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Review

Gaps and opportunities for nutrition research in relation to non-communicable diseases in Arab countries: Call for an informed research agenda



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ABSTRACT

Effective public health nutrition interventions are needed to curb the escalating prevalence of non-communicable diseases (NCDs) in many Arab countries. In order to generate the scientific evidence needed for the success of these interventions, an informed research agenda should be developed. The purpose of this review is to identify gaps and opportunities for research on nutrition and NCDs among Arab countries, which is an important step towards the formulation of this research agenda. Published papers that addressed nutrition and NCDs in Arab countries between the years 2006 and 2015 were reviewed (n = 824). The main gaps identified were related to the predominance of laboratory-based studies with few cohort and intervention studies, and the small percentage of articles examining dietary patterns. While food frequency questionnaires were the main dietary assessment method used, only 35% were validated. Very few studies included children and the majority considered nutrition in isolation, excluding other environmental factors. Opportunities identified included the promising momentum in studying nutrition and NCDs among Arab countries, evidenced by an increasing number of articles published over the years, that may be guided in future nutrition research to fill the identified gaps. In addition, the higher number of articles in high-income countries coupled with the

Abbreviations: NCDs, Noncommunicable diseases; CVD, Cardiovascular diseases; BMI, Body-mass index; DALY, The Disability-adjusted life years; CMD, Cardiometabolic diseases and diabetes mortality; EMBASE, Excerpta Medica database; IF, Impact factor; IDRC, International Development Research Centre; RCT, Randomized controlled trial; JCR, Journal Citation Reports by Thomson Reuters; FFQs, Food frequency questionnaires; SPSS, Statistical Package for the Social Sciences; HIC, High income countries; UAE, United Arab Emirates; KSA, Kingdom of Saudi Arabia; MIC, Middle-income countries; LIC, Low-income countries; R&D, Research and development; GDP, Gross domestic product; QNRF, Qatar National Research Fund.

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impact of papers in middle-income countries suggests an opportunity of synergistic collaboration among these countries. The identified gaps and opportunities in this review may serve as basis for Arab countries to start developing a research agenda in the area of nutrition and NCDs.

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1. Introduction

During the past decades, many Arab countries have witnessed economic, social, and lifestyle changes accompanied by a rapid increase in noncommunicable diseases (NCDs) and obesity prevalence [1]. This increase was the highest in the world between the years 2006 and 2015 [2]. In 2008, the death count due to NCDs in Arab countries was 1.2 million, accounting for almost 60% of all deaths. In addition to these high rates, the profiles of NCDs among Arab countries are significantly different from other countries and even differ between the Arab countries themselves. For instance, the epidemiological transition currently experienced by most Arab countries, from a burden of disease dominated by mortality from infectious diseases to mortality from NCDs, is compressed into a shorter time frame than that experienced historically by developed countries. Additionally, there is a coexistence of infectious diseases and ill-functioning health systems together with the escalating burden of NCDs in many Arab countries [3–5]. Furthermore, there is a clear socioeconomic and wealth gradient as a result of oil production in Arab countries. Such a gradient may have a direct influence on the NCDs profiles of these countries [6].

Concomitant with the escalating burden of NCDs, Arab countries have been undergoing nutrition transition and changes in dietary habits, which were both postulated as major risk factors for most NCDs. In fact, in Arab countries, available data show that diet and high body-mass index (BMI) are the risk factors with the highest attributable disability-adjusted life years (DALYs) for NCDs [7]. Since the turn of the century, due to ongoing rapid urbanization and economic growth, many Arab countries have been witnessing an erosion of traditional dietary patterns (ie, rich in fruits,

vegetables, and complex carbohydrates) and the migration towards a more Westernized type of diet that is lower in carbohydrates and higher in animal-based food. This type of diet is high in sugar and caloric content and contains larger amounts of processed food (eg, chocolate, soft drinks) [1]. A comparative risk assessment study examining the impact of dietary habits on cardiovascular and diabetes mortality in 22 Arab countries showed that low intake of protective foods, namely fruits and whole grains, was the leading dietary risk factor for cardio-metabolic diseases (CMD) and diabetes mortality, accounting for 12% and 11% of CMD deaths, respectively. Furthermore, among harmful dietary factors, high intake of sodium was responsible for the highest proportion of CMD deaths [8].

The escalating prevalence of NCDs and their related risk factors has led most Arab countries to hold national, regional, and international meetings in order to find solutions that will curb the burden of these diseases [9,10]. A common recommendation of these meetings is the need to develop public health policies and interventions tackling the main modifiable risk factors of NCDs, including nutrition and dietary habits [9,10]. These policies and interventions ought to be based on the best available scientific evidence for their feasibility, efficacy, and cost effectiveness [7]. Although studies conducted in developed countries contributed significantly to such scientific evidence, their results may have limited applicability to Arab countries given the distinct NCDs profiles in these countries and the specificities of their dietary habits and practices [11]. Therefore, an elemental step towards the success of public health nutrition policies and interventions to curb the NCDs epidemic in Arab countries is

the formulation of a comprehensive and informed research agenda that will ultimately allow for generating the needed robust context and culture specific evidence base. Such an informed research agenda will support Arab countries in reducing research waste and will assist research funders in setting granting priorities in the area of nutrition and NCDs [12].

Over the past 2 decades, scoping reviews have become an increasingly popular form of knowledge synthesis of health-related research, especially in areas with complex multifactorial concepts, disciplines with emerging evidence, and where various study designs are employed [13]. Among reasons cited for conducting a scoping review, the most relevant in the context of this study are: examining the extent, range, and nature of research activity; identifying gaps and opportunities in the existing literature; informing practice, programs, and policy; and providing direction for future research priorities [14,15].

