Nutrition Research in India

Underweight, Stunted, or Wasted?

Shweta Khandelwal*,†, Karen R. Siegel‡,§, K. M. Venkat Narayan§,||

New Delhi, India; and Atlanta, GA, USA

ABSTRACT

India has experienced dramatic economic growth in the past 2 decades accompanied by a rising burden of noncommunicable diseases, which coexists with the unfinished agenda of undernutrition. Tackling these dual challenges requires strong investment in nutrition research. We compared India's research output with another rapidly developing country (China) and an established developed country (USA). We analyzed trends for each country between the periods 2000 to 2005 and 2006 to 2010, in terms of quantity and quality of the publications. India produced 2,712 articles (1.9% of the global total) in the 2000 to 2005 period and 3,999 articles (2.1%) in the 2006 to 2010 period, and the country impact factor was 191 and 174, respectively. The contributions to the top 10 nutrition journals during 2006 to 2010 was 1%. India must increase investment in and attention towards quality nutrition research and address potential barriers to publish.

India is undergoing rapid economic growth and development [1]. Despite this positive trend, India remains burdened with an unfinished agenda of undernutrition and communicable diseases on the one hand, and a burgeoning epidemic of overnutrition and noncommunicable diseases on the other.

Addressing this dual burden of over- and undernutrition is critical to achieving improved health and sustained economic growth throughout India, and nutrition research is key to effectively tackling the challenges [2]. For example, there is evidence that poor health resulting from nutritional deficiencies can perpetuate poverty and undermine economic growth [3,4]. The Copenhagen Consensus noted that nutrition interventions generate returns among the highest of 17 potential development investments [5]. Furthermore, investment in research is a cost-effective way of improving health [6]. Previous studies suggest a deficiency in India's research output in the fields of science and public health [7–11]; however, no studies have specifically examined the country's research output in nutritional sciences.

Here, we analyze trends in India's nutrition research output from the periods 2000 to 2005 and 2006 to 2010, in terms of quantity (measured by number of publications) and quality (measured by impact factor) and compare it to China, another rapidly growing emerging economy facing similar dual health threats, and the USA, a developed country with a well-established field of nutrition research [12]. The disease burden related to nutrition is high in all 3 countries. While India and China grapple with the dual burden of malnutrition [13–15], USA is in the midst of an obesity epidemic, where no state has a prevalence of obesity >20% [16]. The USA's food consumption trends are often implicated as the leading drivers of the epidemic. Given that malnutrition (including over- and undernutrition) is largely preventable, it is of interest to assess and compare the research energy devoted to these issues, in the form of research outputs (i.e., publications).

We used 3 measures of research output: 1) the total number of nutrition publications for India, China, and USA in the last decade (using PubMed); 2) contribution in the top 10 nutrition journals (using Journal Citation Reports) [17]; and 3) quality of those published papers (using countrywise aggregated impact factor) in the top 10 nutrition journals.

To tally the number of publications during each 5-year period (2000 to 2005) and (2006 to 2010), we performed a search of all "nutrition" categories in the Medical Subject Headings (MeSH) database under the PubMed homepage. This yielded 31 MeSH terms out of which those relevant to humans only (n = 27) were selected (Table 1).The results yielded were then categorized into the 3 countries of interest (India, China, and USA) based on the corresponding author's affiliation/country provided in the address bar. The rest (other than those from the 3 countries) were excluded. Using Excel 2007 (Microsoft, Redmond, WA, USA) and EndNote X4 (Thomson Reuters, Carlsbad, CA, USA), a dataset was created that compiled, tabulated, and summarized all extracted publications. Even though the same terms may have been differently weighted in terms of research priorities in the 3 countries, for consistency and fair comparability, the same search terms and criteria were used to compare the number of publications across the 3 countries. The obtained results (number of publications) countrywise are tabulated.

To measure the relative quality of India's nutrition research, we assessed each country's research output in the top 10 nutrition journals in the world according to

From the *Centre for Chronic Disease Control, New Delhi, India; †Department of Public Health Nutrition, Public Health Foundation of India, New Delhi, India; ‡Department of Nutrition and Health Sciences, Graduate Division of Biological and Biomedical Sciences, Laney Graduate School, Emory University, Atlanta, GA, USA; §Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA; and the ||School of Medicine, Emory University, Atlanta, GA, USA. Correspondence: S. Khandelwal (shweta@ccdcindia.org).

