

Analysis of biomedical and health research in the Eastern Mediterranean Region

Ghazi O Tadmouri^{1,2}, Ahmed Mandil³, Itab Soukarieh^{1,2}, Israa Salma¹, Nada Assaad¹, Marwa Al Khatib¹ and Arash Rashidian⁴

¹Faculty of Public Health, Jinan University, Tripoli, Lebanon. ²WHO Collaborating Centre for Health Research and Bibliometrics, Tripoli, Lebanon (Correspondence to Itab Soukarieh: itab.soukarieh@jinan.edu.lb). ³Epidemiology Department, High Institute of Public Health, University of Alexandria, Alexandria, Egypt. ⁴Department of Science, Information and Dissemination, WHO Regional Office for the Eastern Mediterranean, Cairo, Egypt.

Abstract

Background: Several bibliometric analyses have been conducted in the Eastern Mediterranean Region (EMR), however, there is limited data from such analyses for the establishment of national or regional health research agenda.

Aim: To assess the biomedical and health research outputs in EMR countries for 2004–2018 and their alignment with the regional strategic health priority areas identified by the WHO Regional Office for the Eastern Mediterranean.

Methods: We searched and reviewed health-related articles indexed in PubMed and originating from EMR countries from 2004 to 2018 and used these as indicators of the country's total biomedical research publication level. Data from a very large collection of over 300 000 articles were weighted to EMR's contribution to the global research output. We used the mean and standard deviation to summarise the continuous variables and used frequencies and percentages to summarise the categorical variables.

Results: Biomedical research publication in the EMR increased between 2004 and 2018. Five countries – Islamic Republic of Iran (43%), Egypt (14%), Saudi Arabia (11%), Pakistan (8%), and Tunisia (6%) – contributed 82% of all the publications, while the other countries contributed less than 4%. On average, EMR contributed 2.0% of the global biomedical research publications and 3.12 publications per 100 000 population for 2004–2018.

Conclusion: Biomedical and health research publication increased unevenly across the EMR countries during the study period. Considering the complexity of the public health challenges in the region, there is a need for multidisciplinary and holistic approaches to health research to generate evidence for policy and to improve clinical and public health outcomes.

Keywords: biomedical research, health research, PubMed, global research output, publications, Eastern Mediterranean Region

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Introduction

Scientific research is a critical investment needed to foster innovation, advance knowledge, and for social, health and economic development. Improvements to health and health equity globally rely on research evidence. High-quality health research outputs require a supportive research environment, not only for planning, design and implementation, but also for sharing, using and translating findings into evidence-based policies and cost-effective interventions (1). Inadequacies in the availability, relevance and timeliness of research evidence are among key barriers to evidence-informed policymaking in many countries including in the Eastern Mediterranean Region (EMR) (2,3).

Studying trends in biomedical and health research has increasingly influenced research mapping efforts globally over the years (4–6). Research mapping relies on bibliometric analyses to estimate and analyse research productivity of institutions, countries or regions, in general, or a specific domain of research. Bibliometric methods offer the special advantage of using data that

can be collected from bibliographic databases with minimal bias or researcher involvement.

The lack of reliable, comprehensive and accessible data on health research in the EMR hinders the identification of research gaps and priorities. Therefore, to address the health challenges and set a national or regional health research agenda in the EMR, there is a need to analyse and synthesise data using methods and tools that help map the research output in health and related fields.⁷

Bibliographic studies are key to the identification of research priorities nationally and internationally (8,9). There is an increasing number of bibliometric analyses in the EMR (10–19), although some analyses may have limited geographic or thematic scope and may not completely capture the status of health research publications from the region.

WHO started a new research programme that is based on robust methodology to monitor and assess national or disease-specific research publications in the EMR (20,21). This study is an expansion of the assessment of biomedical and health research outputs in EMR countries from 2004 to 2018. The study assessed the alignment of

these studies with the regional strategic health priority areas defined by WHO, to know if they address the most pressing and pertinent health issues and meet the needs of populations in the region (22).