The objective of this scoping review is to identify gaps and opportunities in nutrition research in relation to NCDs in order to formulate an informed research agenda leading to evidence-based national policies and interventions to curb the escalating burden of NCDs in Arab countries. Using PubMed, a literature search was conducted to retrieve articles that addressed nutrition in relation to NCDs in Arab countries between the years 2006 and 2015. According to *Ulrich's International Periodicals Directory*, approximately 57% of indexed Arabic medical journals are not covered by PubMed [16]. To ensure sufficient coverage of Arabic journals the search was also carried out in Embase, Scopus, EBSCO, and ProQuest. With the addition of these databases, the coverage of indexed Arabic medical journals in this review increased to 82%.

2. Approach

A scoping review method was implemented to examine and study the relevant literature. For the purpose of this study, the methodological framework first proposed by Arksey et al and revised later by Levac et al was used [13,14]. This framework consists of 5 iterative steps: (1) identifying the research question; (2) search strategy; (3) selection of relevant studies; (4) data charting; and finally (5) collating, summarizing, and reporting the results [14].

2.1. Identifying the research question

The primary research question that guided this study: What are the existing gaps and opportunities of current research led by scientists affiliated with institutions in the Arab world in the area of nutrition in relation to NCDs?

2.2. Search strategy

The search strategy was developed by a multidisciplinary team consisting of a nutrition epidemiologist, an NCDs epidemiologist, 2 clinical nutritionists, and a librarian. Three main topics related to the key concepts of the research questions were identified, namely Arab countries, nutrition, and NCDs. Within the search strategy, the terms used for Arab countries were Alger OR Algeria OR Algerie OR Algiers OR

Bahrain OR Bahrein OR Comores OR Comoros OR Djibouti OR Egypt OR Egypte OR Emirats OR Emirates OR Irak OR Iraq OR Jordan OR Jordanie OR Kuwait OR Koweit OR Lebanese OR Liban OR Liban OR Libanaise OR Libya OR Libye OR Mauritania OR Mauritanie OR Morocco OR Maroc OR Oman OR Palestine OR Palestinian OR Palestinienne OR Qatar OR Saudi OR Saoudite OR Somalia OR Somalie OR Sudan OR Syria OR Syrie OR Tunisia OR Tunisie OR Yemen OR Gaza OR West Bank. In PubMed, while keywords and the majority of titles and abstracts are in English language, the affiliation of the authors could be listed in a language different than English. Given that in several countries of the Arab world French is considered an official language in addition to Arabic (such as Lebanon and Algeria), the use of the French in addition to the English versions of country names was deemed important. The terms used for nutrition were Eating OR Nutrient* OR Nutritio* OR Diet* OR Food OR Hunger* OR Malnutritio* OR Malnourish* OR Undernutri* OR Undernourish*. As for NCDs, the following terms were used: Angina Pectoris OR Artery Disease* OR Arterial Disease* OR Atherosclerosis OR Cancer* OR Cardiovascular Disease* OR Cerebrovascular Accident* OR Degenerative Disease* OR Diabet* OR Diabetes Mellitus OR Dyslipidemia OR Dyspnea OR Familial Hypercholesterolemia OR Fibrosis OR Glucose Impairment OR Heart Disease* OR Heart Failure* OR Heart Infarction* OR High Blood Glucose OR Raised Blood Pressure OR Hypercholesterolemia OR Hyperchylomicronemia OR Hyperglycemia OR Hyperinsulinemia OR Hyperlipidemia OR Hyperlipoproteinemia OR Impaired Glucose Tolerance OR Metabolic Syndrome* OR Nerve Degeneration OR Pulmonary Disease* OR Pulmonary Function* OR Stroke* OR Thrombosis OR Transient Ischemic Attack OR Tumor* OR Vascular Dementia OR Vascular Disease* OR Overweight OR Obesity OR BMI.

2.3. Selection of relevant studies

A total of 2851 articles were identified using the search strategy. Several meetings of the research team were held at the beginning, midpoint, and at the end of the review to discuss issues related to selection of relevant studies. The process of choosing the criteria for selecting relevant studies was iterative and relied on examining the title, abstract, and, when necessary, the full text of the articles. Two independent reviewers (HS and SH) examined the titles and abstracts of the 2851 identified articles. When disagreement occurred regarding the inclusion/exclusion of an article, the input of a third reviewer from the research team was sought. For every batch of 500 articles reviewed, the agreement between the 2 reviewers was assessed. Only in one instance was the agreement found to be below 85%, and a meeting was held between members of the research team to clarify the selection process and address concerns.

For an article to be selected and included in this review the following conditions should have been met:

- 1- The affiliation of the first or the corresponding author was with an institution in Arab country. Articles in which the first and/or the corresponding author were affiliated with an institution in any Arab country were included. The affiliations of the first authors were extracted from PubMed. As for the affiliations of the

corresponding authors, they were imported from EMBASE for the years 2005 until 2014, when these affiliations became available through PubMed. The affiliations of both the first and the corresponding authors were considered relevant because in health, nutrition, and medical sciences, both are generally considered the main authors of multi-authored article.

- 2- The article addressed one of the 4 main NCDs as listed by the WHO (cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes) or one of the main metabolic or physiological risk factors for these NCDs (elevated blood pressure, high blood glucose, overweight or obesity, and hyperlipidemia) [17].
- 3- The article addressed nutrition or nutrition-related topics, such as energy, macro- or micronutrients, foods, diets, and dietary habits.

Of the 2851 articles identified through the search strategy, 1771 were excluded at the title and abstract review level for irrelevance and/or for not meeting the inclusion criteria. Upon

reading the full text of the articles, 233 additional articles were excluded. Out of the remaining 847 articles, 23 were duplicates and were also removed. The final count of articles included in this review was 824 (Fig. 1).