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the 2009 impact factor rankings by Journal Citation Reports (JCR) citation index (JCR Science Edition 2009). Under JCR Science Edition 2009, the most appropriate subject category available was selected to represent the field of nutrition ("Nutrition & Dietetics"). The top 10 journals under this category based on the impact factor ratings were selected. Each journal name was then added to the existing search builder (Table 1). The number of articles in each journal from each country in the specified duration was multiplied by the journal's most recent individual impact factor (2009) to get each country's "journal impact factor" (JIF). These JIF were totaled to determine each overall "country impact factor" (CIF). Thus for each country, we computed 2 CIF—1 for 2000 to 2005 and 1 for 2006 to 2010. An example is shown in Table 2. The computation of aggregated CIF can be seen as a superior measure to reporting overall mean impact factor of all journals because the former allowed taking the number of publications into account. This is important because summing the product of both quantity (number of publications) and quality (impact factor of the journal) for each country gave a comparable picture and allowed us to make intercountry comparisons for the same journal and across the top 10 journals.

Because country-specific journals may be more likely to publish articles from their own country, and because many of the top nutrition research journals are USA-based, we also examined selected common nutrition journals from other regions: the *European Journal of Clinical Nutrition* (EJCN), *Asia Pacific Journal of Clinical Nutrition* (APJCN), and the *British Journal of Nutrition* (BJN).

RESULTS

Figure 1 shows the nutrition research output and JIF and CIF for India, China, and the USA. Together, the countries produced approximately one-third of global nutrition research output. India produced 2,712 articles (1.9% of the global total) in 2000 to 2005 and 3,999 articles (2.1% of the global total) in 2006 to 2010. In comparison, China produced 5,146 articles (4.7% of global total) in 2000 to 2005 and 10,982 (5.8% of global total) in 2006 to 2010, and the USA published 42,089 articles (26% of global total) in 2000 to 2005 and 47,408 articles (25.2% of global total) in 2006 to 2010 (Table 3).

Similarly, the CIF for the USA was far higher than that for China or India. India's CIF was 191 in 2000 to 2005 and 174 in 2006 to 2010, whereas China's was 96 and 360 and the USA's was 10,675 and 11,293 in 2000 to 2005 and 2006 to 2010, respectively.

Table 4 shows the contributions from India, China, and the USA in the top 10 nutrition journals in the world (based on 2009 JCR ranking). The USA contributed a much larger percentage than either India or China to the top 10 nutrition journals. Of note, while India's contribution stayed roughly the same between 2000 to 2005 and 2006 to 2010, China's contribution tripled (from 0.3% to 1.4%). A similar pattern was found when