Materials and methods

We described the methods used for the bibliographic assessment of studies from the EMR countries in a previous article (20). Leveraging these methods, we searched biomedical research publications on PubMed from 2004 to 2018, yielding a large collection of over 300,000 articles for analysis.

The country-specific datasets were collected in Medline format text files containing various fields, such as PubMed identification, article title, abstract, journal title, year of publication, article authors and their affiliations, and others. These datasets were imported into offline local databases and their quality was checked to remove articles with incorrect addresses and those from non-EMR first authors (20). We used the number of biomedical and health articles originating from each EMR country for 2004–2018 as an indicator of a country's total biomedical research publication level. For balanced comparison, we normalized the data to assess contribution to the global research output, represented by the total number of articles indexed in PubMed per year and the population size of each country (4). To estimate the population size, we obtained population data from the United States Census Bureau international database (23).

For each article, we reviewed the title, keywords, co-author affiliations, place of publication, and the abstract and assessed whether they addressed any of the WHO's 5 strategic health priority areas for EMR: health system strengthening, maternal and child health, non-communicable diseases, communicable diseases, and emergency preparedness and response (24,25).

We used mean and standard deviation to summarise the continuous variables and used frequencies and percentages to summarise the categorical variables. Fourth degree quartic polynomial trend lines were used in graphs denoting results of this analysis to allow for better comparisons during the 5-year periods 2004–2008, 2009–2013 and 2014–2018. The quality of the trend line was represented with R^2 , the coefficient of determination, where a value close to 1.0 indicated the goodness of fit of the trend line with actual data. The decision to use fourth degree quartic polynomial in trend lines was based on our observation that linear polynomial trend lines did not reveal enough periodic differences whereas higher order polynomials showed unwanted noise.

Results and discussion

Overview of biomedical and health research publications in the EMR

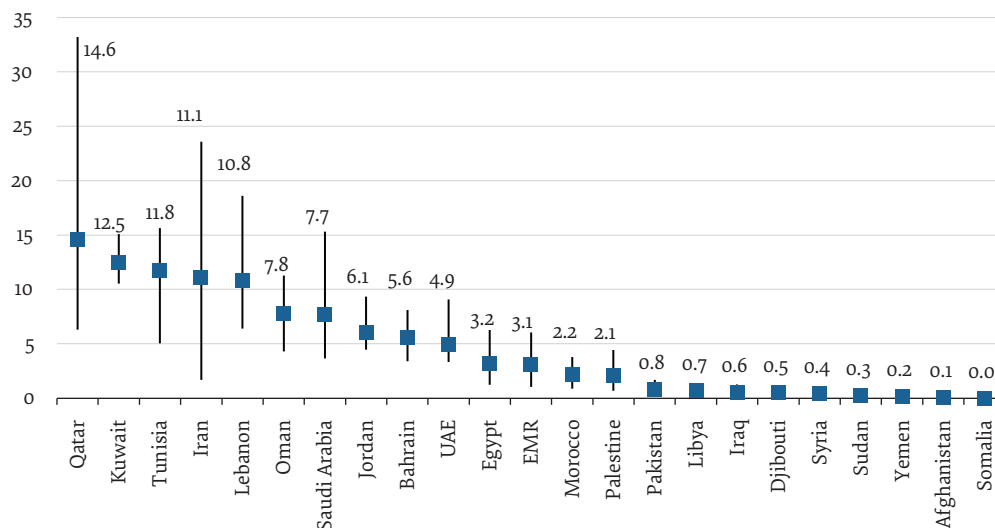
Our study showed an increasing trend in the overall number of biomedical and health research publications and research productivity in the EMR (total 305 159 articles; mean 15 258 articles per year). Notably, Islamic Republic of Iran accounted for nearly 43% of published research articles in the EMR during the study period, followed by Egypt (14%), Saudi Arabia (11%), Pakistan (8%), and Tunisia (6%). These 5 countries contributed nearly 82% of all published biomedical and health research articles in the EMR during 2004–2018. Based on the World Bank economic classification, 4 of these 5 countries are middle-income countries. All the other countries in the region each contributed less than 4% to the overall biomedical and health research publications in the region.