2.4. Data charting

In line with the scope of the research question of this study, the research team developed the data charting form in order to determine which variables to extract. The development process of this form was iterative in that, after the initial version was developed, the 2 researchers who later conducted data extraction independently pilot tested the form by reviewing and extracting data from 15 articles. The research team then met to review the pilot test of this form and used the results to refine it in order to ascertain that the approach that they had used appropriately addressed the research question of the study. The data charting form captured information related to the affiliation of the corresponding author, year of publication, impact factor (IF) of the journal,

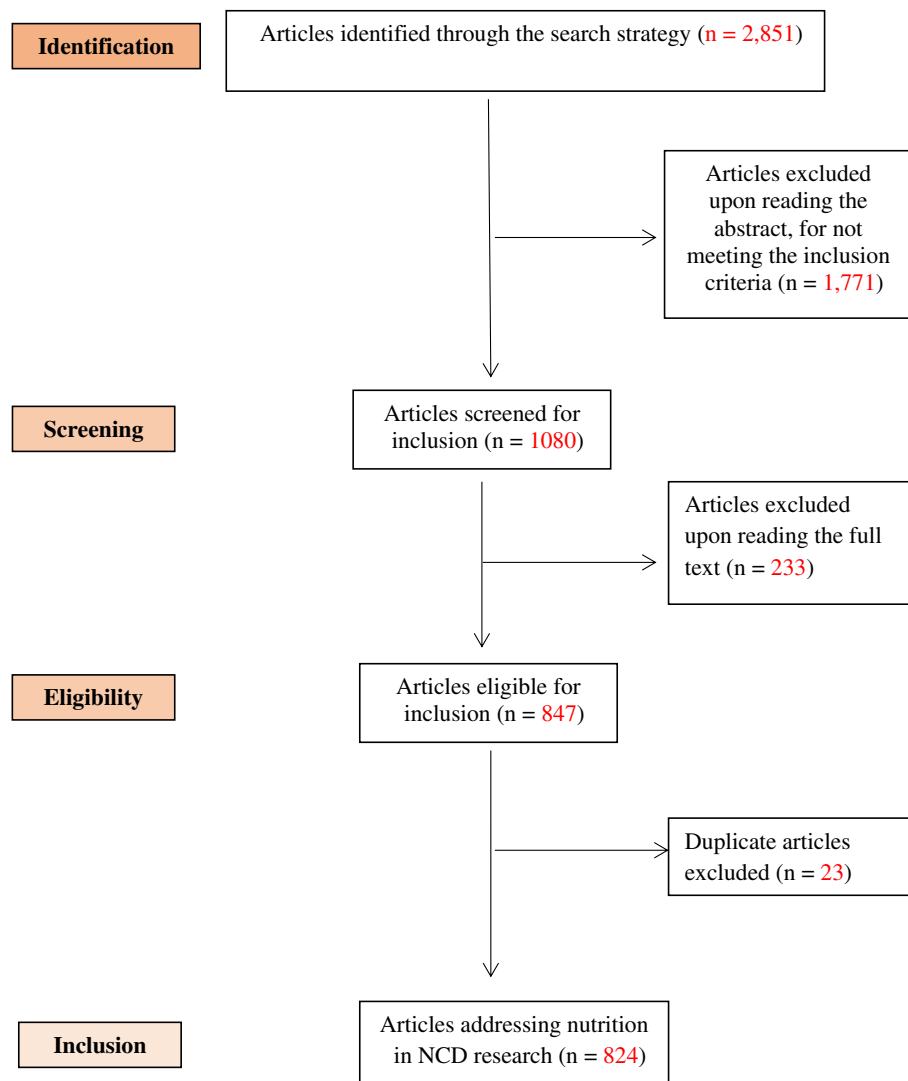


Fig. 1 – Selection of articles in the review of nutrition in NCDs research among Arab countries from 2006 to 2015.

Table 1 – Characterization of research studies addressing nutrition and NCD among Arab countries from 2006 to 2015 (n = 824)

	n (%)
Study design	
Laboratory-based (animal-based/pathological/in vivo studies)	401 (48.7)
Cross-sectional	215 (26.1)
Review	83 (10.1)
Case control	37 (4.5)
Intervention studies *	57 (6.9)
Cohort	12 (1.5)
Systematic review/Meta-analysis	10 (1.2)
Case report	4 (0.5)
Qualitative	3 (0.4)
Commentary/letter to editor	2 (0.2)
Nutrition and nutrition related exposures considered	
Dietary intakes	531 (64.4)
Food Supplements	256 (31.1)
Obesity/BMI/Body composition	37 (4.5)
Type of dietary intake studied (n = 531)	
Food item/Food group	204 (38.4)
Micro/Macronutrients/Energy	194 (36.5)
Dietary patterns/Nutrition transition	32 (6.0)
Therapeutic diets	34 (6.4)
Ethnic eating (Ramadan Fasting)	26 (4.9)
Beverages (tea, coffee, carbonated etc)	8 (1.5)
Nutritional counseling	15 (2.8)
Alcohol	1 (0.18)
Artificial sweeteners and preservatives	2 (0.38)
Breastfeeding	3 (0.56)
Others (such as nutrition knowledge, eating disorders)	12 (2.6)
NCDs and risk factors studied **	
Diabetes	237 (17.4)
CVD and Stroke	226 (16.6)
Cancer	213 (15.7)
Chronic respiratory diseases	2 (0.1)
Hyperlipidemia	239 (17.6)
Obesity	212 (15.6)
Hyper-glycaemia	104 (7.6)
Hypertension	81 (6)
Metabolic Syndrome	45 (3.3)
Age group considered (in human research studies n = 325) ***	
Adults (18–50)	237 (42.2)
Older Adults (≥50)	179 (31.8)
Adolescents (10–18)	97 (17.3)
Children (2–9 years)	29 (5.2)
Pregnant and breastfeeding	10 (1.8)
Infant and child (<2 years)	10 (1.8)
Lifestyle factors considered, in addition to diet	
None	660 (80.1)
exercise	94 (11.4)
smoking	11 (1.3)
Diet drug interactions/Adherence to drug regimen	10 (1.2)
Multiple factors (2 or more of the above)	49 (5.9)
Funding sources	
Not reported	479 (58.1)
Governmental	256 (31.1)
Private/industry	70 (8.5)
NGO	4 (0.5)
International organization	10 (1.2)
Others	5 (0.6)

* Of these interventions studies, 31 (54%) were randomized controlled trials (RCT), 8(14%) were controlled trials, 8 (14%) were randomized trials, and 10 (17.5%) were trials.