TABLE 1. Search strategy and selection criteria

Database: PubMed
Date search done: November 30, 2010
Years—2 time spans: November 30, 2005 to November 30, 2010; November 30, 2000 to November 29, 2005
Keywords: "Diet"[Mesh] OR "Diet, Sodium-Restricted"[Mesh] OR "Diet, Carbohydrate-Restricted"[Mesh] OR "Diet, Protein-Restricted"[Mesh] OR "Diet, Fat-Restricted"[Mesh] OR "Diet, Reducing"[Mesh] OR "Diet, Gluten-Free"[Mesh] OR "Diet Records"[Mesh] OR "Diet, Vegetarian"[Mesh] OR "Diet Therapy"[Mesh] OR "Diet Surveys"[Mesh] OR "Diet Fads"[Mesh] OR "Ketogenic Diet"[Mesh] OR "Diet, Mediterranean"[Mesh] OR "Diet, Macrobiotic"[Mesh] OR "Diet, Cariogenic"[Mesh] OR "Diet, Atherogenic"[Mesh] OR "Diabetic Diet"[Mesh] OR "Food Habits"[Mesh] OR "Food"[Mesh] OR "Legislation, Food"[Mesh] OR "Food Preferences"[Mesh] OR "Food Labeling"[Mesh] OR "Food-Processing Industry"[Mesh] OR "Food Technology"[Mesh] OR "Food Industry"[Mesh] OR "Health Food"[Mesh] OR "Food Packaging"[Mesh] OR "Food, Fortified"[Mesh] OR "Food Habits"[Mesh] OR "Food Analysis"[Mesh] OR "Functional Food"[Mesh] OR "Food and Beverages"[Mesh] OR "Dietary Supplements"[Mesh] OR "Fast Foods"[Mesh] OR "Nutrition Policy"[Mesh] OR "Diet Records"[Mesh] OR "Diet Fads"[Mesh] OR "Soy Foods"[Mesh] OR "Foods, Specialized"[Mesh] OR "Seafood"[Mesh] OR "Nutritional Sciences"[Mesh] OR "Child Nutrition Sciences"[Mesh] OR "Nutrition Assessment"[Mesh] OR "Nutrition Therapy"[Mesh] OR "Parenteral Nutrition, Home Total"[Mesh] OR "Nutrition Surveys"[Mesh] OR "Nutrition Processes"[Mesh] OR "Fetal Nutrition Disorders"[Mesh] OR "Nutrition Policy"[Mesh] OR "Child Nutrition Disorders"[Mesh] OR "Infant Nutrition Disorders"[Mesh] OR "Nutrition Disorders"[Mesh] OR "Enteral Nutrition"[Mesh] OR "Nutritional Physiological Phenomena"[Mesh] OR "Prenatal Nutritional Physiological Phenomena"[Mesh] OR "Nutritive Value"[Mesh] OR "Nutritional Requirements"[Mesh] OR "Maternal Nutritional Physiological Phenomena"[Mesh] OR "Adolescent Nutritional Physiological Phenomena"[Mesh] OR "Infant Nutritional Physiological Phenomena"[Mesh] OR "Child Nutritional Physiological Phenomena"[Mesh] OR "Nutritional Status"[Mesh] OR "Food Labeling"[Mesh]
Extra Notes: Combinations with different countries (the country specified in the corresponding author's address was used) and journals (the top 10 selected based on the impact factor 2009) were used.

TABLE 2. An example to illustrate computation of CIF

Calculation for 1 country, 1 journal—India:

American Journal of Clinical Nutrition—impact factor = 6.307

India's contribution, n
(2000 to 2005) = 24
(2006 to 2010) = 20
JIF (2000 to 2005) = 6.307 × 24

Similar calculation for each journal (i.e., number of articles retrieved in that journal in the specified duration × impact factor of that journal). Add all JIF and we get the CIF (2000 to 2005)
Similarly for 2006 to 2010...

JIF (2006 to 2010) = 6.307 × 20
Add all JIF and we get the CIF (2006 to 2010).

CIF, country impact factor; JIF, journal impact factor.

examining the European and British nutrition journals. The USA contributed approximately 10% of articles (11% in EJCN; 6.9% in BJN), whereas India and China contributed significantly lower proportions (1.6% and 2.2% of articles in EJCN; 2.1% and 2.4% of articles in BJN, respectively). Interestingly, in APJCN, China contributed a larger percentage (13.9%) while India only contributed 4.7%, as compared to the USA's contribution of 9.2% of articles.

These data reveal that India's nutrition research output is small and has remained relatively unchanged over the past decade. In 2000 to 2005 and 2006 to 2010, India contributed only 1% of global nutrition research, whereas China rose from a mere 0.3% (2000 to 2005) to 1.4% (2006 to 2010). In comparison, the USA contributed roughly one-third of global research in nutrition during both periods.

Our analysis has several limitations. First, measuring research output in terms of number of research publications may ignore other forms of output, such as training students and building capacity, implementing community interventions, engaging in advocacy, or working with stakeholders to implement policy and change practice. However, publications are often viewed as a key marker of academic success and productivity. Second, PubMed archives few Indian journals. Thus, our analysis may have underestimated the actual number of publications from India. However, the fact that only a few Indian journals are indexed in PubMed may suggest limited existing research infrastructure, quality, and output and inadequate integration of Indian researchers into the global nutrition field. Third, selection of the top 10 nutrition journals based on 2009 impact factor alone may also induce some bias. However, comparing the same parameters for all 3 countries using same methodology may provide some balance to this approach. The measure of an overall impact factor for each country computed by adding up the products of number of publications and JIF may not be the only approach, but broadly it presents a comparable picture. A few other limitations to be noted while interpreting our results include the publication bias in the compared countries, time points selected, and the attempt to address research efficiency with mere scientific publications.

