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A decade of nutrition research in Africa: assessment of the evidence base and academic collaboration

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Abstract

Background

Despite international efforts, malnutrition rates in Africa have not improved compared to other regions in the world. Investment in the build-up of a strong African research workforce is essential to provide contextual solutions to the nutritional problems of Africa. To orientate this process, we reviewed nutrition research carried out in Africa and published during the last decade.

Methods and Findings

We assessed nutrition research from Africa published between 2000 and 2010 from MEDLINE and EMBASE and carried out an analysis of study design and type of intervention for studies indexed as Major MeSH terms for vitamin A deficiency, protein-energy malnutrition, obesity, breastfeeding, nutritional status and food security. The affiliations for the first authors were visualised as a network and the power of the affiliations was assessed using centrality metrics. Most research on the topics was conducted in Southern (36%) and Western Africa (34%). The intervention studies (9%; n=95) mainly tested technological and curative approaches to the nutritional problems. Only for papers on protein-energy malnutrition and obesity, did lead authorship from Africa exceed that from non-African affiliations. The 10% most powerfully connected affiliations were mainly situated outside Africa for publications in vitamin A deficiency, breastfeeding, nutritional status, and food security. The five most powerfully connected institutions from Africa were all based in South Africa.

Conclusions

The development of the evidence base for nutrition research in Africa is focussed on treatment or technical solutions to nutritional problems. In parallel, the capacity of African research institutions to publish research conducted in Africa is tied to that of their peers in the North. The potential for cross-African networks to publish nutrition research from Africa remains grossly underutilised. Efforts to build capacity for effective nutrition action in Africa will require forging an equitable and true academic partnership between African and non-African research institutions.

Introduction

This is a critical time for Africa to address the nutritional challenges it faces. As the international community prepares to assess success towards meeting the Millennium Development Goals by 2015, progress in improving nutrition in Africa is still a major cause for concern. Undernutrition rates remain high, particularly in sub-Saharan Africa and may have even risen during the last decades in some African countries[1]. The 'double-burden' of concurrent undernutrition and overnutrition increases mortality and morbidity, and has serious economic and social repercussions because of reductions in Gross Domestic Product, lost productivity and inflated healthcare spending[2]. Recent global events, including the food price crisis, global economic recession and climate change are having a profound influence on hunger, health and agriculture and present new challenges to Africa in the field of nutrition, food and nutrition security[3].

To generate the necessary evidence to tackle nutrition issues in Africa, the build-up of a strong African research workforce is essential. Strong national research systems are needed to maximise the incorporation of local context and determinants of malnutrition[4]. Adequate nutrition research from Africa is therefore pivotal to both orient and drive local, national and international action to tackle nutrition problems on the continent[5]. In addition, it is important that research in Africa generates context-specific evidence from intervention studies[6]. Given the public health dimension of nutritional problems in Africa and the scarcity of resources to address them, intervention studies from Africa are critical, as these generate the evidence base and guide policy makers and donors to decide on which policy options are effective to address malnutrition in Africa.

The recent international attention[7;8] and substantial political commitments to nutrition[9] offer a window of opportunity to support and strengthen African nutrition research. To orientate this process, benchmarking of current research topics, study designs, and academic collaboration in nutrition research in Africa is a timely contribution. The present study assessed the status of nutrition research in Africa over the last decade. It is part of the SUNRAY project (www.sunrayafrica.co.za), an EU funded project that aims to develop a sustainable nutrition research agenda for Africa.

Methods

Retrieving and assessing the extent of published nutrition research from Africa

We proceeded in two steps. First, we assessed the global volume of studies published between 2000 and 2010. We searched MEDLINE (through PubMed) and EMBASE with the comprehensive search syntax presented in **Table 1**. We used thesaurus terms (MeSH in PubMed, Emtree in EMBASE) to increase the specificity of the search index[10]. Human studies or studies with relevance to human nutrition that were published between 01/01/2000 and 31/12/2010 in African countries were eligible. There was no language restriction. We included only original studies, i.e. letters, comments, editorials, case reports and systematic reviews were excluded. All references were imported in EndNote X2 (Thomson Reuters, NY) and duplicates were removed automatically. The selection process of papers is presented in **Figure 1.**

Secondly, we conducted an in-depth analysis of a set of topics considered of public health importance for Africa[2;6]: vitamin A deficiency, protein-energy malnutrition, obesity, breastfeeding, nutritional status and food security (MeSH: food supply). Large categories such as 'food' (n=1010) or 'diet' (n=633) were considered to be too generic for a more detailed assessment and most of the studies related to the composition of the foods without reference to nutritional status of humans and were hence considered only marginally appropriate for the purpose of this study. A specific search filter was applied to obtain papers from the database that had those terms tagged as a 'Major topic' in the MeSH (for MEDLINE) and EMTREE (for EMBASE) thesaurus (**Supplementary Table 1**). To evaluate the type of evidence produced, we were interested in the objective and study designs of the interventions and calculated the proportion of the research output that originated from intervention studies for the different topics reviewed. The information on study design was extracted manually from the papers. To assess whether the proportion of intervention studies on the total volume of research output was specific to nutrition research in Africa, we constructed a syntax in PubMed that combined our search syntax with (AND operator) the MeSH term for Europe, USA, Germany and China. The proportion of intervention studies was subsequently determined with the filter tool and included clinical trials, controlled clinical trials and randomised controlled trials.

Assessing affiliations of authors

Co-authorship on scientific publications was used as a proxy for collaboration and academic performance of scholars, as suggested previously[11]. To assess co-authorship of publications in nutrition from Africa, the institutional affiliation and country of the authors as listed on the

papers were extracted manually from the full text version of the articles. Shared authorship of institutes for each of the research topics assessed was visualised as a network structure using the Fruchterman Reingold algorithm[12] in Gephi software[13]. We generated network views with the size of each node and connector proportional to the number of connections. The affiliation of the first author of the paper was considered a proxy for the organisation that took a lead role in the research and its publication. To visualise the institutional networking behind the publication of nutrition research, we extracted the affiliation of the first authors and identified its associations with the affiliations of the co-authors. If more than one affiliation was listed under the first author, all were included. Powerful institutes in the network were identified using centrality measures[14]. Bonacich metrics were calculated in UCINET software[15] for this purpose. Parameters were set so that affiliations publishing on a specific topic were considered more powerful in the network when (i) they had more connections and (ii) when their connections were less connected to others. The power of the affiliations in the network was quantified with a β coefficient. We used normalised β values to compare centrality metrics across the different nutritional topics. We subsequently identified the most powerful 10% of affiliations in the network and categorised them into those based in Africa or not.

The protocol for the SUNRAY project, including this study, received ethical approval from the Institutional Review Board of the Institute of Tropical Medicine, Belgium on June 8th, 2011 (nr 11 21 3 771).

Results

Global scientific production

A total of 10,495 original papers on nutrition research conducted in Africa were retrieved (Figure 1). The ten most popular major MeSH term categories were food (n=1010), diet (n=633), breastfeeding (n=366), food contamination (n=325), nutritional status (n=322), obesity (n=298), nutritional physiological phenomena (n=293), malnutrition (n=269), nutrition disorders (n=234) and food microbiology (n=209). Supplementary Table 1 contains the number of papers per MeSH category from the papers retrieved.

Major topics

Research papers indexed as Major topics of vitamin A deficiency, protein-energy malnutrition, obesity, nutritional status, breastfeeding and food security accounted for 13% (n=1337) of the original papers retrieved. Most research on the topics indexed as Major

MeSH terms was conducted in Southern (36%) and Western Africa (34%). The least research originated from Central Africa (an average of 7% of published papers per topic). South Africa (15%) followed by Nigeria (10%) and Kenya (8%) were the countries that hosted the highest proportion of published nutrition research.

The majority (78%) of authors' affiliations were academic institutions or hospitals. For a large proportion (ranging from 26% to 63%) of the papers analysed, the first author's affiliation was located outside Africa with a fair balance between organisations located in North America (mainly the USA) and Europe (**Table 2**). Affiliations based in South Africa and Nigeria published more papers compared to their peers in other countries.

Figure 2 shows how more than half (on average 57%) of the studies conducted on the topics analysed were observational studies and in particular cross-sectional surveys. Intervention studies accounted for 9% (n=95) of the papers analysed and this proportion remained fairly constant over the period of analysis. The proportion of intervention studies was comparable with those obtained from our analysis for Europe (8%), Germany (11%) and the USA (12%), but was higher than in China (4%).