** Multiple answers were applicable.

study design, the nutrition and nutrition-related exposures, the type of dietary intake, the NCDs studied, age group of the study population, lifestyle factors considered in addition to diet, and funding sources. The IF of the journal was reported according to Journal Citation Reports by Thomson Reuters [18] and the number of citations for each article was retrieved from Scopus.

2.5. Collating, summarizing, and reporting the results

Data was entered into the Statistical Package for the Social Sciences (SPSS) software version 23.0 for Windows [19]. Data files were checked for completeness. Descriptive statistics were presented as proportions, n (%). The number of papers in each Arab country was weighted by its population size in order to account for more populous countries and this was reported as number of articles per million. In addition, in order to study the extent to which each country is conducting research to address its NCDs burden, the number of articles was weighted by NCDs mortality in the country and this was reported as number of articles per 1000 NCDs deaths. Arab countries were classified according to economic status as per the World Bank Gross Domestic Product data: high income countries [HIC; Bahrain, Kingdom of Saudi Arabia (KSA), Kuwait, Oman, Qatar, and United Arab Emirates (UAE)]; upper middle-income countries (upper-MIC; Algeria, Iraq, Jordan, Lebanon, Libya, and Tunisia); low middle-income countries (low-MIC; Djibouti, Egypt, Mauritania, Morocco, Palestine (including Gaza and West Bank), Sudan, Syria, and Yemen and low-income countries (LIC; Comoros and Somalia)) [20].

3. Gaps in nutrition and NCDs research in Arab countries

This review of research articles identified a number of gaps in nutrition research in relation to NCDs in Arab countries. These gaps were related mainly to the design of the studies, type of nutrition exposures used, methods of dietary assessment and their validity, age groups of focus, and consideration of other environmental factors in addition to nutrition.

Regarding the study designs, close to half of the studies reviewed were laboratory-based (48.7%). The second most common study design was cross-sectional (26.1%). Interventions and cohort studies constituted 6.9% and 1.5% of identified studies, respectively (Table 1). The proportion of intervention studies found in this review was lower than those obtained for Europe (8%), Sub-Saharan Africa (9%), Germany (11%) and USA (12%) [21]. In this review, when NCDs and their metabolic risk factors were examined separately, over 40% of the studies were laboratory-based, except for obesity and hypertension where cross-sectional designs were most common (44.7% and 46.9%, respectively; Table 2). Although well-designed cross sectional studies generate valuable information, cohort and intervention studies are listed second in terms of strength of evidence as reported by the pyramid of medical studies (after meta-analyses and systematic reviews), while cross-sectional and in-vitro (laboratory) designs are listed in the fifth and sixth

places of the pyramid [22]. In fact, in Arab countries, the limited funding allocated to research could be considered a limiting factor in conducting cohort and intervention studies [23,24]. Hence, it is important to recommend a greater investment in research in order to expand and diversify the type of research designs in the area of nutrition and NCDs.

An important gap identified in this review was related to the type of nutrition exposure, whereby the majority of studies in Arab countries considered a single nutrient/food/food group with very few studies addressing dietary patterns as an integrated approach for the evaluation of dietary intake. In fact, in this review, 38.4% of studies investigating dietary intake in relation to NCDs focused on food items or food groups (such as fruits and vegetables, milk and milk products, etc), 36.5% considered either energy, macro- or micronutrients (separately or in combination). Dietary patterns and therapeutic diets were examined in 6% and 6.4% of papers, respectively (Table 1). These findings are not in line with the recent recommendations in nutrition research to shift away from calorie counting and single nutrients or foods and shift towards overall diet quality and food patterns, particularly in the case of NCDs [25]. These diseases have complex etiology and it is

rather unlikely that their development could be mediated by a single nutrient or food [26–30]. From a conceptual perspective, the evaluation of the overall dietary patterns appears closer to real dietary practices and may capture the complexity of diet that is often lost in single nutrient-based analyses [26]. Furthermore, the dietary patterns approach accounts for the collinearity between nutrients or foods [31,32]. Therefore, the nutrition research community has emphasized the integration of dietary patterns in the studies of the association of nutrition with NCDs, especially as public health recommendation and dietary guidelines ensuing from such studies may increase the adherence to these recommendations by the community [33–35].

Whether in the form of single nutrient/food/food group or as dietary patterns, assessing nutrition and dietary exposures requires the use of specific tools (such as FFQs, 24 h dietary recalls, diet records, etc) that ought to be validated in the population they are intended to be used with. The findings of this review showed that FFQs were the main dietary assessment method used (51%), however, only 35% of these FFQs were validated. Other dietary assessment methods used included qualitative assessments (22%), 24 hour recalls

Table 2 – Characterization of studies addressing nutrition in NCDs research among Arab countries by main outcome examined in these studies[†]

