

# China: The New Powerhouse of Hormesis Research?

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## Abstract

More than one third of the worldwide hormesis research has been produced at institutions in the United States (US). Although the US ranked first in terms of hormesis publication records from the mid-1980s to the mid-late 2010s, China became the largest producer of hormesis publications in the years 2019-2020. As China is transforming into a powerhouse of hormesis research, new opportunities might arise for the research field.

## Keywords

biphasic response, dose-response relationship, hermetic, publication trends, science publishing, scientific literature

## Main Text

The effective leadership in hormesis research was little in the mid-late decades of the last century.<sup>1</sup> Largely owing to the incorrect link of hormesis to homeopathy, hormesis remained marginalized during most of the 20th century, despite the seminal hormesis works of Anthony R.D. Stebbing and Thomas D. Luckey as well as the equally important work of Elemer Szabadi with biphasic responses in diverse receptor systems.<sup>1</sup> While there was considerable evidence for the occurrence of hormesis in a broad range of experimental models and systems,<sup>2,3</sup> hormesis did not receive the attention it deserved. This was the scene till the mid-late 90 s,<sup>4</sup> when the beginning of a new era would mark the history of hormesis.

The main figure relating to that major turn in hormesis history was Edward J. Calabrese, Professor of Toxicology at the School of Public Health, University of Massachusetts, Amherst (UMass), USA. Calabrese would become interested in hormesis in the early 1990s, establishing the BELLE (Biological Effects of Low Level Exposure) Newsletter, published from 1992 to 2010 (<https://dose-response.org/belle-newsletter-archive/>). He would start publishing extensively on the topic<sup>5</sup> and receiving major funding for hormesis research from various agencies such as the Texas Institute for Advancement of Chemical Technology,<sup>6</sup> the US Nuclear Regulatory Commission,<sup>3</sup> and the US Air Force Office of Scientific Research.<sup>7</sup> He would then establish the international conference “Non-Linear Dose-Response Relationships in Biology, Toxicology, and Medicine” (held at UMass in 2002 and repeated annually since then; <https://dose-response.org/annual-conference/>) and the

journal *Dose-Response*, which formally started publishing in 2003 under the name *Nonlinearity in Biology, Toxicology and Medicine*. By 2005 all these initiatives would lead to the creation of the International Dose-Response Society (IDRS) (<http://www.Dose-Response.org>). In parallel to these massive efforts, an increase in hormesis citations was noted.<sup>4</sup> UMass, and overall the US, has been the world’s center of hormesis scientific activities.

A search for hormesis-relevant records revealed 3,461 publications (Figure 1A) cited by 55,580 articles so far (excluding self-citations). USA (1,140; 33%) and China (492; 14%) score first and second in terms of the number of publications; Italy ranks third with 213 publications (6%). A considerable difference between China and the US was observed for the decade 2000-2009; 398 publications for the US versus 48 publications for China (Figure 1B). However, 2009 was the first year in which China’s publications exceeded ten, and the year that would mark the beginning of a new period for internationally-sound hormesis research in China. In particular,

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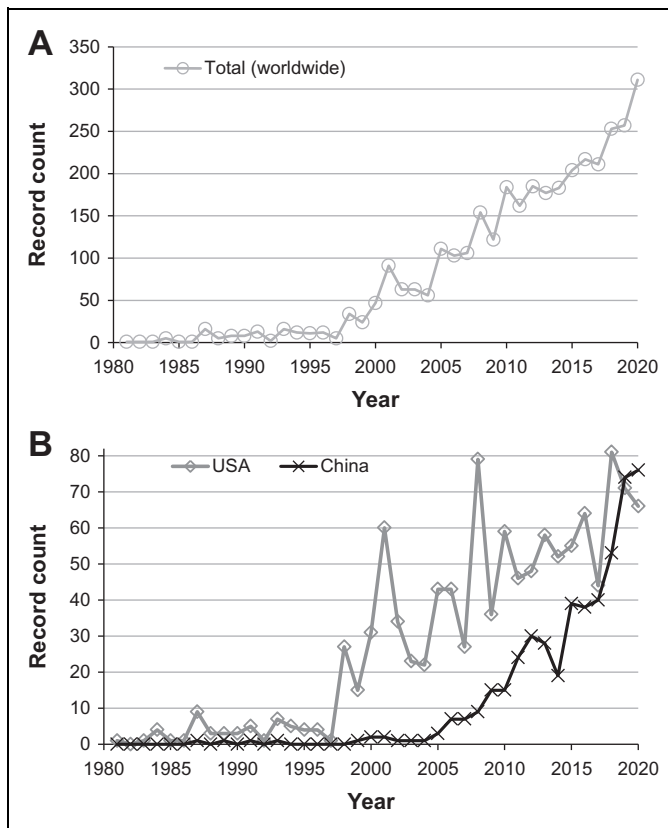
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**Figure 1.** Hormesis-relevant publications. The search was done within Web of Science (Clarivate, Pennsylvania, US), using the keyword “hormesis” (Search mode: Topic; Timespan: All years, excluding 2021), on 21 January, 2021. The figure includes all the publications traced for China and the US. “China” or “Peoples R China” were considered for China, and “USA” or “United States” were considered for the US. Note: for the total (worldwide) counts, there were 1, 1, 1 and 2 publications in 1958, 1956, 1952, and 1947, respectively, which were excluded from the figure for presentation purposes.

an exponential growth occurred between 2009 and 2020. From 2009 to 2016, there were on average 2.2 times more publications for the US. This difference became smaller in 2017–2018, when the average difference declined to 1.3 fold. Then, China ranked first in 2019 and 2020 with 74 and 76 publications, compared to 71 and 66 publications for the US. Here it should be clarified that there are also studies reporting hormesis findings published in China’s domestic journals (www.cnki.net; China Academic Journals Electronic Publishing House Co., Ltd).

The results of this evaluation show that China is on a steady upward trajectory and has outperformed the US in terms of hormesis publications in the last 2 years. In the race to the top, will China sustain its current ranking as the world’s largest producer of hormesis publications in the years to come? China has become the world’s largest producer of scientific articles,<sup>8</sup>

an achievement tracing back to ambitious plans and comprehensive efforts of the China’s government to become a nation of innovation by 2020 and a worldwide scientific power by 2050. Being the top country concerning hormesis publication records, China appears to have the potential to become the new powerhouse of hormesis research.

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### Declaration of Conflicting Interests

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