

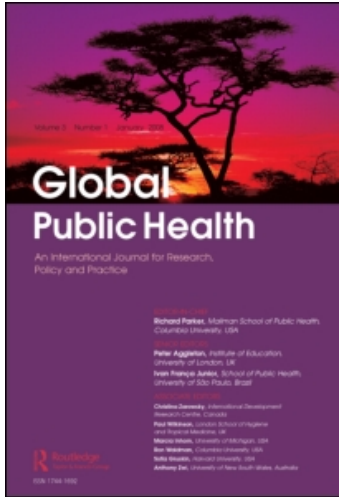
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Bibliographic analysis of scientific research on selected topics in public health nutrition in West Africa: Review of articles published from 1998 to 2008

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Few countries in West Africa have the capacity for carrying out advanced training in nutrition and public health. To provide additional information on current regional applied nutrition research capacity and productivity, we analysed peer-reviewed articles on key public health nutrition topics that were published from 1998 to 2008. Using MEDLINE/PubMed, the following terms were searched: 'breast feeding', 'infant nutrition physiology' (comprising complementary feeding and weaning), 'protein energy malnutrition', 'nutrition and infection', 'vitamin A', 'iodine', 'zinc' and 'overweight', each linked with the term 'Western Africa'. In total, 412 unique articles (37 ± 6 articles per year) were identified. Most research focused on infant and young child feeding practices, selected micronutrient deficiencies, and the emerging problem of overweight and obesity. The primary author of nearly half (46%) the publications was located in an institution outside of West Africa. Most articles were published in English (90%), and nearly half of all articles (41%) were cross-sectional studies. Our findings indicate that few peer-reviewed research studies are being published on key public health topics in the West African region, considering the magnitude of nutrition problems in this region. New approaches are needed to encourage and support research capacity and output in West Africa.

Keywords: public health nutrition; applied research; advanced training; bibliometrics; West Africa

Background

The West Africa region, as defined herein, is comprised of the 16 countries listed below, which are home to approximately 285 million people. The region is one of the poorest in the world, with a weighted mean annual per capita income of US\$743 in 2007 (World Bank 2009); and the regional health and nutrition statistics are alarming. For example, the infant mortality rate is 92 per thousand live births, and the under-five mortality rate is 135 per thousand live births (UNICEF 2009). More than 30% of children less than 5 years of age have a height-for-age less than -2 SD with respect to international growth standards, and approximately one-fourth are moderately or severely underweight (UNICEF 2009). In Africa as a whole, more than three-fourths of pre-school aged children and nearly two-thirds of women of

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reproductive age have anaemia, due to a combination of factors, including iron deficiency, intestinal helminthiasis, malaria and other infections (McLean *et al.* 2009). While national data on other specific micronutrient deficiencies are unavailable for most countries, deficiencies of zinc (Hess *et al.* 2009), iodine and vitamins A, B₁₂ and possibly other B vitamins, are believed to be common (MI and UNICEF 2004).

At the same time, overweight and obesity are becoming an increasing threat to health, as West African countries experience demographic and social changes that affect people's diet and physical activity patterns. Notably, during the past 20 years, national survey data indicate that the prevalence of overweight among preschoolchildren and adult females is increasing in the region, especially in rapidly urbanising coastal countries (De Onis and Blössner 2000, Abubakari *et al.* 2008). The emergence of overweight and obesity as more common problems will further exacerbate nutrition-related health concerns for already over-burdened health systems, which will have to confront the complications of both under- and over-nutrition with the same limited resources.

Recent analyses indicate that more than one-third of childhood deaths are attributable to under-nutrition (Black *et al.* 2008). Thus, to meet the United Nations' Millennium Development Goals (MDGs) to reduce child mortality by two-thirds and to reduce hunger by half by the year 2015, it will be necessary to focus greater attention on scaling up nutrition interventions that are known to be effective. However, there is a dearth of trained professionals in public health nutrition in the region, and limitations in both human resources and institutional research capacity will hinder the ability of health systems to plan, implement and evaluate such programmes using locally relevant scientific evidence. Therefore, to achieve the MDGs, more effort must be devoted to developing institutional research and training capacity and preparing a broad range of professionals who can conduct relevant research for designing and managing evidence-based, public health nutrition programmes.

To provide additional background information on the current regional applied nutrition research capacity and productivity, we have analysed the collection of peer-reviewed articles on key topics in public health nutrition that were published during the period 1998–2008. The objectives of this review were to determine: (1) the number of publications on these topics annually, and language of publication, (2) the countries where the respective research projects were conducted, (3) the countries and institutions where the principal authors were employed, (4) the journals in which the papers were published and their impact factors (a proxy for the journals' importance), (5) the number of times the respective publications have been cited and (6) the major funding agencies supporting this research. This report summarises the results of this bibliographic research.