When normalized to global biomedical citation outputs indexed in PubMed, there was a small, but expanding, contribution of 0.85–3.25% (mean 2.01%) to global biomedical research publication for 2004–2018 from EMR. When normalized to population size, there was progress in biomedical research publications in the region; 1.02–6.04 publications per 100 000 population (mean 3.12 publications per 100 000 population). When the results of biomedical and health research article outputs from EMR countries were normalized to population size, there were 3.12 biomedical research articles published per 100 000 population per year (Figure 1). Among the best performers were Qatar with average 14.6 per 100 000 population per year. Kuwait had a relatively higher number of publications per capita in 2004–2018, similar to the patterns in 1988–2002 (6). Qatar and Kuwait are both high-income countries; low- and lower middle-income countries tend to have fewer publications when adjusted with their population levels (Figure 1).

Institutional biomedical and health research publications in the EMR

The geographical distribution of biomedical and health research publications was analysed by institution, using the institutional affiliations of the lead authors. In PubMed indexed articles we identified 4334 unique addresses (institutions) with at least one paper published during the study period. Nearly half of these institutional addresses were in a few high- and middle-income countries, including the Islamic Republic of Iran (24%), Pakistan (13%), Saudi Arabia (8%), and United Arab Emirates (7%).

In several countries, 5 institutions were responsible for most of the health research publications: Lebanon (84% of the total biomedical and health research publications), Qatar (83%), Oman (82%), and Bahrain (79%). In other countries, e.g. Islamic Republic of Iran, Pakistan, Iraq, and Egypt, a larger number of institutions, in smaller fractions, contributed to the publications.

Figure 1 Biomedical research publications from EMR countries normalized to corresponding population size, 2004–2018

- Values indicate health research publications per 100 000 population per year
- Boxes represent means
- Vertical lines represent minimum-to-maximum ranges
- The entry "EMR" represents average of the overall value for the entire Eastern Mediterranean Region

Detailed address analysis indicated that universities and their affiliated teaching hospitals were the major reporters of health and biomedical research in the EMR. This observation seems to be unchanged across low, lower- and upper-middle, and high-income countries (21).

Tehran University of Medical Sciences was the most prolific health research publisher during the study period, where first authors affiliated to the university contributed to nearly 6% of all health research published in the region between 2004 and 2018. Both Shahid Beheshti University of Medical Sciences (Islamic Republic of Iran) and King Saud University (Saudi Arabia) followed with a contribution of 3% each. Other institutions contributed less than 2.5%. Only 2 research centres in the EMR were featured among the most prolific institutions: the National Research Centre (Egypt) and King Faisal Specialist Hospital and Research Centre (Saudi Arabia). Collectively, the most prolific 25 institutions published 43% of all biomedical and health research articles in the region (Table 1).

The findings from this study indicate that academic research "mega sites" in the EMR, which include large-scale, multidisciplinary and collaborative research institutions act as large incubators for biomedical and health sciences research teams. This is in agreement with a study which demonstrated that universities contributed to an important share of science research activities globally and in the region (26,27). This trend may have been driven mainly by the stringent requirements for academic promotion, the availability of some research infrastructure and capacities (e.g. parks, units, centres), and the role of these institutions in a wide range of activities such as higher education, patient care, service and outreach, and technology transfer (21). Migrant scientists returning to the region, at least in some countries, may also have contributed to this trend, since

many of them have higher publication rates and relative access to international collaborative research networks (28,29).

Co-authorship patterns in the EMR

Data collected within the framework of this study included a cluster of more than 1 369 000 co-authors; each published article had an average of 4.2 co-authors (Figure 2). Annual values demonstrate an increase in co-authorship from 3.9 per publication in 2004 to 5.1 in 2018 (Figure 3). These findings agree with a study of nearly 2 million papers published in 1995–1999, which showed that biological sciences had an average co-authorship rate of 3.8 (30) and a smaller study from 2005 to 2014, which reported a co-authorship rate of 4.3 (31).