Of the papers under Major MeSH term 'vitamin A deficiency', 19 interventions were retrieved (26% of the studies under this topic). All but 4 studies tested the effect of technological solutions in the form of vitamin A supplements (n=16) or fortified foods (n=2). Six of the studies aimed at preventing vitamin A deficiency. Of the 6 interventions retrieved under protein-energy malnutrition (8% of the studies under this topic), all tested the use of special supplements and one was conducted with the aim of preventing undernutrition. One study compared supplements with local maize flour and another against better health care. Of the 10 intervention studies on obesity (4% of the studies under this topic), no study was conducted with the aim of preventing overweight or obesity. Six studies tested the use of physical activity or dietary interventions in overweight or obese and 3 evaluated specific drugs for weight loss or clinical outcomes. Of the 41 interventions on breastfeeding (13% of the studies under this topic), 34 aimed at promoting good breastfeeding practices. The large majority (n=30) of research on breastfeeding was carried out in the context of HIV transmission to children. A total of 13 of the intervention studies used approaches delivered through existing local structures and were primarily counselling and education. Of the 12 interventions on nutritional status (4% of the studies under this topic), 11 aimed at preventing deterioration of nutritional status. All of the interventions used technological approaches, in

particular fortified beverages, drugs, bio-fortified foods and vitamin supplements. Seven interventions (6% of the studies under this topic) were identified for food security. As these interventions were very heterogeneous in nature (pilot farms, food safety training, public work programme, products to treat malnutrition, role play, livestock projects and urban food garden); we were unable to compare them further.

Figures 3-8 show how a number of specific author affiliations distinctly take up central positions in the network of affiliations that publish on the different nutritional topics. Analysis of their importance in the network indicates how non-African institutions have pivotal positions in the network. The majority of the most powerfully connected affiliations were situated outside Africa. Regarding the 10% most powerful institutions, the share of those outside of Africa was 53%, 70%, 67%, 80% for papers on vitamin A deficiency, breastfeeding, nutritional status and food security, respectively. Only for papers on obesity and protein energy malnutrition, there were more African-based affiliations in the 10% most powerful institutions compared to non-African ones. Overall, the most powerfully situated institutes in the networks were (in decreasing order) the North-West University in South Africa (β=10.3 for papers on nutritional status), Stellenbosch University in South Africa (β=8.3 for papers on food security), Institut de Recherche pour le Développement in France (β=7.2 for papers on nutritional status), the University of Washington in the USA (β=6.8 for papers on vitamin A deficiency) and the University of Malawi (β=6.5 for papers on protein-energy malnutrition). Across the different nutritional topics analysed, the five most powerfully connected institutions from Africa were all based in South Africa: North-West University of Potchefstroom (β=10.3), Stellenbosch University (β=8.3), University of the Western Cape (β=6.4), Tygerberg Hospital (β=5.4) and the University of KwaZulu-Natal (β=4.8).

Given their dominance in the networks, we excluded South African research institutes from the analysis and assessed how this affected the findings. The exclusion did not modify the proportion of non-African based affiliations in the network considerably; except for it meant that a higher proportion of research papers was led by non-African institutions. With 75% of the papers published under an African affiliation, lead authorship in Africa exceeded that from non-African affiliations for research into protein-energy malnutrition only. The five most powerfully connected institutions (in decreasing order) were now the Tunisian National Institute of Nutrition, University of Ibadan in Nigeria, University of Yaoundé in Cameroon, The Zvitambo Project in Zimbabwe and the Tanzania Food and Nutrition Centre.

Discussion

Our findings indicate how the development of the evidence base for nutrition research in Africa is focussed on treatment or technical solutions to nutritional problems. In parallel, the capacity of African research institutions to publish research conducted in Africa is tied to that of their peers in the North. Over the investigated decade (2000-2010), a considerable proportion of publications in international indexed journals were dedicated to nutrition in Africa. Intervention studies were a minority of the studies conducted. Similar estimates for nutrition research published in low and middle income countries in the second half of 2005 were obtained[16].

Further scrutiny of the type of intervention studies conducted shows that most of the studies are assessing therapeutic strategies. Only a few studies tested the application of locally available resources or delivery platforms to prevent nutritional problems (for either over- or undernutrition) in Africa. In addition, only a few studies tested interventions on how distal determinants of nutritional status, (e.g. agricultural practices, social dynamics, economic parameters) can be modified to improve nutrition status. These so-called "nutrition sensitive" interventions have a significant potential to create a context for the prevention of malnutrition and therefore deserve more attention[17]. The present study indicates how the type of nutrition research conducted in Africa falls short of providing the evidence for policy makers to develop policies and programmes that enable a context that prevents malnutrition.

It is clear that a substantial amount of this research is driven by organisations situated outside of Africa. The first author of almost half of the studies published had an affiliation with a European or North American institution. This observation was shared by a review of nutrition research in west Africa[18] or in research output in 2005[16]. Similarly, an evaluation of the global research output, as indexed in Web of Science, previously showed that the most frequent co-author on research papers from Africa is based in the USA, followed by the UK, Germany and France[19]. In line with the latter report, we acknowledge that this is in part attributable to training programmes outside Africa. Various African authors might have published their research in the context of a Masters or Doctoral training abroad. However, the network of authors' affiliations of the papers indicates that root causes for this are mainly to be found at a more structural level, in particular in the pivotal role non-African academic institutions play in generating nutrition research in the continent. It is clear that a significant amount of initiative and build-up of knowledge with regard to nutrition in Africa is concentrated in non-

African institutions. In addition, cross-African linkages and networking of institutions within Africa seems secondary to networking with institutions based in the North, in particular in Europe or the USA.

In line with a previous analysis of research on agriculture for improved nutrition[20], the present review shows how African research capacity in human nutrition is tied to that of research institutions in the North. Clearly, international and intercontinental collaboration in research, when used to its full potential, can leverage scientific knowledge and capacity in Africa and help generate answers to address the complex challenges ahead. For such research collaboration to be considered a genuine partnership, it must rely on a balanced and complementary set of capacities[21]. The findings of our analysis identify research institutions in the North, principally USA and Europe, as brokers of nutrition knowledge in Africa. International agreements now explicitly state how development efforts need to build equitable partnerships with low and middle income countries[22]. Similar initiatives are yet to be established. In our opinion, the establishment of a code of conducts for academic collaboration would be a useful start.

Gillespie et al. previously argued how the current political commitment to nutrition needs to translate into the build-up of capacity (including academic) at national and regional level[23]. Our findings suggests that the collaboration between African research groups might not be used to its full potential and calls for a new approach that stimulates networking within the region and nutrition research output from Africa, owned by African institutions. Such an approach however, will require genuine support from stakeholders in the North. African researchers previously indicated that non-African research institutions and donors are instrumental in determining the research agenda of the continent[24].

We acknowledge a number of limitations of this study. Similar to most literature reviews, we assessed research evidence through academic publications. This method entails an inherent bias by limiting this assessment to output from peer-reviewed journals only. However, as discussed earlier[4] this approach remains a fairly objective and structured way to assess research efforts and evidence base to date. Grey literature was not included in this review, as it is not centralised or indexed and mostly not peer-reviewed. Secondly, we retrieved research from MEDLINE and EMBASE, which index papers from most high quality journals from Africa such as the South African Journal of Clinical Nutrition. Some journals that publish nutrition research from Africa (e.g. the African Journal of Food Agriculture Nutrition and

Development) without an impact factor were hence not included in this study. Using both the MEDLINE and EMBASE database, we are confident that we have captured the vast majority of high impact journals in our review. For instance, more than 90% of the 74 journals listed under the subject category nutrition and dietetics in Web of Knowledge were included.

For the purpose of this review, we explored the type of studies and the authorship for a number of specific categories classified with a "Major topic" label in the databases. Studies that dealt with the topics but were only labelled with a usual MeSH or Emtree label for this subject were hence not included in this analysis. As a consequence, restricting this assessment to studies indexed under a major subheading implies that we have missed important studies. We are aware of studies that have tested preventive approaches for malnutrition in Africa[25], using local resources[26] or modifications of environmental factors such as agriculture[27]. These studies did not appear in our assessment, as they were not indexed under the categories reviewed. In general however, we have no reason to believe that the application of Major topics is done differently than the assignment of MeSH terms for the different topics reviewed. Although we have worked on a sub-sample of manuscripts within the topics, biased results are unlikely in this regard.

In addition, our search terms did not capture research on iodine, iron or zinc, as these are classified under inorganic chemicals in the MeSH tree. It is clear that the findings of our analysis are quite consistent over the topics analysed. Hence we have no reason to assume that our findings would be different for other topics of nutrition that are studied in similar ways to the ones reviewed. A last limitation is that we focused our analysis on co-authorship with the first author. We did not analyse co-authorship of authors that were not affiliated with the first author, as this would populate the graphs with networks that might have played a secondary role in the research conducted. Although this appropriately focuses the analysis on the key institutions driving the publication of the findings, it reduces the importance of the last author of the paper, who is often the co-ordinating author.