	Diabetes	CVD	Cancer	Hyperlipidemia	Obesity and metabolic syndrome	Hyperglycemia	Hypertension
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Study design							
Laboratory-based	102 (43.0)	76 (44.2)	127 (59.6)	153 (64.0)	56 (23.0)	52 (50.0)	13 (16.0)
Cross-sectional	57 (24.1)	35 (20.3)	21 (9.9)	29 (12.1)	109 (44.7)	20 (19.2)	38 (46.9)
Case control	11 (4.6)	4 (2.3)	18 (8.5)	6 (2.5)	6 (2.5)	3 (2.9)	1 (1.2)
Intervention studies	21 (8.9)	7 (4.1)	2 (0.9)	22 (9.2)	30 (12.3)	9 (8.7)	6 (7.4)
Cohort	5 (2.1)	5 (2.9)	2 (0.9)	5 (2.1)	4 (1.6)	1 (0.96)	2 (2.5)
Others*	41 (18.2)	45 (26.2)	43 (20.2)	24 (10.0)	39 (16.0)	19 (18.3)	21 (25.9)
Nutrition and related Exposures							
Dietary intake	166 (70.0)	125 (72.7)	106 (47.8)	150 (62.8)	195 (79.9)	71 (68.3)	64 (79.0)
Food supplements	62 (26.2)	41 (23.8)	105 (49.3)	83 (34.7)	30 (12.3)	27 (26.0)	8 (9.9)
Obesity/BMI/Body composition	9 (3.8)	6 (3.5)	2 (0.9)	6 (2.5)	19 (7.8)	6 (5.8)	9 (11.1)
Type of dietary intake							
Food group/Food item	60 (36.1)	46 (36.8)	53 (50.0)	62 (41.3)	54 (27.7)	21 (29.5)	19 (29.7)
Energy/Macro/Micro nutrients	56 (33.7)	44 (35.2)	31 (29.2)	53 (35.3)	76 (39.0)	33 (46.5)	20 (31.3)
Dietary patterns	9 (5.42)	13 (10.4)	5 (4.7)	11 (7.3)	23 (11.8)	8 (11.3)	9 (14.1)
Therapeutic diets	16 (9.6)	8 (6.4)	2 (1.9)	7 (4.7)	14 (7.2)	4 (5.6)	7 (10.9)
Ethnic eating	12 (7.3)	6 (4.8)	5 (4.7)	8 (5.3)	8 (4.1)	2 (2.8)	5 (7.8)
Others**	13 (7.8)	8 (6.4)	10 (9.4)	9 (6.0)	20 (10.3)	3 (4.2)	4 (6.25)
Age group							
Adults	75 (44.9)	42 (42.4)	37 (40.2)	52 (48.2)	98 (41.3)	5 (25.0)	43 (46.7)
Older adults	67 (40.1)	39 (39.4)	35 (38.0)	40 (37.0)	56 (23.6)	13 (65.0)	33 (35.9)
Adolescents	13 (7.8)	11 (11.1)	11 (11.9)	10 (9.3)	65 (27.4)	1 (5.0)	13 (14.1)
Pregnant women and children	12 (7.2)	7 (7.1)	9 (9.8)	6 (5.5)	18 (7.6)	1 (5.0)	3 (3.3)

[†] Chronic respiratory diseases were not included in this table given the small number of articles addressing this NCD (n = 2).

* Systematic review/meta-analysis, case report, qualitative, commentary/letter to editor.

** Beverages, nutritional counseling alcohol artificial sweeteners and preservative, breastfeeding.

(14%), food records (6%) and 7-day food duplicates/weighing (2%; Fig. 2). The predominant use of FFQs as dietary assessment tool found in this review could be reflective of their advantages in terms of reflecting long term food intake patterns, ease of administration, minimal intrusion, and relatively lower cost [36,37]. However, the finding of this review that only 35% of the FFQs used were validated is alarming as it affects the quality of estimation of dietary intake. Validating FFQs and other dietary assessment tools is critical for assuring an accurate reflection of dietary intake in a defined population [38].

An additional gap noted in this review is related to the age groups covered by these studies. The majority of papers addressed the role of nutrition in NCDs among adults (42.2%) and the elderly (31.8%), while less than 10% focused on pregnant women, infants, or children (Table 1). This finding is important especially in light of the recent evidence that early life is a critical window of opportunity for prevention of NCDs. In fact, the last decade has witnessed a plethora of research highlighting the importance of optimal nutrition during the first 1000 days for improving growth and birth outcomes as well as affecting the incidence of NCDs risk later in life [39]. In the 22 Arab countries studied, mother and child cohort studies addressing nutrition and NCDs are limited [40]. Such cohort studies have emerged in most parts of the world as a preferred tool to produce the context specific evidence necessary to formulate guidelines aimed at preventing NCDs [41].

The results of this study also showed that 80% of articles considered the relationship between nutrition and NCDs in isolation from other environmental exposures with only few

studies examining exercise or smoking in addition to nutrition (11.4% and 1.3%, respectively; Table 1). The etiology of NCDs is complex and is dependent on exposure to many environmental factors, rather than a single factor. In fact, prospective epidemiological studies, randomized prevention trials, and many short-term studies have shown that modifiable environmental factors, including diet, physical activity, smoking, and alcohol, are all implicated in the prevention as well as the management of NCDs [42]. Although studies of the association between each of those factors and various NCDs have greatly advanced our understanding of the reasons for the increasing prevalence of these diseases, lifestyle factors often exert their effects in a synergistic manner which would not be captured when studying each factor individually [43]. The results of this review highlighted the need to include other factors such as physical activity and smoking in addition to diet.

4. Opportunities in nutrition and NCDs research in Arab countries

The opportunities unearthed by this review are mainly related to an increasing interest in nutrition and NCDs research, as reflected by the increase in the number of articles published over the years and by the socioeconomic gradient of countries where these articles originated.

During the years that this review covered, there was a steady increase in the number of articles addressing the association of nutrition and NCDs, with the number of articles