Broadly, co-authorship seems to be an established model in biomedical and health research publishing in the EMR especially in the lower- and upper-middle income countries (Figure 2). The lowest rates of co-authorship occurred in Iraq, Syrian Arab Republic and Jordan (range 2.9–3.4). In Egypt, United Arab Emirates, Palestine, Saudi Arabia, Oman, Kuwait, Qatar, and the Islamic Republic of Iran, health research co-authorship were 3.7–4.2. Large co-authorship of 4.3–6.0 were observed in Sudan, Lebanon, Pakistan, Morocco, and Tunisia (Figure 2).

It is worth mentioning that co-authorship patterns decreased briefly in the EMR in 2010–2012 (Figure 3). This may be attributed to the major socio-political instabilities in many EMR countries during this period.

Research collaboration patterns in the EMR

Our co-authorship analysis showed that each EMR co-author partnered with at least 3–5 colleagues to conduct a biomedical or health research. Affiliation analysis of all co-authors showed the extent of collaborations in published biomedical and health research and whether

Table 1 The 25 most prolific institutions in the EMR in terms of PubMed-indexed biomedical and health research articles published from 2004 to 2018

Rank	Country	Institution	#	%
1	Islamic Republic of Iran	Tehran University of Medical Sciences	17368	5.7
2	Islamic Republic of Iran	Shahid Beheshti University of Medical Sciences	10246	3.4
3	Saudi Arabia	King Saud University	9484	3.1
4	Egypt	Cairo University	7352	2.4
5	Islamic Republic of Iran	Isfahan University of Medical Sciences	7171	2.4
6	Islamic Republic of Iran	Shiraz University of Medical Sciences	6939	2.3
7	Islamic Republic of Iran	Islamic Azad University	6315	2.1
8	Tunisia	Tunis El Manar University	5800	1.9
9	Islamic Republic of Iran	Tabriz University of Medical Sciences	5645	1.9
10	Islamic Republic of Iran	Mashhad University of Medical Sciences	5593	1.8
11	Egypt	Mansoura University	4195	1.4
12	Islamic Republic of Iran	Iran University of Medical Sciences	4130	1.4
13	Lebanon	American University of Beirut	4091	1.3
14	Egypt	Ain Shams University	3809	1.3
15	Tunisia	University of Sfax	3738	1.2
16	Pakistan	Aga Khan University	3693	1.2
17	Islamic Republic of Iran	University of Tehran	3656	1.2
18	Saudi Arabia	King AbdulAziz University	3542	1.2
19	Islamic Republic of Iran	Tarbiat Modares University	3506	1.2
20	Egypt	Alexandria University	3172	1.0
21	Kuwait	Kuwait University	2764	0.9
22	Egypt	National Research Center	2703	0.9
23	Saudi Arabia	King Faisal Specialist Hospital and Research Centre	2569	0.8
24	Oman	Sultan Qaboos University	2465	0.8
25	Jordan	Jordan University of Science and Technology	2247	0.7
		Others	172 966	56.7
		Total	305 159	100

the corresponding research was a result of national, regional or international collaborations. In 75% of articles published in 2014–2018, the principal investigator was from an EMR country, indicating major role in the study.

At country level, the Islamic Republic of Iran exhibited a striking result, with 94% of publications led by Iranian researchers; they had non-primary position in only 6% of the publications (Figure 4). The affiliation and institutional addresses in the collection of Iranian published research indicated that most of the biomedical and health research networks were based on collaborations among Iranian science groups affiliated to various national institutions. This was the case in the middle-income countries, while in low-income countries authors were less likely to be lead authors (Figure 4).