TABLE 3. Total number of articles from China, India, and USA, 2000 to 2005 and 2006 to 2010

Years	India	China	USA	Rest of the World	World
2000–2010	6,711	16,128	89,497	232,089	344,425
2000–2005	2,712	5,146	42,089	106,715	156,662
2006–2010	3,999	10,982	47,408	125,374	187,763

Based on our understanding, there are several reasons for India's limited nutrition research. Poor allocation of resources, infrastructural issues, hierarchical and nonprogressive education system, vested interests and bureaucracy, and an overall lack of research culture may all play a role. In particular, low allocation of resources to education and research is a major problem in India [18,19]. For example, India only allocates 0.8% of its gross domestic product to research and development, whereas developed countries generally budget more than 2.7% to such endeavors [20]. Despite efforts by the Indian government to promote higher education, the percentage of India's gross domestic product spent on higher education remains low at 0.37%, compared with 1.41% in the USA and 0.50% in China [21]. India's meager financial investment can be seen in its small number of public health schools (4 schools in 2008). In contrast, there are 72 established public health schools in China and 147 in the USA. Even in the Indian academic institutes of higher education that do exist, research infrastructure in libraries, information technology, laboratories, and classrooms tend to be inadequate. These inadequacies can create a cycle of underinvestment in research, in which the most

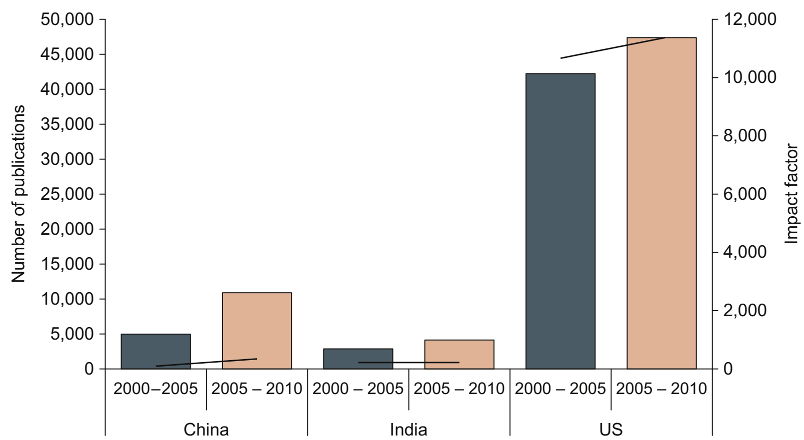

FIGURE 1. Trends in nutrition research output and impact factor. Number of publications is the number of nutrition research articles from the country in the period, according to the PubMed database search. The country impact factor was calculated as the weighted sum of all articles in the top 10 nutrition research journals globally, according to 2009 ranking on Journal Citation Reports (JCR) [17]. The number of articles in each journal was multiplied by the journal's most recent individual impact factor (2009) to get each country's "journal impact factor," and then all of the journal impact factors were totaled to get the overall country impact factor. Source: PubMed database, author's calculations.

talented (and productive) students and professionals seek opportunities abroad, and the institutions, faced with a dwindling student body and a shrinking research output, simply cannot afford to attract—or retain—quality researchers [22–25]. As a result, Indian nutrition and public health institutions simply cannot compete with institutions abroad, and thus have limited presence in global rankings [11,22,26].

TABLE 4. Percentage of research articles from China, India, and the USA in the top 10 nutrition journals, 2000 to 2005 and 2006 to 2010

			China		India		United States	
Journal	Rank	Impact Factor	2000–2005	2006–2010	2000–2005	2006–2010	2000–2005	2006–2010
Annual Review of Nutrition	1	8.783	0	1.3	0	0	85.7	58.7
Progress in Lipid Research	2	8.167	0	0	0	0	31.3	12.5
American Journal of Clinical Nutrition	3	6.307	0.2	0.7	0.9	0.5	39.5	41.3
International Journal of Obesity	4	4.343	0	2.0	0	0.4	21.3	27.3
Proceedings of the Nutrition Society	5	4.321	0	0	0.3	0	10.2	4.9
Current Opinion in Clinical Nutrition and Metabolic Care	6	4.291	0	0	0.3	0.3	21.9	24.7
Journal of Nutritional Biochemistry	7	4.288	0.6	5.3	1.7	1.1	38.4	40.2
Journal of Nutrition	8	4.091	0.7	1.5	0.5	0.4	54.7	50.5
Critical Reviews in Food Science and Nutrition	9	3.725	1.4	2.0	4.9	6.4	32.2	22.8
Nutritional Metabolism and Cardiovascular	10	3.517	0	0.8	0.6	0.4	5.4	4.9
Country average			0.3	1.4	0.9	1.0	34.1	28.8

Note: Rank is based on 2009 rank, from Journal Citation Reports [17].