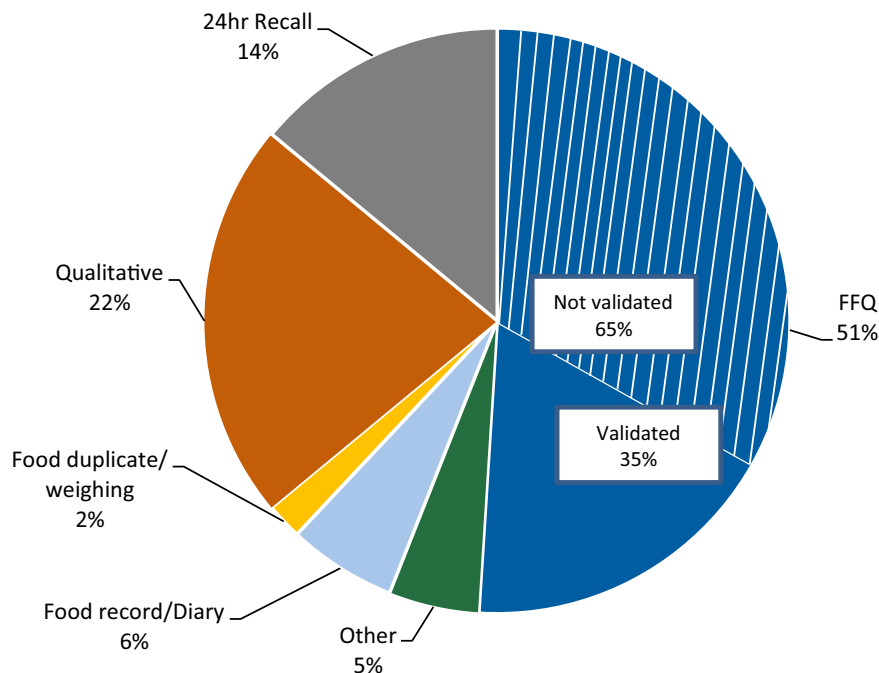


Fig. 2 – Types of dietary assessment methods used in nutrition-NCDs publications among Arab countries from 2006 to 2015 (n = 154). The most frequently reported method was the FFQ (51%), followed by qualitative assessments (23%), 24 hour recalls (14%). Food records and 7-day food weighing were reported in 6% and 2% of articles, respectively. It is important to note that 65% of the FFQs used were not validated in the populations they were used for in these articles.

published between the years 2014 and 2015 being 5 times higher compared to those published in the years 2006 and 2007 (Fig. 3A). This trend held for the majority of countries, except Bahrain and Morocco where no clear increasing trend in the number of published papers was observed (Fig. 3B). These results reflect a promising momentum in these countries in researchers' interest to study the association between nutrition and NCDs. This momentum may be guided in future nutrition research to fill the identified gaps.

Further examination of the distribution of published articles among the various countries of the Arab world revealed the opportunity of a possible synergy that may result from research collaboration between the HIC and MIC. In the 22 Arab countries studied, wealth was related to more proliferous research activity in the area of nutrition in relation to NCDs. For instance, examination of the number of articles (before adjusting for population size) from each country showed that almost 41% of those reviewed originated from HIC, with KSA alone providing 27.5% of the Arab countries' research output. Upper-MIC and low-MIC contributed 29.4% and 29.7% of the total count of papers, respectively. There were no articles published in the LIC. Compared to the MIC and LIC, HIC also had the highest estimates of article counts per 1000 NCDs deaths (Table 3).

In this review, the positive association of wealth with the number of research articles was not paralleled by a similar association with the IF of journals where these publications were featured or with the citation numbers of these articles. In fact, the findings of this review showed that in MIC the mean IF of journals where articles were published and their citation numbers were comparable and in a few instances higher than the mean IF and citation numbers of research articles in HIC (Table 3). It is noteworthy that the highest mean IF was found for Palestine (10 ± 18.7 , Table 3). It could be argued that Palestine and other MIC have been undergoing a

gradual progress in research expertise and infrastructure over the past few decades, which has led to more established research networks and stronger nutrition departments in these countries, whereas oil-producing Arab countries have embarked more recently on investing their wealth in research advancement [44]. Supporting this argument is the high productivity (in terms of published papers per institution) of certain institutions in MIC, despite the fact that HIC has an overall higher count of published papers. In fact, the results of this review showed that 6 out of the 10 leading institutions in research productivity (number of articles per institution) belonged to MIC (Table 4).

These findings encourage the collaboration between HIC and MIC, especially in light of the significant burden of NCDs among these countries, communalities in dietary intake, and similar nutritional challenges that these countries are facing [1]. Such an opportunity is exemplified by the Qatar National research Fund (QNRF) in Qatar, whereby the QNRF (as a resourceful funding agency in the Arab world) supported collaborative research networks between Qatari and non-Qatari investigators including those from Arab MIC [45]. For instance, the QNRF recently funded the first mother and child cohort study in the Middle East to examine the early lifestyle determinants of NCDs in both Lebanon and Qatar (including nutrition) [40]. Although the QNRF offers a promising model of HIC and MIC collaboration, additional similar models are needed to address the heavy burden of diseases in these countries. The findings of this study also showed that a few MIC and LIC Arab countries have limited research output in the area of nutrition in relation to NCDs, despite the considerable NCDs burden in these countries. The developing status of these countries compounded by significant political unrest may be an underlying factor leading to this situation. This finding underpins the recommendations that future studies should investigate human resources and expertise,