Methods

We completed multiple PubMed bibliographic searches during the period 11 June 2008 through 8 March 2009, using the US National Library of Medicine's MEDLINE/PubMed bibliographic search engine (<http://www.pubmed.gov>). By author consensus we identified medical subject heading (MeSH) keywords that represent the major public health nutrition issues of the West Africa region. In

particular, we searched the terms 'breast feeding', 'infant nutrition physiology' (which comprises complementary feeding and weaning), 'protein energy malnutrition', 'nutrition and infection', 'vitamin A', 'iodine', 'iron', 'zinc' and 'overweight', each linked with the term 'Western Africa'. The MeSH bibliographic database defines Western Africa as the following 16 countries: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. The search was limited to the time frame 1998–2008, and to studies classified as being conducted in humans or relevant to human nutrition.

To access the full journal articles, we searched online and at the libraries of the University of California library system, the University Cheikh Anta Diop of Dakar, the US National Library of Medicine, Wageningen University and North-West University (Potchefstroom Campus), South Africa. We also searched the World Health Organisation (WHO) online HINARI and AGORA databases. No language restrictions were applied; and all papers, except those identified as 'Authors' comments' or 'Authors' replies', were considered for inclusion. Retrieved articles reporting exclusively on animal nutrition with no direct relevance for human nutrition were excluded. For articles retrieved under more than one MeSH category, we reviewed the titles, full journal papers (and in the absence of full papers, the abstracts) of those articles that were identified more than once, and we selected the single MeSH category that best reflected the main topic of the article. When opinions differed on the best MeSH category, these discrepancies were resolved by consensus of the co-authors or by two-thirds majority when consensus was not achieved.

We summarised the results of the searches by year of publication, research topic (MeSH category), country in which the research was conducted and the country of the first author's primary institutional affiliation. Cases in which studies were conducted in more than one country were described as 'multi-West Africa' when more than one West African country was included, 'multi-Africa' when one or more of the countries was located in another African sub-region and 'multi-international' when one or more of the countries was located outside of Africa. To identify additional research institutions represented by non-primary authors, we searched the full publications when available.

To determine whether there were changes in research interests during the course of the 11-year interval, we completed a series of regression analyses of the number of articles published per year on each MeSH nutrition topic (dependent variable) and the year of publication (independent variable). For statistically significant models, we used the sign of the regression coefficient to indicate whether the number of publications on a particular topic was increasing or decreasing. To assess the types of research designs that were employed, we categorised the studies as randomised controlled trials (RCTs), observational studies (including cohort studies, cross-sectional studies and case-control studies), descriptive studies (case reports, case series), review articles (meta-analysis, systematic reviews), other reports (technical reports, position statements, practice guidelines, government publications), and laboratory studies (food composition analyses, food microbiology studies). Articles for which we could not retrieve the full paper, and the abstract did not provide enough details for classification, were excluded from this analysis.

To assess the perceived quality of the journals in which these articles were published, we evaluated journal impact factor scores. A journal's impact factor score

is a measure of the average number of citations relative to the number of articles published over a given time period (Borgman and Furner 2002). Thus, the score is used as a measure to rank, evaluate and categorise journals. Journal impact scores were retrieved from the ISI Web of Knowledge journal impact scores database (<http://www.isiknowledge.com/jcr>, accessed 8 June 2009), for the 5-year period 2003–2007, when available, or for the most recent year that a score was provided when a 5-year score was not available. We also determined the number of times each article was cited by conducting a search on the Google Scholar reference database (<http://www.scholar.google.com/>, accessed 8 March 2009). For those articles that we were able to retrieve in full, we prepared a list of the funding agencies that supported the research. A number of articles listed multiple funding sources, so, in separate analyses, we either reported all of the funding agencies that were acknowledged or we listed each funding source percentage-wise, according to the number of supporting agencies indicated in a particular paper.