In high-income EMR countries, many local researchers did not have lead author roles among the collaborative groups: Qatar 53%, United Arab Emirates 50%, Bahrain 44%, Saudi Arabia 43%, Oman 38%, and Kuwait 34%. In most of these countries, co-authorship networks were maintained through collaborations between research groups in local universities or research

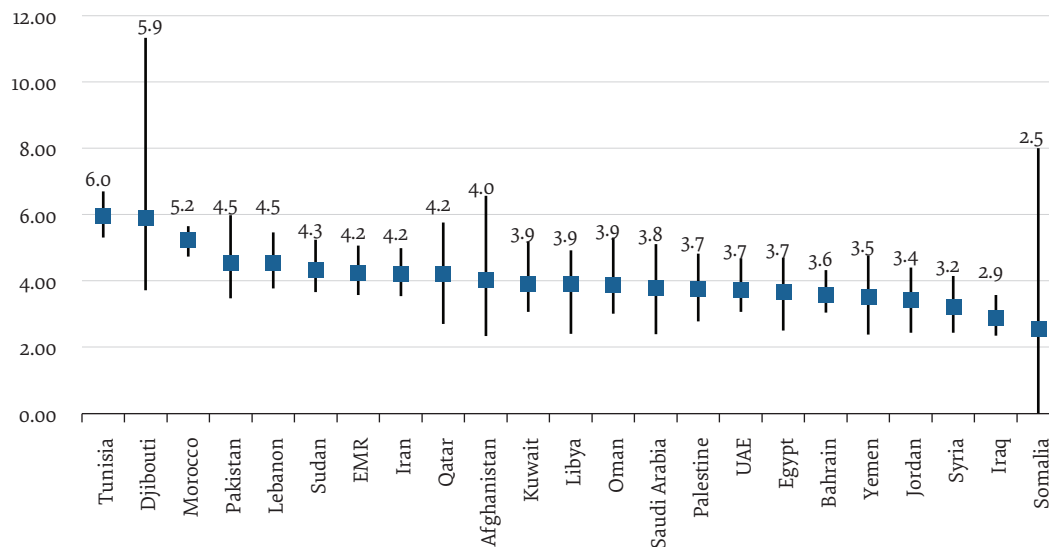
centres and foreign research groups, mainly in North America and Europe.

Biomedical and health research directions in the EMR

A deep analysis of biomedical and health research in the EMR for 2004–2018 revealed that noncommunicable diseases were by far the most researched; between 42% and 48% for different years. This finding remained valid even when EMR countries were divided into sub-regional clusters (e.g. North Africa, the Levant, Arabian Peninsula, and others) (25,32,33). Research on noncommunicable diseases was higher in Morocco and the Levant and Arabian Peninsula countries. In these countries, the burden of disease had shifted from communicable to noncommunicable diseases such as cardiovascular disease, cancer and inherited disorders in the past few decades (34–37).

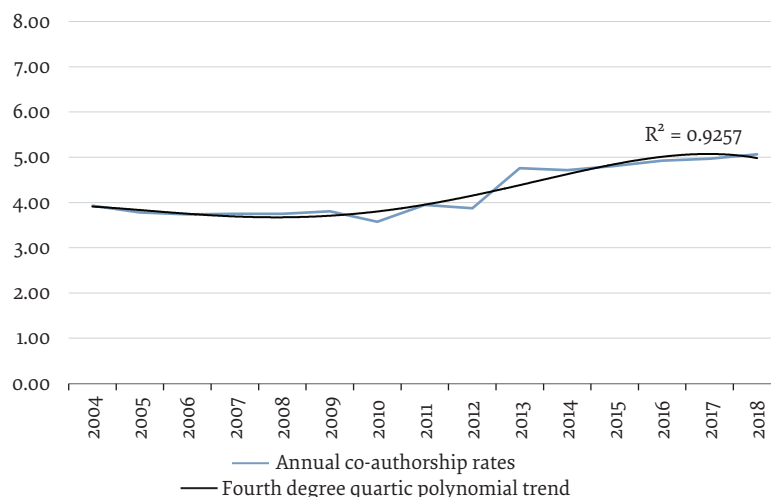
Communicable diseases research was second place in the region, varying from 8% to 15% for different years. Communicable diseases research was most common in countries that are experiencing serious socio-