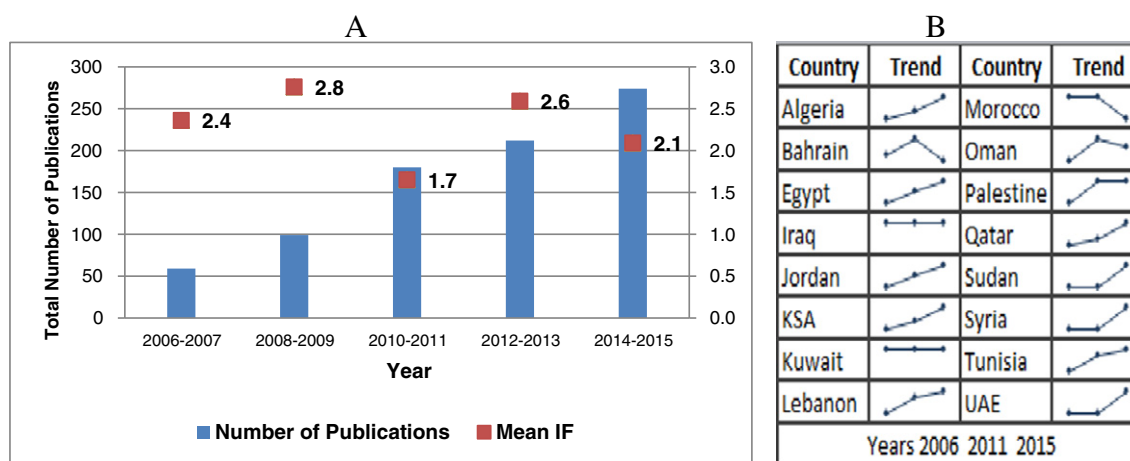


Fig. 3 – Time trend in the numbers of articles addressing nutrition in NCD research among Arab countries from 2006 to 2015. A, Total number of publications and mean impact factor per 2 years interval for the period between 2006 and 2015. Over these years, there has been a steady increase in the count of articles, with the number of published between years 2014–2015 being 4 times higher than that in years 2006–2007. This increase in numbers of articles was not accompanied by an increase in the mean IF of the journals where these articles were published. B, Trend in numbers of publications between 2006, 2011 and 2015 in Arab countries. For the majority of countries, except Bahrain, Morocco and Oman, an increasing trend was found in the numbers of articles.

Table 3 – Number, impact factor (IF) and citation number of peer-reviewed papers addressing nutrition in NCD research among Arab countries from 2006 to 2015 classified by economic status as per the World Bank Gross Domestic Product data

Country	Crude no. of Publications, n (%) [*]	No. of publications per 1000 NCD deaths ^{**}	No. of publications/1 000 000 ^{***}	IF, mean ± SD	Citation number, mean ± SD
High income					
Bahrain	20 (2.4)	9.16	15.17	2.8 ± 1.4	14.94 ± 21.16
KSA	227 (27.5)	3.23	8.02	2.2 ± 1.2	14.47 ± 18.35
Kuwait	25 (3.0)	5.61	7.69	2.0 ± 1.1	15.72 ± 16.15
Oman	21 (2.5)	3.25	6.34	2.2 ± 1.1	31.05 ± 97.82
Qatar	11 (1.30)	5.90	5.36	2.2 ± 0.6	12.47 ± 18.35
UAE	32 (3.9)	5.07	3.48	2.8 ± 1.3	14.21 ± 15.09
Upper-middle income					
Algeria	27 (3.30)	0.16	0.70	2.1 ± 1.3	11.42 ± 12.16
Iraq	8 (1.00)	0.077	0.24	1.0 ± 0.7	9.78 ± 12.38
Jordan	51 (6.20)	2.58	7.28	2.1 ± 2.0	9.45 ± 17.25
Lebanon	59 (7.20)	3.31	12.70	2.8 ± 2.9	16.65 ± 23.71
Libya	2 (0.20)	0.10	0.32	1.4 ± 0	5.50 ± 0.71
Tunisia	96 (11.70)	0.20	8.83	2.3 ± 1.4	16.10 ± 20.4
Lower-middle income					
Djibouti	0	0	0	0	0
Egypt	197 (23.90)	0.44	2.44	2.4 ± 4.5	14.21 ± 23.52
Mauritania	0	0	0	0	0
Morocco	31 (3.80)	0.20	0.95	2.2 ± 1.5	13.57 ± 16.81
Palestine/Gaza/West bank	6 (0.70)	N/A	1.32	10 ± 18.7	13.33 ± 21.52
Sudan	5 (0.60)	0.05	0.13	2.6 ± 1.2	4.2 ± 2.29
Syria	4 (0.50)	0.064	0.18	1.7 ± 1.1	10.75 ± 13.25
Yemen	2 (0.20)	0.0315	0.84	0.7 ± 0	31 ± 28.28
Low income					
Comoros	0	0	0	0	0
Somalia	0	0	0	0	0
Total	824 (100)			2.4 ± 2.9	14.86 ± 24.86

^{*} n (%), refers to the number of papers and the percentage out of the total number of papers.

^{**} NCD mortality data extracted from the WHO 2014 NCD country profiles (<http://www.who.int/nmh/countries/en/>) for all countries except Palestine where data was extracted from the Palestinian Ministry of Health Palestinian Health Information Centre (www.moh.ps/?lang=1&page=4&pid=84) based on the 2005 mortality data.

^{***} Publication per 1 000 000 (source <http://www.who.int/nmh/countries/en/>, http://www.unicef.org/infobycountry/oPt_statistics.html#113).

that financial support should be provided for nutrition and NCDs research in these countries, and that funding allocation should be prioritized as this appears to be an issue in both HIC and MIC.

A couple of limitations must be considered in interpreting the findings of this review. The first limitation is related to the percentage of indexed Arabic journals covered by this review. While the use of PubMed, Embase, Scopus, EBSCO, and ProQuest in this review covered 82% of indexed Arabic journals, 18% (13 journals) were not accessed [16]. Another important limitation could be due to the consideration of the IF and number of citations as indices to reflect the research quality. The use of these indices has been increasing, as they are quasi-qualitative indicators that are readily obtained, providing a measurable assessment of scientific journals and articles. They are used for the assessment of research performance of regions, centers, groups, and even individual scientists [46]. Despite these advantages, there are important limitations to the use of IF and number of citations as visibility indicators of research, most importantly their “lack of timeliness.” A considerable amount of time usually passes before an article will be cited: The article first must be read

and cited by other researchers whose articles require additional time to be published. This process may take many months or years [47]. Furthermore, these indices are less reflective of impact and quality especially when used for journals in peripheral countries where local journals are covered (as is the case of some journals in many Arab countries). Here, the use of the IF as an indicator of quality will lead to a decrease in the perceived quality of the country’s research profile, since national journals usually show very low IFs [48]. Future studies should consider other measures of research quality such the newly proposed Web-based altmetrics [49].