Results

Figure 1 illustrates the flow diagram for inclusion of articles in the review. The bibliographic searches identified a total of 695 references for studies on the nine selected topics in public health nutrition issues that were conducted in West Africa from 1998 to 2008, including some that were listed under more than one MeSH category. After removing overlapping retrievals ($n = 186$), non-relevant articles

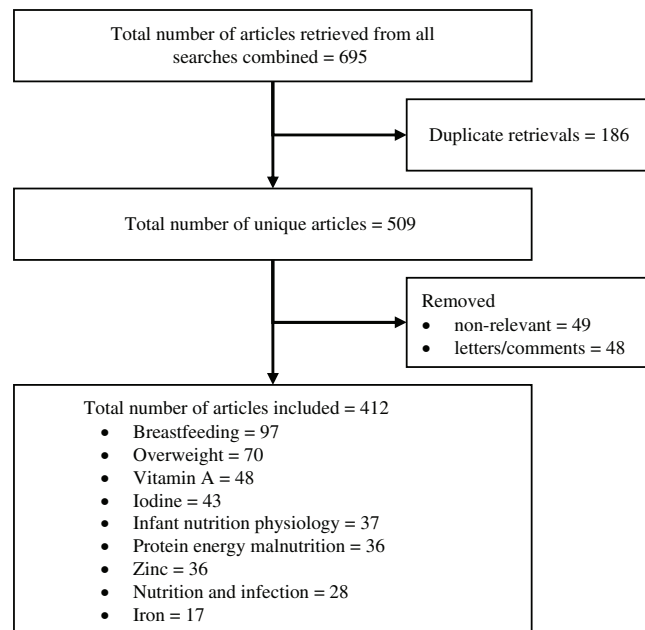


Figure 1. Flow diagram for inclusion of unique articles on select public health nutrition topics from the period of 1998–2008.

Note: Topics included breast feeding, infant physiology and nutrition, protein energy malnutrition, nutrition and infection, vitamin A, iodine, iron, zinc and overweight.

($n = 49$), and authors' letters and comments ($n = 48$), there were a total of 412 unique articles published during the 11-year period, or an average of 37 ± 6 (SD) articles per year. Full journal publications were retrieved for 330 (80.1%) of these articles, while only abstracts were available for the remainder. During the period reviewed, all of the West African countries, except Cape Verde and Liberia, produced at least one article on the selected topics. The mean number of retrievals increased from an average of 29 per year in the biennium 1998–1999 to 45 per year in the biennium 2007–2008 (Figure 2). Most of the articles (90%) were published in English, and all but one of the others was published in French. Among the lead authors affiliated with institutions from Francophone or Lusophone West African countries, authors from Guinea, Guinea-Bissau and Mali published only in English-language journals, while authors from Mauritania published only in French-language journals. Authors from Benin, Burkina Faso, Côte d'Ivoire, Senegal and Togo published in both English- and French-language journals.

The topics that received the greatest research attention were, in descending order: 'breast feeding', 'overweight', 'vitamin A', 'iodine', 'infant physiology and nutrition', 'protein-energy malnutrition' and 'zinc' (see Table 1). The topics 'nutrition and infection' and 'iron' received less attention overall. There were significant trends in the number of articles published on selected research topics. In particular, there was an increase in the number of publications on iron nutrition ($\beta = 0.82$; $p = 0.002$), infant nutrition physiology ($\beta = 0.63$; $p = 0.037$) and overweight ($\beta = 0.64$; $p = 0.037$), and a decrease in the number of publications on iodine nutrition ($\beta = -0.87$; $p = 0.001$) during the period of analysis. In general, the rank order of research topics did not change, regardless of whether single or multiple MeSH topic headings were allowed for the same publication. For the analysis of study research designs, we were unable to classify three articles. For the remaining articles, the most common research designs were cross-sectional observational studies (41.3%), prospective observational (cohort) studies (19.2%), RCTs (14.1%) and retrospective observational (case-control) studies (7.3%). The remaining articles reported mainly on laboratory studies (6.6%), literature reviews (5.3%) or clinical case studies (4.1%).

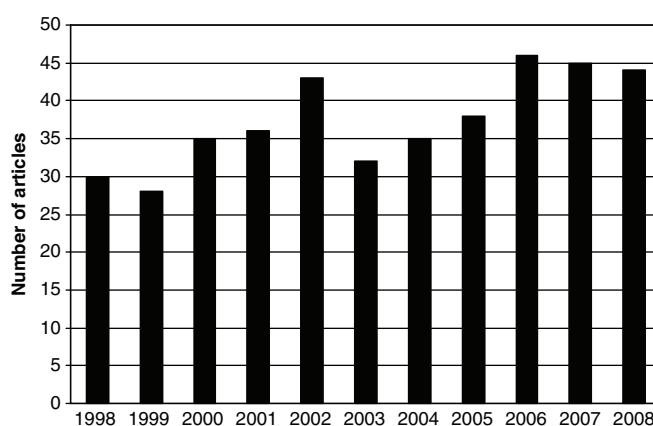


Figure 2. Number of unique articles published per year on nine select public health nutrition topics, by year of publication (1998–2008).