Figure 2 Co-authorship rates of biomedical and health articles from EMR countries, 2004–2018



- Values indicate the number of co-authors per publication
- Boxes represent means
- Vertical lines represent minimum-to-maximum ranges
- The entry "EMR" represents the average overall value for the entire Eastern Mediterranean Region

Figure 3 Annual co-authorship rates in biomedical and health articles indexed in PubMed for the EMR, 2004–2018



R² = Coefficient of Determination

politico-economic conditions, namely, Somalia, Sudan, Afghanistan, Libya, and Yemen.

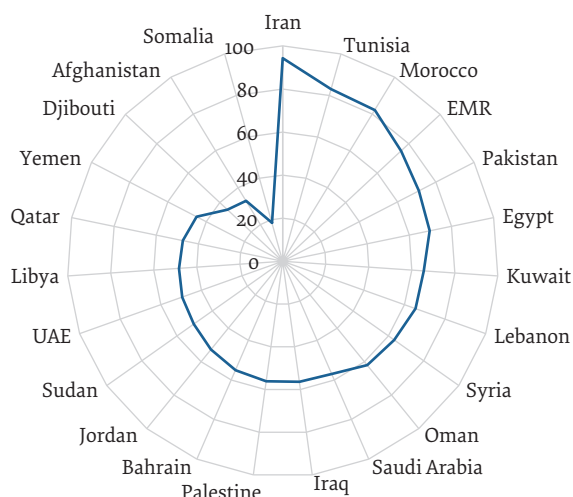
Health system strengthening research was third, ranging between 8% and 15% for different years and having limited publications from Afghanistan, State of Palestine, and Jordan. A regional study had reported dissatisfaction among patients from the region mostly due to inefficient health care practices (38). The enhancement of health information systems will be of paramount value and may allow further research on healthcare priorities and the impact of different interventions (39,40).

Maternal and child health research was reported in 6–12% of the published articles. In the EMR, women and children disproportionately account for the morbidity

burden among conflict-affected populations. In Syria, for example, infant and under-5 mortality rates increased, while coverage of antenatal care, skilled birth attendance and vaccination decreased (41).

Emergency preparedness and response was the least researched in the region, with only 0.2–0.8% of published articles focusing on this. Detailed country analyses showed a handful of research in this area published from Afghanistan and Djibouti. Afghanistan has been ravaged by years of conflict and most of the research published in the country on emergency preparedness and response were by medical teams affiliated to foreign armed forces based in Afghanistan (42,43). Only 1.5% of articles published by the Eastern Mediterranean Health Journal

Figure 4 Percentage of biomedical and health articles from EMR countries indexed in PubMed for which EMR scientists were primary authors, 2014–2018



from 1995 to 2014 focused on emergency preparedness and response (44). More than half of these articles were on injuries (mainly road traffic injuries), followed by emergency health services (e.g. water, floods, earthquakes, and cyclones). These findings contradict the fact that many EMR countries have experienced and/or continue to suffer from emergencies and humanitarian situations. The research deficit in emergency preparedness and response may be averted by strengthening the capacity of academic institutions and prioritizing research in this aspect, and by facilitating the transfer of knowledge from researchers in developed and developing countries that have experience in this vital field (45).

Nearly 24% of biomedical research conducted in the EMR were not directly related to WHO priority areas, they focused mainly on basic science with, probably, long-term outcomes in biomedicine or health (data not shown). Results from a study in the Levant and Arabian Peninsula correlated the increased research activity in non-priority fields with higher income levels (33). In many instances, articles in this category included were on environmental sciences, basic sciences, pharmacology and dosage forms, agriculture, and medical social sciences.