In conclusion, this review shows how the evidence base in nutrition research, is generally limited and focussed on treatment and technical solutions to nutritional problems in Africa. Solutions for nutritional problems that use existing resources and delivery platforms, developed from high quality studies and responsive to African needs and context are urgently needed to respond effectively to the nutritional challenges of the continent. Our analysis shows how the potential for cross-African collaboration, to identify, implement and publish

nutrition research from Africa remains grossly underutilised. Adequate investment in an African-led nutrition research is needed to provide a sustainable response to the nutritional challenges of Africa. This will require equitable academic collaboration between high-income countries and African research institutions, with the balance of power placed with African researchers.

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Conflict of interest

We declare no conflict of interest.

Table 1 Search strategy to retrieve publications on nutrition research in Africa*

Search #1: (Algeria* OR Angola* OR Benin* OR Botswan* OR "Burkina Faso" OR Burkinabe OR Burund* OR Cameroon* OR "Cape Verde" OR "Cape Verdean" OR "Central African Republic" OR Chad* OR Comoros OR Comorian OR "Democratic Republic of Congo" OR "Republic of Congo" OR Congo OR Congolese OR "Cote d'Ivoire" OR "Republic of Cote d'Ivoire" OR "Ivory Coast" OR Ivorian OR Djibouti* OR Egypt* OR "Arab Republic of Egypt" OR "Equatorial Guinea" OR Guinean OR Eritrea* OR Ethiopia* OR Gabon* OR Gambia* OR Ghana* OR Guinea OR "Guinea-Bissau" OR Kenya OR Kenyan OR Lesotho OR Liberia* OR Libya* OR Madagasca* OR Malawi* OR Mali OR Malian OR Mauritania* OR Mauritius OR Mauritian OR Morocc* OR Mozambique OR Mozambican OR Namibia* OR Niger* OR Nigeria* OR Rwanda* OR "Sahara Occidental" OR "Sao Tome and Principe" OR Sao Tomean OR Senegal* OR Seychell* OR "Sierra Leone" OR "Sierra Leonian" OR Somali* OR "South Africa" OR "South African" OR Sudan* OR Swaziland OR Swazi OR Tanzania* OR Togo* OR Tunisia* OR Uganda* OR "Western Sahara" OR Zambia* OR Zimbabwe* OR Africa*[MH]) AND ("nutrition policy"[MH] OR "nutrition disorders"[MH] OR "nutrition therapy"[MH] OR "feeding methods"[MH] OR "Nutritional Physiological Phenomena"[MH] OR "food industry"[MH] OR "food safety"[MH] OR "nutritional sciences"[MH] OR "nutrition assessment"[MH] OR "food chain"[MH] OR "food-drug interactions"[MH] OR "legislation, food"[MH] OR "food preferences"[MH] OR "food hypersensitivity"[MH] OR "foodborne diseases"[MH] OR "food deprivation"[MH] OR "food and beverages"[MH] OR "diet records"[MH] OR "drinking behaviour"[MH]) NOT (editorial[ptyp] OR letter[ptyp] OR comment[pt] OR news[ptyp] OR addresses[ptyp] OR systematic[sb] OR "Case Reports"[Publication Type])

Search #2: (animal[MeSH] NOT human[MeSH])

Search #3: #1 NOT #2

* Developed for PubMed. The search was modified for use in EMBASE, Emtree terms equivalent to MeSH terms were used.

Table 2 Published articles (%) per topic of research with first author's country of affiliation

	VAD	PEM	Obesity	Breast feeding	Nutritional status	Food security
Europe (inc United Kingdom)	16(23)	14(20)	31(14)	46(15)	76(26)	30(24)
USA & Canada	16(22)	13(18)	21(10)	78(25)	64(22)	39(31)
Other	1(1)	0(0)	7(3)	5(2)	9(3)	6(5)
Africa	37(51)	42(58)	164(73)	158(52)	145(49)	47(37)
Egypt	1(1)	10(13)	13(6)	7(2)	11(4)	0(0)
Tunisia	0(0)	0(0)	26(12)	2(1)	5(2)	0(0)
Kenya	5(7)	2(3)	2(1)	13(4)	14(5)	9(7)
Nigeria	4(6)	8(12)	13(6)	34(11)	25(9)	5(4)
Malawi	2(3)	6(8)	0(0)	4(1)	3(1)	1(1)
South Africa	8(11)	6(8)	68(30)	44(15)	34(12)	12(10)
Country not specified	2(3)	3(4)	1(<1)	21(7)	0(0)	5(4)
All	72(100)	72(100)	224(100)	306(100)	294(100)	127(100)

PEM: Protein-energy malnutrition, VAD: Vitamin A deficiency. Countries with all percentages of published papers <5% are not tabulated.