Additionally, India's educational style remains a barrier to promoting research output [21]. Teaching styles remain didactic and nonprogressive, with little encouragement for students to think independently, creatively, or critically, or to question the status quo [24,25]. Curricula fail to infuse interdisciplinary approach, analytical strengths, and effective written and verbal communication skills, which together form the basis of sound research and good quality publications [27–32]. Paucity of skilled mentors and the absence of a "research culture" that can provide protected time for fostering research and writing skills also contributes to poor research output. Fear of criticism, lack of confidence, and language barriers may also play a role [7,8]. India's prime minister, an economist by training, lamented the control that vested interests have on scientific innovation in India and highlighted excessive bureaucracy and in-house favoritism as the 2 main reasons preventing Indians from becoming leaders in science and technology [33].

Current curricula in India reflect a disconnect between educational priority-setting and real-world health challenges, whereby current students are not actively exposed to the links between research and policy, nor to the real-world application of research to improving the health status of the population. This may lead to student ambivalence about researching and publishing. In reality, research is fundamental to raising the quality of service delivery and can lead to public policies that significantly affect the population's health. For example, Denmark's "6-a-Day" campaign to promote consumption of 6 portions of fruits and vegetables per day was the direct outcome of several publications in the late 1990s that demonstrated a clear link between increased consumption of fruits and vegetables and reduced risk of cancer and ischemic heart disease [34]. Similarly, research studies in the USA have shown that consumption of fruits and vegetables substantially lowers health risks; as a result, recommendations to consume sufficient fruits and vegetables ("5-a-day") have been incorporated into population-based dietary guidelines [33,35]. Another example of research-to-policy in the USA is the Active Living Research program, which aims to reduce physical inactivity through evidence-based strategies to prevent obesity in children by making changes at environment and policy levels [20].

Our findings have important implications for policy changes to guide improvements in public health nutrition training. First, reforms in education and the employment sector are needed [36]. Nutrition education should span the entire spectrum from dietetics to research and teaching. Interdisciplinary education that highlights how nutrition fits into broader issues of medicine, agriculture, economics, and policy should be encouraged and incorporated in the existing nutrition curriculum [27,37]. A diverse array of different aspects of nutrition from maternal-child health to micronutrient deficiencies to noncommunicable disease prevention could allow students to appreciate the links between different sectors and gear up to public health challenges in a holistic manner [38–41]. Nutrition research should be raised in status and made attractive to bright young investigators. Better mentoring opportunities (either in the form of short-term trainings or fellowships in institutions outside India) can go a long way in nurturing the evolving young pool of talent. Strong synergistic collaborations/partnerships with developed countries should be encouraged to catalyze solutions to emerging and/or existing threats to public health [42]. A recent commission of global experts from various fields recommended designing new instructional and institutional strategies to combat multiple looming health challenges [26,43]. The recommendations include aligning national efforts through joint planning, especially in the education and health sectors, engaging all stakeholders in the reform process, and developing global collaborative networks for mutual strengthening. They also advocate developing competency-based curriculum of globally recognized high academic standards [35].

There is some promise that these changes are underway. One example is the online post-graduate diploma in public health nutrition started by the Public Health Foundation of India [44]. This well-received peer-reviewed program rises beyond the existing clinical/therapeutic scope of the nutrition education by adding new dimensions of epidemiology and research methods integrated with core nutrition modules. Another example is the increase in the number of national and international fellowships for public health, science, and technology research including public health nutrition over the last decade [45–47]. These clearly indicate the rising demand and highlight the urgent need to invest in more such endeavors.

SUMMARY

We found that India's nutrition research output is disproportionately low, considering its large population and its huge dual nutritional challenges and public health concerns. Investment in nutrition policy research in India could help to guide appropriate modifications in policy strategy and programs for tackling the existing and emerging nutrition problems [2,6]. Although some commentators project that India will become a great academic power by 2025 [48,49], our findings highlight the urgent need for India to invest in research infrastructure and innovation culture to realize this dream.

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