Study limitations

The data used for this study covered a 15-year period, 3 quintuplets, spanning 2004–2018 and complementing a previous investigation which covered the preceding 15 years from 1988 to 2002 (6). Data from 2019 and beyond were not included because of the emerging research focus on COVID-19 pandemic (46,47). Until early 2013, PubMed only indexed the affiliation details of the lead author in a single article, it was in October 2013 that the policy changed to include affiliations of all authors in the PubMed database (48). This may have placed a limitation on the analysis of research collaboration patterns in our study. We acknowledge the importance of other search engines, e.g. Index Medicus of the Eastern Mediterranean

Region (IMEMR), which we did not use for our study due to limited time and logistic constraints.

Conclusion

The big data analytics reported in this study represents the largest and most comprehensive attempt to analyse the collective quantitative and qualitative aspects of biomedical and health research publications in the EMR. The in-depth qualitative analysis reveals the research trends in the region and is helpful in identifying research gaps and enhancing policy and management decision-making.

The complexity of public health problems in the EMR is becoming increasingly challenging. Understanding and designing solutions for these problems require rigorous translation of fundamental scientific findings for better clinical and public health outcomes. The scarcity of dedicated national research centres in many EMR countries has made biomedical and health research activities to become more concentrated in academic institutions (Table 1). However, under optimal conditions, this knowledge can be translated into clinical practice and market, giving patients more options (49), by advocating for multidisciplinary and holistic research approaches to address public health issues in the EMR (50).

The complexity and specialization of health sciences and the large investments in “big biomedical sciences”, such as genomics and translational research, promote collaborative research. As healthcare becomes more precise and personalised, biomedical and health research moves from individuals to groups, from single to multiple, and from national to international levels. Hence, the role of health research networks becomes more crucial. Such networks will ensure viability and effectiveness through adaptation to context and needs by leveraging the potential of health research in the EMR. It will enhance goal attainment to address the health priorities and gaps of the region, enhance integration to

increase capacity and collaboration among researchers and health care providers, and facilitate latent pattern maintenance to increase the recognition and impact of researchers' work (51).

Our study shows a glimpse of the social organization of co-authorship and collaboration patterns in biomedical and health research in the EMR, however, more robust methods are needed to explore this aspect further. Social network analysis is a method that studies the

connections among social actors, such as individuals, groups or organizations. Using bibliometric data from the EMR, social network analysis can show the features of social networks, such as co-authorship networks. These networks can reveal the characteristics of scientific communities in the EMR, such as their sizes, density, diversity, productivity, and centrality. They can also help in investigating changes and trends in co-authorship and collaboration in the region over time.

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Analyse de la recherche en biomédecine et en santé dans la Région de la Méditerranée orientale

Résumé

Contexte : Plusieurs analyses bibliométriques ont été réalisées dans la Région de la Méditerranée orientale, mais les données issues de ces dernières sont insuffisantes pour établir un programme national ou régional de recherche en santé.

Objectif : Évaluer les résultats de la recherche en biomédecine et en santé dans les pays de la Région de la Méditerranée orientale entre 2004 et 2018 et leur conformité aux domaines stratégiques régionaux prioritaires en matière de santé définis par le Bureau régional de l'OMS.

Méthodes : Nous avons effectué des recherches et passé en revue les articles relatifs à la santé indexés dans PubMed et provenant des pays de la Région de la Méditerranée orientale entre 2004 et 2018 et nous les avons utilisés comme indicateurs du volume total de publications relatives à la recherche biomédicale par pays. Les données provenant d'une très vaste sélection de plus de 300 000 articles ont été pondérées par rapport à la contribution des pays de la Région aux résultats de la recherche au niveau mondial. Nous avons présenté les variables continues sous forme de moyennes et d'écart-types, et les variables catégorielles en tant que nombres et pourcentages.

