation analysis shows the quality of publications which also means the academic significance of publications (Choi et al., 2016). The number of citations per paper is a useful index to determine the contribution of a country in a scientific field (King, 2004). In this study, the first four countries according to average citation per item ranking were USA, Canada, Singapore, and Switzerland while h-index ranking was the USA, China, Germany, and India. According to our data, we can say that the qualitative and quantitative properties of countries' nanotoxicology publications show a parallel course. Zheng et al. (Zheng et al., 2016) evaluated micro/nano-bubble related research from 1991 to 2014 on the SCI-E database and similar to this study, the USA was the most productive country had the highest h-index in all countries.

The quality and level of scientific research is a good indicator of a country's developmental status (Vose & Cervellini, 1983). Clinical researches are often expensive and require well-equipped laboratory and biochemical measurements (Dorsey et al., 2010; Nathan, 1998). Therefore, scientific research has traditionally been dominated by the "G5" countries i.e. the USA, The United Kingdom, Japan, Germany, and France (May, 1997). Consistently, we found that GDP per capita was strongly correlated with both PmP index and average citation per item which explain why some countries were both more qualitatively and quantitatively ahead in the field of nanotoxicology publication.

In the study of Man et al. (Man et al., 2004), it was shown that researches in native English speaking countries which have a strong research funding, are presented in highly ranked medical journals. National funding capacity for research is strictly related to the GDP or high income of a country which positively affect the quality and the number of nanotoxicology publications. It should be considered that high-income countries have a better education system (Meo, Al Masri, Usmani, Memon, & Zaidi, 2013). In Turkey, there are not enough funding agencies and only 0.01 % of the total GDP spent on medical research while for example in Sweeden, this ratio is 0.47 %. Therefore, it negatively affects the quality and quantity of the studies.

In concordance with the results of other studies from different counties, this study demonstrated that universities dominate the nanotoxicology literature published in Turkey. Because publications are one of the principal aims of researchers for academic recognition and promotion (Horton, 1998; Ajuied et al., 2013).

We found 8 articles (5 reviews and 3 original

research) in the ULAKBIM database which indicate that Turkish author tends to publish their studies in international journals. International Journal of Nanomedicine with the 4.370 impact factor published most nanotoxicology articles worldwide. But Artificial Cells, Nanomedicine, and Biotechnology with 3.026 impact factor published the most articles from Turkey. This can be explained that why Turkey ranks last by the h-index and the average citations per item.

This study has some limitations. First of all, nanotoxicology studies were searched in the WoS and ULAKBIM databases while other publications in the other databases were not analyzed. But WoS and ULAKBIM are the most important databases worldwide and in Turkey, so this limitation can be ignored. Citation analysis was used to asses the quality of the articles but over the citation, biased citing, audience size, and biased data which are the common criticisms of bibliometric studies, were not analysed (MacRoberts & MacRoberts, 1989). Finally, instead of using the PmP index, to normalize article number by the number of researchers in nanotoxicology field in different countries might be more informative, but getting these data is extremely difficult.

## CONCLUSION

In conclusion, the use of NPs in various products and their potential environmental and human health risks are increasing, therefore, nanotoxicology studies are a really important scientific field. There is a rapid increase in the number of publication in nanotoxicology research from 1945 to 2018. The USA was the first country in the total publications, average citations per item and h-index ranking. Singapore was the first place followed by Denmark and Switzerland when the number of total publications adjusted for population. Turkey was the 21st in the total publication number ranking but ranked last by the h-index and the average citations per item. Although nanotoxicology is one of the comprehensive scientific fields in recent years, this study provides an insight into this area. As a main factors, GDP per capita and research foundation positively affect the quality and quantity of nanotoxicology publications. More studies in the journals with high impact factors and also more financial support for research are needed to increase the scientific output of Turkey in this field.

## CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

## REFERENCES

Ajuied, A., Back, D., Smith, C., Davies, A. J., Wong, F., & Earnshaw, P. H. (2013). Publication trends in knee surgery: a review of the last 16 years, *The Journal of Arthroplasty, 28*(5), 751-758.

Bacanlı, M., & Basaran, N. (2014). Nanotoxicology - New Research Area in Toxicology, *Turkish Journal of Pharmaceutical Sciences,* 11(2), 231-240.

Choi, J., You, J. S., Joo, Y. S., Kong, T., Ko, D. R., & Chung, S. P. (2016). A bibliometric analysis of research productivity of emergency medicine researchers in South Korea, *Clinical and Experimental Emergency Medicine, 3*(4), 245-251.

Çatal, B., Akman, Y. E., Şükür, E., & Azboy, İ. (2018). Worldwide arthroplasty research productivity and contribution of Turkey, *Acta Orthopaedica et Traumatologica Turcica, 52*(5), 376-381.