Table 1. Percent of articles published per year on nine selected public health nutrition topics in West Africa, by research topic and year of publication (1998–2008).^a

Topic	Year of publication (number of articles/year)											All ^b (412)
	1998 (30)	1999 (28)	2000 (35)	2001 (36)	2002 (43)	2003 (32)	2004 (35)	2005 (38)	2006 (46)	2007 (45)	2008 (44)	
Breastfeeding	16.7	21.4	20.0	44.4	25.6	18.8	25.7	26.3	23.9	15.6	20.5	23.5
Overweight	16.7	10.7	14.3	22.2	11.6	15.6	20.0	10.5	23.9	20.0	18.2	17.0
Vitamin A	6.7	14.3	8.6	2.8	18.6	12.5	5.7	15.8	6.5	17.8	15.9	11.7
Iodine	30.0	14.3	20.0	13.9	11.6	9.4	5.7	7.9	6.5	4.4	0.0	10.4
Infant nutrition	6.7	0.0	5.7	2.8	7.0	18.8	5.7	18.4	8.7	15.6	6.8	9.0
physiology												
Protein energy	13.3	14.3	17.1	5.6	4.7	12.5	8.6	10.5	4.3	6.7	4.5	8.7
malnutrition												
Zinc	6.7	10.7	8.6	0.0	14.0	9.4	17.1	2.6	10.9	6.7	9.1	8.7
Nutrition & infection	3.3	14.3	5.7	8.3	7.0	3.1	11.4	0.0	6.5	6.7	9.1	6.8
Iron	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	8.7	6.7	15.9	4.1

^aTable arranged in descending order by research topics receiving the greatest attention overall from the 1998–2008 period.^bValues are percent; *n* in brackets.

Table 2. Percent of articles published per year on nine selected public health nutrition topics in West Africa, by country where the study was conducted and year of publication (1998–2008).^a

Country	Year of publication (number of articles/year)											
	1998 (30)	1999 (28)	2000 (35)	2001 (36)	2002 (43)	2003 (32)	2004 (35)	2005 (38)	2006 (46)	2007 (45)	2008 (44)	All ^b (412)
Nigeria	40.0	32.1	28.6	38.9	39.5	37.5	42.9	26.3	26.1	26.7	40.9	34.2
Ghana	6.7	7.1	8.6	8.3	4.7	9.4	11.4	15.8	15.2	13.3	13.6	10.7
Burkina Faso	10.0	3.6	2.9	5.6	4.7	12.5	0.0	10.5	10.9	4.4	13.6	7.5
Côte d'Ivoire	6.7	10.7	5.7	5.6	9.3	9.4	0.0	13.2	6.5	8.9	4.5	7.3
Senegal	10.0	7.1	11.4	5.6	4.7	9.4	5.7	5.3	8.7	6.7	2.3	6.8
Gambia	3.3	3.6	2.9	11.1	2.3	3.1	8.6	0.0	8.7	4.4	2.3	4.6
Bénin	0.0	0.0	2.9	5.6	4.7	0.0	8.6	2.6	4.3	0.0	4.5	3.2
Mali	0.0	0.0	2.9	0.0	2.3	3.1	5.7	2.6	4.3	6.7	4.5	3.2
Guinea-Bissau	0.0	3.6	0.0	0.0	2.3	3.1	2.9	5.3	2.2	6.7	4.5	2.9
Niger	0.0	0.0	0.0	0.0	4.7	0.0	2.9	2.6	4.3	0.0	0.0	1.5
Togo	3.3	0.0	5.7	5.6	0.0	0.0	0.0	0.0	0.0	2.2	0.0	1.5
Guinea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.5
Mauritania	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Sierra Leone	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.2
Multi-international	13.3	17.9	14.3	11.1	7.0	0.0	8.6	7.9	4.3	4.4	2.3	7.8
Multi-Africa	3.3	0.0	0.0	0.0	4.7	0.0	0.0	2.6	2.2	2.2	0.0	1.5
Multi-West Africa	3.3	14.3	11.4	2.8	9.3	9.4	0.0	5.3	2.2	8.9	6.8	6.6

^aTable arranged in descending order by percentage of overall research output from the 1998–2008 period.^bValues are percent; *n* in brackets.

The countries where the research was conducted are shown in Table 2. More than a third of the studies were completed in Nigeria. Other countries that were ranked in the upper half of the research sites are: Ghana, Burkina Faso, Côte d'Ivoire, Senegal and Gambia. A number of studies were considered 'multi-international' or 'multi-West African' because they were conducted in more than one site. These studies were multi-country review articles, cross-country comparisons or multi-country intervention trials.