Résultats : Le nombre de publications dans le domaine de la recherche biomédicale a augmenté entre 2004 et 2018 dans la Région de la Méditerranée orientale. Cinq pays – la République islamique d'Iran (43 %), l'Égypte (14 %), l'Arabie saoudite (11 %), le Pakistan (8 %) et la Tunisie (6 %) – ont contribué à 82 % du nombre total de publications, tandis que pour les autres pays, ce chiffre était inférieur à 4 %. En moyenne, les pays de la Région ont contribué à 2,0 % du nombre de publications sur la recherche biomédicale au niveau mondial et ont produit 3,12 publications pour 100 000 habitants entre 2004 et 2018.

Conclusion : Le nombre de publications relatives à la recherche en biomédecine et en santé a augmenté de manière inégale dans les pays de la Région de la Méditerranée orientale pendant la période couverte par l'étude. Face à la complexité des défis en matière de santé publique dans la Région, il est nécessaire d'adopter des approches globales et multidisciplinaires pour la recherche en santé afin de produire des données probantes pour établir des politiques et améliorer les résultats en santé publique et clinique.

تحليل البحوث الطبية الحيوية والصحية في إقليم شرق المتوسط

غازي تدمري، أحمد منديل، عتاب سكرية، إسرائيل سلمى، ندى أسعد، مروى الخطيب، آرشد رشيدان

الخلاصة

الخلفية: أُجريت عدة تحليلات ببليومترية في إقليم شرق المتوسط، غير أن هناك محدودية في البيانات المستمدة من هذه التحليلات لإعداد خطة وطنية أو إقليمية للبحوث الصحية.

الأهداف: هدفت هذه الدراسة إلى تقييم مخرجات البحوث الطبية الحيوية والصحية في بلدان إقليم شرق المتوسط خلال الفترة من عام 2004 إلى عام 2018، ومواءمتها مع المجالات الاستراتيجية الصحية الإقليمية ذات الأولوية التي حددها المكتب الإقليمي لمنظمة الصحة العالمية لشرق المتوسط.

طرق البحث: بحثنا واستعرضنا المقالات المرتبطة بالصحة المفهّسة في قاعدة بيانات PubMed التي يعود مصدرها إلى بلدان إقليم شرق المتوسط في الفترة من عام 2004 إلى العام 2018، ثم استخدمناها بوصفها مؤشرات على المستوى الإجمالي لما نشر في مجال البحوث الطبية الحيوية في البلد. ورُجِّحت البيانات المستمدة من مجموعة كبيرة للغاية تضم أكثر من 300000 مقالة لتحديد إسهام إقليم شرق المتوسط في الناتج البحثي العالمي. واستخدمنا المتوسط والانحراف المعياري لتلخيص المتغيرات المستمرة، واستخدمنا معدلات التواتر والنسب المئوية لتلخيص المتغيرات الفئوية.

النتائج: لاحظنا زيادة ما نشر في مجال البحوث الطبية الحيوية والصحية في إقليم شرق المتوسط بين عامي 2004 و2018. وأسهمت خمسة بلدان – وهي جمهورية إيران الإسلامية (43%) ومصر (14%) والمملكة العربية السعودية (11%) وباكستان (8%) وتونس (6%) – بنسبة بلغت 82% من إجمالي المؤلفات المنشورة، في حين أسهمت البلدان الأخرى بنسبة تقل عن 4% لكل منها. وفي المتوسط، أسهم إقليم شرق المتوسط بنسبة 2.0% من المؤلفات المنشورة للبحوث الطبية الحيوية والصحية على مستوى العالم وبمعدل بلغ 3.12 مؤلفاً منشوراً لكل 100000 نسمة خلال الفترة من عام 2004 إلى عام 2018.

الاستنتاجات: زاد ما نشر في مجال البحوث الطبية الحيوية والصحية على نحو متفاوت فيما بين بلدان إقليم شرق المتوسط خلال الفترة المشمولة بالدراسة. ونظرًا إلى الطابع المعقد لتحديات الصحة العامة في الإقليم، ثمة حاجة إلى اتباع أساليب شمولية ومتعددة التخصصات في بحوث الصحة لتوفير الدلائل اللازمة لوضع السياسات وتحسين المخرجات السريرية والصحية العامة.

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