5. Process for the development of a research agenda

Fig. 4 provides an illustration of a 3-staged process that may constitute a roadmap for the formulation of an informed research agenda. The first essential stage entails collecting important baseline knowledge in various countries related to the prevalence and burden of NCDs, lifestyle and dietary

Table 4 – Leading institutions in research productivity (number of articles) in the field of nutrition in NCD research among Arab countries from 2006 to 2015

Name of Institution	Country	Number of Articles (%) [*]	IF Mean ± SD	Citation Mean ± SD
King Saud University	KSA	90 (10.90%)	2.38 ± 1.16	14.20 ± 13.03
King Abdulaziz University	KSA	50 (6.07%)	2.34 ± 1.16	12.53 ± 20.63
American University of Beirut	Lebanon	40 (4.85%)	2.85 ± 2.25	19.22 ± 26.14
University of Sfax	Tunisia	38 (4.61%)	2.17 ± 1.12	19.08 ± 19.90
Cairo University	Egypt	28 (3.40%)	1.96 ± 0.93	14.34 ± 30.16
Ain Chams University	Egypt	27 (3.28%)	1.61 ± 0.85	13.38 ± 21.94
UAE University	UAE	25 (3.03%)	2.89 ± 1.21	14.48 ± 15.50
National Research Center	Egypt	20 (2.43%)	1.82 ± 0.93	10.63 ± 17.03
Alexandria University	Egypt	19 (2.31%)	1.96 ± 1.21	18.32 ± 21.15
Sultan Qabous University	Oman	19 (2.31%)	2.26 ± 1.07	32.31 ± 100.33

^{*} Numbers indicate the count of the articles and the percentage of the total count (824).

habits, and cultural specific dietary and lifestyle factors associated with NCDs [50]. The second stage should aim to map the nutrition and NCDs research among Arab countries, which includes an identification of research gaps and opportunities in the country (as conducted in this study) and an examination of available resources needed for this research. These resources include, among others, financial resources, human expertise, infrastructure, and available policies and procedures. The third stage is multi-stakeholders' priority setting and consensus building to establish an agenda to address nutrition and NCDs research, taking the results of the first 2 stages into consideration. The stakeholders who may be involved include research institutions, policy and decision makers, NGOs and community representatives, research end-users, and funding agencies [12]. Their efforts could be led by national governmental research agencies that will unite the various groups, translate between the different languages and fields of expertise, and

facilitate interactions [51]. Such meetings would be necessary to move the identified research priorities from the realm of academia into that of the formal agenda of donors and policy makers [52].

The aforementioned suggested process for the formulation of an informed research agenda is comparable to that proposed by the Sustainable Nutrition Research for Africa in the Years to come (SUNRAY) [53]. Both processes included mapping of current research, evaluation of capacity in nutrition research, stakeholder's consensus building and priority setting.

6. Future research directions in the area of nutrition and NCDs in Arab countries

Moving forward, Arab countries may follow the proposed process of developing a research agenda, including collecting

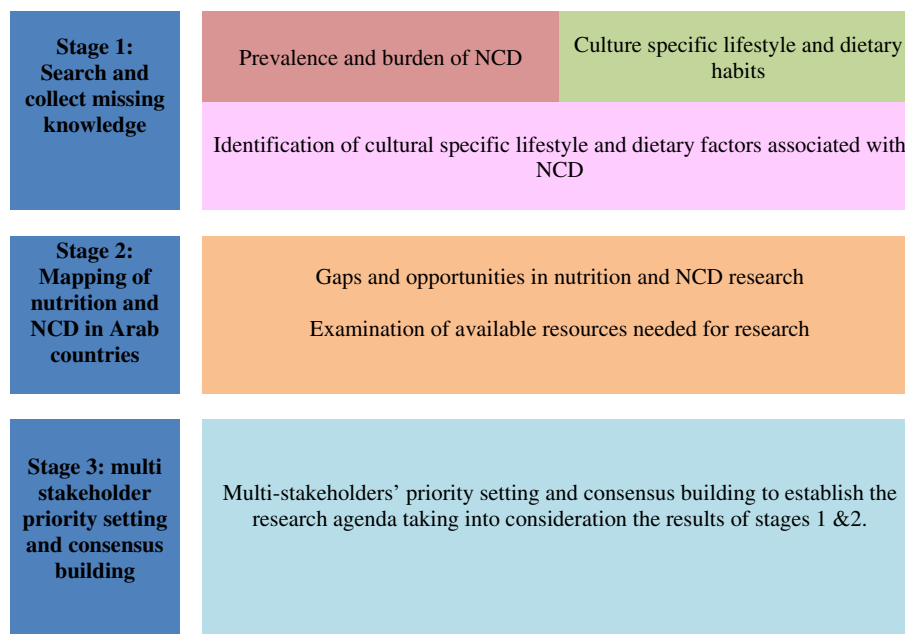


Fig. 4 – A 3-staged process to support the process of development of an informed research agenda related to NCDs nutrition research in Arab countries.

missing knowledge about nutrition and NCDs, mapping of research related resources, and identifying their research priorities. The priorities identified will guide policy makers and other stakeholders, including members of the research community, funding agencies, NGOs, and the private sector to conduct relevant research for the development of culture specific and evidence based intervention strategies to curb the escalating prevalence of NCDs in these countries.

7. Conclusions

The findings of this study have highlighted gaps and opportunities in nutrition and NCDs research in Arab countries needed for the formulation of an informed research agenda. The main gaps were related to limited diversity of research designs with a focus on laboratory studies, emphasis on single dietary exposures as opposed to dietary patterns, limited use of validated dietary assessment tools, scarcity of studies addressing early life nutrition exposures, and considering nutrition in isolation of other environmental risk factors. The opportunities suggested were the promising interest in studying nutrition and NCDs, as evidenced by the increasing number of articles over the years, and a potential synergistic collaboration between high and middle income Arab countries. In addition to highlighting these gaps and opportunities, this review presented a 3-staged process that constitutes a preliminary roadmap supporting the formulation of an evidence informed research agenda for the perusal of concerned stakeholders. Within this context, funding agencies are encouraged to support a priority setting exercise in the field of nutrition and NCDs research in Arab countries.

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