Dorsey, E. R., de Roulet, J., Thompson, J. P., Reminick, J. I., Thai, A., White-Stellato, Z., Beck, C.A., George, B.P., & Moses, H., 3rd. (2010). Funding of US biomedical research, 2003-2008, *JAMA, 303*(2), 137-143.

Hauptman, J. S., Chow, D. S., Martin, N. A., & Itagaki, M. W. (2011). Research productivity in neurosurgery: trends in globalization, scientific focus, and funding. *Journal of Neurosurgery,, 115*(6), 1262-1272.

Horton, R. (1998). Publication and promotion. A fair reward, *The Lancet, 352*(9131), 892.

King, D. A. (2004). The scientific impact of nations, *Nature, 430*(6997), 311-316.

Langer, A., Díaz-Olavarrieta, C., Berdichevsky, K., & Villar, J. (2004). Why is research from developing countries underrepresented in international health literature, and what can be done about it?, *Bulletin of the World Health Organization, 82*, 802-803.

Li, K., Rollins, J., & Yan, E. (2018). Web of Science use in published research and review papers 1997-2017: a selective, dynamic, cross-domain, content-based analysis, *Scientometrics, 115*(1), 1-20.

Litvinova, E. V., & Posylkina, O. V. (2016). Features of the Patent Researches of Nanotechnology Based Drug Development, *Turkish Journal of Pharmaceutical Sciences, 13*(1), 121-134.

MacRoberts, M. H., & MacRoberts, B. R. (1989). Problems of citation analysis: A critical review, *Journal of the American Society for information Science, 40*(5), 342-349.

Man, J. P., Weinkauf, J. G., Tsang, M., & Sin, D. D. (2004). Why do some countries publish more than others? An international comparison of research funding, English proficiency and publication output in highly ranked general medical journals, *European Journal of Epidemiology, 19*(8), 811-817.

May, R. M. (1997). The scientific wealth of nations, *Science, 275*(5301), 793-796.

Meo, S. A., Al Masri, A. A., Usmani, A. M., Memon, A. N., & Zaidi, S. Z. (2013). Impact of GDP, spending on R&D, number of universities and scientific journals on research publications among Asian countries, *PLoS One, 8*(6), e66449.

Michalopoulos, A., & Falagas, M. E. (2005). A bibliometric analysis of global research production in respiratory medicine, *Chest, 128*(6), 3993-3998.

Moore, M. N. (2006). Do nanoparticles present ecotoxicological risks for the health of the aquatic environment?, *Environment International, 32*(8), 967-976.

Nathan, D. G. (1998). Clinical research: perceptions, reality, and proposed solutions. National Institutes of Health Director's Panel on Clinical Research, *JAMA, 280*(16), 1427-1431.

Oberdörster, E., Zhu, S., Blickley, T. M., McClellan-Green, P., & Haasch, M. L. (2006). Ecotoxicology of carbon-based engineered nanoparticles: Effects of fullerene (C60) on aquatic organisms, *Carbon,* 44(6), 1112-1120.

Öner, F. (1983). Nanopartiküller: Katı Kolloidal İlaç Taşıyıcı Sistemler, *FABAD Journal of Pharmaceutical Sciences, 8*, 250-260.

Shvedova, A., Pietroiusti, A., & Kagan, V. (2016). Nanotoxicology ten years later: lights and shadows, *Toxicology and Applied Pharmacology*, 299, 1-2.

Toensmeier, P. A. (2004). Nanotechnology faces scrutiny over environment and toxicity, *Plastics Engineering –Connecticut*, 60(11), 14-17.

Vance, M. E., Kuiken, T., Vejerano, E. P., McGinnis, S. P., Hochella, M. F., Jr., Rejeski, D., & Hull, M. S. (2015). Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory, *Beilstein Jounal of Nanotechnology, 6*, 1769-1780.

Vergidis, P. I., Karavasiou, A. I., Paraschakis, K., Bliziotis, I. A., & Falagas, M. E. (2005). Bibliometric analysis of global trends for research productivity in microbiology, *The European Journal of Clinical Microbiology & Infectious Diseases, 24*(5), 342-346.

Vose, P., & Cervellini, A. (1983). Problems of scientific research in developing countries, *IAEA Bulletin, 25*(2), 37-40.

Walters, C. R., Pool, E., & Somerset, V. (2016). Nanotoxicology: a review. In M. Larramendy (Ed.), *Toxicology - New Aspects to This Scientific Conundrum*: InTech.

Zheng, T., Wang, J., Wang, Q., Nie, C., Shi, Z., Wang, X., & Gao, Z. (2016). A bibliometric analysis of micro/nano-bubble related research: current trends, present application, and future prospects, *Scientometrics, 109*(1), 53-71.