Figure 1 Flow chart of selection of studies for the review

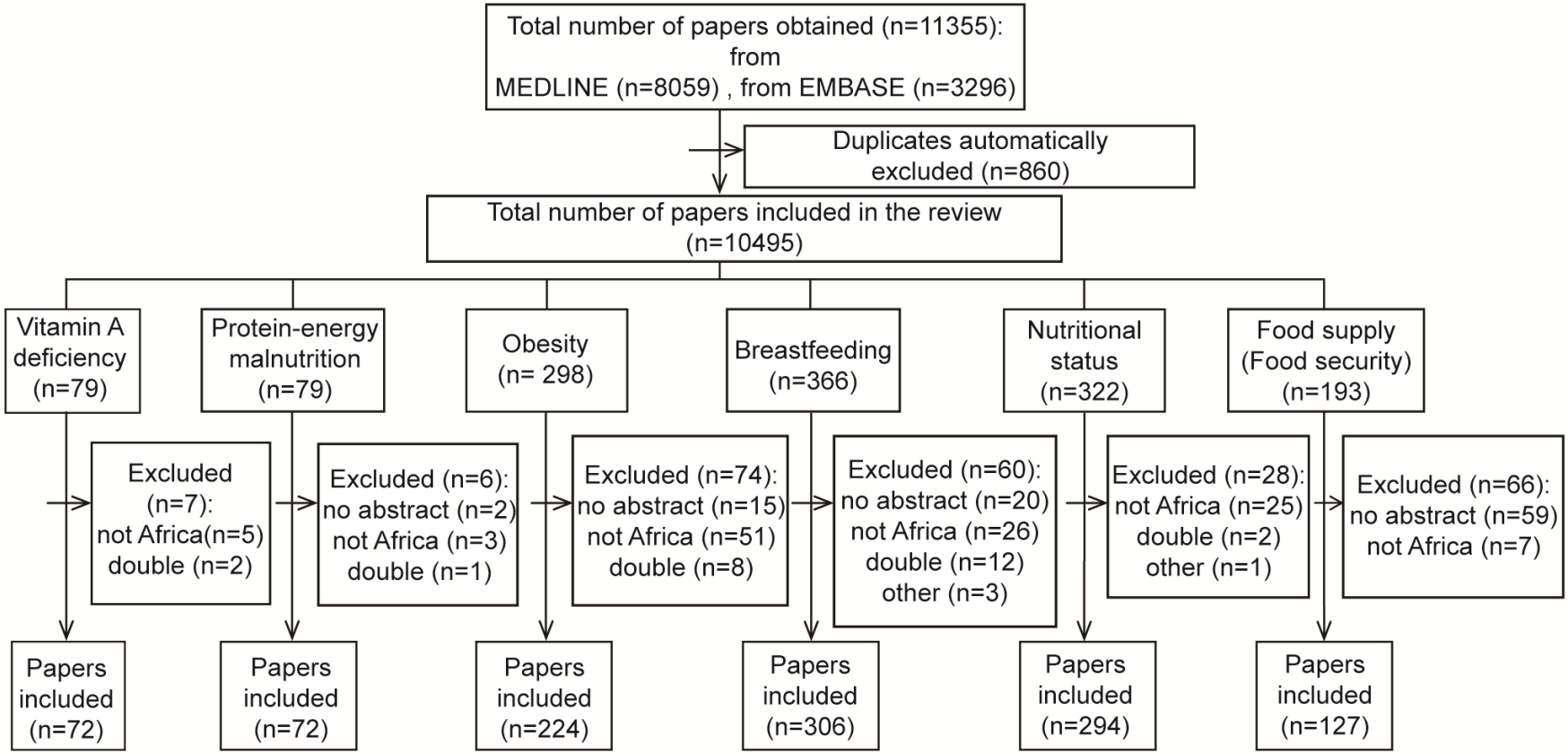
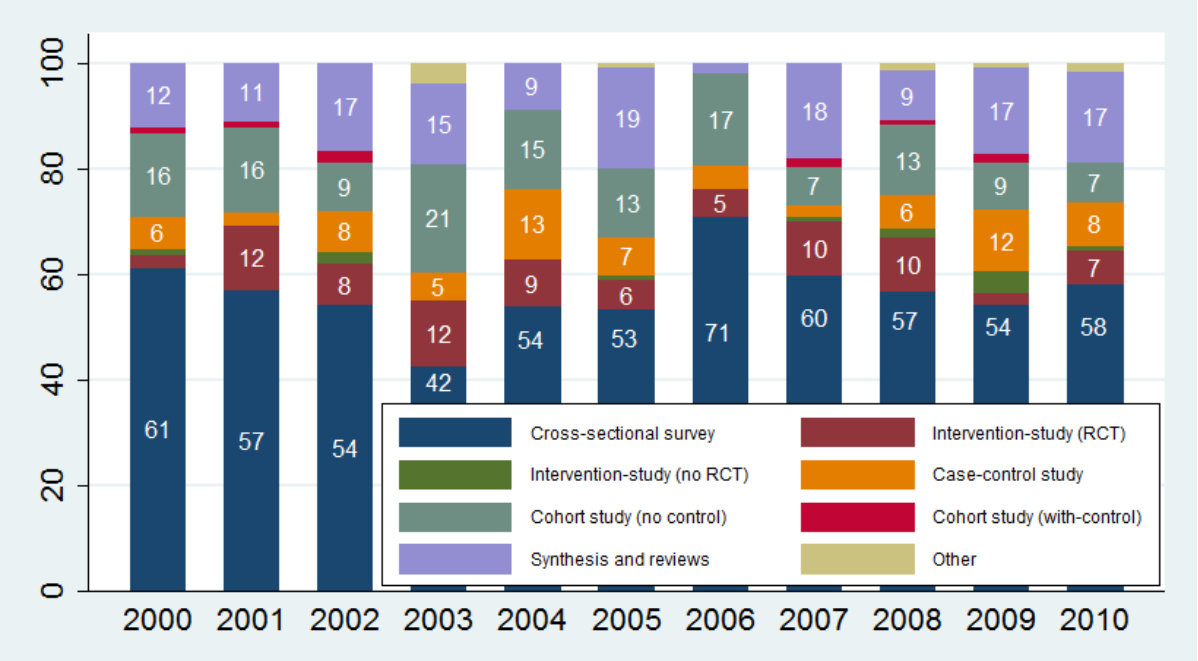
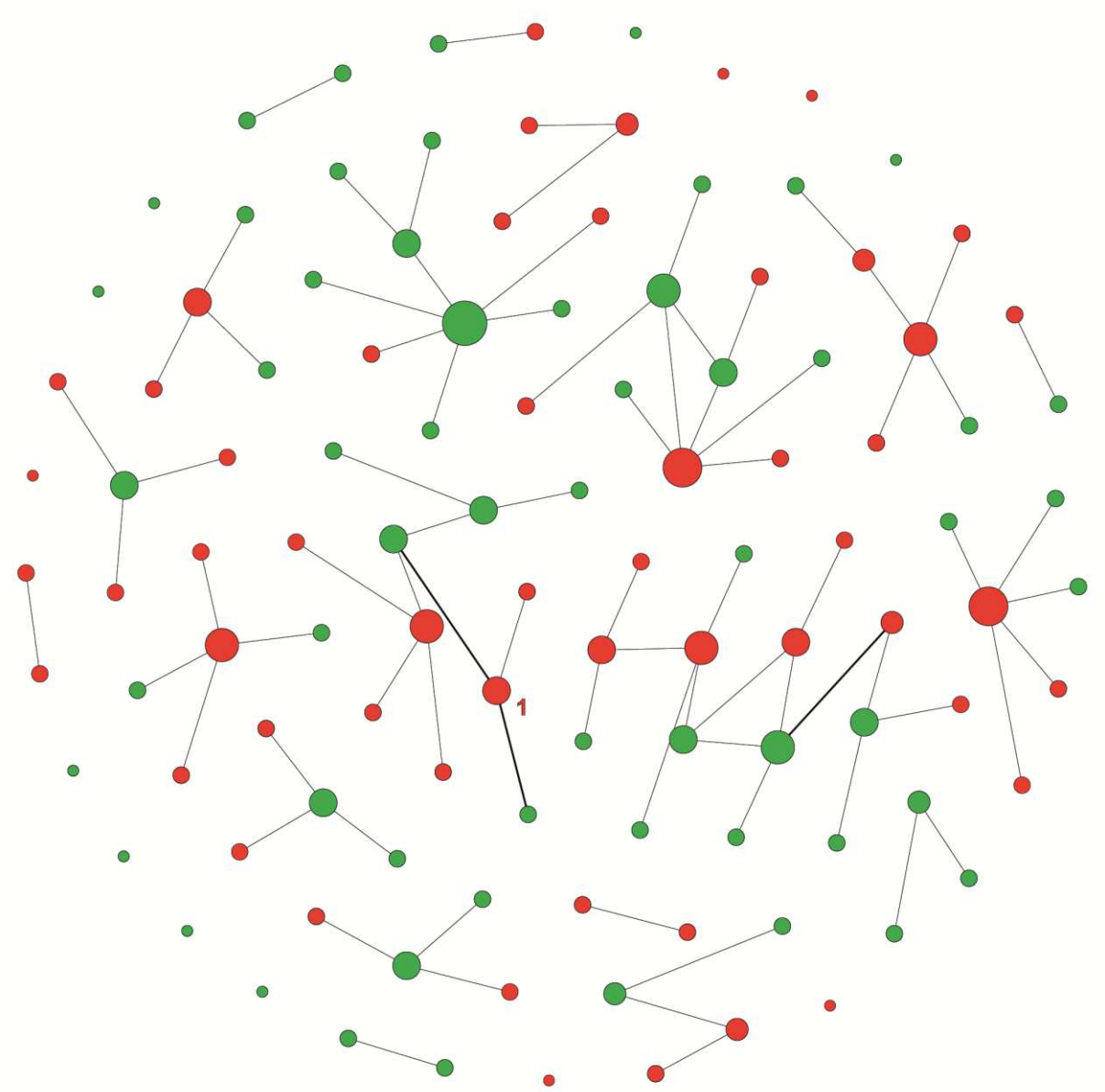


Figure 2 Designs of nutrition research conducted in Africa for 6 major topics*



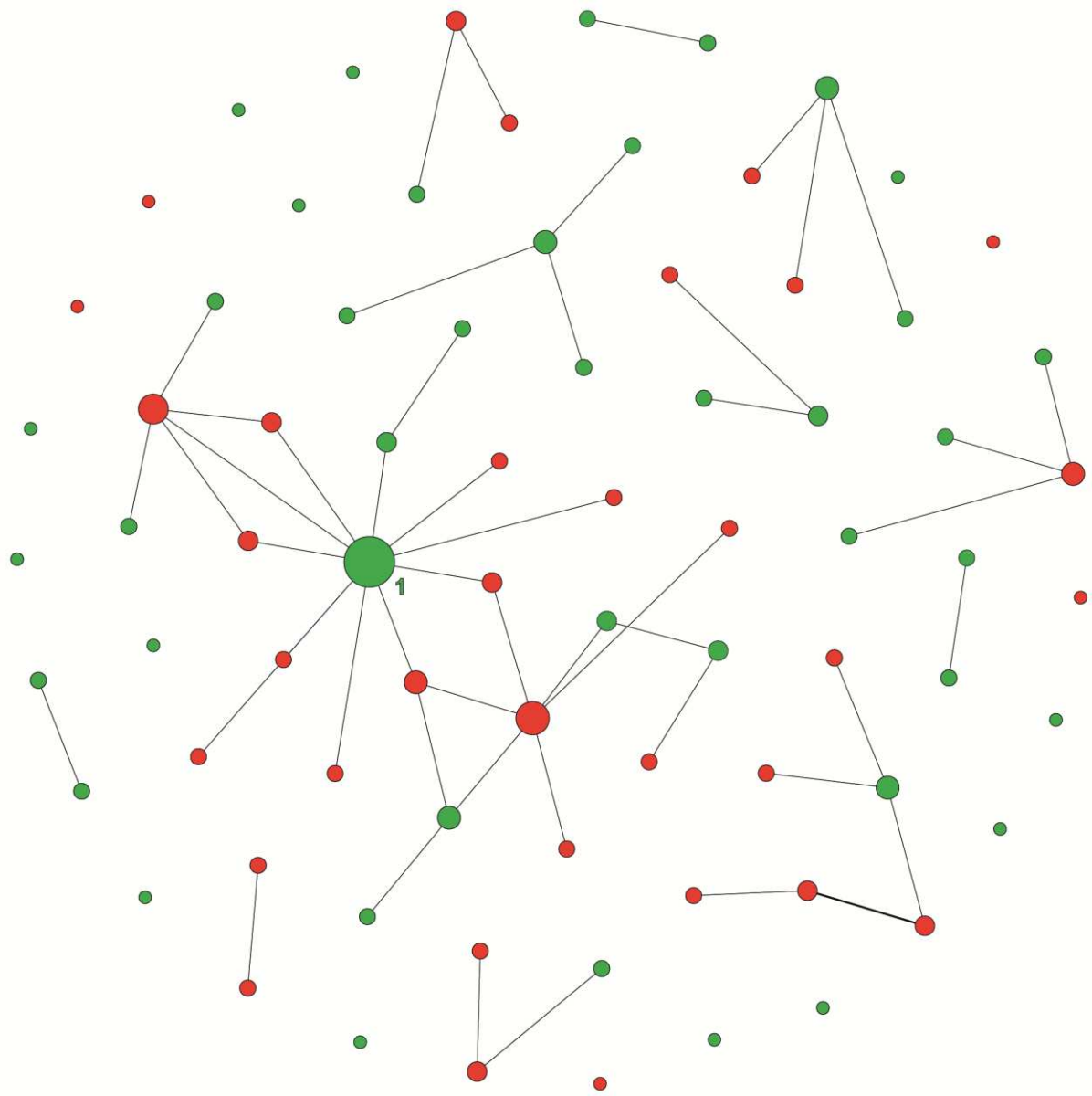
* Only papers indexed as Major MeSH on Vitamin A deficiency (n=72), Protein-energy Malnutrition (n=72), Obesity (n=224), Breastfeeding (n=306), Nutritional status (n=294) and Food security (n=127) are included. Percentages for categories <5% are not displayed.