The locations of the institutions that were primarily responsible for conducting the foregoing studies are listed in Table 3. These analyses were completed by assigning credit exclusively to the institutions represented by the lead authors of the individual articles. Nigeria was ranked as the country with the greatest number of articles published under the lead authorship of someone whose home institution is based in that country. Europe and North America were ranked as the next most common sites of the research institutions, followed by Ghana, Burkina Faso and Senegal. Notably, nearly half the articles (46%) were published from institutions located outside the West African region, mostly in Europe and North America. We also prepared a list of the specific institutions that were involved in the greatest numbers of published articles, by completing a separate analysis based on the institutional affiliations of all identifiable co-authors involved in each of the publications (see Table 4). Six of the most prolific institutions were based in Europe or North America or were closely linked with European institutions, four were based in Nigeria, two were based in Ghana, and one was based in Côte d'Ivoire.

In an attempt to assess the quality of the journals in which the articles were published, we calculated the mean and median impact factors for these journals. However, this analysis was complicated by the fact that more than a third of the articles were published in journals that are not included in the major databases for journal impact factors. Therefore, in Table 5 we present the summary data for the country-specific journal impact factors: (1) for all articles combined (in which case, the scores for journals with no available impact factor were considered to be zero) and (2) for the subset of articles that were published in journals for which an impact factor was available. The overall mean impact factor of journals where the foregoing articles appeared was 2.2 ± 3.4 (median = 1.1, $n = 412$), when all articles were included in the analysis, and 3.6 ± 4.1 (median = 2.8, $n = 255$), when just those articles that appeared in journals with published impact factors were considered. The mean impact factor for journals in which English-language articles appeared was 2.4 ± 3.5 for all articles ($n = 376$) and 3.6 ± 3.7 for the subset of articles in journals with impact factors ($n = 249$), whereas the respective impact factors were 0.1 ± 0.2 ($n = 35$) and 0.5 ± 0.3 ($n = 6$) for the journals in which French-language articles appeared. The highest journal impact factors were observed for articles published by senior authors based in Gambia, Mali and Guinea-Bissau, although the authors based in these countries published a relatively small number of articles. Authors based in Europe, Burkina Faso and North America accounted for the next highest rankings for journal impact scores, and these authors were responsible for a much greater percentage of the published studies. By contrast, many of the articles produced by authors based in Benin, Guinea, Nigeria and Senegal were published in journals with relatively low impact or non-available impact factors.

On average, the published articles were cited 8.8 times, although the number of citations was highly skewed (median = 3.0). Generally consistent with the results for

Table 3. Percent of articles published per year on nine selected public health nutrition topics in West Africa, by country or continent of institution represented by lead author and year of publication (1998–2008).^a

Country	Year of publication (number of articles/year)											
	1998 (30)	1999 (28)	2000 (35)	2001 (36)	2002 (43)	2003 (32)	2004 (35)	2005 (38)	2006 (46)	2007 (45)	2008 (44)	All ^b (412)
Nigeria	40.0	32.1	17.1	33.3	34.9	28.1	37.1	23.7	28.3	24.4	29.5	29.6
Europe ^c	20.0	28.6	34.3	25.0	14.0	28.1	25.7	26.3	21.7	24.4	18.2	23.8
North America ^d	13.3	14.3	17.1	22.2	20.9	18.8	14.3	21.1	19.6	24.4	31.8	20.4
Ghana	6.7	7.1	8.6	2.8	2.3	6.3	5.7	2.6	8.7	4.4	0.0	4.9
Burkina Faso	3.3	3.6	2.9	2.8	4.7	0.0	2.9	7.9	8.7	0.0	11.4	4.6
Senegal	6.7	3.6	11.4	0.0	4.7	6.3	2.9	5.3	2.2	6.7	2.3	4.6
Côte d'Ivoire	3.3	0.0	0.0	2.8	4.7	3.1	0.0	5.3	2.2	2.2	2.3	2.4
Guinea-Bissau	0.0	7.1	0.0	0.0	2.3	0.0	0.0	2.6	2.2	6.7	2.3	2.2
Gambia	0.0	0.0	2.9	8.3	0.0	3.1	2.9	0.0	4.3	0.0	0.0	1.9
Bénin	0.0	0.0	0.0	0.0	7.0	0.0	5.7	2.6	2.2	0.0	0.0	1.7
Other ^e	3.3	3.6	0.0	0.0	2.3	0.0	2.9	0.0	0.0	2.2	2.3	1.5
Togo	3.3	0.0	2.9	2.8	0.0	0.0	0.0	0.0	0.0	2.2	0.0	1.0
Mali	0.0	0.0	0.0	0.0	2.3	6.3	0.0	0.0	0.0	0.0	0.0	0.7
Mauritania	0.0	0.0	2.9	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.5
Guinea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.2

^aTable arranged in descending order by percentage of overall research output from the 1998–2008 period.^bValues are percent; *n* in brackets.^cIncludes Austria, Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Spain, Sweden, Switzerland and UK.^dIncludes Canada and USA.^eIncludes Bangladesh, Congo, Guatemala, India, Japan and Malaysia.

Table 4. Institutions that accounted for the greatest number of articles published on selected public health nutrition topics in West Africa (1998–2008).^a

Rank	Institution	Number of publications	Percent ^b
1	Institut de Recherche pour le Développement (IRD) Burkina Faso, Côte d'Ivoire, France, Senegal and Vietnam	36	8.7
2	Medical Research Council (MRC) Gambia, South Africa, UK	25	6.1
3	University of Ibadan, Nigeria Departments of Chemical Pathology, Epidemiology and Medical Statistics, Food Technology, Human Nutrition, Medicine, Obstetrics and Gynecology, Ophthalmology, Pediatrics, Pharmaceutical Chemistry, Physiotherapy, Radiotherapy, Surgery	24	5.8
4	University of Ghana, Ghana Departments of Community Medicine, Medicine, Nutrition and Food Science, Obstetrics and Gynecology, Surgery; and affiliated units Institute for Statistical, Social and Economic Sciences, Korle Bu Teaching Hospital, National Diabetes Management and Research Centre, Noguchi Memorial Institute for Medical Research	23	5.6
5	London School of Hygiene and Tropical Medicine, UK Departments of Epidemiology and Population Health, Infectious and Tropical Diseases, International Nutrition; Immunobiology Unit; Nutrition and Public Health Interventions Research Unit	16	3.9
6	Université Victor Segalen, France Institut National de la Santé et de la Recherche Médicale (INSERM)	15	3.6
7	Loyola University, USA Department of Preventive Medicine and Epidemiology	14	3.4
7	Kintampo Health Research Centre (KHRC) Ghana	14	3.4
9	Bandim Health Project Guinea-Bissau Ministry of Health in partnership with INDEPTH Network, Danish Epidemiology Science Center and Statens Serum Institute, Denmark	13	3.2
9	University of Jos, Nigeria Departments of Chemical Pathology, Community Medicine, Family Medicine, Pediatrics	13	3.2
11	Obafemi Awolowo University, Nigeria Departments of Biochemistry, Chemistry, Community Health, Demography and Social Statistics, Mental Health, Microbiology, Morbid Anatomy and Histopathology, Nursing Science, Obstetrics Gynecology and Perinatology, Sociology and Anthropology, Pediatrics	12	2.9

Table 4 (Continued)

Rank	Institution	Number of publications	Percent ^b
11	Centre Hospitalier Universitaire de Treichville, Côte d'Ivoire Projet Agence Nationale de Recherches sur le SIDA (ANRS)	12	2.9
13	University of Benin, Nigeria Departments of Anesthesia, Child Health, Community Health; and affiliated unit Institute of Child Health	11	2.7

^aTable arranged in descending order by research institution publication output from the 1998–2008 period.

^bPercentage of total publication output ($n = 412$).

journal impact scores, the average number of times the articles were cited was greatest for those studies presented by researchers based in Gambia, Europe, North America, Ghana, Burkina Faso and Mali (see Table 6). As with the journal impact factors, the average number of citations of articles prepared by authors in Benin, Senegal, Nigeria, Mauritania, Togo and Guinea was relatively low.

The top funding agencies that supported the foregoing research are listed in Table 7. Overall, the rank order of the funding agencies did not change when adjusted for situations in which multiple donors supported individual studies. Almost all of the top funding agencies were based in either North America or Europe.

Discussion

The current analyses, based on information retrieved from multiple bibliographic searches, found that there was an average of approximately 40 articles published annually in West Africa on nine key topics in public health nutrition during the 11-year period from 1998 to 2008. The PubMed bibliographic search engine that was used for these searches scans all publications from a total of 8400 scientific journals representing the full range of biomedical research, including nutrition and some related social sciences. Although the West African publication output increased slightly during this time interval, the average number of publications reached only 45 per year in 2007–2008. Obviously, the number of articles identified would have been greater if we had included more research themes and keywords, but the specific search topics were chosen because they represent the principal nutrition issues of presumed public health importance for the region. Moreover, by using a reasonably small number of specific topics we were able to conduct a manageable, unbiased analysis of publication output by year, country and institution. Among the research topics that were selected for consideration, most of the attention was focused on infant and young child feeding, particular micronutrient deficiencies and the emerging problem of overweight and obesity. Surprisingly few articles were identified under the category 'nutrition and infection', and several micronutrients of presumed public health importance received relatively little attention. Most articles were published in English, and the primary authors of nearly half the publications were located in institutions outside West Africa.