Figure 3 Network view of the first author affiliations of studies conducted in Africa on vitamin A deficiency*



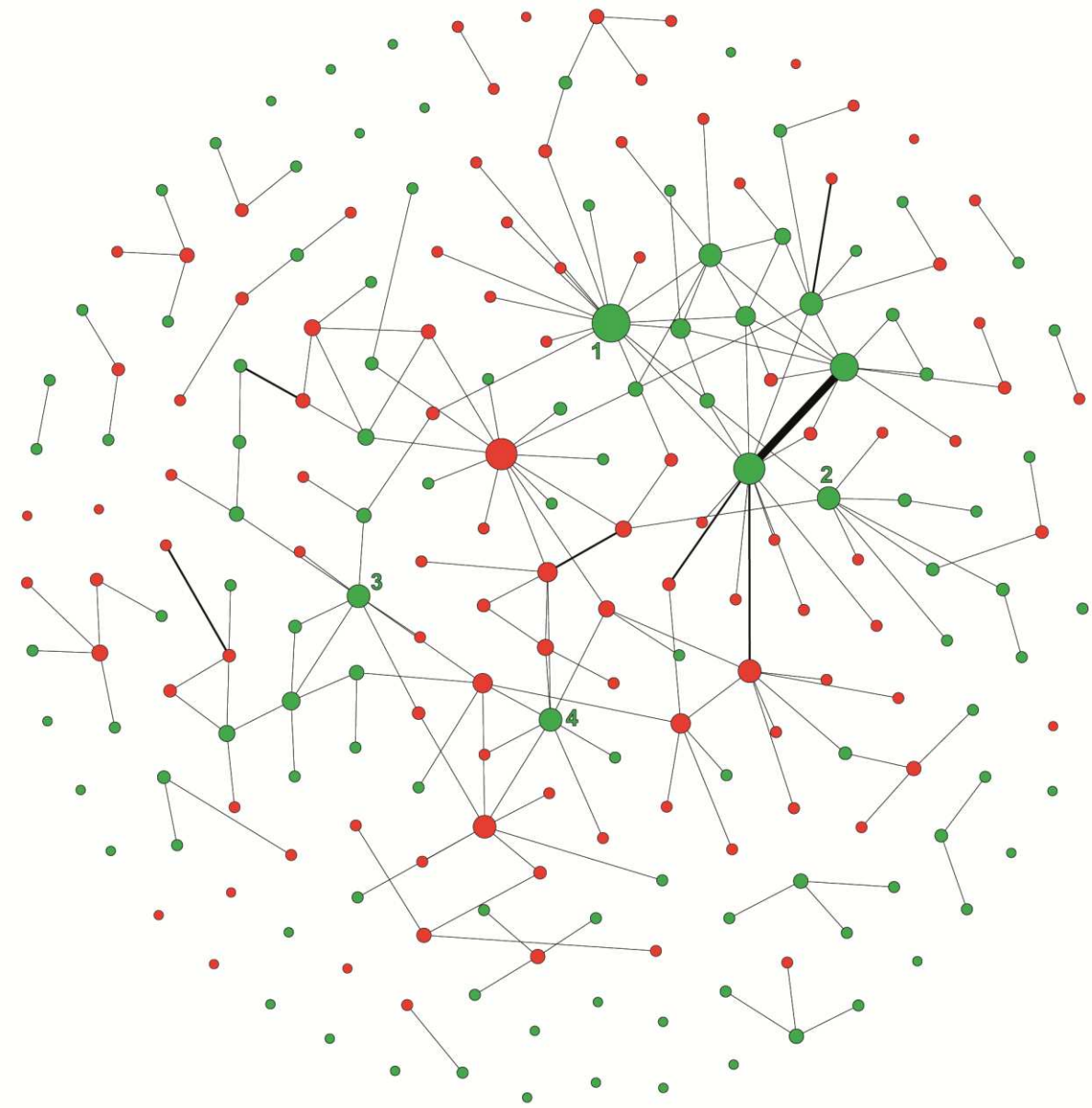
* Affiliations (n=112) of the first author for papers (n=72) with indexed as Major MeSH term "Vitamin A deficiency" are included. The size of the node and connecting lines is relative to the number of connections. Affiliations based in Africa are in green, the ones outside African in red. 1: University of Washington, USA

Figure 4 Network view of the first author affiliations of studies conducted in Africa on protein-energy malnutrition*



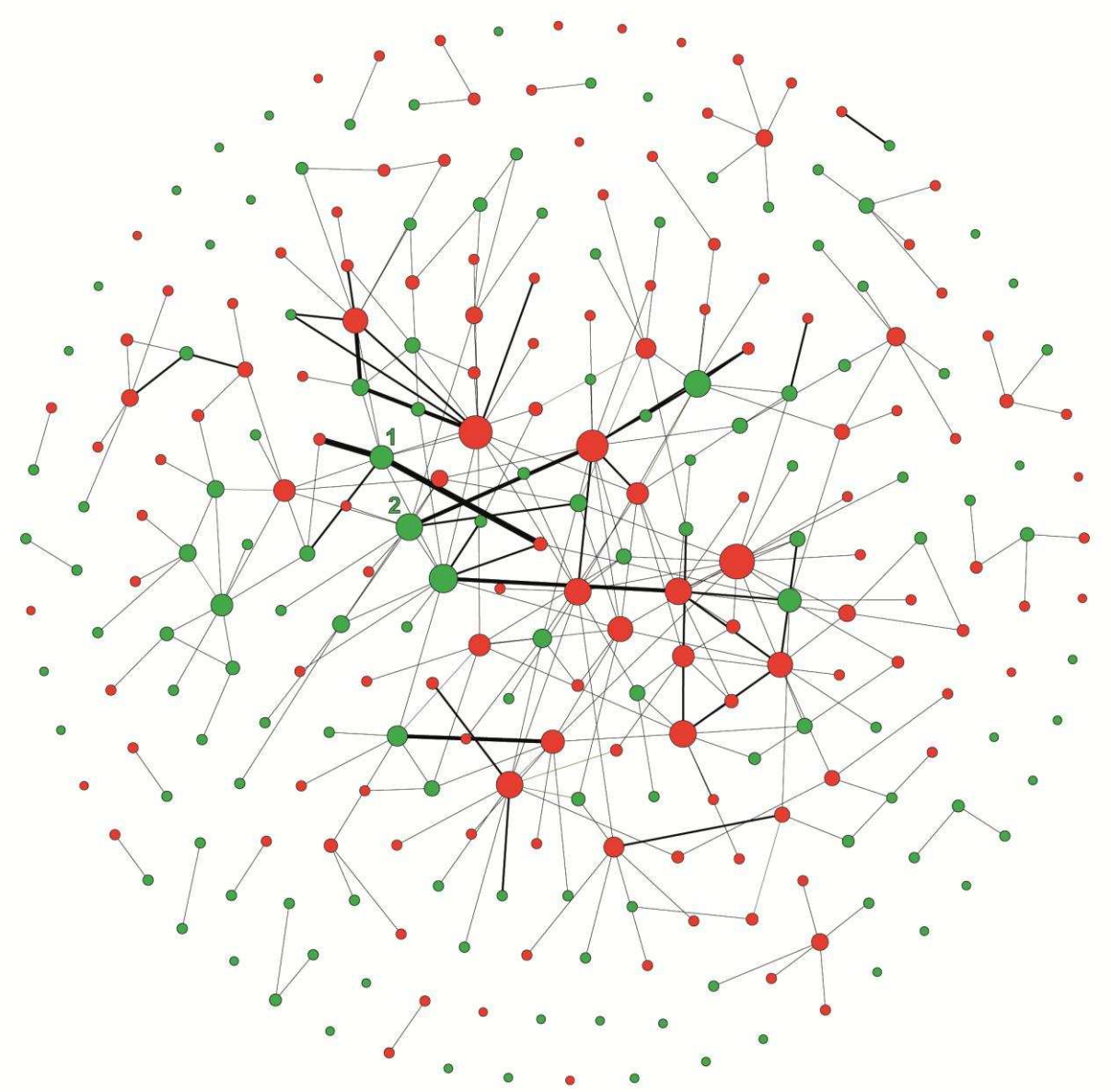
* Affiliations (n=76) of the first author for papers (n=72) with indexed as Major MeSH term "Protein-energy malnutrition" are included. The size of the node and connecting lines is relative to the number of connections. Affiliations based in Africa are in green, the ones outside African in red. 1:University of Malawi, Malawi