Table 5. Impact factor of journals in which articles were published on selected public health nutrition topics in West Africa (1998–2008), by country or continent of lead author's institution and whether or not articles considered were from journals with no published impact factor.

Country	Including journals with no impact factor available ^a			Excluding journals with no impact factor available		
	Number of articles	Mean impact factor score	Median impact factor score ^b	Number of articles	Mean impact factor score	Median impact factor score ^b
Gambia	8	4.8±3.7 ^c	4.2	8	4.8±3.7	4.2
Mali	3	3.0±0.0	3.0	3	3.0±0.0	3.0
Guinea-Bissau	9	5.8±7.2	2.8	9	5.8±7.2	2.8
Europe	98	3.6±4.5	2.8	77	4.5±4.7	3.0
Burkina Faso	19	2.3±1.8	2.7	14	3.1±1.4	2.9
North America	84	2.8±2.5	2.7	68	3.4±2.4	3.0
Mauritania	2	1.9±2.8	1.9	1	3.9±0.0	3.9
Bénin	7	1.3±1.4	0.9	5	1.8±1.4	1.2
Togo	4	1.1±1.5	0.8	2	2.3±1.1	2.3
Ghana	20	2.9±5.6	0.7	11	5.3±6.7	4.3
Other	6	1.4±1.9	0.4	3	2.8±1.8	3.2
Côte d'Ivoire	10	1.5±2.3	0.2	5	3.0±2.5	4.3
Guinea	1	0.0±0.0	0.0	0	–	–
Nigeria	122	0.5±1.0	0.0	40	1.6±1.1	1.1
Senegal	19	1.3±2.0	0.0	9	2.8±2.1	2.8
All West Africa	224	1.4±2.9	0.0	107	3.0±3.6	2.3
All non-West Africa	188	3.1±3.7	2.7	148	4.0±3.8	3.0
All countries and continents	412	2.2±3.4	1.1	255	3.6±3.7	2.8

^aImpact factor considered zero when no published impact factor was available.

^bTable arranged in descending order by median impact factor score.

^cMean ± SD (all such values).

We assessed the quality and impact of these publications by using common metrics, such as journal impact factors and numbers of citations of individual articles. Although it is generally assumed that the journal impact factor and citation index of individual papers provide the best objective evidence of the likely impact of a particular publication on future research activity and national health policy, this may not be the case in lower income countries, where local researchers and policy-makers may have better access to national or regional journals (possibly published in a language other than English) than to international journals. Moreover, because the national and regional journals generally have a smaller number of subscribers, their impact factors are much lower, or are excluded from international databases on journal impact. Thus, there is a dilemma in trying to assess the true impact of these publications within the West Africa region. Bearing these caveats in mind, it is still worth noting that the articles prepared by researchers based in institutions outside of West Africa were more likely to be published in journals with known impact factors, and the impact factors for these journals tended to be higher than for the journals in

Table 6. Number of citations of articles published on selected public health nutrition topics in West Africa (1998–2008), by country or continent of lead author's institution.

Country	Number of articles	Total number of citations	Mean (\pm SD) number of citations	Median number of citations ^a
Gambia	8	178	22.3 \pm 13.6	19.5
Mali	3	18	6.0 \pm 1.0	6.0
North America	84	957	11.4 \pm 19.6	5.0
Bénin	7	30	4.3 \pm 4.6	4.0
Europe	98	1436	14.7 \pm 40.5	4.0
Côte d'Ivoire	10	61	6.1 \pm 9.0	3.5
Ghana	20	199	10.0 \pm 17.6	3.5
Other	6	34	5.7 \pm 6.4	3.5
Guinea-Bissau	9	53	5.9 \pm 7.5	3.0
Mauritania	2	4	2.0 \pm 2.8	2.0
Nigeria	122	448	3.7 \pm 5.0	2.0
Burkina Faso	19	115	6.1 \pm 12.3	1.0
Togo	4	6	1.5 \pm 2.4	0.5
Senegal	19	79	4.2 \pm 7.0	0.0
Guinea	1	0	–	–
All West Africa	224	1191	5.3 \pm 9.1	2.0
All non-West Africa	188	2427	12.9 \pm 32.1	4.0
All countries and continents	412	3618	8.8 \pm 23.0	3.0

^aTable arranged in descending order by median number of citations.

which researchers based in West African institutions submitted their articles. Likewise, the articles published by principal authors from non-West African institutions had a considerably greater number of citations.

The majority of the articles that provided information on their funding sources reported that the research was supported by donor agencies outside West Africa, including foreign research institutions, bilateral aid agencies, international technical agencies and private foundations. This analysis of funding agencies was limited, however, by the fact that 54% of the articles provided no information on the funding source. Most of the latter articles originated from African institutions (half from Nigeria), suggesting that the research might have been conducted using internal university resources.

In summary, the research output for studies of human nutrition was disappointingly low, especially considering the magnitude of the nutrition problems in the West Africa region. This result is not entirely surprising, though, given the small number of graduate training programmes in nutrition (Pepping 2010) and public health (Ijsselmuiden *et al.* 2007) in the region. Nevertheless, there are several limitations to the current study methods that must be recognised. Firstly, because we only selected the subset of nine nutrition-related themes that were deemed most important for public health in the region, it is likely that additional nutrition-related articles were published on other topics during this time period and were not included in our

Table 7. Funding agencies that supported the greatest number of articles published on selected public health nutrition topics in West Africa (1998–2008).

Rank	Organisation	Number of publications supported ^a	Percent	Adjusted percent ^b
1	National Institutes of Health (NIH), USA	35	8.5	5.3
2	United States Agency for International Development (USAID), USA	25	6.1	3.6
3	Nestlé Foundation, Switzerland	17	4.1	1.7
4	Institut de Recherche pour le Développement (IRD), France	13	3.2	2.0
4	European Commission (ECHO), Belgium	13	3.2	1.5
4	Agence Nationale de Recherches sur le SIDA (ANRS), France	13	3.2	1.2
7	Medical Research Council (MRC), UK	10	2.4	1.5
7	The United Nations Children's Fund (UNICEF), USA	10	2.4	1.3
9	World Health Organisation (WHO), Switzerland	9	2.2	0.8
10	Swiss Federal Institute of Technology, Switzerland	8	1.9	1.0
10	Thrasher Research Fund, Salt Lake City, USA	8	1.9	0.8
12	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Germany	7	1.7	0.8
12	French Ministry of Education, Research and Technology, France	7	1.7	0.6
12	Danish International Development Agency (DANIDA), Denmark	7	1.7	0.4
15	Danish Council for Development Research, Denmark	5	1.2	0.7
15	US Public Health Service, USA	5	1.2	0.6
17	Micronutrient Initiative (MI), Canada	4	1.0	0.5
17	Canadian Institutes of Health Research (CIHR), Canada	4	1.0	0.5
17	French Ministry of Cooperation, France	4	1.0	0.5
17	Canadian International Development Agency (CIDA), Canada	4	1.0	0.4

^aTable arranged in descending order by the number of publications supported by respective funding organisations.

^bAdjusted for presence of multiple funding agencies for single publication (see text).

search. Additionally, many institutions and funding agencies may produce abstracts or reports that are not submitted to peer-reviewed journals and are therefore not indexed in the PubMed database. Thus, our analysis undoubtedly underestimates the total nutrition-related research productivity in the region. Secondly, because we were

unable to obtain the full text for roughly 20% of the articles, it is possible that more institutional affiliations and funding sources would have been identified if we had had access to all the published articles.

Despite these limitations, it seems clear that there is relatively little peer-reviewed research being published on key public health nutrition topics in West Africa. Thus, new approaches are needed to encourage and support research in this region, and to ensure that the results of this research are published in accessible journals so that they can influence public health policy. The fact that a large proportion of relevant articles that are currently being published were written by researchers based in institutions outside the region might be viewed as a condemnation of West African research capacity. Yet, it could be argued just as forcefully that the cross-regional collaboration that is implied by such publications might be the most efficient way of rapidly expanding research capacity and output in West Africa. In the latter case, however, it would be important to ensure that the research is indeed conducted collaboratively with West African institutions and investigators, and that the research agenda is developed by the local research and public health community and is focused on indigenous nutritional and health problems and priorities. Otherwise, the research results would be much less likely to shape the development of culturally sensitive, economically feasible and sustainable approaches for mitigating these problems in West Africa. New methods for establishing research priorities to reduce the disease burden in lower income countries are currently being developed, taking into account issues of feasibility, cost-effectiveness and the likelihood the research leads to subsequent programme implementation and equitably distributed improvements in health (Rudan *et al.* 2007). Such priority-setting exercises can be used to ensure the relevance of nutrition research for addressing public health problems.

Earlier working groups convened by the United Nations University, other United Nations agencies and the International Union of Nutritional Sciences in 1978 and 1996 (UNU and IUNS 1997) have consistently noted the need for regional training institutions in Africa, where currently only a few countries have the capacity for carrying out advanced training in nutrition and public health. More recently the Global Ministerial Forum on Research for Health (Global Forum for Health Research 2009) reached a similar conclusion. After more than 30 years of discussion on this theme, it seems that action to establish such centres of advanced training and applied research is long overdue.

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