Figure 5 Network view of the first author affiliations of studies conducted in Africa on obesity



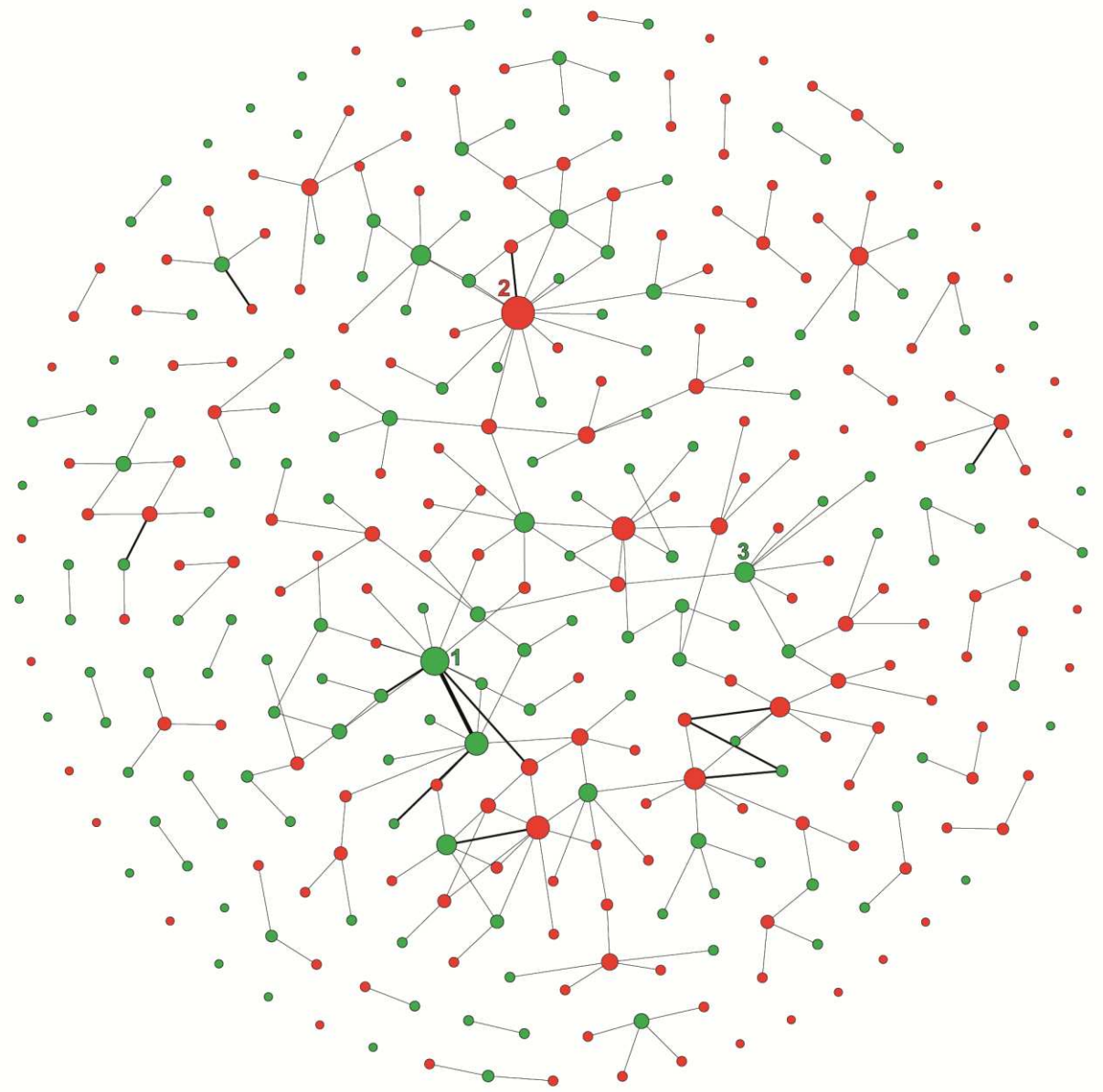
* Affiliations (n=215) of the first author for papers (n=224) with indexed as Major MeSH term "Obesity" are included. The size of the node and connecting lines is relative to the number of connections. Affiliations based in Africa are in green, the ones outside African in red. 1: University of the Western Cape, South Africa; 2: University of Ibadan, Nigeria; National Institute of Nutrition, Tunisia; University of Yaoundé, Cameroun

Figure 6 Network view of the first author affiliations of studies conducted in Africa on breastfeeding



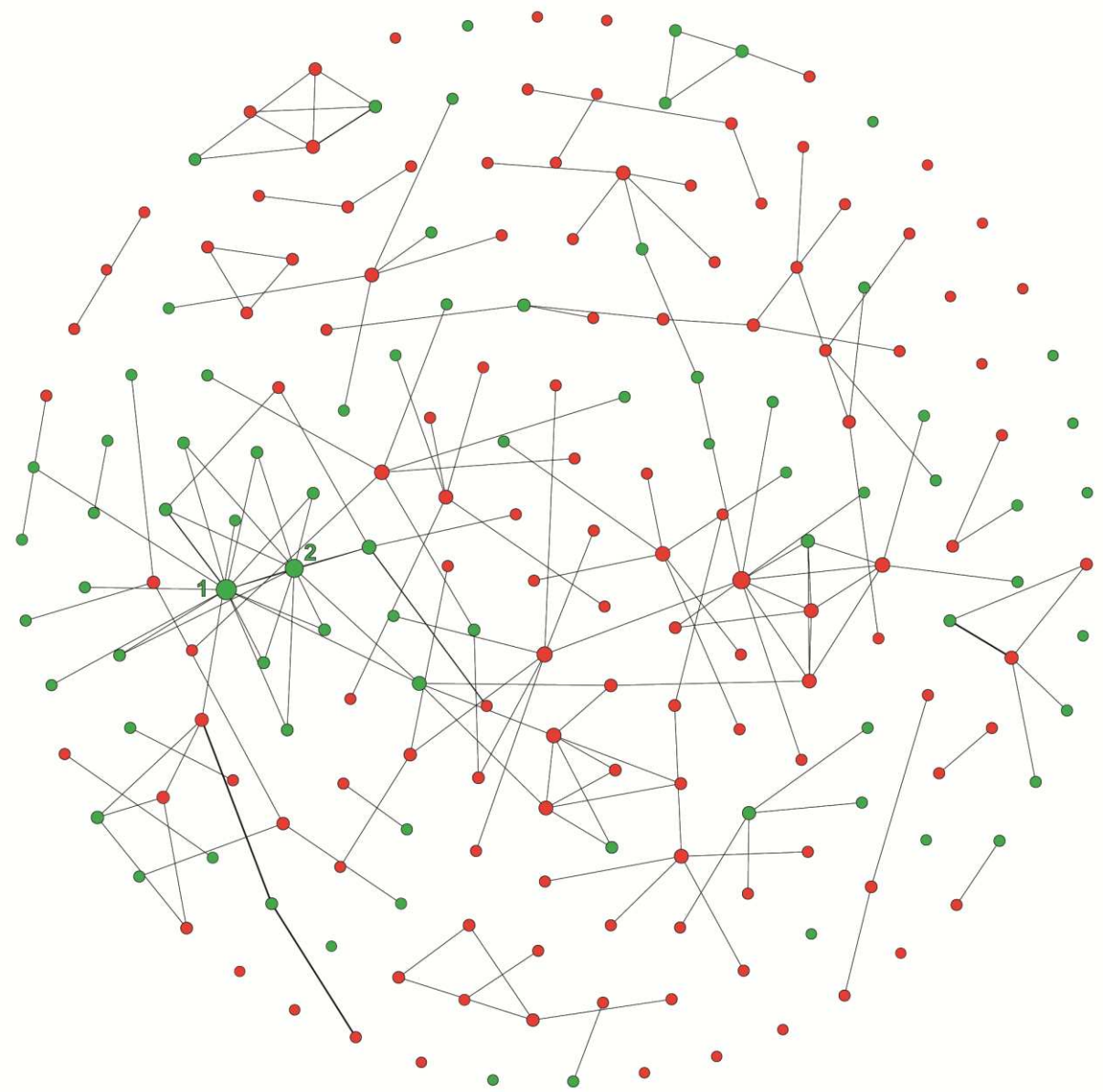
* Affiliations (n=266) of the first author for papers (n=306) with indexed as Major MeSH term “Breastfeeding” are included. The size of the node and connecting lines is relative to the number of connections. Affiliations based in Africa are in green, the ones outside African in red. 1:University of Kazulu-Natal, South Africa; 2:Zvitambo project, Zimbabwe

Figure 7 Network view of the first author affiliations of studies conducted in Africa on nutrition status



* Affiliations (n=329) of the first author for papers (n=294) with indexed as Major MeSH term "nutrition status" are included. The size of the node and connecting lines is relative to the number of connections. Affiliations based in Africa are in green, the ones outside African in red. 1: North West University, South Africa; Institut de Recherche pour le Développement, France; 3: Food and Nutrition Centre, Tanzania

Figure 8 Network view of the first author affiliations of studies conducted in Africa on food security



* Affiliations (n=199) of the first author for papers (n=127) with indexed as Major MeSH term "food supply" are included. The size of the node and connecting lines is relative to the number of connections. Affiliations based in Africa are in green, the ones outside African in red. 1: 2: Stellenbosch University, South Africa; 2: Tygerberg Hospital, South Africa

Supplementary table 1: Topics and number of publications on research on nutrition conducted in Africa

MeSH term (Emtree-equivalent) **Number of articles indexed as Major topic**

Nutrition Disorders (nutritional disorder) **234**
- Child Nutrition Disorders (nutritional disorder) **135**
- Hypervitaminosis A (retinol intoxication) **1**
- Infant Nutrition Disorders (nutritional disorder) **41**
  - Vitamin K Deficiency Bleeding (newborn hemorrhagic disease) **0**
- Malnutrition (malnutrition) **269**
  - Deficiency Diseases (nutritional deficiency) **23**
    - Avitaminosis (vitamin deficiency) **2**
      - Ascorbic Acid Deficiency (Ascorbic Acid Deficiency) **5**
        - Scurvy (scurvy) **5**
      - Vitamin A Deficiency (Retinol deficiency) **79**
      - Vitamin B Deficiency (vitamin deficiency) **0**
        - Choline Deficiency (vitamin deficiency) **0**
        - Folic Acid Deficiency (folic acid deficiency) **9**
        - Hyperhomocysteinemia (Hyperhomocysteinemia) **25**
        - Pellagra (pellagra) **4**
        - Riboflavin Deficiency (Riboflavin Deficiency) **2**
        - Thiamine Deficiency (Thiamine Deficiency) **4**
        - Beriberi (beriberi) **0**
        - Wernicke Encephalopathy (brain diseases) **0**
        - Vitamin B 12 Deficiency (cyanocobalamin deficiency)**1**
          - Anemia, Pernicious (pernicious anemia) **2**
            - Subacute Combined Degeneration (subactute combined degeneration) **0**
        - Vitamin B 6 Deficiency (pyridoxine deficiency) **0**
      - Vitamin D Deficiency (Vitamin D Deficiency) **32**
        - Osteomalacia (Osteomalacia) **2**
        - Rickets (rickets) **30**
          - Hypophosphatemic Rickets, X-Linked Dominant (X linked hypophosphatemic rickets) **1**
          - Renal Osteodystrophy (Renal Osteodystrophy) **5**
      - Vitamin E Deficiency (alpha tocopherol deficiency) **5**
        - Steatitis (steatitis) **0**
      - Vitamin K Deficiency (Vitamin K Deficiency) **0**
        - Vitamin K Deficiency Bleeding (newborn hemorrhagic disease) **0**
    - Magnesium Deficiency (Magnesium Deficiency) **6**
    - Potassium Deficiency (Potassium Deficiency) **1**
    - Protein Deficiency (Protein Deficiency) **2**
      - Protein-Energy Malnutrition (protein calorie malnutrition) **60**
        - Kwashiorkor (kwashiorkor) **20**
    - Swayback (Swayback) **0**
  - Fetal Nutrition Disorders (fetal malnutrition) **3**
  - Refeeding Syndrome (refeeding syndrome) **0**
  - Starvation (starvation) **54**
- Overnutrition (overnutrition) **1**
  - Obesity (obesity) **298**
    - Obesity, Abdominal (abdominal obesity) **5**
    - Obesity Hypoventilation Syndrome (Obesity Hypoventilation Syndrome) **0**
    - Obesity, Morbid (morbid, obesity) **8**
    - Prader-Willi Syndrome (Prader-Willi Syndrome) **0**

Wasting Syndrome (wasting syndrome) **20**
HIV Wasting Syndrome (wasting syndrome) **10**

Nutrition Therapy (diet therapy) **6**
Diet Therapy (diet therapy) **117**
Caloric Restriction (caloric restriction) **2**
Diabetic Diet (diabetic diet) **1**
Diet, Carbohydrate-Restricted (low carbohydrate diet) **1**
Diet Fads (alternative medicine) **0**
Diet, Fat-Restricted (low fat diet) **0**
Diet, Mediterranean (mediterranean diet) **0**
Diet, Protein-Restricted (protein restriction) **2**
Diet, Reducing (low calory diet) **7**
Diet, Sodium-Restricted (sodium restriction) **3**
Diet, Vegetarian (vegetarian diet) **2**
Diet, Macrobiotic (macrobiotic diet) **0**
Ketogenic Diet (ketogenic diet) **0**
Nutritional Support (nutritional support) **18**
Enteral Nutrition (enteric feeding) **18**
Parenteral Nutrition (parenteral nutrition) **16**
Parenteral Nutrition, Home (parenteral nutrition) **0**
Parenteral Nutrition, Home Total (total parenteral nutrition) **0**
Parenteral Nutrition, Total (parenteral nutrition) **0**
Parenteral Nutrition, Home Total (total parenteral nutrition) **0**

Feeding Methods (food intake) **10**
Bottle Feeding (bottle feeding) **24**
Enteral Nutrition (enteric feeding) **18**
Parenteral Nutrition (parenteral nutrition) **16**
Parenteral Nutrition, Home (parenteral nutrition) **0**
Parenteral Nutrition, Home Total (total parenteral nutrition) **0**
Parenteral Nutrition, Total (total parenteral nutrition) **0**
Parenteral Nutrition, Home Total (total parenteral nutrition) **0**

Nutritional Physiological Phenomena (nutrition) **293**
Animal Nutritional Physiological Phenomena (animal food) **13**
Child Nutritional Physiological Phenomena (child nutrition) **125**
Adolescent Nutritional Physiological Phenomena (child nutrition) **47**
Infant Nutritional Physiological Phenomena (infant nutrition) **96**
Breast Feeding (breast feeding) **366**
Weaning (weaning) **47**
Diet (diet) **633**
Diabetic Diet (diabetic diet) **1**
Diet, Carbohydrate-Restricted (low carbohydrate diet) **1**
Diet Fads (alternative medicine) **0**
Diet, Fat-Restricted (low fat diet) **0**
Diet, Gluten-Free (gluten free diet) **1**
Diet, Mediterranean (mediterranean diet) **0**
Diet, Protein-Restricted (protein restriction) **2**
Diet, Reducing (low calory diet) **7**
Diet, Sodium-Restricted (sodium restriction) **3**
Diet, Vegetarian (vegetarian diet) **2**
Diet, Macrobiotic (microbiotic diet) **0**
Energy Intake (caloric intake) **53**
Caloric Restriction (caloric restriction) **2**
Ketogenic Diet (ketogenic diet) **0**
Elder Nutritional Physiological Phenomena (no equivalent) **0**
Hunger (hunger) **22**
Appetite (appetite) **8**

Appetite Regulation (food intake) **21**
Maternal Nutritional Physiological Phenomena (maternal nutrition) **26**

Prenatal Nutritional Physiological Phenomena (maternal nutrition) **13**

Nutrition Processes (nutrition) **174**

Appetite Regulation (food intake) **21**
Breast Feeding (breast feeding) **366**
Digestion (digestion) **13**
Salivation (found salivation) **1**
Eating (eating) **35**
Drinking (drinking) **49**
Mastication (mastication) **10**
Intestinal Absorption (intestine absorption) **25**
Weaning (weaning) **44**
Nutritional Requirements (nutritonal requirement) **26**
Nutritional Status (nutritional status) **322**
Nutritive Value (nutritional value) **24**
Glycemic Index (glycemic index) **6**

Food Industry (food industry) **34**
Food Handling (Food Handling) **174**
Cooking (cooking) **63**
Cookbooks as Topic (books) **0**
Cooking and Eating Utensils (kitchen) **13**
Food Dispensers, Automatic (food handling) **3**
Food Packaging (Food Packaging) **18**
Food-Processing Industry (food industry) **25**
Meat-Packing Industry (meat industry) **1**
Abattoirs (slaughterhouse) **18**
Food Services (catering service) **88**
Food Service, Hospital (hospital food service) **2**
Menu Planning (health service) **22**
Restaurants (catering service) **9**
Food Supply (catering service) **193**
Food Technology (food handling) **23**
Food Analysis (food analysis) **74**
Food Inspection (food control) **7**
Food Microbiology (food control) **209**
Food Packaging (Food Packaging) **18**
Food Labeling (Food Packaging) **6**
Food Parasitology (food control) **15**
Food Preservation (food preservation) **75**
Food Irradiation (food irradiation) **14**

Food Safety (food safety) **12**
Food Contamination (food contamination) **325**
Food Contamination, Radioactive (radioactive contamination) **12**
Food Microbiology (food control) **209**
Food Parasitology (food control) **15**
Food Inspection (food control) **7**

Nutritional Sciences (nutritional science) **26**
Animal Nutrition Sciences (nutritional science) **0**
Child Nutrition Sciences (nutritional science) **20**

Dietetics (dietetics) **5**

Nutrition Assessment (**Nutritional Assessment) 49**

Nutrition Surveys (nutrition) **188**

Diet Surveys (diet) **81**

Food and Beverages (food) **147**

Beverages (beverage) **87**
Alcoholic Beverages (alcoholic beverage) **4**
Absinthe (Absinthe) **0**
Beer (beer) **5**
Wine (wine) **34**
Carbonated Beverages (carbonated beverage) **2**
Coffee (coffee) **12**
Milk (milk) **62**
Cultured Milk Products (dairy product) **2**
Infant Formula (artificial milk) **12**
Milk, Human (breast milk) **25**
Milk Substitutes (artificial milk) **4**
Infant Formula (artificial milk) **12**
Soy Milk (soybean milk) **0**
Mineral Waters (mineral water) **2**
Tea (tea) **20**
Food (food) **1010**
Bread (bread) **8**
Candy (sugar) **4**
Chewing Gum (chewing gum) **2**
Cereals (cereal) **23**
Avena sativa (oat) **2**
Fagopyrum (Fagopyrum) **0**
Hordeum (barley) **0**
Oryza sativa (rice) **35**
Panicum (millet) **4**
Secale cereale (rye) **3**
Triticum (wheat) **72**
Zea mays (maize) **162**
Condiments (condiment) **10**
Spices (spice) **17**
Black Pepper (black pepper) **0**
Crops, Agricultural (crop) **114**
Animal Feed (animal food) **35**
Avena sativa (oat) **2**

Fagopyrum (fagopyrum) **0**

Helianthus (sunflower) **9**
Lolium (lolium) **1**
Medicago sativa (alfalfa) **0**
Mustard Plant (brassica) **4**
Panicum (millet) **4**
Secale cereale (rye) **3**
Silage (silage) **5**
Soybeans (soybean) **43**
Zea mays (maize) **162**
Dairy Products (diary product) **7**
Butter (butter) **1**
Cheese (cheese) **7**
Ice Cream (ice cream) **1**
Margarine (margarine) **0**

Milk (milk) **62**
Cultured Milk Products (dairy product) **2**
Yogurt (yogurt) **8**
Infant Formula (artificial milk) **12**
Milk, Human (breast milk) **25**
Milk Proteins (milk protein) **7**
Dietary Carbohydrates (carbohydrate diet) **30**
Dietary Sucrose (sugar intake) **19**
Dietary Fats (fat intake) **44**
Butter (butter) **1**
Cholesterol, Dietary (cholesterol intake) **0**
Dietary Fats, Unsaturated (edible oil) **15**
Cod Liver Oil (cod liver oil) **0**
Corn Oil (corn oil) **0**
Cottonseed Oil (cotton seed oil) **2**
Fatty Acids, Omega-3 (omega 3 fatty acid) **10**
Alpha-Linolenic Acid (linolenic acid) **1**
Docosahexaenoic Acids (Docosahexaenoic Acids) **4**
Neuroprostanes (no equivalent) **0**
Eicosapentaenoic Acid (cosapentaenoic acid) **2**
Safflower Oil (safflower oil) **1**
Sesame Oil (sesame seed oil) **1**
Soybean Oil (soybean oil) **2**
Margarine (margarine) **0**
Dietary Fiber (dietary fiber) **23**
Prebiotics (prebiotic agent) **0**
Dietary Proteins (protein intake) **36**
Egg Proteins, Dietary (protein intake) **0**
Milk Proteins (milk protein) **7**
Vegetable Proteins (vegetable protein) **3**
Dietary Supplements (diet supplementation) **170**
Prebiotics (prebiotic agent) **0**
Probiotics (probiotic agent) **45**
Synbiotics (symbiotic agent) **0**
Yeast, Dried (yeast) **5**
Eggs (egg) **14**
Egg Proteins, Dietary (protein intake) **0**
Egg White (egg white) **2**
Egg Yolk (egg yolk) **1**
Fast Foods (fast food) **6**
Flour (flour) **34**
Food Additives (food additive) **4**
Fat Substitutes (fat substitute) **1**
Flavoring Agents (flavoring agent) **9**
Calcium Citrate (citrate calcium) **0**
Safrole (safrole) **2**
Sweetening Agents (sweetening agent) **4**
Food Preservatives (food preservative) **17**
Food, Genetically Modified (genetically modified food) **11**
Food, Organic (no equivalent) **1**
Food, Preserved (food preservation) **0**
Frozen Foods (food freezing) **2**
Foods, Specialized (food) **147**
Food, Formulated (no equivalent) **12**
Infant Formula (artificial milk) **12**
Food, Fortified (diet supplementation) **95**
Prebiotics (prebiotic agent) **0**
Functional Food (functional food) **0**
Health Food (health food) **6**

- Infant Food (baby food) **86**
  - Infant Formula (artificial milk) **12**
- Fruit (fruit) **151**
- Honey (honey) **37**
- Meat (meat) **57**
  - Meat Products (meat) **17**
  - Poultry (poultry) **14**
    - Poultry Products (food) **1**
  - Seafood (sea food) **30**
    - Fish Products (sea food) **8**
      - Fish Flour (sea food) **1**
    - Shellfish (shellfish) **7**
- Micronutrients (trace element) **110**
  - Trace Elements (trace element) **68**
  - Vitamins (vitamin) **86**
- Molasses (molasses) **14**
- Nuts (nut) **198**
- Seeds (plant seed) **194**
- Vegetables (vegetable) **88**
  - Allium (garlic) **3**
    - Garlic (garlic) **18**
    - Onions (onion) **6**
  - Brassica (Brassica) **13**
  - Capsicum (pepper) **23**
  - Chicory (chicory) **0**
  - Chive (chive) **0**
  - Cucumis sativus (cucumber) **0**
  - Daucus carota (carrot) **4**
  - Fabaceae (legume) **188**
    - Arachis hypogaea (peanut) **41**
    - Peas (pea) **22**
    - Soybeans (soybean) **43**
      - Soy Foods (soybean) **5**
        - Soy Milk (soybean milk) **0**
        - Soybean Proteins (soybean protein) **3**
  - Lettuce (lettuce) **5**
  - Lycopersicon esculentum (tomato) **6**
  - Mustard Plant (brassica) **4**
  - Rheum (rhubarb) **0**
  - Shallots (shallot) **1**
  - Solanum tuberosum (patato) **18**
  - Spinacia oleracea (spinach) **4**
  - Vegetable Proteins (vegetable protein) **3**

Food Chain (food chain) **5**

Food-Drug Interactions (food drug interaction) **6**
Legislation, food (law) **11**
Food preferences (food preference) **20**
Food deprivation (food deprivation) **2**
Diet records (medical record) **10**
Food hypersensitivity (food allergy) **15**
- Egg Hypersensitivity (egg allergy) **1**
- Milk Hypersensitivity (milk allergy) **7**
- Nut Hypersensitivity (nut allergy) **0**
- Peanut Hypersensitivity (peanut allergy) **1**
- Wheat Hypersensitivity (wheat allergy) **1**

Foodborne Diseases (food poisoning) **25**
- Botulism (botulism) **2**

Ciguatera Poisoning (ciguatera) **0**
Favism (favism) **0**
Mushroom Poisoning (Mushroom Poisoning) **1**
Salmonella Food Poisoning (Salmonella Food Poisoning) **0**
Shellfish Poisoning (Shellfish Poisoning) **1**
Staphylococcal Food Poisoning (Staphylococcal Food Poisoning) **0**

Drinking Behavior (drinking behavior) **16**
Alcohol Drinking (drinking behavior) **1**

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